ALTERRA
WAGENINGEN UR

EBONE in Mediterranean and desert sites in Israel, with notes on South Africa

Report on field tests in LTER sites and habitat monitoring

Linda Olsvig-Whittaker, Eliezer Frankenberg, Yonat Magal, Yehoshua Shkedy, Shmulik Amir, Margareta Walczak, Melanie Luck-Vogel, David Jobse, Adriaan de Gelder, Lior Blank, Yohay Carmel, Noam Levin, Ruthie Harari-Kremer, David Blankman and Bertrand Boeken

ALTERRA WAGENINGEN UR

SEVENTH FRAMEWORK PROGRAMME

EBONE
EUROPEAN BIODIVERSITY OBSERVATION NETWORK

EBONE in Mediterranean and desert sites in Israel,
with notes on South Africa

EBONE in Mediterranean and desert sites in Israel, with notes on South Africa

Report on field tests in LTER sites and habitat monitoring

Linda Olsvig-Whittaker[1], Eliezer Frankenberg[1], Yonat Magal[1], Yehoshua Shkedy[1], Shmulik Amir[1], Margareta Walczak[1], Melanie Luck-Vogel[2], David Jobse[3], Adriaan de Gelder[3], Lior Blank[4], Yohay Carmel[4], Noam Levin[5], Ruthie Harari-Kremer[5], David Blankman[1] and Bertrand Boeken[6]

[1] Israel Nature and Parks Authority, Israel
[2] Council for Scientific and Industrial Research, South Africa
[3] Wageningen University, The Netherlands
[4] Technion, Israel
[5] Hebrew University, Israel
[6] Ben Gurion University of the Negev

Abstract

Linda Olsvig-Whittaker, Eliezer Frankenberg, Yonat Magal, Yehoshua Shkedy, Shmulik Amir, Margareta Walczak, Melanie Luck-Vogel, David Jobse, Adriaan de Gelder, Lior Blank, Yohay Carmel, Noam Levin, Ruthie Harari-Kremer, David Blankman and Bertrand Boeken, 2011. *EBONE in Mediterranean and desert sites in Israel, with notes on South Africa, Report on field tests in LTER sites and habitat monitoring*. Wageningen, Alterra, Alterra Report 2260. 54 pp.; 21 fig.; 8 tab.; 12 ref.

We examined several aspects of the EBONE project. At large scales, remote sensing is important, and perhaps the main tool, with in situ habitat and biodiversity data mainly used for 'training' the RS interpretations. Inaccuracies in RS interpretation of habitat will probably always occur, so when the concern is small scale, the need for accuracy may require in situ habitat mapping as the primary tool. Analyses of habitat correlation with biodiversity suggest examination of assemblages and rare species separately. Hence some flexibility should be inherent in the EBONE system. Workshops and training exercises clarified the need for user feedback: a strategy is needed to collect and analyze user needs when EBONE is implemented.

Keywords: Habitat, remote sensing, biodiversity, mediterranean, desert, Israel, South Africa

Alterra Report 2260
Wageningen, December 2011

Contents

1   Introduction

The overall objective for the work carried out in Israel and South Africa 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 from 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.

1. The first objective 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, and Greece.

2. The second objective 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 ongoing as database methodology develops in the overall project.

3. The next step in the overall work is to test the habitat mapping and description procedure in a variety of biomes, sampled in a rational and statistically viable manner.

4. As the use of Remote Sensed data can be of importance the following objective is to link biodiversity data with habitats and remote sensing data.

5. Finally we wanted to provide guidelines for extending the EBONE monitoring approach to other biomes. However, that is not part of this report, but will be reported separately in the beginning of 2012.
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 a semiarid steppe LTER site at 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 near the end of the project.

Database work is ongoing in connection with database development in EBONE and the ILTER program.

Essentially, the work progressed as a series of separate projects, which will be discussed individually below. We should note that many of these projects are still continuing. Several were student projects done in cooperation with EBONE, including the analysis of LiDar and habitat by Lior Blank (Technion, under Dr. Yohay Carmel), 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 (both from Wageningen University, supervised by Prof. Karle Sykora).

2 Testing the mapping procedures

2.1 Site selection

In Israel we selected two LTER sites which were endpoints of the Mediterranean to desert gradient.
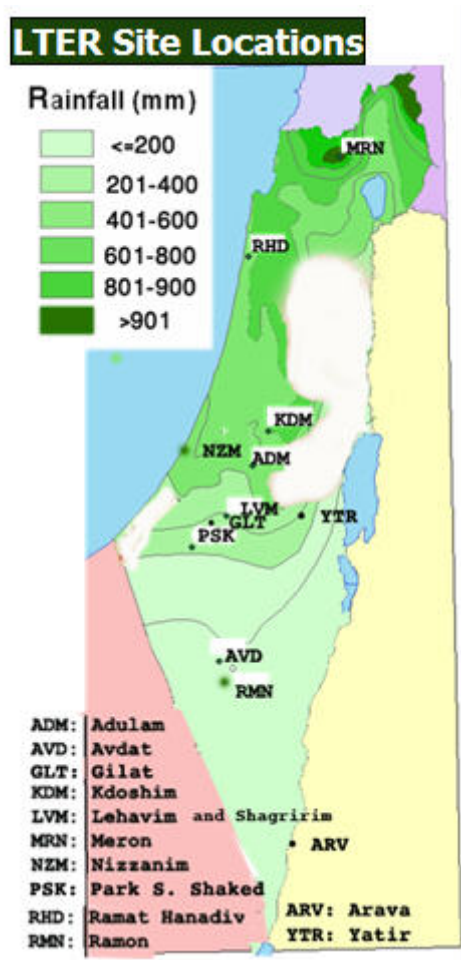
Figure 1
LTER sites in Israel, from the Israel LTER network (http://lter.bgu.ac.il/Default.aspx).

The Mediterranean Ramat HaNadiv LTER site (RHD, Figure 1) is located in the southern part of Mt. Carmel, in the Mediterranean climatic part of Israel. Annual rainfall is 600 mm; elevation is 120 m (maximum); size is 500 ha. Vegetation in this area is Mediterranean garrigue, Mediterranean maquis (Figure 2), open rangelands, planted pine and cypress groves, rocky cliffs, dry riverbeds, springs, orchards, cultivated gardens.

Ramat HaNadiv is a park covering an area of 500 hectares, 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 several thousand years 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 many projects, mostly short-term applied or theoretical scientific research, have been carried out in the park. Today, the orientation of research in Ramat HaNadiv is towards long-term thinking and planning, including an LTER site established in 2003.

Figure 2
Mediterranean open maquis in Mt. Carmel.

The types of data collected in RHD 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 chukar partridges; 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. For more information see the Israel LTER network, http://lter.bgu.ac.il/sites/rhd.aspx

The desert site, LTER Avdat (AVD, Figure 1), is arid shrub-steppe consisting of rocky slopes (Figure 3), loessal ephemeral streambeds, and ancient agricultural terraces. Mean maximum summer temperature is 32 °C; mean minimum winter temperature is 5 °C. Vegetation is dominated by dwarf shrubs (*Hamada scoparia* on plains, *Artemisia crassifolia* and *Zygophyllum dumosum* on slopes).

Figure 3
Negev Desert near Avdat.

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 and irrigation channels are still evident. Currently Bedouin inhabitants practice sedentary pastoralism with goats, sheep and camels. Livestock grazing has been excluded from parts of the site. (from the Israel LTER network, http://lter.bgu.ac.il/sites/avd.aspx)

Our resources enabled us to fully map four square kilometers 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, with sampling based on remote sensing imagery.

2.2 Mapping: testing EBONE habitat field sampling in Israel - procedures and results

2.2.1 Timetable

Our testing of EBONE habitat mapping methods actually predated the approval of the EBONE project, 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 generated considerable enthusiasm. This was followed by more training exercises conducted in Hebrew at Park Britannia on 22 February 2007, again with participation of Bob Bunce (with a translator), in which professionals were able to evaluate BioHab versus

the mapping approaches in current use in Israel. 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 a condensed version of it). This was done by Margareta Walczak and provided the basis for our field trials during EBONE. Another one day workshop with stakeholders was combined with a working visit by Bob Bunce in October 2008 to inspect various desert types in Israel. 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 yearly gathering of stakeholders 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 developed them.

