

Book of Abstracts

**The 4th International Conference on
Drylands, Deserts and Desertification**

**November 12-15, 2012
Bluastein Institutes for Desert Research
Sede Boqer Campus of Ben-Gurion University, Israel**

Website: www.desertification.bgu.ac.il

E-mail: desertification@bgu.ac.il

Editors

**Samara Bel
Nina Gordon-Kirsch
Ehud Zion-Waldoks**

Disclaimer:

*The organizers apologize in advance if any abstract has unintentionally been omitted from the printed book of abstracts.
Any mistakes shall be corrected in the electronic PDF version to be sent to participants following the conference.*

Monday, 12 November

Time/ Location	Evans Auditorium	Old Administration Building	Hydrology Seminar room	Classroom 1	Classroom 2	Other
8:00-9:00	Registration & Reception					
9:00- 10:30	Greetings Plenary by Prof. Paul Ehrlich					
10:30-11:00	Coffee Break					
11:00-12:30 PS1 parallel sessions	Public Health and Life in Deserts and Drylands (1)	Desert Agriculture (1): Water and Energy Fluxes from Agricultural Soils	Strategies for Development Assistance to Drylands: Lessons Learned. Special session hosted by Mashav, Israel's Agency for International Development Cooperation, Ministry of Foreign Affairs	Cook Workshop on Desert Architecture and Urban Planning Part I ** including Cook Award Ceremony	Grey Water Utilization in the Drylands	Remote Sensing (1): Tools and Implications in the Drylands @ Solar Center
12:30-14:45	Tours & packed lunch- 1) Kibbutz Sde Boker modern agriculture; OR 2) Avdat World Heritage site & ancient agriculture; OR 3) Agricultural R&D center, Ashalim (includes PS2 session in (general) Desert Agriculture)					
15:00-17:00 PS2 parallel sessions	Climate change in the Drylands: Adaption and Beyond	Remote Sensing (2): Tools and Implications in the Drylands	Creating Water Sensitive Cities in Israel	Workshop on Desert Architecture and Urban Planning Part II	Desertification as a catastrophic regime shift: : Empirical and Mathematical Aspects	Public Health and Life in Deserts and Drylands (2) @ Bein-Tkhumi
17:00-17:10	Room Change					
17:10-18:40 PS3 parallel sessions	Desert Agriculture (3): Water and Energy Fluxes from Agricultural Soils	Remote Sensing (3): Tools and Implications in the Drylands	Water Management in Arizona and Lower Colorado River Basin (USA): Good Practices and Long-term Challenges	Workshop on Desert Architecture and Urban Planning Part III	Desertification and Bedouins in the Middle East: Project Wadi Attir	Public Health and Life in Deserts and Drylands (3) @ Bein-Tkhumi
18:30-19:00 19:00-21:30	Reception Saluting the Green Belt Movement and dinner					
21:00-22:30	Film re. Wangarai Maathai					

Tuesday, 13 November

Time/ Location	Evens Auditorium 300/150	Old Administration Building 90-100	Hydrology Seminar room 40-50	Classroom 1 30-40	Classroom 2 30-40	Agriculture Seminar Room	Other
8:00-9:00	Registration & Reception						
9:00- 10:40	Plenary Zero Net Land Degradation , Segment I: Scientific Segment						
10:40-11:00	Coffee Break						
11:00-12:30 PS4 parallel sessions	“Zero Net Land Degradation: Operationalizing a Sustainable Development Target.” Segment II: Implementation Segment	Public Health and Life in Deserts and Drylands (4)	Friends of the Earth Middle East Presents a Joint Palestinian/Jordanian Program for Restoring the Southern Jordan River	Studies of Biological and Structural Soil Crusts with Geoinformation	Environmental Education (1)		Evolution, Climate and Man as Factors Leading to Degradation and Productivity Loss in Terrestrial Biomes @ Biology classroom
12:30-13:30 13:30-14:15	Open Campus Authentic Israeli picnic lunch and international desserts...						
14:30-16:30 PS5 parallel sessions	Rehabilitation of Desertified Areas Through Sustainable Afforestation and Forest Management – Solutions and Successes in the Long Term	Restoring Water Resources: Practice, Research and Watershed Management (1)	Long-term Observation of Dryland Ecosystems	Yair Etzion Workshop on Desert Architecture (1)	Grazing (1): Application of Modern Technologies in Rangeland Research	ZNLD workshop	Environmental Education Tour
16:30-16:45	Room Change/ coffee break						
16:45-18:45 PS6 parallel sessions	NGO Perspectives on Dryland Development	Restoring Water Resources: Practice, Research and Watershed Management (2)	Ecosystem Services	Yair Etzion Workshop on Desert Architecture (2): Green Building in Israel	Grazing (2): Grazing and Soils	ZNLD workshop	Environmental Education Roundtable @ Bein Tkhum
19:00-21:30	Kibbutz visit and dinner (Mashabim/Sde-Boker)						
21:30	1st round of buses return home OR Israeli Folk Dancing at Mashabim....						
23:00	Final Buses return						

Wednesday, 14 November- Tentative Excursion Day Program

- **Tour I: Desert Architecture in the Negev & the Hura Waddi Attir Project**
Guided by Arch. Matti Cones, Cook Award recipient for 2012
- **Tour II: Environmental Education: The Negev Highland as a Man and Biosphere Reservation: Toward a Process of Formulating the Foundation for UNESCO Standards**
The tour will expose us to key issues in Mitzpe Ramon, the Makhtesh and the Negev Highland, headed for a process of formulating the foundation for UNESCO standards Mark in this region, discussing topics such as: 'living on the edge of landscape reservation'; 'tourism development and nature conservation' in times of decrease in precipitation; 'conservation of camel grazing tradition, army training areas and nature conservation' and 'the influence of private homesteads on the social-ecological system.
- **Tour III: Afforestation**
The tour will focus on the challenge and various techniques of afforestation and forest management in the semi arid and arid areas of the Negev. Aspects of water harvesting, soil conservation and rehabilitation, long term research and monitoring, drought, urban forestry and seedlings production, will be demonstrated through the tour.
- **Tour IV: Ecological Tourism in the desert milieu**
The tour will focus on visits to family farms and other sites and attractions that have integrated sustainable tourism, ecological tourism, agricultural tourism and nature-oriented tourism. The sites we visit will present different ecological facets, such as integration of ecological "green" construction, utilization of natural resources for tourism, utilization of the means of agricultural production for tourism, etc. The tour will include food and beverage tasting and a fascinating encounter with the amazing people behind these desert enterprises.
- **Tour V: Hydrology and Advanced Water Technologies**
The tour presents some advanced technologies to produce and conserve water, as well as advanced agricultural developments in arid areas.
- **Tour VI: Agriculture in Drylands: Modern agriculture and technology under extreme desert conditions (Dead Sea area)**
The tour will focus on advanced irrigated agriculture in the arid northern Arava and Arad Valleys and will discuss techniques and technologies for coping with stress causing factors including high water demand, salinity and extreme climate conditions. We will visit experimental research stations/sites and commercial farms. Participants are encouraged to bring a bathing suit.
- **Tour VII: The Route towards Mine Rehabilitation in the Ramon Crater: Is it possible to achieve a stable, functioning and productive ecosystem similar to the natural environment, by dirt works?**
The aim of this tour is to explore concepts and work methods that have been used over the last 15 years in mine- rehabilitation projects at the Ramon crater in the Negev desert. The tour will pass through different rehabilitated sites and will introduce different implementation techniques, as well as other beautiful sites and phenomena of the Ramon crater.
- **Tour VIII: Regenerating Energy in the Desert**
The tour will explore the National Solar Center at Sde-Boqer and will also take participants to the Renewable Energy Technology Center in the Eilat region (Arava).
- **Tour IX: Life Strategies in the Desert**
This tour will concentrate on various aspects of life in the deserts and ways of sustainable use of its limited resources, both in agriculture, tourism and education...

Thursday, 15 November

Time/ Location	Evans Auditorium	Old Administration Building	Hydrology Seminar room	Classroom 1	Classroom 2	Biology Classrooms (33+ 132)
8:30-10:30 PS7 parallel sessions	Saving the Dead Sea: Evaluating Red Sea- Dead Sea Water Conveyance	Carbon accounting and Minimization in Rural and Arid Environments	Italian-Israeli Bilateral Cooperation Session	Soil and Land Restoration in the Drylands (1)	Informal Employment of women in Rural Arid Lands	Special program Spanish/ Russian Mashav groups (2 rooms)
10:30-10:40	Room change and coffee break					
10:40-12:10 PS8 parallel sessions	International Arid Lands Consortium (IALC) Program Review	Transboundary management of Water Resources in the Drylands	Nomadic People in Desert Regions: Rethinking Citizenship in the 21st Century from the Perspective of Marginalized Nomadic Peoples	Soil and Land Restoration in the Drylands (2)	Environmental Education (2)	Special program Spanish/ Russian Mashav groups (2 rooms)
12:10-13:30	Closing Remarks					
13:30-14:30	Lunch					
15:00	Buses depart					

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Opening Statement

Israel, Desertification, and the Human Predicament

Paul R. Ehrlich

Humanity is faced with an array of environmental problems that threaten a collapse of civilization. They include climate disruption, loss of biodiversity (and thus ecosystem services), land-use change and resulting degradation, global toxification, ocean acidification, decay of the epidemiological environment, serious resource depletion, and resource wars (which could go nuclear). This is not just a list of problems, it is an interconnected complex, driven by overpopulation, overconsumption among the rich, and the use of environmentally malignant technologies and socio-economic-political arrangements to service the consumption.

Israel is one of the most scientifically-advanced countries, and can play a major role in bringing all of these problems to global attention. But its great experience in combating one major element in the deadly nexus -- land degradation, especially desertification, gives it an ethical duty to not only help other nations to prevent and reverse the damage, but also to be sure it deals properly with relevant local and regional aspects.

Israel is, after all, in a location that some climate models indicate may become both hotter and drier in the near future. It seems clear that Israel and its neighbors, already marginal ecologically, will be required to adapt to a global climate regime that will involve both general heating and more extremes of weather. These, in turn, likely will exacerbate its desertification problem. Adaptation will be much more difficult if Israel's population remains (like the rest of the world) unsustainable -- far over its human carrying capacity (it already has an ecological footprint several times its area). It would be wise for the nation to institute measures to discourage over-reproduction of its own population, reducing its total fertility rate from a disastrous 3.0 to the vicinity of 1.6 and holding it there until a necessary gradual decline in population size can be humanely instituted.

Israel could set an example to be the first rich nation to explicitly deal with the population driver of its environmental peril, something totally ignored by the United States and most European countries. In addition, if it hopes to survive the building crisis, it should build on its experience to put in place even more advanced programs of water conservation, create water-handling infrastructure designed for flexibility, and negotiate the fairest possible sharing with neighbor nations. Water shortage is soon likely to become an even more general and contentious element in Middle Eastern politics, especially in view of the vast overpopulation of the whole area and high population growth rates (which, fortunately, are showing some signs of reduction in Muslim nations). The sooner all countries in the region face their common dilemma, halt their population growth and start gradual declines toward sustainable numbers, and cooperate in adaptation, the less likely it will be that shortages will lead to another, and much more devastating, "water war."

Ecological security is even more vital than military security. You can negotiate with an enemy, but you can't negotiate with nature. Either the nations of the Middle East will forget about ancient myths and past grievances and change their ways to deal with a catastrophe facing them all, or nature will change their ways for them.

Application of modern technologies in rangeland research

The measurement of states and rates that are central to the functioning of rangelands are critical to research, development, monitoring and management of these systems. Modern technologies can make it possible to measure variables that could not be measured before, or introduce improvements in realms such as cost, ease, functionality, spatial and temporal resolution, accuracy and precision. They may be applied to various aspects of rangeland production systems, including climate, soil, vegetation, animal and management. Modern technologies that have been applied to rangeland research include, but are not limited to, remote sensing, GIS, GPS, spectroscopy, pedometry, acoustics, modeling and geostatistics, decision support systems and web-based applications.

Temporal evolution of grasslands and open shrublands in pastoral landscapes of Greece

D. Chouvardas, I. Ispikoudis, M. Siarga, K. Mitka, Ch. Evangelou and V.P. Papanastasis
Laboratory of Rangeland Ecology, Aristotle University, P.O. Box 286, Thessaloniki 54124, Greece;
xouv@for.auth.gr

In recent years, studies of temporal evolution have been carried out in several pastoral landscapes of Greece based on aerial photographs. These studies covered a total area of 69,372 ha and included the Kolchiko and Hortiatias watersheds of central Macedonia, the Kopatsari and Askio region of western Macedonia, and the valley of Portaikos – Pertouli in Thessaly. The temporal transformation of these landscapes was evaluated by means of Geographic Informational Systems (G.I.S.) and the digitization of sequential sets of aerial photographs and orthophotos, covering a period from 1945 to 1998. Changes in grassland pattern were evaluated by the use of landscape metrics. Demographic and socioeconomic inventory data were also collected in order to explain the landscape changes. From these studies, it became evident that the pastoral landscapes have significantly changed over the last 65 years, in terms of land use/ cover structure and landscape pattern. A major trend has been the reduction of the area covered by grasslands, from 14% to 7%, during the study period in favour of forests and dense shrublands, as well as agricultural lands. Furthermore, a reduction of open shrublands in favour of dense ones was also recorded. Landscape metrics also revealed that grassland patches have become more fragmented and dispersed over the years. Population ageing, a significant decline of people employed in the primary economic sector and a change of traditional management practices (animal husbandry and forestry) are considered as the main factors causing the recorded landscape changes. The reduction of grasslands and the negative prospects for their future recovery (based on a future projection model for the Kolchiko landscape) represent a major obstacle to employing sustainable practices in livestock husbandry.

State of the art in monitoring the behavior and nutrition of grazing animals: the Italian and Israeli experience

G. Molle¹, E.D. Ungar², A. Brosh³, Z. Henkin^{2,3}, M. Acciaro¹, M. Decandia¹ and S.Y. Landau²

¹ Department of Research for Animal Production, Agris Sardegna, 07040 Olmedo, Italy, gmolle@agrisricerca.it

² Department of Agronomy and Natural Resources, ARO, the Volcani Center, Bet Dagan 50250, Israel

³ Beef Cattle Section, ARO, Newe Yaar Research Center, Ramat Yishay 30095, Israel

The accurate monitoring of feeding behavior and nutrition of herbivores is still a challenge. This review is aimed at highlighting the pros and cons of the most widely implemented methodologies and technologies to assess and geolocate the feeding behavior and nutrition of grazers from a temporal scale of seconds to seasons and a spatial scale of cm² to hectares.

Biting, i.e. the severing of herbage, is the key act of grazing, and bite mass is probably the most important explanatory variable of intake. It is, therefore, basic to measure the timeline of grazing and properly count the number of bites. While direct observations can be deployed with satisfactory accuracy and precision, they are time-consuming and not always feasible. Automated measurement of grazing activity can be based on different systems, among them the IGER behavioral recorder (IBR) based on nose-band sensors of jaw movements and acoustic

monitoring, which records “the sound of grazing.” This technology is promising, but the automated analysis of the sound signal is a bottleneck that prevents its wider application.

The N-alkanes method, based on the determination of faecal markers associated with the waxy layer of plants, provides an effective tool to assess animal intake, diet digestibility and botanical composition under a broad spectrum of grazing conditions. However, the length and cost of the laboratory procedure, the use of hazardous solvents to extract alkanes, and the need to accurately measure alkane faecal recovery for the estimation of diet composition curb widespread adoption of the method. The real-time determination of n-alkanes by near infra-red reflectance spectroscopy (NIRS) without extraction can partially overcome the above shortcomings.

An application of NIRS called faecal NIRS (FNIRS) aimed at estimating dietary composition (crude protein, fiber components, and energy content), but not intake, from the analysis of faecal spectra, has proven successful in many grazing studies. Most likely, FNIRS ranks as first among scientific methods and technologies applicable at farm scale. The effectiveness of FNIRS, however, depends mostly upon the size and accuracy of a reference database and its relevance to the specific grazing system it is applied to.

Energy expenditure, a relevant energy output in grazing herbivores, can be reliably estimated by the method based on heart rate (HR) recording, coupled with the measurement of O₂ pulse (O₂P, consumption of O₂ per heart beat). When the HR-O₂P method is used in conjunction with sensors of animal position (GPS) and movement (pedometers), one can measure the distance walked and the time devoted to grazing, walking, and resting while lying or standing, as well as the energy spent in each of these activities. Moreover, combining top-quality pedometers with GPS can provide data on geo-located foraging, i.e., we can assess where and when grazing pressure is actually exerted in large paddocks. These technologies are being actively developed, and this could shortly result in their adoption by commercial farms.

To conclude, i) while all the above monitoring tools are valuable for scientific purposes, very few are applicable in a commercial farming context; ii) synergy of methods and technologies has been proven in several circumstances: e.g., n-alkane + NIRS, GPS + pedometers + HR-O₂P; and iii) hence, collaboration among researchers of contrasting skills and backgrounds can be fruitful.

Possibilities and limitations of intake estimation in goats foraging a Mediterranean shrubland using acoustic variables

Shilo Navon^a, Aharon Bellalou^a, Ezra Ben-Moshe^a, Hussein Muklada^a, Tzach Aharon Glasser^b, Serge Yan Landau^a, Eugene David Ungar^a

^aDepartment of Agronomy and Natural Resources, Institute of Plant Sciences, Agricultural Research Organization – the Volcani Center, P.O. Box 6, Bet Dagan, Israel 50250, shilo.navon@gmail.com

^bGanei Ramat Hanadiv, P.O Box 325, Zichron Yaakov, Israel 30900

Despite decades of research, the feeding behavior of free-grazing domesticated herbivores has not yet been well quantified, largely due to methodological constraints. In the last decades, some researchers shifted their attention to monitoring methods that focus on the interface between the herbivore and the vegetation. From this point of view, the most basic element of grazing behavior is the jaw movement – biting the herbage and chewing it. Grazing can then be defined in terms of the sequence of bite-and-chew jaw movements over time. Acoustic monitoring is a relatively novel and promising approach to identify jaw movement sequences. In this study, we describe one application of acoustic monitoring.

Goat herding on Mediterranean shrublands in Israel serves as an ecological management tool and exploits the goat's unique ability to be fed efficiently from the woody vegetation and transform it into milk. Efficient and sustainable management of these grazing systems requires quantification of foraging behavior and goat nutrition in the field. However, quantification of herbivore foraging behavior in such environments is problematic, not least because they are dominated by woody vegetation that is extremely difficult to measure.

We investigated the possibilities and limitations in using acoustic variables to estimate the intake of goats foraging woody vegetation. Feasibility of the approach depends heavily on some fundamental questions that involve animal physiology and feeding behavior patterns. These include the effect of bite weight and satiety level on chewing requirements, the stability of the chewing coefficient, the variability of bite weight on the individual shrub, and the variability of chewing requirements among individual goats and different shrub species.

Patch-size distribution of dwarf shrubs in a semiarid grazing land under different soil moisture conditions

Tal Svoray¹ - tsvoray@bgu.ac.il, Shai Sela¹ and Shmuel Assouline²

¹ Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva, Israel

²Environmental Physics and Irrigation, Agricultural Research Organization; Bet Dagan, Israel

Climate-vegetation interactions and feedbacks are the subject of many rangeland studies, and recently, the rainfall-plant-soil interplay in the hillslope scale is a focus of ecohydrology. As most of the models in this scale rely on synthetic environments, there is a need for studies that use remotely sensed and *in-situ* data to examine the effect of hillslope hydrological processes on ecosystem functioning and plant population spread in a more realistic manner. A major problem is the difficulty encountered in quantifying water budget and measuring vegetation at the individual shrub level. In this research, a typical hillslope was chosen, offering variations in slope decline and orientation, soil depth and vegetation cover, at the LTER Lehavim site in the center of Israel. The annual rainfall is 290 mm, the soils are brown lithosols and arid brown loess, and the dominant rock formations are Eocene limestone and chalk with patches of calcrete. The vegetation is characterized by scattered dwarf shrubs (dominant species *Sarcopoterium spinosum*), and patches of herbaceous vegetation, mostly annuals, are spread between rocks and dwarf shrubs. Eight aerial photographs of the slope, between the years 1978-2005, were acquired and georeferenced, and shrub cover was estimated based on the supervised classification of the aerial photos. An extensive spatial database of soil hydraulic and environmental parameters (e.g., slope, radiation, bulk density, soil depth) was measured in the field and interpolated to continuous maps using geostatistical techniques and physically-based modeling. This spatio-temporal database was used to characterize 1187 spatial cells serving as an input to a numeric hydrological model (Hydrus 1D) solving the flow equations to predict soil water content at the single storm and seasonal scales. The model was verified by sampling soil moisture at 63 random locations at the research site, during three consecutive storms in the 2008-09 rainy seasons. The results show that shrub-grass ratio reached a steady state phase with 20% cover in 1992 (after 14 yrs). This recovery rate is in agreement with previous field studies. Patch-size distribution in the slope scale showed that the size of patches in the field varies with the soil moisture conditions of the last 30 yrs. Quantification of the factors affecting shrub establishment was done using stepwise regression, showing that slope decline, radiation, soil texture, and rockiness are the leading physical factors.

Carbon Accounting and Minimization in Rural and Dryland Environments

Elevated carbon emissions among other greenhouse gases have been recognized as a major contributor to global climate change and there is desire by countries to reduce it. This was reinforced at the recent Durban conference. Carbon Footprint quantification analysis and reduction are essential to preventing this change. For example, settlement & landscape design, building design, use of appropriate building materials, enhancing energy efficiency, mitigating carbon emissions by means of green energy and/or compensating for C emissions by carbon offsets preferably within the settlement or village would lead to carbon neutral regions and ultimately to reducing C emissions. This session invites studies that are related to carbon accounting, and minimization in rural and arid environments.

Climate change impact on the livelihood of farmers

Priscilla M Achakpa-Executive Director, Women Environmental Programme; Abuja, Nigeria;

Priscilla.achakpa@wepnigeria.net

Climate change directly impacts agricultural productivity and food security. This is largely due to the fact that agricultural productivity depends – to a large extent – on external steady weather patterns. Agriculture is highly sensitive to climate change, largely because it depends on biodiversity and ecosystems. Sufficient water supplies, fertile soil, air temperature and average weather conditions all contribute to continuing agricultural productivity. Once there is a disruption in such patterns, there will be a direct bearing on agricultural output and, for the many

who depend on it, a threat to their livelihoods. The presentation will explore the links between climate change and its impact on the livelihoods of farmers and agricultural workers in Nigeria. While the presentation does not represent a comprehensive and holistic picture of agricultural activities in Nigeria, it does, however, provide a bird's eye view of the sector and how farmers are grappling with the decline in productivity and the loss of their livelihoods. It also highlights perspectives of multi-stakeholder engagement in supporting or strengthening the capacities of local farmers, particularly those from the non-governmental angle. It will dovetail into proffering critical recommendations on how donors and other stakeholders can support farmers in order to mitigate the effects of climate change in the sector. These will form the basis for the sharing of information and best practices.

Options to reduce greenhouse gas emissions during wastewater treatment for agricultural reuse

Pinchas Fine^{a*} and Efrat Hadas^b

^aMinistry of Agriculture, Agricultural Research Organization, Volcani Center, Institute of Soil, Water and Environmental Sciences, PO Box 6, Bet-Dagan 50250, Israel; finep@volcani.agri.gov.il

^bMinistry of Agriculture, Investment and Financing Authority, POB 30, Bet Dagan, 50250, Israel; efrath@moag.gov.il

Treatment of primarily-domestic sewage wastewater involves on-site greenhouse gas (GHG) emissions owed to energy inputs, organic matter degradation and biological nutrient removal (BNR). BNR causes both direct emissions and loss of fertilizer value, thus eliminating the possible reduction of emissions caused by fertilizer manufacture. In this study, we estimated on-site GHG emissions under different treatment scenarios, and present options for emission reduction by changing treatment methods, avoiding BNR, and by recovering energy from biogas. Given a typical Israeli wastewater strength (1,050 mg COD l⁻¹), the direct on-site GHG emissions rate due to energy use was estimated at 1,618 and 2,102 g CO₂-eq m⁻³, respectively, at the intermediate and highest treatment levels. Of these, the respective GHG emission abatement potentials, incurred via the exploitation of the biogas and fertilizers embodied in the wastewater, were approximately 55% and 25%. The wastewater fertilizers constituted a GHG abatement potential of 342 g CO₂-eq m⁻³. The component of them that remains in the effluent was 304-254 g CO₂-eq m⁻³ and 65-34 g CO₂-eq m⁻³, respectively, following intermediate and enhanced treatment levels. The raw sludge constituted approximately 47% of the overall wastewater fertilizer load with an abatement potential of 162 g CO₂-eq m⁻³ (385 kg CO₂-eq dry tonne⁻¹). Inasmuch as anaerobic digestion reduced it to 76 g CO₂-eq m⁻³, the GHG abatement gained through renewable biogas energy (up to 428 g CO₂-eq m⁻³) favored the digestion. However, composting reduced the fertilizer value to 21 g CO₂-eq m⁻³ or less (if emissions, off-site inputs and bioavailability losses were considered). Taking Israel as an example, fully exploiting the wastewater-derived GHG abatement potential could reduce the State's overall GHG emissions by almost 1%. This demonstrates the possibility of optional carbon credits which might be exploited in the construction of new wastewater treatment facilities, especially in developing countries.

Carbon accounting in smallholder dryland farming for sustainable development

Stefan Leu; Desert Research Institutes, Sde Boker 84990, and R&D Center Judea, Carmel; Microalgal Biotechnology Laboratory, Israel; stefanleu3@gmail.com

Based on recent definitions, the majority of the world's drylands can be considered degraded as their biological productivity is reduced significantly below that achievable under the same climatic and soil conditions in fully functioning ecosystems. Regarding Israel's Negev Desert, a few tiny locations of well-conserved reserves, as well as some artificially planted forests, woodlands and savannas, reveal the full productivity potential of the area, while most open space and rangelands fall far short of those productivities and must thus be considered degraded. Restoration of such degraded drylands offers enormous potential for restoring biodiversity, agricultural productivity and economic welfare, while sequestering carbon dioxide into soil and biomass. Executed on private farm land with the purpose of maximizing grazing capacity and farm income by means of silvopasture and agroforestry techniques, such restoration technologies can provide enormous economic gains while contributing to food and water security and alternative energy production. Thus restoration of degraded drylands is a key pillar in progressing towards sustainable development. We will present four case studies from the arid – semi arid interface in the Northern Negev and Africa, applying sustainable approaches towards sustainable low carbon agriculture; two sustainably managed

single family farms in the Northern Negev, a sustainable advanced livestock farming system near Hura, and a planned farming community in Northern Kenya will be assessed by analyzing environmental indicators, such as energy consumption, greenhouse gas balance, soil conservation, eutrophication and water consumption. Our research indicates that incorporation of food and fodder trees is an essential step in improving the environmental balance of such systems. These trees also contribute to an improved economic balance by increasing fodder availability and providing high value non-forest products. On the other hand, the need for irrigation water can have severe environmental impacts due to the high energy cost of water pumping, transport or purification. The possibility to finance part of the investments required by means of carbon trading/CDM will be discussed, whereby current rules prevent any funding of small holder property and dryland forestry operations due to inadequate carbon legislation. Were the carbon sequestration potential of a 100 hectare dryland farm compensated in advance, the full costs of carbon neutral sustainable farming systems could be covered by a well-designed, carbon-based crediting system and would solve the world's most acute food and energy problems in some of its poorest locations.

Carbon cautious: Israel's policies regarding afforestation and carbon sequestration

Alon Tal; Chair, KKL Committee for Land Development (Overseeing Israeli Forestry); Blaustein Institutes for Desert Research, Ben Gurion University; Sede Boqer, Israeli; alontal@bgu.ac.il

China was the first developing country, under the Kyoto Protocol, to receive carbon credits for a major tree planting project in the Pearl River Basin in Guangxi Province, meeting the somewhat convoluted documentation demands set forth by the U.N. Climate Change Convention. Moldova, Bangladesh, India and Uganda were soon to follow, receiving carbon credits for afforestation initiatives under the U.N. system that they could then sell to a developed "Annex 1" nation, according to the Kyoto Protocol. These projects were largely conducted in temperate regions. What is the potential of tree planting projects for generating profitable carbon credits in dryland regions? During the past 60 years, afforestation has transformed Israel's landscape, with forests planted or and planned on 10% of the country's land, much of it with less than 300 mm of annual precipitation. After early efforts to establish a successful commercial timber industry failed, recreation and ecosystem services came to dominate forestry policy objectives. Given Israel's status as a 'developing country' under the Kyoto Protocol, forests' economic potential through carbon sequestration was also explored, but did not prove to be compelling. Several considerations cooled the initial enthusiasm for seeking international carbon credits through afforestation. These include administrative obstacles associated with international accreditation (e.g., the small size of available land and the difficulty in proving "additionality"), low potential economic profitability, and ethical considerations. Rather, a voluntary offsetting program was adopted, allowing donors to plant trees in Israel that balance individual carbon emissions. Afforestation in drylands does exhibit meaningful potential to counteract chronic carbon loss due to land degradation and deforestation. Trees planted in Israel's semi-arid and arid regions exhibit surprisingly high carbon sequestration properties that are comparable to forests in temperate Europe. Based on this phenomenon, the potential for offsetting may become a growing factor in dryland forestry policies, particularly once regulation of CO₂ emissions becomes more widespread and expected of dryland countries. Afforestation in degraded drylands, it is argued, produces considerable benefits, but the primary gain from "carbon sequestration" at present may not be economic, but rather the sense of satisfaction in contributing to critical international efforts to reduce the atmospheric concentration of green house gases.

On-site sheep and goat manure digestion followed by Biogas production & aerobic composting.

Yair Teller¹, Tareq Abu- Hamed¹ and Amit Gross²

¹Center for Renewable Energy and Energy Conservation, The Arava Institute for Environmental Studies, Kibbutz Ketura, Eilat, Israel; yair@ecogas.co.il

² Zuckerberg Institute for Water Research, Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Midreshet Ben Gurion, Israel

In many rural areas, there is a need for decentralized waste management solutions.

For example in the Negev Desert, there are about 90,000 Bedouins who live in unrecognized villages (i.e., no waste management infrastructure) and grow about 300,000 head of sheep, camels and goats which produce about 200 tons of manure per day.

The focus of this project is to adapt a waste recycling process, based upon anaerobic digestion and composting technologies, for the organic solid wastes produced in small rural settlements in arid zones, such as the Bedouin villages in the Israeli Negev.

Four anaerobic digesters were built by the Arava Institute for Environmental Studies in arid and rural, semi-nomadic villages: two-plug flow reactors in the south of Mount Hebron, one in the upper Negev Mountain, and one dome-like reactor in the Arad Plain. All the reactors are operated by the local families. Raw or partly treated greywater from the households is collected into a barrel where it is mixed with the animal manure at a ratio of about 1:4 (solid:water). Then, the slurry is introduced into the digester. Biogas is collected and mainly used for cooking, but other possible uses include lighting, heating, warming bath water, refrigeration and electricity from a biogas generator. The digested slurry is reused either by re-inputting it into the digester or for composting by drying it and using it as a solid fertilizer.

Water, manure and the digested slurry are routinely tested for a variety of chemical and microbial properties. Biogas is also collected and analyzed for CH_4 and CO_2 . All analyses follow standard analytical and GC procedures, respectively.

In one reactor, a preliminary C mass balance was completed, and it was estimated that 1kg of goat manure contains about 300g C and produces up to 65 L biogas. This corresponds to 40 g of C as biogas from which about 22 g is methane (29.3 g CH_4), and the remaining 18 g is mostly carbon dioxide (103 g CO_2). The stabilized manure after digestion is further composted aerobically and, overall, about 170g can be returned to the soil as stabilized organic C which could potentially account for about 34 tons daily (assuming all manure would be collected and treated). The suggested project has the potential for improving the quality of life of the Bedouin communities while helping to reduce the health risks associated with untreated manure, such as the spread of diseases, as well as environmental risks, such as pollution, odors and C and other GHG emissions.

Decision support system for development and integration of technologies for energy reclamation from municipal wastes

Assaf Yoshi, Ben Gurion University, Department of Industrial Engineering & Management, POB 653, Beer-Sheva, Israel, 84105 assaf.yoshi@gmail.com

Air pollution, soil and water contamination are major issues in municipal waste treatment. We present a variety of waste treatment methods that can be combined with energy recovery. The challenges are related to feasible sustainable solutions for tackling diverse scenarios. These consist of selecting adequate technologies according to: the location of wastes sources, the waste characteristics, the energy reclamation processes, the environmental considerations and the energetic- economic aspects. Energy reclamation from solid wastes, nowadays, is based on bio-chemical and thermo-chemical technologies for producing fuel from the organic fraction of municipal wastes. These include: anaerobic digestion processes for producing biogas that is utilized in Combined Heat and Power (CHP) plants; Plasma Gasification Melting (PGM) producing syngas that activates steam turbo-generator systems; and Simultaneous Saccharification and Fermentation (SSF) producing ethanol. The work presents a new type of generic Web-based Dynamic Knowledge Base (WDKB) and a Decision Support System (DSS) for strengthening decision-making efforts to optimally design, integrate, evaluate and operate solid waste treatment and energy reclamation sustainable systems. The WDKB contains values of the energy production-chain stages, from collection (waste streams' quantity, moisture content, organic matter fraction, age and others) through process and facility (energetic input and output, cycle time, facility capacity, facility cost) up to energy consumption (availability, restore capability, caloric value, environmental footprint, timing, location). For each production stage, the DSS will include functions that refer to the above variables. Initial results show that an optimal treatment in the 4.9 million tons of municipal solid waste annually produced in Israel

Climate Change in the Drylands: Adaptation and Beyond Abstracts

During the past few years, climate change has moved from being a gloomy prediction by Al Gore to a new reality in many dryland regions. Increasing severity of drought, more violent storms and higher temperatures all appear to indicate the first signs of what will be a challenging climatic future. Adapting to climate change has in the past received less attention than mitigation efforts designed to prevent global warming. However, proactive efforts to prevent the worst economic, ecological and cultural impacts are increasingly critical to ensure that future generations will suffer as little as possible from the effects of climate change. This session offers a diverse group of perspectives on this issue – from top international experts from around the globe.

Adapting drylands to the changing climate

Rattan Lal; Carbon Management and Sequestration Center; The Ohio State University Columbus, OH 43220 USA

World's drylands, covering an area of $\sim 52 \times 10^6$ km² or 40% the Earth's land area, affect and are affected by the abrupt climate changes (ACC). Therefore, drylands can also play a critical role in achieving the objective of limiting the global warming to 2°C. With a population of 2 billion, mostly living in developing countries, adapting drylands to ACC is pertinent to well being of the people, and provisioning of the essential ecosystem services. The term "mitigation" of ACC implies reducing its severity by avoiding emissions and sequestering of greenhouse gasses (GHGs). The term "adaptation" implies reducing vulnerability to ACC. The later is achieved by: i) implementing appropriate technical measures such as levees, flood dams, etc, and ii) enhancing ecosystem/soil resilience. The resilience, ability of a system to recover from a perturbation, depends on its inherent characteristics. Important characteristics of dryland ecosystems are vegetation cover and species diversity, ecosystem C pool, nutrient reserves and recycling, hydrologic and energy balance, etc. Similarly soil characteristics influencing its resilience include solum depth, clay content and mineralogy, soil organic carbon (SOC) concentration and pool, available water retention capacity, soil structure including crusting and compaction, nutrient reserves, vulnerability to water runoff, susceptibility to erosion by water and wind, etc. In the context of ACC and the global C cycle, total C pool in the ecosystem and soil are essential characteristics. Therefore, choice of an appropriate land use and adoption of the best management practices (BMPs) are important to enhancing ecosystem/ soil resilience and adaptation to ACC. There is no silver bullet with a universal applicability, but a menu of BMPs which need to be fine-tuned under site/soil specific conditions. Restoration of degraded/desertified lands need enhancement of ecosystem/soil C pools. In general, the strategy is to create positive budgets for C, macro/micro plant nutrients, while also conserving water and reducing losses by runoff and evaporation. Examples of BMPs include afforestation/reforestation and the management of albedo, controlled grazing at low stocking rate, establishment of improved pasture species, complex crop rotations including agroforestry, conservation agriculture and integrated nutrient management. Timing of farm operations, flexibility in time of sowing and harvesting, is relevant to avoidance of drought/inundation and buffering against extreme events.

Multilateral Climate Change Funds and the Governance of Climate Risks

Orr Karassin, Public Law Department, Open University, Raanana Israel, karassin@gmail.com

The effect of climate change on dryland regions is expected to be particularly severe, exacerbating existing drought conditions and hindering soil restoration efforts. Many of the negative impacts, however, can be avoided through a proactive and sophisticated strategy to "adapt" to the anticipated shifts in temperature and rainfall. Accordingly, dryland nations and regions need to be particularly interested in taking advantage of international funding frameworks for climate change adaptation. Relatively new players in the international arena, multilateral climate change funds (CCFs) are of growing importance in the governance of climate change. Several of these funds, including the Adaptation Fund (AF) and Pilot Program for Climate Resilience (PPCR), are dedicated to reducing climate induced risks, through funding adaptation in developing countries. Investigating the patterns in

which these funds are affecting risk has driven the articulation of three models of possible risk governance through adaptation funding. "Risk compensation" is purported to be highly correlative with the position held by many developing countries viewing transfers as entitlements and compensation. "Risk redistribution" denotes the position held by many developed countries, viewing transfers by CCFs as serving a distributive function that is commensurate to parties' shared and reciprocal responsibilities. "Risk regulation" is suggested as a close representation of the manner in which similar international financing institutions have been found to work and perceive their role. The roles played by the AF and the PPCR are assessed in light of these three models. Despite the differences, findings suggest both funds are far closer to the risk regulation model than would be expected or is mandated by the United Nations Framework Convention on Climate Change. The understanding that climate change funds are emerging as regulators, instead of compensators or redistributors, should be viewed with caution, particularly in dryland regions that are particularly vulnerable to the negative effects of climate change. In the future, it may provide the basis for a possible reassessment of the design and governance of these international organizations.

The Green Belt Movement's Grassroots Community Empowerment: Climate Change Adaptation and Beyond

Peter Ndunda, GIS and Climate Change Specialist at the Green Belt Movement, Kenya,
pndunda@greenbeltmovement.org

Kenya, with a population of more than 43 million people, has more than 2/3rds of its population living in arid and semi-arid lands. This percentage of the population lives in drought-prone areas and are vulnerable to impacts of droughts which have contributed to limited access to water resources, limited access to energy, food insecurity, famine and poverty in the country. Climate change is expected to exacerbate this condition, with rural poor communities who depend primarily on natural resources for their livelihoods being the most affected. Adaptive capacity and adaptation related to water resources, energy resources, food production and income generation are very critical to these grassroots communities.

Founded by Professor Wangari Maathai, the Green Belt Movement (GBM) has worked with grassroots communities across Kenya over the past 30 years to empower and build their capacity to restore their environment (and the functions of natural ecosystems), promote good governance and develop sustainable livelihoods. Through GBM's community empowerment and education programme, GBM takes women and men through a process of understanding their environment, their natural resources, identifying their problems and together exploring sustainable solutions to these problems that affect their livelihoods.

GBM's experience shows that when the communities understand the linkages between their environment, actions and their livelihood situation (poverty, water scarcity, soil loss and food insecurity), they take action for change and develop practical solutions for climate resilience.

This paper highlights GBM's experience in mobilizing and strengthening rural communities' capacity in Kenya to foster climate resilient development that addresses their water needs, food security, energy requirements, biodiversity and sustainable livelihoods.

Creating Water Sensitive Cities in Israel

The session will present various aspects of creating WSC in Israel. In order to materialise this goal and interdisciplinary approach is needed, and thus the presentations in the session will come from different disciplines. It will start by presenting the definition, rationale and vision of WSC in Israel (Friedler); the second presentation will describe a physically based approach for predicting urban stormwater pollution (Wallach); the third talk will address the interlinkage between sustainable urban water management and urban design by analysing several case studies (Alon-Moses & Rosenberg), the fourth lecture will address the interactions between moisture provided by water sensitive design, vegetation and thermal comfort in desert cities (Erell), while the last talk will describe WSC practice in Israel, the experience gained in a

dual purpose – stormwater harvesting and aquifer treatment – pilot-scale biofilter being operated for more than two years now in Kfar-Sava (Zinger).

