EBONE

European Biodiversity Observation Network:

Design of a plan for an integrated biodiversity observing system in space and time

D 9.1 Report on field tests of LTER and habitat monitoring.

Ver 2.0
Document date: 2010-16-04

Document Ref.: EBONE-D9.1-2.0

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EC-FPV Contract Ref: ENV-CT-2008-212322

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1. Executive Summary

1.1. Objectives

The overall objective for WP9 is to develop a prototype system for monitoring mediterranean and desert ecosystems outside Europe, using EBONE principles and methodology. We did this from two perspectives: first, from the need of EBONE for testing methods, and second, from the need for Israel to develop and implement a biodiversity monitoring system

The work was done in a collaboration of partners in Israel, South Africa, France and Greece, with methodological guidance from Alterra and ILE-SAS. The objective was divided into five tasks (see below). The field testing is ongoing and will continue in INPA after the EBONE project ends, but a snapshot of field testing results until now will be given in this report.

The objective of Task 9.1 is to develop habitat categories for biomes outside the EU27, and enable the linkage of European mediterranean to non-European mediterranean and desert habitats. So far this has been tested in two LTER sites in Israel and several semiarid sites in South Africa and has resulted in a modification of the habitat description manual for the project. Further field work is planned for semiarid western Australia, South Africa, and Greece during the coming year.

The objective of Task 9.2 is to establish habitat databases compatible with those used in the EU and to determine whether pre-existing data can be used for our purposes. This process is on-going as database methodology develops in the overall project.

The objective of Task 9.3 is to test the habitat mapping and description procedure in a variety of biomes, sampled in a rational and statistically viable manner.

The objective of Task 9.4 is to link biodiversity data with habitats and remote sensing data.

The objective of Task 9.5 is to provide guidelines for extending the EBONE monitoring approach to other biomes. We will focus on this in the final year of the project.

1.2. Key Results

Field work has been completed in two LTER sites (mediterranean Ramat HaNadiv and Negev Desert site Avdat), in each of which four squares of 1 sq. Km area were mapped using EBONE methods. In Ramat HaNadiv pre-existing species diversity data were studied in an effort to connect these with habitat type; in Avdat new species diversity data were collected in a sampling design oriented to the mapping. In Ramat HaNadiv, existing work on remote sensing using Lidar was related to the habitat mapping.

A new remote sensing module was started in Israel this summer, analyzing habitat categories in relation to remote sensing data at three scales in three LTER sites: Ramat HaNadiv, Avdat, and semiarid steppe LTER site Lehavim. This work is in progress, and includes partial habitat mapping of Lehavim.

Field exercises, a local workshop and one international workshop were held in Israel to connect with local stakeholders. This has been quite successful and will be continued with another international workshop if funds permit.

Database work is ongoing in connection with WP7 and the ILTER program.

Essentially, the work progressed as a series of separate projects, which will be discussed in brief below. We should note that many of these projects are still continuing. Those which are complete (mostly work by graduate students) have separate reports which are included in the Appendix. This includes the analysis of LiDar and habitat by Lior Blank, the M.Sc. thesis of David Jobse on habitat and biodiversity in Ramat HaNadiv LTER, and the M.Sc. thesis of Adriaan de Gelder on habitat comparison through time in En Afeq Nature Reserve.

2. Testing the mapping procedures

This project addressed Objective 9.3, and served as a necessary precursor to Objective 9.1.

2.1. Site Selection

In Israel we selected two LTER sites which were endpoints of the Mediterranean to desert gradient.

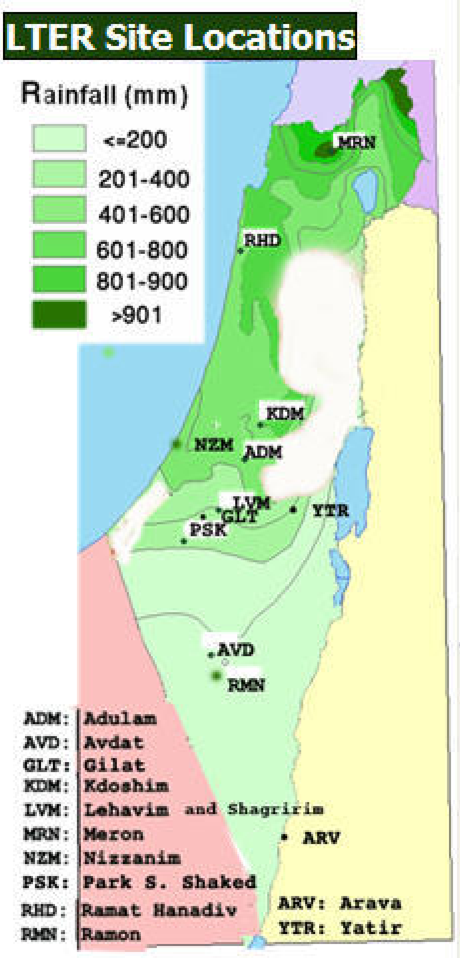

Figure 1: LTER sites in Israel, from the Israel LTER network, http://lter.bgu.ac.il/Default.aspx

The Mediterranean site, the Ramat Hanadiv LTER site is located in the Southern part of Mt. Carmel, in the Mediterranean region of Israel. Annual rainfall is 600 mm; elevation is 120 m (max); size is 500 ha. Vegetation is Mediterranean garrigue, Mediterranean maquis, open rangelands, planted pine and cypress groves, rocky cliffs, dry riverbeds, spring, orchard, cultivated garden.

Figure 2: Mediterranean maquis in Mt. Carmel

The park covers an area of 500 hectares, and is patchy in nature and rich in biological diversity. The area is covered by garrigue communities, dominated by the moderate-sized shrubs *Phillyrea media*, *Pistacia lentiscus*, *Calycotome villosa* and the dwarf shrub *Sarcopoterium spinosum*. It has experienced a long history of human usage and impact, including grazing and clearing activities. The park was fenced in 1950 and grazing was excluded for 40 years. The area was burnt by a wild-fire in 1980. In 1992, a fuel break zone was established in the park to reduce fire damage and distribution. Technically the private property of the Rothschild family, the area was designated by the Rothschild Foundation twenty years ago for public use, education and ecological research. However, during these twenty years, mostly short-term scientific research, both applied and pure, has been carried out in the park. Today, the orientation is towards long-term thinking and planning, including an LTER site established in 2003.

The types of data collected (on a routine basis) include: herbaceous community diversity and woody vegetation structure, in different habitats and grazing regimes; population dynamics and habitat preferences of gazelles, wild boars, jackals, mongoose and chukars; species diversity and habitat preferences of butterflies, songbirds and snails; monitoring re-introduced raptors and roe deer. The park is a distinctive example in Israel of a well-investigated and carefully-managed natural area. As such, it has become a model for the conservation, rehabilitation and management of Mediterranean ecosystems in Israel. (Information from the Israel LTER network, http://lter.bgu.ac.il/sites/rhd.aspx)

The desert site, LTER Avdat, is arid shrub-steppes consisting of rocky slopes and loessial ephemeral streambeds and ancient agricultural terraces. Mean maximum summer temperature is 32 ºC; mean minimum winter temperature is 5 ºC. Vegetation is dominated by dwarf shrubs (Hamada scoparia on plains, Artemisia crassifolia and Zygophyllum dumosum on slopes).

Figure 3: Mediterranean maquis in Mt. Carmel

The site was established in 1958 by the Hebrew University of Jerusalem. Livestock grazing has taken place in the area for thousands of years. Remains of ancient Nabatean runoff agriculture (ca. 0-300 AD) in the form of terraces are still evident. Currently Bedouin inhabitants practice sedentary pastoralism with goats, sheep and camels. Livestock grazing has been excluded from parts of the site. (Information from the Israel LTER network, http://lter.bgu.ac.il/sites/avd.aspx)

Our resources enabled us to fully map four squares in each of the two sites. These were randomly selected within a 100 sq. km. grid, with some qualifying restrictions in the Mediterranean site (not on the sea and not in urban areas). Recently we added to that LTER site Lehavim, in semiarid steppe, intermediate between the earlier two sites.

2.2. Mapping: Testing EBONE habitat field sampling in Israel – procedures and results

Timetable

Our testing of EBONE habitat mapping methods actually predated the approval of the EBONE grant, since we held our first BioHab mapping workshop during 6-7 March 2006, after participating in a similar exercise led by Bob Bunce in Portugal. This workshop was taught by Bob Bunce and Marc Metzger, and attended by about 30 professionals in conservation and ecology. Field exercises were held in LTER Ramat HaNadiv. This workshop gave us our first formal exposure to BioHab mapping in the field, and generate considerable enthusiasm. This was followed by more training exercises in Hebrew at Park Britannia on 22 February 2007, again with participation of Bob Bunce, in which professionals were able to evaluate the mapping approaches in current use, versus BioHab. As a group, we decided to continue this exploration of methods .

Various needs became clear from these workshops: first to have a Hebrew language translation of the BioHab forms and the field manual (at least condensed). This was done by Margareta Walczak and provided the basis for our field trials during EBONE.

After EBONE was funded, we held another working visit with Bob Bunce at the end of October 2008 with special focus on desert habitats, an inspection of various desert types in Israel, and an one day workshop with stakeholders. During this visit, classification problems with arid lands were clarified, and Margareta Walczak joined Bob Bunce in a revision of the field manual in light of these developments.

This regular participation of stakeholders on a yearly basis has generated considerable momentum in Israel to use EBONE approaches on a national basis, in a collaboration of several national agencies under the auspices of the Israel LTER system. It has also provided us with valuable field experience and professional criticism of the methods as we develop them.

In 2009, the first formal EBONE habitat test mapping was done, first in the Negev Desert, Avadat area in February 2009, and then in the Mediterranean – Ramat HaNadiv and Ramot Menashe area in March 2009. (We added the Mediterranean-to-desert transition zone – Lahav and Lehavim area in July 2010.)

Practical tasks included time and man-power estimation since we worked with contracted field staff. Additional work included translation of necessary parts of the BioHab Field Manual into Hebrew – about 10 working days (80 hours), preparation of a field manual in Hebrew - about 4 working days (40 hours) and preparation of tables of relevant Qualifier codes - about 4 working days (40 hours). This was followed by preparing a program to train the field staff and training the contracted staff (mostly from stakeholder organizations or freelancers) in the EBONE mapping pro – altogether about 5 days of work. In advance of the field work, the INPA GIS laboratory prepared Ortho-photos and maps for field work – about 6 working days (60 hours)

The field sampling done so far is as follows

Area	Square Number	Square size	People*days
Avdat	33	1 sq. km	5
Avdat	42	1 sq. km	8
Avdat	63	1 sq. km	8
Avdat	68	1 sq. km	8
Ramat-HaNadiv	17	1 sq. km	7
Ramat-HaNadiv	40	1 sq. km	9
Ramat-HaNadiv	55	1 sq. km	8
Ramat-HaNadiv	57	1 sq. km	6
Lehavim	1	0.25 sq. km	0.5
Lehavim	2	0.25 sq. km	1
Lehavim	3	0.25 sq. km	1
Lehavim	4	0.25 sq. km	0.5
Lehavim	5	0.25 sq. km	0.8
Lehavim	6	0.25 sq. km	0.8

Lehavim	8	0.25 sq. km	1.2
Lehavim	9	0.25 sq. km	0.8
Lehavim	10	0.25 sq. km	0.8
Lehavim	11	0.25 sq. km	0.8
Lehavim	12	0.25 sq. km	0.8

Table 1: Study areas, sampled squares and work invested.