In 2009, formal EBONE habitat test mapping began, first in the Negev Desert, Avdat 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 ten working days (80 hours), preparation of a field manual in Hebrew - about four working days (40 hours) and preparation of tables of relevant Qualifier codes - about four 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 protocol - altogether about five days of work. In advance of the field work, the INPA GIS laboratory prepared Ortho-photos and maps for field work - about six working days (60 hours). The time and manpower estimations for the field sampling are given in Table 1.

Table 1
Study areas, sampled squares and work invested.

| 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

Ramat HaNadiv and square 55
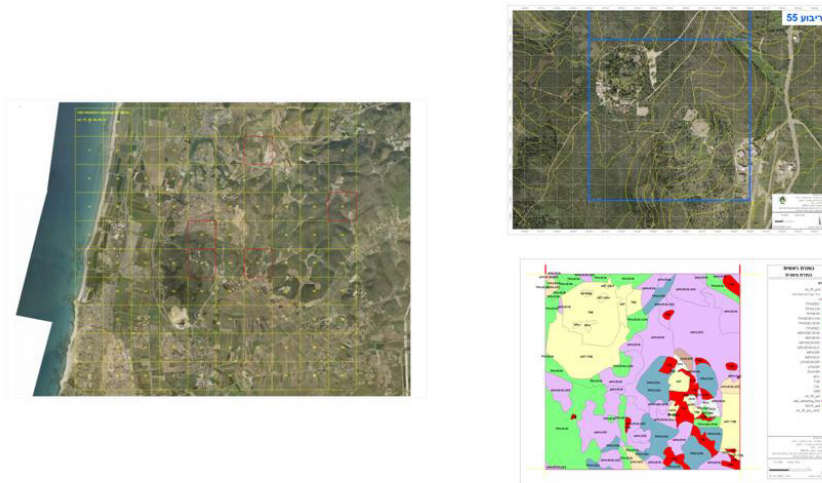
Figure 4

Orthophoto and maps of Ramat HaNadiv.

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 mapping team consisted of nine people, mostly experienced field biologists and ecologists with 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.

2.2.2 Mapping Results

Ramat HaNadiv 10 x 10 sq km grid, the sampling squares, and an example square kilometer are shown in Figure 4. 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).

In contrast, the desert landscape of Avdat (Figure 5) is mainly determined by geomorphology, although the ruins of ancient agriculture are clearly visible as terraces.
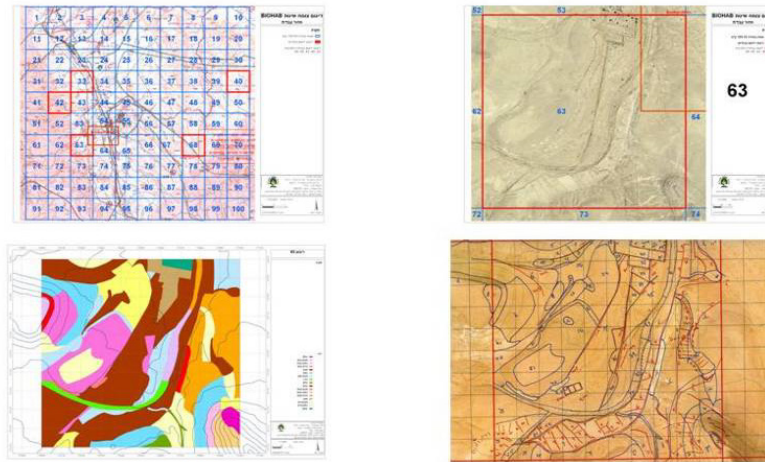
Avdat and Square 63

Figure 5

Orthophoto and mapped areas in Avdat.

Table 2 summarizes the general results of the mapping. In all the mapped areas we recognized 72 different General Habitat Categories (after modification introduced as described farther on). In the Avdat area there 32 GHCs identified (16 before the modification), in Lehavim area - 22 GHCs, in Ramat HaNadiv area - 39 GHCs.

Table 2

Polygons and GHC's per sampled square.

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

3 Definition of new habitat categories

3.1 Modification of habitat mapping procedure and categories

Mapping in desert areas according to the EBONE procedure proved to be inadequate for this kind of biome. Nearly entire 'natural' areas were 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 into 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 a modification was introduced to the Field Manual and the 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 0.05-0.20 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

ROC and other categories of TER can also occur in combinations such as STO/GRV when both categories cover 40-60% (Bunce et al 2011).

3.2 Mapping through time

3.2.1 Introduction

During spring 2010, M.Sc. student Adriaan de Gelder (De Gelder, 2010) 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 (Table 3), with a particular emphasis on evaluating conservation management.

Table 3

Comparison of EBONE and classic phytosociology at En Afeq.

Aspect	Phytosociological	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 in Israel	EBONE provides an universal classification system

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 twelve years. We were able to relocate Mr. Burgerhart in the Netherlands and acknowledge (?) 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.

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 (Figure 6). 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.
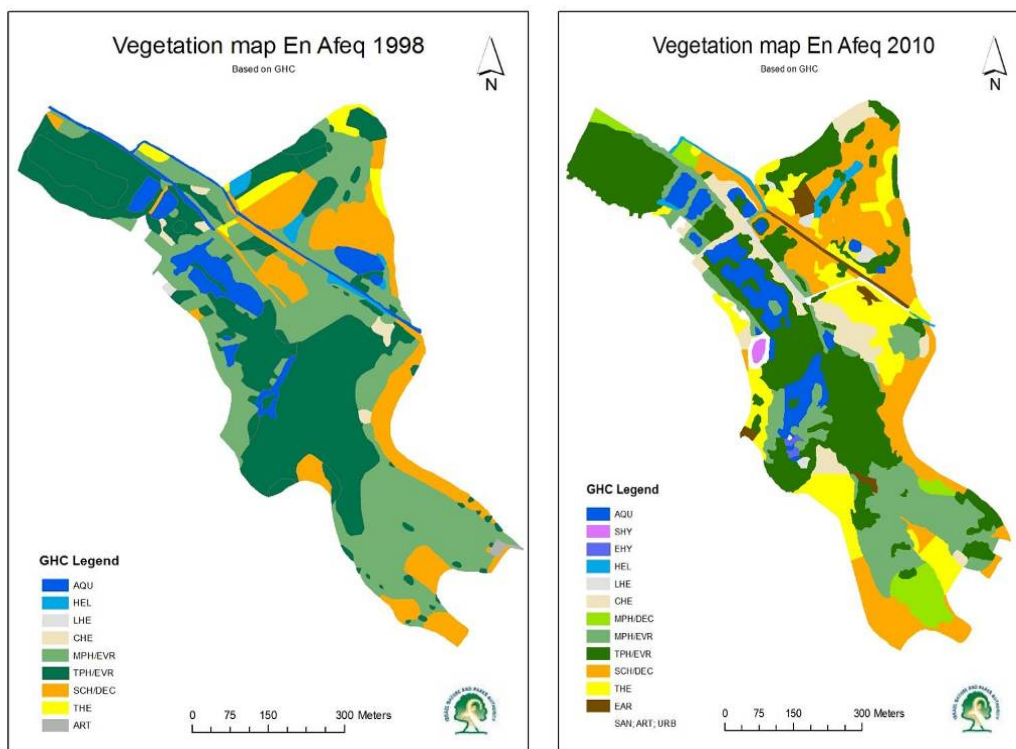

Figure 6
En Afeq GHC maps for 1998 and 2010.

4 Connecting habitat with remote sensing: Lidar

4.1 Introduction

The specific objective of the EBONE 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., 2011). The EBONE methodology is a system for consistent field recording of habitats and for subsequent monitoring. This is done by field recording of 'General Habitat Categories' (GHCs), 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 a heavy demand for time, money, and human industry, 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 EBONE vegetation mapping? The overall objective of this project was to compare the EBONE 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 EBONE GHC classification (Table 1).

4.2 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 for Ramat HaNadiv. 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.

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 EBONE products, we need to make the two layers compatible. We overlaid the EBONE 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.

In the summer of 2009 a digital color orthophoto of the study area was generated by Ofek™ aerial photography, at a spatial scale of 0.25 m. 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.

4.3   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 EBONE protocol (hereafter referred to as LiDar, air photo, and EBONE, respectively). The pairwise comparison (i.e. two methods at one time) involved 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 EBONE protocol and the LiDar.

