Predicting biodiversity with BioHab mapping

Correlating habitat mapping method with in situ biodiversity data

David Jobse

Jerusalem, August 2009

Predicting biodiversity with BioHab mapping

Correlating habitat mapping method with in situ biodiversity data

Student:

BSc .David Jobse, Forest and Nature Conservation, Specialisation in Plant Ecology at Wageningen University, the Netherlands.

Mail: dod_david@hotmail.com

Supervisors:

Dr. Linda Olsvig-Whittaker, Science and Conservation Division of Israel and Nature Parks Authority, Jerusalem, Israel.

Prof. Dr. Karlè Sykorá, Nature Conservation and Plant Ecology Group at Wageningen University, The Netherlands.

Internship:

Internship for Nature Conservation and Plant Ecology Group, Course code: NCP-70724.

Period: April –August 2009 in Ramat Hanadiv and Jerusalem.

Abstract

This paper presents the research on correlating habitats with in situ biological data from the Ramat Hanadiv Park, Israel. This is part of the work for the Ecological Biodiversity Observation Network (EBONE). EBONE is an FP7 project started in various European countries, with the goal to apply it also on other continents. Israel is cooperating in this project in order to adopt the methods to Mediterranean landscapes. It is using biological proxies to make habitat maps. One of the methods used for habitat mapping is BioHab, a European project which ended in 2005. BioHab uses the Raunkiær plant growth forms to classify the various habitat types. As this classification is based on the vegetation structure, Remote sensing can be used to detect differences between habitats. Together with remote sensing data this could be done on a large scale. Since the goal is to link these habitats with remote sensing data this is done with an aerial perspective; starting with the tall growth forms and going down to the surface. The classification is based on the height and cover of the various growth forms.

The aim of this research was to correlate the habitat types distinguished by the BioHab mapping method with patterns in biodiversity. The research question was:

Can we use the BioHab mapping as a predictor of biodiversity?

The data used contained vegetation data, both relevés and cover of woody species, from the Long Term Ecological Research (LTER) site Ramat Hanadiv and bird data from the same area. Using ordination techniques and numerical classification allowed us to compare the species composition between the sites. We used also conventional methods like One-Way ANOVA and regression to compare the species richness and abundance of species and species groups.

The relevé data showed clearly that the three shrub lands are very much the same in species composition and richness. We will only see that the two planted groves are very distinctive, in growth forms and clearly also in species composition and richness.

Combining the data set for the woody vegetation with the earlier mentioned data set made clear that the two forest habitats are clearly different in species numbers and species composition. The tree cover could be beneficial for many species, however possibly the soil type, historical land use and the management are more important in explaining the differences. So these habitat descriptors should be used as well.

The uneven sampling effort for the bird data made that these observations could hardly be related to the area of the habitat polygons. However, the data suggest that the garden area, the open areas and the groves sustain high bird diversity. And besides that we see that point features like lookouts are important to be mentioned.

In general BioHab seemed to be suitable, though we should recognize that we need the habitat descriptors in order to distinct for example between planted groves.

339 words, Key Words: BioHab – vegetation composition – species richness

Map of content

Acknowledgment

Writing this paper was possible due to the help of several people during the analytical and writing process. First of all I want to say a grateful word to Dr. Linda Olsvig-Whittaker who helped, advised and stimulated me during this whole research to get the most out of it. A special word of thank goes to the people of Ramat Hanadiv, especially to Liat Hadar, who provided the data and a lot of site information and advice. Without this cooperation this research could not have been done. I hope this cooperation will be continued to the benefit of ecological research and the parties involved, the Nature Parks and Authority of Israel and Ramat Hanadiv.

1. Introduction

This report presents the results of the analyses done on the various ecological data in Ramat Hanadiv (RHN), including Long Term Ecological Research (LTER) areas and bird observations. The report starts with a short introduction and an area description. The research question is stated afterwards followed by a description of the methods which were used. Since various methods were used for the analyses, these are explained followed by the results. Finally some conclusions are made with the implications for the EBONE project and some recommendations for the methodology for EBONE and future data collection.

EBONE (European Biodiversity Observation Network) is a FP7 project with the goal to design a plan for an integrated biodiversity observation network in time and space (www.ebone.wur.nl/UK; Halada et al. 2009). This is done by building on the knowledge and network of previous European networks, like BioHab (www.nbu.ac.uk/biota/biohab_page.htm). In the EBONE project we were restricted to a structural vegetation classification, so the link to species composition is only to find a relation between the habitat classification and floristics. By linking these habitats to remote sensing data we hope to be able to use this method on a national and even international scale. The goal of this paper is more down to earth, namely to correlate the habitat mapping method with in situ biological data collected in the same area. In the Description of work (Annex I 2008) this written as: The Biohab project has concluded that the way forward is to measure habitat diversity as a proxy for biodiversity on the basis of plant life forms but also including information on environmental variation in humidity and trophic levels using a stratified random sampling system." Therefore the main research question is:

Research question

Can we use the BioHab mapping as a predictor of biodiversity?

BioHab mapping is basically a method to define different habitats on a large scale. At Ramat Hanadiv this was done by a team of ecologists (see figure 1 for the map). Ramat Hanadiv is situated on the southern edge of the Carmel ridge, just south of Zikhron Yakov. One square km within the park was randomly selected together with four other squares. The square in Ramat Hanadiv (Square 55) contained various vegetation types and different habitat types. See figure 2 for a map with the habitat polygons inside square 55. Table 1 gives a short description of the General Habitat Categories (GHC's) occurring in square 55.