In both Avdat and Ramat HaNadiv, the squares were placed randomly in a 100 sq km grid, with limitation on the amount of agricultural or urban land included. Lehavim squares were selected according to remote sensing signals, since this work was done in direct cooperation with the laboratory working on our remote sensing studies. Only small areas were needed for this particular purpose, hence smaller squares.

The core of the of mapping team consisted of 9 people, mostly experienced field biologists and ecologists bearing good knowledge of the mapped areas and of the local flora. Many were "freelance" environmental consultants, some graduate students (including Lior Blank, who contributed the LiDar study to this report), and staff from stakeholder organizations. We therefore had an unusually qualified team.

Mapping Results

The Ramat HaNadiv 10 x 10 grid, the sampling squares, and an example square kilometer are shown below. The anthropogenic nature of much of the landscape in the Mediterranean is quite clear both from the orthophoto (the estate grounds in the upper left and the quarry in the lower left of Square 55, for example).

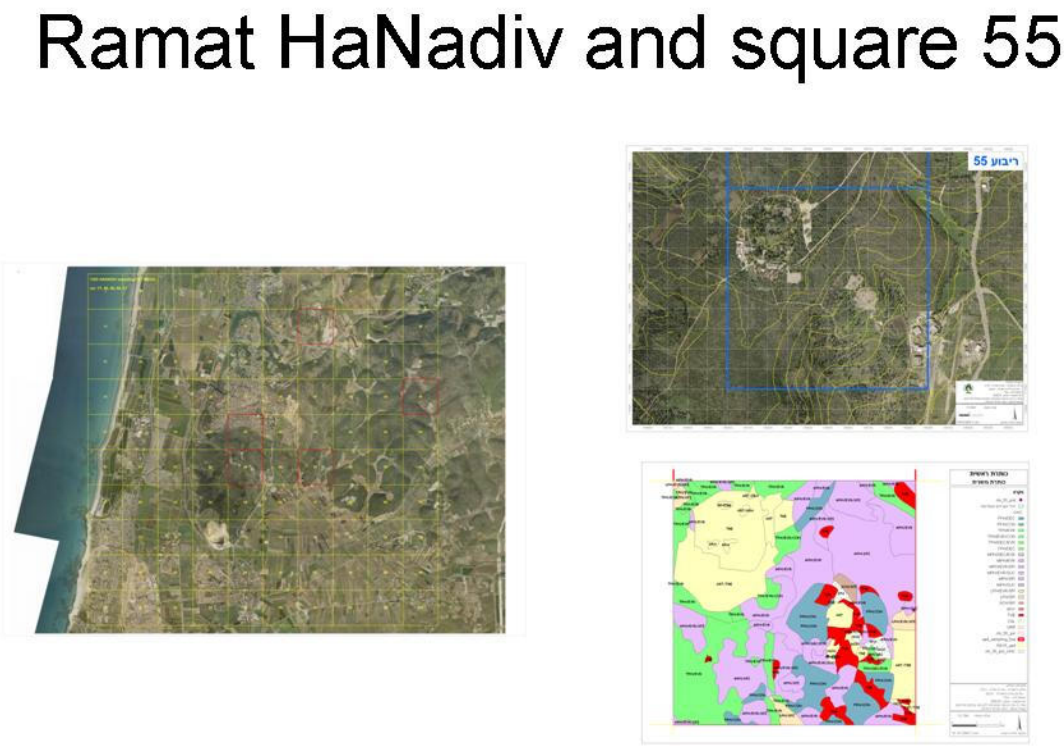

Figure 4: Orthophoto and maps of Ramat HaNadiv

In contrast, the desert landscape is mainly determined by geomorphology, although the ruins of ancient agriculture are clearly visible as terraces.

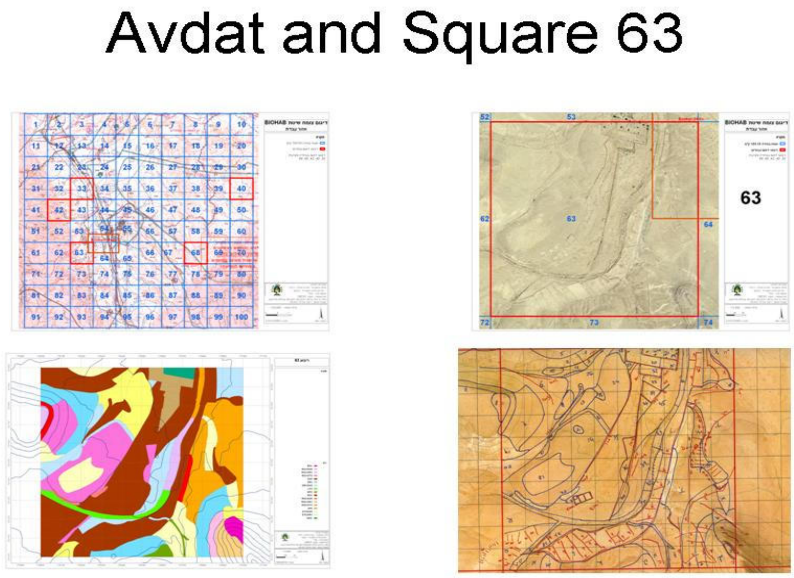

Figure 5 : Orthophoto and mapped areas in

The following table summarizes the general results of the mapping. In all the mapped areas we recognized 72 different General Habitat Categories (after the modification introduced as described farther on). In Avdat area there 32 identified categories (16 before the modification), in Lehavim area – 22 GHCs, in Ramat HaNadiv area – 39 GHCs

Area	Square Number	Number of Polygons	Number of Linear Features	Number of GHC – original classification	Number of GHC – revised classification
Avdat	33	58	24	13	24
Avdat	42	54	23	4	16
Avdat	63	67	33	7	19
Avdat	68	55	17	3	16
Ramat HaNadiv	17	96	not mapped	27	27
Ramat HaNadiv	40	92	not mapped	16	16
Ramat HaNadiv	55	98	not mapped	25	25
Ramat HaNadiv	57	68	not mapped	19	19
Lehavim	1	9	not mapped	5	5
Lehavim	2	21	not mapped	4	4
Lehavim	3	18	not mapped	9	9
Lehavim	4	8	not mapped	4	4
Lehavim	5	11	not mapped	6	6
Lehavim	6	20	not mapped	9	9
Lehavim	8	34	not mapped	9	9
Lehavim	9	18	not mapped	2	2
Lehavim	10	22	not mapped	6	6
Lehavim	11	17	not mapped	5	5
Lehavim	12	19	not mapped	7	7

Table 2 Polygons and GHC's per sampled square

3. Definition of new habitat categories:

Modification of habitat mapping procedure and categories

Mapping in Desert area according to the BioHab procedure proved to be inadequate for this kind of biome. Nearly entire "natural" area was originally classified as SPV/TER sparsely vegetated – terrestrial. From the field observation we realized that although the vegetation cover was below 30% and usually below 5%, the area was clearly divided to various habitats, characterized by different plant species composition. It seemed that the kind of bare ground coverage was well correlated with these habitats. Following this experience the modification was introduced to the Field Manual and SPV/TER category was divided as follows
ROC continuous rock divided by cracks, crevices or gullies
BOU boulders over 0.20 m diameter
STO rocks and stones 0.05-20 m diameter
GRV gravel 0.01-0.05 m diameter
SAN sand 0.001-0.01 m diameter
EAR earth, mud, silt and bare soil below 0.001 m diameter

Note: ROC and other categories of TER can also occur in combinations when they are 40-60% (from R. Bunce)

4. Mapping through time

4.1. Introduction

During spring 2010, an M.Sc. student named Adriaan de Gelder from Wageningen University conducted a mapping exercise in En Afeq Nature Reserve, testing the efficiency and usefulness of EBONE structural mapping methods versus traditional phytosociological mapping, with a particular emphasis on evaluating conservation management.

En Afeq is a small wetland nature reserve in the western Galilee (map) with several management problems, including drop in the water table, changing vegetation, and invasive plant species. We were asked to repeat a mapping done in 1998 by another Wageningen University M.Sc. student, Nico Burgerhart, to see what changes had taken place under management over 12 years. We were able to relocate Mr. Burgerhart in the Netherlands and enlisted his help in this work.

Analysis of the habitat changes is still underway but it is possible to compare EBONE versus phytosociological mapping done on the same areas in this study.

Aspect	Phytosociology	EBONE
Time investment	5-8 samples/day	15-20 polygons per day
Knowledge	Extensive list of species	Dominant species and life forms
Coverage	Only part of the area in the field	The whole area in the field
Rules	Clear and objective	In development, subjective
Biodiversity	Alpha and beta diversity only	Beta diversity only
Classification	Syntaxonomy is missing here	EBONE provides an universal classificationsystem

Table 3: comparison of EBONE and classic phytosociology at En Afeq

It was possible to work backwards from the vegetation maps made by Nico Burgerhart to create an EBONE habitat map of the area for 1998 as well as 2010 (Fig ***). Despite ambiguities in the reconstruction, the changes in habitat are interpretable and fit with the experience of the staff at the nature reserve. Active management resulted in increased habitat complexity and reduction in the coverage by invasive Tamarisk (TPH/EVR) which was clearly reflected in the habitat maps. This work is ongoing; the resulting thesis by Mr. De Gelder will be appended to this report when he is finished with it.

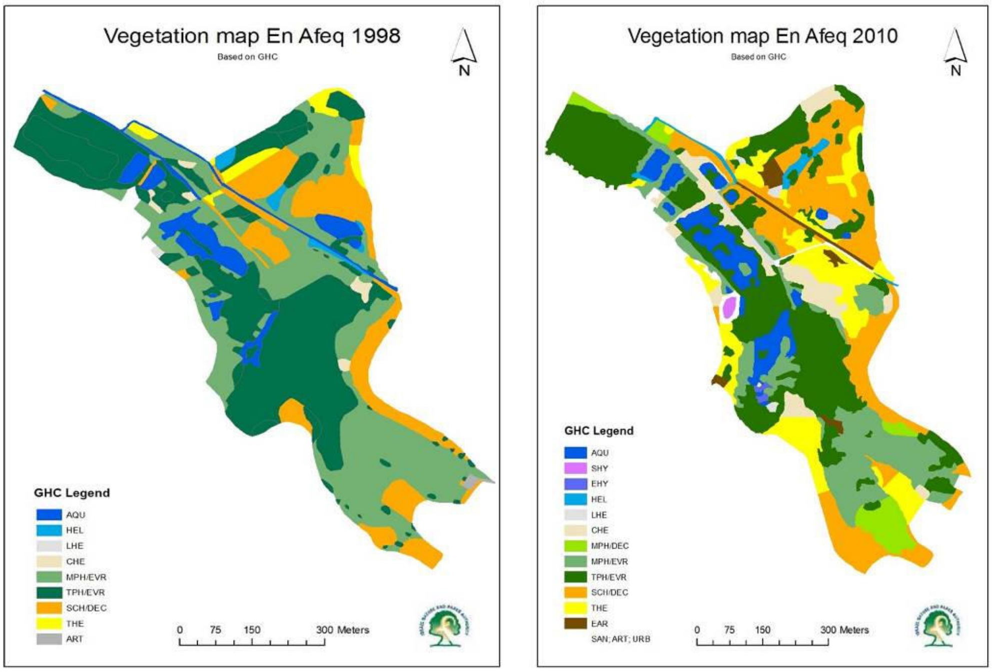

Figure 6: En Afeq GHC maps for 1998 and 2010

5. Connecting habitat with remote sensing: Lidar

5.1. Introduction

The specific objective of the BioHab framework for a European-wide monitoring of habitats, is"…to obtain statistically robust estimates of their extent and associated changes in biodiversity" (Bunce et al. 2005). The BioHab methodology is a system for consistent field recording of habitats and for subsequent monitoring. This is done by field recording of so-called General Habitat Categories, and is based on the hypothesis that habitat structure is related to environmental factors. This is a practical, transmissible, and reproducible procedure for surveillance and monitoring habitats which can produce statistics integrated at the landscape level.