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 EBONE we found higher average difference of about 20% (Figure 7). The magnitude of the absolute difference was not correlated to polygon size.
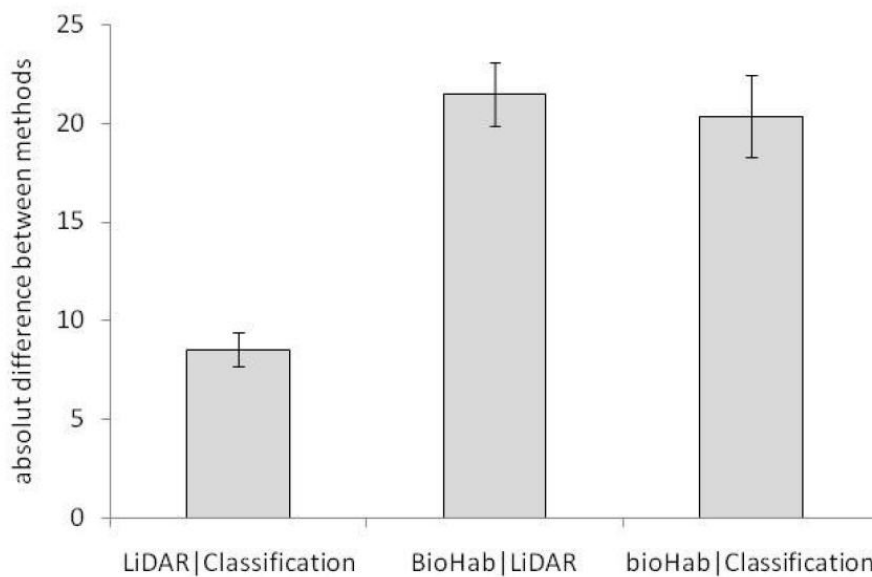

Figure 7

Comparison of LiDAR and BIOHAB/EBONE 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).

4.4   Discussion

Relatively large differences were found in woody cover estimates between each of the two remote sensing products and the BioHab/EBONE 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 EBONE mapping. Artifacts and error in LiDAR data are introduced through LiDAR system settings, operator error, machine malfunction, and aircraft pitch calibration and horizontal displacement error: see Su and Bork, 2006; Hodgson and Bresnahan, 2004.

In other cases EBONE estimates were mistaken. EBONE 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 EBONE product. However, some of the information derived using the EBONE method cannot 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 EBONE 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 EBONE 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 strength and weakness of each approach is fully exploited. For example, remote sensing methods are recommended for estimating vegetation cover while the EBONE protocol should be used for identifying vegetation life forms and management types.

5 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 (Table 4) 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 closed 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-type field mapping of habitats has so far been conducted only within two areas in Israel, Ramat HaNadiv in the north, and Avdat in the south). An additional site is being mapped as part of this work in the transition area between the desert and the Mediterranean (e.g., Lehavim, Figure 8a).
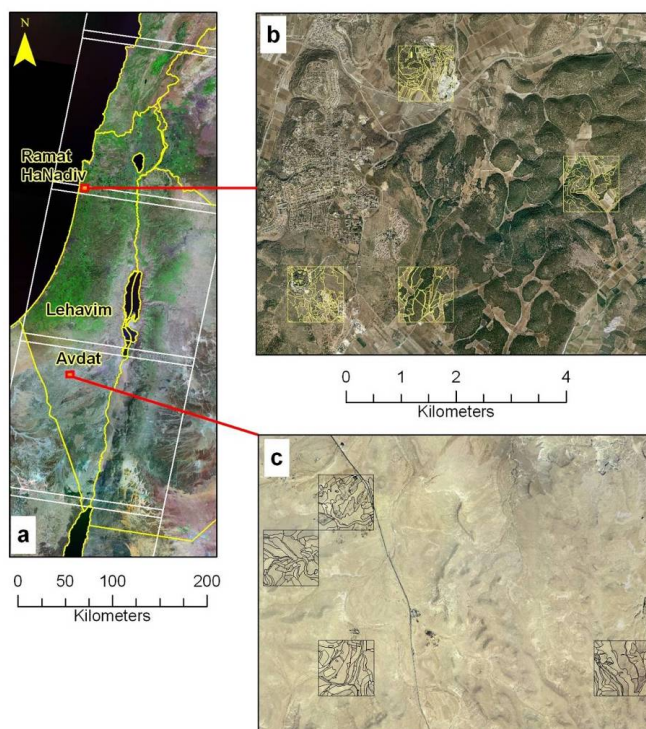

Figure 8

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

We will develop and test our methods on the field sites, and then apply them to the entire country.

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 EBONE 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).

Table 4

The different remote sensors used in this study.

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

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).
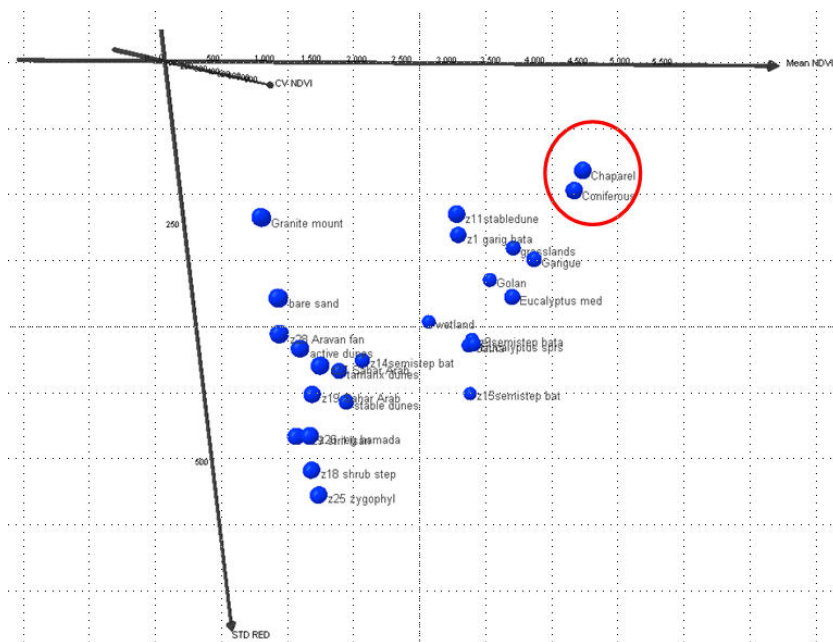

Figure 9

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), but we still have to work on separating a few classes.

We may distinguish between 'un-separable' classes using other methods (Figure 10), like NDVI (the Normalized Difference Vegetation Index (Pinty and Verstraete, 1992). The next major task is correlating the same remote sensing data with habitats mapped according to EBONE. This work is ongoing.

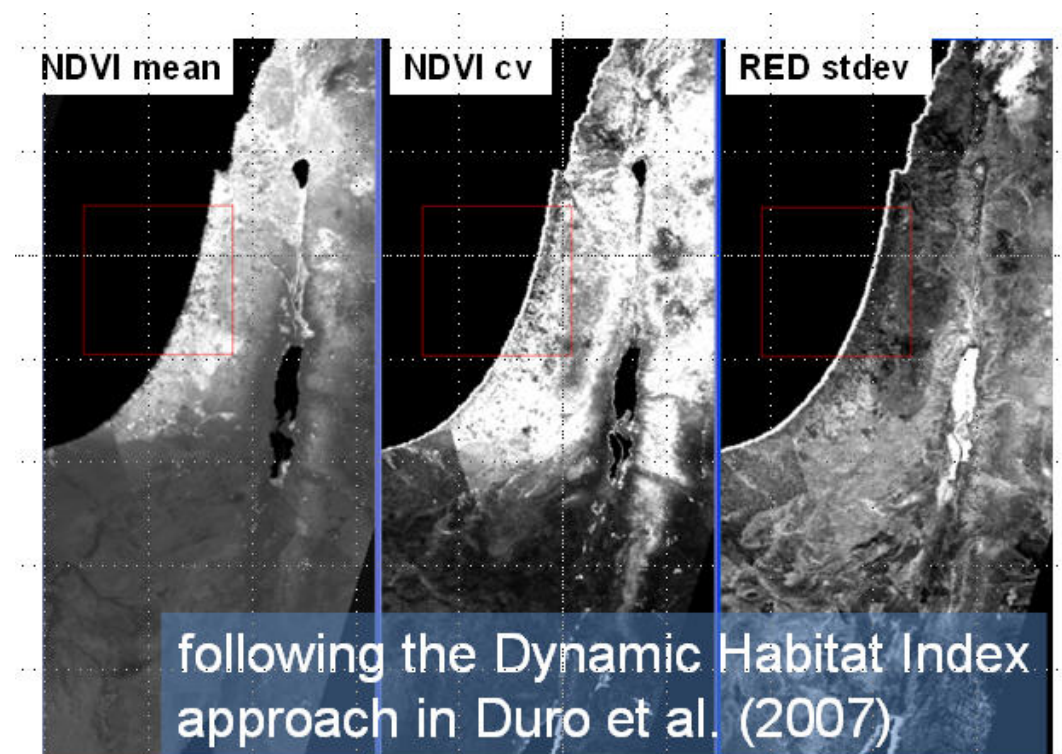$$NDVI = (NIR - RED)/(NIR + RED)$$

Figure 10
Variables calculated from the MODIS time series.