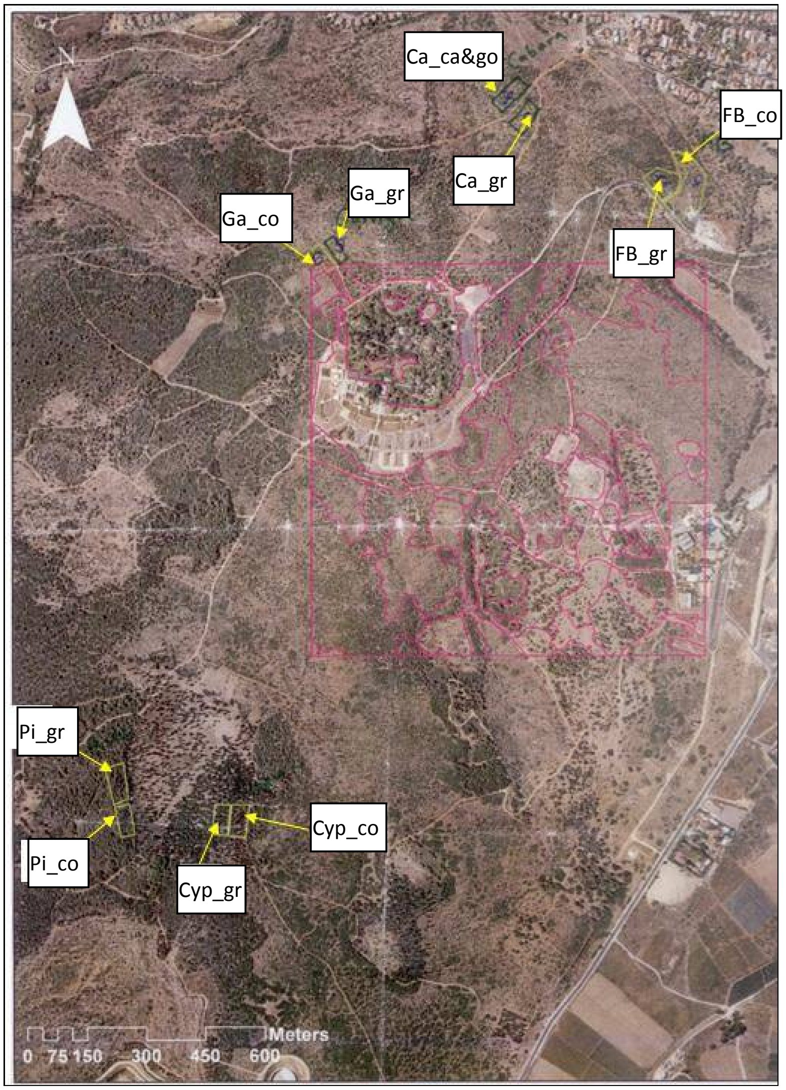

Figure 1 Areal picture of the Ramat Hanadiv site with square 55 and the polygons (in purple) and the various LTER areas. The picture is from May 2009.

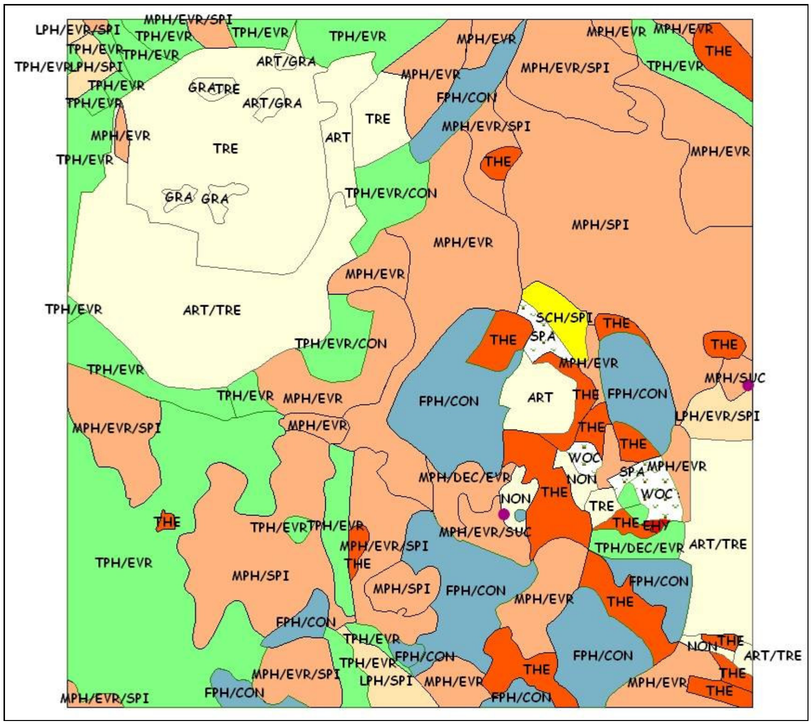

Figure 2 Map of square 55 with the various habitat polygons and its'

Table 1 Overview of the general habitat categories (GHC's) and its' descriptions defined in square 55, Ramat Hanadiv. Derived from Bunce et al. 2005.

GHC	Description of GHC
ART	Artificial area
GRA	Planted grasses (lawns)
NON	Non-vegetated
TRE	Trees
SPA	Sparsely vegetated
WOC	Woody crops
THE	Therophytes (annuals)
SCH	Sub Chaemophytes
LPH	Low Phanerophytes (0.3-0.6m)
MPH	Mid Phanerophytes (0.6-2m) – Shrubland
TPH	Tall Phanerophytes (2-5m) – Low forest
FPH	Forest Phanerophytes (>5m) – Forest
EVR	Evergreen
CON	Coniferous
SPI	Spiny cushion
SUC	Succulent

BioHab mapping method is mainly based on the dominant growth forms, which are only noted down when having a cover higher than 10%. In addition this categorization is done from an aerial viewpoint; first the tall growth forms followed by the lower forms.