Rethinking the Law and Policy of Protected Areas in a Warming World

Pamela S. Chasek, Ph.D., International Institute for Sustainable Development, 300 E. 56th St., New York, USA; pam@iisd.org

The idea of setting aside natural areas for protection or restricted use has a long history, and its practice dates back more than 2,000 years in the Middle East, where large tracts of rangeland were set aside to prevent overgrazing, and in northern India, where the Mauryan kings established reserves to protect forests, elephants, fish, and wildlife. In 1872, the United States established its first “modern” protected area or park to preserve remnants of a local ecosystem—Yellowstone National Park. The dominant underlying philosophy in establishing protected areas until the second half of the 20th century in the United States and elsewhere remained the preservation of nature and wilderness for future generations, while recognizing their potential economic values for tourism and science. Today, however, the challenges of protected area policy are different. As climate change induces shifts in the habitats and ranges of plant and animal species, the ecological attributes and values of areas that have already been protected are changing, and it is far from clear whether and how the existing network of protected areas can keep pace with these changes. Nor is it clear, given the pressure that population growth and economic development place on the remaining unprotected estate, that new protected areas or even networks of protected areas can be created as a response or adaptation to climate change. The ecosystems impacted by climate change will adapt without the intervention of a political constituency. But the adaptation through law and public policy of the existing protected area system will not occur without political initiative and intervention. The question, therefore, arises of whether there is a political constituency for adapting protected areas to climate change and, if not, whether one can be created.

This article examines the impact of climate change on the thinking about protected areas, noting a turn away from species protection toward ecosystem-based adaptation planning, the establishment of wildlife corridors or connectivity conservation, adaptive management, and a land acquisition strategy that can accommodate climate change-related species migration. The final section details ways in which American conservation organizations and the US government are already changing their strategic direction and revising their approach to protected areas in response to the realities of climate change.

Sustainable urban water management and Urban Design: the Israeli case

Tal Alon-Mozes and Associate Professor Elissa Rosenberg, Faculty of Architecture and Town Planning, Technion-Israel Institute of Technology; artal@technion.ac.il

As distinct from conventional approaches, the integrative perspective of sustainable urban water management, which brings together engineering, hydrological, ecological and urban perspectives, demands new holistic frames of analysis (Hill 2009). This paper will suggest a framework for assessing the emerging field of water sensitive design in Israel that relates hydrological functionality to urban design. Criteria will include a review of spatial aspects of stormwater management practices within the urban context; locations within watersheds; land use adjacencies; connectivity; scale/size; degree of integration within the urban fabric and the level of multi-functionality and public use. We will analyze recent projects situated along Israel's coastal plain and Judean Hills, and point out the achievements and the potentials for better design of water sensitive cities in Israel.

Water-sensitive urban design: Effect of surface moisture and vegetation on thermal comfort in desert cities

Evyatar Erell; Desert Architecture and Urban Planning, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel; erell@bgu.ac.il

In addition to collection and treatment of water intended to recharge the aquifer, water sensitive urban design (WSUD) may be implemented to enhance quality of life, and in particular, to modify the urban microclimate and to mitigate the urban heat island. The primary means of doing so is by planting vegetation, either as an integral part of storm water treatment elements incorporated in the urban landscape, or as independent parks supported by water obtained from such facilities.

A growing number of cities world-wide have adopted policies supporting extensive planting of vegetation in existing neighborhoods, based on a consensus that the effects of vegetation are almost always beneficial. Trees, for example, are assumed to contribute to a better microclimate. However, the effects of vegetation on environmental comfort, and in particular on thermal comfort, may differ according to city size, geographical location, local climate, the size and distribution of the planted areas, and the properties of the plants. The talk will present the findings of a study on the effects of trees and grass on thermal comfort in a desert city, based on a monitoring experiment carried out at Sede Boqer and on subsequent computer modeling. In particular, it will be demonstrated that in warm conditions, vegetation affects comfort primarily by reducing radiant loads (short-wave and long-wave) and wind speed – changes that typically have opposite contributions. The effect of reductions in air temperature on thermal comfort is, by contrast, minor. To apply WSUD successfully in Israel, the integrated contribution of novel storm water treatment and aquifer recharge facilities that incorporate vegetation should be assessed - both in terms of water conservation and in the enhancement of thermal comfort in adjacent outdoor urban spaces. Lessons learned separately about these two aspects of such facilities should be evaluated in an integrated way in the urban context of Israel, which is quite different than that of other countries where WSUD is being investigated, such as Australia.

Setting the Scene and Vision for Water Sensitive Cities in Israel

Eran Friedler, Faculty of Civil & Environmental Engineering, Technion – Israel Institute of Technology;
eranf@tx.technion.ac.il

Israel is facing pressures related to water availability and urbanization. Israeli cities are expanding, while experiencing water shortages and degradation of aquifers. At the same time, public health is further threatened by the effects of the urban heat island, as cities become hotter due to climate change and rapid urbanization. It is therefore clear that Israeli cities must become resilient to climate and social pressures if they are to assure long term sustainability. Current centralised urban water management, whilst fundamental to the development of our cities to date, cannot solely provide the multiple benefits required for these future needs. We thus must find new, integrated solutions that address climate change and urban growth by delivering simultaneous benefits for water security, the natural environment, and liveability of our cities. Visioned Water Sensitive Cities adopt and combine decentralised and centralised water management solutions to deliver water security in both water-poor and water-abundant futures, healthy improvements in urban climates and landscapes, and a reduction in the city's carbon footprint.

A physically-based approach to simulate urban stormwater pollution

Rony Wallach; Dept. of Soil and Water Sciences, The R.H. Smith Faculty of Agriculture, Food and Environment;
 The Hebrew University of Jerusalem, Rehovot, Israel; Wallach@agri.huji.ac.il

Stormwater pollution is a major problem in urban areas. The loads and concentrations of suspended solids, nutrients and other contaminants are much higher in urban stormwater runoff than in runoff from unimpaired and rural areas. Estimation of urban stormwater pollutant loads is required to assess the impact of stormwater pollution on drainage waterways and receiving waters and to design methods for minimizing these impacts. A clear understanding of the processes involved in the pollutant uptake and transport by runoff enables a better design of means to reduce the momentary pollution concentration of the flowing water and facilities to treat the water at the end point (biofilter, etc.). The pollutant concentration in surface runoff depends on the rainfall intensity and duration, antecedent dry period, the interval between subsequent rainstorms, and slope and roughness of the surface. A physically-based mathematical model to predict hydrographs and pollutographs from different urban sub-catchments will be presented. This model is based on a comprehensive one that was developed by the author to predict pollution of surface runoff from agricultural lands by agrochemicals.

Piloting water sensitive urban technologies in Israel; 1st pilot in Kfar-Sava

Y. Zinger^{1*}, A. Deletic¹, T. D. Fletcher¹, Asher Brener², T. Wong¹

¹ Centre for Water Sensitive Cities, Department of Civil Engineering, Monash University, Victoria, Australia, 3800

² Biotechnology & Environmental Engineering, Faculty of Engineering Sciences, Ben-Gurion University of the Negev.

* Corresponding author, e-mail yaron.zinger@monash.edu

Stormwater biofilters have been demonstrated to be effective for stormwater treatment. A dual-mode biofiltration system has been constructed in Kfar-Sava to combine stormwater harvesting, detention and treatment during the wet season, while being used to treat polluted aquifer groundwater (aquifer recovery) during the dry season. In addition to demonstrating treatment effectiveness, direct and infiltration aquifer recharge solutions of the treated water were tested to determine their performance and their relative efficiency. The results show that the system was able to effectively treat a range of pollutants in urban runoff (heavy metals, nutrients and pathogens) and met the Israeli and Australian guidelines for irrigation, aquifer recharge and streams health. The Kfar-Sava biofilter marked an important milestone for implementing Water Sensitive Urban Design (WSUD) principles in Israel, while in two years Israel will launch at least two pilot systems across the country, with the aim being to establish policies and processes to underpin widespread adoption as part of “Creating Water Sensitive Cities in Israel” science-practice program.

Desert Agriculture: Water and Energy Fluxes From Agricultural Soils

One of the biggest unknown variables in desert environments is evaporation from the soil. The session will focus on understanding and measuring evaporative processes with emphasis on agriculture in arid regions. Topics covered will include: evaporation from porous media; separating components of evaporation and transpiration; modeling evaporative processes; evaporation and salinity buildup; novel methods for estimating evaporation, evaporation from heterogeneous soils; methods for minimizing evaporative losses in agriculture.

Soil evaporation in a drip-irrigated vineyard in a desert area

Nurit Agam^{1,*}, Dilia Kool^{1,2}, Naftali Lazarovitch², Joshua L. Heitman³, Tom J. Sauer⁴, Alon Ben-Gal¹

¹ Gilat Research Center, Agricultural Research Organization, Israel

² French Associates Institute for Agriculture and Biotechnology of Drylands, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel

³ Department of Soil Science, North Carolina State University, Raleigh, NC, USA

⁴ Soil, Water, and Air Resources Research Unit, USDA, ARS, AMES, IA, USA

* agam@agri.gov.il

Separating evapotranspiration into soil evaporation and canopy transpiration is challenging, but key for crops with precise water requirements and large areas of exposed soil. Wine vineyards are planted in widely spaced rows and require very exact water application to maximize water productivity, as well as to enhance fruit quality by allowing moderate levels of stress during certain phenological stages. Minimization of soil evaporation, which is an unproductive use of water, is an important strategy for maximizing water productivity. However, active actions in this direction are worth investment only if the fraction of soil evaporation is significant. The objective of this research was to quantify soil evaporation in a drip-irrigated vineyard under arid conditions with a specific focus on its spatial and temporal variations along the inter-row.

The experiment was conducted in an isolated commercial desert vineyard planted in a north-south row orientation, with a mean annual precipitation of 90 mm. Continuous measurements above the canopy included evapotranspiration, solar radiation, air temperature and humidity. Short-term intensive measurements below the

canopy were conducted at ground level, spread along transects from vine row to adjacent vine row. Measurements included actual and potential evaporation using micro-lysimeters and micro-pans, respectively, as well as solar radiation using pyranometers. Results show a clear effect of shading on potential evaporation below the canopy, with distinct and different periods of high and low daytime rates at the various positions across the inter-row. The consequences of below canopy observations for an entire (vineyard) system's water and energy budgets will be highlighted.

Evaporation from layered soil profiles: Impact of soil surface sealing on water regime in a semiarid hillslope

Shmuel Assouline, Institute of Soil, Water and Environmental Sciences, ARO, Bet Dagan;
vwshmuel@volcani.agri.gov.il

Marc Prat Institut de Mécanique des Fluides de Toulouse IMFT CNRS INPT UPS, Toulouse, France

Shai Sela, Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva, Israel
Tal Svoray, Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva, Israel

Heterogeneity in soil hydraulic properties has a significant impact on evaporation. The impact of heterogeneity on evaporation can be considered at different scales, from the pore to the field. The primary scale, the pore scale, can highlight the main factors and variables shaping the role of heterogeneity on evaporation, leading to the formulation of a model that could be up-scaled to help in estimating the effect at larger scales. We therefore investigate the effect of heterogeneity in the hydraulic properties of porous media at the pore network scale, an intermediate laboratory scale, and the hillslope scale.

The soil heterogeneity under study results from horizontal layering. The results at the pore scale reveal the existence of an interesting and somewhat unexpected phenomenon: a giant Haine's jump (burst invasion) when the invading gas phase reaches the fine/coarse layer interface. The results at the intermediate scale, from soil column experiments, show that the presence of a finer soil overlaying a coarse soil reduces evaporation from the soil profile. At the hillslope scale, soil layering is represented by the presence of a seal layer at the soil surface. Modeling water budget components of a semiarid hillslope indicates that accounting for the soil surface seal reduces evaporation losses. It was also found that the reduced evaporation compensates for the loss in infiltrated water due to runoff enhancement. Depending on rainfall intensity and soil depth, a transition could occur from a positive feedback mechanism where the seal layer suppresses evaporation and conserves water stored in the profile to a negative one where the seal layer mainly reduces infiltration and increases water losses through runoff. Thus, the sealing process was found to affect substantially water budgets at all observed scales in the experimental site.

Nano irrigation: The next step in water management practices

Natan Barak; Netafim Kibbutz Hatzerim, D.N.Negev, 85420, Israel; natan.barak@netafim.com

Nano-irrigation is the newest concept in drip irrigation, and it is based on almost fifty years of experience and global implementation of micro-irrigation systems. This innovative concept uses less water and less energy due to the most updated developments that enable ultra-low flow emitters to work properly with the harshest water sources. The above-mentioned technique, combined with new water management techniques, leads to achieving the current requirement in the irrigation field. Nano-irrigation is based on ultra-low flow drippers (less than 1 liter/hour discharge) that operate on very low pressure (less than 1 bar), combined with crop management technologies that enable monitoring and managing the nutrification / chemigation systems.

Drip-irrigation was introduced, in the mid-60s, by a group of pioneers in the Israeli Negev Desert. The innovation came out of necessity – making the desert bloom in spite of water scarcity. Micro-irrigation is today an agricultural tool used to precisely and uniformly deliver water, nutrients and crop protection chemicals directly to the plant root systems, maximizing crop yield and quality, with minimal waste of inputs and no damage to the environment. "Drip irrigation remains without any doubt the most efficient irrigation technique and most powerful solution towards improving water productivity and ensuring food security" (*Water Conservation Technical Brief No. 15, SAI*)

Platform, June 2012). Large quantities of water are needed to produce any agricultural product--food, feed, fiber, fuel-- and any additional savings allow us what we need most – getting more with less input. By mid-century, the world will need 100% more food than is produced today. It is estimated that about 70% of the increase in food production is expected to come from higher yields. Drip irrigation is, then, not an option but a real need. Our mission is to leverage the potential of drip and micro-irrigation to efficiently employ the world's most precious resources--arable land, water and energy--and by doing that, to ensure greater food security for the global population while preserving the environment. More than 80% of the global agricultural land is not irrigated (less than 20% is irrigated, supplying 40% of the world's food). Disappointingly, just 4% -5% is irrigated efficiently with drip-irrigation systems. We know that irrigation is a key component in the required water revolution. Drip-irrigation is, therefore, a key component in sustainable water management solutions. This is the moment to introduce the 2nd drip-irrigation revolution – the nano-irrigation system.

Study of evapotranspiration for estimation of harvested water storage efficiency

G. Carmi, B. Rewald, and P. Berliner; The French Associates Institute for Agriculture & Biotechnology of Dryland; The Jacob Blaustein Institutes for Desert Research; Ben-Gurion University of the Negev; Sede Boqer, Israel; genadi@bgu.ac.il

Water is a primary limiting factor to agricultural development in arid and semi-arid areas. In these regions, much of the annual rainfall occurs as a result of a few intensive convective storms. A technique of runoff collecting, known as runoff harvesting, may be used for food and fuel production and flood and erosion control, as well as for landscape development. The efficiency of runoff generation is an important issue in water harvesting schemes, but the critical component is the water availability to the tree/crop planted in the runoff receiving area. The area in which the runoff water is collected is usually a depression located in the immediate vicinity of the runoff generating area. Evaporative losses play a major role in determining the amount of water that will be available to the plants and/or trees planted in the shallow depressions. We hypothesize that when water is collected in deep trenches, it infiltrates through the trenches' bottom and into the surrounding walls as well, and the evaporative losses will be smaller than those that can be expected for shallow depressions. The experiment was carried out in Sede Boker, Israel from January 2011 to January 2012. The effects of water collection in i) deep trenches and ii) microcatchments were investigated; each treatment was replicated three times. Three olive trees were planted at the bottom of the 12 m long, 1 m deep and 1 m wide trenches. Microcatchments had a cross-sectional area of 9 m² (3x3 m) with one olive tree planted in the middle. The trenches and microcatchments were flooded simultaneously in April 2011 with 1.5 m³ water per tree; the soil water content was continuously monitored through the access tubes using a neutron probe. To estimate transpiration, stem sap-flow was measured by a Granier system. Evapotranspiration for each trench and microcatchment was calculated by the mass balance method. Transpiration was deducted from the resulted evapotranspiration. Total evapotranspiration in the trenches was 50% of the water amount applied by flooding, while microcatchments lost 132% (flooded water plus additional soil water left after the rainy season). The results show that water losses from microcatchments were significantly higher than those from the trenches, and that evaporation of the collected water in trenches was more effectively prevented.

Estimating precipitation and actual evaporation from precision lysimeter measurements

Wolfgang Durner; Institute of Geoecology; TU Braunschweig; Braunschweig, Germany; w.durner@tu-bs.de

Lysimeters are excellent tools for obtaining reliable data about seepage water quantity and quality. Large weighable lysimeters, furthermore, permit the quantification of the water balance of the soil and the precise measurement of water exchange at both the soil-atmosphere interface, by rain, dew, fog, and rime, and the flux below the root zone toward the groundwater. If well embedded into a similarly vegetated environment, they avoid errors made by traditional measurement systems, such as the wind error of Hellman rain samplers, or the island error of class-A pans, or the heterogeneity error that affects any readings from *in situ* instrumentation of soil water state variables. If the amount of seepage water is recorded separately, the time series of the lysimeter mass represents the other parts of the water balance equation: increasing mass shows precipitation amount, decreasing mass is the effect of evapotranspiration, the mass difference in the evaluation period indicates the change of stored water volume.

Whereas the soil water mass balance (precipitation minus actual evapotranspiration) is always accurate in lysimeter systems, a particular problem arises if both precipitation and evapotranspiration are estimated from the lysimeter because increases and decreases in weight in specified time intervals are affected by random fluctuations in lysimeter weight, which might be caused by wind or other disturbances. The analysis of precipitation, evapotranspiration and the change of stored water volume from the time series of the lysimeter mass will, therefore, need a strategy where a threshold parameter is applied that integrates random noise from different sources (technical noise, wind velocity ...). The contribution demonstrates, with synthetic and real measured data from large lysimeters, which strategies of data management can be applied, and which degree of accuracy can be reached when estimating the actual soil-atmosphere boundary fluxes and the soil water balance from lysimeter data.

Effects of wind and sand on cotton seedling establishment and survival.

Jhonathan Ephrath; French Associates Inst. For Agriculture and Biotechnologies of Drylands; Ben Gurion University of the Negev, Sede Boqer, Israel; yoni@bgu.ac.il

Wind-blown soil particle abrasion negatively impacts millions of hectares of crops annually. The goal of this study was to examine the effects of wind and wind-blown sand abrasion damage on cotton (*Gossypium hirsutum* L.) seedling biomass partitioning to leaves, stems, and roots. Seedlings of three cotton cultivars were exposed to no wind (untreated controls) or sand abrasive flux densities of 0, 0.1, 0.25, 0.35, and 0.5 g cm⁻² width s⁻¹ at a wind velocity of 13.4 m s⁻¹ in a suction- type laboratory wind tunnel. In another experiment, the age of the seedling and the time of exposure was tested as well. Plants were destructively sampled at the time of the sand abrasion treatment and at approximately 2 and 4 wks after exposure. These three sampling dates provided two time intervals for assessing the amount of plant damage and re-growth using classical growth analysis. With increasing sand and abrasive flux density, whole plant, leaf, stem, and root biomass, as well as leaf area, were all reduced in both harvest intervals ($P \leq 0.05$). Net assimilation rate (NAR) accounted for 96 and 75% of the variability in relative growth rate (RGR) in the first and second harvest intervals, respectively, with small but significant differences in leaf area ratio (LAR). Increasing plant damage caused by sand abrasion treatment resulted in preferential biomass partitioning to the damaged stems rather than the roots during the first harvest interval, while a much more stable allometric allocation of biomass among plant organs was observed in the second harvest interval.

Biocrusts increase evaporation from sand dunes: The role of surface albedo, temperature and wind upon evaporation

Giora Kidron; Laboratory of Geosimulation and Spatial Analysis; Dept of Geography and Human Environment, Tel Aviv University; Tel Aviv, Israel; gkidron@post.tau.ac.il

Covering the surface with a distinct 1- 10 cm thick layer, biocrusts (also called biological soil crusts or microbiotic crusts) may affect the evaporation rate and, hence, the water loss of the underlying parent material. In the Hallamish dune field in the Negev Desert, four cyanobacterial and one moss-dominated crust were defined, and their impact upon the evaporation rate of the underlying sand was examined along with bare sand. The crusts and sand were subjected to wetting by rain and sprinkling (in Petri dishes and within 25 cm diameter plots), and the crust and sub-crust temperatures and moisture content were measured. In addition, the albedo of the crusts was also measured. Whereas thick and high- biomass crusts tended to retain higher amounts of water in the Petri dishes, they were found to increase subsurface temperatures (by up to 3.9°C at 5 cm depth) under field conditions, subsequently decreasing the 0-10 cm moisture content. As a result, moisture content at the crusted plots was significantly lower than that of non- crusted plots, with crusted plots having, on average, an evaporation rate 1.4 times higher than the bare sand. Yet, following the use of novel atmometers that have the capability of measuring evaporation on inclined surfaces, the study of the combined effect of radiation and wind was facilitated.

Study of vulnerability of the Northern Negev agriculture to droughts with the spatially explicit model of agriculture land-use dynamics

Giora J Kidron, Tiferet Zilberman and Itzhak Benenson, Laboratory of Geosimulation and Spatial Analysis; Dept of Geography and Human Environment, Tel Aviv University; gkidron@post.tau.ac.il; z.tiferet@gmail.com; bennya@post.tau.ac.il

Based on the data on precipitation, irrigation and wheat yield during the last 20 years in two kibbutzim in the northern Negev (Beit Kama and Mishmar HaNegev), we have developed a spatially explicit high-resolution model of crop dynamics in the northern Negev at the resolution of a single field. The dynamics of crops in the Negev is defined, primarily, by the irrigation. Based on the field data, crop cycles are estimated, separately for irrigated (e.g., potatoes, wheat, carrot) and rain-fed fields (e.g., wheat, legumes), as an autoregression of the second or third order. The residuals of wheat are regularly used by the Bedouin herds during the critical months of the year (June-September), when the other sources of sheep food are exhausted. Bedouin husbandry, thus, critically depends on Jewish farming, and the model enables us to understand the interaction between Jews and Bedouins in the Negev. The model is calibrated based on precipitation, the irrigation network and crop data (type, yield) collected in each kibbutz during 1990- 2010. The analysis of the model for different scenarios of climatic change during 2010 -C 2030 shows that with the employment of intensive irrigation, crop yield per hectare will drop by only half the amount in comparison to a hypothetical situation during which no irrigation would have been employed. Furthermore, the drop in crop yield may be even less substantial when the increase in wheat yield in fields that were irrigated during the previous year (during potato or carrot cultivation) is accounted for. With the increase in wheat yield (and subsequently with the increase in the residual wheat used by the Bedouins), the resilience of both communities, the Jewish and the Bedouin, increases. Yet, as the field capacity is limited and following population growth, further expansion of the Bedouin agriculture will necessitate intensive husbandry.

Soil evaporation revisited – what controls evaporation dynamics from porous surfaces?

Dani Or; Department of Environmental Systems Science; ETH Zurich; Zurich, Switzerland; dani.or@env.ethz.ch

Evaporation dynamics from soil surfaces reflect interactions between internal liquid and vapor transport, energy input for phase change, and mass transfer across air boundary layer. The roles of two key interfaces controlling evaporation dynamics are studied: (1) interactions of wet evaporating surfaces with an air boundary layer; and (2) the role of a receding drying front. At a critical drying-front depth defined by soil pore-size distribution, capillary liquid continuity essential to supplying surface evaporation is disrupted and the evaporation rate transitions to diffusion-controlled stage-2. This characteristic length is modified by evaporation rate, hence reflecting the interplay of capillary, gravity and viscous forces. For surface-boundary layer interactions, we quantified a nonlinear behavior of drying porous surfaces responsible for enhanced vapor fluxes from remaining active pores as they become increasingly isolated (with soil surface drying). Experiments show that in contrast to nearly-constant evaporation rates at low atmospheric demand (typically <5 mm/day), evaporation fluxes under high atmospheric demand exhibit a continuous decrease with surface drying even when internal capillary flow is not limiting. The increased spacing between active pores at the drying surface under low atmospheric demand (low air speed, thick boundary layer) results in a significant increase in evaporative flux per pore that may fully compensate for the reduced evaporative surface area and thus sustains a constant surface evaporation rate. Such compensation is less efficient and limited within thin boundary layers associated with high atmospheric demand; hence, the average evaporative flux continually decreases with surface drying irrespective of internal supply. Measurement aspects of these interfacial processes and implications for hydrological estimates of evaporative losses from heterogeneous surfaces will be discussed.

Saline Aquaponics: Perspectives for Drylands Food Production

Edoardo Pantanella¹, Giuseppe Colla¹, Shmuel Appelbaum²

¹ Università della Tuscia. Dep. DAFNE. Via S. C. de Lellis snc 01100 Viterbo, Italy edpantanella@gmail.com , giucolla@unitus.it

² Ben Gurion University of the Negev. Albert Katz Department of Dryland Biotechnologies. The Bengis Center for Desert Aquaculture. Jacob Blaustein Institute for Desert Research. BGU, Sede Boqer Campus, Midreshet Ben-Gurion 84990, Israel sappl@bgu.ac.il

Aquaponics is the practice of soilless plant cultivation on aquaculture water. In aquaponics, fish wastewater supplies nutrients to plants, which grow and reclaim water back to aquatic animals. Beyond this ecological management, fish-plant integration has many advantages, not only in terms of sustainability, due to full reuse of nutrients, high water productivity and organic management, but also in terms of income opportunities. To date, aquaponics has been mainly developed using freshwater species following common horticultural practices. Nevertheless, the use of salt-tolerant plants (halophytes), as well as of brackish water with moderate salinity, can open up interesting opportunities for food production and livelihoods in drylands and marginal areas. In horticulture, halophytes are sold in specialty markets or used as companion plants for limiting the impact of salinity in less salt-tolerant crops. On the other side, the addition of saline water is a common practice in horticultural management for raising the quality in certain vegetables. Nevertheless, the role of halophytes is not marginal, as witnessed by the large number of species used worldwide, which include leaf vegetables, grains and plants for edible oil or biofuels.

The paper analyzes the potentialities of halophytes and horticultural crops grown in aquaponic systems. Production and the qualitative traits of plants are explored under different salinity levels.

Agro-biowaste management scheme: Biosolids stabilization and reuse as amendment to arid agricultural soil

Roy Posmanik^{a*}, Sophia Yee^b, Allison Busgang^b, Ali Nejidat^a and Amit Gross^{a*}

^a Department of Environmental Hydrology and Microbiology, Zuckerberg Institute for Water Research, Ben-Gurion University of the Negev, Sede Boqer Campus, 84990, Israel; posmanik@post.bgu.ac.il and amgross@bgu.ac.il

^b Department of Bioresource Engineering, Macdonald Campus, McGill University Ste-Anne-de-Bellevue, McGill University, Quebec H9X 3V9, Canada

Agro biowaste, such as animal manure, poses global environmental challenges, necessitating a proper management scheme for safe disposal. Traditional methods attempting to utilize animal manure for agricultural purposes often result in major nutrient loss and greenhouse gas emissions to the atmosphere, and they may even pose sanitary risks. The concept of the LOFPS (liquid organic fertilizer production system) was recently suggested as an alternative biowaste management scheme, aimed at reducing the risk of contamination (Fig. 1). The LOFPS combines anaerobic digestion of N-rich biowaste with biofiltration of the resulting gaseous ammonia and its conversion to nitrate by nitrifying microorganisms. Rinsing the filter-bed with water allows the recovery of the N as a nitrate-rich solution to be used as a fertilizer in organic agriculture. The addition of CaO to the digest towards the end of the digestion process enhances ammonia volatilization into the biofilter, as well as sanitizing the biosolids. The resulting lime-treated slurry can be further utilized as soil amendment as it contains high nutritional value and meets Europe's strict "low-risk biowaste" regulations.

The concept was proven and characterized as an environmentally safe approach for biowaste management and reuse. High N recovery (>67%), under an ammonia loading rate of up to 40 g NH₃ m⁻³ biofilter h⁻¹, was established using manure biowaste as the N source. A high quality of the recovered fertilizer was confirmed, and it was demonstrated by the yield performance of model crops. Moreover, complete elimination of NH₃, H₂S, CH₄ and N₂O was achieved, confirming the environmental safety of the suggested technology. However, the long-term land application of the slurry on soil properties, fertility and microbial community was not examined, but it is currently being studied. In this study, slurry (5 kg/m²/year) from the LOFPS has been periodically spread on loamy-clay and sand plots for over 18 months. Field work is being carried out on a research field located in the Ramat Negev Desert Agro-Research station (Ashalim). The soil physicochemical properties, together with pore water quality and greenhouse gas (CH₄, N₂O and CO₂) emissions from the soil profile, are being monitored at this site. The scheme and its environmental footprint will be presented.

New technique for measuring surface energy balance and soil water evaporation beneath sparse plant canopies

Thomas Sauer; Soil, Water, and Air Resources Research Unit; USDA-ARS-NLAE; Ames, Iowa, United States; tom.sauer@ars.usda.gov

Non-uniform surfaces, like sparse canopies in arid environments, offer unique challenges for the measurement of the surface energy balance and evapotranspiration (ET). Obtaining separate measurements of soil water evaporation (E) and plant transpiration (T) is often critical to improving irrigation water-use efficiency. Sap flow techniques can be used to measure T of individual plants, but the apparatus is expensive and requires frequent attention, and scaling up to the canopy level can be challenging. Measurement of E can be accomplished by micro-lysimeters or soil water balance techniques, but both techniques often require many replicate measurements to deal with spatial variation. We developed a micro Bowen ratio energy balance (MBREB) measurement system to determine E beneath and between rows of vineyards in arid southern Israel and humid western North Carolina, USA. The system measured air temperature and water vapor pressure 1 and 6 cm above the soil surface. Net radiation (R_n) was measured with three types of net radiometers, and soil heat flux (G) was measured with flux plates. An eddy covariance system above the canopy measured ET for the vineyard. T was measured with sap flow gauges, and E was measured with micro-lysimeters and heat dissipation sensors over select intervals for comparison. Overall, the MBREB approach showed great promise although some challenges remain. Accurate measurements of very small vapor pressure gradients and large temperature gradients so near the soil surface require special care. Uncertainty in the measurement footprint and the complex, dynamic solar radiation pattern in the vineyard make selection of the relevant net radiometer viewing area challenging. The MBREB has several advantages, including continuous measurement, no soil disturbance, a relatively large footprint providing good spatial averaging, and the potential to also obtain soil CO₂ flux data.

Sustainable agriculture in water-stressed, arid regions using aeroponics

Navin Kumar C. Twarakavi, Associate Professor, Desert Research Institute, Las Vegas, NC 89119. Phone: 001-702-715-7223. Email: navin.twarakavi@dri.edu

With agriculture contributing minimally to the economy of Nevada under conditions of a burgeoning population and increased stress on the availability of food and water, the future is highly dependent on the sustainable growth of its urban centers (such as Las Vegas and Reno). Given that tourism is a major industry in Nevada, the need for high quality fresh produce cannot be understated. Currently, fresh produce (such as fruits and vegetables) are imported in to Nevada, both nationally and internationally. There are a number of issues associated with the transportation of fresh produce to cater to the demands of Nevadans. Firstly, the carbon footprint of transporting fresh produce is quite significant. Research has shown that growing fresh produce causes 5% of a person's carbon footprint each year. However, when this fresh produce has to be transported long distances, the amount of the carbon footprint changes to 28%. Secondly, transportation of fresh produce results in a loss of taste and nutritional quality and a decreased shelf-life. Also, depending on the type of fresh produce, the cost of transportation can be as high as 30% of the total cost. The above-stated issues are especially true in the case of "cash" crops, such as micro-greens, nutraceuticals, and spices, among others. In order to grow non-local food locally, greenhouses have been used in the past. Other systems, such as hydroponics, have been introduced to address the same issue. However, these approaches do not reduce the water demand, which is not suitable in water-stressed environments such as Nevada. Systems that allow for high production rates, higher yield/ acreage and year-round production would be suitable. Aeroponic systems are ideally suited to address these requirements. Here, we present aeroponic systems that are currently being adapted for Nevada to encourage sustainable agriculture.

Modelling the water balance in low rainfall cereal systems of Southern Australia

Anthony M. Whitbread^{1,2} and Jeff A. Baldock³

¹CSIRO Ecosystem Sciences, Waite Precinct, Adelaide; awhitbr@gwdg.de

² Crop Production Systems in the Tropics, Georg-August-Universität, Göttingen Germany

³CSIRO Land and Water, Waite Precinct, Adelaide; jeff.baldock@csiro.au

Farming profitably and sustainably in the low rainfall cereal areas of Southern Australia depends on the efficient capture of rainfall, excellent agronomy and sound management decisions. Knowledge of site-specific yield potential and in-season prediction of grain yield has become key information and depends on understanding the water balance. This paper validates the use of a one-dimensional tipping bucket water balance model which is a component of the APSIM modelling framework used to simulate crop growth. By using continuously measured soil water data over three years from two long term studies, undertaken in typical low rainfall rotation systems in the region, it was possible to model volumetric water content, layer by layer (0-0.1, 0.1-0.2 and 0.2 m increments to 0.8 m depth) and cumulatively (0-1 m layer) during periods of both fallow and crop growth (wheat, peas, canola). For the Calcarosol soils of this study, soil hydraulic parameters, such as crop lower limit (CLL), were only usefully defined at depth by measuring volumetric water content (Θ_v) late in the cropping season rather than by laboratory suction or pressure plate measurements. Parameters that describe first and second stage evaporation and diffusivity were estimated from the measured data and default values. These parameters, along with CLL, largely influence model performance in low rainfall situations, so the implications of using APSIM in highly diverse soil types are discussed.

Desert Architecture

The most marginal communities in developing countries are the ones most severely affected by desertification and the lack of appropriate housing. Developed dryland countries are seriously affected as well, and are forced to address energy shortages, water scarcity and a variety of urban planning challenges associated with the extreme climatic conditions.

The key to successful efforts to overcome and reverse desertification are linked to creating new strategies that will allow for communities in drylands to live in harmony with their arid environments. This includes the establishment of alternative livelihoods – and of course identifying innovative ways of living more sustainably within the demanding desert environments. In developed countries, some 40% of all energy is consumed for heating, cooling, and making buildings habitable. When the energy costs of building construction and materials, on the one hand, and urban transportation, on the other, are added to this basic load, it becomes clear that most of society's energy use is influenced by architects and planners. The 2012 workshop will therefore be aimed at architects and planners who seek to make buildings in the desert more responsive to the natural conditions, resources availability and, of course, climate. Among the key challenges are providing thermal comfort while reducing energy consumption, and redefining urban form along guiding principles that may be sustainable in the long term.

Practical research supporting climatic and sustainable design in Zin School

Eran Kaftan and Avinoam Levin; Man in the Desert; Ben Gurion University; Kfar Saba, Israel; kaftan@bgu.co.il

The Zin Elementary School, named after Andre and Katherine Merage, which is located at the Ben-Gurion educational campus, was chosen by the Israeli Ministry of Education to be designed as one of six green schools in honor of 60 years of Israeli independence. Therefore it was designed to accommodate the local desert climate. The design employed several climatic strategies, such as passive cooling of the building mass through summer night ventilation, and winter passive heating through southern windows. In addition, a special emphasis was given to providing quality daylight, through roof monitors, southern windows with light-shelves, and both fixed and dynamic shading systems. The design process included practical research; which is applied research carried out in practice, enabling better climatic performance.

Architecture and city planning in dry areas: A case study of the Pink city of India

Shailendra Mandal and Kamini Sinha; Department of Architecture; National Institute of Technology, Patna, India; vastumandala@yahoo.com

Jaipur which is also referred to as the Pink City of India is noted for its architectural wonder. The architecture of this capital city of Rajasthan is a beautiful fusion of yesteryears and modern architecture. Jaipur is the first planned city of India, located in the drylands of Rajasthan. Jaipur was planned as a grid system with wide straight avenues, roads, streets and lanes and uniform rows of shops on either side of the main roads, all arranged in nine rectangular city sectors (chokdis), representing the ancient Hindu map of the universe.

The renaissance approach of the 18th century walled city of Jaipur is reflected not only in its exclusive and innovative architecture and city planning but also in the conception of the city as a thriving trade and commerce hub in the dry region of the country. These two significant factors guiding the planning of Jaipur has provided a unique urban identity and continuity to the 21st century capital. Historically, Jaipur became a commendable example of architecture and city planning visited by many domestic and international travelers from the 18th till the 20th century. The post independence Jaipur developed and extended as a modern city yet retained the living, historic core as the image of the city. However, the recent trends in global architecture and economic pressures within the walled city have lead to an increasing transformation of the urban fabric, observed in the construction of unauthorized, multi-storied commercial complexes that are fast replacing some of the beautiful havelies in the inner residential areas of the region. There is an urgent need to arrest this process as well as to readdress the present situation in lieu of the recent architecture and city planning reform initiatives and the new invasion of global tourism. It is equally crucial to evaluate the traditional architecture and city planning principles of the city and the extent of their applicability in the present context.

The proposed paper presents the similarities and contrasts between the 18th century vision of the city, the perceptions of historic visitors to the city, the urban form, streets, spaces and usage vis a vis the '21st century Heritage Vision' of Jaipur, as it is a very apt example of the architecture and city planning in the dry region of the country. The fundamental contention of this paper is that architecture and city planning play a key role in strengthening adaptive capacities. It evaluates the present circumstances, the socio- economic situation, the residents' aspirations, the linkages to their pasts and their expression, and translation and interpretation in the global environment. It also presents the conflicting approaches to heritage fabric and its usage by the residents, NGOs and the local government departments. It concludes with the question - whether an integrated, holistic approach through the proposed Heritage Plan can again showcase Jaipur as the 21st century Renaissance city which stands as an appropriate example of great architecture and city planning in dry areas.

The services of cultural heritage in drylands: An approach from water traditional technologies as a territory heritage system of desert

Gabriela Pastor - gpastor@mendoza-conicet.gob.ar; Dra. Laura Torres - ltorres@mendoza-conicet.gob.ar; Argentine Institute of Dryland Research – CONICET; Mendoza, Argentina

The concept of heritage no longer suffices to define and identify the hallmarks of identity upon which the territory is built. The definitions and declarations expressed within the framework of international organizations can barely point out the "photograph" of some elements in which the hallmarks of identity attested to by these testimonies are overlooked or invisible. On the other hand, traditional technologies are a heritage system that exceeds the testimonial object, while simultaneously containing it, to integrate not only people and environmental resources but territory as well.

This communication aims at characterizing the social, economic, political, and landscape services that traditional technologies, in their character as territory heritage systems, are capable of assuming, whilst allowing for a discussion not only on the notions and concepts of heritage but also on its standing in the field of more sustainable development. To this end, a case study linked to strategies for access to water in drylands of the Argentinean west is undertaken. The starting point is assuming that these strategies articulate traditional knowledge and landscapes that provide an account of processes, resources and positioning which transcend the material and immaterial facts of heritage to synergize the same restrictions but in favour of the territory. Material testimony and associated knowledge are analyzed, as well as their implications to the provision of services that aid in building the territory

and its landscape. Finally, the conclusions pose some theoretical-conceptual considerations as well as new questions in light of the resilience capacity of these systems in the new scenarios.

Recognizing morphological patterns in built environments

Aviva Peeters; Desert Architecture and Urban Planning Unit; The Swiss Institute for Dryland Environmental and Energy Research; Jacob Blaustein Institutes for Desert Research; Ben-Gurion University of the Negev, Israel; apeeters@bgu.ac.il

The process of urbanization has evolved in the last decade into one of the most significant global phenomena; demographic projections for 2050 predict an accelerated growth in urban population, primarily in the less developed regions which will account for 92% of this growth. Various spatial phenomena are a result of urbanization such as the "urban climate", urban pollution and urban sprawl. An important generator of the urban climate is urban geometry, and therefore constructing and updating databases of urban geometry is essential for analyzing the characteristics of the "urban climate".

While the development of GIS-based urban databases has become a common practice in developed countries for large-scale spatial analysis, in less developed urban centers such databases frequently do not exist, often due to the lack of adequate surveying practices. A suitable option for creating these databases, especially when no town plans or field survey data are available, is to use remotely-sensed data for automated recognition of urban objects, such as buildings, roads and trees.

Remote sensing in combination with advanced image processing techniques provide powerful tools for the quantitative study of urban form. Accurate remotely-sensed data with a high spatial and spectral resolution can now facilitate large-scale spatial and temporal analysis of urban patterns off-site, reducing the need for time, labour and capital-intensive processes inherent to field surveys and manual digitizing.

To address the challenges involved in the automated extraction of urban objects from complex urban settings, a context-based recognition model was developed focusing on the recognition of urban open spaces. Morphological patterns were extracted from the recognized objects and analyzed for their spatial distribution in relation to climatic conditions. Accuracy results are promising and highlight the potential of the model as a generic method for urban object recognition and as a valid method for constructing and updating GIS databases of urban form.

Exploring barriers to providing resilience to buildings through design

Maritt Sever, Y. Garb and D. Pearlmutter; Department of Man in the Desert, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel; maritts@gmail.com

Located in a politically, environmentally and seismically prone area, residential buildings in Israel have to resist a whole range of threats. These special circumstances bring to light the need for an integrated approach to the production of buildings, which considers the possible synergies between structural durability and energy efficiency. In this presentation we describe the need for an integrated approach to building design which considers the possible synergies between structural durability and energy efficiency. Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduce three levels of integration needed when designing for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, i.e. integrated design or co-design, and (3) integration of long-term and short-term considerations.