The methodology is based on classical plant life forms, used in biogeography since the nineteenth century. The principal advantage of the GHCs is that they enable the primary decision on habitat category to be made in the field without the necessity of subsequent data analysis. Their primary disadvantage is the demanding resources of time, money, and human industry involved, restricting such mapping to relatively small areas. It was proposed that remote sensing and image analysis could be combined for automating mapping of GHCs, to complement mapping in situ, which could then be used for evaluation purposes. The major question here is how well could remote sensing products correspond to in situ

BioHab vegetation mapping. The overall objective of this project was to compare the BioHab classification conducted in Ramat HaNadiv Nature Park in 2009 with a specific remote sensing product, based on LiDar.

Two independent remote sensing sources were used to calculate the proportion of woody cover. The first is based on LiDar (Light Detection and Ranging) data and the second is based on image classification. LiDar height data were also used to construct an estimate of the proportion of each height class (FPH, TPH, MPH and LPH) in each polygon, fully compatible to the BioHab GHC classification (Table 1).

5.1.1. LiDar data

A LiDar point cloud was acquired by Ofek™ in 2005, with an Optech™ ALTM2050 LiDar, which operates at 50 KHz, and recorded the first return for each laser pulse. Flight altitude was 1500 m. Following geocorrection, the vertical accuracy of the LiDar points was 0.15 m, and the planimetric accuracy was 0.75 m. A digital elevation model (DEM, representing ground height) was generated by overlaying the LiDar on a color orthophoto (0.25 m pixel size), identifying LiDar hit-points located on the ground, and extrapolating the data from these points to create a 2 m grid. In order to derive the height of each point, the DEM value underneath each point was subtracted from the point elevation.

5.1.2. LiDar-based woody cover layer

We assumed that woody vegetation was taller than 0.2 m (approximately the minimal height of *Sarcopterum spinosum*, the smallest woody shrub in the study area). We then reclassified the DTM into a binary image of two classes: woody vegetation and background (consisting of herbaceous vegetation, rocks, and ground). In order to compare between LiDar and BioHab products, we need to make the two layers compatible. We therefore overlaid the BioHab polygon contours on top of the LiDar-based vegetation cover layer. A LiDar –based estimate of woody cover for each polygon was calculated as the polygon-specific proportion of woody vegetation pixels.

5.1.3. LiDar-based GHC layer

We overlaid the BioHab polygon contours on top of the LiDar-based vegetation cover layer. A LiDar –based estimate of the height categories for each polygon was calculated as the polygon-specific proportion of woody vegetation pixels at each specific height category.

5.1.4. Aerial photo – based woody cover layer

A digital color orthophoto of the study area was generated by Ofek™ aerial photography, in the summer of 2009 at a spatial scale of 0.25 m (Figure 1). The image was classified into two classes using unsupervised Iso-Data classification (Campbell 1996). In the summer there are only two major spectral classes, corresponding to woody vegetation and non-vegetated areas, since there is no herbaceous vegetation in the dry season.

5.2. Methods evaluation

We compared the three methods that were used to calculate the percentage of woody cover: LiDar-based, aerial photo-based and the field-based mapping done using the BioHab protocol (hereafter referred to as LiDar, air photo, and BioHab, respectively). This pair-wise comparison (i.e. two methods at one time) calculated the average of the absolute differences between the proportion cover estimated for each polygon. In the same way we calculated the differences in cover of each height class in each polygon as estimated by the BioHab protocol and the LiDar.

5.2.1. Results

LiDar and air photo resulted in quite similar estimates of woody cover, with an average difference of about 8.5% when comparing 88 polygons. However, comparing each of these methods to BioHab we found higher average difference of about 20%. The magnitude of the absolute difference was not correlated to polygon size.

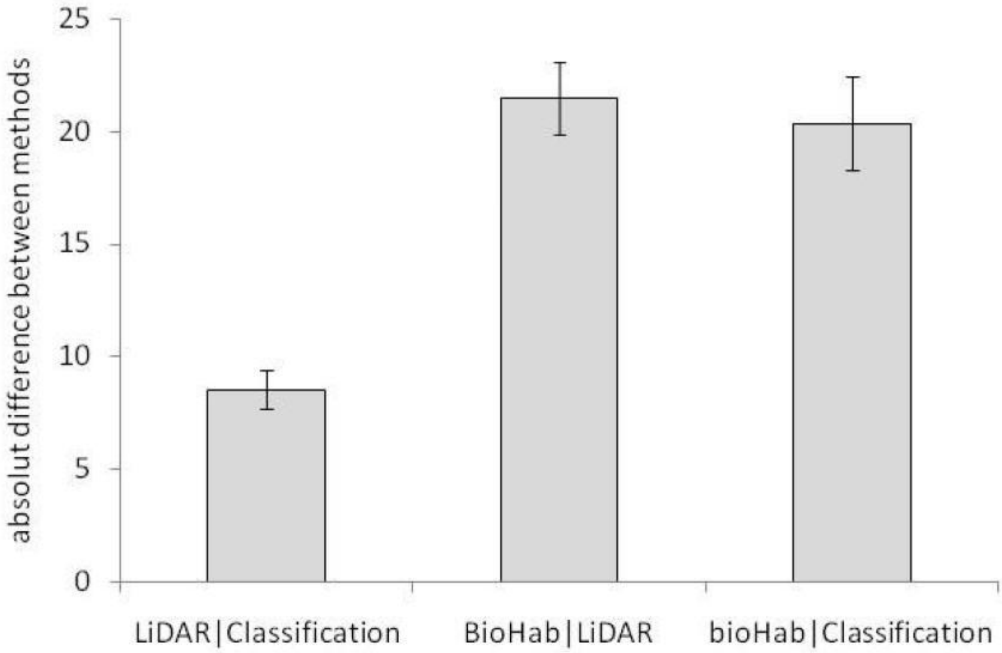

Figure 7: Comparison of LiDAR and BioHab classification in Ramat HaNadiv. Y axis represents The absolute average difference in estimating the percentage of woody cover between pairs of the three methods (±SE).

5.3. Discussion

Relatively large differences were found in woody cover estimates between each of the two remote sensing products and BioHab product, while smaller differences were found between the two independent remote sensing products. In addition to the formal accuracy assessment, we evaluated the products qualitatively, based on inspection of the air photos and our acquaintance with the area. We noticed incidences where LiDar-based estimates were clearly wrong, possibly because of the inherent error in LiDar scanning hardware and the four years difference between the time the image was acquired and the BioHab mapping. (Artifacts and error in LiDAR data are introduced through LiDAR system settings, operator error, machine malfunction, aircraft pitch calibration and horizontal displacement error; see Su and Bork, 2006; Hodgson and Bresnahan, 2004.)

In other cases BioHab estimates were mistaken. BioHab errors could be attributed to the misidentification of locations on the air photo or to the erroneous estimation of cover and height by the surveyors.

LiDar imagery may be used to construct a vegetation map which is partially compatible to the BioHab product. However, some of the information derived using the BioHab method can not be gained from LiDar observations, such as the dominant species and the management regime in the area.

The above considerations lead us to conclude that cover estimates of the LiDar-based product are more reliable than those of the BioHab product, at least in complex and dense Mediterranean vegetation. Similarly, we feel that cover estimates of the vegetation height-classes based on LiDar are more accurate than the field based BioHab estimates. However, for the height class estimates there is no additional validation source, and independent accurate height measurements need to be made in the field in order to evaluate the performance of both methods.

Future mapping should integrate field survey and remotely sensed mapping components to ensure the strengths and weakness of each approach is fully exploited. For example, remote sensing methods are recommended for estimating vegetation cover while the BioHab protocol should be used for identifying vegetation life forms and management

6. Connecting habitat with remote Sensing: Thematic mapping Remote sensing of Israel's natural habitats

Here, the aim is to develop a remote sensing methodology for mapping EBONE land cover categories from space-borne sensors and to examine the relationship between the remotely sensed categories and in-situ habitat data. The plan is to evaluate various sensors in order to develop a general methodology and specify sensors that offer good performance and yet are not prohibitively costly. In addition, we will examine what are the limitations of remotely sensed based classification with respect to the EBONE categories and the spatial heterogeneity characterizing Israel's Mediterranean and desert landscapes. Once the project is over the resulting layers will be made available for public use.

Our study area covers the State of Israel and ranges from extreme desert in the south to Mediterranean areas in the north of the country. While our aim will be to map natural land cover categories throughout Israel, EBONE-wise field mapping of habitats has so far been conducted within two areas in Israel, Ramat HaNadiv in the north, and Avdat in the south). An additional site will be mapped as part of this work in the transition area between the desert and the Mediterranean (e.g., Lehavim, ***Figure 1***). We will develop and test our methods on the field sites, and then apply them to the entire country.