The goal of this range of analyses was to take in situ data collected independently from the area and to see if the habitat mapping is correlated with patterns of different biodiversity indicators. If this can be done, habitats can predict biodiversity.

For this correlation we obtained some data sets from the area by agreement with the owners, Ramat Hanadiv research facility. These biological data sets will be described below.

In situ data which we could use were:

- Data set with the understory vegetation in 5 LTER areas
- Data set with the understory vegetation in 5 LTER areas
- Woody vegetation in 5 LTER areas
- Bird data

Data set with the understory vegetation in 5 LTER areas

This data set contained presence/absence data of the plant species in 5 different areas. The tall woody vegetation was also surveyed in these areas, but it is a different data set which is discussed in the next paragraph. These areas were chosen by Ramat Hanadiv staff to monitor the impact of the grazing management in the area over a longer period. These areas are used for Long Term Ecological Research (LTER), so they are called LTER areas.
These areas are named after the dominant species or the name of the specific zone. They are: Cabara, Fuel-break, Garrigue, Cypress and Pines. See figure 1 (page 6) for the location of these LTER areas. As they were established to monitor the grazing impact over time we have data from both control and grazing plots over various years. Only Cabara is an exception here as it is divided into a part were cattle graze and a part were also goats graze the vegetation and it was only surveyed in 2008. In each control and grazing plot 6 transect of 25 m were chosen. In these transect there were 25 quadrates of $0.5m^2$, each 0.5 m apart from each other. See table 2 for an overview of the number of quadrates done within the various years.

Table 2 Overview of the number of quadrates surveyed in the LTER plots within the various years.

Year	2003	2005	2006	2008	2009
Cabara grazing				150	
Cabara cattle & 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	

Unfortunately these areas were located outside the square km in which the habitats were mapped. Therefore we decided to do the mapping in both the control and grazing plots. The latter because we could be sure whether the grazing did not change the vegetation structure that much that also the general habitat category (GHC) would change. Table 3 (next page) gives an overview of the GHC's assigned to the various plots. See table 1 for an overview of the abbreviations.

Table 3 Overview of the general habitat categories (GHC's) assigned to the various plots according to the BioHab mapping method.

Site / Treatment	Cabara	Cypress	Fuel-break	Garrigue	Pines
Control		FPH/CON	MPH/EVR	TPH/EVR	FPH/CON
Cattle grazing	MPH/EVR	FPH/CON	MPH/EVR	MPH/EVR/SPI TPH/EVR	FPH/CON
Cattle and goat grazing	TPH/EVR				

Woody vegetation in 5 LTER areas

The woody vegetation, shrubs and trees, was surveyed in the same LTER areas in Ramat Hanadiv (see previous paragraph), but not in squares but with a line-transect method. So these are not only presence/absent data, but also the height and the cover of the individual shrubs and trees can be derived from the data. Table 4 gives an overview of the number of transects surveyed within the various years.

Table 4 Overview of the number of transects surveyed in the LTER plots within the various years.

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

Bird data

The bird data contains two data sets with bird observations in the area of Ramat Hanadiv. The observations are GIS referenced, so they can be linked to the habitat map. The focus was on the bird species which are also nesting in the area. The initial goal of these surveys was to compile a species and an estimate of the population size. In the surveys of the last decade the aim was also to characterize the relation between population size and their habitat of management regime (Menachem Adar, in press). However, these habitats are defined by the observers and with a structural method like BioHab. Consequently we see that these habitats and the GHC's do not always match, so that we do not have an equal sampling effort over the whole area. Though this did not allow us to standardize the number of birds or the number of observations to the area of the polygon it gave us an idea about distribution of the bird species. Figure 3 gives an overview of various observations done in the area. From figure 4 a and b it is clear that the observations did not fully cover square 55. Therefore we deleted the polygons which were not or only party surveyed.