Building design teams usually consist of professionals from different backgrounds who share and create knowledge through design communication. This collaborative process is known in the literature as integrated design or co-design. Integrated design is a procedure which allows for consideration and optimization of the building as an entire system for its whole life span. This can be achieved when all actors in the project cooperate across disciplines.

Traditionally, however, this collaboration is not simultaneous – rather it is a linear process, in which architects, engineers and other consultants intervene at different points in a chronological chain. In addition, design solutions are based largely on short-term considerations and existing building practices.

We stipulate that true integrative design of resilient buildings requires non-linear processes and decision-making based on long-term considerations. Moreover, the common goal of the professionals involved in the design process of resilient buildings is to meet the multiple requirements of the people and society in an optimized way during the

life cycle of the built facility. Integrative design processes ensure taking into account seismic aspects together with other matters of sustainability in order to make sure the building will not only be functional and energy efficient but also will be able to structurally survive in the event of an earthquake.

For example, architectural decisions dealing with the geometry of the building and the location of different elements in the plan have a significant impact not only on the building's routine functionality and aesthetics, but also on its stiffness and dynamic response in the event of a major earthquake at some point in the future. From an energetic perspective, a seismically resistant configuration may encourage structural solutions which rely, for example, on less reinforcing steel and as a result may reduce the initial energy embodied in the building's production – with the economic and environmental implications of that energy consumption manifest over an extended time frame.

The aim of this study is to examine barriers to the integrated design of resilient buildings by looking at incentives and disincentives for non-linear co-design processes along the extended building supply chain. The study will use a novel research approach employing the Delphi technique, a systematic, interactive forecasting method which relies on panels of experts to identify potential and actualized relationships among industry actors.

Desertification as Catastrophic Regime Shift: Empirical and Mathematical Aspects

Desertification is commonly viewed as a dynamical transition from a productive stable state to an alternative less productive stable state. The transition can be induced by an environmental change or by a disturbance, and becomes feasible near an instability point of the productive state. The session will address mathematical aspects of such transitions, taking into account the possibility of the productive state being spatially patchy. Questions to be addressed include mechanisms of desertification, warning signals for imminent desertification and restoration of desertified areas. The session will also address field observations of vegetation patterns and pattern dynamics, and attempt confronting model predictions with empirical data.

Desertification as a gradual regime shift in spatially extended ecosystems

Golan Bel, Hezi Izhaq, Aric Hagberg and Ehud Meron; Department of Solar Energy; Ben-Gurion University of the Negev; Sede Boqer Campus, Israel; bei@bgu.ac.il

Ecosystem regime shifts are conceived as abrupt global transitions from one stable state to an alternative stable state, induced by slow environmental changes. Spatially extended ecosystems, however, can also respond to local disturbances by the nucleation of small domains of the alternative state. Such a response can lead to gradual regime shifts involving front propagation and coalescence of alternative-state domains. When one of the states is spatially patterned, a multitude of intermediate stable states appears, ranging from holes in periodic patterns to localized states, giving rise to step-like gradual shifts. Vegetation dynamics in drylands is a spatially extended ecosystem that exhibits a bi-stability of patterned and uniform states. We demonstrate the existence of localized states in a vegetation model that captures two pattern-forming feedbacks, one associated with infiltration contrast between vegetated areas and bare soil and the other with root-shoot relationships. We further evaluate numerically a bifurcation diagram that shows the forms of the localized solution branches. It is shown that under certain climatic conditions, gradual regime shifts involving intermediate localized states, may take place. In addition, the effects of the two feedbacks on the bifurcation diagram and, hence, on the nature of the regime shifts are studied. We show that the larger the root-shoot feedback, the more gradual is the degradation of the vegetation and the more abrupt is the recovery of the vegetation from localized states into a patterned state. We propose indicators to probe gradual regime shifts and suggest that a combination of abrupt-shift indicators and gradual-shift indicators might be needed to unambiguously identify regime shifts. Our results are particularly relevant to desertification in drylands where transitions to bare soil take place from spotted vegetation, and the degradation process appears to involve step-like events of local vegetation mortality caused by repeated droughts.

Critical transitions due to interactions between climate and vegetation in drylands

Victor Brovkin; The Land and Earth System Department; Max Planck Institute for Meteorology; Hamburg, Germany; victor.brovkin@zmaw.de

Numerous paleodata reveal that the Sahara was much greener in the early to mid-Holocene, ca. 8,000 to 6,000 years before present, when northern subtropical regions received much more solar radiation during the summer season. Analysis of marine sediment cores suggest that the desertification of the Western Sahara about 5,500 years ago was rather abrupt in comparison with slowly changing orbital forcing. Mechanisms behind abrupt vegetation changes in the Sahara are still under debate, but one of the leading hypotheses includes biogeophysical feedback between vegetation and precipitation through changes in albedo and transpiration. This feedback amplified the decrease in rainfall induced by decreasing summer radiation. Simulations of several coupled climate-vegetation models support this theory, although the strength of the vegetation-climate feedback in drylands differs among them. An important question is whether this feedback will operate under CO₂-induced global warming and cause abrupt changes in vegetation cover in drylands. Elevated CO₂ concentration increases water use efficiency of plants and could additionally contribute to the greening of drylands. We investigate these mechanisms using Earth System Models (ESMs) of different complexity. Results from most recent simulations of ESMs contributing to the next IPCC Assessment Report will be presented.

Pattern dynamic in self-organized semi-arid vegetations: field and remote-sensing evidences

Vincent Deblauwe and Nicolas Barbier; IRD, UMR AMAP, Botany and Computational Plant Architecture, Montpellier, France; vincent.deblauwe@ird.fr

We will review the growing body of empirical evidence supporting or opposing the mechanistic hypotheses and predictions of self-organization models applied to the case of spatially periodic vegetation patterns found in semiarid and arid areas around hot deserts. At system scale, emphasis will be put on spatial and temporal pattern dynamics, and in particular pattern emergence and modulation along environmental gradients, as well as banded pattern migration. At local scale, the available information on processes, such as positive and negative plant resource feedbacks will be discussed. Overall, remarkable qualitative –and sometime quantitative– agreement is found between the rich theoretical framework and the results of field and remotely sensed investigations.

The dynamics of vegetation patterns under slowly varying conditions

Arjen Doelman; Mathematics Institute; Leiden University; Houten, Netherlands; doelman@math.leidenuniv.nl

In this talk we introduce a conceptual model for vegetation patterns that generalizes the Klausmeier model for semi-arid ecosystems on a sloped terrain, the generalized Klausmeier-Gray-Scott model. This model not only incorporates downhill flow, but also linear or nonlinear diffusion for the water component. We consider the onset of pattern formation through a Turing or a Turing-Hopf bifurcation by varying the parameter A that measures yearly rainfall. We perform a Ginzburg-Landau analysis to study the weakly nonlinear evolution of small amplitude patterns and we show that the Turing/Turing-Hopf bifurcation is supercritical under realistic circumstances. Next, we numerically construct Busse balloons to follow the family of stable spatially periodic (vegetation) patterns beyond the Ginzburg-Landau setting into the realistic area of localized vegetation patterns. We find that destabilization (and thus desertification) can be caused by three different mechanisms: fold, Hopf and sideband instability. Finally, we assume that A -- the yearly rainfall parameter -- is a slowly decreasing function of time and study the trajectory of the vegetation patterns through the Busse balloon. We found that the vegetation patterns undergo a number of intriguing 'mini-catastrophes' as the trajectory approaches the boundary of the Busse balloon before they reach the final catastrophe of desertification.

Desertification vulnerability in Morocco

Rachid Ilmen; High Commissary of Water, Forests, and Combating Desertification; Morocco; ilmenrachid@gmail.com

Moroccan natural resources have only a slight resistance to desertification. More than 93% of the country is arid and semi-arid. Drought is frequent and severe. Soils are mainly not very developed, shallow (<50 cm), silt-sandy, with a low content of organic matter (<3%) and consequently very sensitive to all forms of degradation (mostly water and wind erosion, salinization, crusting, and compression). The natural vegetal cover, mainly consisting of steppes and matorrals, provides little resistance.

For more than 50 years in Morocco, natural resources have been suffering from intense degradation. Under the pressure of a fast growing demography, crop lands are taking the place of forest and range lands. Forests are overgrazed and overexploited, respectively for 3.5 and 3 times their capacities. More than 35.000 ha/year of surface cover is being lost. Crop lands being planted with unsuitable techniques are becoming eroded by aggressive rains and runoff. Dam reservoirs are silted at an unacceptable rate (1.5% yearly). Desertification is one of the most serious handicaps for the development of the country. The main objective of the National Agriculture Strategy and National Forest Program developed for 2020 is: combat desertification. Morocco signed the Convention to Combat Desertification and developed a national program in order to fight this issue. A lot of studies were necessary to reach this target.

More than 2/3 of the national territory suffers from a low quality climate. More than 63% is very arid. The vegetal cover is of low quality and therefore inadequate to protect against desertification. Most of Morocco has a high risk of low fires (94.25%), a strong chance of erosion (90%) and a low resistance to drought (75%). More than 40% of soils is comprised of a soft parental material. More than 50% are shallow. More than 73% have loamy and sandy textures. More than 80% of Moroccan soil is vulnerable to desertification.

In conclusion, most of Morocco's environment is threatened by desertification mainly in the south and near the desert regions. The government, in conjunction with the population and local NGOs, has to act quickly and efficiently. Human and rural developments are necessary to combat deep poverty; the single most responsible factor for the spread of deserts and human emigration to Europe. Social security is closely linked to Ecological security.

Ecosystem Services

Ecosystem services are the services and goods that nature provides people. There are 3 main disciplines that study this concept: ecology, economics and sociology (with anthropology). The main issue that is studied is: how the management of ecosystems affects the services that the human society is receiving from them. Also, ecosystem services deals with how the changes in ecosystem service supplies affects management. The study of ecosystem services in arid areas is pretty sparse and any study that focusses on the services from a cultural, management, ecological, economics or any other aspect is contributing to the field.

Drylands conundrums: kangaroos versus sheep for conservation of Australia's rangelands

Dror Ben-Ami¹ – drorba7@hotmail.com, Daniel Ramp², David B Croft³, and Keely Boom¹

¹THINKK, the think tank for kangaroos, Institute for Sustainable Futures, University of Technology Sydney, Broadway 2007 New South Wales, Australia

²School of the Environment, University of Technology Sydney, Broadway 2007 New South Wales, Australia

³School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney 2052 New South Wales, Australia

Like other rangelands around the world, Australia's rangelands have been substantially degraded from over-production of livestock. Restoration activities have investigated alternatives to livestock grazing and include the

sustainable use of wildlife. The latter has become of great interest globally and efforts to adopt this concept in Australia warrants detailed examination. The consumptive use of kangaroos has been suggested to provide incentive to grazers to conserve biodiversity and to reduce dependence on livestock. Since 1991, the commercial harvest of between 1.9 and 3.5 million kangaroos per year has provided pet meat, meat for human consumption, and skins for leather goods. We review the capacity of this use of kangaroos to facilitate rangeland restoration by considering some key ecological relationships, market conditions, and conservation benefits that would underpin the utility of this approach in Australia.

Overview of Jordan biodiversity and ecosystem services

Adnan Budieri, Friends of the Earth Middle East; adnan@foeme.org

Jordan has four distinctive biogeographic zones: Mediterranean, Irano-Turanian, Afro-subtropical and Arabo-Saharan. These biogeographic zones are divided into main ecosystems and habitats: Mountainous, Forest, Wetlands, Deserts and Marine. Distinctive habitats and ecosystems in Jordan are the Hamada and Harrah deserts, Jordan Valley (including Jordan River and Wadi Araba), Dead Sea and the Red Sea.

Such ecosystems offer valuable services to both wildlife and human populations, as well as contributing much to the national and local economies in the fields of medicine, agro products, fisheries, building materials, aesthetic, cultural and tourism values and others.

To date it is estimated that Jordan is home to more than 2,500 plant species, 4-5 amphibians, 90 reptilian species, 520 avifauna, 90 mammals, 28 fresh water and 1000 marine fish. Jordan is also on one of the most important internationally recognized bird flyways. More than 500 million migratory birds benefit from the unique habitats offered by Jordan's Aqaba-Rift Valley as they embark upon their annual migration from Europe to Africa and vice versa.

Jordan's first foray into the world of nature conservation came in 1922 with the country's first forestry laws, followed by wildlife regulations in the 1950s and the establishment of the Royal Society for the Conservation of Nature in 1966. To date 12 natural reserves have been declared and six established, while 28 wetland sites have been proposed with only one official Ramsar site, the Azraq wetland reserve, and about 29 Important Bird Areas declared and recognized internationally. Jordan's Biodiversity country study and strategy were finalized in 1997 and 2001 respectively. Jordan has signed and ratified a number of environmental conventions and treaties, such as the Biodiversity, UNCCD, UNCCC, and Bonn, Ramsar and CITEIS conventions and the AEWa agreement on migratory species.

Despite this positive action, inadequate awareness programs, lax law enforcement and a weak regulatory environment have lead to the degradation of a number of Jordan's unique ecosystems. The country's oak and pine forests, the Dead Sea, and areas including Hamada, Harrah and the Jordan River have been seriously affected, with their unique natural values coming under threat and their biodiversity impacted. As such, species including the Brown Fish Owl, Syrian Brown Bear, Roe Deer, Mountain Gazelle, Leopard, Cheetah, Ostrich and Squirrel have been all but wiped out in this region.

Such loss of biodiversity and the natural and aesthetic values of ecosystems represent not only a blight on the country's environmental record, but also a lost opportunity for potential local income generation and the social welfare that accompanies it. With eco- and sustainable tourism now widely recognized as a good source of income for governments and local communities, Jordan is joining the global movement towards the creation and promotion of such enterprises. To sustainably benefit most from the ecosystems and natural resources services the following action is recommended:

1. The improvement of laws, regulations and policy to ensure the sustainable maintenance and management of habitats that are of global importance for biodiversity and ecology.
2. The development and national and international promotion of certain Jordanian sites as ecological corridors for wildlife, bird watching and ecotourism sites.
3. The enhancement of environmental education as a tool for increasing the environmental awareness of the locals and visitors.
4. The enhancement of scientific monitoring and research of ecologically important sites in Jordan and the region at large.

Spiders in Desert Agro-Ecosystems

Yael Lubin, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel Email: lubin@bgu.ac.il

Agro-ecosystems in arid environments are comprised of watered crops and natural desert habitats. The marked differences in productivity and habitat structure influence the movement of ‘natural enemies’ (predators and parasitoids) and of crop pests between adjacent habitats. We are investigating the interactions between spiders and crop pests in desert agro-ecosystems in the northern Negev and Arava valley. We found that some spider species move from desert habitats into annual crop fields, but they do not complete their life cycle in the crop and therefore require nearby desert refuges. Re-colonization from desert refugia is likely, as some species show movement out of the crop fields into nearby desert habitats after the harvest. In the laboratory, we are investigating predator-prey interactions between desert and agrobiont spider species and various crop pests. Finally, we found that crop pest species disperse over large distances into the surrounding desert and can survive and reproduce on desert plant species. This spillover of crop pests may have implications for the native arthropod communities in the desert environment.

An Ecosystem Service Inventory: Lessons from the Northern Negev long-term social ecological research (LTSER) platform

Daniel Orenstein, Department of Architecture and Town Planning, Technion – Israel Institute of Technology, Haifa, Israel 32000; danielo@ar.technion.ac.il

Despite the burgeoning popularity of the use of the term ‘ecosystem services’, relatively little work has yet been done to identify, characterize and quantify ecosystem services and their spatial distribution across the landscape. In this study, we test a methodology for taking inventory of ecosystem services in Israel’s semi-arid Northern Negev region. We survey site managers of five long-term ecological research (LTER) sites regarding the presence/absence of 86 ecosystem services, and their level of confidence regarding their answers. There were a high percentage of services in three categories (provisioning, regulating and cultural) across all sites, and no significant differences based on environmental factors. The only factor that correlated with differences in the package of services offered at each site was management agency (Ministry of Agriculture or Keren Kayemeth LeIsrael). Through principle component analysis, we find that management agencies, through their land use policies, can alter the package of services, for example by emphasizing agricultural- or forestry-oriented services or particular cultural services, like those associated with education or tourism. We conclude our analysis with a discussion of both the distribution of services and our reflections on the learning process from our ecosystem service assessment.

Trans-border perceptions of ecosystem services in the desert: A social inquiry in the Southern Arava Valley on both sides of the Israeli-Jordanian border

***Hila Sagie**, Yodan Rofè, Avigail Morris and Daniel Orenstein

* Man in the Desert Department, BGU AKIS, hilush3@hotmail.com

The concept of ecosystem services has emerged as a dominant theme for sustainable natural resource management and land use policy. Ecosystem services are benefits derived from nature that humans require for biological life and quality of life. These services can have material (economic) value or non-material (aesthetic, cultural, spiritual) value for humans. Despite numerous calls to integrate diverse disciplinary approaches into the assessment of ecosystem services, the overwhelming amount of research has been conducted by ecologists and to some extent by economists (Ohl et al 2007). In this research, our goal is to introduce the use of qualitative-anthropological tools to assess the connection between ecosystem services and human well-being in general, the intangible values of cultural services that do not have monetary value in particular and to show their importance in desert ecosystems. This research reports on the results of in-depth interviews that were conducted in the southern Arava Valley on both sides of the Israeli-Jordanian border in order to assess the different perspectives of local residents of the ecosystem services they receive from their environment. The southern Arava is a hyper-arid desert that is shared by two neighboring cultures located on two sides of a political border, and are differentiated by not only nationality (Israeli/Jordanian), but also religion (Jewish/Muslim), lifestyle (Kibbutz/Bedouin) and level of income (above and

below their respective national averages). The results of this research contribute to knowledge regarding ecosystem service assessment in three ways: 1) The research emphasizes the importance of the use of qualitative research methods from anthropology to assess awareness of ecosystem services and their importance to the general public, 2) Findings show that, despite the perception that deserts are often considered to be lacking in ecosystem services (Naidoo et al 2008), one can find many services there, in particular cultural services, and 3) Findings show that local residents from different cultures that live in a similar ecosystem use and value ecosystem services differently, which has important policy ramifications.

Ohl, C., Krauze, K., & Grunbuhel, C. 2007. Towards an understanding of long-term ecosystem dynamics by merging socio-economic and environmental research: Criteria for long-term socio-ecological research sites selection. *Ecological Economics*, 63(2-3): 383-391.

Naidoo, R., Balmford, A., Costanza, R., Fisher, B., Green, R. E., Lehner, B., et al. 2008. Global mapping of ecosystem services and conservation priorities. *Proceedings of the National Academy of Sciences*, 105(28): 9495-9500.

Environmental Education

This theme will address environmental, social-cultural and ethical challenges characterizing drylands and desertification processes that need to be addressed in the educational arena.

Topics included in the environmental education theme:

- Educational programs and projects conducted within formal and informal frameworks, and community initiatives.
- Management and education - Examples of degraded dryland restoration projects that integrate the community and/or educational frameworks.
- Science and education- Implementation of scientific knowledge in environmental education addressing dryland challenges; scientific studies that provide an educational resource and integrate students.
- Biophysical, social and educational research conducted on / that provides insight for the challenges of drylands and desertification processes.
- Educational success stories including quantitative and qualitative indicators of success.
- Indigenous and local knowledge in education for sustainability in drylands
- Advanced green technologies in the desert and their inclusion in environmental education.

Waste hazard implications on health and welfare in the Negev's Bedouin Arab community- the children's point of view

Orit Ben-Zvi Assaraf, Sedawi Wisam¹ & Julie Cwikel²

¹ Department of Science and Technology Education, Ben-Gurion University of the Negev, Israel, ntorit@bgu.ac.il

² Spitzer Department of Social Work, Ben-Gurion University of the Negev, Israel

The Bedouin of the Negev region of Israel are a formerly nomadic, indigenous, ethnic minority. At present, approximately 40% live in unrecognized villages without organized, solid-waste disposal. This study addresses the manner in which 4th-5th grade children from unrecognized Bedouin settlements in Israel's Negev desert perceive waste and its effects on health and the environment, with an eye towards compiling a future model for their environmental education. These children participate in local practices with environmental repercussions, such as incinerating waste or collecting it for reuse and sale. These lead to injury, exposure to toxic chemicals and chronic disease. Understanding such dangers would not only help these children avoid future environmental and personal harm, but potentially allow them, through generational influence, to impact the knowledge, affect and behavior of adults in their community as well.

Data was collected by a combination of interviews, illustrations and observations, with results divided into 3 main categories: knowledge, affect and behavior. We found that though waste is an integral part of the children's domestic environment, their knowledge of it was only superficial, based in social and personal experience. In terms of affect,

children's reactions were ambiguous -- proclaiming environmental responsibility whilst simultaneously describing a lack of care towards environmental preservation. The children described several waste-related everyday behaviors: going to the valley to dump waste, burning or playing with it, making toys from discarded objects, and gathering metals, batteries, and bottles for sale. Together, the three aspects of this study reveal the extent and pervasiveness of waste's impact on these children's lives. They also highlight the areas to target with environmental education if positive change is to be achieved. These results indicate that the waste problem in these unrecognized Bedouin settlements is complex, influencing their environment, community and health. Any solution to this problem must include an educational intervention program that fosters behavioral change – an epidemiological-social challenge.

Construction of new place identity in an unrecognized Bedouin village – from alienation to environmental responsibility

Noa Avriel-Avni; Nachal Paran, 6, Mitzpe Ramon 80600; Israel; avrielav@bgu.ac.il

The study focuses on an unrecognized Bedouin village in the Negev, which was created in the early 1980s because of Israeli government policy. Two years ago, a small group of men was organized in order to give the village a new identity as a center of learning about the Bedouin desert culture. During this process, the men were required to recount their distant past as nomads, to confront their more recent past as uneducated people of the unrecognized village, and to weave a dream about a new personal identity as the owner of valuable knowledge about desert sustainability. Narrative analysis of a series of in-depth interviews that were made with the leaders of the process allows us to identify the process of formulating a new place identity and to reveal its complex components. The residents have developed pride in their past identity as nomads and place attachment to the new place. At the same time, they have developed environmental responsibility. Transference and resettlement is not unique to the Negev Bedouin. Modern society is characterized by high mobility of populations, causing people to disconnect from the environment in which they grew up and move to new places, where they develop a sense of social and geographical alienation. In such a reality, their place attachment loses its strength and, with it, their environmental responsibility is weakened. Through in-depth analysis of the process of new place identity formation in the Bedouin village, we seek to identify principles for educational and community intervention in order to support and strengthen the connection and responsibility of other communities to their new place.

Developing a renewable energy curriculum, based on experts' and 9th grade students' perceptions

Tami Fishel¹, Orit Ben-Zvi Assaraf¹, and Hanan Ginat²

¹The Department of Science and Technology Education, Ben-Gurion University; Israel; Tami.fishel@gmail.com and ntorit@bgu.ac.il

²Dead Sea and Arava Science Center; Israel; hanang@school.ardom.co.il

The world-wide energy crisis emphasizes the need to develop new energy sources and reduce energy consumption. Agenda 21 defined the importance of education in creating sustainable development and environmentally literate citizens. Therefore, one of the solutions for the energy crisis is using education to encourage renewable energy and consumption reduction.

In order to promote the field of renewable energies in Israel, in May 2006, the Eilat- Eilat renewable energy innovative was established; one of its goals was to introduce the subject of renewable energy into education. In Israel, the 9th grade junior high curriculum includes energy-related science, but renewable energies are not included. In order to implement this topic into the curriculum, the advice of experts in energy science is needed, as well as knowledge of students' perceptions of the subject.

This study sought to develop a curriculum for renewable energy in junior high, including field trips, labs, student projects and more. The research approach was based on two main steps: 1. Appeal to the scientific community to determine which scientific principles are of real importance to the subject. This was done by interviewing experts in the field of energy.

2. A research tool was built to assess students' perception of renewable energy, based on the knowledge of the experts in the field. Information gathered by these tools was used in building guidelines for the development of a new curriculum. The research approach included the combination of qualitative tools (interviews with experts and students) and quantitative tools (specially developed questionnaires).

The results derived from the experts' interviews emphasized the need for the 9th grade curriculum to recognize relationships between earth systems and humans, as well as the importance of finite energy sources and increasing environmental awareness. The students expressed relatively high awareness of environmental issues, but there is a gap between students' awareness and their actual knowledge. In addition, there is a deep gap in the perception of different aspects of sustainability between experts and junior high students; it was difficult for students to use critical thinking on subjects which were defined as "green," while the experts emphasized the importance of critical thinking about any environmental issue.

Based on the findings and conclusions of this study, a curriculum for the 9th grade was developed, including different pedagogical principles in order to achieve awareness and deeper understanding of the subject.

A place-based approach to enhancing 7th-9th grade students' systems thinking and understanding of biodiversity

Adi Keynan and Orit Ben Zvi Assaraf

Department of Science and Technology Education, Ben-Gurion University of the Negev, Israel;
ntorit@bgu.ac.il and odedadi@gmail.com

The year 2010 was pronounced "Biodiversity Year" by the UN, in response to the critical importance of drawing humanity's attention to the ongoing biodiversity crisis. While biodiversity has become a part of the K-12 curriculum, its point of view remains narrow, focusing primarily on humanity's influence on nature. We suggest that a fuller examination of ecosystems' complexity, with their interactions and connections, is required, to provide students with a broader view and enhance their systems thinking skills. The study presented here included 20 students, in grades 7-9, who live in villages located in the arid Arava area of Israel. All of them voluntarily participated in an after-school science program that included three labs and involved three field trips for inquiry, within the ecological system at the Shezaf Nature Reserve, followed by knowledge integration activities.

In this study, we assessed the impact of studying biodiversity in a place-based educational framework on students' systems thinking skills, using the Systems Thinking Hierarchy (STH) model. The model's characteristics are arranged in ascending order of advancement into three sequential levels: (A) analyzing system components; (B) synthesizing system components (identifying and organizing the components, their processes and their interactions within a framework of relationships); (C) implementation (generalization of patterns, recognizing hidden dimensions of the system and thinking temporally). Each lower level is the basis for developing the next level's thinking skills. Data was collected based on the Repertory Grid technique interview, conducted before and after the learning unit. Our results suggest that the students came with an already effective readiness to discuss the subject of biodiversity, and were familiar with the concept previous to the course. Their familiarity with the concept enhanced the development of a more complex systematic understanding of their local ecosystem.

Qualitative analysis showed that the students developed a more complex view of the ecological system at the Shezaf Nature Reserve, both in the hidden dimension and the time dimension. The students also learned to generalize some of the ecological phenomena, leading to improved understanding of the interactions between humans and their environment, a tool that may help them cope better with complex environmental issues related to biodiversity.

Outdoor education and ecology literacy in the desert

Viktorija Keding; NaDEET Director, P.O. Box 31017, Pioniers Park, Windhoek, Namibia; vkeding@nadeet.org

The Namib Desert is a fog-dependent coastal desert spanning across the whole of Namibia's western boundary. Here, species have had millions of years to adapt to the extreme conditions of the desert. Outdoor education programmes at the Namib Desert Environmental Education Trust (NaDEET) Centre give Namibians the opportunity to explore first-hand the unique adaptations and survival mechanisms of the desert's biodiversity. Key species, such as the Tenebrionid beetle, locally known as the Tok Tokkie, provide the basis for a dynamic food chain as they transfer the energy and nutrients found in wind-blown detritus into higher levels. Through outdoor education activities, the unique adaptations and relationships between Tok Tokkies and many other species are explored. Participants build their ecological literacy through biodiversity exploration dune walks and nocturnal catch and release trapping. NaDEET's It's Time to Identify gives them information about species in an easy-to-understand format. These activities are the basis for understanding a healthy desert ecosystem from which participants can take

lessons for adapting and mitigating the causes and effects of global environmental disasters, such as desertification and climate change.

With an increased understanding of the Namib's desert ecology and its practical application at NaDEET Centre, participants gain skills and the necessary attitude to live in a more sustainable manner in their own communities. NaDEET Centre's approach is, therefore, to learn from the desert and to apply it to human needs. Living at NaDEET Centre for a week-long programme allows participants to temporarily forget the demands of their daily lives and immerse themselves in the beauty of the desert. Just as desert creatures do, participants learn to live with less water and to utilise the ample sunshine for all of their energy needs, for example, using solar cooking. NaDEET Centre's facilities are designed to respect the natural resources available in the area and to utilise them in a sustainable manner. This can be an example for environmental education programmes to teach participants the necessary skills to deal with a changing climate.

Learning to live more lightly: Children's understanding, attitudes and behavior in arid regions

Constantinos C. Manoli; University of Cyprus; manoli@ucy.ac.cy

Bruce Johnson; University of Arizona; brucej@email.arizona.edu

Andreas Ch. Hadjichambis; CYCERE¹; a.chadjihambi@cytanet.com.cy

Demetra Hadjichambis; University of Cyprus; demhad@ucy.com.cy

Yiannis Georgiou; Cyprus University of Technology; yiannis_epa@hotmail.com

Hara Ioannou, CYCERE¹; hara_art@hotmail.com

¹Cyprus Centre for Environmental Research and Education

Introduction: While educational programs provide the foundations of environmental awareness and concern about human impact in an effort to shape the development of environmental behavior (Bogner, 1998, 2004; Gigliotti, 1990), many of these programs focus primarily on environmental issues and problem-solving skills, failing to address the attitudinal and behavioral components (Johnson & Manoli, 2011; Waliczek, & Zajicek, 1997). Empirical studies provide evidence that addressing knowledge alone is not enough to lead to changes in behavior (Johnson & Manoli, 2008). In order for humans to make decisions and take action for a more sustainable life in arid regions (for example, reducing water consumption), they need to understand the natural systems of the world, grasping the big picture of how life works and learning how to live within them (Johnson, 2007). The present study investigated the impact of an earth education program, Earthkeepers, on students' ecological understandings, environmental attitudes and ecological behavior in Cyprus, an island with very limited access to fresh water. The program helps children make personal choices on how to live more lightly on the planet, such as using less energy and fewer materials. **Methods:** Participants were 196 fourth – seventh grade students from six public schools in Cyprus. All students participated in Earthkeepers (Van Matre & Johnson, 1988), an earth education program that helps participants construct ecological understandings, develop positive feelings for the natural world and make choices about their personal environmental behaviors (Johnson, 2003). For the purpose of this study, students' ecological understandings, environmental attitudes and ecological behavior were measured and compared both before and after the program. Finally, individual semi-structured interviews with 12 students and 9 teachers helped verify the quantitative results and provide further information about the impact of the program.

Results: The analysis of the results showed gains both in students' understandings as well as changes toward more pro-environmental attitudes (due to the limit of the abstract, statistical results/tables will be provided during the presentation). The student and teacher interviews supported the quantitative results and confirmed that the participants undertook more ecological actions after the program. Very similar results were found in arid regions in the US (Arizona) and other countries where the Earthkeepers program is used (Martin, 2003; Johnson & Manoli, 2010). Earth education programs can make a great contribution to learning about sustainability in the arid lands as they have the potentials to enhance students' ecological understandings, attitudes and behavior for a more sustainable lifestyle.

Turning a green leaf towards sustainability

Mary Margaret Otieno, Wildlife Clubs of Kenya, PO Box 12913 , Nairobi, Kenya;
meg@wildlifeclubsofkenya.org

The proposed presentation covers the results of the implementation of the Lake Victoria Catchment Environmental Education Programme (LVCEEP), in the pilot areas, from September 2008 to September 2011. The aim of this presentation is to share the experiences, activities, values, lessons learnt and the benefits achieved in the implementation of the Lake Victoria Catchment Environmental Education Programme (LVCEEP) Education for Sustainable Development (ESD) projects in the selected areas, aimed towards the recovery of the ecological integrity and the restoration of the lake's resources.

Engineering for developing communities: A case study of education for sustainability in higher education

Tali Tal - rtal@technion.ac.il and Keren Mintz; kerenk@technion.ac.il
Department of Education in Technology and Science, Technion; Haifa, Israel

Engineering for Developing Communities is an example of an undergraduate Education for Sustainability (EfS) course. The course is collaboratively taught by two professors--one from the Technion and one from the University of Colorado, Boulder--and also engages several other instructors. While studying other courses to identify EfS in higher education, we identified this course as exemplary in many aspects. Israeli and American students from different programs enrolled in this course that makes use of Service Learning, which is a practice that promotes students' learning by engaging them in service in the community. The course characteristics -- active learning, team work, working on real problems, communicating with stakeholders, and reflection process -- suggest a comprehensive approach to EfS.

In studying the course, we used a mixed-method approach and collected data in the forms of class observations, and semi-open questionnaires administered three times: pre, post, delayed post. The students indicated a range of learning experiences in the cognitive, social and affective domains. They appreciated the hands-on experiences, the professional skills they acquired and the interdisciplinary content that they learned. Six months after the course ended, there was almost no decline in students' self-reported learning, with some aspects that even increased. Although the teaching and learning model of Engineering for Developing Communities course cannot be applied across undergraduate studies, we argue that enrolling in such a course, even once, can make a long-lasting impact on the students, our future engineers, who are the next generation of decision makers and informed citizens.

The schoolyard as a tool for addressing sustainable development and environmental issues in arid countries

Liza Ttooulia ; Frederick University Cyprus; marioslia@cytanet.com.cy;
Aravella Zachariou ; Frederick University Cyprus; aravella@cytanet.com.cy;
Constantinos C. Manoli ; University of Cyprus; manoli@ucy.ac.cy

Introduction: When addressing environmental issues at school, the schoolyard provides a dynamic environment for intervention and action and serves as the intersection that integrates the local with the broader environment. In Cyprus, the role of the schoolyard, in the context of sustainable development and environmental issues, has been gaining in critical importance the last few years, since Environmental Education (EE)/Education for Sustainable Development (ESD) has been officially introduced for the first time in the Cyprus Primary School Curriculum recently, and national and regional issues, such as climate change, desertification, soil degradation, etc. are at the core of the curriculum. These interests, when approached from the perspective of sustainable development, require the transfer of the learning process in the field, such as the schoolyard, as the most directly relevant environment for students to acquire experience and stimuli that can be decisive in shaping sustainable patterns of behavior in relation to the above issues. Based on the aforementioned, this paper explores the use of the schoolyard in elementary

schools in Cyprus as a tool to study issues related to desertification and climate change while elaborating on an ideal schoolyard model as an effective field approach in primary education.

Methods: The study was conducted in 15 primary schools in Cyprus, and the data collection included quantitative and qualitative methods. Specifically, a questionnaire was administered to 100 teachers, while interviews were conducted with 15 other teachers. Characteristics of elementary schoolyards were also recorded using observations.

Results: The analysis of the results revealed that the current schoolyards in primary schools of Cyprus are virtually neglected sites and rather hostile to the students. The majority of teachers believe that the use of the schoolyard depends entirely on the personal interest and initiative of individual teachers. Using the schoolyard as a learning tool for environmental issues and sustainable development (desertification, land degradation, biodiversity, etc.) is of secondary importance and of limited use in some courses, such as science, for conducting soil and climate change experiments. Finally, as significant barriers to the utilization of the schoolyard, teachers emphasized the lack of practical and experiential training and content knowledge of the above issues, the lack of time to transfer the learning to the field and the extra burden on an already busy schedule. The results are discussed in relation to the pedagogical frameworks of EE and the ESD, as well as in relation to the didactic and methodological framework for examining issues related to desertification and soil degradation.

Evolution, Climate and Man as Factors Leading to Degradation and Productivity Loss in Terrestrial Biomes

Hot deserts are found at the lower extreme of the terrestrial biomes productivity gradient where tropical forests and temperate forest are found on the upper one. In order to understand the function of the desert we need a general theory on the structure of terrestrial biomes and the relation between productivity and biome's structure. Currently, there are 3 non-exclusive models explaining this relation, namely (a) a fixed structure (Hairston, Smith et al. 1960) HSS "The green world theory"), (b) an increase in the number of trophic levels with productivity and desert having the lowest productivity has only one trophic level ((Oksanen and Oksanen 2000) and (c) a decreasing number of trophic levels with productivity and deserts have four ((Ayal 2007; Ayal 2011).

These three different theories were developed by scientists working in different biomes, the first working in temperate forest, the second working in grasslands and tundra whereas the third working in deserts. The proposed session will bring representatives of the 3 groups to try to unify the theories and through it understand how terrestrial biomes work and especially arid ones: hot deserts, dry grasslands and cold deserts (tundra). This is essential for understanding how biomes structure will change due to climate change, especially the expected increase in aridity, the way to preserve arid biomes.

From evolutionary to anthropomorphic habitat degradation: a lesson from past cycles of "desertification" to the present crises

Yoram Ayal; Department of Ecology; Ben-Gurion University of the Negev, Israel; ayal@bgu.ac.il

Desertification is the process of degradation of the landscape in drylands. It is often a consequence of human activities and reduces the future economic use of the land. The main factor currently driving this process is the increase in human population size. This leads to over-exploitation of the environment, which not only reduces production per se, but also results in detrimental changes in the landscape that make it difficult, or even impossible, to recover past production. These processes are expected to be further enhanced by anthropomorphic global climate changes. However, these processes are not new and, in part, are rooted in past evolutionary changes of the landscape resulting from animal, mainly herbivore, population growth that lead to over-exploitation of their food resources. This, with the aid of a changing climate, the landscape was degraded and the animals' food resources reduced.

Man first appeared as an important player on the stage during the late Pleistocene and his early effect as a top predator was apparently positive. Through hunting, man controlled the mega-herbivores, decelerating their overexploitation of their food supply and probably enhanced the mega-herbivore population production for hunting. Later man became over-effective, and due to his own population growth and improved hunting techniques, man over-exploited these animals and drove them to extinction. This resulted in global changes in plant population structure and distribution in some major terrestrial biomes that became dominated by woody plants. Ever since, the most prominent changes in the natural environment have been anthropomorphic. The result is a destructive cycle that continues to exacerbate desertification today. Human innovation in exploitation of the natural environment (e.g., animal husbandry and agriculture) lead to increased population growth and over exploitation, whereas climate change played a lesser role in the background. Understanding this cycle leads us to the conclusion that the major process behind the destruction of natural resources that precipitates environmental crises is population growth and mankind's development of new techniques to enhance food production. In the short term, such techniques may resolve economic problems, but will rebound soon after, causing even more acute problems. While such development follows its inevitable path, we must deal with the acute force that drives them, i.e., uncontrolled population growth. Thus, the main lesson from the past is that human population control is the only way to stop the destructive cycle leading to environmental degradation. Yet, it is the most difficult goal to achieve as it involves both cultural changes and revised economic perceptions that currently focuses on growth of production.

Spatial heterogeneity and food-web complexity – the role of ecosystem engineers in dryland ecosystems

Bertrand Boeken; French Associates Institute for Agriculture and Biotechnology of Drylands, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev; bboeken@bgu.ac.il

All energetic, metabolic and allometric considerations aside, food web complexity (FWC) in terrestrial ecosystems is known to depend, in addition to productivity, on species richness and spatial heterogeneity (SH, reflecting 3D variation in structural properties). Both SH and FWC vary with ecosystem productivity at various scales in space (geographical and local productivity gradients), and in time (through evolution and succession), from sparse single-layer vegetation with low SH and FWC to forests with multiple canopy layers and high SH and FWC.

This relationship is partly based on utilization of resources, conditions and sites, as species diversity increases with SH, and more species with different functional traits have more trophic interactions. The second, structural connection between FWC and SH is based on the phenomenon that some producers, consumers and decomposers are actively involved in modifying SH, as what is now commonly known as autogenic and allogenic ecosystem engineers (EEs). Autotrophic plants create structural diversity by accumulating biomass, mainly woody material (autogenic EE). Allogenic EEs add structural diversity by altering their surroundings, usually coupled with concentration of limiting resources (water or nutrients), and therefore contribute even more to the relationship between FWC and SH. These patch-forming EEs (also called landscape modulators) include micro-organisms, plants, fungi and animals that individually or collectively alter structures, conditions and resources, in addition to their different trophic functions and interactions with other organisms.

An example is the island-of-fertility phenomenon in semi-arid ecosystems as some shrub species create distinct landscape patches, where canopy architecture enhances resource supply by forming soil mounds with high water infiltration. The mound (allogenic EE) and the supported shrub canopy (autogenic EE) create both horizontal and vertical SH that facilitates annual plants, herbivores, granivores, detritivores, decomposers and predators, and thus FWC. At the larger spatial scale, the shrub patches increase resource retention and utilization. In more productive ecosystems, the horizontal SH component is less conspicuous and less important for concentrating limiting resources.

I will examine how SH and FWC vary among ecosystems, and how this is related to diversity of auto- and allogenic EEs, with special attention to the differences between arid and more productive ecosystems. In addition to the general hypothesis that diversity of EEs drives structural heterogeneity, which in turn controls FWC, I propose the hypothesis that as ecosystems are more productive and more limited by light, SH and FWC are mostly due to autogenic EEs that increase vertical structure, while in unproductive ecosystems where NPP is limited by soil resources (nutrients, water) the contribution of allogenic EEs to both SH and FWC increases due to enhanced resource uptake and transfer efficiency.