6 Connecting habitat type with biodiversity indices

6.1 Ramat HaNadiv studies

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 with 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 Ramat HaNadiv researchers on vegetation and birds, in LTER areas classified for this study using EBONE habitat classification methods (Table 5).

The data were collected by a variety of methods, and could thus only be used as presence/absence values. 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).

6.2 Method

6.2.1 Data used in the analyses

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.

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

Diversity data sets used in the study:
Plant data were based on permanent transects sampled over several years, with small plots for herbaceous species (Table 6) and line intercept data for woody plants (Table 7).

Table 6

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

Year	2003	2005	2006	2008	2009
Cabara grazing				150	
Cabara cattle and goat				150	
Cypress control			150	150	
Cypress grazing			150	150	
Fuel-break control	150		150	150	
Fuel-break grazing	150		150	150	
Garrigue control	150	137	150	150	
Garrigue grazing		150	150	150	150
Pines control			150	150	
Pines grazing			150	150	

Table 7

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

	Plot Year	2003	2005	2008
Cabara grazing				6
Cabara cattle and 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

Nesting bird data consisted of two surveys, geo-referenced with GIS, of all birds in the entire park (2001 - 2004 and 2007) which could be linked to the square 55 mapped by EBONE.

Diversity indices:
Several aspects of biodiversity were considered: species richness, guild (growth form) richness, and assemblage composition (Jobse, 2009). The relation of assemblage composition to GHC was studied using both direct and indirect ordination.

6.2.2   Results

Assemblages: Vascular plants

Herbaceous and woody species (Figure 11) 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.
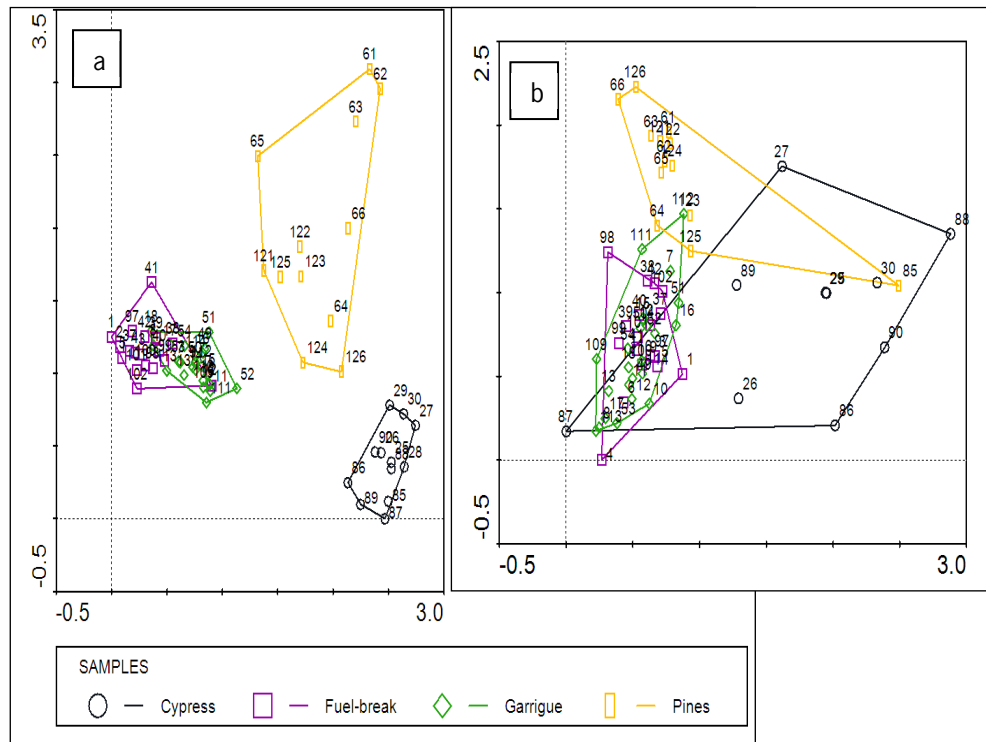

Figure 11

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 14.3.

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 12).

Figure 12

RDA ordination of RHD nesting birds versus EBONE General Habitat Categories.

Species richness patterns: Vascular plants showed highly complex patterns (Figure 13). 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.
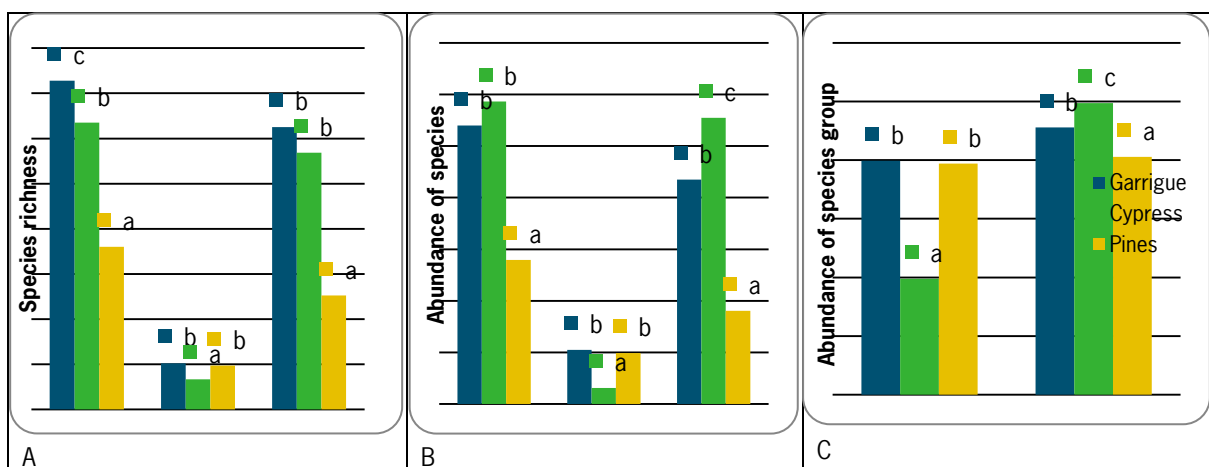

Figure 13

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 (Figure 14) 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.
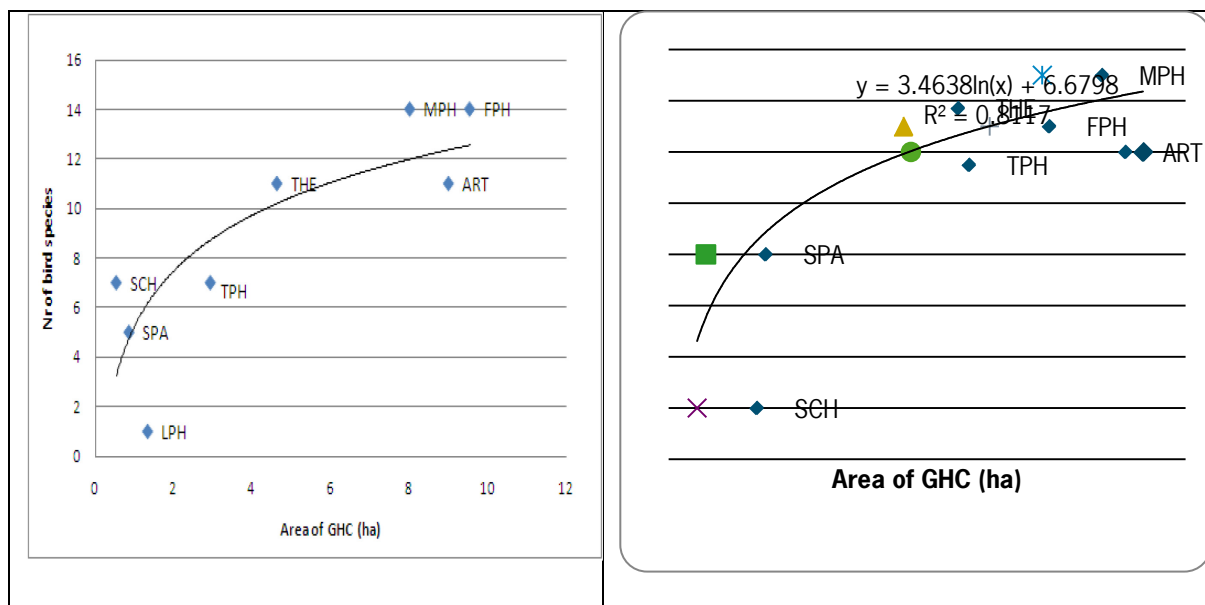
Figure 14

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 at page 12.