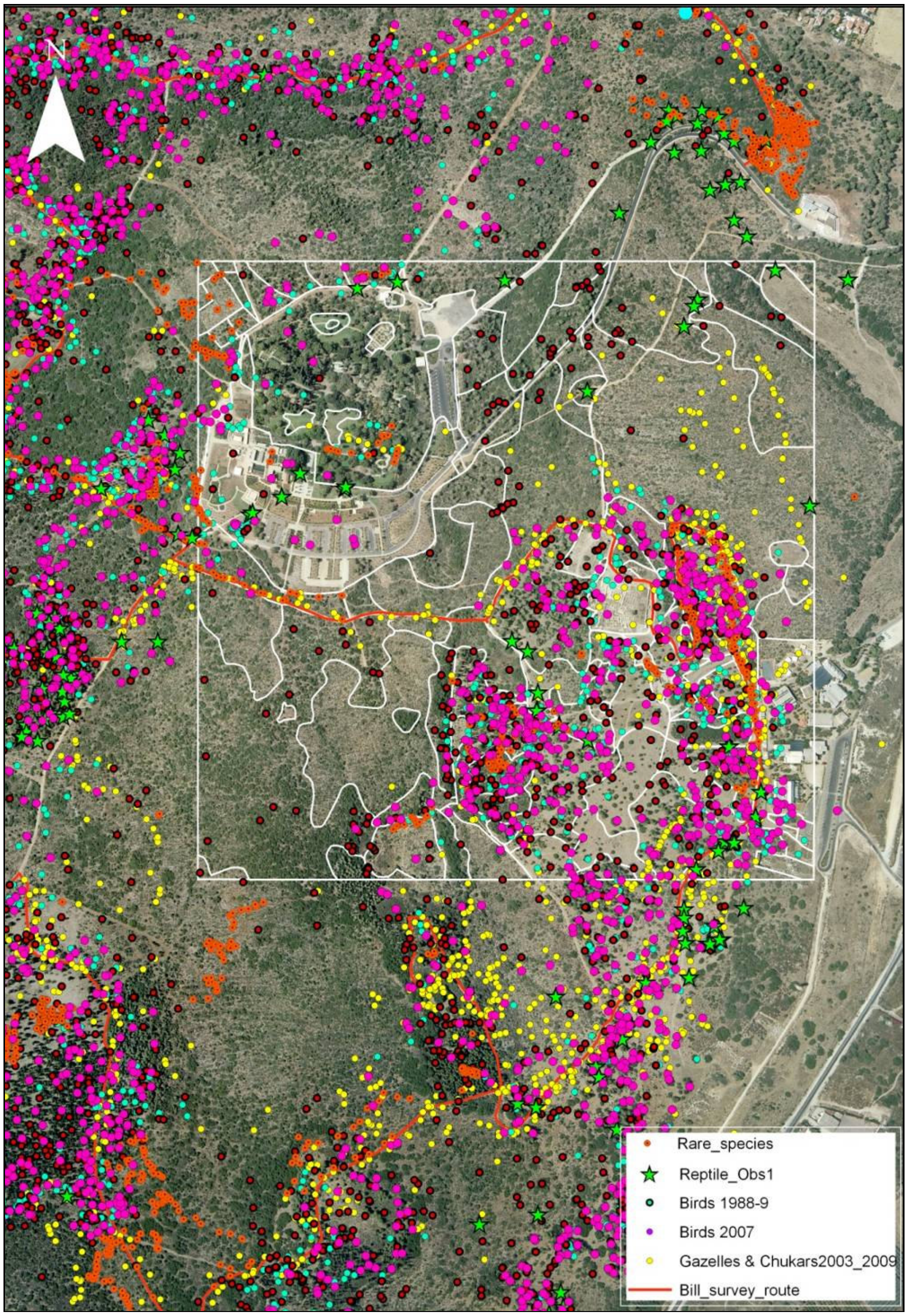

Figure 3 Areal picture or Ramat Hanadiv with square 55 and the observations done in the area. See the legend for the symbols for the various observations.

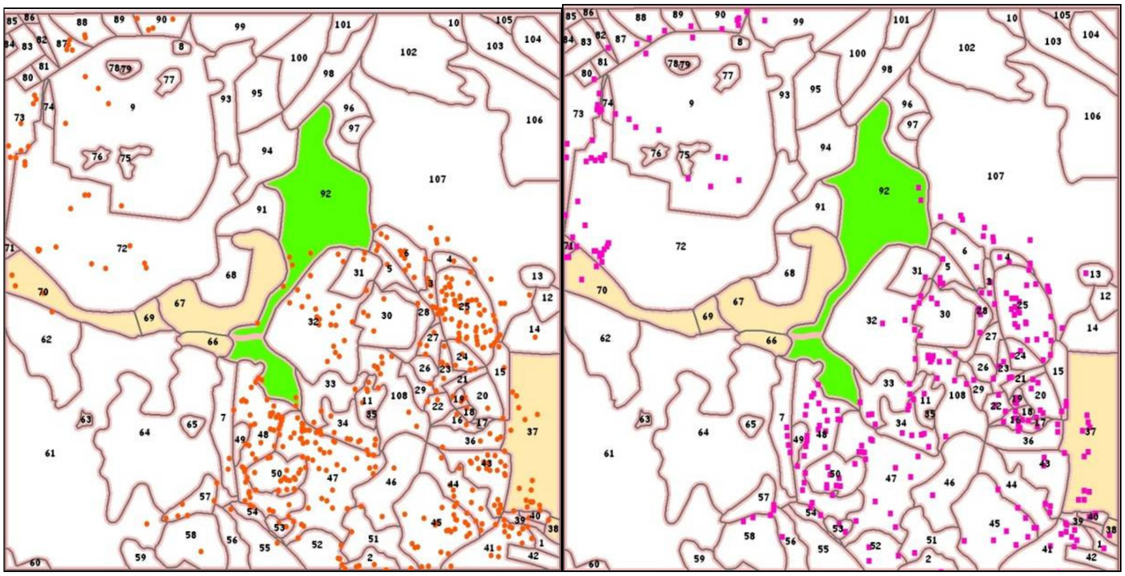

Figure 4 Square 55 with the bird observations of 2001 and 2004 (left figure) and 2007 (right figure). The polygons represent different units of habitats.

2. Methods

Various methods were used to analyze the data sets. Here, the methods are described in general. More detailed information is provided when describing the results.

Habitats in EBONE are defined by structure, in contrast to more conventional methods which rely on floristic information. Part of the analyses done was to compare structural patterns determined by BioHab to patterns in species composition, to see whether the results are at all similar. Another part of the analyses done was to test the significance of correlation between EBONE habitat types and functional group distributions. Both questions use ordination and classification tools in their analyses.

To explore species composition within the area we used ordination techniques. These were used on the understory vegetation in the LTER areas and on the bird observations. The ordination was done in Canoco for Windows 4.5 (Ter Braak 1987).

To get a general idea about the species composition we used an indirect ordination technique, the Detrended Correspondence Analysis (DCA; Ter Braak and Šmilauer, 2002). As this analysis was to explore the data and the treatment and year are only plotted as passive variables. So the variation in the diagram is described only by the species composition.

When the different growth forms were analyzed we also used a direct ordination technique, a Redundancy Analysis (RDA) in which a species or growth form matrix is correlated against a matrix of environmental variables. As environmental variables we used the three General Habitat Categories (GHC's): Garrigue, Cypress and Pines as dummy variables (0 and 1 values). As co-variables we used year, site, treatment, transect and grazing. We choose these variables and co-variables because we wanted to know the relation between the various areas and the species richness irrespective of year and treatment

TWINSPAN for Windows 2.3 was also used in order to see if a numerical classification would give us the same results as gained by the ordination analysis. We used the default settings, using the species occurring at least 5 times in the dataset.