Uncertain ecosystems: the ecology of open, non-forested vegetation

William J. Bond, Botany Department, University of Cape Town, Private Bag, Rondebosch, 7701, South Africa; william.bond@uct.ac.za

Climate has long been considered the prime factor determining the distribution of major vegetation formations implying that there is a single stable vegetation state for a given climate. However this is not true for large parts of the world where strikingly different vegetation states, such as forests and grasslands, occur in the same landscapes under the same climate. For most of the last century the non-forested ('open') ecosystems were thought to be secondary vegetation produced by deforestation and anthropogenic burning. However open ecosystems include some of the world's richest biodiversity hotspots, implying a long evolutionary history. Recent fossil and phylogenetic evidence supports their antiquity while Quaternary studies are showing that some open ecosystems were even more extensive before the rise of human populations. Recognition of the age and extent of open ecosystems challenges traditional ecological concepts. Succession, driven by competition for resources and especially light, should result in dominance of taller- shade-tolerant growth forms where resources permit. Yet open ecosystems dominated by low-growing plants have persisted for millions of years. Recurrent disturbance, especially by fire, but also by large vertebrate herbivores, is important in maintaining open ecosystem states. Though understanding of the global importance of fire has grown rapidly in the last decade, there are still many uncertainties about the importance of mammals in creating and maintaining open ecosystems, both now and in the past. Recognition of the global extent of uncertain ecosystems, and of factors maintaining open ecosystems, is essential for understanding future global change of terrestrial vegetation.

Fragmentation and biodiversity patterns in fragmented semi-arid landscapes

Yoni Gavish; Ben-Gurion University of the Negev, POB 653, Beer-Sheva, 84105, Israel; gavishyoni@gmail.com
Yaron Ziv; Ben-Gurion University of the Negev, POB 653, Beer-Sheva, 84105, Israel; yziv@bgu.ac.il

Two main processes that drive the current global biodiversity crisis are global climate change and the transformation of natural habitats into human dominated land-uses (habitat loss). As human settlements and agricultural practice in desert environments are relatively scarce, the world's deserts have experienced relatively low levels of habitat loss. As such, the effects of habitat loss and fragmentation on desert systems are relatively unexplored. In contrast, semi-arid landscapes, which lie at the edge of the world's desert belt, have already been subjected to high levels of habitat loss and fragmentation. We have sampled spiders in three fragmented semi-arid landscapes along the sharp climatic gradient of Israel. Various methods to decouple fragmentation from habitat loss reveal that fragmentation actually maximizes diversity. We explain this result using an occupancy-based null model for the species-area relationship. The null-model reveals that rare species are found on small patches more than expected by chance. We further develop the link between occupancies and species-area relationship to theoretically explore the effect of fragmentation on species diversity. This exploration reveals that when the evenness of the distribution of area between patches is low, fragmented landscapes will sustain higher species diversity than continuous landscapes. We suggest that if we wish to understand how climate change and human effects influence biodiversity, we should apply quantitative models and methods in order to recognize underlying mechanisms.

Elimination of predators is a sufficient condition for steppification

Lauri Oksanen^{1,2} - lauoks@utu.fi, Tarja Oksanen^{1,2} and Risto Virtanen³

¹Department of Biology, section of Ecology, University of Turku, FI-20014 Turku, Finland

²Section of Sciences, Finnmark University College, Alta, NO-9504 Alta, Norway

³Department of Biology, University of Oulu, FI-90014 Oulu, Finland

During the last three millennia, vast forested areas have changed into treeless communities, dominated by graminoids or prostrate dicots. Sometimes the vegetation has become scanty enough to warrant the term desertification, but in most cases, steppification is a more appropriate term, since even in the new state, > 50% of ground is covered by plants.

Typically, four simultaneous processes have contributed to steppification: increasingly arid climate, logging, elimination of big predators, and large scale introduction of domesticated grazers and browsers. This has made the relative importance of each of these processes hard to judge. An interesting natural experiment on the role of predator elimination is provided by the island of Rùm off the west coast of Scotland, which is today covered by steppe-like vegetation except for the east coast, which has been reforested during the past 150 years. Drought can be ruled out because the climate of the island is among the wettest in western Europe. Pollen data indicate about large scale logging on the east coast between 2000 and 1000 BC, but since then, the pollen cores of this area contain a constant fraction of forest tree pollen, indicating that other parts of the island remained forested. Also the Norse names of the mountains, such as Askival (= Askvål = Roundish Mountain with Ash Trees), and the Gaelic name of the island, Rìoghachd na Forraiste Fiadhaich (The Kingdom of the Wild Forest) provide testament to the prevalence of forests. During the Scottish rule, the island was a hunting ground of the noblemen. In the 1600's wolves were eradicated from Scotland. In a report published in 1703, Rùm is characterized as "a forest full of high mountains and abundance of little deers in it," indicating that the deer were both unusually numerous and dwarfish due to shortage of browse. By the end of the 1700's both the forests and the deer were gone. In 1828, deer were successfully re-introduced, and have survived thereafter. Reforestation has been problematic and has only succeeded on the fenced east coast. Just fencing has changed the structure of the grassland but has not resulted in the invasion of trees or shrubs.

The case of Rùm indicates that elimination of big predators is a sufficient condition for steppification. Food limited, native browsers prevent the regeneration of trees. When the old trees die, steppification is inevitable. Thereafter, several stabilizing factors enter the scene, making reforestation a slow process.

Vegetation response to grazing management in a Mediterranean grassland: A long-term synthesis

Marcelo Sternberg; Department of Molecular Biology and Ecology of Plants; Tel Aviv University, Israel; marcelos@tauex.tau.ac.il

A long-term synthesis (18 years) on the effects of cattle grazing on the structure and composition of a Mediterranean grassland in north-eastern Israel is presented. This study provides new insights on the response of the vegetation and soils to rainfall and grazing management. The relationships among plant functional groups were studied in the context of the effects of grazing pressure of the most recent and former grazing seasons, as well as on the rainfall amounts of the most recent and previous rainfall seasons. Treatments included manipulations of stocking rates (moderate, heavy and very heavy) and of grazing regimes (continuous vs. seasonal), in a factorial design. The results indicate that inter-seasonal rainfall variation was a dominant factor in the expression of different grazing treatments on the structure of the plant community. Species diversity was significantly affected by grazing treatments and their effects were stronger in years with dry springs. Grazing effects were stronger on tall annual grasses and annual legumes in wet rainfall years. In dry springs and years, an increase in plant cover was noted in crucifers and thistles with increasing grazing intensity. A reduction in cover of tall grasses was correlated with an increase in cover of less palatable groups such as annual and perennial thistles as well of prostrate and shorter groups such as annual legumes and short annual grasses. Cover of functional groups composed by hemicryptophytic species were less variable (lower CV), in response to grazing treatments compared to functional groups with annual species. Increasing grazing intensity produced a shift in dominance of less palatable functional groups and was rainfall dependant. However, persistency of tall grasses and more palatable species support the idea that Mediterranean grasslands are highly resilient. This long-term study shows that the community is rather stable despite important variation in grazing pressures and rainfall conditions. The results are further discussed under the climate and land use change predictions for the region and its consequences for forage production and quality.

Friends of the Earth Middle East Presents a Joint Palestinian/Jordanian Program for Restoring the Southern Jordan River

Friends of the Earth Middle East (FoEME) is a regional organization bringing together Jordanian, Israeli and Palestinian environmentalists. FoEME works on transboundary environmental issues, mostly having to do with water. A prime example of a FoEME focus area is the Lower Jordan River, a unique shared ecological system that necessitates regional cooperation if it is to be preserved.

In 2012 FoEME launched a project to develop a regional NGO master plan for the Lower Jordan River with the following aims:

- To develop a comprehensive master planning programme to rehabilitate the Lower Jordan River and its tributaries.
- To determine coordinated regional flow regimes, set water quality standards, identify solutions to treat all pollution sources, launch restoration and preservation programs, establish ecological corridors, and identify opportunities to expand ecotourism infrastructures in the Jordan Valley including the preparation of regional heritage routes.
- To complement the Israeli government's process to prepare a master plan for the Israeli section of the Lower Jordan River. See details below.
- To develop complementary plans for the Palestinian and Jordanian sections of the Lower Jordan resulting in the production of the first ever comprehensive regional NGO master plan for the Lower Jordan.

Finally FoEME believes that the Lower Jordan need no longer be a symbol of separation. It has historically been the site for exchange between flora, fauna, peoples, cultures and ideas, and we would like to see this interaction continue.

Overview of FoEME's Jordan River work with focus on the ecology of the Lower Jordan River

Budieri, A.; Abu Jabal, N., Ya'ari, E.

The Jordan River situated in the Great Rift Valley, while unique in its natural and cultural wealth, is threatened by excessive water diversion and pollution, and treated as a backyard dumping ground. The river is significant to billions of people from diverse religions and countries worldwide but is presently under threat. Of the 1.3 billion cubic meters of water that would naturally flow down the River Jordan to the Dead Sea each year, an estimated 96% is diverted for domestic and agricultural uses. A regional integrated approach to water management issues in the Lower Jordan River Valley is desperately needed to repair and restore the once "mighty" river. Since much of the river is a closed military zone and off limits to the public, most people simply do not know that the river is drying up. The Jordan Valley is also a lush, wetland ecosystem that is the biological heart of the region at large. In addition to the flora and fauna on the ground, the valley is one of the world's most important crossroads for migratory birds - 500 million birds migrate each spring and autumn season, an attraction to birdwatchers from across the globe.

Water plan for the Rehabilitation of the Lower Jordan River

Safier G., Arbel Y., Bromberg G., and Yaari E.

October 2012: The objective of this work was to provide a roadmap for the initial phase of the rehabilitation of the LJR, by suggesting implementable measures to reintroduce water and reduce salinity in the river from the Israeli side. The method was to simulate and calculate the forecasted flows (discharges) and salinities in a monthly resolution at different reaches of the LJR and its tributaries for the years 2011-2041, at two basic alternative model-scenarios: 1. **Zero Scenario (ZS)**, which is continuing the 'business as usual' with approved plans. 2. **Rehabilitation Scenario (RS)**, with the following environmental requirements: Average annual flow of 220 mcm including minimum base flow of 9 mcm/month from Degania dam and small winter flood¹; and maximum salinity of 750 mg/L (Cl). Implementation of these requirements would allow natural riparian plant communities to recover and restore stable communities of flora and fauna while achieving a fair to high ecosystem integrity and health.

Both Scenarios were calculated under assumption of climate change and the resulting water balance (Rimmer, Givaty and Alpert, 2011); and are based on the **Current Accounts (CA)**, which represents the present situation (1996-2010). The CA model is based on the Chen A. (2011) model, originally developed by GLOWA JR.

The tool used is WEAP (Water Evaluation And Planning) software, which is based on the principle of closing the water balance in a basin by drawing a scheme and inserting flow data of all the water sources, reaches, demand sites, etc. This modeled scheme can be reused for calculating flow for different scenarios. Discharge, salinity and consumption data were compiled from various sources including the Israeli Water Authority, Mekorot, local water associations, National Parks Authority, local farmers, literature, etc. The CA model was calibrated to measure discharge at hydrometric station in the Harod stream, and to biannual salinity measurements along the LJR (NPA measurements since the 1990s).

RESULTS:

CURRENT ACCOUNTS: Today, the condition of the LJR is grim with flows that equal 3-5% of the historical flow and high levels of pollution and salinity in the river. The annual flow at the confluence with the Bezeq Stream is 76 MCM. The overall amount of water that enters the LJR south of Alumot is roughly 106 MCM/Yr but by the time the water reaches Bezeq, about 17 MCM are directly pumped out from the river and 13 more is lost through evaporation. The highest flow is in February at 11 MCM, while in June, the flow goes down to 3.3 MCM. The saltiest spot is the mouth of the Saline Water Carrier (SWC) (at Alumot dam), with an average of more than 2,000 mg/L. Salinity falls as we go southwards down to a level of 1,500 mg/L at the confluence with Bezeq Stream. In October-February however, owing to discharges from fishponds, salinity increases below Harod Stream and via Emeq Hamaayanot.

Zero Scenario: In the next 30 years, the situation is expected to improve with the rise in the water level of the Sea of Galilee (SoG) as a result of decreasing yields to the National Water Carrier and the partial desalination of the SWC. In the 2020's overflows of the SoG will even return instances of high flows to the LJR, albeit not in the same magnitude as historical flows.

Salinity wise, the river will be split at Harod Stream as a result of the SWC brine being transferred to Emeq Hamaayanot and the fishery reform. Upstream of Harod, the LJR salinity will be reduced to about 1,300 mg/L. Between Harod and Bezeq, the LJR's salinity will increase sharply, especially at autumn and early winter when it can top 2,000 mg/L, unless the brines will be transferred to the Dead Sea.

Rehabilitation Scenario: The first recommendation is to change the operation of the Deganiya dam after the rise in the Sea of Galilee by releasing 125 mcm/yr with a minimum flow of 9 MCM in the summer and a maximum flow of 14 MCM in March. During periods when the lake drops below the bed level at Deganiya dam, the released flow should be halved. The model shows that **this release is sustainable**, and that the lake will remain above the bottom red line even in extreme situations. Nevertheless, the anticipated improvement is not enough to sustain a healthy biological system in the LJR and further actions will be needed.

Besides the operation of Deganiya dam, 10 distinct measures in the RS were identified that aim at increasing flows and reducing salinity in the LJR. Among the most important measures are transferring the SWC brine to the Dead Sea instead of to Emeq Hamaayanot, a further reduction in the pumping to the NWC, reducing agricultural consumption in the basin and the fishponds particularly by nearly 50 mcm/yr by 2020 and limiting quotas in the Upper Jordan. **The combination of measures that are suggested could, within 10-15 years, restore the LJR to adequate environmental condition.**

¹ Flood lasting for at least 24 hours with discharge of 50 m³/s to a total of 4.3 mcm.

Although in average years the environmental goals are achievable, in drought years, especially if consecutive, that will not be possible. Meeting the salinity goal of 750 mg/L will be most difficult downstream of Harod Stream. Having said that, the proposed plan will greatly improve the condition of the LJR even in the driest of years to a level that could probably sustain the ecological system to a degree that it could quickly recover in average years.

Part of the proposed plan includes cutting back existing water allocations in the area. Much of the water reintroduced into the LJR could be reused downstream of Bezeq Stream and even in Emeq Hamaayanot, as the expected quality should allow all forms of saline irrigation.

Economic Benefits and Ecotourism in the Lower Jordan River

Abdel Rahman Sultan, Dr. David Katz et al.

Part of FoEME's strategy to rehabilitate and promote prosperity in the Lower Jordan River Valley is to encourage and develop sustainable tourism. The historical, cultural, religious, and biological heritage of the Lower Jordan River has the potential to attract large numbers of tourists to the Valley. In 2012, Friends of the Earth Middle East conducted a study to investigate the economic benefits of the rehabilitation of the LJR. Through the use of Travel Cost Methodology, Choice Modeling, and Contingency Valuation, the study measured the benefits of rehabilitation finding that benefits are maximized when Jordan, Palestine, and Israel all work together to share the costs of rehabilitation.

FoEME's Sharhabil ben Hassneh EcoPark (SHE Park) in Jordan is a successful model of sustainable tourism in the Valley. FoEME improved water management and protected resources for the highly degraded Ziglab Dam and surrounding area, resulting in increased biodiversity, leveraged funding, and interest from locals and internationals. Construction of ecolodges, greywater systems, and solar energy technology allows the park to accommodate guests while educating them about environmental issues and minimizing impact on the local environment. SHE Park has provided jobs for residents in the area and installed a sense of pride in the local community. The rehabilitation of the Ziglab Dam area is a micro view of what FoEME hopes to encourage throughout the Lower Jordan River Valley.

Grazing and Soils

The soil is arguably the most basic resource of a rangeland upon which primary, and in turn secondary, production depends. But important feedbacks exist from primary and secondary production back to the soil. This session focuses on the direct (e.g. trampling, compaction, dung and urine deposition) and indirect (e.g. selective or non-selective consumption of plant material) effects of grazing animals and their management on soils. These effects can be in various realms, examples of which include soil physical and chemical properties, degradation, organic matter content, moisture infiltration, content and retention capacity, respiration, carbon and nitrogen cycling, and the abundance and diversity of soil micro-organisms.

Moderate livestock grazing increases ecosystem resilience after drought

Bertrand Boeken, Hezi Yizhaq, Oren Hoffman, Shirly Elbaz, Natalie de Falco, Gerdien Groenendijk; Wyler Department of Agriculture; Blaustein Institutes for Desert Research; Ben Gurion University; Sede Boqer, Israel; bboeken@bgu.ac.il

Long-term studies on the dynamics of vegetation and landscape of hilly semiarid shrubland in the Northern Negev desert of Israel in Park Shaked LTER have shown that moderate sheep grazing pressure has many effects, most negative and some positive. Moderately grazed herbaceous vegetation, the grazers' primary resource in the inter-shrub space and in shrub patches, show a drop in recruitment and production to a lower but relatively stable level. Since this primarily affects the dominant species, the reduction increases species density at the small scale, alleviating diffuse competitive suppression of minor species. At the same time, some browsing of new shrub shoots

occurs, as well as grazing of herbaceous understory vegetation, and trampling of the soil mound of the shrub patches. Exclosure experiments showed that under these conditions the shrubs and their mounds become smaller, while runoff and resource loss from the slopes increases. Heavy grazing has more negative impacts, as complete shrub removal and crust disruption lead to loss of sediment, organic matter, nutrients and seeds, and further to gully erosion.

In the last 13 years there were two sequences of two dry years (1999-2000 and 2008-2009) that brought about some drastic changes in the shrub-crust landscape and inherent resource dynamics. Most notably, besides a temporary dip in herbaceous productivity, the dominant dwarf-shrub *Noaea mucronata* started to die off at an accelerated rate, significantly reducing shrub canopy cover. Thus large proportions of the existing shrub patches with developed soil mounds and herbaceous understory vegetation became denuded and eroded, and ceased functioning as sinks for capturing materials and as favorable habitats for numerous annual species.

However, on mid-slope locations in the fenced research watershed, *N. mucronata* mortality was much lower, and fewer shrub patches lost their understory vegetation and their sink function. Also in areas with moderate grazing, the shrubland landscape was maintained, including its resource dynamics. Simultaneously, we found that in grazed shrubland, new seedlings and juveniles of the smaller dwarf shrub *Atractylis serratuloides* had appeared, but not in exclosures. This signals shrubland renewal, as the species is the pioneer landscape modulator of shrub patches, capturing sediment as a juvenile and starting shrub-mound formation.

We conclude from these and more detailed results that some minimal level of disturbance, either by moderate grazing or strong wind and runoff flows, enhances the resilience of the shrub-crust landscape at the small and larger scale, mitigating the degrading impacts of prolonged drought.

A systems-based approach to understanding the relative effects of grazing and encroaching shrubs in a semi-arid woodland

David J. Eldridge - Evolution and Ecology Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, NSW 2052, Australia; d.eldridge@unsw.edu.au
Santiago Soliveres - Departamento de Biología y Geología, Escuela Superior de Ciencias Experimentales y Tecnología, Universidad Rey Juan Carlos, c/ Tulipán s/n, 28933 Móstoles, Spain
Matthew A. Bowker - Northern Arizona University, 2255 N. Gemini Drive, Flagstaff, AZ 86001, USA

The encroachment of woody plants into open woodlands and savannahs has been widely reported over the past few decades. We examined the relative effects of changes in shrub cover and grazing rates on ecosystem functions at semi-arid sites in eastern Australia, varying in shrub cover and grazing. Our aim was to test the notion that encroachment effects on measures of function are more strongly related to grazing than to increases in shrub cover. On loams, grazing generally dampened the positive effects of increasing shrub cover on most response variables and our three measures of ecosystem function related to water infiltration, nutrient cycling and surface stability. On sandy soils, however, while there were generally stronger effects of grazing, most attributes did not change in response to increases in shrub cover. Structural equation modeling indicated generally strong positive effects of increasing shrub cover, and generally negative, or neutral, effects of grazing on soil carbon and three measures of ecosystem function. The system-based approach provides a basis for improving our understanding and management of shrublands for oft-competing goals of functional habitat, maintenance of soil processes, and pastoral productivity.

Grazing in the planted forests of Israel: requirements and reality

David Evlagon, JNF/KKL, Department Forest Department - Central Region, Israel; davide@kkk.org.il

The understory of the planted forests of Israel has multiple values: It increases the biological and landscape diversity of the forest; it adds amenity value for recreation and nature appreciation; it serves to prevent soil degradation; and it provides forage and browse for both domestic and wild grazing animals. From the point of view of forest managers, a central function of grazing is to reduce the amount of inflammable biomass in a fire-prone environment. Till recently, the number of animals needed to utilize the available forage in the forest was not determined objectively and allocation of permits for forest grazing was based rough estimates of carrying capacity. The botanical composition of the understory vegetation includes both herbaceous and woody species, each with their respective

values for different classes of livestock. The grazing value of the woody component was especially difficult to estimate and was usually ignored. Browsing animals, especially goats were not encouraged to graze the forests. As a result, the undisturbed increase of dwarf shrubs and shrubs created an increasing fuel store. An analysis of the forest inventory data that are routinely recorded by the local forest service was conducted to determine an objective estimate of the carrying capacity of the understory vegetation for both grazing animals (sheep and cattle) and browsing animals (goats). This analysis was the basis of a survey that was applied to the forests of the central region in Israel provided an estimate of the number of sheep, cattle or goats that could be maintained in the forests under the grazing conditions imposed by the forest authority. It showed that the number of animals needed to control the understory vegetation was considerably greater than the numbers that actually were permitted to graze the forests. In particular, the important role of goats in managing the understory vegetation was given a quantitative dimension. The results of the survey have given rise to suggestions for more efficient use of the available goat herds by concentrating goat grazing in critical fire breaks. Means for encouraging the increase of goat herds have been defined and some of the suggestions are already being applied. The survey should provide an objective basis for more efficient management of multi- species grazing in the forest.

Range, Range Management and Desertification in Argentine

Israel Feldman; Ministerio de la Produccion, Santa Fe, Argentina; Rosario, Argentina; ifeldman@express.com.ar

Animal husbandry is an important economic activity in Argentina, as there are 50,000,000 cattle, 22,000,000 sheep, 4,000,000 goats, 1,500,000 horses, and around 800,000 camelids. High levels - 85% of cattle and horses and 100% of the other species mentioned, live on rangelands. Argentina has a marked slope from the Andes Mountains in the West to sea level in the East. The country owes varied ecological conditions, which in turn determine the existence of different vegetation types. The climate is highly varied: from 200 mm annual rainfall to 2,000 mm. The Patagonia region, in the South of the country, has a cold and windy climate. In the central area, the climate is temperate and no snowfalls occur in the winter, even though temperatures often fall below 0° C. The North West has a semiarid climate with extreme summer temperatures, up to 48°C. In the North-East, the climate is humid subtropical. Rangelands are spread all over the country under different ecological conditions. Most of the huge Pampa prairies were ploughed for agriculture. The Puna highland prairies, the Patagonian, and the Chaco region steppes face severe desertification problems due to range mismanagement, with sheep in the first two areas and with cattle in the last one. In some areas of the Chaco region, as well as parts of the central areas of the country, brush invasions are a consequence of range mismanagement. Long distances to watering areas paired and large paddock size are among the most important factors causing trampling and overgrazing. This creates a positive feedback with a continuous increase in deteriorated areas. During the last 50 years many efforts have been done in order to determine the causes of range deterioration and the subsequent desertification. Lowering stocking rate, and in some areas (especially where brush invasion is an important problem), different brush control methods, smaller range paddocks, and adequate distribution of water supply, are among the recommended measures. Range deterioration can be stopped and in some cases it can even be reversed.

Carbon sequestration in agricultural soils: Case studies from the Mediterranean area

Roggero Pier Paolo^{1,2}, Cocco S³, Corti G³, Lai R¹, Ledda L^{1,2}, Madrau S^{1,2}, Orsini R³, Seddaiu G^{1,2}, Toderi M³

¹ Desertification Research Centre, University of Sassari, viale Italia 39, 07100 Sassari, Italy nrd@uniss.it

² Dipartimento di Agraria, University of Sassari, viale Italia 39, 07100 Sassari, Italy, pproggero@uniss.it

³ Dipartimento 3A, Polytechnic University of Marche, via Breccie Bianche, 60131 Ancona, Italy. g.corti@univpm.it

Agricultural soils of drylands are considered to be a possible source or sink of atmospheric CO₂. The soil organic C (OC) stock of drylands, other things being equal, is around half of that of the soils from moist environments, since sequestration is constrained by water-limited inputs of OC from crop residues, the cost of balancing nutrients to achieve higher C inputs from crop residuals, and the faster OC turnover. However, dry croplands are often C-depleted because of mismanagement, hence can be a potential sink for atmospheric CO₂ through conservative cropping systems. The Mediterranean area includes a wide range of agroecosystems and climatic regimes characterized by hot dry summers and mild wet winters. In this paper we propose a synthesis of the research findings of three research teams along a climatic gradient in the Mediterranean basin and a variety of crop

management conditions. In the hills of central Italy, with silty clay to silt loam soils, we assessed the long term impact of no-tillage management and fertilization on soil OC sequestration produced by a rainfed wheat-maize cropping system, where maize production is heavily constrained by summer drought. In a dairy district located in a reclaimed wetland of Sardinia characterized by sandy loam to loamy sand soils and a long term very intensive irrigated cropping system, we assessed C sink and soil respiration seasonal dynamics under different fertilization management systems. In a dryland agro-silvo-pastoral system of Sardinia, the soil OC sequestration was assessed along a gradient of management intensity under the same sandy loam soil type and climate: cork-oak forest, wooded grasslands, grass covered or tilled vineyards and abandoned land. The most arid sites were located in Tunisia: one oasis and two pre-deserts. In these sites we contrasted natural and cultivated soils with sand to loamy sand texture. In the oasis we compared soils under natural vegetation made of canes with soils under henna cultivation; in the pre-desert of Matmata we considered bush soils and soils under orchard/vegetable garden with drip irrigation; while in the pre-desert of Menzel Habib the soils were under bush and olive tree cultivation occasionally irrigated. All soils were sampled by horizons till the depth of about 1 m to quantify, among others, organic C, texture, pH and bulk density. The underlying hypothesis is that the comparative analysis provides evidences for OC sequestration potential of Mediterranean agricultural areas under a range of climatic, soil and agricultural management contexts.

The potential use of biochar in restoring degraded rangelands

Ilan Stavi; Dead Sea & Arava Science Center; Ketura, Israel; istavi@yahoo.com

Extensive rangelands around the world are degraded. Depletion of the soil's organic carbon stocks is a main indicator of degradation processes. The organic carbon is important for supporting the soil's quality and fertility. Biochar, the by-product of the pyrolysis process that produces bio-energy, has proven to improve soil quality and productive capacity. At the same time, the inert nature of the biochar enables the sequestration of carbon in soil over the long term. Yet, to date, the application of biochar has been examined almost exclusively in arable lands, not in rangelands. Also, despite being potentially promising, the widespread implementation of this practice may face some impediments. One example is the low availability of biomass that could be used as feedstock for biochar production. This is because extensive rangelands are located in either dry regions or degraded lands where such biomass is scarce. In the event of invasive vegetation covering rangelands, it may be harvested or uprooted, and then pyrolyzed. However, the major challenges involved with this practice stem from its high financial cost, as well as from the environmental damage associated with heavy-machinery operations. This damage includes shearing and compaction of ground surface, degradation of the soil's physical quality, and increased soil erodibility. Another obstacle to biochar application in rangelands as compared to that in croplands, is associated with management practices used to mix the biochar into the soil. While in croplands this is accomplished through regular inversion tillage practices, the use of such methods in rangelands may be destructive, increasing the magnitude of erosional processes. With regard to the soil's biological activity, it is important to consider the alkaline nature of the biochar, which alters the soil pH. This feature may be advantageous in highly-weathered soils, where biochar may neutralize their acidity. However, under the alkaline conditions that are prevalent in drylands, this characteristic of biochar may hamper the microbial activity of the soil. Therefore, raising awareness of this management practice is crucial in order to encourage research and development in this field. Progress in knowledge and understanding on this topic could contribute considerably to the restoration of degraded rangelands. At the same time, it would potentially boost their capacity for carbon sequestration over the long term to a rate of between 0.69 and 10.7 Pg. Large-scale implementation of this practice should be based on payments for improvement in ecosystem services.

Greywater Utilization in the Drylands

Grey water utilization is as old as modern plumbing, but recognition of its value has grown in recent years, especially in dryland regions. As water scarcity became more acute throughout the world, water prices rose, quotas dropped and households and buildings began to seek greater hydrological self-sufficiency. Many countries, communities and households came to understand the potential environmental dividend that recycled household waters can provide depleted water budgets and began to promote policies accordingly. This sessions will describe practical developments in greywater technologies as well as different regulatory strategies for both encouraging greater utilization of this resource while assuring quality control and prevention of possible environmental risks.

Onsite greywater recycling and its potential future impact on desalination and wastewater reuse in Israel

Mike Adel¹ L. Shmueli², Y. Bas², E. Friedler³

¹ Consultant, Igal Alon 19, Zichron Ya'akov 30900, Israel; mikiadel@gmail.com

² EcoFinance-Consulting & Responsible Investments, 1 Ben Gurion Rd. (BSR 2 Tower) Bnei Brak, 51201 Israel; liorsh@ecologicalfinance.com

³ Faculty of Civil and Environmental Engineering, Technion, Haifa, Israel; eranf@tx.technion.ac.il

Greywater recycling produces a viable alternative for high value potable water exactly where it is needed – on location in high density urban settings where consumption growth rates are highest. In Israel, greywater recycling is broadly perceived by the general public to be of substantial benefit in alleviating water scarcity. However, a number of concerns regarding greywater recycling have been raised, including economic viability versus desalination and the impact on the availability of treated wastewater for agricultural reuse. In this talk, the authors will present the results of analysis, based on the use of standard greywater reuse models applied to the current Israeli Water Authority's long term plan. Quantitative projections on the impact of greywater recycling at the national level on both desalination and wastewater reuse will be presented versus the current water authority model. It will be shown that there are substantial economic, water and energy benefits at the national level if greywater reuse is widely adopted, with marginal impact on wastewater availability for agriculture.

Grey Water Reuse for Agricultural Purposes at Gore-Deir Alla in the Jordan Valley

Ayoub M. Ghrair¹, **Othman Almashaqbeh**¹ (Lead Presenter), and Sharon B. Megdal² (Corresponding Author and Co-Presenter)

¹Royal Scientific Society, Knowledge, Amman - al Jubaiha, Jordan

²The University of Arizona, Water Resources Research Center; 350 N. Campbell Ave. Tucson, Arizona 85719; United States; megdal.sharon@gmail.com or smegdal@cals.arizona.edu

Jordan is known to be one of the most water-scarce areas of the world. Practices designed to support agricultural activity are important to the sustainability of agriculture in the Jordan Valley, where cesspools are typically used to collect household wastewater. Installation of decentralized grey water treatment systems in small rural communities can contribute to a lower-cost and more reliable water supply. The presentation reports on a project of the Royal Scientific Society, located in Amman Jordan, that (1) investigates the technical feasibility of grey water systems through installation of a pilot system using locally available filtration materials, and (2) assesses attitudes about collection and reuse of grey water in rural communities in the Jordan Valley through a community survey. The project, established with support from USAID, is located in the farming community of Deir Alla, Jordan. In addition to presenting information on the system design and installation, results of a door-to-door survey, which was conducted by Royal Scientific Society interviewers, will be reported. The survey results provide information on household views on general water and wastewater issues, along with perspectives related to installing grey water systems and reusing grey water for irrigation. Survey results suggest that residents of rural communities find reuse

of treated grey water for irrigation acceptable. Interest was also expressed in learning more about grey water treatment and reuse. The presentation will also discuss opportunities for the use of a mobile grey water treatment system as a learning tool and the potential to expand the project to include additional sites.

Assessment of bacterial pathogens in greywater systems and irrigated soils

Maya Benami, Osnat Gillor, Amit Gross*

Department of Environmental Hydrology & Microbiology, Zuckerberg Institute for Water Research, J. Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer 84990, Israel;
mayabenami@gmail.com

*Corresponding author:

Zuckerberg Institute for Water Research (ZIWR), Blaustein Institutes for Desert Research (BIDR)
Ben Gurion University of the Negev, Sede Boqer Campus, Midreshet Ben Gurion 84990
Israel; amgross@bgu.ac.il

Recycling greywater (GW) has been recognized as a sustainable source of water. However, its reuse can carry possible environmental and health risks due to the possible presence of contaminants (e.g., surfactants and micropollutants) and pathogens. This concern often inhibits wide-spread usage and the legalization of GW, such as in the case of Israel where water is scarce. The use of quantitative culture-independent methods (qPCR) to detect GW pathogens has not been widely used and its comparison to culture-dependent methods (traditional plate counts using selective media) is lacking. Plate counts cannot detect all the bacteria in water samples. However, it can be applied to analyze the viable, active bacteria or the bacteria with some special features. The type of method or media may have an effect on the types and amounts of pathogens found in the treated GW and irrigated soils. The aims of this study were to elaborate on the abundance of pathogens in treated GW and irrigated soils, as well as to compare the results from qPCR and traditional plating methods.

qPCR and traditional plating methods were compared using percentage agreement (the amount of times both the qPCR and traditional plating overlapped in the presence or absence of the bacteria) to detect the types and amounts of pathogens present in the treated GW and irrigated soils. The fecal indicator *Escherichia coli* was similarly detected using both methods at 64% agreement for GW and 58% in the soil. The percentage agreement of *Pseudomonas aeruginosa* was 36% for GW and 53% agreement for the soils. *Staphylococcus aureus* percentage agreement between the two methods was lowest at 14% for GW and 26% in the soil. The metrics and matrices tested may have an effect on the detection of these indicator bacteria, as the soil data had a larger overlap (46%) between qPCR and traditional plate count results, than did the GW data (38%).

Indices, such as those used by the U.S. EPA for an infectious dosage of pathogens, use culture-based techniques to quantify cells. In the GW, we found a 1-3 log magnitude difference in cells detected by qPCR vs. traditional plating methods. We speculate that the qPCR quantified numbers could be used as a baseline to create an additional index for a pathogen infectious dosage based on molecular detection. We also suggest that more work is required to attempt an accurate quantification of viable pathogenic microorganisms or to correlate the current standard testing procedures with molecular pathogen detection.

Greywater reuse, scale, opportunities and impediments

Eran Friedler - Fac. Of Civ. & Env. Eng., The Grand Water Res. Inst. - Technion, IL Inst. of Technol.
eranf@tx.technion.ac.il

Due to population growth and increasing water scarcity, the pressure on existing water resources continues to grow all over the globe. One of the possible ways to alleviate this everlasting pressure is to develop alternative water sources. Decentralized greywater treatment and reuse can act as an alternative water source, reducing domestic water consumption and thus contributing to more sustainable use of water within urban areas. Greywater as an alternative source is especially important in arid and semi-arid regions, where it can sustain non-potable uses that otherwise would not be possible. Indeed in recent years, greywater reuse has gained attention, from both practitioners and researchers, with tens or hundreds of million units worldwide. However, GW contains various pollutants that potentially can pose a threat to the environment and to public health. Thus, its reuse should be carried out after proper treatment. In the talk, the water saving potential for different options of greywater reuse will be

assessed; the status of greywater reuse in various countries will be addressed; motivations and impediments will be discussed; and at the end of the talk, some case studies will be described.

Grey wastewater management in poor dry land

Monther Hind, PWEG , P.O.Box 3665, Ramallah, Palestine; monther@palweg.org

PWEG has successfully contributed to wastewater infrastructure improvement and food security in the Bedouin area, in the south east of Yatta in the Hebron Governorate in the West Bank, by implementing a one year grant project; this project is funded by Italian Cooperation. The project includes the construction of 20 Grey Wastewater Treatment Plants (GWWT) and 20 home gardens, 500 m² each; the project provides 3600 m³ per year of unconventional water that also has enabled the production of at least 12000 Kg of vegetables and fruits per year. The Al-Ka'abna Bedouins at An Najadah and Az Zuweidin, in south east Yatta, are considered to be some of the poorest Palestinian communities. They have a population of 1,300 inhabitants. These communities have extensive poor and marginalized populations and households with food insecurity and high unemployment rates. The results of the surveyed beneficiary households showed that the average family size was 9.8 people. 86 % of the labor force work in agriculture without any person employed full time, and 14% are employed in the Israeli market. The average monthly income of the surveyed families is 1775 NIS. Only 10% of their agricultural land is used for different agricultural activities, mainly because of the lack of water and investment ability.

Grey wastewater represents about 80% of the total water used at the household level. At least 60% of gray wastewater can be recovered, treated and reused. By doing this, at least 150,000 liters of fresh drinking water are annually saved per household.

Through the implementation of 20 GWWT and reuse schemes in agriculture at An Najadah and Az Zuweidin, a large amount of water is well managed, treated and reused in irrigating home gardens.

The general shortage of water in Palestine and the high gray wastewater production from households require a careful consideration of alternative solutions that can be locally applied, considering environmental elements, health issues and socio-economic situations. Septic tank up flow gravel filters, followed by aerobic filter systems, installed at An Najadah and Az Zuweidin households have proved to be a highly efficient decentralized wastewater management system, satisfying the community.

The main goal of this study is to assess and audit the impacts of gray wastewater systems on the environment, and on socio-economic factors at the household level. Within the framework of this study, 20 pilot gray wastewater treatment and reuse systems and households were investigated through a field survey by using a questionnaire and sampling and testing.

Informal Employment of Women in Rural Drylands

The main drawback in the approach of development agencies to the successful integration of rural women in economic development projects in developing countries is the lack of consideration of women's roles and women's unpaid work in the household and beyond. Similarly, development agencies' failure to recognize the unequal power relation between the genders in these countries and the unique informal contribution of rural women to development has added to the marginalization of women as a consequence of the top-down approach adopted by these agencies.

The current session aims to shed light on this neglected field that combines home, community and female employment. Although informal, i.e., not included in official statistics, this employment may certainly be defined as a form of economic participation/income that has an economic impact and that makes a contribution to the women, to the family household, and to changing women's gender roles in the family and community spheres. We aim to learn how to foster women's employment in these poor rural-arid regions through utilizing their traditional & feminine skills as well as to learn how to engender a local economy that maintains the environmental, social, and cultural and gender needs and roles of women.

Geographical indications, employment generation, and women empowerment – a Nigerian perspective

Adejoke Oyewunmi; Faculty of Law; University of Lagos; Lagos, Nigeria; adejoke21@yahoo.com, Asikia Ige; asikiaige@gmail.com
Oluwakemi Adekile; Faculty of Law, University of Lagos, Nigeria. kemiadekile@yahoo.com
 oadekile@unilag.edu.ng

Against the background of extreme poverty confronting rural dwellers, this research examines possibilities for employment generation and economic empowerment of rural women in Nigeria. The paper seeks to answer the following questions: What possibilities do geographical indications present for empowerment of rural women? What products primarily produced by women are amenable to the use of these legal tools? What challenges militate against the utilization of geographical indications to stimulate employment for women and what options exist to overcome these hurdles? The paper adopts a predominantly doctrinal research methodology, while also building on data from previous empirical research. The study finds that the establishment of niche markets with respect to certain products such as local beverages (in the Northern arid region), roasted cashew nuts (in the East) and tie and dye and local potteries (in the southwest), can be used to stimulate employment among rural women in Nigeria. For the most part, women operate informally in these sectors based on their geographical proximity to the raw materials, while also leveraging traditional knowledge and practices in the production of these items, which have been handed down from one generation to the other, mostly through the maternal lineage. These economic activities are particularly suitable for women because, for the most part, they are not capital intensive, and further afford women the opportunity to combine their economic activities with their family responsibilities. Key Words: Women, Employment, Empowerment, Geographical Indications, Nigeria Relevant Theme: Informal Employment of Women in Rural Arid Lands

Bustan's women empowerment program

Alon Shepon, Bustan; P.b. 842, Beer Sheva, Israel 841060; alon@bustan.org,

As the Bedouin population has been urbanized and sedentarized by Israeli government policies, they have shifted in status from producers to consumers. This has been particularly devastating for Bedouin women, whose traditional power and status in the community as producers of food has been undermined. This has resulted in high unemployment rates and an identity crisis.

Bustan's Women Empowerment project in Qasr A-Sir aims to concentrate efforts to re-integrate sustainable approaches into their daily life, and to elevate the economic power of the women of the village by means of business initiatives and confidence building. By working with a leading group of women on identifying available resources and traditional methods of exploiting them, the women are gradually utilizing these methods in their home and eventually initiating small businesses (e.g. a sewing cooperative, a catering business and an educational greenhouse).

Alon Shepon is an environmental scientist from the Weizmann Institute of Science and is currently working as Deputy Director of Bustan. As a longtime volunteer he initiated a tree planting project (Shatla) in Bedouin communities in the Negev under the framework of Bustan. He is also involved in sustainability research at the Weizmann Institute of Science.