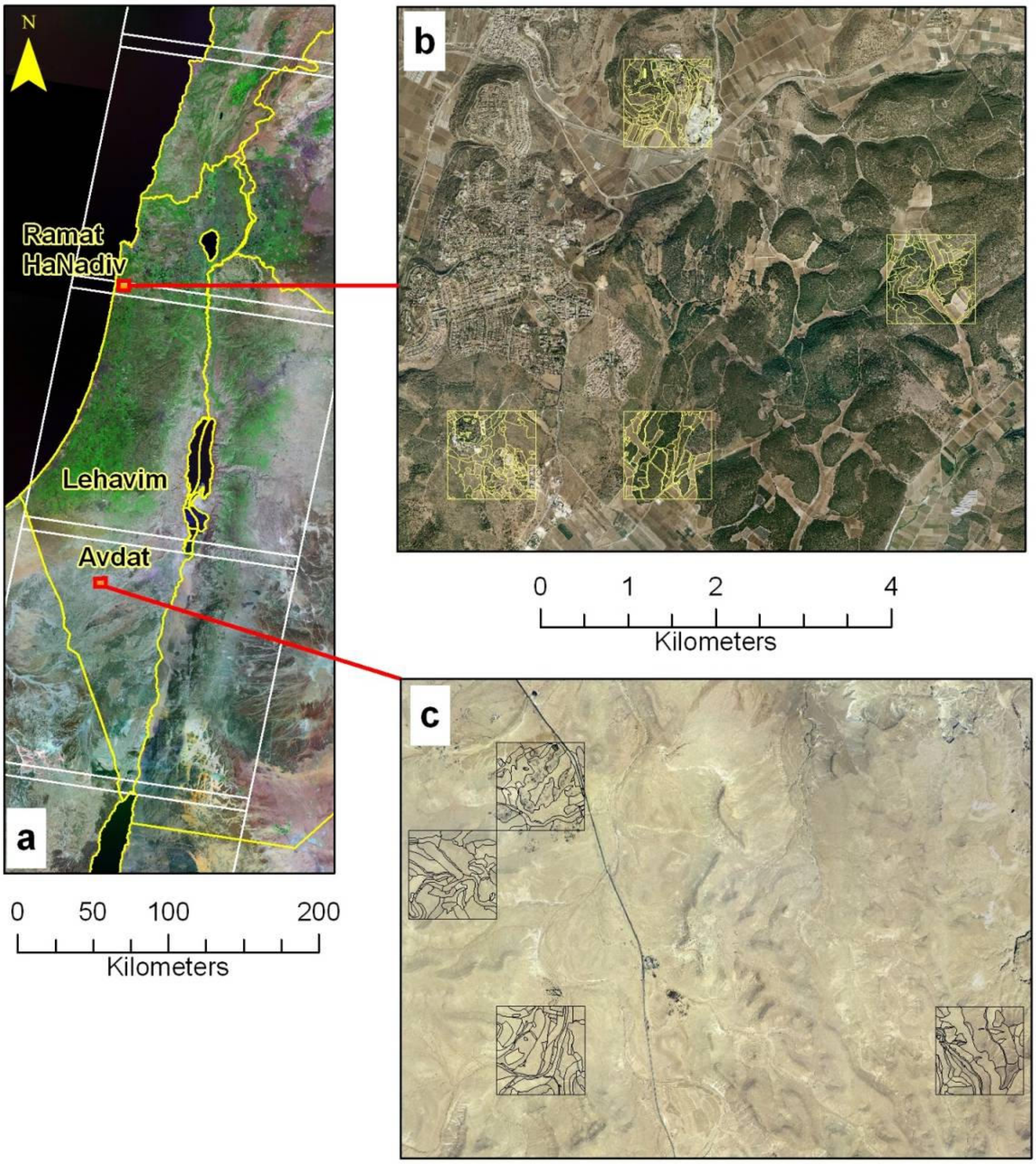

Figure 8: Study area map. a: Extent of Landsat scenes (in white) covering Israel; b: Ramat HaNadiv field mapping sites; c: Avdat field mapping sites.

Our classification scheme aims at reflecting the primary EBONE classes. These include four height classes of woody vegetation: (1) FPH--Forest Phanerophytes, FPH>5m. (2) TPH- Tall Phanerophytes, 5m>TPH>2m. (3) MPH- Mid Phanerophytes, 2m>MPH>0.6m. (4) LPH- Low Phanerophytes, LPH<0.6m. Our scheme will reflect the major BIOHAB woody vegetation types: (1) conifers, (2) deciduous, and (3) evergreen broad leaves. In the arid areas the classification may be based in addition to remotely sensed parameters related to vegetation, on topographic and geomorphologic variables. The minimum mapping unit defined within EBONE is 20×20m, roughly corresponding to the spatial resolution of Landsat TM (30×30m).

Sensor	Spatial resolution (m)	Spectral resolution	Temporal resolution
MODIS (MOD13Q1)	250 500 1000 250	2 bands 7 bands 36 bands EVI, NDVI	1-2 days, 16 day composite
Landsat TM	30	6 bands	Varies (cloud free), theoretically 16 days
QuickBird	2.5	4 bands	Only when tasked

Table 4 The different remote sensors used in this study:

Preliminary results – spectral separability. We calculated the following variables from the MODIS time series: NDVI mean, NDVI CV, and STDEV of the RED band, and arranged data from known habitats in Israel along three corresponding axes.

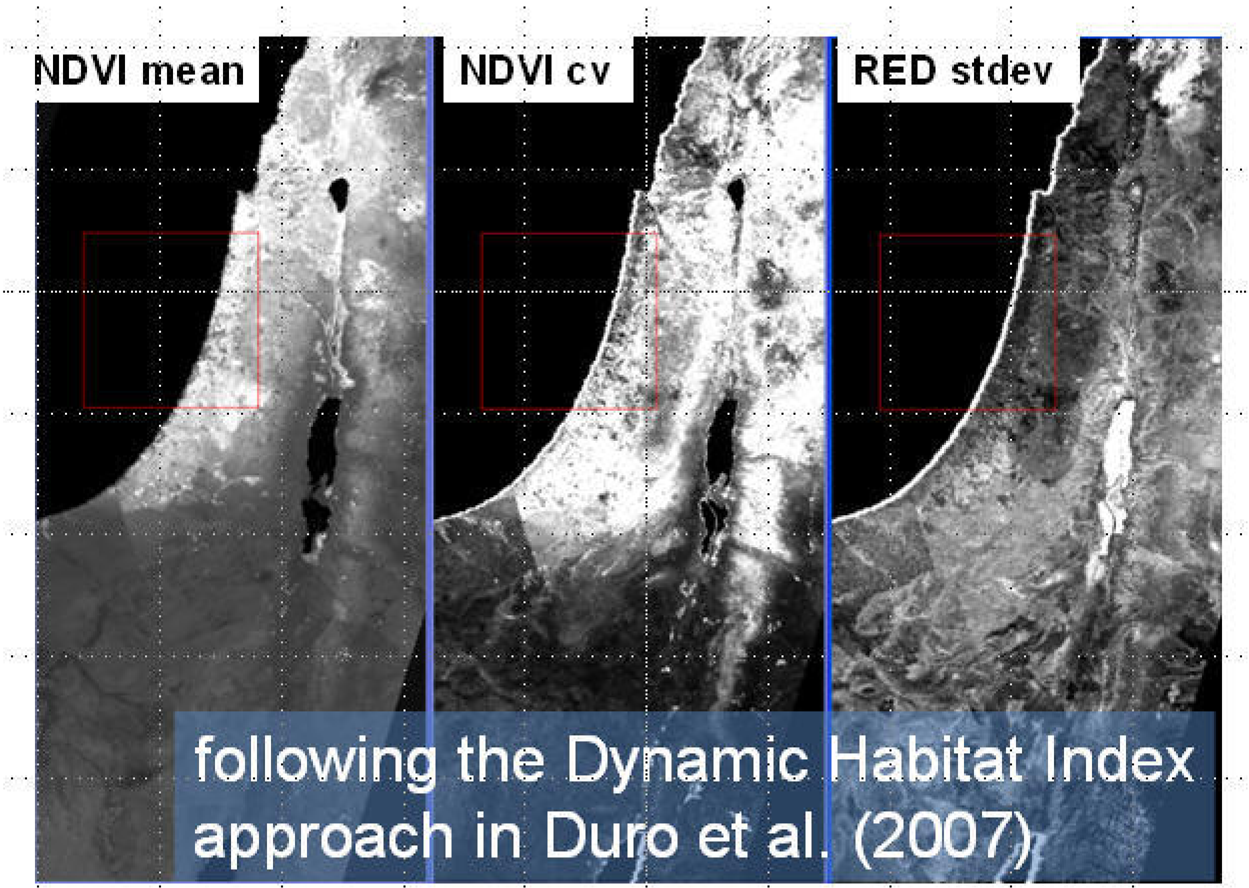

Figure 9: Variables calculated from the MODIS time series

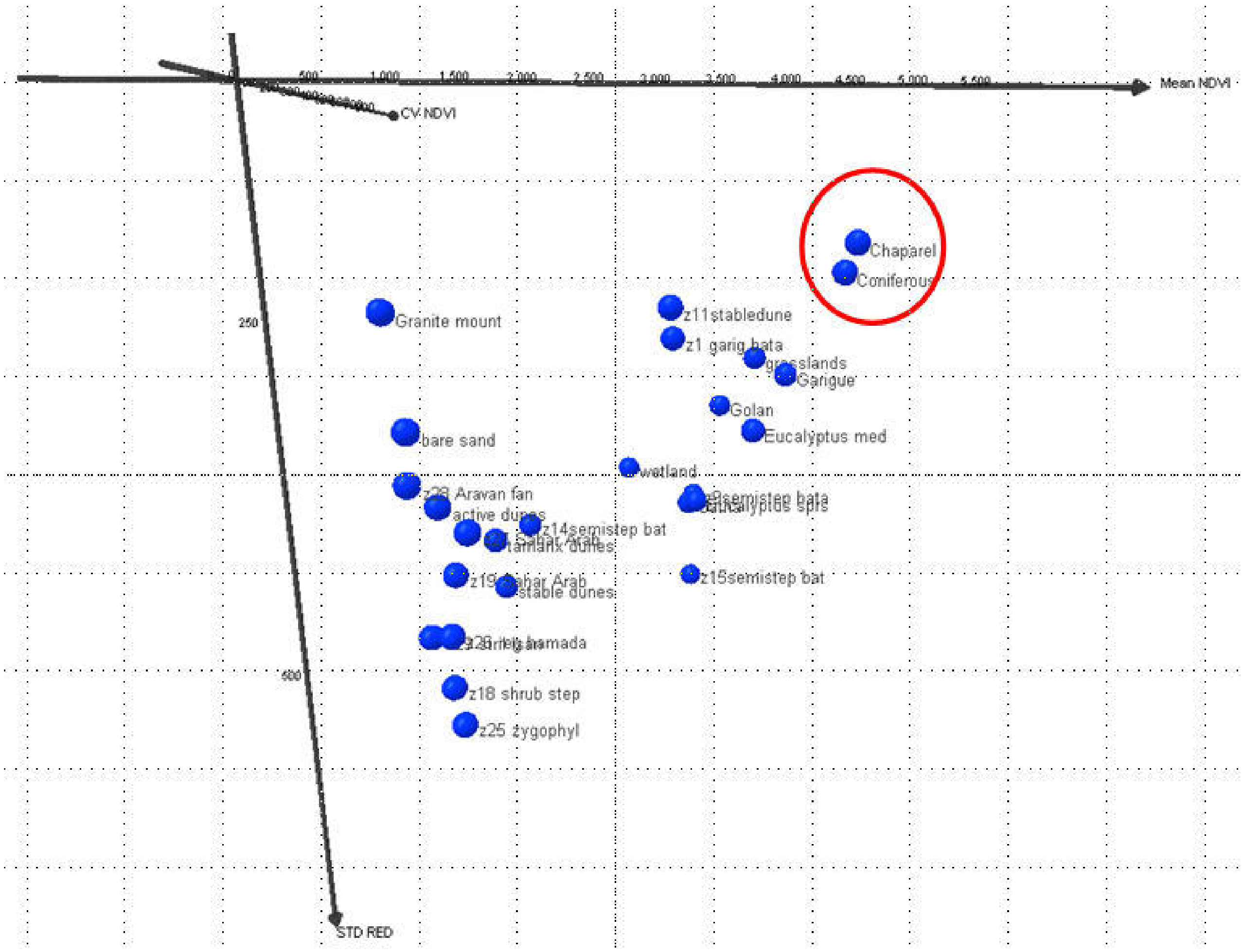

Figure 10: Three dimensional graph of MODIS variables: NDVI mean, NDVI CV, and STDEV of the RED band.

Results so far indicate that

We can separate between most of the vegetation categories observed using MODIS (free of charge; high temporal resolution)
We still have to work on separating a few classes
We may distinguish between “un-separable” classes using other methods, like NDVI (the Normalized Difference Vegetation Index (Pinty and Verstraete,1992)

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

(work still ongoing in 2011)

The next major task is correlating the same remote sensing data with habitats mapped according to EBONE. This work is ongoing.