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.

6.3   Avdat studies

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 during spring of 2010 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.

6.3.1   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).

Table 8
New desert habitat categories at Avdat.

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	

6.3.2   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 the approximate 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 explicable 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 nested plots, which produce species/area curves. There seem to be two groups: BOU, BOU/STO, AND ROC/BOU with relatively high species richness and the other habitats with lesser richness (Figure 15). 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 (Olsvig-Whittaker et al., 1983) so is not surprising.
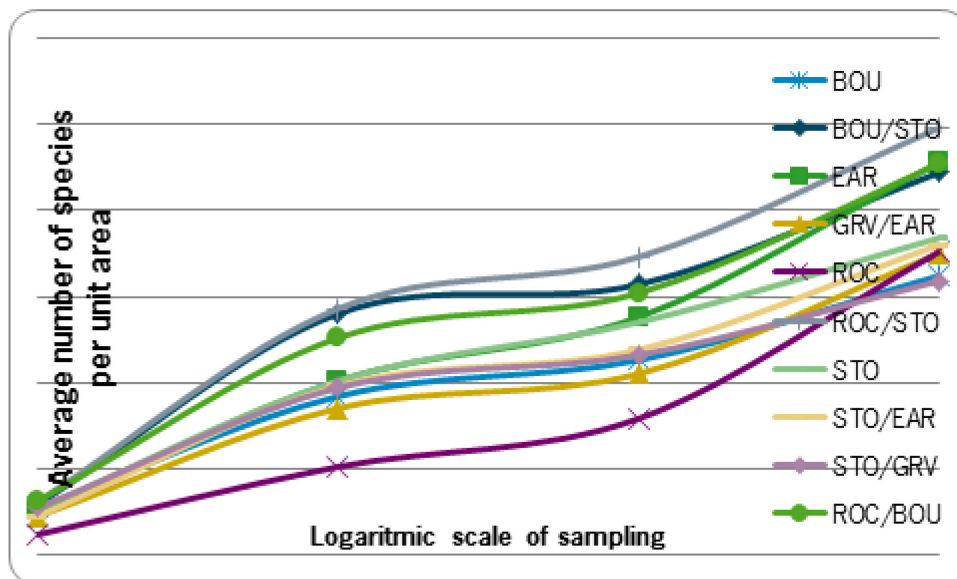
Figure 15

Species area curve with the average number of species per unit of area. The logarithmic scale goes from 1 (1 m^2) to 4 (1000 m^2). Noted should be that the number of species at 1 m^2 level is an average of 10 1 m^2 plots.

6.3.3 Reptiles

The reptile populations were sampled on two days, one at 31 March and one at 15 April. The 31st of March was four 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 were: BOU, STO/GRV, STO/EAR, and GRV/EAR.

Sampling was done in three different ways. The first 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 on parallel lines. For any reptile observed at the transect, we recorded the time of observation, the species, the distance perpendicular from the transect and (if the reptile could be caught) the length and weight. The starting and finishing times of the transect were recorded.

After that the survey was continued by rock overturning. This was done on the same transects 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 were also recorded. For each reptile caught, the time, coordinates, size of the overturned rock and species were recorded when feasible.

Besides looking in the selected polygons, reptiles observed between polygons were also recorded. For these individuals the following was recorded: the specimen, the time, the coordinates and if possible the measurements, but not the habitat.

Results: Species richness
The greatest species richness of reptiles (Figure 16) was in the earth (EAR) habitat, but variance was high, and sample sizes too small to detect significance.
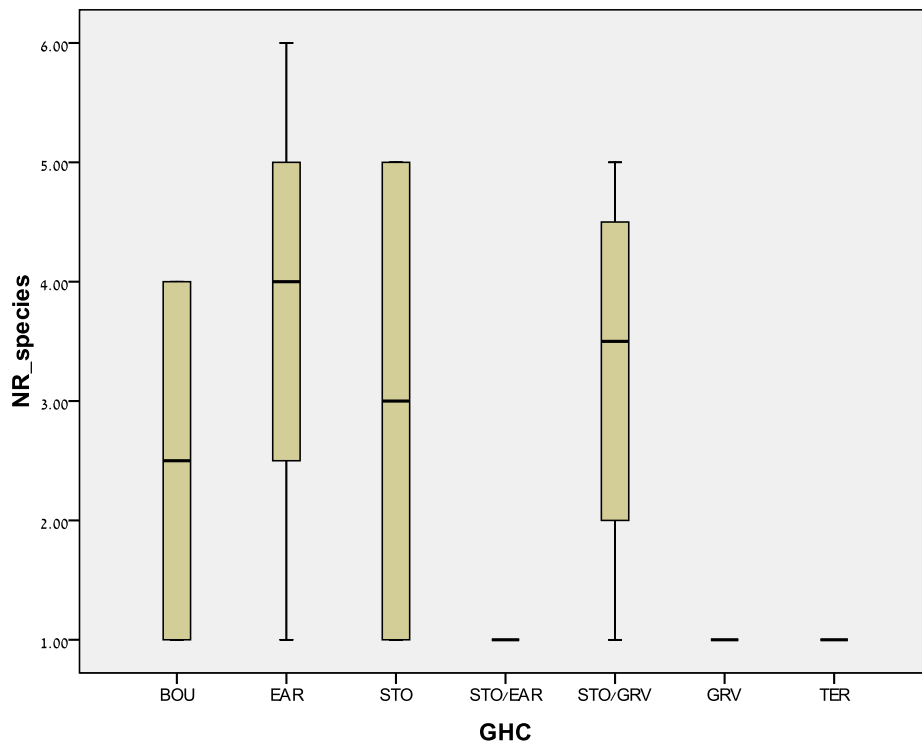
Figure 16

Boxplot with the number of reptile species per GHC. The graph shows the median and the maximum and minimum value.

Results: assemblage composition

Distinctive groups were seen in the DCA ordination of reptile data (Figure 17), which fit with herpetologists' knowledge of the usual habitats for these species. This figure shows the species by sample biplot from DCA, with samples labeled according to habitat type. However, the sample size was too small for direct ordination.
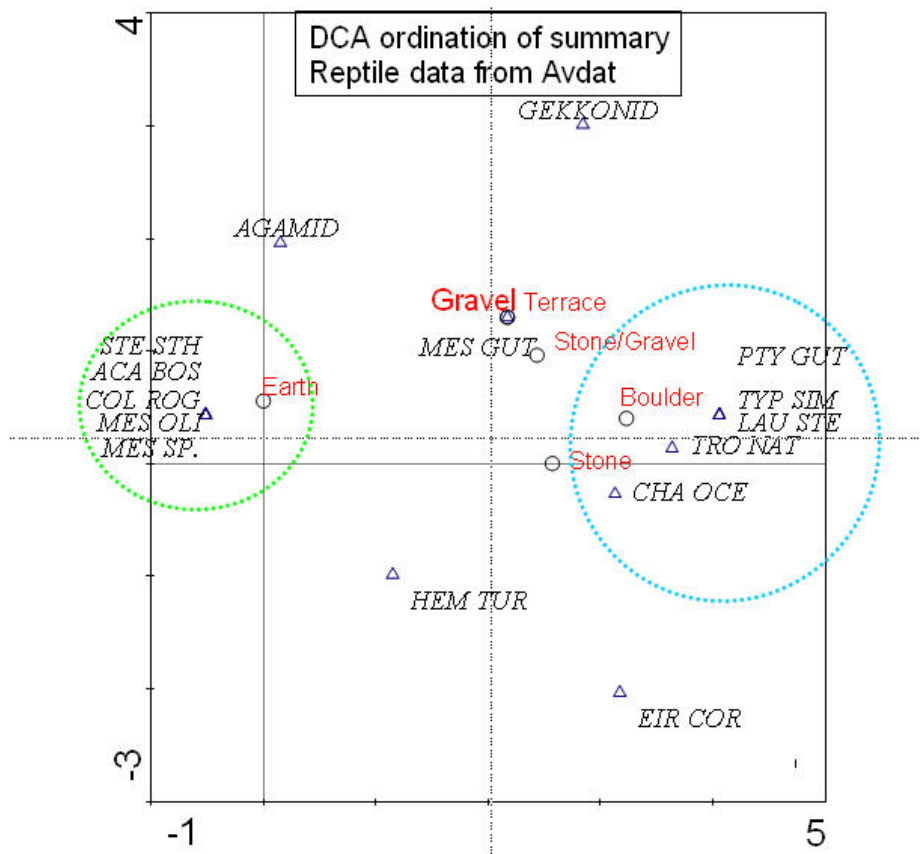
Figure 17

DCA ordination of reptile data at Avdat.