Enabling Rural Women's Economic Empowerment in Arid Western Rajasthan in India

Judith D'Souza; Gender, Social Inclusion and Knowledge Management Officer; IFAD India Country Office, New Delhi, India, dsouzajudith@gmail.com

The presentation examines how poor rural women in Western Rajasthan, one of the poorest and most arid regions in India, have come together to set up small savings groups to not only have access to credit but also to value add to their traditional skills and develop linkages with markets through the International Fund for Agricultural Development (IFAD) assisted Mitigating Poverty in Western Rajasthan Project (MPOWER). Today the cumulative savings of the 4219 groups is about USD 508,925 after only three years of intervention. The paper traces how some 50,000 women have been able to obtain new avenues of income by building on their traditional skills and initiatives

through the intervention of the project. The paper highlights the utilization of these spaces for also furthering the agency of women and in addressing greater social issues, entitlements and local development.

International Arid Lands Consortium Program Retrospective

The International Arid Lands Consortium Program is a consortium of universities and agencies based at the University of Arizona. The IALC has supported research in deserts and drylands for over a decade with dozens of successful studies involving sustainable living, water management, forestry and agriculture in the drylands. The staff of the IALC will present examples from its research history and discuss its future research agenda and vision.

Speakers:

Charles Hutchinson, University of Arizona,
Stuart Marsh, University of Arizona
Sharon Megdal, University of Arizona

Long-term Observation of Dryland Ecosystems: Theory and Practice

Observation of change has been identified as a major goal by global change programs including GNDRI, DNI, ILTER and GEOSS. While a number of conceptual papers aiming towards a Dryland Observation System have been published already, there is still the need for methodological progress to come to an adequate and harmonized Observation System.

This symposium offers space for contributions leading towards a Dryland Observation System. Contributions may include conceptual papers discussing the scope for products and services needed by various user groups. It may also encompass talks on the definition of essential variables to be measured in order to describe and understand processes and mechanisms of change. It should further allow technical papers on methodological progress, e.g. linking earth observation based on remote sensing with ground truth. Finally, desert research institutes are invited to report on the results of monitoring programs established by their institute. All participants of this symposium are asked to point out how their contribution could possibly become a building block within a future Dryland Observation System.

Evolution of annual grasses under rapid climate change: differences in germination rates

Iris Aviezer; The Botanical Garden, Dept. of Molecular Biology and Ecology of Plants, Tel Aviv University, Ramat Aviv, Tel Aviv 69978, Israel; Eyeris.a@gmail.com

Models of future climate change predict a decrease in precipitation and lower water availability. In order to survive this climate change, plants may develop evolutionary adaptation. Adaptation can be expressed as a plastic response, which arises during the plant's development, or as an evolutionary-genetic response, which is driven by natural selection. These adaptations can be expressed in life history traits, such as germination rate and flowering time. Naturally occurring climate gradients provide an ecologically valid setting for studying the outcome of climate changes. Thus, the arid areas in Israel can serve as the prediction for the projected climate in the Mediterranean region. Studying plants along this climate gradient can provide predictions on the potential evolvability of plants to climate changes.

This study provides evidence for a rapid evolution of life-history traits as a result of rapid climate change. We tested germination rates of two annual grasses, *Brachypodium distachyon* and *Aegilops peregrina*. Seeds in the experiment were collected from two sites along the north-south climatic gradient in Israel, one in the Mediterranean region and one in the semi-arid region. In each site, we used seeds from control plots and from plots where 30% of the rain was prevented (drought plots). Seeds were collected in the fifth and the ninth year of the experiment, which correspond to five and nine generations of divergent selection, respectively. All seeds were planted in a common-garden plot in a fully-randomized array in the Botanical garden of Tel Aviv University. Germination rates and the fraction of germinating seeds were the highest in the seeds from the drought plot from the semi-arid site, suggesting a pre-adaptation for climate change. Germination rates and the fraction of germinating seeds were the lowest in the seeds from the control plots of the Mediterranean site. Similar germination rates were recorded for seeds from the control plots of the semi-arid site and from the drought plots in the Mediterranean site, suggesting that after as little as five generations, the plants from the reduced rain regime in the Mediterranean region evolved traits similar to the plants in the equivalent climate conditions in the semi-arid region. In the future we will search for adaptation in other traits and will use molecular tools in order to explore the mechanism of the change. Results of this research will provide a better understanding of the possible evolutionary trajectories of plants in the era of climate change.

Changes in population density of the desert isopod (*Hemilepistus reaumuri*) as an indicator of changes in the Negev rain regime

Yigal Granot; Midreshet Sde-Boker, Interdisciplinary Center, Ben-Gurion University of the Negev, Israel.
Yigalg.boker@gmail.com

The aim of this article is to show that there is a connection between three phenomena observed in the Negev highlands: 1) change in the perennial rain regime 2) a sharp decrease in the population size of the desert Isopod 3) changes in the population size of the desert Isopod may have an effect on the whole ecological system because it is a key species that acts against soil salinization. We attempt to promote the assumption that there is a relationship between the changes in the rainfall regime and the collapse of the Isopod population. Analysis of the rain regime shows that we can differentiate among three periods in the 38 years the Isopod populations were monitored. The first period (1973 – 1992) is characterized by a rainfall amount similar to the perennial average rainfall (101 mm per annum) and four droughts. The second period ('drought period' 1993 – 2000) is characterized by a decrease in the average rainfall amount (74 mm per annum) and five drought years. The third period (2001 – 2011) is characterized by average annual rainfall less than the perennial rainfall amount (85 mm) and three drought years. Isopod populations were monitored at two sites. On the rocky slopes of the Halukim Ridge, population size started to decrease from 1998 continuing to 2011. On the Sde-Zin loessial plain the population remained relatively stable during the same period - until 2011 when a sharp decline was observed. Research on the desert isopod has shown that they are critical in enhancing desalinization of the soil. Therefore if the population becomes extinct we can expect dire consequences to the ecosystem. From our research, we conclude that in order to understand the effects of changes in the rain regime on population densities, long term research must be carried out. We must also take into consideration periodical averages and extreme events of the annual rainfall amounts. We also learned that the effect of changes in the rain regime on deviations in population density depends on habitat traits. Therefore the research should be carried out on the same organism in different habitats. We show that in the case of the Desert Isopod the extreme changes in population size in the two habitats were influenced by the long term changes in rainfall regime.

Standardized observation of dryland biodiversity – experiences and proposals for a future Drylands Observation System (DOS) derived from the BIOTA AFRICA network experience.

Norbert Jurgens; Biodiversity, Evolution and Ecology of Plants, Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Ohnhorststr. 18, 22609. Hamburg, Germany; Norbert.Jurgens@t-online.de

Within the international, interdisciplinary biodiversity research project BIOTA AFRICA standardized biodiversity monitoring methods have been developed and tested in a range of arid ecosystems in Namibia, South Africa and Morocco over nearly a decade (2001-2010). Because of the project's emphasis on drylands ecosystems, some building blocks of the BIOTA approach may be suitable for a future Drylands Observation System (DOS). The

presentation will critically review the lessons learned by the BIOTA AFRICA project in general (based on Jürgens et al. 2012) and the potential for further improvements of the methodological approach for a DOS, specifically.

Involvement of para-ecologists in long-term observation of biodiversity in drylands

Ute Schmedel: Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Ohnhorststrasse 18, 22609 Hamburg, Germany; Ute.Schmedel@uni-hamburg.de

Long-term biodiversity observation in arid rangelands and conservation areas can provide valuable insight into environmental changes, which occur due to changing land use or climatic conditions. The scientifically sound evidence of environmental trends can help to identify even inconspicuous changes well in advance and can thus inform land management decisions that may lead to adaptation to these changes. However, this requires that land users have access to this knowledge without delay and information loss. Thus, the recent paradigm shift from applied research FOR land users to research together WITH land users also affects long-term observation approaches. Initiatives like local level monitoring projects, for instance, aim to provide long-term information on local farming resources that are critical for sustainable farm management. The employment and training of para-ecologists - i.e. members of local land user communities who have extensive knowledge of their natural and social environment, in scientific long-term observation initiatives - is another strategy to integrate the different knowledge systems. Para-ecologists (also called para-taxonomists or biodiversity facilitators) are communicating with the local and scientific communities, contributing to both scientific research and local development. The talk will present and discuss the benefits, but also the challenges of para-ecologist programs in long-term observation programs in arid areas. The talk will also introduce the recently launched internet-based para-ecologist platform (www.paraecologist.org) that aims to provide information on para-ecologists, para-ecologist initiatives and a broad range of helpful resources.

NGOs' Role in Promoting Sustainable Development in the African Drylands

For decades, nongovernmental organizations have served a particularly critical role in promoting sustainable development across Africa. Often, civil society is given responsibility for implementation of programs by international aid agencies that typically might be government responsibility. NGOs also have been pioneers in introducing new concepts, technologies and approaching to development issues among different African countries. In this special forum, four outstanding leaders from African NGOs will convene to share from their experiences in this field. Their perspectives on what has worked and hasn't worked and what approaches and priorities should African NGOs embrace in their future work will be the basis for a general discussion on this critical aspect of dryland development.

Speakers:

Priscilla Achakpa, Women Environmental Programme, Nigeria

Wanjira Mathai, Green Belt Movement, Kenya

David Mutekanga, Mbarara University, Uganda

Josephine Simon, Maasai Women Development Organization, Tanzania

Nomadic People in Desert Regions: Rethinking Citizenship in the 21st century from the Perspective of Marginalized Nomadic People

Different desert and semi-desert regions of the world have long been a stage for troubled relationships between centralized state powers and marginalized nomadic and post-nomadic populations. After more than a century of global democratization and despite an ideology of mass equal citizenship, nomadic people, now sedentarized in many nation-states, seem to be left out of the benefits of universal citizenship and are subjected to impoverishment, dispossession and violence. They face not only persistent effort to control their migration by state powers but also deterritorialization due to increasing urbanization, privatization, and neoliberal policies.

We open this panel for both theoretical and empirical explorations of the relationship between nomadic populations and centralized state powers in diverse societies and cultures in the 21st century. We are particularly interested in applying recent debates about the definition of citizenship in such settings.

Shifting sands -- lives and vulnerabilities of Banjaras, a nomadic tribe from the deserts of Rajasthan, India

Paras Ram Garasiya (Banjara); Mazdoor Kisan Shakti Sangathan and School for Democracy; 278, SFS Apartments, Hauz Khas, New Delhi, India; parasbanjara@gmail.com

One of the main nomadic communities found in the desert state of Rajasthan, western India, ‘Banjaras’ (better known as gypsies or roma in Europe) have richly contributed to the country’s and the state’s economy, culture and development over the decades. But paradoxically, they themselves have faced constant oppression and marginalization all along--whether under the British colonial rule, or the so-called post-independence era.

To start with, Banjaras were designated as ‘born criminals’ by the British under the Criminal Tribes Act 1871. The community was traditionally composed of travelers who moved from town to town selling cattle, salt and other goods. But that changed after draconian colonial laws came into being.

The salt trade was replaced by cattle, but that too ended when the Rajasthan government passed the Rajasthan Bovine Animal (Prohibition of Slaughter and Regulation of Temporary Migration or Export) Act in 1995, and it was misused against the Banjaras by Hindu fascist forces.

Dwindling livelihood options are only one side of the story. Although willing to give up their nomadic lifestyle, today the Banjaras are set apart, whether in villages or cities, and harassed by administrations. They lack official identity, housing, education and even the most basic facilities like water and health access.

To date, many Banjaras find difficulty in obtaining ration cards (primarily issued by the government to access subsidized grain but widely accepted as a proof of identity and residence in India) and voter identity cards, as they are seen as floating populations not easily accepted as permanent residents of a particular village.

An even more serious dimension of exclusion is their land and housing rights. Tagged as criminal-minded, they face discrimination from co-villagers and local administrations in obtaining pattas –a piece of paper which defines land ownership–despite being settled in the same place for decades. Large numbers of Banjaras in Rajasthan are constantly under the threat of eviction and displacement.

Compared to other vulnerable communities, the Banjaras of Rajasthan do not have any special constitutional and legal safeguards.

Recent talks of a special reservation status for Banjaras, along with three other communities, appear to hold little promise, as benefits tend to get usurped by the more powerful of the communities.

This paper seeks to examine the many facets of a growing alienation of the Banjara community over the years, the apathetic government response, and recent efforts of organization by the community and civil society groups to bring their issues onto the government radar.

Various local Banjara community organizations, along with well-known peoples’ groups under the banner of the Mazdoor Kisan Shakti Sangathan and School for Democracy, have been raising the above-mentioned issues through the means of public hearings, protests and continuing dialogues with the government.

The politics of claims: forms of mobilization for Arab-Bedouin rights and citizenship in Israel

Alexander Koensler; Department Man in Drylands, Blaustein Institutes, Sde Boker Campus, Midreshet Ben Gurion, Israel 84990; alexanderiht@yahoo.de

The question of how to advance justice for marginalized groups, including indigenous or nomadic peoples, leads to the heart of a polarized debate. We find a widely diffused 'right to culture' stance, on one hand, and a critical, constructivist stance, on the other. By taking up Isin's notion of 'acts of citizenship', this paper follows the way in which voices and imaginations about Bedouin and/or nomadic culture and rights are produced in the conflict over access to resources and land rights in the Negev Desert. Forms of protest include not only more traditional forms of political mobilization, but also silent practices of resistance, and carnivalesque, as well as spontaneous, forms of dissent. This case shows how those forms of mobilization that revitalize the 'right to culture' stance create often new and often virtual sites of contestation.

From mountain Turks to loyal Kurds: Analysis of the changing concept of citizenship in Turkey

Ceng Sagnic, Haviva Reikh; Ben-Gurion University of the Negev; 8/11, Beer Sheva, Israel, sagnic@post.bgu.ac.il

In the framework of modern Turkish nationalism, the concepts of homeland and citizenship are not merely unifying factors for the entire population, as they are thought of and codified in the Turkish law. As in many nationalist projects, the concept of homeland, alongside citizenship, was utilized by one ethnic group's elites to homogenize local populations, mostly by assimilating them into the Turkish ethnic identity. The process was called Turkification by many scholars, and the Kurds, who constitute more than 20% of the entire population, have become the major targets of the official Turkification policy.

But despite the common belief, the Turkification of the non-Turkish subjects of Turkey was based on achieving the adherence and attachment of Turkish citizens to the imagined Turkish nation vis-à-vis succeeding in modernization, secularization, and Westernization, and by everybody in the country adopting Turkish. Yet the struggle between the Turkish state and the Kurds in the 20th and 21st century shifted from being a struggle of two nationalisms competing over control of land and resources, and became a struggle over meaning. Many commentators suggested that Turkification also gave rise to a self-assimilation process of the Kurds, which is neither controlled nor administrated by the Turkish state anymore.

In this regard, both Turkification and self-assimilation give more importance to the Kurds' own conceptualization of their subjective identities and that of others in the study of citizenship and identities in Turkey. More to the point, the discourse that the Kurds of Turkey employ to make sense of their relations with their ethnic identity, as well as the indigenous Kurdish identity's representation in the greater picture of Turkey, is still dominated by the legacy of Turkification and the common belief in the supremacy of Turkishness. The dialogic formation of the perception of Kurdishness and knowledge about Kurdish identity in the wake of the establishment of modern Turkey, if examined, can be summarized as the Kurds' unseen dialogue with the official Turkish ideology throughout the 20th century. This study will attempt to analyze the Kurds' own relationship with their subjective identities in Turkey, the historical development of the official Turkish ideology and its treatment of the Kurds, self-assimilation, and the alienation of the Kurds from their own culture, space and language. The examination of the dialogic production of knowledge in Turkey's Kurdistan, both in the Turks' and Kurds' perceptions, will constitute the theoretical framework of the study.

Common use of natural resources, appropriation of territory and desertification: A case study with post-nomadic groups in Mendoza, Argentina

Laura M. Torres, Gabriela Pastor & Carla Accorinti; Instituto Argentino de Investigaciones de las Zonas Áridas (IADIZA) - Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICET), Argentina; ltorres@mendoza-conicet.gob.ar

This study is inserted in a wider analytical field, and is interested in examining the social reproduction processes of livestock producers, in the context of globalization processes. Within a system of social organization of space based on common use and ownership of land, the present study explores those social mechanisms that organize access to

resources, among those who are part of the “community”. Qualitatively constructed data are set forth, based on a case study located in the northwest of Mendoza (Argentina). The area is a vast arid plain, with 100 mm of mean annual rainfall, embedded in the Argentinean drylands (Roig et al 1991) and affected by desertification processes. Inside this territory, a sedentary pastoral subsistence economy is currently developed, focused on goat production. The present system is the result of a transformation of past nomadic practices. As result of the policies for disciplining labour and for establishing the population into the territory, the people became sedentary during the 19th and 20th centuries (Katzner 2009), without a concurrent parallel process of citizenship building. Due to an alleged concern for combating desertification, these producers are currently experiencing intervention. Overall, the policies implemented by the provincial State, some scientific agencies and non-governmental organizations seek to “modernize” these producers, contemptuously labelled as “traditional”. Motivated by interests of nature conservation or aiming to achieve better levels of territorial competitiveness, ongoing interventions suggest parcelling out the land to allow for its “proper management” and thus prevent a worsening of desertification. In a parallel manner, however, the producers are reluctant to adopt this type of solution, a situation that results in enhancement of the rhetoric that marks them as irrational. In contrast to these views, this study holds that the territory is internally organized, that diverse social mechanisms converge on this task, and that interventions, in the sense of parcelling out the land, might increase the producers’ vulnerability and put their social reproduction at risk.

Operationalizing the Zero Net Land Degradation Target

This session has three segments. The first "What is it all about", includes an introductory lecture, followed by two lectures addressing the scientific background of the issue. In the second segment "Operationalizing the ZNLD - insights from the ground", five speakers will share their experience in addressing land degradation, and use it for expressing their opinion on the ZNLD target. The third segment is a workshop during which a draft framework for actions taken to operationalize the ZNLD will be compiled.

Managing land degradation in a regional context: The case of the Great Limpopo Transfrontier Conservation Area

Paolo Caroli; Limpopo Transboundary Programme; 2nd Floor, 14 Loop Street, Cape Town 8001, South Africa; Paolo@limpopo-tp.net

With the establishment of the Great Limpopo Transfrontier Park, GLTP (35,000 km²) and the Great Limpopo Transfrontier Conservation Area, GLTFCA (100,000 km²) in 2012, the Governments of Mozambique, South Africa and Zimbabwe committed to joint management of a large African ecosystem shaped by a variety of land tenures and uses, with rich ecology and economic systems. This ecosystem is affected by an erratic climate, unpredictable weather, low average yearly rainfall and land degradation, which requires continuous adaptation of strategies. The peoples' traditional livelihoods are derived from dryland agriculture, forest products and wildlife, and livestock grazing. However, since the establishment of national parks and protected areas during the last 50 years, new opportunities have arisen through tourism economy that have taken off in this area.

Continued expansion of human activities and increased pressure on natural resources are endangering the ecosystem and hence the communities themselves, while droughts deplete what accumulates in "good years", such that the local economy is trapped in an erratic pattern of overexploitation and crisis. Furthermore, the problems are exacerbated at the regional scale due to the uneven exploitation of resources across borders, which often lead to conflicts. The major issue therefore is how to use the land without degrading it.

Since a country's resource use affects its neighbors, a regional approach balancing tradeoffs of different land uses across borders is required. The Limpopo Transboundary Programme contributes to a balanced resource use across the three countries and promotes sustainable livelihoods with a transboundary perspective in mind by integrating sectors, improving efficiency, and looking at management issues to reduce and minimize degradation and overexploitation on a larger scale. In this respect institutional roles and actions are paramount to achieve integrated and regionally balanced resource management. An enabling environment to sustain transboundary cooperation and management is vital to ensure that no country loses its environment at the expense of its neighbors. By integrating

the regional perspective with a holistic view of the problems, the Limpopo Transboundary Programme contributes to the management and decision making of institutions and communities to enhance sustainable use of resources and balancing different land uses. In this way, zero net land degradation can be achieved at the regional scale.

The new world atlas of desertification and its potential for addressing the ZNLD

Michael Cherlet; Via E. Fermi 2749 TP280, I-21038 Ispra (VA); michael.cherlet@jrc.ec.europa.eu

The RIO+20 Conference Parties decided “to strive to achieve a land degradation neutral world in the context of sustainable development.” This is a noble but maybe controversial target as it is not clear what and where land degradation is taking place globally. Also the notion ‘neutral’ is debatable as many interpretations are still open, restoration and/or improving versus degrading? However, at all scales, comparing or offsetting area percentages cannot be done straightforwardly as areas have different productive values and diverse land use options and economic trade-offs.

Land degradation neutrality is also not a static condition, implying that constant review and updating of the situation is required. To address this complex global challenge, decision makers and environmental managers have to be able to rely on a dynamic framework for monitoring and data integration.

The new World Atlas of Desertification (WAD) aims to provide exactly such a framework. The JRC coordinates this international activity compiling a new global reference on where desertification and land degradation happens. This endeavor is undertaken in partnership with the UN Environment Programme (UNEP) and in collaboration with a vast network of the best experts worldwide.

The WAD strives at being a pragmatic exercise and illustration of applying at global and regional levels the current scientific concepts of LDD assessments to provide up-to-date information on the state and trends of the degradation of the land, its causes and effects, to which routes for solutions, such as sustainable land management options, can be coupled.

To prepare the WAD, JRC has developed a scientific, transparent and repeatable methodology for global assessment and mapping of LDD. Based on satellite imagery series, various aspects of ecosystem dynamics are calculated and mapped. These are then integrated into a land productivity dynamics indicator, which is a base layer for combining further thematic and local information to identify and assess on-going land degradation.

The WAD assessment method will be operationalized to monitor changes in land productivity and land degradation that can be useful towards evaluation of land degradation neutrality. WAD will also be made available as a digital platform; hence interaction with stakeholders is expected to optimize repeated valuations at various scales contributing towards reaching the challenging goal for a land degradation neutral world.

From combating desertification in drylands to global land degradation neutrality – the Zero Net Land Degradation

Luc Gnacadja; United Nations Convention to Combat Desertification (UNCCD); Hermann-Ehlers-Str.10, 53113 Bonn, Germany; lgnacadja@unccd.int

Despite the implicit value of soils in sustaining vital ecosystem services and in supporting water, energy and food security, this non-renewable resource is increasingly threatened by land degradation and desertification worldwide. If, in the drylands, 12 million hectares of land are lost every year through desertification and drought alone, globally, the yearly loss of fertile soil amounts to 75 billion tons, affecting more than 1.5 billion people. These figures are expected to increase in response to population dynamics and the growing pressure from competing land uses for cropping, forestry, and pasture, as well as for energy production, infrastructure, and raw materials extraction.

At the recently concluded United Nations Conference on Sustainable Development, global leaders recognized the significance of sustainable land management (SLM) for the prevention of further degradation and the restoration of productive, resilient, and well-functioning ecosystems. Acknowledging the interdependence between SLM and livelihood well-being, they agreed to strive to achieve a land-degradation neutral world in the context of sustainable development. This agreement paved the way for a paradigm shift in land stewardship for sustainable development. Going land-degradation neutral means: avoiding the degradation of new areas, but where this is inevitable, to offset land degradation by restoring at least an equal area of land to that which is degraded, ideally in the same landscape,

in the same community, and in the same ecosystem. It means aligning policies and building accountability frameworks and mechanisms to deliver on SLM, especially on drylands ecosystem restoration. However, scientific and societal bottlenecks preclude a rational policy toward global land-degradation neutrality (LDN). A science-based approach is needed to develop and implement a sound monitoring and assessment system for detecting and quantifying land degradation and for tracking progress towards this goal at the local, national, regional and global level. Such an assessment should also aim at quantifying the costs, benefits and impacts of SLM on food security, water availability and climate change mitigation for better targeted investments. While some elements of such an analysis are available, particularly in terms of loss/gain of agricultural productivity, other human, economic and environmental aspects which are necessary to develop a ‘total economic value’ approach, that properly considers the ecosystem services provided by the land, remain elusive, ill-defined and data limited. Based on improved insights into ecosystem function, governments can promote more healthy land use / restoration strategies and policies and thus empower local farmers, herders and foresters to protect and restore their lands through improved access to technology and finance. Finally, at the intergovernmental level, an agreement on a new dedicated legal instrument would allow to focus efforts and empower the international community to act with the speed and scale required to address this crucial problem.

Restoring degraded lands and the flow of its provisioning services

Rattan Lal; Carbon Management and Sequestration Center, The Ohio State University; Columbus, OH, 43210 USA; lal.1@osu.edu

Land degradation - soil degradation, reduction in vegetation/forest cover and species diversity, decline in freshwater supply and its quality - leads to decline in provisioning services such as food and biomass production, water filtration and renewal, elemental cycling, carbon sequestration etc. Land degradation is driven by natural and anthropogenic perturbations and it leads to the decline in key properties and processes to below the threshold/critical limits (e.g., soil organic carbon content, nutrient reserves, elemental and hydrological imbalance). Estimates of land degradation indicate that 3.5 billion hectares (23.5% of earth’s land area) may be affected by some type and severity of degradation, the annual rate of which is estimated at 5 to 10 million hectares. The adverse impacts are exacerbated because of the increasing demand for the finite land resources for urbanization, biofuel plantations, recreation, aesthetic and cultural uses, and are also aggravated by climate change and the increase in frequency of extreme events. Economic loss of land degradation can be 1 to 10% of agricultural gross domestic product. Thus, it is essential to adopt strategies to reduce the rate of land degradation and increase that of restoration to achieve land degradation neutrality. The goal of Zero Net Land Degradation (ZNLN) can be effectively realized through restoration of degraded lands and ecosystems. The latter entails conversion of degraded lands to a restorative land use (e.g., afforestation and establishment of perennial vegetation cover), establishment of enclosures against open grazing, water harvesting and recycling, application of soil amendments, and strategies of creating positive nutrients and carbon budgets. Payments to land managers for provisioning of ecosystem services are an important strategy towards adoption of recommended land use and management practices. Furthermore, cooperation is needed among stakeholders including UNCCD, UNFCCC, UNCBD, MDGs and others. Because of the close interaction between land degradation and deforestation, there are already initiatives to achieve Zero Net Deforestation (ZND) by 2020. Achieving these targets of ZNLN and ZND necessitate development and implementation of standardized protocols for measurement, monitoring and verification (MMV) of land quality at different temporal and spatial scales on benchmark sites in global hot spots of land degradation (e.g., Sub-Saharan Africa). While technological options for land restoration may be known, political will and policy instruments are essential to achieving the ZNLN target by 2020. The costs of action are comparatively lower than those of no action, and the time to act is now.

Land Degradation from Ecosystems Management and Resilience Perspectives

Veronica Muthui; United Nations Development Programme, Regional Service Centre – Africa; 351 Schoeman St, P.O.Box 13196, The Tramshed, Pretoria, 0126, South Africa; veronica.muthui@undp.org

The importance of ecosystems and ecosystem services in sustaining biological productivity of the land and resilience has steadily gained recognition since the Millennium Ecosystem Assessment. Indeed resilience thinking has become influential in the management of many conservation areas, where the emphasis is shifting from preventing change and reducing the effects of environmental variability, to managing for heterogeneity and complexity, aiming to enhance the resilience of these ecosystems (Vetter 2009). This is set to gain even more momentum following the recent operationalization of IPBES (Inter-governmental Platform on Biodiversity and Ecosystems). This presentation will discuss land degradation in the context of ecosystem degradation and management, highlighting the differences between rehabilitation, restoration and reallocation (of land to alternative uses). It will also examine the ZNLD-relevant links between land degradation and loss of resilience, highlighting the role of adaptability in cropland, rangeland and woodland ecosystems.

Exploiting provision of land economic productivity without degrading its natural capital

Ephraim Nkonya; International Food Policy Research Institute; Washington DC; e.nkonya@cgiar.org

About 16% of the global terrestrial land area saw improvement while a quarter of the area experienced degradation between 1981-2006. Much of land improvement occurred on managed ecosystems – namely rangelands, forests and croplands. About 42% of the very poor and 32% of the moderately poor live on degraded lands and this contributes to poverty and hunger. The major reason for severe land degradation and its impact on poverty is the limited investment in land improvement in developing countries.

A number of strategies are required to achieve sustainable natural capital management and its accompanying socio-economic characteristics. Regions which have succeeded in prevention of land degradation and/or rehabilitation of degraded lands offer useful lessons. We highlight four major strategies, which empirical evidence has shown could effectively enhance sustainable natural capital management if they are simultaneously provided:

- (i) *Economic incentive for sustainable natural capital management*: A number of studies in developing countries have shown that when poor land users receive decent prices for their land-based products, they are likely to sustainably manage their lands. For example, the famous study in Kenya – “more people less erosion” – showed that farmers in Machakos in Kenya managed to invest in the prevention of soil erosion because they had better market access and received decent prices for their agricultural produce.
- (ii) *Strong national and local institutions & policies*: A recent study showed consistently that government effectiveness - government’s capacity to implement policies with independence from political pressures and with respect to the rule of law – positively affects land improvement. Additionally, policies and institutions favorable to land management lead to better land improvement and to prevention of land degradation. For example a *rural code* statute in Niger gave farmers tree tenure and this led to more widespread protection of trees.
- (iii) *Access to rural services*: Access to technical advisory services, market services and other rural services favors sustainable land management.
- (iv) *Payment for ecosystem services (PES)*: Since sustainable land management (SLM) can provide both local and global benefits, PES can help internalize the off-site benefits of SLM. However, PES has been working best in countries with efficient markets and less so in countries with poor markets.

Achieving ZNLD through people power

Tony Rinaudo; World Vision—Australia; 1 Vision Drive, East Burwood, Victoria, 3151 Australia;
tony.rinaudo@worldvision.com.au

Between 1984 and 2012, tree density on Nigerien farms increased from about four to 50 trees per hectare, largely in the absence of NGO or government support. The uptake appears to have spread from farmer to farmer, by word of mouth. Understanding and applying the dynamics and lessons learnt from this ‘people’s movement’ could make a significant contribution towards achieving the goal of Zero Net Land Degradation.

People’s actions have caused much of the world’s land degradation. To a large degree, it is people’s actions that are required to reverse it. Building on the Niger experience, the following seven steps are seen as key requirements for achieving Zero Net Land Degradation through creating a people’s movement for land restoration and for sustainable land use:

1. Identification, training and enabling of peer champions/ natural leaders.
2. Application of behaviour change communication approaches through multiple outlets, including radio and print media, peers, government services, religious leaders and theatre to reach all stakeholders (women, men, children, traders, sedentary and nomadic land users) in multiple ways, times and forms.
3. Creation of an enabling environment giving individuals and communities confidence to invest time and money into improving their land, knowing that they will benefit. Elements of this enabling environment include:
 - ease of access to markets
 - benefits (economic and other) from forestry/agroforestry are higher than from alternatives
 - farmer access to and understanding of a viable forestry production technology e.g. Farmer Managed Natural Regeneration (FMNR)
 - farmer access to sufficient areas of land and security of tenure or secure user rights to that land and/or to the trees, and
 - farmer confidence in being able to control risk, such as fire, pests and theft.
4. Build / build on social capital.
5. Exchange visits to successful sites and peer to peer training to open eyes and minds and stimulate action as individuals see firsthand how other communities are dealing with the same issues they face.
6. Regular, consistent follow up by responsive extension service providers who come along side community members, teach and encourage them.
7. Provision of basic health services including access to appropriate family planning services.

This approach can contribute to both the restoration of already degraded land, and to the sustainable maintenance of vulnerable land in a healthy and productive state.

Combating Aeolian Desertification in Northern China

Xian Xue; Key Laboratory of Desert and Desertification, Cold & Arid Regions Environmental & Engineering Research Institute; Chinese Academy of Sciences, 320 West Donggang Road, Lanzhou, 730000 China;
xianxue@lzb.ac.cn

Progress in combating and preventing aeolian desertification (land degradation resulting from wind erosion) has been achieved in an agro-pastoral ecotone of northern China since the mid-1980s. This lecture reviews three common measures used to combat and prevent aeolian desertification in such regions. The first measure is stabilization of dunes with straw checkerboards (SCM); the second measure is controlling wind erosion in farmland by planting wind-shelter forests (SFM) and the third measure is the protection of grassland using enclosures (EM). In addition we introduces a case study on the recovery of a degraded semi-arid ecosystem in order to provide regional lessons and support theoretical and practical approaches to desertification prevention and reversal on a global scale. Based on the analysis and evaluation of three kinds of typical measures and one regional scale case, it can be concluded that the rehabilitation of degraded land and the prevention of degradation in non-degraded land can be achieved as long as sustainable land-use policies and scientific methodologies are implemented. The selection, combination and implementation of measures and technologies to combat and prevent aeolian desertification depend largely on the regional ecosystem characteristics and the aeolian desertification pattern. That

is to say, only when measures taken to control aeolian desertified land work with nature, can the measures be effective and sustainable. In sum we think that human caused aeolian desertified land can be rehabilitated and non-degraded land can be protected from degradation. Although the technologies and management of combating aeolian desertification in an agro-pastoral ecotone of northern China still need further improvement through more experimentation and practical application in the future, the experience gained to date contains important lessons for the recovery of degraded land and the protection of non-degraded land on a global scale, and provides better support for achieving the "Rio+20" aspiration for global land degradation neutrality.

Evidence on the Ground of ZNLD: Case study of Community Development Centre, Aranayake, Sri Lanka

Dinali Jayasinghe and Prof. Ranjith Bandara; UN Development Programme (UNDP), Global Environment Facility (GEF), Small Grants Programme (SGP); 202-204, Buddhhaloka Mawatha, Colombo 7, Sri Lanka; dinali.jayasinghe@undp.org

Land degradation is considered an important issue that has to be addressed in the world today. Zero Net Land Degradation is a sustainable development goal proposed by the United Nations Convention to Combat Desertification (UNCCD) which advocates the prevention of the degradation of productive land and the restoration of land that is already degraded. In this endeavor the community plays a vital role in achieving this target by ensuring sustainable land management in the home garden. Community Development Centre, Aranayake located in the district of Kegalle in Sri Lanka is a community group whose main objective is to conserve indigenous varieties of tubers whilst using soil conservation methods in the home gardens. The UNDP/GEF/SGP funded this initiative of restoration and protection where an attempt was made to evaluate the impacts of soil conservation methods used by farmers in their home gardens and the usefulness of small grants in such initiatives.

The soil conservation methods the community has primarily used are the Sloping Agriculture Land Technology (SALT) method (60%), Lock and Spill Drains (56%), Vegetation Cover (33%) and Stone Hedges (30%). The responses of the beneficiaries are encouraging after the restoration of land using soil conservation methods, as eighty seven percent (87%) say that their income increased and ninety three percent (93%) say that the quality of soil has increased; More than eighty percent (80%) say that there has been a fifty percent (50%) or above increase in the harvest. Moreover it was observed that soil erosion has decreased by ninety percent (90%) and eighty two percent (82%) say that the land that could be cultivated in their home garden has increased.

Based on this study it can be concluded that there is a clear possibility of minimizing land degradation by providing small scale funding, goods, knowledge and services to small groups of farmers. However, the issue of land degradation has to be dealt with at a macro and micro level. From a macro point of view, each country has to have inclusive policy frameworks emphasizing the importance of minimizing land degradation, with supportive legislation. At the micro level it is evident that each individual farmer has a role to play in soil conservation as has been demonstrated in the study. The research reiterates the importance of the role of the individual farmer whose efforts not only brings personal benefits but also contributes to the larger efforts of conservation.

Is Zero Net Land Degradation in Dry Areas a Feasible Operational Goal?

Alan Grainger; School of Geography, University of Leeds; Leeds LS2 9JT, UK; a.grainger@leeds.ac.uk

A Zero Net Land Degradation (ZNLD) goal, which in dry areas would reduce the rate of desertification and increase the rate of restoration of desertified land, has been proposed as an intermediate step toward halting desertification completely. This paper evaluates the feasibility of this proposal, and suggests that while the goal could attract widespread political support among the Parties to the UN Convention to Combat Desertification (UNCCD) and be feasible at local scale, national implementation of a scheme with such a compound goal would encounter difficulties, owing to societal and environmental constraints and delays in refining national planning systems to encompass the complexity of land use and land cover change in dry areas. Monitoring restoration of desertified land by revegetation should be feasible immediately, but monitoring a reduction in rates of desertification would not, because no baseline rates are currently available and national and international scientific capacities to measure desertification are lacking. This paper therefore suggests introducing a ZNLD scheme in phases. Phase 1 would focus on restoring degraded lands, improving national land use planning systems, and expanding international and

national monitoring capacities - which would be used initially to identify baseline desertification rates. Phase 2 would then also reduce desertification rates with the support of fully integrated systems for land use planning and monitoring. Phase 3 would set a target year for realizing a ZNLD goal, based on experiences in Phases 1 and 2.

Project Wadi Attir

This session will focus on various aspects of Project Wadi Attir, an innovative project of a Bedouin community in the Negev for establishing a sustainable, desert, farming operation integrating social, environmental, technological and economic considerations. The project, a joint initiative of the Sustainability Laboratory, a US-based non-profit and the Hura Municipal Council, the governing body of a local Bedouin township, is designed to leverage Bedouin traditional values, aspirations, know-how and experience with sustainability principles, modern day science and cutting edge technologies. The project showcases a breakthrough model of sustainability practices in an arid environment, valid and replicable locally as well as in other regions around the world.

Speakers:

Dr. Michael Ben-Eli, the Sustainability Laboratory: *Sustainability principles in project Wadi Attir*

Dr. Mohammed Alnabari, Hura Municipal Council: *The Bedouin community and project Wadi Attir*

Dr. Stefan Leu: The Blaustein Institutes for Desert Research: *Soil enhancement and agro-forestry in project Wadi Attir*

Mariaam Abu Rakayek, founding member project Wadi Attir: *Reintroduction of indigenous vegetables to local communities.*

Prof. Amit Gross, The Blaustein Institutes for Desert Research: *Waste water and biogas in project Wadi Attir*

Prof. Isaac Meir, The Blaustein Institutes for Desert Research: *Green building design in project Wadi Attir*

Public Health and Life in Deserts and Drylands

Desertification and life in the desert and drylands are tightly connected to public health. In this theme we are looking especially for the integration of research at the interface between ecological and health sciences. We invite presentations regarding (1) climate change, desertification and life in the desert and health, including changing patterns of infectious diseases, (2) desertification, access to water and water quality, (3) access to energy in the desert and health, including air pollution (indoor and outdoor), and (4) access and barriers to medical services in the desert.

Serological and molecular survey of Leishmania parasites in apparently healthy dogs in the West Bank, Palestine

Amer Al-Jawabreh, LRU-Jericho, 3 Palestine St., Jericho, Jordan; islahjr@yahoo.com

Canine visceral leishmaniasis (CVL) is caused by *Leishmania infantum* in all Mediterranean countries. The *Leishmania* parasite is transmitted by the bite of a corresponding sand fly vector and is primarily maintained in nature by wild and domestic reservoirs, including dogs, foxes and jackals. Infected dogs are the primary reservoir host in endemic regions and pose the most significant risk to humans for infection. The present study aimed at assessing the prevalence of infection with *Leishmania* and identification of *Leishmania infantum* in domestic dogs in the West Bank, Palestine.

Methods: The infection rate among domestic dogs, collected from seven districts in the Palestinian West Bank, was investigated by examination of parasites in culture from the buffy coat using serological and molecular methods, based on ELISA, internal transcribed spacer 1 (ITS1) and cysteine protease (CPB) PCR.

Results: Out of 215 dogs examined for *Leishmania*, 36 (16.7%) tested positive in at least one method. Twenty-three

animals (11.5%) were positive for Leishmania DNA, whereas ELISA and culture revealed 16 (7.5%) and 4 (1.5%), respectively. CPB-PCR on one of three culture-positive isolates revealed *Leishmania infantum* as the causative agent for Leishmania infection in dogs.

Conclusions: Our study showed that canine leishmania infection is prevalent in varying degrees in all the seven studied districts in Palestine, despite the absence of human VL cases in four of these districts. The causative agent was confirmed to be *Leishmania infantum*.

Rio+20 and Global Environmental Justice: Environmental Ethics in the Age of Eco-Colonialism

Paul Brandt-Rauf, Dr.P.H., M.D., Sc.D. Dean of the School of Public Health, University of Illinois at Chicago, 1603 W. Taylor St., Chicago, USA; pwb1@uic.edu

The Rio+20 UN Conference on Sustainable Development aimed to find a more fair and robust approach to addressing global climate change. Global climate change is probably the prime example of global environmental injustice currently, but it can be viewed as only one symptom of a broader threat to global sustainable development, namely the inequitable distribution of all eco-system services around the world. Today the military and economic colonialism of the past has been largely replaced with eco-colonialism by which more developed nations use their accumulated technological and financial advantages to expand their ecological footprints at the expense of the less-developed nations. As a result, less-developed nations are being slowly “kicked out of the lifeboat,” their populations becoming endangered and facing extinction. The folly of this approach is not only that some of the current generation are threatened but also that all future generations may be threatened. For sustainable development to be achievable, a re-thinking of our distribution of ecological footprints inter-generationally and intra-generationally will be necessary, such that notions of progress and prosperity are no longer rooted in growth and consumption.