7. Connecting habitat type with biodiversity indices.

One aspect of EBONE is the relationship between habitats and indices of biodiversity. The European framework for biodiversity indices is the SEBI 2010 report (EEA 2007)
We decided to go forward respect to correlations between habitat type and species diversity in the areas mapped by us in mediterranean (Ramat HaNadiv) and desert (Avdat).
The central question was whether EBONE habitat categories could be predictors of the above mentioned measures of biodiversity. The test data were pre-existing data collected independently by RHN (what is RHN?After which method did the collect the data?) researchers on vegetation and birds, in LTER areas classified for this study using EBONE habitat classification. Hence this study was also a test of the ability to use pre-existing biodiversity data, as proposed in EBONE (See the EBONE Description of work, section B1. "Concept and objectives, progress beyond state-of-the-art", methodology and work plan, paragraphs 3-4.)

7.1 Method

7.1.1. Study sites

7.1.1.1. Ramat HaNadiv studies

Short description of the site (and sub sites?) or refer to description in 2.1.

7.1.2. Description of Work.Data used in the analyses

Site	Treatment	GHC	FPH	TPH	MPH	LPH	CHE	THE
Cypress	Control	FPH/CON	40	0	0	0	0	60
	Grazing	FPH/CON	40	0	0	0	0	10
Pines	Control	FPH/CON	90	0	5	0	2.5	2.5
	Grazing	FPH/CON	90	0	5	0	0	0
Garrigue	Control	TPH/EVR	0	40	30	5	0	25
	Grazing (a)	MPH/EVR/SPI	0	1	40	20	0	10
	Grazing (b)	TPH/EVR	0	30	30	5	0	5
Cabara	Grazing	MPH/EVR	0	10	24.4	0	0	20
	Cattle&goat	TPH/EVR	0	20.1	40	0.1	0	35
Fuel-break	Control	MPH/EVR	0	5	20	10	0	55
	Grazing	MPH/EVR	0	20	60	0	0	20

Table 5: The LTER sites mapped to EBONE GHC's. GHC abbreviations are in Appendix 1 of this report. Values are % coverage by the GHC in the site.

Diversity data sets used in the study:

Plants

Year	20	2005	2006	2008	2009
Cabara grazing				150	
Cabara cattle & goat				150	
Cypress control			150	150	
Cypress grazing			150	150	
Fuel-break control	15		150	150	
Fuel-break grazing	15		150	150	
Garrigue control	15	137	150	150	
Garrigue grazing		150	150	150	150
Pines control			150	150	
Pines grazing			150	150	

Table 6: Understory: 25 0.5 m2 plots, random start on transects, 0.5 m2 apart

Plot Year	2003	2005	2008
Cabara grazing			6
Cabara cattle & goat			6
Cypress control		6	6
Cypress grazing		6	6
Fuel-break control	6		6
Fuel-break grazing	6		6
Garrigue control	6		6
Garrigue grazing	6		6
Pines control		6	6
Pines grazing		6	6

Table 7 : Woody plants: line intercept including information on height and coverage of individual shrubs and trees.

Nesting birds: 2 surveys of the entire park (2001 - 2004 and 2007) (geo-referenced with GIS) could be related to the square 55 mapped by EBONE.

Diversity indices.

We were not constrained by European requirements for biodiversity indices, so were free to select what seemed most useful to us. Generally we considered the Whittaker (1972) classic set of alpha, beta and gamma diversity indices across taxonomic groups (see also Huston 1996 for a review of biodiversity indices.) The relation of assemblage composition to GHC was studied using both direct and indirect ordination.

7.1.3. Results

Assemblages: Vascular plants

Herbaceous and woody species showed different ordination-based patterns of statistical correlation in relation to sites and habitats, partly because the herbaceous vegetation differed between the two FPH (forest phanerophyte) habitats

However, a Redundancy Analysis of all plant species against habitat did show a highly significant correlation, as would be expected (p = 0.002 for most variables). It is important to note that the variances accounted by pine and cypress (the two FPH habitats) were independent, but together explained 29% of the variance.

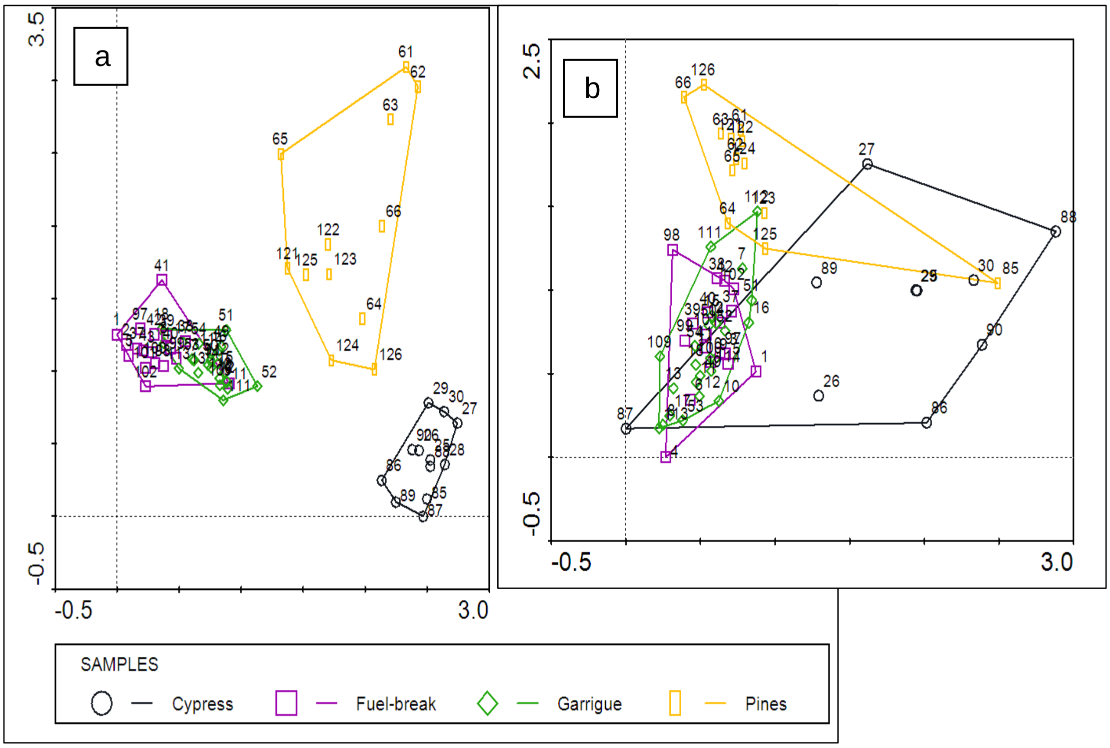

Figure 10: DCA ordination of vascular plants at Ramat HaNadiv. a: DCA control plots with the herbaceous species. The different symbols represent the transects of different areas which are shown in the legend. The numbers represent the sample numbers of the transects (in total 138 transects). b: DCA on the control plots with only the woody species: the shrubs and climbers. See Appendix, Section 14.2 for taxonomic names

Assemblages: Nesting birds.

There was also a significant correlation of nesting bird distributions with habitat (p = 0.5) with most variance explained by the presence or absence of forest, the FPH habitats.

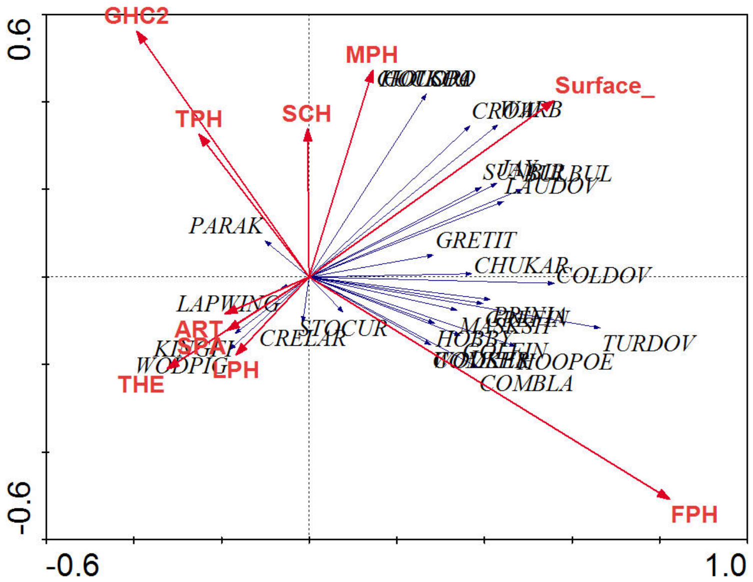

Figure 11: RDA ordination of RHD nesting birds versus EBONE General Habitat Categories. See Appendix 14.2 for taxonomic names

Species richness patterns: Vascular plants showed highly complex patterns. Herbaceous species richness was greatest in shrublands; woody species richness was greatest in forest, but pine forest was relatively poor in species and cypress woodland was relatively rich. Thus generalizations about species richness and habitat category are not possible.

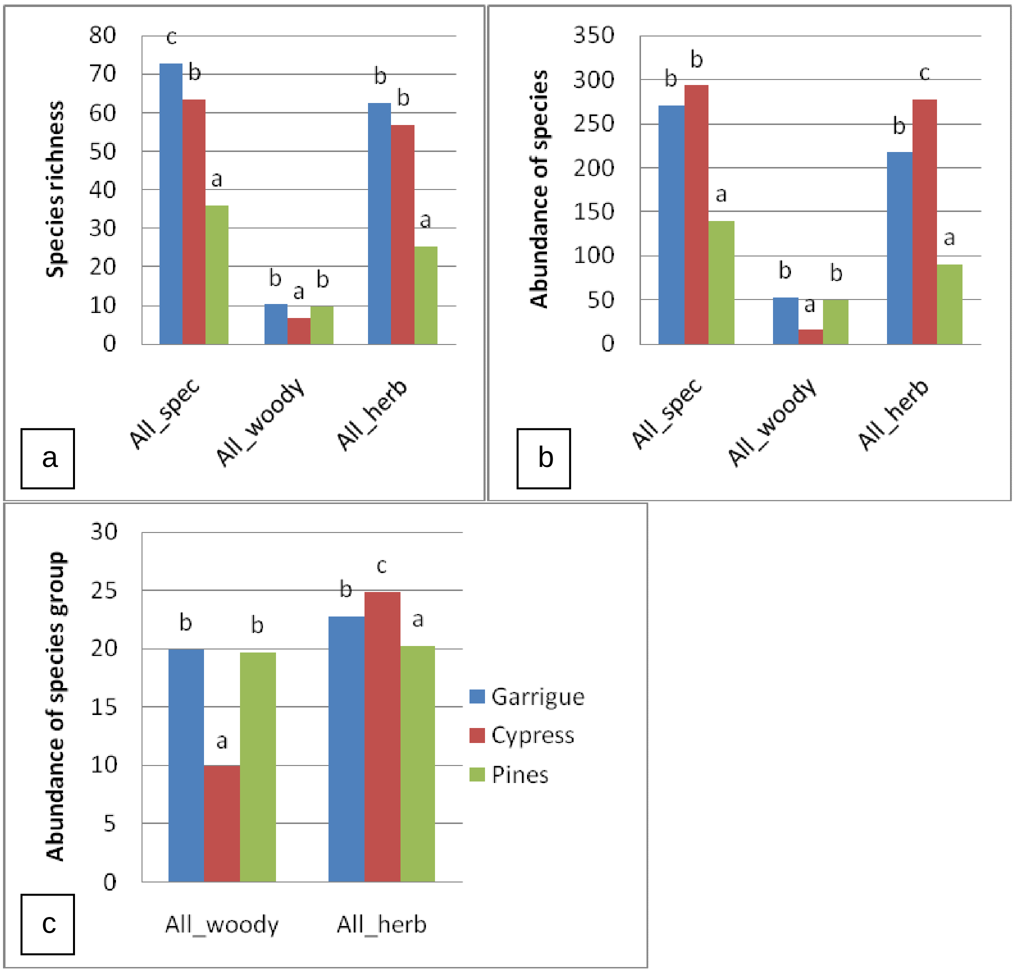

Figure 12: Species diversity in Ramat HaNadiv. a) Average species richness, b) average species abundance (sum of positive hits per transect) and c) the average abundance of the species groups (maximum of 25) in the three GHC's in the LTER areas at transect level

Bird species richness was problematic but seemed to be a function more of the total area covered by a habitat type than any attribute of the habitat per se.