6.3.4   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 during 4-7 April 2010 followed by the pitfall traps in square 63 during 12-15 April 2010. A total of fifteen polygons were sampled, three for each of the five habitat categories. In each polygon were ten0 pitfall traps on each transect of 45 m, leaving five meters in between each pitfall trap. These transects were directed along the gradient of the slope (along the contour of the hill). 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 (Figure 18) was highest in the Earth (EAR) habitat and much lower elsewhere. Presumably this relates to the ease of burrowing in the friable soil of the Earth habitat.
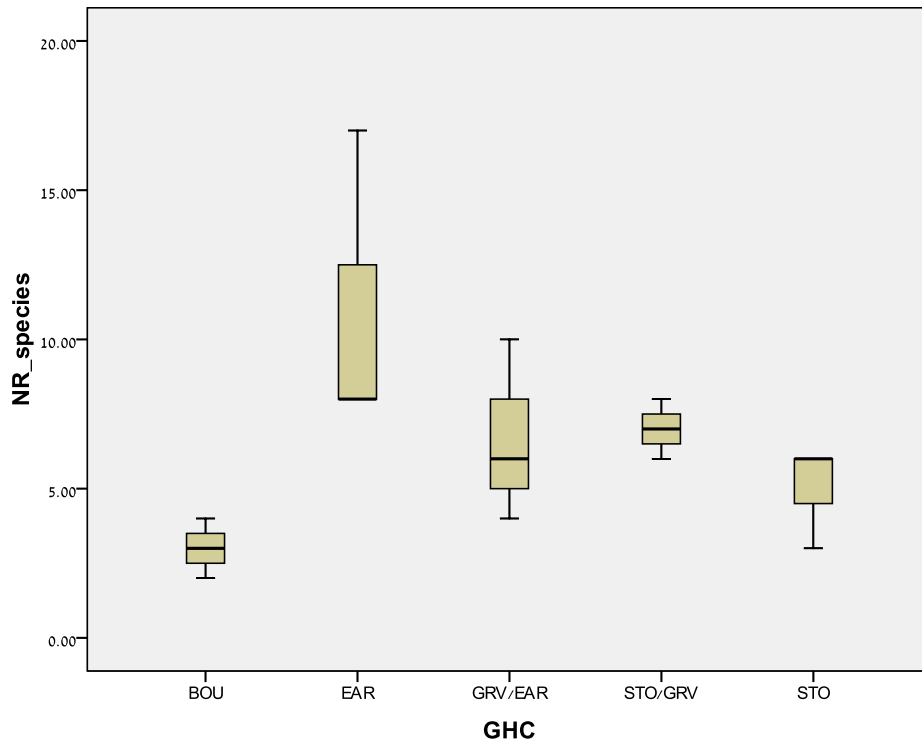
Figure 18

Box plot with the number of arthropod species in the various GHC's. The graph shows the median and the maximum and minimum value.

Results: Arthropod assemblage composition

Likewise, RDA analysis of pitfall traps versus GHC's (Figure 19) showed that 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.
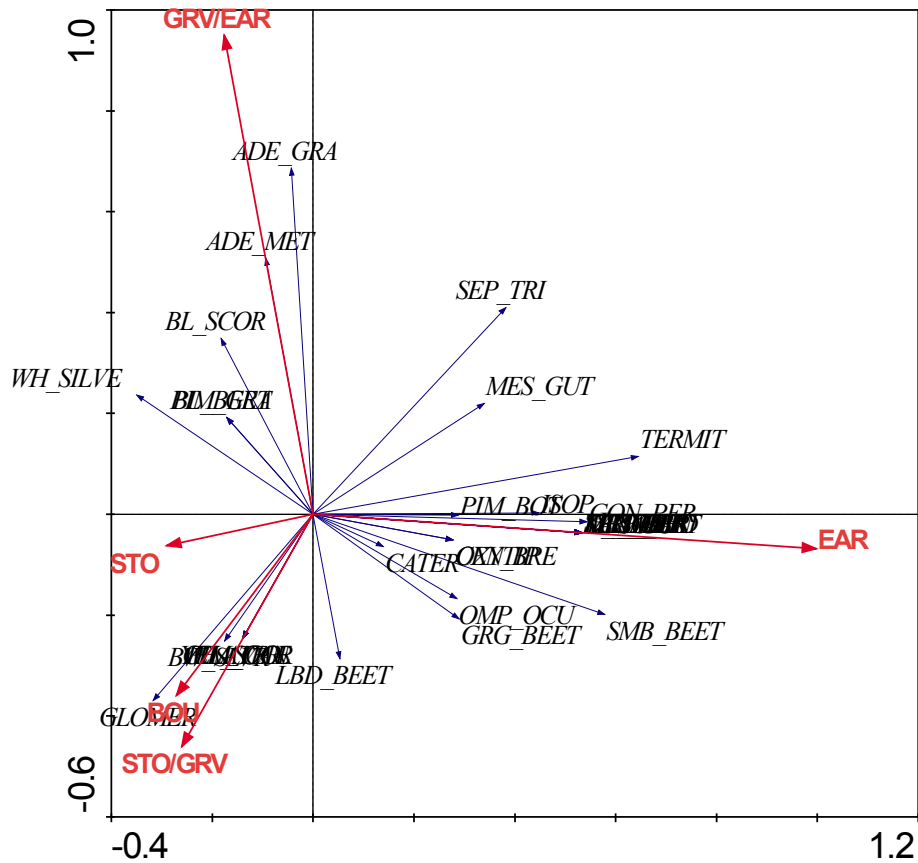
Figure 19
RDA ordination of pitfall trap data in Avdat.

6.4 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. Assemblage composition is not often considered as a measure of biodiversity, and deserves more attention.

7   Reaching stakeholders

7.1   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 Marc 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 (Cemagref, WP6, responsible for EBONE exploration of life forms outside Europe). In response 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 two 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 joining 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 eleven EBONE members. Most of the participants were stakeholders or Israelis who 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 approach 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 Hebrew University led by Dr. Noam Levin.) This work is continuing, and will result in a special report comparing several remote sensing approaches.

We agreed that the greatest challenge is the study of biodiversity. The INPA team decided 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.

8 Data management

Data have been recorded in Israel using traditional paper forms, 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 commentary is in Hebrew as well.

In order to insert the data from Excel spreadsheet into the field database developed in WP6 and WP7, it is necessary to transform the format of the spreadsheet data. Because the data was collected before the field database design was finalized, the spreadsheet was setup for ease of entry and analysis with little attention paid to its eventual inclusion in a database. The data transformation will use a combination of ETL tools and Excel VBA.

In most cases the data will be inserted directly into the back end database and bypassing the user interface. Part of the process of inserting the data into the database is to create an Israeli species list. This species list will map Hebrew names with Latin names, species codes will be created, and add life form information. The local Israeli species list is not meant to be comprehensive, that is, it will not list all species found in Israel, but will include all of the species that were identified in the sites surveyed.

9 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.

9.1 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.

9.2 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.

9.3 Connection with biodiversity

Here, the problem has always been to decide which measures of biodiversity are of interest to our work. Coming from a conservation perspective, the INPA staff naturally thinks 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 freer to consider our options.

It seems to us that species composition is a useful and predictable measure of biodiversity 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 it is. 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.

9.4 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 higher resolution).

LiDar is the most expensive approach 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.

9.5 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.

10 South Africa

The focus of the work in South Africa was two-fold. First the general applicability of the EBONE field sampling system has been tested. The trials have been conducted in the South African Sandveld region (Fynbos shrubland vegetation, Mediterranean climate conditions) on selected polygons rather than mapped areas, not unlike the work done in Israel at Lehavim. Secondly, in response to the stakeholder feedback on the EBONE experience, an approach was developed to derive information on the ecosystem state (and thus biodiversity intactness) from medium resolution satellite data.