The Integration Nexus for Health Development: Recurring Option for the Nomadic Settings, Amref's Experience

Dawit Seyum Buda, Awoke Tasew and Florence Temu; AMREF, Shola Market, Addis Ababa, Ethiopia; dawitseyum@gmail.com

Drylands in Ethiopia are characterized by multiple deprivations, including social, economic, political and environmental. Delivery of social services, including health and water, to Ethiopia's 12-15 million pastoralists is recognized as a particular challenge by government and development partners. Pastoralist areas, characterized by mobility, conflict, food insecurity and drought, have historically been sidelined by development policies and programs. Processes have overlooked the lifestyle and culture of pastoralists, who remain out of reach of mainstream social services. Afar region is home to 1.4 million people, and is an extremely harsh environment, characterized by frequent drought. More than 90% of the population are nomadic pastoralists. The overall health status of the population is poor, with extremely high maternal and child mortality.

Method: A periodically classified program, regional government reports and findings of studies (2004-2011) from the region were systematically analyzed. Major findings and conclusions of the respective reports were validated, compared and contrasted to the general health outcome reported by the Ministry of Health and Demographic and Health Survey 2011.

Results: The period 2004 to 2007 was characterized by several vertical programs specifically addressing diseases, such as malaria, trachoma and other waterborne diseases. Cognizant of the drawbacks and informed by a new strategy in 2007, programs were introduced to address systematic ‘bottlenecks’. Furthermore, in 2008/9, comprehensive health and development programs, based on an integration model, were introduced. The approach attracted sectoral actors, including government, and strengthened complementary initiatives. Instead of disease focused programs, health system strengthening, community partnership and research for policy and practice became cornerstones. This introduced an integrated approach to address maternal, reproductive and child health, water and sanitation, capacity building (human resource development and infrastructure), and to address communicable diseases. Gender and lifestyle sensitivity significantly improved buy-in from communities. As a result, statistically significant improvements in the health outcomes of the nomadic population were seen.

Conclusion: Evidence indicates that in nomadic settings, improvement in health outcomes can be significantly improved through integrated programming which addresses demand, through partnerships with communities, and supply, through health system strengthening. Operations research informed policy and practice. We found that vertical demand-only or supply-only approaches cannot address the needs of communities in resource-scarce settings.

Recommendation: In a resource-poor setting, integration of health programs and leveraging vertical funding for health system strengthening should be strived for.

Health on the Move 2. Policies for health-promoting transport: A resource for public health and transport professionals

Dr Jennifer Mindell, Health and Social Surveys Research Group, Research Department of Epidemiology & Public Health, UCL (University College London), London, UK; j.mindell@ucl.ac.uk

Issue/problem: Transport affects health in both positive and negative ways. It provides access to many health-beneficial facilities (health centres, swimming pools), meetings with families and friends, work, and opportunities to buy healthy food. Walking and cycling offer excellent ways to build physical activity into everyday life. Transport also causes stress, disruption of communities, injuries, noise and air pollution, and greenhouse gas emissions. Transport's effects also exacerbate inequalities, with the benefits of motorised transport gained mostly by the better off, while the harmful effects fall particularly on the already disadvantaged. *Health on the Move*, first published 20 years ago by the Transport & Health Study Group (THSG), described the links between transport and health.

Results: THSG has fully updated and expanded this report for a second edition, based on a thorough review of evidence and addressing changing policy drivers. Sustainable transport policies must reduce the need to travel and promote a modal shift. Congestion can be tackled only by a combination of road pricing, comprehensive and universal public transport networks, more home-working, and more walking and cycling. Traffic in streets diminishes social support and community spirit, raising far-reaching spatial planning questions about how we perceive streets. Cycling is an inherently safe activity with major positive benefits for life expectancy, but exaggerated perceptions of its dangers lead to a poor take-up. Climate change demands less use of the car and plane and more use of the cycle and train. Encouraging walking and cycling can reduce obesity, improve health, and reduce adverse effects of car-based transport.

Lessons: Transport is a public health challenge comparable to sewers in the 19th and clean air in the 20th century in England in its difficulty, financial implications and consequences. Cross-disciplinary approaches, taking advantage of synergies between sustainability/low carbon approaches and health, are important.

Agro-Pastoralists' Preparedness for Climate Hazards Under Rapid Environmental and Institutional Changes in the Gobi Desert: Consequences for Food Security and Public Health Governance

Henri Rueff, Oxford University Centre for the Environment, South Parks Road, Oxford, United Kingdom; henri.rueff@geog.ox.ac.uk

The Gobi Desert, straddling Mongolia and northern China, supports 25 million inhabitants, mostly pastoralists and farmers. They face drought and extreme winters in the form of unusual snow, ice or freezing winds, affecting livestock access to forage (dzuds). Alone or coupled, drought and dzud can devastate communities. The worst natural disaster in the history of Mongolia was the drought-dzud of 1999-2001 with the loss of 30% of the national herd. Despite the scale of this event, climate extremes in the region received little scientific attention. Unraveling the complexities of combined drought and dzud in the Gobi is important not only for understanding the human and environmental implications in this part of Asia, but also for establishing the range and sensitivities of changes that the continent can experience. Gobi agro-pastoralists concurrently face drastic socio-economic and institutional changes, presenting new challenges and opportunities and affecting exposure and resilience to disasters. The Gobi region, and more so Mongolia, is one of the fastest growing economies, thanks to its large mining reserves. Both Mongolia and China have embraced the free-market ethos. Nevertheless, China and Mongolia today differ in that China remains largely technocratic and centralized. This paper will provide possible research directions to better understand climate hazard occurrences and agro-pastoralists' level of preparedness considering this contrasting institutional setting between Mongolia and China and recent socio-economic development. The perspective of food security and public health governance related to desert agriculture will be explored in this rapidly evolving context.

Exploring the potential contribution of woodlands to public health in Southern Africa

¹Stephen Syampungani and ²Paxie W. Chirwa

¹Copperbelt University, School of Natural Resources, Box 21692 Kitwe, Zambia

²University of Pretoria, Lynwood Road, Faculty of Natural and Agricultural Sciences, Pretoria, South Africa; syampungani@cbu.ac.zm

There is an extricable link between the forest resources and the livelihoods and health of the rural communities of Southern Africa. More than 80% of the rural population is poor and traditionally relies on forests for their livelihoods. Additionally, 80% of the rural communities depend on medicinal plants for most of their health needs and also income generation. The demand for herbal medicines has increased over the years due to the inadequacy of conventional medicinal facilities in the region. Weak health infrastructure and poverty continue to pose problems for the provision of health care services in Southern Africa. Herbal medicines have been observed to improve the quality of life for people with various ailments, including HIV/AIDS. Currently, up to 100 million consumers are said to be accessing herbal medicines dispensed by over 500,000 traditional healers. Medicinal plant species are readily available in the region. Even indigenous fruit trees are important sources of medicine for the both the rural and urban dwellers, with almost two-thirds of the rural households using indigenous fruit trees for medicines. Additionally, herbal medicines are a source of income for many communities. The market in raw materials for the medicinal or therapeutic plants and products of Southern Africa is readily available; between 35,000 and 70,000 tonnes are exported annually with a market value of US\$75-150 million, and between 50,000 to 100,000 tonnes are consumed locally per year. It can, therefore, be concluded that woodland resource use is important in the spread risk associated with the availability of food over critical periods of the season and conventional medicines, as indigenous fruits are also used for medicinal purposes. The paper, therefore, highlights the importance of woodland resources in supporting the health care systems of Southern African.

Rehabilitation of Desertified Areas Through Sustainable Afforestation and Forest Management – Solutions and Successes of Long Term

The session will present long term success case studies that deal with degradation problems. The case studies will demonstrate the experience and efforts of communities and organizations in proper rehabilitation and sustainable management of their natural resources.

In order to reverse or mitigate the effects of land degradation, land management practices will be presented which include: advanced forest management and afforestation, agroforestry, soil and water conservation and the human dimension.

Building the resilience of sand dune communities in the sahelian ecosystem through domestication of a wood production initiative and livelihood improvement strategies

Paul Adeogun¹ - ffadeogun@yahoo.com, Sotannde O. A¹., Usman, A¹., Garba S².

¹Department of Forestry and Wildlife, University of Maiduguri

²Department of Geography, University of Maiduguri

A pilot project was carried out in the Yunusari Local Government of Yobe State, Nigeria on 13°15'N, 11°48'E. The sahelian environment is highly susceptible to vagaries of weather and thereby vulnerable to the effects of climate change through drought and desertification. Often, the communities inhabiting this environment are largely dependent on the natural resources around them for their survival. Consequently, this dependence has resulted in unsustainable exploitation of the natural resources leading to scarcity and its attendant environmental degradation. Their ability to cope with the after effects of changing climatic conditions depends on strategic adaption mechanisms to the effects of drought, desertification, and land degradation and the availability of robust external support from government, NGOs and institutions. A participatory community approach has been identified as a

means of getting tangible results from efforts to ameliorate the global environmental effects of climate change. Hence, improving the livelihoods of the people may be done through (1) domestication of a wood production initiative (DWPI) for checking the spread of sand dunes, (2) stabilizing the soil for sustainable agricultural production, (3) development of fodder farming practices as an enterprise to earn additional income during the dry seasons when grazing grounds are bare of fodder for the large population of animals in this zone, and (4) relying less on felling trees for their energy needs through the densification of agricultural residues and biomass wastes, such as wheat offal, rice bran and groundnut shell using a cowdung mixture as a binding agent for briquette production with appropriate simple locally fabricated machines and tools. The role of women in environmental management of sand dune communities is highly significant. Women played an active role in raising the seedlings at home and nursing them, and they did the planting during the tree planting campaign. The community requires monitoring beyond the first few years of participation in order to maintain the communal focus of sustained domestication of wood production initiative (DWPI), sustained manufacture and marketing of briquettes for community consumption and fodder farming enterprise management. In a community of 300 households, if each produces 200 seedlings per year, that will translate into 60,000 trees in the environment which can be planted in their farm using available agroforestry techniques that will allow for the combination of crops and tree in a sustainable re-greening manner.

"Climate proof" plants: Combating aridity through improved agro-techniques

Mauro Centritto; Institute for Plant Protection, National Research Council, Florence, Italy; mauro.centritto@cnr.it
Giuseppe Scarascia-Mugnozza; Department of Agronomy, Forestry and Land Use, Agricultural Research Council of Italy, Rome, Italy

Dry-land functioning and resilience and, thus, the sustainability of drylands ecosystem services are disproportionately threatened by a number of converging trends, including land degradation, climate change and population growth. There is, therefore, an urgent need to improve, adapt and promote techniques that could mitigate the increasing impact of aridity and lead to an increase in productivity. Central elements in the overall strategy to increase dryland productivity include the valorization of superior germplasm/landrace (through a combination of high-throughput phenotyping for drought resistance and improved water optimization, genetic and molecular approaches) adapted to aridity conditions and the adoption of sustainable management of scarce water resources and of water harvesting and conservation agro-technology systems. A key issue in combating land degradation in arid areas is to recover "climate proof" plants (i.e., climate-resilient plants that have evolved historically in the harsh environments of the dry regions) that make improved use of areas affected by erratic rainfalls, drought and other associated stresses. The characterization of "climate proof" plants with high agro-ecological values has enormous relevance to mitigate the effect of drought and, consequently, to halt desertification and land degradation. Studies have been carried out in Morocco on the characterization of the indigenous germplasm of *Argania spinosa*. This research is within on-going project activities started in 2011. Similar projects, also involving training and capacity-building activities in sustainable agricultural water management, have been started in 2012 in Pakistan and Tunisia. *A. spinosa* is an endemic tree of south-western Morocco where it is adapted to grow in harsh environments (extreme drought and poor soil, i.e., in a region where rainfall hardly exceeds 200 - 300 mm/year, and at times stays well below 120 mm/year). *A. spinosa* is of great economic interest and plays vital roles in protecting the environment by slowing down desertification. *A. spinosa* is physiologically, genetically and molecularly very poorly known. We explored the variability in photosynthesis traits, in water-use efficiency and in polymorphic SSR markers among eight provenances of *A. spinosa* growing along aridity gradients to provide information on the capability of adaptation to climate change of this key species. Although we found that the Agadir population showed the higher values of genetic diversity, in general, the genetic divergence among provenances had low results. This low level of genetic divergence among the populations analysed can be the result of the small geographic distance between them and human influence on the cultivation of the species. Furthermore, the ecophysiological data and, in particular, water-use efficiency show that the degree of variability within the same provenance is higher than that across the different populations. These results clearly indicate diversity within the studied populations and, consequently, imply a wide genetic potential of *A. spinosa* to adapt to climate change.

Landscape approaches to climate change: The place of agroforestry, afforestation and reforestation in drylands

Peter A Minang; Global Coordinator, ASB Partnership for the Tropical Forest Margins, World Agroforestry Centre, UN Avenue, P O Box 30667-00100 GPO, Nairobi, Kenya; a.minang@cgiar.org

Global climate policy has so far segregated mitigation and adaptation as distinct issues, and followed separate approaches for agriculture and forestry, based on historical institutional divides. Yet, large parts of the landscape in developing countries exists in and a large proportion of the rural population live in dry, semi-arid, and arid regions where intermediary tree-based systems, such as agroforestry, woodlots and dry-forest margins and transitions to farm-based forestry, are critical. In these areas, land degradation, also called desertification, has been associated with poverty and traps or spirals of environmental degradation and loss of vegetation cover related to climate impacts (ecosystems, hydrological systems, etc.). Evidence-based policy development can do well by starting from the reality of rural livelihoods and actual carbon stock dynamics in living landscapes, and find ways to develop ‘high carbon stock development’ pathways. The paper will provide a number of case studies on how more integrated approaches can avoid the pitfalls of segregated policies at international, national and local levels.

Forests and agro-forestry restoration in arid zones using treated waste water: preliminary results from Italian projects in North Africa and the Middle East

Giuseppe Scarascia-Mugnozza and Giovanni Mughini; Agricultural Research Council of Italy-CRA, Rome, Italy; giuseppe.scarascia@entecra.it

Paolo DeAngelis; University of Tuscia, Viterbo, Italy

Mauro Centritto; CNR-IBAF, Rome, Italy

Alberto Del Lungo; FAO-Forestry Department, Rome, Italy

Forest cover is the main green infrastructure of North Africa and the Middle East and is mostly characterized by arid and semi-arid conditions, recurrent forest fires, excessive pressure by animal grazing, low soil fertility and low forest cover. Nevertheless, wood remains the main source of energy in the rural areas, and wood resources are overharvested and sought further away from settlements. On the other hand, planted forests could provide a wide range of wood, non-wood and fibre products, reduce the pressure on natural forests, and increase the production of quality wood. The integrated use of planted forests and agroforestry systems are effective tools to combat hunger and reduce poverty through the direct or indirect provision of services that help improve farmers’ livelihood and increase income. Desertification control and planted forest development are crucial in the countries of North Africa and the Middle East, since the natural woodland resources are inadequate to meet the increasing demand for forest products and services. In this region, future scenarios project an intensification of conflicts to gain access to scarce water resources (population, agriculture, industry), a depletion of fossil water in the mid to long term, and an increase in soil salinization and desertification caused by extensive use of fossil water. One opportunity to address these concerns is the use of municipal wastewater (both sewage and industrial effluent) to irrigate planted forests, greenbelts and amenity trees, where ecological conditions allow, at low risk to the water table and the environment in general. In collaboration with the Government of Italy, the FAO has been implementing, since June 2008, a program in selected Mediterranean and Central- South Asian Countries that aims to improve the contribution of planted forests in meeting sustainable livelihoods and land use. The FAO- Italy program is in line with the Millennium Development Goals aiming to “eradicate extreme poverty and hunger; ensure environmental sustainability;and implement a global partnership for development”. Explaining the objectives, methodology and preliminary results of this research and development program are the goals of this presentation.

Assessment of afforestation management systems by soil quality and primary productivity in a semi-arid area

Moshe Shachak¹; Tarin Paz-Kagan¹ - paztarin@gmail.com; Arnon Karnieli¹ - karnieli@bgu.ac.il; Eli Zaady²

¹ The Remote Sensing Laboratory and the Mitrani Department for Desert Ecology, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sde-Boker campus, Midreshet Ben-Gurion, 84990, Israel

² Department of Natural Resources and Agronomy, Agricultural Research Organization, Gilat Research Center, Mobile Post Negev 2, 85280, Israel

There are two prevailing methods of afforestation in the semi-arid areas of the northern Negev Desert, Israel: (1) Rain Fed Afforestation (RFA) where direct rainfall is the main water resource and planted trees replace the natural growing shrubs; and (2) Runoff Harvesting Afforestation (RHA) that spatially integrates natural and man-made systems in order to harvest runoff water from the natural system and concentrate it into water-enriched patches where trees are planted. The study aims were to compare between and within the two afforestation systems. The comparisons were: (1) within the managed and unmanaged sites in relation to natural shrubland; (2) between the planted areas; and (3) between the natural areas.

In order to carry out the comparisons, two key variables were selected -- soil quality and primary productivity of herbaceous vegetation. Overall soil quality cannot be measured directly. Therefore, a three-stage methodology was used, including indicator selection, indicator transformation, and integration of the soil transformed data into soil quality indices. In addition, we measured the primary productivity herbaceous vegetation as aboveground biomass. The results are as follows: (1) the comparisons within RFA and the adjacent shrubland show that the RFA system creates a new landscape mosaic. The consequences in terms of soil quality and productivity are reductions in both; (2) the comparisons within RHA and the contributing natural shrubland show that the RHA system creates an integrated landscape mosaic. The consequences, in terms of soil quality and productivity in the system, are improvements in both; (3) the comparisons between the natural adjacent and contributing shrubland in the crust patches showed reduction in aboveground biomass and improvement in the soil quality in the RFA, and the opposite trend in RHA. The differences in the crusted patches of the shrubland may derive from the changes in the rainfall gradient and development of the soil crust; and (4) the comparisons between the RFA and the RHA types exemplify transformed systems (RFA) and integrated systems (RHA) that differ in their connection to the shrubland area. The RFA system transforms the natural soil sink system into a sink system, while RHA preserves the source-sink system. It is concluded that an integrated system provides a higher bundle of ecosystem services and function. We suggest preserving the key principle of dryland ecosystems, which is redistribution of rainfall to runoff in order to create water-enriched patches.

Keywords: Rain Fed Afforestation; Runoff Harvesting Afforestation; Soil Quality; primary productivity; ecosystem services; and ecosystem function.

Balancing biodiversity and afforestation policies in the drylands: Evaluating the Israeli experience

Alon Tal, Blaustein Institutes for Desert Research, Ben Gurion University; Chair, KKL Committee for Land Development (Overseeing Israeli Forestry); alontal@bgu.ac.il

Given its location at the junction of three continents, Israel is recognized as a biodiversity hotspot, with 534 bird species, 115 mammal species, 103 reptile species and 2,780 types of flowering plants. The country has also embarked on an ambitious afforestation program throughout the country, including in semi-arid regions where rainfall often does not exceed 250 mm/year. Based on rainwater harvesting techniques, these stands are largely comprised primarily of conifers and eucalypts. There are voices among Israel's nature conservation community that criticize the new forests as damaging to local biodiversity. In particular, the Society for Protection of Nature in Israel, the country's largest environmental NGO, has expressed reservations. This presentation considers Israel's dryland forestry policy in light of this critique.

Among the main concerns of the ecological perspective are:

1. Forests are often planted in sensitive regions with nationalistic rather than environmental objectives and without adequate environmental impact statements prior to commencement of afforestation;

2. Forests in regions where trees are not natural disturb the natural balance endangering sensitive species' survival in Israel's Negev desert;
3. Foresters look at the progress of the trees as the sole indicator of forest health rather than the forest's total ecological resilience and diversity;
4. No clear criteria exist for establishing the degree of the degraded lands that need restoration and what soil restoration objectives should be for afforestation projects;
5. Biodiversity maximization needs to drive afforestation policy: "biodiversity is the source of ecosystem services – and not the opposite".

Research in a range of disciplines confirm that the new forests in Israel's drylands produce a variety of ecosystem services, including carbon sequestration, soil restoration and recreation. Recently published studies suggests that the overall number of flora species in the dryland Yatir forest (Israel's largest) is somewhat lower (79 plant species) than in the non-afforested surrounding lands (95 species). The total biomass of the undergrowth is also much poorer, with the quantity of shrubs and herbs on the forest floor a fraction of those growing on the nearby open spaces. Many of the indigenous plants have not yet been able to successfully establish themselves inside the forest. At the same time, when the seed banks of the two areas were compared, the gap drops to a trivial difference of 109 versus 100.

Yet, dryland forests can be designed to mitigate these problems. New forests contain diverse patches to reflect site-specific topographic and drainage properties: in the Lahav forest near Beer Sheva, for example, pines are planted on the hill tops, jujubes, Atlantic terebinth and other species on the slopes, and olive trees in the valleys. Researchers expected pine needle litter to reduce germination due to its allelopathic (chemical suppression) effects. In fact, parcels with pine needles had 25% more species than the uncovered areas (22 versus 18 species per sample). Rather than sunlight, competition for water and nutrients between herbs and trees probably causes the reduced number of shrubs and generally lower biomass of herbs on the forest floor relative to surrounding areas. This can be addressed through careful planning of forest structure. A recent study shows clear associations between species richness in the Yatir forest and topographic conditions and soil type. The steeper the incline of the land and the higher the carbon / nitrogen ratio, the greater the number of plant species in the understory – with stands ranging from 6 to 65 grassy species. Although no formal surveys have been conducted, considerable anecdotal evidence points to a diverse range of large mammals that have migrated to Israel's dryland forests, apparently due to the disappearance of Mediterranean habitats in the north. In general, results of most research suggest that careful planning of dryland forests can produce high biomass quantity while balancing biological diversity with other ecosystem services.

Remote Sensing: Tools and Implications in Drylands

Environmental problems of drylands, such as desertification processes, land degradation and rehabilitation, land cover and land use change, climatic change, droughts, early warning, and more, are characterized by both spatial and temporal dimensions. Therefore, remote sensing techniques, based on long-term monitoring and repetitive data, over vast expanses of unsettled regions, are applicative and powerful tools for research and implementation in these areas.

Remote sensing – Tools and implications: Case study South Sudan

Edmund Asare; Forest Sciences; University of Helsinki; Helsinki, Finland; gomes80@hotmail.com

One important driver of vegetation change and degradation in the Sudan is land use practice, particularly, clearance of forest and rangelands for mechanized rain-fed agriculture. The present study was undertaken generally for the purpose of assessing the changes in vegetation cover from 1984 to 2010 in a sample unit covering parts of Renk County in South Sudan. In this study, two sets of data were used: Firstly Normalised Difference Vegetation Index (NDVI) derived from satellite sources and secondly rainfall obtained from ground rainfall stations for South Sudan (1984–2010). Remotely sensed multispectral datasets were processed comprising Landsat Thematic Mapper (TM)

and Enhanced Thematic Mapper plus (ETM+). NDVI was used to analyze the remote sensing images to indicate the trend of vegetation cover changes over time and space, including peace and war periods. The research results from the remote sensing analysis suggest a significant change in the vegetation in the study location. The persistence and spatial coherence of drought conditions during the 1980s is well represented by the NDVI anomaly patterns and corresponds with the documented rainfall anomalies in South Sudan during the period from 1984 to 1991. The time series was dominated by low NDVI values. The results point to a decline in vegetation in the 80s. On the other hand, the findings also indicate a large area of Renk County that has been colonized by green vegetation: This positive NDVI occurring in 1994, 2002, 2005 and 2010 and the main cause of the increased vegetation expansion or probably the rate of woodland encroachment in grassland savanna zone can be attributed to a variety of factors such as: Availability of moisture (e.g. irrigation), changes in rainfall patterns and minimum or no human impact, particularly during the north-South war. Precipitation shows considerable positive correlation with NDVI values in South Sudan within each year. This study also provides an insight into the possible causes of vegetation loss in Renk County. The study demonstrates a strong relationship between rainfall and various vegetation indices could be used in monitoring the dynamics of vegetation cover change with remotely sensed multispectral datasets in the tropics. There could be extrapolation of the techniques developed in this research to examine forest-savanna vegetation changes in the tropics in order to identify other environmental and anthropogenic factors that cause the variations in NDVI.

Integration of satellite observations

Inbal Becker-Reshef; Geological Sciences; University of Maryland; College Park, United States;
ireshef@geog.umd.edu

Eric Vermote, Chris Justice Department of Geographical Sciences, University of Maryland

In recent years there has been a dramatic increase in the demand for timely, comprehensive global agricultural intelligence. The issue of food security has rapidly risen to the top of government agendas around the world as the recent lack of food access led to unprecedented food prices, hunger, poverty, and civil conflict. Timely information on global crop production is indispensable for combating the growing stress on the world's crop production, for stabilizing food prices, developing effective agricultural policies, and for coordinating responses to regional food shortages. The need for improving this information is internationally recognized and highlighted in several recent reports and action plans, in particular in the recent G20 Action Plan on Food Price Volatility and Agriculture. Satellite observations offer a practical means for generating such information as they provide global, timely, cost-effective, and synoptic information on crop condition and distribution. Their utility for crop production forecasting has long been recognized and demonstrated across a wide range of scales and geographic regions. Nevertheless it is widely acknowledged that satellite data could be better utilized within the operational monitoring systems and thus there is a critical need for research focused on developing practical robust methods for agricultural monitoring. Within this context this paper is focused on earth observations (EO) based methods for crop yield forecasting and on demonstrating the potential relevance for adopting EO-based crop forecasts for providing timely reliable agricultural intelligence.

Effects of precipitation, radiation and rock type on response of Pinus halepensis forests to drought stress: evaluation by means of remote sensing

Michael Dorman¹- michael.dorman@mail.huji.ac.il, Avi Perevolotsky² and Tal Svoray¹

¹ Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

² Department of Agronomy and Natural Resources, Agricultural Research Organization, Volcani Ctr, Bet Dagan 50250, Israel

Global climate change impacts, such as mass tree mortality in forest ecosystems, are being observed with increased frequency worldwide. One of the knowledge gaps in this scientific venture is the identification of the climatic and physical conditions that generate a significant change in forest state. On a large scale, decline due to drought stress is expected at the arid forest edge, since trees are closer to their physiological tolerance limit. Conversely, greater decline may occur at more humid locations, since density dependent factors, such as competition, may become more

significant under drought stress. In analogical manner, uncertainty exists regarding the pattern among different local habitats at a given site. The present study attempts to elucidate some of these questions.

Remote sensing is a suitable tool for monitoring vegetation performance on a large spatial scale, yet with high spatial and temporal resolution. Vegetation indices obtained by remote sensing contain physiologically meaningful information regarding forest state. The most commonly used index in ecological studies is the Normalized Difference Vegetation Index (NDVI). NDVI expresses the difference between reflectance of red and infra-red light by vegetation, which is in accordance with green biomass quantity.

In Israel, an apparent increase in the mortality rate of *Pinus halepensis*, the most common species in the planted forests, was recently observed. The purpose of this study was to examine the effects of annual precipitation amount, solar radiation amount and rock type on NDVI changes in the planted *P. halepensis* forests in Israel during the period 1992-2011, along a precipitation gradient of ~200-900 mm.

Annual precipitation in Israel has decreased during the last two decades; however the NDVI response to these changes was not spatially homogenous. Forests situated in the semi-arid regions were characterized by NDVI decrease, while forests at more humid regions were characterized by no significant NDVI change or NDVI increase. This has caused an increase in the range of observed NDVI values along the rainfall gradient, combined with a contrast increase between the northern and southern parts of the gradient. Forests located on hard rock had lower NDVI than forests located on soft rock, in accordance with previous studies. Radiation effect on NDVI was negative. A negative interaction between radiation and rainfall gradient effects was observed in dry years, indicating change in the importance of the radiation amount according to both the current climatic conditions and location along the climatic gradient.

Estimation of TOP Soil Organic Matter in Arid Lands using TM Multispectral Images

Zhihai Gao; Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, No. 1 Dong Xiao Fu, Haidian District, Beijing 100091, China, Email: zhihai_gao@163.com

Zengyuan LI; Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, No. 1 Dong Xiao Fu, Haidian District, Beijing 100091, China, Email: zengyuan.li@caf.ac.cn

Xiaosong LI; Institute of Remote Sensing Application, Chinese Academy of Sciences, No. 20 Datun Road, Chaoyang District, Beijing 100101, China, Email: lixs@irsa.ac.cn

Bengyu Wang; Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, No. 1 Dong Xiao Fu, Haidian District, Beijing 100091, China, Email: wangfy@caf.ac.cn

Lina Bai; Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, No. 1 Dong Xiao Fu, Haidian District, Beijing 100091, China, Email: bailn@caf.ac.cn

Soil Organic Matter (SOM) is a key soil property closely related to soil quality, and a critical indicator for assessment of land degradation in arid lands. Some studies may prove that SOM could be spectrally detected by hyperspectral sensors. However, nearly no attempts for prediction of SOM contents using multispectral data have been reported so far, due to lower spectral resolution of multispectral data. In this study, a new method for prediction of top layer SOM in arid lands using Landsat TM multispectral images was developed, by applying the Spectral Information Measure (SIM), to create an effective approach for estimating SOM contents in arid lands at regional scale.

The study was carried out at two selected study areas in the arid lands of northwest China - Gonghe in Qinghai Province and Minqin in Gansu Province. The Landsat TM images covering the study areas were acquired in winter on February 2007, when the surface soil was less sheltered from vegetation. Simultaneously, field sampling was investigated over two study areas. The modeled TM data (MTM) for comparison with actual TM data were produced by modeling the measured spectral data of soil samples. A key SIM-based variable—Normalized Spectral Signature (NSS) was defined, in which both information of an SOM sensitive band and all other bands were considered.

The study results revealed the correlations between NSS and measured SOM were greatly enhanced in comparison with the correlations between original reflectance (R) of bands and measured SOM. The higher correlations were observed at band 3, band 5 and band 7. The patterns of correlation change with bands were consistent for MTM and TM data, which reflected the objectivity and validity of SIM-based processing on TM data for estimation of SOM contents. Based on correlation analysis, the simple linear regression models using NSS derived from TM band 3, 5 and 7 for prediction of SOM contents were established respectively. The results of stand-alone validations showed

the RMSE observed in the model of band 3 was much smaller than the others, reflecting that band 3 of TM data is the optimal band for predicting land surface SOM contents using a SIM-based variable. This study provided a successful example for estimating SOM contents in sparse-vegetated arid lands using multispectral data taken in winter.

Degraded soils and the Great Barrier Reef: A desktop approach for mapping and modeling gullies over large areas

Uri Gilad; Department of Environment and Resource Management; Queensland Government; Dutton Park, Queensland, Australia; uri.gilad@qld.gov.au

Land degradation has a negative impact on the resilience and health of the Great Barrier Reef, Australia. Over-grazing and other land management practices in the contributing catchments lead to increased soil erosion, resulting in high sedimentation rates over the Reef. Recent work suggests that gully erosion is the main contributor of such sediments from the Burdekin - one of the largest Reef catchments. As part of the science program for the Great Barrier Reef Protection Plan, this study aimed to identify the location of gullies as well as the landscape characteristics associated with gully presence in the Burdekin. Data were collected by random sampling using high resolution imagery on Google Earth. Large areas were then removed after being identified as having low gully presence using a spatial-statistical analysis. The remaining areas were then manually mapped, assisting in the creation of a predictive model. A semi-quantitative gully presence map was also created by visually inspecting imagery at 25 km² grid cell resolution. Results showed a strong relationship between gully presence and low tree cover, proximity to drainage features and low slopes. The resulting predictive model has correctly allocated more than 90% of gullies within less than 20% of the Burdekin's extent. The manually derived mapping product comprises the most comprehensive gully data available for the Burdekin, while the high-resolution predictive model and the gully presence map will allow better targeting of gullied areas in later stages of this research. The information produced by this study improves our knowledge of the distribution of gullies throughout the Burdekin by quantifying the environmental features associated with gully presence. The methodology used here could be applied elsewhere to undertake cost-effective mapping and modeling of gullies or other erosional features over extensive areas. We demonstrate how Google Earth could be used as a reliable platform for mapping gullies and discuss the limitations of using remotely sensed data for gully mapping and modeling.

Long term monitoring of Queensland rangelands using remote sensing

Uri Gilad; Department of Environment and Resource Management; Queensland Government; Dutton Park, Queensland, Australia; uri.gilad@qld.gov.au

Australia's continental land mass is comprised of about 80% rangeland environments. These areas contribute to the environmental, agricultural and economic sustainability of the nation. The rangelands of Australia are subject to a range of land uses including agriculture, particularly grazing, mining, tourism and traditional land management. Land degradation due to climatic variability and land management in Australia's rangelands poses a significant threat to the long-term sustainability of these environments, with widespread implications for unique biodiversity, agriculture and traditional land management. Prolonged droughts, changing fire regimes and increased demand for food production apply ever-increasing pressure on Australia's fragile rangeland ecosystems. Over 80% of the state of Queensland in north-eastern Australia is rangeland environments. A range of legislation and government policies and initiatives apply to the management and use of these areas. It is imperative that accurate, long-term monitoring of landscape attributes be carried out to assess the condition of these areas. For over 20 years, the Queensland Remote Sensing Centre and collaborative partners has been developing systems and methods to map and monitor land cover in the rangelands using satellite imagery and airborne sensors. Programs conducted by the Centre include ground cover and woody vegetation monitoring using Landsat and other imagery, gully mapping and monitoring using a range of imagery and multi-date lidar, land use mapping, burnt area mapping, biomass mapping using radar, using remote sensing to support compliance investigations, and extensive field monitoring for validation and calibration. The range of products produced support rangeland monitoring and modeling and agricultural extension activities. This presentation will provide an overview of these programs and products and discuss how they are

being used to support monitoring and policy implementation for Queensland and Australia's rangeland environments.

Estimating outdoor water consumption in a coupled human-environment system using remote sensing

Shai Kaplan*, Soe Myint, Chao Fan; School of Geographical Sciences and Urban Planning; Arizona State University, Coor Hall, 975 S. Myrtle Ave., Fifth Floor; P.O. Box 875302, Tempe AZ 85287-5302, United States; *skaplan3@asu.edu

A high rate of urbanization in arid lands exerting additional pressure on outdoor water use in arid cities such as the Phoenix metropolitan area is a key to achieve sustainable development and ensure water security. Evapotranspiration (ET) can be used as a proxy for outdoor water consumption. Traditional methods for ET estimation are point based and data intensive. Remote sensing offers a feasible and reliable methodology for estimating ET at a regional scale coupled with the human environment system. The objectives of this research are to use remote sensing to quantify outdoor water consumption by different land use land cover types within the urban settings, and compare the spatio-temporal variation of water consumption between drought and wet years. A remote sensing energy balance model called S-ReSET (Simplified Remote Sensing of Evapotranspiration) was applied to Landsat time series images to estimate daily and seasonal ET for the Central Arizona Phoenix – Long Term Ecological Research (CAP-LTER) region. Model ET estimations were compared against parks' water use and showed good agreement, explaining 71% of the variance. This demonstrates that the S-ReSET model can be used effectively to estimate and map water consumption in a coupled human environment system. Results indicate that ET varies with land-use/land-cover types. Seasonally, active agriculture shows high ET (>500 mm) for both wet and dry conditions, while the desert and urban land cover experienced lower ET during drought (<300 mm). Within the urban settings, some areas show significant difference between the years, suggesting a more xeric landscape. Other areas retain their ET values (400-500mm) during drought, implying the considerable use of irrigation to sustain their green space. As urbanization continues to intensify, this may have significant implications for future development plans and the region's water security.

Characterization of urban growth and water demand in a desert city – Tucson, Arizona

Stuart Marsh; School of Natural Resources; University of Arizona; Tucson, Arizona, United States; smarsh@email.arizona.edu

Accelerating population growth in the U.S. Southwest coupled with an ever more limited water supply and anticipated increasing temperatures have fostered new interdisciplinary research. Our work has focused on the nature of this growth in and around Tucson, Arizona which is especially illustrative of issues related to growth and water. We created a multi-temporal (1984-2010) view of land cover change and analyzed growth in relation to climate variability and water consumption (gallons per capita per day - GPCD). We were able to establish correlations between these variables in relation to growth both in established urban neighborhoods and in ex-urban settings where large master-planned developments many miles from the urban center have been created. This analysis allowed us to evaluate whether consumption varied between these settings, the nature of urban growth, and ultimately allowed us to integrate these findings to help inform water management and policy within the context of this desert city.

Using two complementary long-term remote sensing datasets to globally assess dryland vegetation responses to multiple drivers

Tim McVicar¹, Niels Andela², Yi Y. Liu³, Albert I.J.M. van Dijk^{1,4}, Richard A.M. de Jeu²

¹ CSIRO Land and Water, GPO Box 1666, Canberra, 2601, ACT, Australia; Tim.McVicar@csiro.au

² Earth and Climate Cluster, Department of Earth Sciences, Faculty of Earth and Life Sciences, VU-University, Amsterdam, Netherlands

³ Water Research Centre, School of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia

⁴ Fenner School of Environment & Society, The Australian National University

Drylands, covering nearly 30% of the global land surface, are characterized by high climate variability and sensitivity to land management. Two satellite observed vegetation products are used to study long-term (1988-2008) vegetation changes of global drylands: (1) the widely used reflective-based Normalized Difference Vegetation Index (NDVI) and; (2) the recently developed microwave-based Vegetation Optical Depth (VOD). The NDVI is sensitive to the chlorophyll concentrations in the canopy and the canopy cover fraction, while the VOD is sensitive to vegetation water content of both leafy and woody components. Therefore it can be expected that using both products helps to better characterize vegetation dynamics, particularly over regions with mixed herbaceous and woody vegetation. Linear regression analysis was performed between antecedent precipitation and observed NDVI and VOD independently to distinguish the contribution of climatic and non-climatic drivers in vegetation variations. The changes in the persistent and recurrent vegetation signal components were further analyzed using both products. The contributions of fire, grazing, and atmospheric CO₂ concentrations to vegetation trends were assessed. Results suggest that NDVI is more sensitive to fluctuations in herbaceous vegetation, which primarily use shallow soil water. Whereas VOD is more sensitive to woody vegetation, which additionally can exploit deeper water stores. Globally, evidence is found for woody encroachment over drylands. In the arid drylands (with a ratio of precipitation to potential evapotranspiration, P/ETp<0.3; especially shrublands) woody encroachment seems to be at the expense of herbaceous vegetation and a global driver is inferred. Trends in semi-arid drylands (P/ETp 0.3-0.7) vary widely between regions, suggesting that local rather than global drivers caused most of the vegetation response. In savannas, besides precipitation, fire regime plays an important role in shaping trends. Our results demonstrate that NDVI and VOD provide complementary information, bringing new insights on global vegetation dynamics and how the relative contribution of key drivers varies across the world's drylands.

Characterizing drylands in the Ganga River Basin using geoinformatics and modeling techniques

Shafique Matin; IIT Kharagpur, India; shafiquematin@gmail.com

Desertification is a multifaceted process governed by several variables, which influence each other. It is thus not possible to draw a general picture from a single factor alone, and hence interdisciplinary research is needed. Dryland characterization needs an integrated approach to understand and model the pattern of change in the vegetation, landscape, surface hydrology, primary productivity, climate, anthropogenic disturbance etc., to spatially adjudicate the desertification trend leading to conservation prescription. In this study the changes in land cover have been analyzed via various factors, like (i) long-term natural changes in climatic conditions; (ii) geomorphologic and ecological processes (e.g., soil erosion and natural vegetation dynamics); (iii) human-induced alterations of vegetation and landscapes (e.g., deforestation and land degradation); (iv) inter-annual climatic variability (e.g., recurrent droughts and floods); and (v) human-induced climatic changes. These processes have different effects on ecosystems and human societies, occur at different rates and scales, and all are characterized by varying degrees of reversibility. The study was conducted at a test site of the Ganga river basin, India; a highly fertile and densely populated basin running along the Himalayan range of mountains. With the launch of the first remote sensing satellite in 1972 named ERTS, a new era of geomorphological change studies was also started. Here in this study we have used geoinformatics technology coupled with field and observation data. Major emphasis has been given to the different vegetation attributes in the region with its micro and macro climate. Land degradation has been understood through long-term studies as the linkage of vegetation shift, identification of flagship species, land use changes, shift in microclimate, and edaphic properties along with various climate variability. In-situ observations of plant species as indicators along with vegetation types mapped in the region have been linked together to understand the

microclimate. Radiation in the form of photosynthetic active radiation (PAR) and absorbed photosynthetic active radiation (aPAR) were used to estimate the light use efficiency (LUE) and the rate of photosynthesis, primary productivity and evapotranspiration. The study takes into account the multi-faceted nature of land degradation via a multi-approach process at different scales of time, space and methodology.