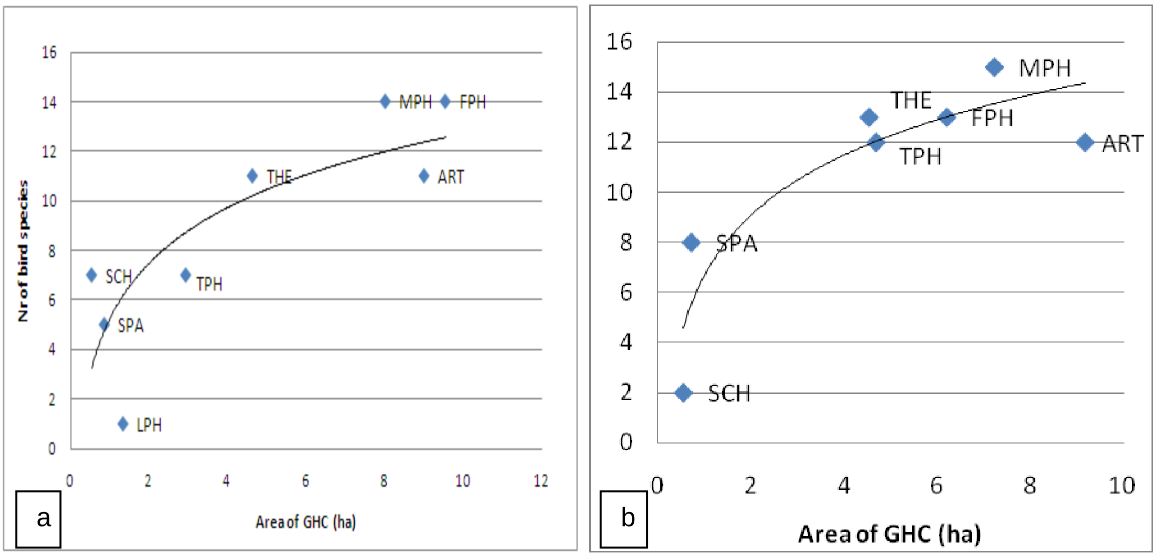

Figure 13: The relation between the number of bird species and the area of the GHC (ha) for a) the bird data of 2001 and 2004 and b) the bird data of 2007. A logarithmic trend line was added through the various GHC's. The abbreviations are given in table 1.

Curiously, and somewhat to our amusement, the artificial areas (ART) seemed to attract a lot of bird species. This may be due to the abundance of nesting sites in the public gardens, or the visibility of birds in them, or the preference of birds for outlook points. However, the nature of the data collection did not support more rigorous conclusions about this pattern.

7.2. Avdat studies

7.2.1. Introduction

After the work at Ramat HaNadiv, it was clear to us that using pre-existing species data in our effort to connect biodiversity to habitat had many problems mostly due to inappropriate sampling design. Therefore, in the desert at Avdat LTER, we decided to collect our own species diversity data in a statistically valid sampling design based on the habitat mapping done in 2009.

Three taxonomic groups were sampled: vegetation, reptiles, and terrestrial invertebrates. Vegetation was sampled in three of the four mapped squares at Avdat, and both reptiles and beetles were sampled in two of the squares.

7.2.2. Sampling design

10 General Habitat Categories (GHC's) were sampled in Avdat. These were new categories for desert conditions, based on geomorphology (see Definition of New Habitat Categories, above)

Habitat category	GHC Code	Vegetation samples	Reptile Samples	Arthropod Samples
Rock	ROC	5		
Rock/Boulder	ROC/BOU	5		
Rock/Stone	ROC/STO	5		
Boulder	BOU	5	3	3
Boulder/Stone	BOU/STO	5		
Stone	STO	5	2	3
Stone/Gravel	STO/GRA	5	3	3
Stone/Earth	STO/EAR	5	1	
Gravel/Earth and Gravel	GRA/EAR & GRA	5	1	3
Earth	EAR	5	3	3
Terrace	TER		1	

Table 8: New desert habitat categories at Avdat

7.2.3. Vegetation

The vegetation sampling was done by using Whittaker plots (Shmida 1984), which are replicated nested squares with multiples of 10 at 1 sq m, 2 at 10 sq m, 1 at 100 sq. m and 1 at 1,000 sq m, thus giving an estimated species/area curve. The Whittaker plots were located in approximately the centre of the polygon. If the size of the polygon allowed us we made a 50 x 20 m plot. In some cases we had to make a plot of 100 x 10 m in order to get to the 1000 m^2 scale. Species occurrences were recorded, but not coverages.

Results: Composition versus habitat

RDA ordination of perennial plants was more explainable than that of annual plants (not surprising, given the unpredictability of annuals in desert conditions – Danin 1983). In this case the correlation of perennial plant species composition in tenth hectare samples was p = 0.0020 with a total of 25 % of variance explained, mostly by EAR (loessal earth) as the most important factor, followed by STO/GRV (stone and gravel, e.g. streambeds).

Results: Species richness versus habitat.

The most promising results for species richness patterns are in the Whittaker plots. There seem to be two groups: BOU, BOU/STO, AND ROC/BOU with relatively high species richness and the other habitats with lesser richness. This may be related to the spatial heterogeneity of the first three habitats, or the tendency of zones with boulders to have microsites of rainfall runoff accumulation where less xeric species may grow. This is a well-known pattern in the Negev Highlands, at any rate (ref….) so not surprising.

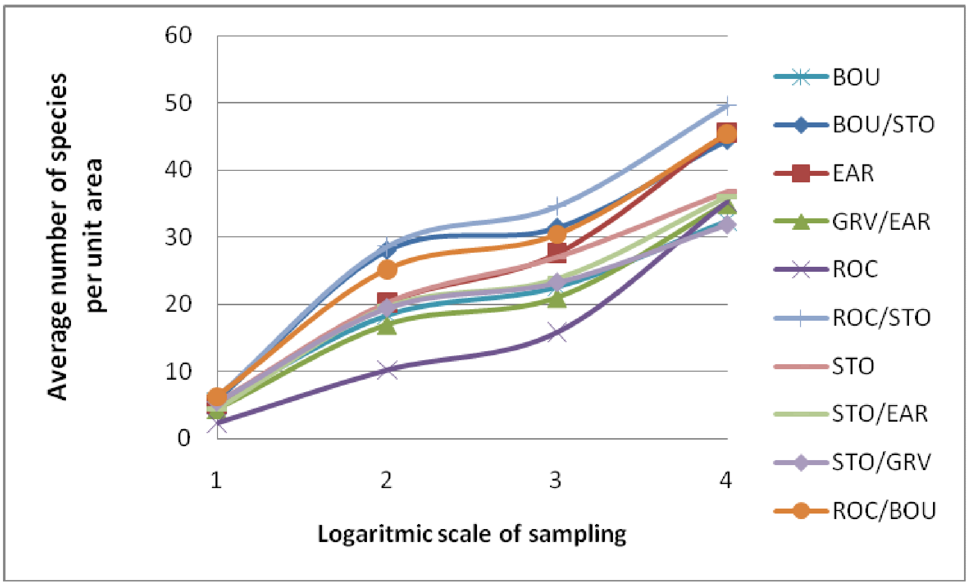

Figure 14: Species area curve with the average number of species per unit of area. The logarithmic scale goes from 1 (1 m2) to 4 (1000 m2). Noted should be that the number of species at 1 m2 level is an average of 10 1 m2 plots.

7.2.4. Reptiles

The reptile populations were sampled on two days, one at 31 March and one at 15 April. The 31st of March was 4 days after a rain event, whereas 15 April was a hotter day. The sampling was done in 9 polygons in square 42 and 63. Four habitat categories were sampled with two replications (for one of the categories three replications). The habitat categories sampled are: BOU, STO/GRV, STO/EAR, GRV/EAR. This sampling was done in three different ways. The first was method was a transect of 100 m. Each of the observers (in this case Boaz Shacham and David Jobse) walked about 20 m from each other along a transect. Boaz walked at transect 1 and David at transect 2. For any reptile observed at the transect the time was recorded, the species, the distance perpendicular from the transect and if the reptile could be caught the length and weight was also recorded. The starting and finishing time of the transect was recorded.

After that the survey was continued by rock overturning. This was done on the same transect for about 20 minutes so that a total of about 100 rocks of various sizes was overturned. The starting and finishing time of this transect was also recorded. For each reptile caught the time, coordinates, size of the overturned rock and species was recorded. In most cases the measurements could also be done.

Besides looking in the chosen polygons reptiles observed in between polygons were also recorded. For these individuals the following was recorded: the specimen, the time, the coordinates and if possible the measurements.

Results: Species richness

Here too the greatest species richness was in the Earth habitat, but variance was high, and sample sizes too small to detect significance.

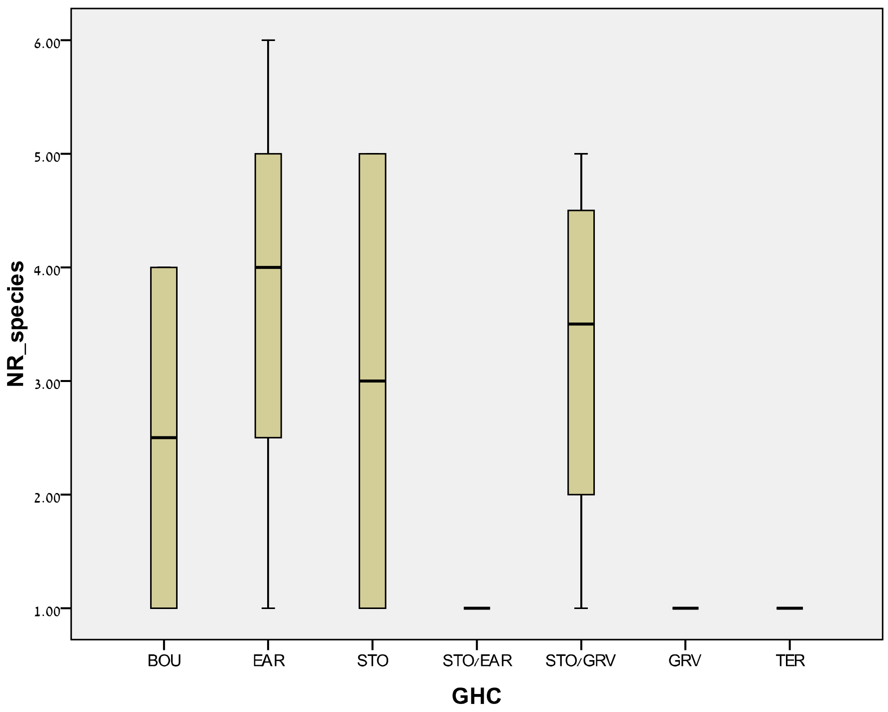

Figure 15: Boxplot with the number of reptile species per GHC.