10.1 EBONE sampling

The results and experiences derived from the EBONE application on subsets of fourteen representative 1 km^2 sites in the Sandveld region have been shared in 1:1 meetings with relevant national biodiversity management stakeholders and practitioners. The aim of the meetings was the introduction of the system and to compare BioHab with existing biodiversity field assessment methods which are currently applied in South Africa. The results showed that the EBONE assessment principally is applicable in the South African context, even if some extra life form classes had to be generated and implemented into the key. The ecosystem assessment practitioners acknowledged the system in that it provides a standardized system which would allow the spatial and temporal comparability of the results. However, the readiness of the practitioners and stakeholders to adopt the EBONE scheme was relatively low, for various reasons.

Firstly, for conservation planning and management in South Africa the stratification of the landscape usually is conducted according to transformed, non-transformed and pristine landscape criteria. The further stratification according to life forms was perceived as not giving enough information on the state of the biodiversity or ecosystem intactness, as relevant changes (e.g. degradation) takes place at a subtle scale (shift in species composition, damage or loss of biological soil crusts or loss of plant litter) which cannot be picked up by the EBONE approach. The ecosystem intactness or degree of degradation in South Africa is the key criterion for biodiversity management and planning, as it is crucial for the definition of protection zones and for monitoring the success of management actions.

With regard to the site specific detailed plant species assessment on a 400 m^2 patch as suggested by the EBONE guidelines, it has been pointed out that the 'pure species counting approach has long been abandoned in South Africa'. This is related to the huge richness of species, which can lead to about 1,000 species per square kilometer which will simply exceed the capacity and capability of feasible biodiversity management. This also explains why CSIR failed to source complete geolocated species lists for the validation of the remote sensing approach described below: complete species lists have not frequently been generated.

The overarching perception was therefore that the benefit gained from the training and labour intense EBONE approach would be too low as it would not deliver the information required for effective ecosystem intactness (and biodiversity) management.

10.2 Development of an ecosystem state/ biodiversity index

The CSIR therefore decided to invest into the development of a remote sensing-based approach to derive ecosystem intactness (and hence biodiversity) information from medium scale satellite data. The approach should allow the manager to assess the intactness of the field and to pick up gradual changes in the field condition over time with minimal costs and labour required. This development of an alternative approach was in accordance to the EBONE project, which asked to develop and compare different biodiversity assessment methods.

10.2.1 Field based validation system

In order to link the results to field-based ecosystem evaluation keys which are already accepted by the South African stakeholder community, an ecosystem intactness/biodiversity scoring system was created and used for the generation of ground truthing data.

The scoring system consisted of the following ten questions:
1. Has the area been transformed (to agricultural fields or other)?
2. Are there signs of lifestock (manure, trampling)?
3. Are there signs of management related soil degradation (bare roots, damaged soil crust)?
4. Presence of plant litter?
5. Is the grazing intensity high (according to signs on vegetation)?
6. Is there an increase of less palatable species?
7. Is the natural vegetation life form variety reduced?
8. Is the natural multistory life form composition given?
9. Does the vegetation occur with the natural small scale cover patchiness?
10. Are there signs of vegetation senescence?

If the respective "yes" or "no" answer is positive for the intactness of the ecosystem, a score of 1 was given. Depending on the answers to these questions, a maximum score of 10 for pristine landscapes can be achieved while lower values indicate the respective damage or degradation of the ecosystem. This scoring system was adopted from the book 'Karoo Veld - Ecology and Management' 2006 by K.J. Esler, S.J. Milton, R.J. Dean (eds.). However, the above catalogue of questions is preliminary and might be subject to change following additional expert consultations.

The scoring system was applied to 64 random points which have been visited during a field trip to a 30 x40 km susbset of the Sandveld region around Elandsbay. Together with the information derived from playing out the ten questions, photos, GPS coordinates and general information on vegetation, soil and general life form compositions have been recorded, too. This additional information technically allows the conversion of the field trip data into the general habitat classifiers of the EBONE scheme. The 64 random points were collected during three days in August 2011 and were sampled from pristine fynbos shrublands, fynbos used as rangeland, active and abandoned transformed croplands and wetlands. These scores were related to the remote sensing index described below.

10.2.2 Remote sensing derived ecosystem intactness/biodiversity index

Based on medium resolution multispectral remote sensing imagery an index has been developed using spectral and structural landscape parameters. As independent input images a SPOT 5 mosaic from January/February 2009 scenes (10 meter resolution) and a pan-sharpened, atmospherically corrected Landsat

7 ETM+ scene from August 2011 have been chosen. August is the peak-vegetation season in that region (winter-rainfall dominated Mediterranean climate). The Landsat acquisition date coincides with the field campaign conducted in August 2011 during which the 64 field validation points described above were collected.

The blank lines in the Landsat image caused by the known scan line correction error that has been affecting Landsat 7 since May 2003 have not been corrected which results in blank diagonal stripes in the results image, too. After the geometric and radiometric correction of both images and the pansharpening of the Landsat 7 scene to 15 meter resolution (initial trials have shown that the original 30 meter resolution is not sufficient to pick up relevant structural landscape characteristics), the images were segmented using eCognition software. For the resulting polygons, mean brightness ('albedo' as inverse measure for vegetation density), the mean standard deviation of the NIR band values (as indicator for vegetation structure heterogeneity) and the compactness (as measure of the shape of the segments) were extracted. The derived shape files were re-rastered and normalized to 0-to-1 data ranges. The assumption is that an increase in NIR band standard deviation is proportional to ecosystem/biodiversity intactness while an increase in polygon compactness and brightness usually is related with a decrease in ecosystem/ biodiversity intactness, Therefore the normalized compactness and brightness data have been inverted. Those three layers then have been added up and the results stretched to a data range between 0 and 10 (to match the field scoring system range), with 10 being the optimal and 0 being the worst possible ecosystem/biodiversity state.

The results are two independent maps for the SPOT 5 image from 2009 and the 2011 Landsat image (see Figures 20 and 21).
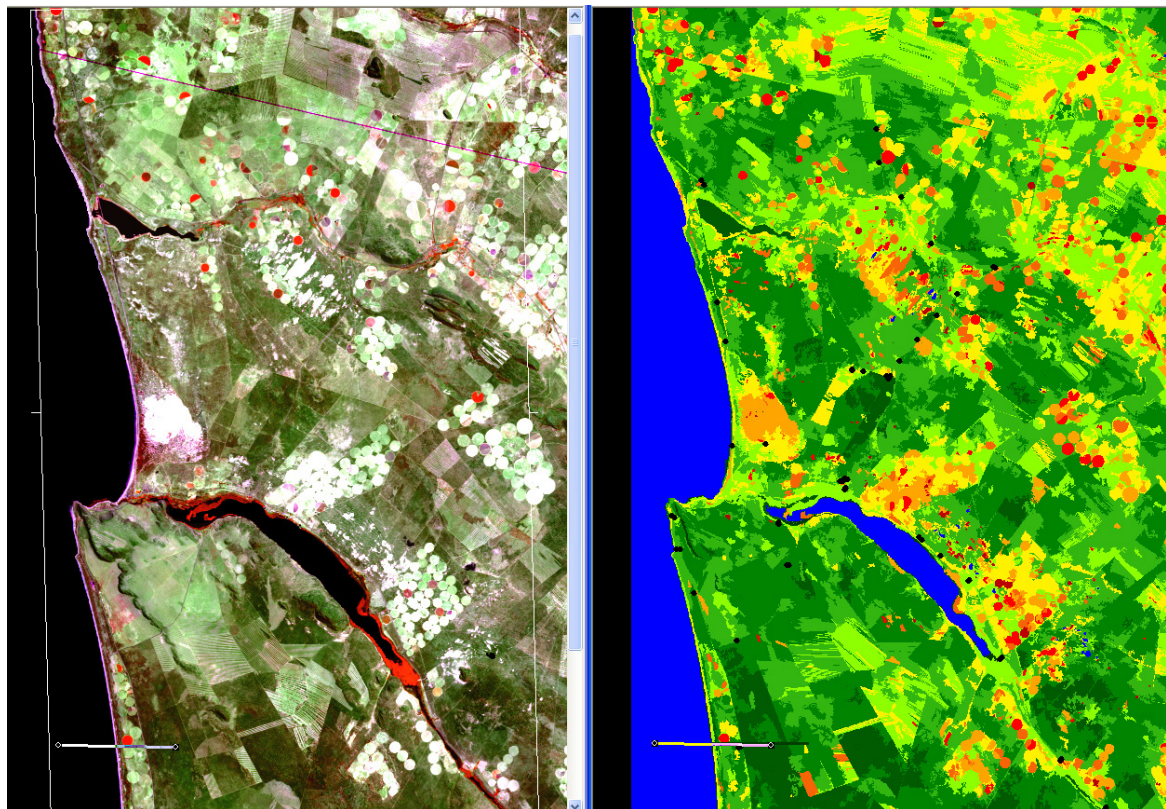