Land change and degradation along the US-Mexico border; the case of Ambos Nogales

Soe Myint, School of Geographical Sciences and Urban Planning, Arizona State University 975 S. Myrtle Ave. Tempe, AZ 85287, United States; soe.myint@asu.edu

The continued expansion of the paired US–Mexican border cities of Ambos Nogales presents many environmental management and urban planning challenges. This study focuses on a comparative study of spatial patterns and rates of land-use and land-cover change, in relation to land degradation, deforestation, and urban growth over different time periods. Based on historical data, the study suggests that both cities have experienced high land degradation; land on the Arizona side has been more stable and less degraded. However, the study found there were more severely degraded areas in Nogales, Arizona, than in Nogales, Sonora. The delineation of land use change and the severity of land degradation provides important information to planners about areas that should be targeted for development and other areas that require restoration to natural settings.

The impact of detailed land-cover classes on desert urban warming

Soe Myint, School of Geographical Sciences and Urban Planning, Arizona State University 975 S. Myrtle Ave. Tempe, AZ 85287, United States; soe.myint@asu.edu

Different land-use and land-cover characteristics can alter thermal energy in urban areas. In situ measurements of air and surface temperatures have traditionally been used to quantify surface energy balances that have an impact on urban warming or the heat island effect. However, these measures typically represent a local-scale analysis that covers small areas with a limited number of observations. Moreover, point measurements of air and surface temperature may not represent urban warming over a sizeable area when dealing with the interactive nature of different land covers within complex urban settings. We investigate the direct relation between detailed land-cover classes derived from Quickbird 2.4 m spatial resolution data and surface temperature (Celsius) generated from ASTER kinetic temperature data in a desert city (i.e., Phoenix, Arizona). We co-registered the land cover map and ASTER datasets to minimize the locational error. Spatial resolution of the original land-cover map was degraded to 90 m to match the spatial resolution of ASTER data after computing the mean of each land cover class within a local window of approximately 90 m. Results from this study revealed that there is a positive relation between tree fractions and nighttime temperature whereas grass fractions lower the nighttime temperature. However, tree fractions were found to be more effective in lowering daytime temperature than grass fractions. There was no relation observed between buildings and nighttime temperature. A very low relation between buildings and daytime temperature was found, but the relation was not statistically significant. In contrast, we found a strong relation between other paved materials and surface temperatures. Keywords: urban, Quickbird, ASTER, thermal

A long-term terrestrial data record for drought impact studies

Eric Vermote and Inbal Becker-Reshef; Department of Geographical Sciences; University of Maryland, College Park, MD, United States; ireshef@geog.umd.edu

The continuity of coarse resolution global data from the AVHRR and MODIS and VIIRS observations provides a unique basis for establishing a set of climate data records (CDR's) for the land community. As new findings from the observation record and innovative peer-reviewed methods emerge, they can be applied to establishing an improved long term data record. In this context, one of the objectives of this research is to extend, refine, and validate global land surface records at 0.05 deg spatial resolution, using a combination of mature and tested algorithms and the best available coarse resolution, polar orbiting satellite data from 1981 to present. This record uses the best available data, addressing the dynamic data continuity of the input observations, which will be

primarily from the AVHRR and MODIS with differing spatial resolutions 4km GAC (1981–present), 1km HRPT and LAC (1992–1998), 250m to 1km MODIS (2000–present) and VIIRS in the future. This new 30+ year data record is comprised of one fundamental climate data record (FCDR), the Surface Reflectance product and three Thematic CDR's (TCDR's) derived from the FCDR: the normalized difference vegetation index (NDVI), LAI/FAPAR. These products currently available for MODIS are used extensively for climate change research, as well as applications of societal benefit, and as a longer term data record spanning multiple instruments will be responsive as Essential Climate Variables (ECV's) identified by GCOS in support of the UNFCCC. The accuracy of the TCDR's is assessed through a rigorous validation program using published procedures and which in turn will provide feedback on the quality of the Surface Reflectance FCDR. We present several examples of the use of this terrestrial data record in the context of drought impact studies. We focus particularly on the impact of drought on agriculture by using a previously developed yield prediction model for wheat.

Restoring Water Resources: Practice, Research & Watershed Management Abstracts

Water is essential for our life and therefore the quality and quantity of our water resources is of upmost importance. This is true everywhere but especially in arid environments where water resources are scarce and vulnerable. In the frame of this topic we are interested in studies in which the quality and/or quantity of water resources is explored, especially in arid environments. Research of interest includes, but not limited to:

- water resources management tools and practices.
- surface water-groundwater interaction and water resources renewal.
- rehabilitation of dryland catchments.

Although studies in all scales are welcome, a special emphasize is given to large scale, watershed, studies.

Data scarcity vs. data greed: Strategic monitoring concepts to improve hydrological process understanding

Theresa Blume; GFZ German Research Centre for Geosciences Telegrafenberg; 14473 Potsdam, Germany; blume@gfz-postdam.de

Trying to understand what is going on in the world around us, we are all greedy for data: We want more of it, with higher spatial and higher temporal resolution, larger spatial extent, longer time series, more data points, larger sample sizes... All this data can help us in detecting patterns, or threshold processes or even trends as a result of global change. It might even allow us to parameterize a detailed physically based model that can then help us with all of the above. However, despite all this need for data we are faced with data scarcity on the one hand and many challenges when it comes to monitoring on the other hand: cost, time, accessibility and technical limitations. Another challenge is the fact that we often need time series, the longer the better, but if we start measuring now, it will take forever to get a solid data set which covers enough extreme events, enough seasons and years to allow us to understand system response in all its variability as well as its susceptibility to changing climate or land use conditions.

Possible ways of dealing with these challenges are strategic monitoring concepts combined with the use of proxies on the one hand and strategic monitoring of representative functional units on the other hand. Establishing links is essential in this task: for example, extracting the information of past water availability stored in tree rings and linking this with today's measurements: This would allow us to reconstruct past drivers, controls and processes extending our recent time scales to capture variability of past centuries. Linking landscape elements and their hydrological functioning: This would reduce minimum data need and still allow for process analysis and physically based modeling at larger scales. Linking sediment temperature patterns with ground water exfiltration rates makes it possible to investigate groundwater - surface water interactions at larger scales. Examples for hydrological research

projects using the above approaches will be presented from several case studies both from Europe and Southern Chile.

Diagnostic analysis of a distributed water balance model in the Mediterranean basin

Vito Iacobellis; DIAC, Via E. Orabona 4, Politecnico di Bari, Italy; v.iacobellis@poliba.it

In the Mediterranean environment, hydrological processes are largely variable both in time and space due to the high variability of rainfall regime, topography, soil and land use. In this context, distributed hydrologic models may provide a valid support in water management. They account for the spatial variability of the catchment characteristics by subdividing the territory in small portions often using a regular grid of cells. Today, while the potential of distributed models is undoubted, their superiority in terms of predictive performances with respect to lumped models is not fully recognized. Besides parameterization, a crucial issue is also represented by the quality of observed data used to provide input variables which strongly influences the level of accuracy of model results. The high number of parameters raises the problem of equifinality, and stresses the need for suitable performance metrics in selecting the proper model structure and evaluating “optimal” parameters. We believe that advances in model accuracy may be obtained by enhancing the role of physical information provided by remote sensing data and by investing more effort in scientific validation of hydrological models. With this aim, diagnostic techniques should be further exploited for selecting an appropriate model structure, input and parameterization. In this framework we analyze the performances of different performance metrics and evaluate their capacity for detecting the optimal set of input and parameters to be used for the simulation of river flow discharges with a semi-distributed hydrologic model applied in continuous simulations, at daily scale, in a semi-arid basin of Southern Italy.

Effects of climate change on water resource availability and ecosystems

Salvatore Manfreda; University of Basilicata, Potenza, Italy; salvatore.manfreda@unibas.it

Society is facing growing environmental problems that require new research efforts to understand the way ecosystems operate and survive and their mutual relationships with the hydrologic cycle. This is fundamental to advance predictive models used by researchers, industry, and environmental managers. In this frame, ecohydrology faces this task with the aim to provide improved forecasting and mitigation of flood and drought risk, better understanding of implications of land use changes on terrestrial ecosystems (such as deforestation or desertification), improved weather and climate predictions, better comprehension of climatic change effects on terrestrial ecosystems. The scope of the present research is to deepen our understanding of the mutual relationship between climate, vegetation and basin water budget within an ecohydrological framework. With this aim, a coupled hydrological/ecological model is adopted to describe simultaneously land vegetation evolution and hydrological water budget at the river basin scale. Analyses have been carried out over the Basilicata Region (in Southern Italy) that is an ideal test area located in the core of the Biodiversity Hotspot area of the Mediterranean basin and with a significant variety of climatic conditions ranging from humid to semi-arid and arid. The hydrological analysis was carried out by continuous simulation, taking into account any change in the spatial organization of vegetation caused by climate. Results describe the non-linear relationship between climatic forcing, vegetation patterns and water budget. It is interesting to underline that in the most vulnerable ecosystems a small change in climatic conditions may produce significant changes in vegetation patterns and water resources availability. This makes possible a quantitative assessment of the effects on soil water balance of future climatic scenarios and to identify the most vulnerable areas of the region under study.

The good groundwater governance project: Developing a framework for groundwater governance

Sharon Megdal¹ (Presenter and Corresponding Author), Alice Aureli², Frank van Weert³, Robert Varady¹

¹The University of Arizona, Water Resources Research Center; 350 N. Campbell Ave. Tucson, Arizona 85719 USA; megdal.sharon@gmail.com or smegdal@cals.arizona.edu

²UNESCO, Paris, France, ³IGRAC, Delft, The Netherlands

This presentation will discuss the ongoing Good Groundwater Governance (GGG) Project, funded by the Global Environmental Facility (GEF) in collaboration with FAO, UNESCO and others. (See www.groundwatergovernance.org.) Officially inaugurated in September 2011, the project has as its object to slow or reverse trends in groundwater depletion and degradation through improved governance, with a focus on human behaviors that impact groundwater quantity and quality. The three-year project is conducting multiple consultation sessions world-wide to learn about challenges and opportunities for improving groundwater governance, including identification of good groundwater governance practices. For purposes of the project, Groundwater Governance has been defined as “the process by which groundwater is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law. It is the art of coordinating administrative actions and decision making between and among different jurisdictional levels—one of which may be global.”

The presentation will share information gathered at the regional consultations conducted to date and plans for upcoming consultations. It will also discuss policy aspects of groundwater governance, as covered in one of the project’s 11 thematic papers, entitled “Groundwater Governance and Policy,” authored by Robert G. Varady, Frank van Weert, Sharon B. Megdal, Andrea Gerlak, Christine Abdalla Iskandar, and Lily House-Peters.

Water Management in Arizona and the Lower Colorado River Basin (USA): Good Practices and Long-term Challenges

Sharon Megdal, Moderator and Session Organizer; The University of Arizona, Water Resources Research Center, 350 N. Campbell Ave. Tucson, Arizona 85719, USA; megdal.sharon@gmail.com

Arizona, located in the southwestern United States, depends on the Colorado River for a significant amount of its water supplies. Groundwater and other surface supplies are also important water sources. About 70% of water withdrawals and diversions are for agricultural purposes. Mining is an important component of Arizona’s economy, as is tourism. In the face of growing population and water scarcity (average rainfall in the metropolitan regions ranges from 100 mm to 300 mm annually), Arizona has had to adopt a multi-faceted approach to water management. The Central Arizona Project, a large constructed open canal, transports Colorado River water uphill into Central Arizona. The energy used to pump the water is generated by a coal-fired plant. Depending on federal regulatory policy, the costs of meeting environmental regulations related to power generation may result in significantly higher water costs. Groundwater use is regulated, but only in certain parts of the state. Arizona shares an international border with Sonora, Mexico, and is home to several sovereign Indian Nations. Water management practices are developed and implemented in a complex environment, one that has many similarities to other water-scarce arid and semi-arid regions.

Water managers and professionals from Arizona will discuss both short-term and longer-term strategies to meet water demands of the municipal, industrial, agricultural and environmental sectors. The importance of water reuse, the role of water desalination, alternative conservation practices, water banking, and planning for uncertain climate conditions and surface water flows will be among the topics addressed. The session will employ a question and answer roundtable format so that the panelists can share experiences and lessons learned as well as engage in dialogue among themselves and with the audience.

Watershed Management: The role & challenges for drylands & deserts downstream – the case of the Nile Basin, a preliminary discussion paper

David Mutekanga (PhD); P. O. Box 25657, Kampala, Uganda; drmbaleke@yahoo.co.uk

This paper is a preliminary analysis of the roles and challenges faced in managing watersheds, the sources of the waters being used in drylands and deserts downstream, using the Nile Basin in Africa as an example. It aims at raising the role of managing watersheds which play a significant role in cross border drylands and deserts. The Nile Basin consists of the following countries: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, South Sudan, Tanzania and Uganda. Of these, Egypt, Sudan and South Sudan are mainly covered by drylands and deserts. They depend mainly on the Nile River for water. However, this river, which comes from Lake Victoria, depends on the watersheds of Rwanda for over 80% of its water.

This paper analyses the roles of watersheds in Rwanda as an important source of water for Lake Victoria and in turn the Nile River and in turn the drylands and deserts in Egypt, Sudan and South Sudan. Effective management of these watersheds, which are currently believed to number over 20 and which belong to the five sub-basins in Rwanda, is very significant in ensuring water availability in Lake Victoria hence the deserts and drylands north of Lake Victoria.

The paper also lists some of the emerging challenges which include the fact that this issue is taken lightly and its significance relatively downplayed. There is need at a global level to identify these cross border critical watersheds whose role in deserts and drylands is very significant. The difficulties in doing this are relatively well known but this is exactly why there is need to identify these watersheds and a global initiative taken to manage them well.

The way forward calls for a need to document effectively these critical watersheds and show their importance for drylands and deserts.

Water consumption of agriculture and natural ecosystems along rivers in central Asia

Niels Thevs; University of Greifswald, Institute of Botany and Landscape Ecology, 17487 Greifswald, Germany 17487 ;thevs@uni-greifswald.de

The man-made ecosystems, mainly cotton under irrigation, and the natural ecosystems in the arid lowlands of Central Asia depend on river water as their main water source. In an arid climate with annual precipitation of less than 100 mm, all agriculture depends on irrigation. Irrigation water is mainly diverted from the rivers, like the Tarim, Amu Darya, or Syr Darya. The natural ecosystems, i.e. riparian forests, grasslands, and shrub vegetation, depend on the groundwater for their water supply. The groundwater is recharged by the rivers. The sources of the rivers are melting water and precipitation in the mountain regions, e.g. in the Tianshan, Hindukush, and Pamir Mountains. Due to climate change and an increasing area under irrigation, the water runoff into the downstream parts of the river systems decreases and becomes more and more unreliable for water users. Against this background it is crucial to understand the water consumed by irrigated land and natural ecosystems along such rivers, in order to point out needs for environmental flows or potential for water saving. Along the Tarim and Amu Darya, evapotranspiration (ET) maps were made based on MODIS satellite images from 2009 and 2010 following the approach of Senay et al. (2007), which is based on the model of Bastiaanssen et al. (2005). The annual ET of cotton ranges from 700 mm to 1100 mm. At the middle and lower reaches of the Tarim River crop failure is frequent due to water shortage. The riparian forests have an annual ET of 350 mm to 700 mm. Natural stands of *Apocynum pictum* show an annual ET of 200 mm to 300 mm. *Apocynum pictum* is a natural plant along the Tarim River, which can be used for medicinal purposes or as a source of fibre. Under the conditions of water shortage along the downstream of the Tarim River natural plants like *Apocynum pictum* could provide water saving utilization options. References: Bastiaanssen, W. G. M.; Noordman, E. J. M.; Pelgrum, H.; Davids, G.; Thoreson, B. P.; Allen, R. G. (2005): SEBAL Model with remotely sensed data to improve water resources management under actual field conditions. *Journal of Irrigation and Drainage Engineering*, Jan./Feb.: 85-93. Senay, G. B.; Budde, M.; Verdin, J. P.; Melesse, A. M. (2007): A coupled remote sensing and simplified surface energy balance approach to estimate actual evapotranspiration from irrigated fields. *Sensors*, 7: 979-1000.

Woody plant encroachment paradox: Rivers rebound as degraded grasslands convert to woodlands

Bradford P. Wilcox and Yun Huang; Texas A&M University, Department of Ecosystem Science and Management; bwilcox@tamu.edu

The related phenomena of degradation and woody plant encroachment have transformed huge tracts of rangelands. Woody encroachment is assumed to reduce groundwater recharge and streamflow. We analyzed the long-term (85 years) trends of four major river basins in the Edwards Plateau region of Texas. This region, in which springs are abundant because of the karst geology, has undergone degradation and woody encroachment. We found that, contrary to widespread perceptions, streamflows have not been declining. The contribution of baseflow has doubled—even though woody cover has expanded and rainfall amounts have remained constant. We attribute this increase in springflow to a landscape recovery that has taken place concurrently with woody expansion—a recovery brought about by lower grazing pressure. Our results indicate that for drylands where the geology supports springs,

it is degradation and not woody encroachment that leads to regional-scale declines in groundwater recharge and streamflows.

Degradation and restoration of water resources at the Minqin Oasis in northwest China

Xian Xue, Cuihua Huang, Jie Liao; Key Laboratory of Desert and Desertification, Chinese Academy of Sciences; Cold and Arid Regions Environmental and Engineering Research Institute, CAS; 320 West Donggang Road, Lanzhou, China, 73000; xianxue@lzb.ac.cn

Minqin Oasis is located in the down reach of Shiyang River of northwest China (Gansu Province), and has a typical arid continental climate, characterized by low and irregular rainfall with mean annual amounts of less than 150 mm and strong evaporation with mean annual amounts of more than 2,500 mm.

Shiyang River is the main water resource for the locals' living and production. Due to the ever-increasing population and irrigated farmlands in the upper and middle reaches, the Shiyang River runoff flowing into Minqin Oasis had decreased from $5.8 \times 10^8 \text{ m}^3$ in the 1950s to $2.3 \times 10^8 \text{ m}^3$ in the 1980s and $1.7 \times 10^8 \text{ m}^3$ in the 1990s and less than $1 \times 10^8 \text{ m}^3$ in 2000. The shortage of river runoff forces local farmers to overexploit the groundwater to irrigate farmlands. The amount of overexploiting had reached $2.5\text{-}3 \times 10^8 \text{ m}^3$ in 2005, which caused the rapid descent of the regional groundwater table. The lower groundwater table caused the natural vegetation to dry up and the shelter forest degraded. The loss of shelter forest function leads to sand dune moving into the oasis and burying farmlands and villages. Moreover, overexploiting groundwater and strong evaporation cause groundwater quality deterioration. The value of total dissolved solids (TDS) in the groundwater in the northern region of the Minqin Oasis has reached 8 g/l from the 1960s to 2010. Saline water irrigation not only causes the soil salinization, but also results in the further increase of mineralization and salt content of ground water. In past half centuries, desertification including aeolian desertification, soil salinization and water resources degradation severely restricted the sustainable development of local society, economy and environment.

Since 2005, measures such as reducing the farmland area, controlling the exploitation of ground water, developing drip irrigation and plastic mulch agriculture, region diversion, and industry restructuring have been implemented to restore the water resources and combat desertification in the Minqin Oasis. Some success has been obtained in recent years. For example, the runoff of Shiyang River flowing into the Minqin Oasis was restored to $2 \times 10^8 \text{ m}^3$ in 2012, and the groundwater table ascended by 40 cm from 2005 to 2011. However, new environmental problems such as aggravating salinization and soil and air pollution emerged due to popularization and application of plastic mulches after measures restoring water resources were implemented in the Minqin Oasis. Therefore, how to establish a sustainable water resource management system and counteract the negative impacts of anthropic activities are proposed.

Saving the Dead Sea: Evaluating Red Sea-Dead Sea Water Conveyance

Recently, the long-awaited draft report supported by the World Bank, evaluating a project that would address the depletion of the Dead Sea and chronic water shortages in Jordan and Palestine has been published. The project involves conveying water from the Red Sea to the Dead Sea along the "Arava" section of the Syro-African rift which would both replenish the Dead Sea, which has seen an annual drop of water level of over 1 meter and be part of a massive desalination plant that would produce drinking water. The environmental and economic implications were considered by a mutli-national team of experts. The report will be presented and a diverse group of stakeholders and experts will consider the findings.

Speakers:

Dr. Ittai Gavriel, Director, Geological Survey of Israel

Munqeth Muher, Chairman, Friends of the Earth Middle East, Amman

Noam Goldstein, The Dead Sea Works, Israel

Sarit Caspi, Israel Union for Environmental Defense (Adam Teva V'din)

Moderator: Noam Weisbrod, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel

Soil and Land Restoration

- Soil conservation under shifting climatic conditions. The predicted forthcoming climatic shift (Global warming) will have, most likely, a particularly strong effect on semi-arid regions, since a relatively small change in precipitation rate or in frequency and intensity of rain events may make arable land unsuitable for cultivation, if proper actions are not taken. Such actions may include importing water for irrigation from outside the region or taking steps to prevent erosion. Measures needed to be taken if predictions arising from the most commonly considered global warming scenarios come true, to prevent deterioration of soil quality or to restore the land's quality once damaged, will be discussed;
- Maintaining soil productivity under irrigation with marginal water. Agriculture in arid and semi-arid regions is often supported by irrigation with water of marginal quality. Low quality water, and in particular saline water, may bring about a reduction in the productivity of the irrigated land. Cases of irrigated valleys that turned into salt plateaus are reported periodically from various regions of the globe. Means to prevent deterioration in soil quality and to reclaim deteriorated soils under irrigation with marginal water will be presented;
- Effect of overgrazing on soil quality and restoration procedures. Overgrazing is one of the most important causes of land deterioration in arid regions. Overgrazing exposes the soil to erosion and increases runoff and flood damages. Cases of overgrazing-induced damage, grazing regimes intended to minimize such damage and protocols to reclaim land damaged by overgrazing will be described and discussed.

Rethinking drylands development: Sustainable land management in arid lands of Mendoza, Argentina, lessons learnt and still to be learned.

Elena Maria Abraham; IADIZA-CONICET; Abraham@mendoza-conicet.gob.ar

A proposal is put forward about desertification assessment and mitigation achieved in the Monte Desert, Mendoza, Argentina, which includes assessment and participatory monitoring of the processes and, at the same time, contributes to recovering desertified territories and incorporating deserts into economic and production circuits. As the area is representative of natural and social conditions in the drylands of the Argentine West, the proposal has a high likelihood of being replicated. The major goal is to contribute to an integrated/participatory system for desertification assessment, to strategies for sustainable land management, and to the implementation of demonstrative experiences reappraising the worth of drylands and improving living standards for their people. Activities were organised around the following axes: research, development, transfer, technical assistance, management, and training of human resources. Desertification is approached as a complex system through an integrated assessment procedure based on benchmarks and indicators, with a strong participatory approach that contributes to awareness raising and the empowerment of local communities. Studies are articulated around three components: natural, economic and socio-cultural, relating conceptual frameworks of combat of desertification, sustainable land use and land management.

An alternative dryland development model has been designed that contributes to improving desertified lands through a better use of the territory's endogenous resources, by diversifying goat production, reducing the stocking pressure on fields and raising the income level of producers. Activities include revegetation, reforestation, goat genetic improvement, healthy meat and milk production, commercialization, access to goods and services, training and technical assistance. A demonstrative experience has been implemented at the "Tres Cruces" locality. Associated with this is the design of an observatory of natural and social processes. This enterprise has had the contribution of a

great number of research works conducted by interdisciplinary teams of IADIZA in Argentina. The site is one of the case studies for land assessment at the local level initiated by the LADA Project in Argentina. The objective is to submit, for discussion, analysis and reflection, the lessons learned from this experience. The challenge involved the “doing,” insofar as this “doing” means generating knowledge and providing alternatives to the communities. Proof that the desert may be sustainable is contributing to the design of public policies at the local and provincial level.

Intensive agriculture: Additional aspect of desertification

Gil Eshel, Ministry of Agriculture and Rural Development, Soil Erosion Research Station, Emeck-Hefer, Israel, 40250, eshelgil@gmail.com

Conventional intensive agriculture is characterized by high productivity, high water-use efficiency and low need for manpower, but also by bare soils, which are commonly found at the beginning of the rainy season. In this context, the rain-drop impact, which is a micro-scale process that seals the soil surface, should be considered as a significant process in generating runoff, as it affects large areas of cultivated bare land. Thus, agricultural watersheds may experience long-term changes in the hydrologic regime, e.g., increases in rainfall-runoff coefficients, decreases in groundwater recharge, and frequent flashfloods -- all typical to desert areas with very small annual rainfall depths. In this talk, we will present this conceptual idea and provide some evidence to support it, based on observations and records from Israel and around the world.

The evaluation of restoration actions to combat land degradation and desertification in the Kalahari region, South Africa

Klaus Kellner, Albert van Eeden and Christiaan Harmse; School of Environmental Sciences and Development, North-West University, Potchefstroom Campus, South Africa; Klaus.Kellner@nwu.ac.za

The degradation of natural resources in the Kalahari region, South Africa is caused by the over-utilization of rangelands, which has negative socio-economic impacts on the communities in this area. Land degradation is characterised by a decrease in the vegetation cover, density and diversity, a poor biomass production, an increase in the woody density of shrubs, especially in the sand dune areas, and a decrease in the soil quality. Several restoration actions have been carried out by the local farmers to combat the land degradation and desertification processes. These include (1) bush/shrub control, (2) dune stabilization, (3) revegetation and (4) the implementation of better grazing management strategies. The aim of the project was to evaluate the restoration actions using quantitative sampling methods and to correlate the results to the 11 indicators identified by the farmers for assessing the effectiveness of the restoration actions.

The Fixed Point Monitoring of Vegetation Methodology (FIXMOVE) (Morgenthal & Kellner, 2008) was used to determine the density and biomass of the grass species composition. Soil samples were taken to determine the total organic carbon content in the soil surface. The status of the rangeland condition and grazing capacity were derived from these results. The application of better management practices, which is characterized by a rotational grazing system with periods of rest and no over-stocking, had the best results in terms of biomass production, an increase in the density of large tufted, palatable grasses, the amount of litter and grass species diversity. Bush/shrub control in the dune veld was ranked as the second best restoration action, followed by dune stabilization and re-vegetation. The availability and supply of water was ranked as the highest indicator by the farmers in the Kalahari, as this indicator promotes the application of better management practices. Personal factors, such as the finances and future wellbeing of the family was ranked second highest, whereas the amount of plants/grasses and animal conditions, together with biomass production, were ranked as the third most important indicators after the implementation of restoration actions. The application of these actions will, however, depend on the financial status of the farmer, as some require high inputs, such as the control of shrubs or the stabilisation of dunes.

Although the “personal factors” were not quantitatively assessed, the study confirmed that there is a strong correlation between the quantitative data and the local knowledge gained from the farmers when assessing restoration actions.

This project forms part of the global PRACTICE program (Prevention and Restoration Actions to Combat Desertification an Integrated Assessment).

Studying land degradation in Mali (West Africa) with an agent-based model of farmers' decision making

Giora J Kidron¹, Yulia Grinblat¹, Itzhak Benenson¹, Arnon Karnieli²

¹Laboratory of Geosimulation and Spatial Analysis, Dept of Geography and Human Environment, Tel Aviv University, Tel Aviv, Israel; gkidron@post.tau.ac.il

²The Remote Sensing Laboratory, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel

With increasing population and a growing demand for food, the soils in West Africa are undergoing fast degradation. We have investigated degradation processes and developed a model of agricultural land degradation based on the data collected in the Kita area, Mali. Twelve fields around Kita were sampled. Seven of these fields were under cultivation, at different states of the succession cycle, whereas the remaining fields were fallow or virgin soils. The amount of N-NO₃, N-NH₄, P, K, and the soil organic matter (SOM) were determined. Of all variables, only nitrogen and SOM showed significant linear relationships with cotton lint, with only SOM showing a clear threshold (of 18 t/ha) that distinguishes between fertile and infertile fields. In parallel, the LANDSAT images of the Kita area in Mali (26x26 sq km) for 1975, 1986 and 2003 were analyzed, and suitable (cultivated and non-cultivated) and unsuitable land for agriculture use were identified. The analysis clearly demonstrates that towards 2003, all lands that could have been used for agriculture were already used. Based on SOM, GIS layers of settlements and roads and demographic data, a spatially explicit model of the agricultural land-use in the Kita area was developed, aiming to provide a link between agricultural practice and soil degradation. The model accounts for the practice of crop rotation (currently, one year of cotton and two-three years of cereal), the use of manure and chemical fertilizers, and the practice of leaving one of the farmer's fields to rest (fallow) while cultivating the second field. The model agents (farmers) decide each year, depending on the history of the crops and their yield, whether to cultivate cotton or cereal or to leave the field for fallow. New farmers also decide whether to establish new settlements in areas where suitable virgin land is available. The model shows that under the current practices of cultivation, land degradation will take place, resulting in "dead" periods (2-3 years each) during which SOM in both farmer fields will be below the necessary threshold for cultivation. This implies periods with 2-3 years of a lack of income. We, therefore, conclude that intensive cultivation practice, which accounts for the cardinal role of SOM, should be adopted.

Setting up a desert restoration hub

Benz Kotzen, University of Greenwich and COST, School of Architecture, Design and Construction, 50 Mayfield Avenue, London, United Kingdom N146DU; b.kotzen@gre.ac.uk

The establishment of the COST-funded 'Arid Lands Restoration and Combat of Desertification: Setting Up a Drylands and Desert Restoration Hub' commenced in response to the issues of restoring degraded drylands and, particularly, the establishment and management of vegetation. I found, as a researcher and as a consultant working in the Middle East, that information was dispersed and very hard to find and that although there were numerous organisations involved, particularly in the desertification field, regarding policies and economic and climate change, there wasn't a dedicated place for stakeholders to deposit and discuss methods, techniques and developments in restoration. Of course, much is known about restoration techniques and, particularly, traditional methods, but it is still hard to come by, and it takes an enormous effort to arrive at anything comprehensive and useful.

COST projects focus on inclusive networking, innovation, dissemination of information and education, and this COST project aims at all of these, with its focus on the restoration of drylands and combat of desertification. It is well understood that tackling these issues requires enormous effort and will and that it can be best achieved through a holistic approach and combining the skill and knowledge of experts and practitioners in various fields. These fields include soils, hydrology, ecology, agronomy, climate, landscape etc. It also requires expertise from a broad range of environments and countries. Do we in Europe know about the mine restoration projects in South Africa and Namibia, and more to the point, do the stakeholders, for example, in North Africa know of the expertise and methods being used some thousands of miles to the south?

The aim of this paper is firstly to discuss the requirements for restoration to be undertaken holistically, bringing in all the skills that may be available – and to realise that no one group, soil scientist or hydrologist or ecologist have all the answers and also that local people also need to be included in the equation. The paper will draw on the experience of the close to 40 Management Committee and Working Group members of the Action, many of whom are actually soil scientists. Additionally, the aim is publicise the Action and to expand participation in the Action and outreach to those individuals and institutions gathered at Sede Boquer. It is understood that this is not science but more like ‘advertising’. But this project, which is about bringing knowledge and people together in one place, is an important step towards tackling the real difficulties in establishing and managing vegetation in drylands and desert areas and helping towards the combat of desertification.

Reclamation of the Greater Rann of Kachchh, Gujarat, India – a pilot approach

Vijay Kumar and Arun Kumar Roy Mahato Gujarat Institute of Desert Ecology, Bhuj-370001, Gujarat, India; vijay196129@gmail.com

The Greater Rann of Kachchh (GRK) is a marshy and highly saline area, under the desert bio-geographic zone, located in the westernmost part of Gujarat state, India. GRK is characterized by a harsh climate with minimum or scant rainfall. Topographically, the Rann is flat with some elevated land areas locally known as ‘Bet’. Many of the bets are barren and ecologically fragile due to very low soil moisture and high soil salinity. Therefore, an attempt to restore / reclaim the Rann, on a pilot scale, was initiated during the year 2001. Restoration of fragile land and its ecosystem functions is of paramount importance for the environment and human society. Restoration of degraded land is a slow process; it depends on time and space, and is influenced by geographical and climatic factors and ecological conditions of the area. To accelerate the natural recovery process through eco-friendly exercises, two bets, namely, the Kuar and Mori bets, and some fringe areas of the Greater Rann of Kachchh were selected for the experiment. In order to reclaim the ecological function of the GRK, some traditional techniques of land resource practices were applied for the conservation and management of soil and water. In total, a 1776 ha area has been reclaimed under the project. The comparative analysis of the post-monsoon imageries of 2001 and 2006 highlights that dense scrub has been increased by 120%, grassland by 113%, and surface water storage by 4100%, which has subsequently reduced the barren area by 73% between the abovementioned periods. In the project area, the species of flora increased from 113 species in 2001 to 131 species in 2006. The density of trees increased from 15/ha in 2001 to 145/ha in 2006, while the shrub density has increased from 181/ha in 2001 to 3292/ha in 2006. As per the monitoring data, the grass fodder and biomass developed in the project area at the end of the project was 1,659 tons annually. The results of the above restoration programme in the highly saline GRK have been found to be highly successful, which is evident from the development of vegetative cover, soil fertility, control of erosion, and the development of surface water bodies, which in turn has attracted many faunal species and enhances the biodiversity of the GRK.

Chenopodium quinoa: A high quality food crop as an opportunity for evaluating soil improvement in arid agroecosystems

Enrique Martinez, Centro de Estudios Avanzados en Zonas Aridas (CEAZA), La Serena, Chile and PhD Program on Applied Biology and Ecology (Dr-BEA), Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile. Enrique.a.martinez@ceaza.cl

Bhargava A¹, Bazile D², Fuentes FF³, Negrete J⁴, Martínez EA⁵, Thomet M⁶, Vega-Galvez A⁷, Zurita A⁵.

¹Amity Institute of Biotechnology, Amity University Lucknow Campus, Lucknow-226010, India

²CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), UPR47, GREEN, Montpellier, France

³Departamento de Agricultura del Desierto y Biotecnología, Universidad Arturo Prat, Casilla 121, Iquique, Chile

⁴Instituto de Geografía Pontificia Universidad Católica de Valparaíso– Valparaíso, Chile

⁵Centro de Estudios Avanzados en Zonas Aridas (CEAZA), La Serena, Chile and PhD Program on Applied Biology and Ecology (Dr-BEA), Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile.

Enrique.a.martinez@ceaza.cl

⁶CET-Sur ONG, Temuco, Chile

⁷Universidad de La Serena, Facultad de Ingeniería, Av. Raúl Bitrán s/n, Box 599, La Serena, Chile

The FAO has highlighted the outstanding nutritional value and the surprising stress-tolerance mechanisms of quinoa (*Chenopodium quinoa* Willd.). This Andean food presents an opportunity to address the hunger and climatic challenges that are occurring today all over the world. For instance, Dr. Atul Bhargava, from India, stated that a program for the genetic improvement of quinoa for the agroecosystems and for the climatic conditions of India is an opportunity for seven hundred million small-scale farmers and their families. This is not just a market opportunity, but an opportunity for food security. Most of them are vegetarians. Producing one kilogram of beef might require 15,000 liters of water, something not affordable in many places of the world. Quinoa grains have the whole set of twenty amino acids, including all the essential ones, plus vitamins, minerals, excellent quality flavonoids, starch and good quality fatty acids, among other useful properties.

Chile, very far from India, could be of some help in facing the challenge, under the scenario of widespread desertification. Our narrow land has three thousand kilometers in length where quinoa has been cultivated for the last three thousand years, across many latitudes, day lengths, soils and climate types. Such diversity is agro-ecological, but it also contains the agricultural practices of the ancient peoples of the Andes Mountains. Such crop adaptation has provoked genetic differences among quinoa populations, grouped in two main ecotypes: salares and coastal/lowland, representing a great genetic diversity between 18° and 40° of southern latitude in soils from the arid areas to the cold-temperate areas of Chile.

Here, we summarize how simple soil management of our arid region can significantly improve quinoa grain yields under extreme low irrigation. Our soils are almost depleted of organic matter, a millenary condition that modern intensive agricultural practices can render even worse if the addition of chemical fertilizers continue to be the predominant practice. Technological solutions, such as drip irrigation, might help the water economy, but soils will continue accumulating salts. Here, we show how quinoa yields are high, even in saline soils, plus how yield improvements are made by adding organic matter, a practice almost abandoned by many modern farmers. Integrated crops further reduce soil salinity. Paradoxically, our region loses tons of organic matter, thrown away weekly from our towns, due to a lack of city planning or regulations related to the discarding of household and agro-industrial organic wastes. These results also present an opportunity for many arid agro-ecosystems of the world.

Late Holocene dune mobilizations in the northwestern Negev dunefield: A response to combined grazing and short-term intensified windiness

Joel Roskin Itzhak Katra, Dan G. Blumberg¹ Dept. of Geography and Environmental Development, Ben-Gurion University of the Negev, Israel. P.O.B. 653, Beer-Sheva, 84105, Israel; joelr@bgu.ac.il

The study of the effects of past climates on ancient cultures is usually based on geologic records pertaining to rainfall and temperature fluctuations and shifts. This study proposes a paradigm of anthropogenic activity and windiness fluctuations to explain aeolian sedimentation and dune mobilization in the northwestern (NW) Negev Desert dunefield. The proposed paradigm contributes a different approach to estimating the effect of climate changes on the unprecedented agricultural and urban settlement expansion during the late Roman to Early Islamic period and on the decline in the northern and central Negev Desert. Based chiefly on luminescence ages coupled with analysis of archaeological finds and historical texts, we suggest that whereas the NW Negev dunefield was generally stable during the Holocene, intermittent dune mobilizations during the late Holocene, at ~1.8 ka and mostly 1.4–1.1 ka, are linked to periods of human occupation. The idea that the late Pleistocene dune encroachments alone formed the NW Negev dunefield between the Last Glacial and the onset of the Holocene is connected to northern hemisphere cold-event windy climates that may have intensified East Mediterranean cyclonic winter storms, but cannot explain the late Holocene dune mobilizations. We conceptually model a connection between late Holocene dune mobilization, widespread anthropogenic occupation and activity, and windiness. We maintain that historic grazing and uprooting shrubs for fuel in the past by nomads and sedentary populations led to decimation of dune stabilizers—biogenic soil crusts and vegetation—causing dune erodibility and low-grade activity. Short-term events of amplified wind power, in conjunction with periods of augmented anthropogenic activity that triggered major events of dune mobilization (elongation) and accretion, have been preserved in the dune chronostratigraphy. Because they were short lived, the dune mobilization events, corresponding windiness, and probable dustiness that were examined affected the northern Negev landscape differentially, though they cannot be proved to have affected the environment sufficiently enough to influence the decline of the late Byzantine and Early Islam agricultural establishment. This study demonstrates the sensitivity of dunes in arid and semi-arid regions to a combination of local and short-term fluctuations in windiness at times of widespread grazing (anthropogenic activity). The results

remind us that in similar future scenarios, sand mobilization may be similarly retriggered to varying degrees.

Impact of treated wastewater irrigation on soil water repellency and soil aggregate stability -- Results from a case study in Israel

Karsten Schacht, Ruhr-University Bochum, Suedstrasse 18, Muenster, Germany, karsten.schacht@rub.de

Irrigation with treated wastewater (TWW) is gaining in importance in these times of declining water availability in dry regions. In addition to other potential adverse effects on soil quality, TWW irrigation can cause hydrophobic effects on soil surfaces, reducing initial sorptivity and promoting the formation of preferential flow paths. This could lead to increased runoff, soil erosion, irregular subsoil wetting behavior and, finally, increased leaching of pollutants to the groundwater. Soil structure deterioration is another matter of concern, resulting in lower soil aggregate stability and reduced infiltration capacity.

In spring and summer 2010, *in-situ* infiltration measurements, using a Mini Disk Tension Infiltrometer (Decagon Devices Inc.), were performed in various agricultural plantations in Israel to assess the impact of different irrigation water qualities on selected soil properties. In most plantations, long-term test sites were accessed, comparing adjacent plots irrigated either with TWW or fresh water (FW). Topsoil samples were collected and analyzed regarding selected physical and chemical characteristics. Soil aggregate stability (SAS) of soil aggregates between 1 and 2 mm diameter from clayey sites was determined by wet sieving.

ECe values were consistently higher on TWW sites (+20.9 to 92.9 %). Soil SAR was strongly elevated in 4 out of 5 TWW sites (+214.7 to +639 %). Soil water repellency index R was elevated on 4 out of 5 TWW sites from +25.1 up to +135.7 %. Hydraulic conductivity k was lower on 4 out of 5 TWW sites (-25.4 to -61.24 %). At the clayey sites, SAS was consistently lower on the TWW plots (-11.3 to -32.4 %).

The results show that irrigation water quality clearly influences the physical and chemical properties of the top soil. Thus, reusing TWW for irrigation imposes side effects which have to be taken into account, in particular regarding water use efficiency and groundwater protection.