Results: Assemblage composition.

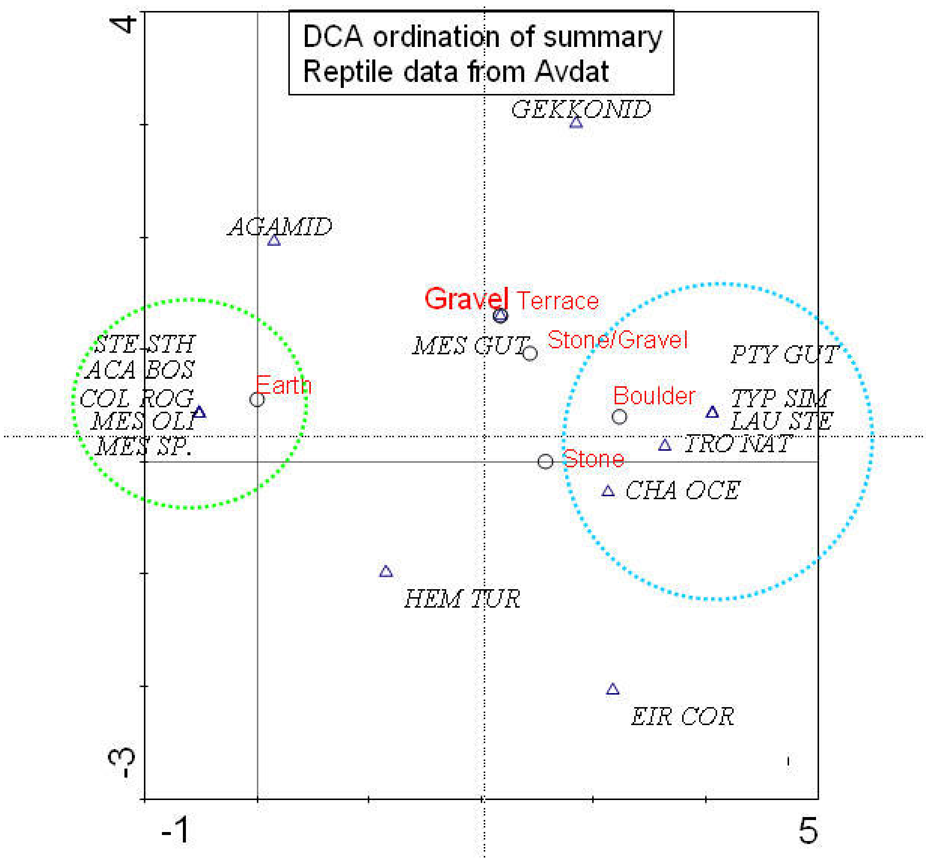

Figure 16: DCA ordination of reptile data at Avdat. Species names are given in Appendix 14.2

Distinctive groups were seen in the DCA ordination of reptile data, which fit with herpetologists' knowledge of the usual habitats for these species. This figure shows the species/sample biplot from DCA, with samples labeled according to habitat type. However, the sample size was too small for direct ordination.

7.2.5. Invertebrates

The arthropod populations were sampled by use of pitfall traps. The sampling was done in two weeks (4-7 and 12-15 April) over four sequential days. The pitfall traps were checked in the morning on the same sequence. The pitfall traps in square 42 were done the first week during Pesach followed by the pitfall traps in square 63 in the second week. A total of 15 polygons were sampled, three for each of the five habitat categories. In each polygons were 10 pitfall traps on each transect of 45 m, leaving 5 meters in between each pitfall trap. These transects were directed along the gradient of the slope (so not down- or uphill) and the coordinates of the first traps are given including the direction of the transect. The traps were put in the ground so that the entrance was at the ground level. The top was covered with a rock, so that the cup would be overshadowed but still accessible for arthropods. Each trap contained two cups, so that with each visit only the top cup had to be taken out and put back. If the species could not be determined in the field it was taken to the lab, otherwise it was identified and released on the spot. Ants, spiders and caterpillars were not identified, but lizards and scorpions were.

Results: Species richness.

Species richness of arthropods was highest in the Earth habitat, and much lower elsewhere. Presumably this relates to the ease of burrowing in the friable soil of the Earth habitat.

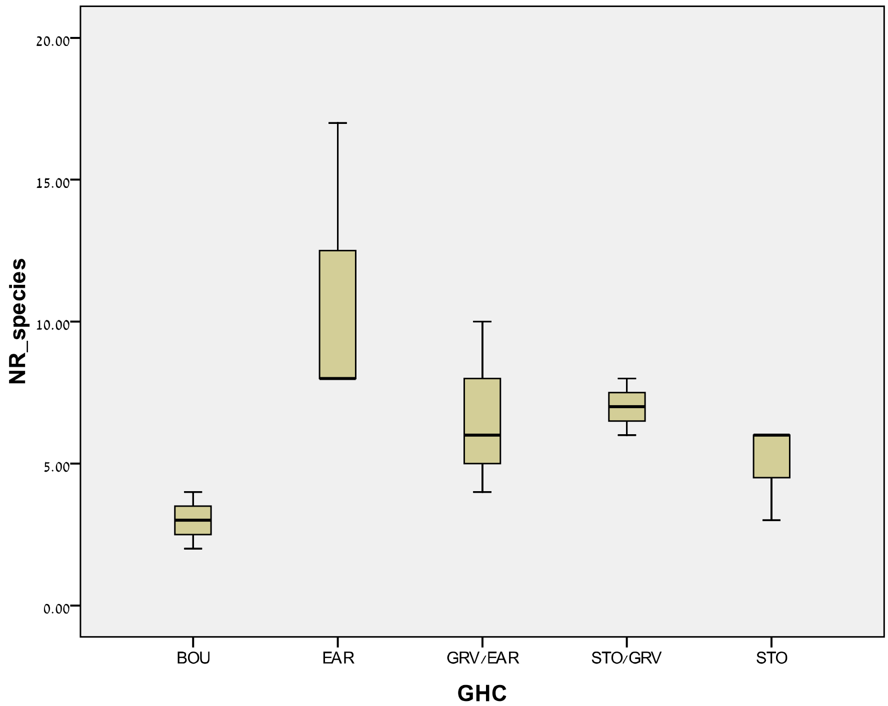

Figure 17: Boxplot with the number of arthropod species in the various GHC's. The graph shows the median and the maximum and minimum value.

Results: Assemblage composition.

Likewise, RDA analysis of pitfall traps versus GHC's showed nearly all the variance (28%) was explained by one habitat, Earth (EAR), with p = 0.03. However, the ordination overall was not significant (p = 0.18 on the first axis; p = 0.35 on all canonical axes.) This is probably due to the small number of individuals in samples.

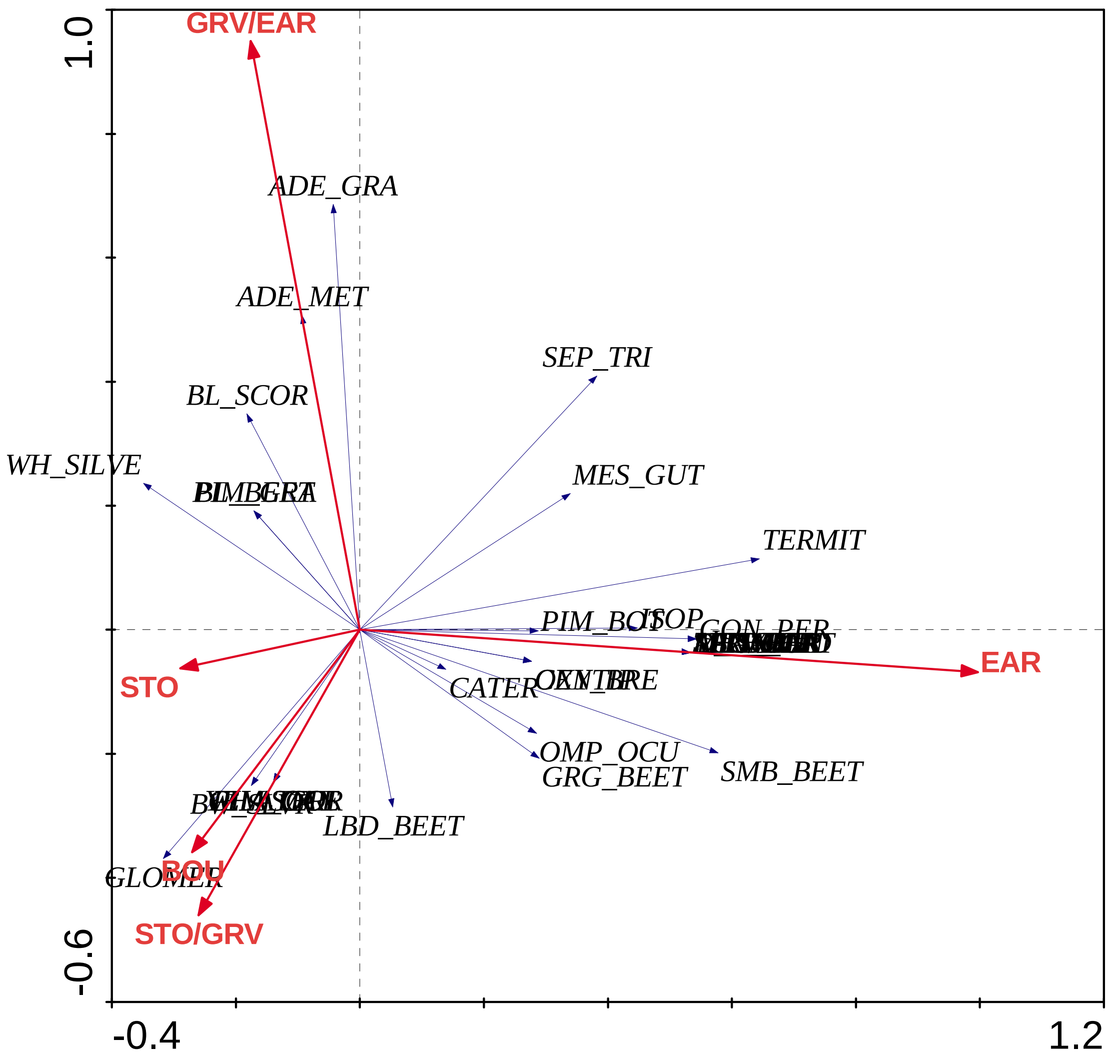

Figure 18: RDA ordination of pitfall trap data in Avdat. Taxa in Appendix 14.2

7.2.6. Summary.

The correlation of habitat and biodiversity was more significant and interpretable when the diversity samples were collected on the basis of the mapped habitats. This raises doubts about the usefulness of mining pre-existing biodiversity data.

While correlations exist between richness and habitat, these are not particularly interpretable or predictive. Assemblage information seems more useful: a particular habitat type probably contains a predictable assemblage of more common species.

8. Reaching stakeholders

Field training exercises:

There was much curiosity about BioHab approaches to habitat mapping even before EBONE started. We had a workshop taught by Bob Bunce and Rob Metzger in 2007, which was followed by several one-day training exercises led by Margareta Walczak. These led to organizational interest in EBONE and a national workshop which was held for one day in Eshtaol Forest Research station on 30 October 2008, in which Bob Bunce participated and led discussions.