Figure 20

Left: Subset for the Elandsbay-Lambertsbay region of SPOT 5 mosaic from Jan/Feb 2009. Right: derived ecosystem/biodiversity indicator map (colour code see next figure). Black dots: location of field validation sites. The scale bar in the lower left corner is equal to 5 km.
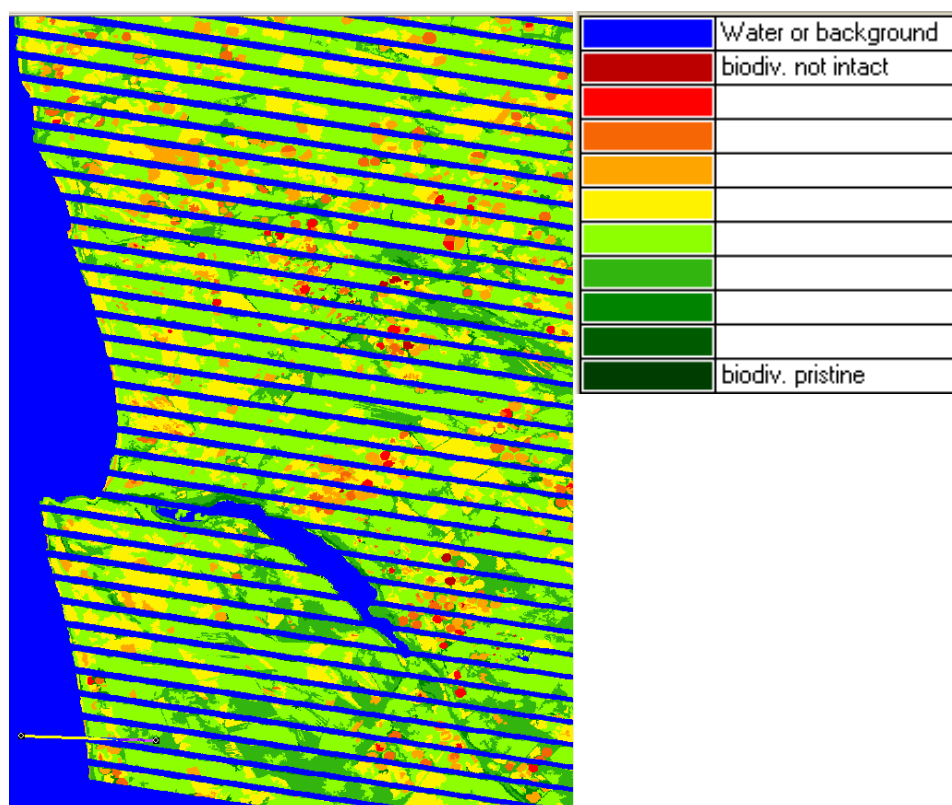
Figure 21

Subset of the Landsat 7 derived indicator map for the same region displayed in the figure above. The colour code indicates the gradient from not intact to pristine and intact areas (Indicator range 0 to 10). Scale bar = 5 km.

For the validation of the maps, the scores for the 64 field sites were compared with the respective remote sensing derived scores. For the purpose of this first approach we assigned a 'correct' to all points where the difference between field score and remote sensing score was $\leq \pm 2$, i.e. if the field score was 5 and the remote sensing score was between 3 and 7, it scored as correct. With this assumption, the 2011 Landsat derived index got an accuracy of 75%, while the 2009 SPOT derived index got an accuracy of 54%.

The low accuracy of the 2009 image is not surprising as 1. the 2009 image has been taken in Jan/Feb which is dry season while the field campaign was conducted in Aug 2011 which is peak rainy season. Secondly in this highly dynamic intensely used agricultural landscape a high degree of land cover change, i.e. in terms of crop rotation and fallow systems is to be expected. In some cases the field campaign also revealed areas which have been burnt before or after 2009 and were in different stages of recovery in the 2011 image. Obviously this has impact on the scoring at the different years.

The moderately satisfactory accuracy of 75% for the 2011 image might be partly related to Landsat's scan line error artefacts which probably have impact on the image segmentation results. Furthermore, during the discussion of the results with the stakeholders it was argued that the normalization applied to the input layers might not be uniformly applicable over whole landscapes but should be adapted to the individual land cover types. Therefore, a stratification of the landscape before the data normalization is expected to improve the results further.

Nevertheless, the stakeholders appreciated the outcomes of this approach and assured that this approach even with its current flaws might be very helpful for their work as it allows a fast assessment of large areas

(the entire processing chain for an entire Landsat image of 180x180km extent takes about one day) and as the use of radiometrically corrected images allows a quantitative comparison of multitemporal data sets. This means, if a region scores an 8 in one year and a 5 in a later image this change is significant and might alert management actions (given seasonal comparability of the input images).Therefore the stakeholders urge the CSIR to publish the results formally and to make the approach available to the user community.

To conclude, the EBONE approach technically is feasible in the South African Mediterranean context. However, the outputs and the concept of the habitat and life form based approach does not seem to meet the requirements of the national and regional biodiversity conservation planners. Approaches which provide more immediate information on the degree of ecosystem state (intactness or degradation) as indicator for biodiversity are perceived as more valuable.

11 Acknowledgements

12   References

Blank, L., 2010. Comparison between BioHab mapping and remote sensing. Project report, submitted to the Nature and Parks Authority. 16 pp.

Bunce, R.G.H., M.M.B. Bogers, P. Roche, M. Walczak, I.R. Geijzendorffer and R.H.G. Jongman, 2011. Manual for Habitat and Vegetation Surveillance and Monitoring, Temperate, Mediterranean and Desert Biomes

Danin, A., 1983. Desert Vegetation of Israel and Sinai. Cana Publishing House, Jerusalem, 148 pp.

De Gelder, A., 2010. Tracking and evaluating changes in vegetation and habitat structure in the En-Afeq Nature Reserve, Israel. A comparative study. MSc thesis Wageningen University. 93 pp.

Duro, D.C., N.C. Coops, M.A. Wulder and T. Han, 2007). Development of a large area biodiversity monitoring system driven by remote sensing. Progress in Physical Geography, 31, 235-260.

European Environment Agency, 2007 Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. EEA Technical report No 11/2007, 182 pp.

Hodgson, M. and P. Bresnahan, 2004. Accuracy of airborne LiDAR-derived elevation: empirical assessment and error budget. *Photogrammetric Engineering and Remote Sensing* 70: 331-339.

Jobse, D., Biodiversity data. MSc thesis Wageningen University, 36 pp.

Olsvig-Whittaker, L., M. Shachak and A. Yair, 1983 Vegetation patterns related to environmental factors in a Negev Desert watershed. *Vegetatio* 54: 153-165.

Pinty, B. and M.M. Verstraete, 1992 'GEMI: A non-linear index to monitor global vegetation from satellites', *Vegetatio*, 101: 15-20.

Shmida, A., 1984. Whittaker's plant diversity sampling method. Israel Journal of Botany 33: 41-46.

Su, J. and E. Bork, 2006. Influence of vegetation, slope and LiDAR sampling angle on DEM accuracy. *Photogrammetric Engineering and Remote Sensing* 72: 1265-1274.

Appendix, GHC abbreviations

GHC abbreviations used in this report (from Bunce et al 2011)
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)
Caespitosehemicryptophytes (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)

Alterra is part of the international expertise organisation Wageningen UR (University & Research centre). Our mission is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine research institutes – both specialised and applied – have joined forces with Wageningen University and Van Hall Larenstein University of Applied Sciences to help answer the most important questions in the domain of healthy food and living environment. With approximately 40 locations (in the Netherlands, Brazil and China), 6,500 members of staff and 10,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the exact sciences and the technological and social disciplines are at the heart of the Wageningen Approach.

Alterra is the research institute for our green living environment. We offer a combination of practical and scientific research in a multitude of disciplines related to the green world around us and the sustainable use of our living environment, such as flora and fauna, soil, water, the environment, geo-information and remote sensing, landscape and spatial planning, man and society.

More information: www.alterra.wur.nl/uk