In order to compare the mean species richness of the abundance of species between areas, years of treatments we used One-Way ANOVA in SPSS 17.0. A Tukey post doc test was used if we had more than 2 different groups to compare, e.g. 5 areas, or 4 years.

In case of the bird data we used also a linear regression in Excel in order to plot the relation between the area of the polygon and the number of bird observations or the number of bird species.

3. Results

3.1 Understory vegetation in the LTER areas

In May 2009 we checked the LTER areas to define the habitats by using the BioHab method (Bunce et al. 2005). Table 3 gives us an overview of these General Habitat Categories (GHC's). Generally we could define two GHC's. The first was shrubland (mid Phanerophytes) with some low forest (tall Phanerophytes) in Cabara, Fuel-break and Garrigue. The other GHC was assigned to Cypress and Pines, namely forest phanerophytes (FPH).

The question is whether we see the same pattern when looking into the in situ data.

According to BioHab we could distinguish two main categories, namely MPH and FPH (table 5). BioHab maps according to the Raunkiær growth forms and life forms (Bunce et al. 2005). See table 1 (page 7) for details and the description of the GHC's. Only if we look in detail to the various vegetation types, or habitat descriptors, we see differences between the LTER areas and between the management implemented.

Table 5 An overview of the GHC's assigned to the various plots including the relative cover (%) of the various vegetation types also called the habitat descriptors.

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

However, the question is whether the in situ data show the same patterns. The results of the various analyses are shown below.

Ordination

First an indirect gradient analysis was done to see how the species composition in these areas looks alike.

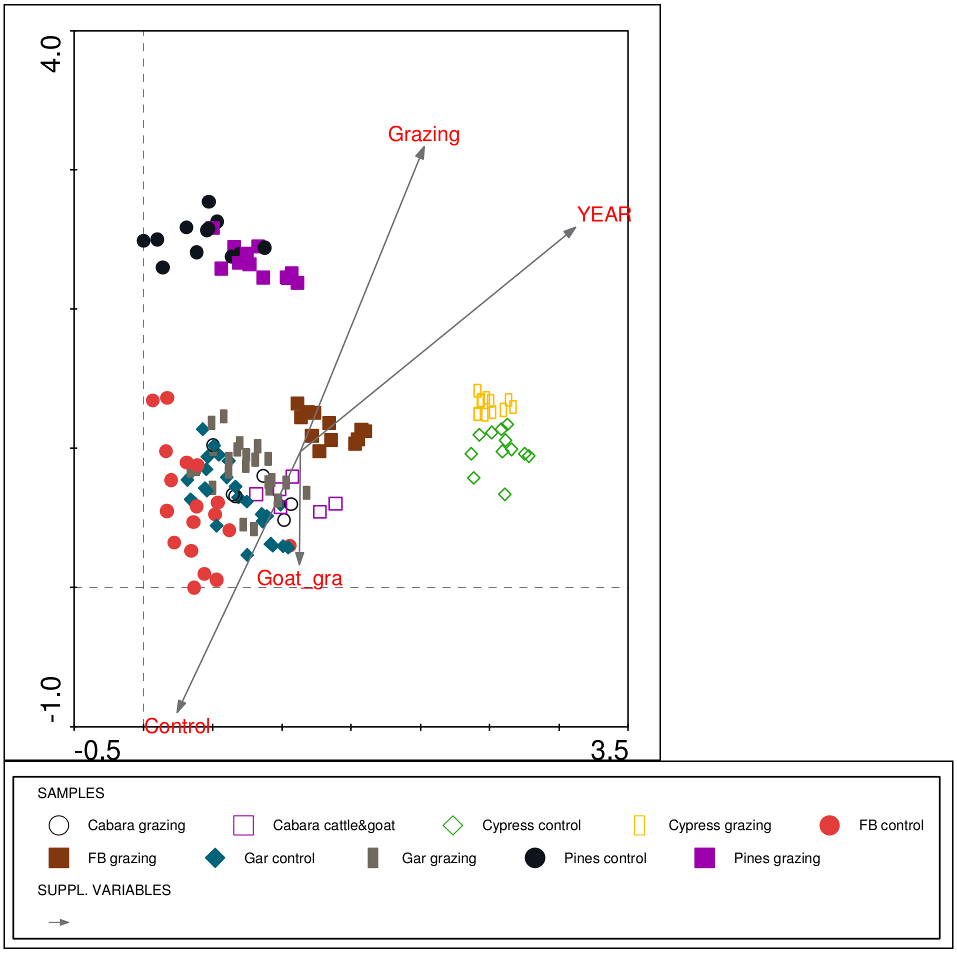

Figure 5 DCA on all species data with passive variables. The passive variables are year, Control, Grazing and Goat. The symbols in the diagram represent transects which were surveyed in the various years. The legend shows which symbols were in which LTER area.

According to the DCA ordination three different main groups can be distinguished differing in species composition; a Pine group, a Cypress group and a cluster of the other LTER's of which only Fuel-break grazing appeared to be a non-overlapping subgroup. (see figure 5). The length of the first ordination axis was 2.783 and the variation along the first ordination axis was mostly correlated with Year (weighted correlation = 0.2746) and along the second ordination axis with Grazing (0.3267). In general we see three clusters, 1) Cabara, Fuel-break and Garrigue, 2) Cypress and 3) Pines. The LTER's are ordered along the first axis as follows: Pines, Fuel-break, Garrigue and Cabara mix up partly and Cypress is distinctive. Along the second axis Pines is distinctive from the other LTER areas. Along the third axis the areas mixed up, though the two years of Cypress clustered on the extremes.. We see a small differentiation between the treatments, but only for Fuel-break this is a major difference.