Organizations such as the Jewish National Fund (the Israeli equivalent of a forestry service) and the Society for Protection of Nature in Israel were invited to give their experience and express their particular needs for habitat mapping. In addition, several academics and independent environmental consultants were invited to speak and share their experiences. The workshop was divided into three sessions:

- Mapping natural and semi-natural Mediterranean.
- Agricultural and industrial landscapes
- Large scale survey approaches

This was followed by a discussion session.

Bob Bunce summarized the workshop as follows:

The Mediterranean has the most diverse structure of all landscapes in Europe. Israel should work with the life forms as developed by Philip Roche (Cemegref, WP6, responsible for EBONE exploration of life forms outside Europe). In respnse to a specific question about recommendations for implementation of BioHab in Israel, Bob outlined the following steps:

a. Rewrite the BioHab handbook in adaptation to Israel
b. Circulate it for comments
c. Test it
d. Present results of the testing at the international workshop (in October 2009)
e. Conduct field training (about 2 weeks of training)
f. Start sampling, using smaller plots (1/4 sq. km.)

The workshop concluded with an agreement to continue the effort as a committed working group in the future. Interested participants submitted their email addresses to Margareta Walczak.

The positive responses generated by this first workshop led to another, more international one with several participants from EBONE in Europe and South africa joinging in. This was held at Neve Shalom, 27-29 October 2009

Visiting EBONE participants included Bob Bunce, France Gerard, Lubos Halada, Melanie Luck-Vogel, Sander Mucher, and Philip Roche. Israeli EBONE members included Eliezer Frankenberg, Yonat Magal, Linda Olsvig-Whittaker, Yehoshua Shkedy, and Margareta Walczak.

The first day consisted of formal presentations on remote sensing in habitat classification, habitat mapping in EBONE, stakeholders and their needs, and biodiversity and in-situ data. Altogether, 47 participants were in the first day of meetings, including the 11 EBONE members. Most of the participants were stakeholders or Israelis who had participated in EBONE field and analytical work as students. We also had a representative of the European

Commission in Israel who spoke to us on scientific cooperation between Europe and Israel. All presentations from the first day are in the internal EBONE wiki as pdf files in the folder (available on request to those not in EBONE).

The second day was a field excursion mainly organized to give the visiting EBONE members a grasp of the variety of Israeli landscapes covered in very short distances. We traveled from Mediterranean to desert landscapes, ending at the oasis of Ein Gedi and the ancient fortress of Masada, a World Heritage Site, where the manager conducted our visitors on a guided tour that finished with cheese and wine on the terrace of the visitor's center. Altogether, our visiting guests had a good dose of Middle Eastern history, landscape, culture, hospitality, and food.

The third day was a smaller workshop of EBONE members and Israelis who had worked closely with us. This was organized into three morning sessions: habitat, remote sensing, and biodiversity, and an afternoon session to pull together our work plan for the next stage. Among the new ideas, the Israeli team will work with the WP5 partners to determine the most suitable remote sensing appraoch for our needs. (This has since been picked up as a special project during the past half year, in a subcontract to a remote sensing laboratory in Herew University led by Dr. Noam Levin.) This work is continuing, and will result in a special report comparing several remote sensing approaches.

The greatest challenge is the study of biodiversity. We agreed among ourselves to select some preliminary biodiversity parameters and start making correlations with both habitat mapping and EO land cover data during the coming year. We recognized the need to cooperate more closely with the other partners and developed some specific plans for remote sensing and biodiversity work in the coming year.

This in turn has led to closer cooperation with the Israel LTER system, itself developing a national biodiversity monitoring plan. We are planning further workshops aimed towards implementation of EBONE in the design for this plan, meeting at least once during the coming year.

9. Data management

Data have been recorded in Israel using traditional paper foms, which are later transcribed to Excel files. We are now in the process of incorporating these into the databases developed in WP6 and WP7. Israel has the additional complications of using Hebrew nomenclature for species names, and of course commentary is in Hebrew as well.

10. Discussion: Products for EBONE

Gradually we are achieving some clarity about which aspects of EBONE work for us in Israel. Our principle needs are to map and monitor patterns of distribution and change in biodiversity (however we choose to define that) on a national basis with wall-to-wall coverage of the country, and secondarily to establish a national standard for habitat classification and description, especially to facilitate exchange of information across agencies. We are making progress in that by testing and adapting the EBONE approaches to local needs and conditions.

10.1. Field sampling

Our studies indicate that EBONE habitat mapping indeed is four times as fast as traditional phytosociological sampling. We needed to simplify the process and continue to simplify even further in order to make this approach practical on a large scale. Only areal features are mapped in the Mediterranean part of Israel, but we find linear features very important in the desert (wadis, terraces, etc) and have added them. Our explorations of tradeoff between simplification of the mapping process and obtaining adequate information must continue.

10.2. New habitat categories

Desert mapping required new habitat categories based on geomorphology. It is likely that as EBONE expands into new types of habitat, an ongoing dialogue between field workers and some central standardization authority must continue, just as we were in dialogue with Bob Bunce about developing these new categories.

10.3. Connection with biodiversity

Here, the problem has always been decided what measures of biodiversity are of interest to our work. Coming from a conservation perspective, we naturally think of species richness and the distribution of rare species. However, both are somewhat unpredictable from habitat type or GHC, even if correlations may be good. Hence the utility of simple species richness as a biodiversity index is questionable. The European Union has clear topical priorities for biodiversity, which are not of concern in Israel. Hence we are somewhat more free to consider our options.

It seems to us that species composition is a useful and predictable measure of biodivesity which we can correlate readily with our habitat types, using multivariate analysis approaches. This is hardly surprising since vegetation scientists have always been able to predict plant species assemblages on the basis of physical habitat. Our pleasant surprise is that correlation with animal assemblages is also feasible. Is this useful information? From the conservation perspective, definitely yes. We need to pursue this line of work further.

Rare species are far less predictable in their relation to habitat, and it is likely that their relationship with GHC must be studied and modeled on an individual species basis, as in the EuMon project.

Hence we propose a two-track approach, correlating habitat with both assemblages (for more common species) and individual rare species of interest.

10.4. Remote sensing: Scale questions

There are clear tradeoffs between cost and information value in remote sensing. The finer resolution remote sensing connects more readily with habitat, but is expensive. The optimal approach to use of remote sensing in habitat monitoring may differ between desert and mediterranean (the latter requiring a more higher resolution).

LiDar is the most expensive appraoch and produces the finest resolution of all. It should have the best correlation with habitat type when the latter is structurally defined as in our methods. However, our studies so far do show that the match is still problematic, so clearly high resolution is not the sole answer to the problem of predicting habitat.

However, the fact that remote sensing can give wall-to-wall coverage of an area is such an advantage that we must continue to explore it as an approach for monitoring habitat change in the country as a whole. For smaller areas (such as nature reserves) mapping in situ may still be preferable.

10.5. Co-opting Stakeholders

Our experience so far has emphasized the importance of co-opting stakeholders early and keeping them engaged. We offered training in the field and in workshops every year, and this has kept the momentum going also on policy making decisions. The dialogue and cooperation has been excellent. Maybe this is the consequence of operating in a small and intimate country where everyone who is interested can get involved, and may be less useful in large countries.

11. South Africa

The South African partners in CSIR have mainly focused their tests on the connection between biodiversity and remote sensing, with habitat mapping mainly as training for the remote sensing. Trials have been conducted in sandveld (desert/mediterranean border zone) on selected polygons rather than mapped areas, not unlike the work done in Israel at Lehavim.

11.1. Field sampling

The study area was scanned by remote sensing using e-Cog-segmented Landsat eTM (July-September 2002) , testing the relationship of plant species richness to four components of Landsat data: brightness, compactness, NDVI and near-IR band Standard Deviation. Biodiversity data were also compared to SPOT5 scan (January/February 2009), which has a 10 meter resolultion (akin to QuickBird in Israel)

11.2. Analysis

Results were similar between the two remote sensing methods in three of the parameters; only NIR St.Dev showed differences at the two spatial scales, which so far is interpretable as difference in detection of land use type (strip farming)

11.3. Analysis

In the South African studies, the trend is to skip the habitat mapping and focus directly on the link between remote sensing and biodiversity. Analysis continues, as well as definition of which biodiversity parameters are useful.

12. Summary

WP9 has carried out trials of several aspects of the EBONE project. Research on remote sensing application to habitat, and habitat connection to biodiversity are ongoing. Results so far suggest a two-pronged approach to connection of biodiversity with habitat, analyzing assemblages and individual rare species separtely. Much more thinking should be invested in determining which indices of biodiversity will be more useful before more work on data collection and analysis is done.

When national or multinational priorties are considered, remote sensing will be very important, and perhaps the main tool with in situ habitat and biodiversity data mainly used for "training" the RS interpretations. It is likely, however, that inaccuracies in RS interpretation of habitat will always occur, no matter which RS system is used.

Therefore, when the concern is local (for example, management of a network of protected areas) then the need for local accuracy may require in situ habitat mapping as the primary tool, with RS mainly as a guide for sampling and mapping strategy.

Hence some flexibility should be inherent in the EBONE system, depending on the particular goals and user needs. For this purpose, our repeated workshops and training exercises have been extremely useful. User feedback will be critical and a strategy is needed to collect and analyze that as the EBONE project reaches its final stage, and when implementation occurs.

13. References

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14. Appendices

14.1. GHC abbreviations used in this report

GHC abbreviations used in this report
(from Bunce et al 2010)
.
Artificial (ART)
Non-vegetated (NON)
Urban (URB) Vegetables (VEG)
Herbaceous (GRA)
Woody (TRE)
Combinations
Cultivated bare ground (SPA)
Cultivated herbaceous crops (CRO)
Crops (CUL)
Sparsely Vegetated (SPV)
Bare rocks (ROC)
Boulders (BOU)
Stones (STO)
Gravel (GRV)
Sand (SAN)
Earth (EAR)
Vegetated Herbaceous (HER)
Caespitose hemicryptophytes (CHE)
Therophytes (THE)
Geophytes (GEO)
Herbaceous Chamaephytes (HCH)
Stem Succulents (CAC)
Dwarf Chamaephytes (< 0.05 m) (DCH)
Shrubby Chamaephytes (0.05-0.30 m)(SCH)
Evergreen (EVR)
Vegetated tree/shrub (TRS)
Low Phanerophytes (0.30-0.6 m) (LPH)
Coniferous (CON)
Mid Phanerophytes (0.6 – 2 m) (MPH
Tall Phanerophytes (2- 5 m) (TPH)
Forest Phanerophytes (>5 m) (FPH)

14.2. Taxonomic entitities identified in the studies (attached Excel file)

14.3. Lior Blank: (attached pdf)

Comparison between BioHab mapping and remote sensing. Project report, submitted to the Nature and Parks Authority. 16 pp

14.4. David Jobse:(attached pdf)

Predicting biodiversity with BioHab mapping: Correlating habitat mapping method with in situ biodiversity data. M.Sc. Internship report for Wageningen University. 36 pp.

14.5. Adriaan de Gelder: to be added 15 March

Evaluating BioHAB, vegetation changes and management. M.Sc. Thesis, Wageningen University. (Not yet complete, due 15 February 2011)