Land-use change effects on soil structure and hydraulic properties of Ethiopian Vertisols

Itamar Shabtai¹ - itamarshabtai@hotmail.com, Moshe Shenker¹, Meni Ben-Hur²

¹Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Rehovot, Israel

²Institute of Soil, Water and Environmental Sciences, the Volcani Center, Israel

During the last decades, large-scale sesame farming and population increase have led to drastic changes in the land-use and cover in the lowland plains of arid and semi-arid northwestern Ethiopia. The dominant soil type in these regions is chromic Vertisol, a soil rich in hydratable smectite minerals. Vertisols swell when wetted and shrink when desiccated, causing cracks to form. The CaCO₃ and organic matter content of these soils is typically low. Immense clearing of the native *Acacia seyal* and *Balanites aegyptiaca*-dominated savannah and subsequent cultivation have taken place in these regions.

Conversion of these native woodlands and shrublands to cultivation may degrade the soil structure, which, in turn, could adversely affect soil hydraulic properties. Soil hydraulic conductivity, which governs the ability of soil to conduct water, is an important parameter affecting water and solute transport and water availability for plants. In arid and semi-arid regions, where precipitation is unevenly distributed, the capacity of the soil to conduct and store water is, therefore, crucial.

The major aim of the present study was to evaluate the effects of conversion of native savannah to cultivated land in the Kafta Humera region in Ethiopia on the structure and hydraulic conductivity of Vertisols.

Three main processes that can reduce hydraulic conductivity by means of soil structure degradation are (i) aggregate slaking, (ii) soil swelling, and (iii) clay dispersion.

The magnitude of these processes largely depends on soil structure stability under wetting conditions. Soils from native woodlands and adjacent cultivated plots were sampled and analyzed for physical and chemical characteristics. The saturated hydraulic conductivity under different water qualities, as well as clay dispersion, aggregate swelling and slaking, were determined for the different soil samples.

An increase in the exchangeable sodium percentage (ESP) with soil depth was measured in every plot sampled. Saturated hydraulic conductivity (K_s) of low ESP soils, in the absence of dispersion and slaking, was 360 mm h⁻¹ in

the savannah soil compared to an average of 240 mm h⁻¹ in the cultivated fields. In addition, cultivated soils displayed a greater sensitivity to dispersive conditions in all ESP values and decreased the K_s values to 20 mm h⁻¹ at ESP 8. These results suggest that conversion of native savannah to cultivated land deteriorated the soil structure and the hydrology conditions in the Kafta Humera region in Ethiopia.

The practice project: Towards an integrated assessment of prevention and restoration actions to combat desertification

Claudio Zucca^{1,2} - clzucca@uniss.it, Massimo d'Angelo³; Sergio Campus⁴; Maria Laura Congiu²; Carlo Cucca²; Leonarda Dessena^{6,1}; Francesco Fava¹; Valeria Fiori²; Salvatore Madrau^{1,2}; Mustapha Mortaji⁵; Maurizio Mulas^{6,1}; Silvia Musinu²; Giuseppe Pulighe²; Roberto Scotti⁴; Fabian Sporer⁴; Cynthia Vagnetti⁴.

¹NRD, Nucleo Ricerca Desertificazione, Università di Sassari, Italy.

²Dipartimento di Agraria, Università di Sassari, Italy.

³Ente Foreste della Sardegna (EFS), Cagliari, Italy

⁴Scuola Forestale di Nuoro, Università di Sassari, Nuoro, Italy.

⁵Direction Provinciale de l'Agriculture de Marrakech, Marrakech, Morocco.

⁶Dipartimento di Scienze della Natura e del Territorio, Università di Sassari, Italy.

And with contributions from: Franco Previtali, Selim Kapur, Mchich Derak, Anna M. Urgeghe, Ángeles G. Mayor, Manuel Pulido-Fernández, Paolo Dui, Stefano Sioni, Raffaella Lovreglio, Gianna Melas, Filippo Giadrossich.

Desertification is an important environmental and socio-economic problem that affects much of the world's drylands, resulting in a significant loss of biological and economic productivity.

Responding to desertification by improving the efficiency of land and resource management represents a crucial step towards social welfare in drylands. While science has made noticeable progress in aiding our understanding of the drivers and processes of desertification, the evaluation of the practices to combat desertification, the exchange of experience and knowledge, and the incorporation of social dimensions in the solutions often remain limited, compromising the adoption of best practices in prevention and restoration efforts.

PRACTICE is an EC-FP7 global initiative that gathers scientists and stakeholders from among the most affected regions of the world to combine local and scientific knowledge to help address the desertification challenge. The NRD, Desertification Research Group of the University of Sassari is a partner of the project.

To pursue its goal, PRACTICE developed and applied integrated evaluation protocols to assess the effectiveness of prevention and restoration practices: the protocols integrate the multiple dimensions of land degradation based on the unifying conceptual framework provided by the analysis of the desertification impacts on ecosystem goods and services and on human well-being, across different spatial scales (by integrating field and remote sensing approaches). The evaluation tools implemented by Practice are participatory. They integrate the human and biophysical dimensions of desertification, involving stakeholders at all levels, including farmers and ranchers, natural resource managers, scientists, and policy makers.

PRACTICE involves research teams and stakeholder platforms in 12 countries: Chile, China, Greece, Israel, Italy, Mexico, Morocco, Namibia, Portugal, Spain, and South Africa. The project seeks to create an international network of long-term monitoring sites aimed at supporting future synthetic analysis, improving the accessibility and use of long-term data, and facilitating the exchange of knowledge.

Two study sites are specifically considered by the present contribution, which also considers the wider project outcome: the Pula reforestation site (*Pinus communis* – *Pinus halepensis*) in Sardinia, Italy, and the Ouled Dlim fodder shrub plantations (*Atriplex nummularia*) in Morocco, which are under the scientific responsibility of the NRD.

In each study area, representative plots were selected in restoration sites, as well as in “non-intervention” reference sites, to perform comparative analyses. The integrated protocol was implemented to define the suitable assessment indicators, along with multiple evaluation criteria based on ecosystem goods and services, by involving the stakeholders. The Landscape Function Analysis (LFA) was taken as the reference method to study the effects of the restoration actions on the soils and on the ecosystem functions. The results obtained show that (i) restoration actions impact in different ways (both positive and negative) the provision of ecosystems goods and services; (ii) the overall impact is, in some cases, controversial, also in terms of social perception; and that (iii) multi-criteria analysis can provide an effective tool to describe and trade-off the effects of the restoration actions.

Studies of Biological and Structural Soil Crusts with Geoinformation

Soil crusts, biological as well as structural, act as important components of desert ecosystems due to their effect on water budget and surface processes. Remote sensing and spatial modeling can shed new light on the spatial distribution of crusts, their functioning in the slope and watershed scales and their temporal dynamics. This session will focus on the use of hyperspectral as well as multispectral remote sensing and dynamic modelling of soil crusts to better understand dry ecosystems. Among the themes to discuss are the following: spectroscopy of structural and biological crusts; modeling of surface sealing; and ecosystem functioning and soil crust.

Multi-annual analysis of the spatial distribution of biological soil crusts in the Northwestern Negev sandfields

Arnon Karnieli; The Remote Sensing Laboratory, Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev; karnieli@bgu.ac.il

The brightness contrast across the Israeli-Egyptian political borderline is a typical example of a desertification phenomenon triggered by human impacts on a fragile ecosystem. The sand dunes of the Negev (Israel) are almost completely covered by biological soil crusts undisturbed by anthropogenic activity. These crusts consist of microorganisms called cyanobacteria along with fine soil particles. On the other side of the border, in the sand dunes of Sinai (Egypt), such crusts are absent from the topsoil due to intensive trampling by humans and animals. Consequently, the Israeli Negev dunes are stable with more vegetation, while the Sinai dunes are bare and mobile. The two sides of the political borderline, although similar from geological, geomorphological, pedological, and climatic points of view, demonstrate opposing processes of desertification in Egypt and rehabilitation in Israel.

The current project summarizes long-term land cover and land-use change studies acquired by different spaceborne systems since 1960s until now. Two desertification indicators are involved. The first is dune stability that was investigated by deriving brightness and albedo values from Landsat, CORONA, and NOAA-AVHRR images. The brightness index is affected by the spatial distribution of cyanobacteria-dominated biological soil crusts vs. bare sands. The second indicator is vascular plant cover that was calculated from aerial photographs. Results of these independent remote sensing systems similarly and consistently demonstrate the changes in the brightness contrast across the Israeli-Egyptian political borderline with respect to historical events. The contrast decreased when the border was open for human activity and increased when the border was closed.

Identifying and characterizing biological soil crusts using LWIR spectroscopy and remote sensing

Offer Rozenstein, BIDR, BGU, P.O. box 339, Midreshet Ben-Gurion, Israel 84990; offeroz@yahoo.com

Biological soil crusts (BSCs) cover vast regions in drylands worldwide. BSCs consist of soil granules and various microphytic communities, including cyanobacteria, algae, fungi, mosses, and lichens. Situated at the atmosphere-soil boundary, BSCs play an important role in dryland ecosystems, including soil stabilization, prevention of wind and water erosion, carbon and nitrogen fixation, and effect plant germination and establishment. Previous studies have demonstrated that BSCs possess unique spectral characteristics in the VIS-NIR-SWIR spectral regions. This enables the use of remote sensing to map their distribution in relations to microphytic vegetation and bare soil. While those previous studies employed reflectance spectroscopy to this end, we will demonstrate that this mapping could also be achieved using multispectral and hyperspectral TIR emissivity in the LWIR spectral region. This innovative technology

enables data collection, even when there is not enough radiation in other spectral regions (for instance, at night, or under cloud cover).

Improving validation schemes of remote sensing missions under soil surface sealing conditions

Shai Sela¹, Tal Svoray¹, Shmuel Assouline²

¹ Dept. of Geography and Environmental Development, Ben-Gurion University of the Negev, Israel, selas@bgu.ac.il

² Dept. of Environmental Physics and Irrigation, A.R.O - Volcani Center, Israel

Remote sensing missions (e.g. SMOS) enable the prediction of top soil water content (0-2 cm). A critical phase in the robustness of the usage of these products lies in proper calibration and validation, done against field sampling. The sampling scheme needs are based on sampling sites which are representative of the average area soil moisture value. Therefore, many studies have focused on the temporal stability (TS) of soil moisture in different climatic regions. In dry climates, soil moisture dynamics are affected by the formation of surface seals. The effect of these seals on the TS of the soil is still unclear. To address this issue, a typical hillslope (0.115 km²) was chosen at the LTER Lehavim site in the south of Israel (31°20' N, 34°45' E) that offers different aspects and a classic geomorphologic banding. The annual rainfall is 290 mm, the soils are brown lithosols and arid brown loess. An extensive spatial database of soil hydraulic and environmental parameters (e.g., slope, radiation, bulk density) was measured in the field and interpolated to continuous maps using geostatistical techniques and physically based modelling. To explore the effect of soil surface sealing, Mualem and Assouline (1989) equations, describing the change in hydraulic parameters resulting from soil seal formation, were applied. This spatio-temporal database was used to characterise 8240 spatial cells (3X3m²) serving as an input to a numerical model (Hydrus 1D) solving the flow equations to predict soil water content at all temporal scales. Following intense verification, the model was used to track down explicitly the evolution of top soil TS during different climatic scenarios. The results indicate no significant difference in the first 48 hours following a precipitation event, as water redistribution occurs at the soil. However, once the soil enters longer drying periods, the seal layer reduces water content variability and improves its temporal stability, an effect augmented with time. Step-wise regressions found this process to be shaped by aspect during the first few days of drying, followed by soil depth and porosity.

Classification of biological soil crusts by means of hyperspectral remote sensing imagery

Bettina Weber; University of Kaiserslautern, Dept. Biology, Plant Ecology and Systematics, P.O. Box 3049, 67653 Kaiserslautern, Germany; weberb@rhrk.uni-kl.de

Biological Soil Crusts (BSC), consisting of cyanobacteria, algae, lichens, mosses, fungi and other bacteria in varying proportions, provide important ecosystem services, like soil stabilization, moisture conservation and nutrient input within arid and semiarid regions around the world. Due to their key role in sustainable land management, as well as for global carbon and nitrogen balances, a mapping methodology is urgently needed.

For that purpose, hyperspectral CASI data, with a spatial resolution of 1m, were recorded in combination with field spectrometric measurements at two sites in the Succulent Karoo, South Africa. Original BSC spectra, as compared to bare soil and vascular plant vegetation, revealed no suitable characteristics to reliably differentiate between the different types of soil coverage. Only after removal of the overall continuum, small scale characteristics could be identified to establish five rules that allowed a reliable delimitation of BSC against bare soil, vascular plant vegetation and cryptogamic organisms on rocks. In an accuracy assessment, a kappa-index of 0.831 was reached, certifying a very good classification result. The first site, where the algorithm had been developed, was characterized by gently sloping hills with some granite inselbergs and recent erosion phenomena. Here, 16% of the whole area was classified as BSC; in parts of this region without roads and inselbergs, coverage reached 26.8%. The actual coverage is expected to be still somewhat higher (around 35%), since BSC under dense shrubs are not registered with this method. The algorithm was also successfully applied to the second site, which is located within the same

biome, but is characterized by a large coverage of quartz pebbles. Here, BSC coverage on soil reached only 9%, but additional BSC growth underneath translucent quartz pebbles was identified and calculated during field work, summing up to a total BSC coverage of approximately 25%.

The newly developed classification methodology proved to produce reliable results within the Succulent Karoo biome. After adaption to the local spectral soil characteristics, this algorithm should also be transferable to other biomes around the world.

Transboundary Management of Water Resources in Drylands

Watershed boundaries have little to do with political borders making the management of transboundary surface and groundwater a particular vexing political and technical challenge. This session will consider the unique aspects of these dynamics in areas that face perennial shortages. In conjunction with the academic presentations, a field trip will be offered on day three of the conference that will follow the river Jordan's flow from the Kinneret Lake (Sea of Galilee) to the Dead Sea.

FoEME's Perspectives in Desertification Issues through new Protecting Ground Water Project

Malek Abualfailat Friends of the Earth Middle East; malek@foeme.org

The communities in the region suffer from both leakages and pollution of water resources. Many are located over huge aquifers. In many of these communities, water use is limited to 17 L/capita/day. Friends of the Earth's new Protecting Ground Water project focuses on promoting and empowering the municipal staff in these communities to protect the underlying aquifers in the region. The presentation will describe the current situation of water in FoEME's communities in the West Bank due to their importance in agriculture and livestock. It will also consider how the water management practices may affect the land desertification rate. Through the presentation, alternatives for reducing desertification will be presented through using reclaimed water for agriculture. Also, the alternative of treating wastewater using natural treatment systems will be considered. This has the potential to raise the vegetation rate and improve the soil quality. This presentation will explore how the common commitment to solving the water problems in the region can be a cornerstone to help our common resources of lands and save water.

Wastewater contamination in transboundary Palestinian –Israeli watersheds: The case of Wadi Nar and the Kidron Streams

Iyad Aburdeineh, Palestinian Wastewater Engineers Group – PWEG; Palestine St., Doha – Bethlehem, Palestine; iyad@palweg.org

Transboundary watersheds between Palestine and Israel are a significant source of pollution. At the same time, the effluents generated can offer a meaningful source of potential additional water for agriculture and for providing "green space" in the generally dryland landscapes. The main challenges for using this resource involve the political situation and existing definitions regarding the rules and roles of wastewater reuse. The fact that these watersheds are transboundary by nature and lack a clear political arrangement constitutes an obstacle to their utilization and serves to extend the ongoing problem. Reaching an agreement requires an analysis of the political aspects with regard to the so-called "green line" and the policies within the Israeli controlled areas of the West Bank, given the directives in the interim "Oslo" peace agreement. Wadi Nar / the Kidron valley and the Hebron/ Besor streams provide cases which will be analyzed and discussed, showing complex examples of transboundary watersheds that are contaminated

with chronic pollution by discharged sewage. The presentation will discuss these cases within the broader political context.

Transboundary Water Management in the Great Lakes Basin

Abdel Raouf Darwish, Aqaba Development Company, Jordan, darwish1jo@yahoo.com

The period from 1909 to 1987 could be characterized as achieving notable successes in the management of the Great Lakes waters. The successes during this interval provide important lessons for shared water resources elsewhere. However, the period from 1987 forward saw more obstacles in restoring and maintaining the waters in the Great Lakes Basin. Since 1987, progress toward cleaning up the most seriously degraded locations, the Areas of Concern (AOCs), in the Great Lakes Basin has been slow. Forty-three Areas of Concern were identified in the Great Lakes Basin. There were 26 sites in the U.S., 12 sites in Canada, and 5 binational sites shared between the U.S. and Canada. Since 1987, the Remedial Action Plans (RAPs) have been completed for only five of the 43 AOCs that were identified in the Great Lakes Basin, and none of them have been binational. The RAP process has three stages. The first stage is definition of the problems, sources, and causes of impairments to beneficial uses. The second stage includes selection of appropriate remedial measures and identification of agencies or organizations responsible for implementing selected remedial measures. The third stage is surveillance and monitoring processes to track the effectiveness of remedial measures, leading to eventual confirmation of the restoration of beneficial uses. Several reports pointed to the causes that have stymied the effectiveness of the Remedial Action Plans (RAPs) in general. Lack of leadership, decline of the governments' support to the RAPs, and lack of accountability represent some of the main constraints to progress in implementation of the RAPs. Other significant impediments to the RAPs include: 1) the inability to understand and incorporate the ecosystem approach in developing and implementing the RAPs; 2) the high costs required for remediation; 3) the non-binding nature of the Great Lakes Water Quality Agreements and hence, RAPs; 4) the lack of public involvement; and 5) disagreement on common delisting targets.

Water Management in Arizona and the Lower Colorado River Basin (USA): Good Practices and Long-Term Challenges

Arizona, located in the southwestern United States, depends on the Colorado River for a significant amount of its water supplies. Groundwater and other surface supplies are also important water sources. About 70% of water withdrawals and diversions are for agricultural purposes. Mining is an important component of Arizona's economy, as is tourism. In the face of growing population and water scarcity (average rainfall in the metropolitan regions ranges from 100 mm to 300 mm annually), Arizona has had to adopt a multi-faceted approach to water management. The Central Arizona Project, a large constructed open canal, transports Colorado River water uphill into Central Arizona. The energy used to pump the water is generated by a coal-fired plant. Depending on federal regulatory policy, the costs of meeting environmental regulations related to power generation may result in significantly higher water costs. Groundwater use is regulated, but only in certain parts of the state. Arizona shares an international border with Sonora, Mexico, and is home to several sovereign Indian Nations. Water management practices are developed and implemented in a complex environment, one that has many similarities to other water-scarce arid and semi-arid regions. The session will address both short-term and longer-term strategies to meet water demands of the municipal, industrial, agricultural and environmental sectors. The importance of water reuse, the role of water

desalination, alternative conservation practices, water banking, and planning for uncertain climate conditions and surface water flows will be among the topics addressed.

Speakers and Topics:

Richard Morrison - Attorney, Salmon, Lewis & Weldon, PLC, and Trustee, Farm Foundation: *The Importance of Colorado River Water to the Municipal and Agricultural Sectors in Central Arizona*

Aaron Citron - Policy Analyst, Environmental Defense Fund: *Sustaining Healthy Communities, Working Landscapes, and the Environment in the Colorado River Basin*

Sharon Megdal - Director, Water Resources Research Center, The University of Arizona: *Arizona Water Management Achievements and Challenges*

Poster Session

Movement of cattle by the pastoralist fulanis in the federal capital territory of Abuja, Nigeria

Michael Adedotun; Federal Territory of Agricultural Development Program; Garki Abuja, Nigeria; Agricproject2009@yahoo.com

The pastoralist Fulani farmers move along with different cattle in search of food and water for their different animals such as cattle and sheep, using different technologies, which, while best known to them, have not been documented for research purposes. Topics such as how the different cattle feed on different varieties of food, such as grass and water, or the various communication processes the pastoralists use to communicate with their animals and their fellow pastoralists via GSM mobile communications, have yet to be sufficiently studied. Pictures were taken in order to ascertain the mode of movement and transportation on different farms, communication processes, the depositing of feces, and destruction of agricultural farms. Questionnaires and farm and home visits were also made.

Characterization of yeasts colonizing desert plants for biotechnological applications

Said Abu Ghosh¹, Carmi Korine^{2,3} and Samir Droby¹

¹Department of Postharvest Science, Agricultural Research Organization (ARO), The Volcani Center, Bet Dagan 50250, Israel; wwwsaid78@yahoo.com

²Mitrani Department of Desert Ecology, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, 84990 Midreshet Ben-Gurion, Israel

³The Dead Sea and the Arava Science Center, Tamar Regional Council, 86910 Neveh Zohar, Israel

We studied species richness of epiphytic yeasts on selected desert plants from the Dead Sea area and examined the ability of some of these yeasts to tolerate the harsh conditions and discover their unique features for possible future biotechnological applications. We sampled yeast populations mainly from four common plant species; *Ochradenus baccatus*, *Capparis spinosa*, *Ziziphus spinachrist* and *Atriplex halimus*. Following standard isolation procedures, morphological, microscopic and molecular identifications were performed for each of the selected yeast isolates. Results showed that the species composition on plants underwent seasonal fluctuations and were at maximum in autumn. *Cryptococcus* spp. appeared to be the most predominant yeast followed by *Candida* spp. Representative strains of the yeasts were screened for their ability to tolerate different stressful growth conditions (high temperature, elevated salt concentration and oxidative stress). When exposed to high temperature of 50 °C for 90 minutes, most strains showed high tolerance. Cell viability of *C. magnus* isolated from *Z. spinachristi* at Ein Gedi area was the highest (72%) among the other strains, whereas, *C. albidus* isolated from the same plant species appeared to be more resistant to high H₂O₂ concentrations, i.e. cell vitality was the highest (64.4% at 500 mM¹). The growth of the salt tolerant yeast *Debaryomyces hansenii* isolated from *O. baccutus* in the Ein Tamar area showed high tolerance to salinity and to dehydration. Our results indicate that yeasts isolated from desert-dwelling plants have unique features with promising potential for future studies related to biotechnological and agricultural applications.

The study of land-use degradation in West Africa with an ALADYN simulation model

Yulia Grinblat^{1,2§}, Giora J Kidron¹, Arnon Karnieli³, Itzhak Benenson^{1§}

¹Department of Geography and Human Environment, Tel Aviv University

²Porter School of Environmental Studies, Tel Aviv University

³Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev
juliagri@post.tau.ac.il, bennya@post.tau.ac.il

West Africa faces rapid population growth and subsequent demand for food production. Despite increasing demand, local farmers still follow traditional practice and to overcome low productivity, continuously expand cultivated areas. To estimate the consequences of this process we developed a spatially explicit agent-based ALADYN model of agricultural land-use in the savannah around Kita, Mali. The model is based on the remote sensing data for the agricultural land-use in the Kita area, Mali and field surveys there. The ALADYN simulations clearly demonstrate that traditional agriculture is not sustainable. Even under the optimistic scenario of a declining rate of population growth, the current agricultural practice results in all available lands being used for agriculture by 2025. Agricultural production thus reaches its maximum and from then on, every household will experience repeating, 1-2 year in 15-20 year period, gaps of overexploitation, when none of the fields are worth cultivating. Constant and high emigration will be the only way to avoid starvation in these circumstances. The model highlights the great need for new agricultural practices in Mali and the entire savannah area of West Africa.

Biogenic crust dynamics on sand dunes

Shai Kinast¹, Ehud Meron^{1,2}, Hezi Yizhaq¹, Yosef Ashkenazy¹

¹ Department of Environmental Physics and Solar Energy, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev

² Department of Physics, Ben-Gurion University of the Negev
shaikinast@gmail.com

Sand dunes are often covered by vegetation and biogenic crusts. Despite their significant role in dune stabilization, biogenic crusts have hardly been considered in studies of dune dynamics. Using a simple model we study the existence and stability ranges of different dune-cover states along gradients of rainfall and wind power. Two ranges of alternative stable states are identified: fixed crusted dunes and fixed vegetated dunes at low wind power, and fixed vegetated dunes and active bare dunes at high wind power. The results suggest a cross-over between two different forms of desertification.

Spatial periodic forcing can displace patterns it is intended to control

Yair Mau*, Aric Hagberg, Ehud Meron

Ben-Gurion University of the Negev, Physics Department; Beer Sheva, Israel. yairmau@gmail.com

Spatial periodic forcing of pattern-forming systems is an important, but largely unstudied, method of controlling patterns. It can be used to control the amplitude and wave number of one-dimensional periodic patterns, to stabilize unstable patterns, and to induce them below instability onset. We show that although in one spatial dimension the forcing acts to reinforce the patterns, in two dimensions it acts to destabilize or displace them by inducing two-dimensional rectangular and oblique patterns.

These results may have important implications for practical applications of spatial forcing in various fields of science including nonlinear restoration ecology. An interesting example is rehabilitation of banded vegetation on hill slopes by water harvesting. Water harvesting methods often involve parallel contour ditches that accumulate runoff and along which the vegetation is planted. Our results suggest that the system may not respond as expected in a 1:1 resonance, but rather form 2d patterns that involve long lasting processes of mortality and re-growth. Because the analysis is based on universal amplitude equations near an instability point, we expect it to hold for a wide variety of spatially forced systems.

Towards the tendencies of coastal ecosystems' plant cover: Changes in the Small Aral Sea (North Aral Sea)

Ulzhan Mukiyanova (a), Galina, Parshina (a), Walter Wucherer (b)

(a) L.N.Gumilyov Eurasian National University, Astana, Kazakhstan

(b) Greifswald University, Greifswald, Germany

mulzhan@mail.ru

The Small Aral Sea is a small and shallow water body, which was about 1/9 of the whole Aral Sea area until 1960. The huge irrigation projects in Central Asia during Soviet times caused the catastrophic desiccation of the Aral Sea. Since 1960 the surface area has decreased drastically. About 90% of the water body and the water surface are lost. The area of the dry sea floor, the Aralkum, is about 60,000 km² today. The new land is being steadily invaded by plants. The landscapes, ecosystems and flora of the dry sea floor of the Aral Sea are in a stage of transformation, with steady new developments and high dynamic processes.

The region around the Small Aral Sea is known as Priaral'ye. The sea water level of the Small Aral Sea is stable –42 m asl. There are three important landscape units in the region: desert (Aralkum or dry seafloor), coastal escarpments – chinks, and the land adjacent to the coasts (sand deserts Priaral'ye Karakum and Bolshoi and Malyi Barsuki, North Aral plateau deserts). The knowledge and information on the status of the ecosystems and the biodiversity around the Small Aral Sea is still insufficient. The information is not current and there is currently no monitoring of these processes in the region. There are many open questions like what geological, geomorphological and edaphical processes are affecting the present development of the botanical and landscape diversity; what factors determine species richness and plant community structure; how do the abiotic conditions change in space and time and in which way do they influence or even predetermine the development of plant composition and landscape structure. Today, unique landscapes are formed on the site of nature conservation and they are environmentally vulnerable. The uniqueness of the coastal ecosystems of the Small Aral Sea region and its biosphere role led to the special conservation, ecosystems' management and to the creation of a protected area north-west of the Small Aral Sea. Moreover, the need to investigate these ecosystems is necessary for the detection of territories with a high priority for protection and for the development of sustainable use methods in these vulnerable ecosystems.

Microbial Pathogens and Fecal Indicator Bacteria in an Effluent Irrigated Tomato Field

Ezra Orlofsky¹, Arti Kundo², Karen Shapiro³, Nirit Bernstein⁴, Stefan Wuertz² Woutrina Miller³ and Osnat Gillor¹

¹Zuckerberg Institute for Water Research, Jacob Blaustein Institutes of Desert Research, Ben-Gurion University, Israel

²Dept. of Civil and Environmental Engineering, UC Davis, United States

³School of Veterinary Sciences, Dept. of Pathology, Microbiology and Immunology, UC Davis, United States

⁴Agricultural Research Organization, Volcani Center, Bet Dagan, Israel

The aim of this project is to establish whether pathogens (including bacteria, viruses and protozoa) would transfer from wastewater through the soil to the irrigated crops. We compared FIB and pathogen levels in five replicate tomato plots drip-irrigated with secondary treated effluents, and five replicate plots drip-irrigated with potable water. The purpose of using secondary treated effluents was to establish our ability to detect pathogens in environmental matrices, with the understanding that such low quality water would not be used to irrigate food crops in Israel or the United States. Indeed, effluents were found to contain high (>1600 MPN/100 mL) amounts of fecal indicator bacteria (FIB), including *Enterococcus* spp., fecal coliforms and *E. coli*, but were not appreciably contaminated with protozoan parasites and viruses. Potable irrigation water had no detectable FIBs. We found no significant differences in the number of FIB in the soil or on the crops between potable and effluent irrigated plots (N=40, p>0.1). Furthermore we found that the particular types of enteric bacteria present in the secondary water, e.g. *Proteus* spp., and *E. coli*, were not detected in the irrigated soil. The presence of bacterial and viral pathogens, e.g. *Salmonella enterica*,

Pseudomonas aeruginosa, and Enterovirus I were detected in both tap and effluent irrigated soil and on the respective tomato samples. Our findings to date suggest that 1) the transfer of FIB and microbial pathogens from effluent water to drip-irrigated soil may be marginal, 2) FIB screening of either the irrigation water or the soil may not be a reliable predictor of crop contamination.

Irrigation water re-use: Harnessing water for development by re-thinking traditional concepts of efficiency and wastage

Rahul Pillai Sivashanmugham; Department of Political and Cultural Change, ZEF (Centre for Development Research, University of Bonn, Walter-Flex Str 3, Bonn 53113, Germany; rpillai@uni-bonn.de

Canal systems are often long and winding, and may not be conducive to easy maintenance. Water, transported over longer distances, is bound to have losses through seepage. The efforts towards limiting seepage losses are mainly in the cement-lining of the canals, thus preventing water from percolating down. But being a costly procedure, and one that requires constant upkeeps and maintenance, it does not offer a fool-proof solution. The governments, acting through engineers and officials at the irrigation department and similar bodies, decry wastage and endeavor to spend more funds towards physical measures to stop seepage, and thereby to enable more water to reach the intended beneficiaries. But the story does not end here. The water that is lost from the irrigation canal need not actually be wasted. How? Water, once out of a guided and controlled system, reverts to following the local natural drainage, which the irrigation system usually juggernauts over. Thus, following the topography, this water would tend to move towards the lowest gradient, following the contours of the land. This usually leads to small brooks, where this water may appear as surface flows or continue as sub-surface flows. It is from such sources that farmers, often subsistence or small holding individuals, try to obtain water to irrigate their crops, which are otherwise almost exclusively rain-fed. This water can often be the difference between a successful harvest and crop failure, especially in drier areas with erratic rainfall. These conclusions were arrived at by the author based on the fieldwork conducted in semi-arid areas of the province of Andhra Pradesh, Southern India. It was, however, observed that water was available in the non-perennial streambed well outside the monsoon period. This could only imply seepage from the irrigation canals and the irrigated fields in the canal command area. This “stream” water was being used by farmers, in the lands designated as rain-fed, for agricultural purposes. In an effort to understand the mechanism better, surveys about motor-pumps along the natural drainage were conducted during the dry season in the study area, and the locations were digitized into the topographic sheet of the area, giving a clear idea of the extent of irrigation water re-use. The conclusions arrived at are just an effort to take forward the understanding of the interconnectedness of irrigation, agriculture and the whole livelihoods system, which we often consider separate worlds.

Latitude, basin size, and microhabitat effects on the viability of acacia trees in southern Israel

Ilan Stavi^{a*}, Silver, M.^b, Avni, Y.^c

^aDead-Sea & Arava Science Center, Ketura, 88840, Israel; ^bArava Drainage Authority, Sapir, 86825, Israel; ^cGeological Survey of Israel, Jerusalem 95501, Israel; istavi@yahoo.com

In the hyper-arid Arava Valley and eastern Negev desert of Israel, the acacia species of *raddiana*, *tortilis*, and *pachyceras* play a central role as keystone species. Many studies implemented during the last few decades have revealed considerable changes in acacia populations, including high mortality rates and low recruitment. This study aimed to examine the relationships between presumed water availability for acacia populations and their mortality. This was conducted by examining the effect on tree mortality of latitude, basin size, and microhabitat within the valley floor. A total of 1,980 acacia trees in 11 wadis along the Arava Valley and eastern Negev region were studied. The obtained results revealed a highly varied inter-wadi mortality rate, ranging between 6.7% and 72.2%. Overall, mortality within species occurred in 14.7% of *A. pachyceras*, 16.8% of *A. tortilis*, and 29.4% of *A. raddiana*. A highly negative correlation coefficient ($r=-0.56$; $P<0.0001$) was recorded between latitude and acacia mortality. However, a low and not

significant correlation coefficient was recorded between basin size and acacia mortality ($r=-0.24$; $P=0.2103$). In terms of overall occurrence in microhabitats across the valley floor, 6.4% of the trees were in main channels, 9.8% in high banks, 10.4% in bars, 19.1% in secondary channels, and 54.3% in low banks. However, the effect of microhabitat on acacia mortality was not statistically significant ($P=0.2240$). Also, the canopy height and diameter were measured in order to calculate a size-index for the trees. The values of this index were divided into four groups in order to represent the size distribution of trees. The overall occurrence of 3.6% of the small-size group is worrisome, as it presumably indicates very low recruitment rates.

Threats of Desertification in Mountain Valleys of the Kyrgyz Republic Due to Moraine-glacial Lake Outbursts and Mud Streams

Tamara Tuzova; Institute of Water Problems and Hydro Power; Bishkek, Kyrgyzstan;
Tv_tuzova@mail.ru

There are about 2000 high-mountain moraine-glacial and moraine-nogging lakes with a surface area of more than 0.1 km² of the territory of the Kyrgyz Republic. 10% of them have a potential danger of outbursts. The lakes are generally formed near glacial areas of river heads. More than 95% of the settlements of the Kyrgyz Republic are situated along their banks, in a dangerous zone of mudflow and freshet flow effects. Those flows can be especially disastrous during mountain lake outbursts. Highways, power lines, pipelines, villages, agricultural lands, and pastures are caught in the damage zones. About 70 dangerous mountain lake outbursts have happened during the last 50 years on the territory of the Kyrgyz Republic; several hundred people died, and the damage was about US\$ 500 million due to loss of cultivated lands along the river beds. Lake outbursts are accompanied by strong mudflows. They turn flowering mountain valleys into stone and dirt deserts.

In this paper different assessment methods of possible damage caused by mountain lake outbursts, including the use of uranium-isotopic ones, are described. The mechanism of lake outburst is determined and outburst flow discharge is calculated; the danger of a mudflow in the mountain valley, where the outburst flow would pass, is assessed; the damage zone of outburst flow is traced. Maps of damage zones from outburst flows and mudflows are charted for potentially dangerous mountain valleys. The degree of land degradation due to possible outbursts is realized and recommendations on lowering risk and damage caused by such phenomena are given.

Total uranium C content and ratio of its even isotopes $\gamma = {}^{234}\text{U}/{}^{238}\text{U}$ in the ices and waters of six mountain moraine-glacial lakes of Northern Tien-Shan has been calculated. The uranium-isotopic characteristics of the main sources of those lakes' tributaries have been determined. The possibility of using uranium-isotopic parameters as one of the criteria to estimate the danger of moraine-glacial lakes outbursts has been shown.

Identification of lake outbursts is carried out by means of aero visual flights over glacial mountain territories and by studying aerial and space prints thoroughly. The discovered lakes are recorded in a special catalogue. The form of the catalogue of outbursts is developed by specialists from the Czech company GEOMIN. New information on changes in outburst lakes development is regularly added to the catalogue. At the present time information on 364 lakes, studied in the period from 1966 to 2012, is recorded in the catalogue. They are divided into three categories:

1st category – the most dangerous ones. Lake is in a stage of outburst; it is necessary to carry out protective and preventive engineering actions to prevent possible catastrophic consequences of outburst.

2nd category – dangerous ones. In its development a lake is nearing the stage of outburst, but at the present time there is no direct threat; Observation points must be organized on the lake.

3rd category – the less dangerous ones.

At the present time out of 364 lakes included in the catalogue of the Kyrgyz lake outbursts, 18 are the most dangerous ones, and 56 are the dangerous ones. The rest are less dangerous.

The lakes of the moraine-glacial pose the biggest threat. In the catalogue of lake outbursts there are 47% of them; 12% of the lakes are obstructed ones; 1% are glacial ones.

To assess the danger of outburst of alpine lakes land investigation of their dams and baths is carried out.

Out of 18 lakes of the first category of outbursts danger, 12 are of moraine-glacial type, 3 are landslip-obstructed ones, 2 are mudflow-obstructed ones, and one is glacial.

In order to provide reliable prognosis of mountain lake outbursts posing a threat to the capital of the Kyrgyz Republic, Adygene, the only glacial hydro-meteorological station, has been functioning at the height of 3660 meters since 2008. It was built with the financial support of the Czech Republic; now enthusiastic glaciologists are needed at the station. Organization of such stations in all the zones with concentrations of mountain lakes will allow the minimization of risks and damages caused by their outbursts. However, without international collaboration and considerable funding it is impossible.

Microlysimeter Station for Long-Term Non-Rainfall Water Input and Evaporation Studies

Olga .M. Uclés¹, L. Villagarcía², Y. Canton³ & F. Domingo¹

1. Estación Experimental de Zonas Áridas. Carretera de Sacramento s/n. 04120 - La Cañada de San Urbano Almería, (Spain). olgaucles@yahoo.es; poveda@eeza.csic.es

2. Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Carretera de Utrera Km1, 41013 – Sevilla (Spain). lvilsai@upo.es

3. Departamento de Edafología y Química Agrícola. Universidad de Almería. La Cañada de San Urbano s/n. Almería (Spain). ycanton@ual.es

We present an automated weighing microlysimeters station capable of measuring evaporation and dewfall condensation in field conditions. This station is designed to handle rainfall and other meteorological variables. Furthermore, it avoids possible movements that could throw the microlysimeters out of balance, allowing the possibility of long-term studies. The weighing microlysimeters consisted of a home-made balance using a single point aluminum load cell (model 1022, 3 kg rated capacity, Vishay Tedeá-Huntleigh, Switzerland). The microlysimeter had a resolution of 0.01 g under laboratory conditions, the total error was 0.02% of the rated output and there was internal temperature range compensation. The microlysimeter was designed to minimize the remaining temperature dependence, i.e. it was built with aluminum and polystyrene materials and a waterproof cover. The sampling cup was made with PVC with 0.152 m of diameter and 0.090 m deep, and it was capped at the bottom with a Teflon cup. Twelve weighing microlysimeters were located in a Mediterranean semiarid steppe ecosystem (Balsa Blanca, Almería, SE Spain). They were located in groups of three inside wooden boxes and buried in the field, so the surface of the sampling cup was level with the surrounding surface. These boxes were anchored and leveled in the soil with steel rods. A total of four boxes were buried, and each of them had a drainage tube connected to a pit. A pipeline connected the pit with the surface so that the pit conditions could be checked after each rainfall event. Boxes were filled with polystyrene material. The surfaces of the boxes can be covered with sand from the surroundings so as not to change the albedo properties near the samples. Changes in mass and other meteorological variables were monitored and stored in a data-logger. The system was energy supplied by a solar panel installation and a voltage stabilizer. Field calibrations using standard loads were made once a week. The microlysimeters station was tested in the field to monitor water condensation and evaporation on different surface covers (bare soil, biological soil crusts, stones and small plants).

Sediments in Semi-arid Wetlands: U. S. Southern High Plains

Richard Zartman^{1*}, Carlos J. Villarreal², Dennis Gitz³, Ken Rainwater⁴ and Loren M. Smith⁵

¹Department of Plant and Soil Science Texas Tech University, Lubbock, TX 79409-2122; richard.zartman@ttu.edu

²Former graduate student of the Plant and Soil Science Department, Texas Tech University, Lubbock, TX 79409-2122 currently with the USDA-NRCS, Bryan, TX. ³USDA-ARS-WEWC, 3810 4th Street, Lubbock, TX 79415. ⁴Water Resources Center, Texas Tech University, Lubbock, TX 79409-1022. ⁵Department of Zoology, Oklahoma State University, Stillwater, OK.

Playas are semi-arid wetlands on the U.S. Southern High Plains that serve as runoff catchment basins and are thought to be focal points of Ogallala aquifer recharge. Sediments in playas alter biodiversity and hydroperiods. The purpose of this study was to evaluate the effects of outerbasin vegetation on post-

cultural sediment deposition in three pairs of cropland/native grassland playas. A hydraulic probe was used to collect soil cores for particle size distribution and soil color determination. Particle size distribution was useful in identifying sediment distribution. Soil color transitions with depth from very dark grayish brown (10YR 3/2) to very dark gray (10YR 3/1) were present in cropland playas, but not in grassland playas. Sediment volume in each playa was calculated from sediment thicknesses and was related to outerbasin land use. Sediment thicknesses were interpolated between sampling locations using a kriging model. Sediment volume was directly related to watershed land use with more accumulated sediment in cropped playas than in grassland playas. Sediment deposition from cultivated outerbasins contributed sediments that decrease playa depth.