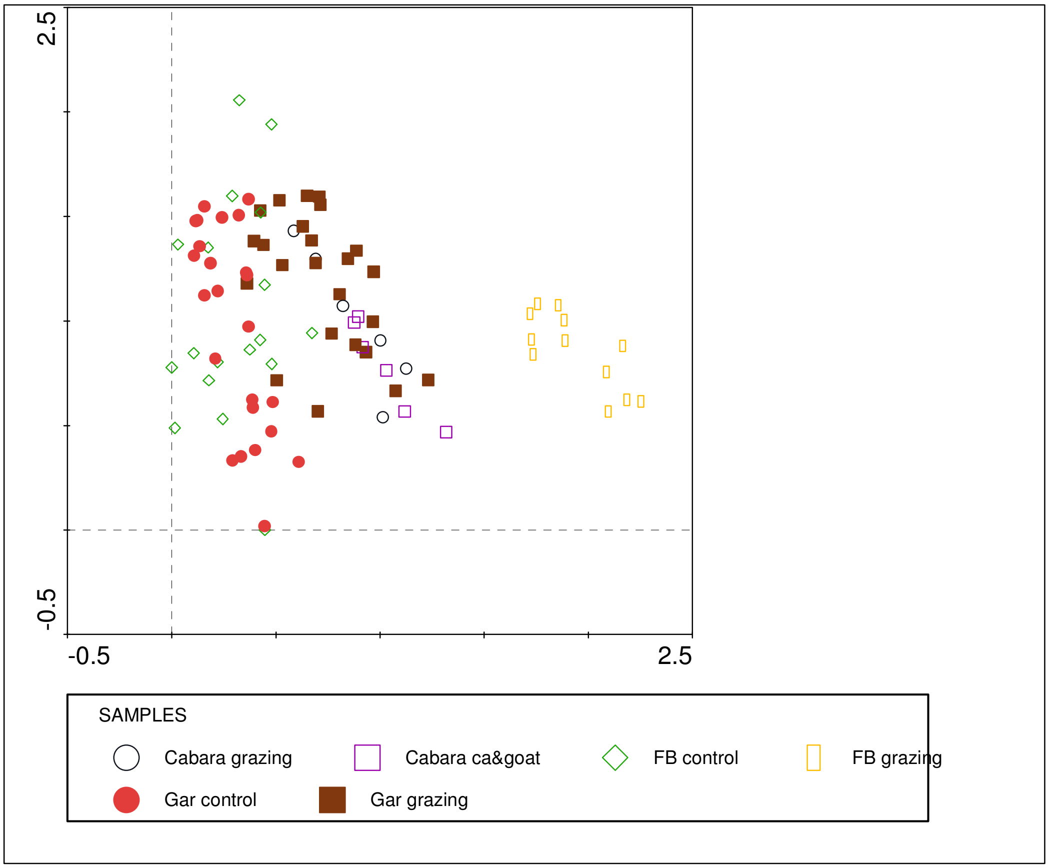

Figure 6. DCA on all species with only the transects from Cabara, Fuel-break and Garrigue. The meaning of the symbols is shown in the legend.

When doing this same analysis without Cypress and Pines we see that the length of the first axis is shorter (2.253 compared to 2.783 with all data) and it's more obvious that the species composition in Fuel-break grazing is indeed differentiating along the first ordination axis (see figure 6). However, the other sites are overlapping on the first, second and third axis.

These figures show that we can indeed consider Cabara, Fuel-break and Garrigue as one main GHC. Only the grazed area of Fuel-break is differentiating. However, the species composition was also diverging between Cypress and Pines. This was not coming out of the BioHab classification, as it didn't make a difference between these two areas. Actually we see two gradients, namely Garrigue to Pines and Garrigue to Cypress.

The hypothesis was that a gradient of light availability between Garrigue and Pines (with Pines being darker) could explain the differences in species composition and species diversity. Separating between the herbaceous species and the woody species might give an explanation, as they probably react differently to these gradients. We decided to separate the control and grazed plots for this analysis as an One-Way ANOVA was showing us that there was sometimes an effect of grazing on the herbaceous and the woody species richness (see table 6 below).

Table 6 One-Way ANOVA on grazing effect on number of herbaceous and woody species in the various areas and the years. No effect is indicated with a 0, a positive effect of grazing (or inclusion of goats in the case of Cabara) with a +. One + means that P≤0.05 and ++ means that the P≤0.01.

Areas	Species groups	Herbaceous species	Woody species & climbers
Cabara	2008	0	0
Fuel-break	2006	++	0
	2008	0	0
Garrigue	2005	0	0
	2006	0	0
	2008	0	+
Cypress	2006	0	++
	2008	0	++
Pines	2006	++	0
	2008	+	0

In the control and grazing plots (figure 7 and 8 respectively) we saw different patterns for the herbaceous versus the woody species in the Cypress and Pines.

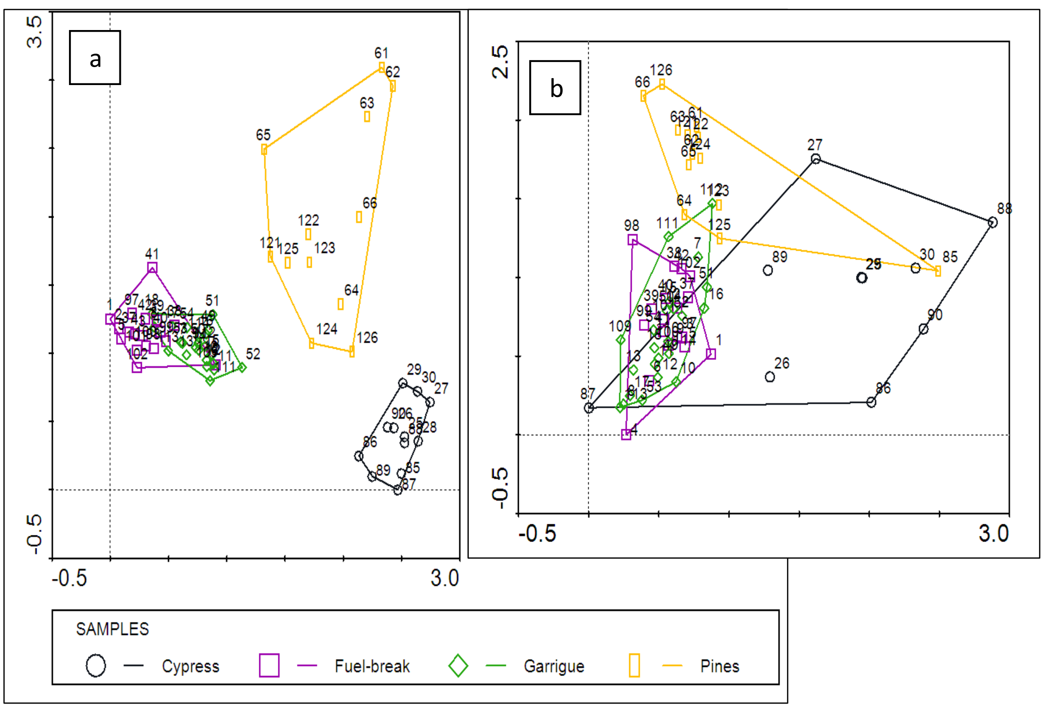

Figure 7 a) DCA control plots with the herbaceous species. The different symbols represent the transects of different areas which are shown in the legend. The numbers represent the sample numbers of the transects (in total 138 transects). b) DCA on the control plots with only the woody species: the shrubs and climbers.

We see a positive effect of grazing on the species richness; however this differed between the herbaceous and woody species. So we did a DCA on respectively the herbaceous and the woody species in the control and grazed plots (figure 7 and 8).

Figure 7 and 8: In all plots, either with herbaceous species or with woody species the Cypress and pine are clearly separated from the other LTER's except in case of the control plots with woody species where the LTER's overlap. Cypress and Fuel break are always overlapping, except in the grazed plots with herbs only. Here there is a clear order in the species composition from Cypress, Fuel breaks, Pines, to Garigue and Cabara. In all cases Cabara is overlapping with Garrigue. When looking at all four graphs (figure 7 and 8, both a and b) we see on the first axis that Cypress differentiated from the other areas (see also table 6). In the grazing plots we see that the second axis is even differentiating between the two years. Pine differentiates also on the third ordination axis, but less than the Cypress. This is confirmed by table 7 in which we summarized the graphs by highlighting the areas occurring on both ends of the ordination axes. The herbaceous species composition in the grazed Pines plot differed only on the third ordination axis (see table 7 as this is not really clear from the two-dimensional graph). In the other graphs this is already the case at the second ordination axis. It is clear that different herbaceous species occurred in the grazed Fuel-break plot when comparing it to Cabara and Garrigue (clear from the first ordination axis in figure 8a).

Table 7 Table with the various transects sorted along the ordination axes. This was the results of a series of DCA's. This was done for the herbaceous and the woody vegetation in both the control and the grazing plots. All years were included in this analysis. FB and Garr are the abbreviations for Fuel-break and Garrigue respectively.

		Herbaceous vegetation			Woody vegetation	
	Axes	1st Axis	2nd Axis	3rd axis	1st Axis	2nd Axis
Control plots	Low values at ordination axis	FB and Garr	FB and Garr		Garr and FB	FB, Cypress and Garr
	High values at ordination axis	Cypress	Pines		Cypress	Pines
Grazing plots	Low values at ordination axis	Cypress	Cypress 2006	Garrigue	Cypress	Garr and FB
	High values at ordination axis	Garr	Cypress 2008	Pines and some Garr 2009	Pines, FB and Garr	Pines

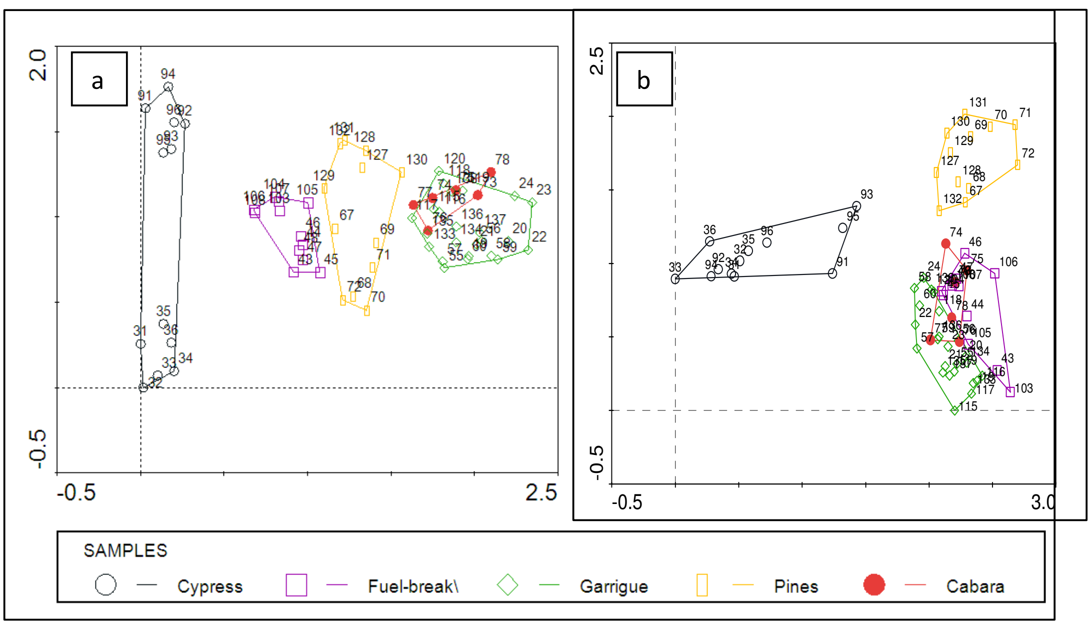

Figure 8 a) A DCA on the grazing plots with the herbaceous species. The different symbols represent the transects of different areas which are shown in the legend. The numbers represent the sample numbers of the transects (in total 66 transects). b) DCA on the grazing plots with only the woody species, so the trees, shrubs and climbers. The legend shows the symbols used for the various areas.

Cabara, Fuel-break and Garrigue still seem to behave the same, except for the herbaceous species composition in the grazed Fuel-break plot (figure 7a). This was confirmed by doing a numerical classification in Twinspan on all the data with only the species that occurred at least 5 times in the data set (see Annex I for the TWINSPAN table). On the first cut level we could separate Cypress from the other areas. On the second cut level it was Pines which was distinctive from the rest and the two surveys done in Cypress were separated. Only on the third level we found Fuel-break grazing differentiating from Cabara, Fuel-break control and Garrigue. Besides that, some of the transects in Pines in 2006 and 2008 differed from the other transects in the same site. However, these differences in between years and between the tree MPH areas seem to be smaller than in between the three main GHC's. So also this analysis supported the decision of taking the areas Cabara, Fuel-break and Garrigue together as one GHC and to separate Cypress and Pines.

Species richness and abundances

From here we decided to compare these three GHC's, Garrigue, Cypress and Pines with respect to the species richness, occurrence of species, and abundance of these two main species groups.

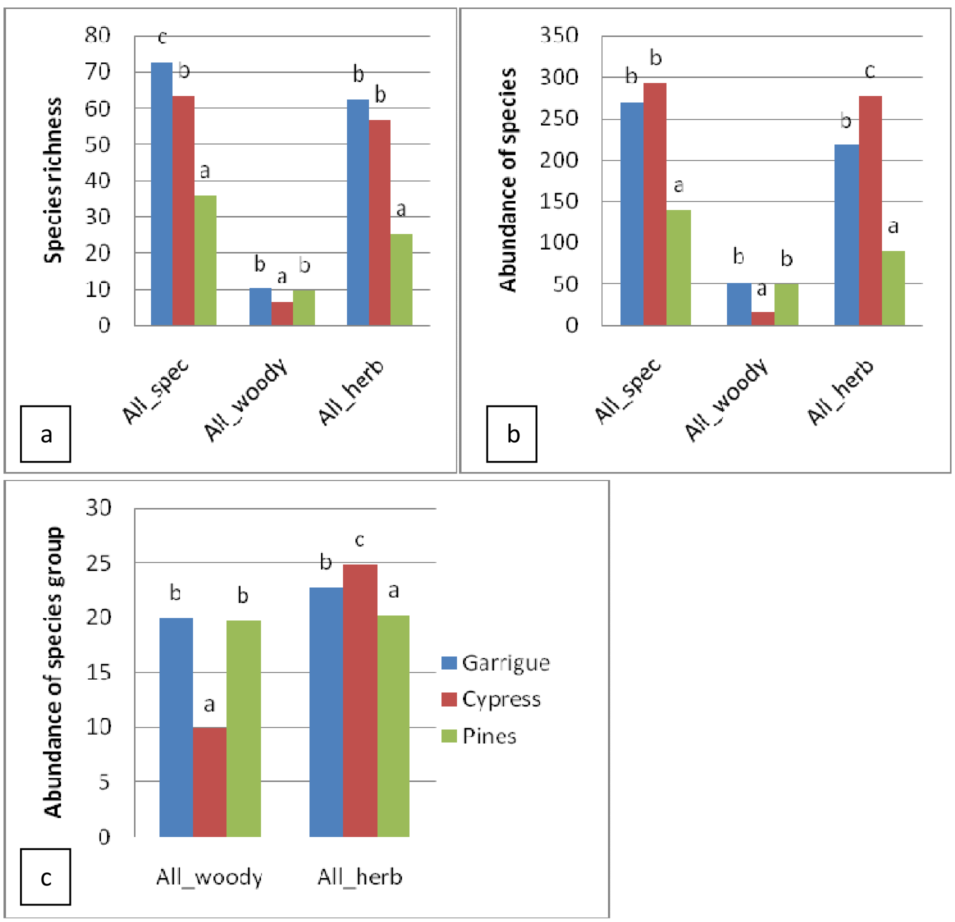

Figure 9 a) Average species richness, b) average species abundance (sum of positive hits per transect) and c) the average abundance of the species groups (maximum of 25) in the three GHC's in the LTER areas at transect level. The species group are: all species (All_spec), all woody species (All_woody) and all herbaceous (All_herb). The data of all areas and all years were used for this comparison. Garrigue is a combination of Cabara, Fuel-break and Garrigue. The letters a, b and c in the bar graphs give the significant differences between the numbers. These are the result of a Tukey post doc test in One-Way ANOVA.

From these graphs (figure 9 a, b and c) it becomes clear that Garrigue and Cypress are relatively rich in herbaceous species compared to Pines, but that Garrigue and Pines are relatively rich in woody species compared to Cypress. Looking back to the ordination graphs in the previous part it seemed that the species richness was inversely related to the variability of species assemblages inside the areas (read clustering of the transects in the graph). The differences between Garrigue and Cypress switch when looking at the species richness or the abundance of the species (compare figure 9a with b).

Growth form

The plant species can be separated into growth forms according to the Raunkiær used in the Israeli checklist (Fragman et al. 1999).

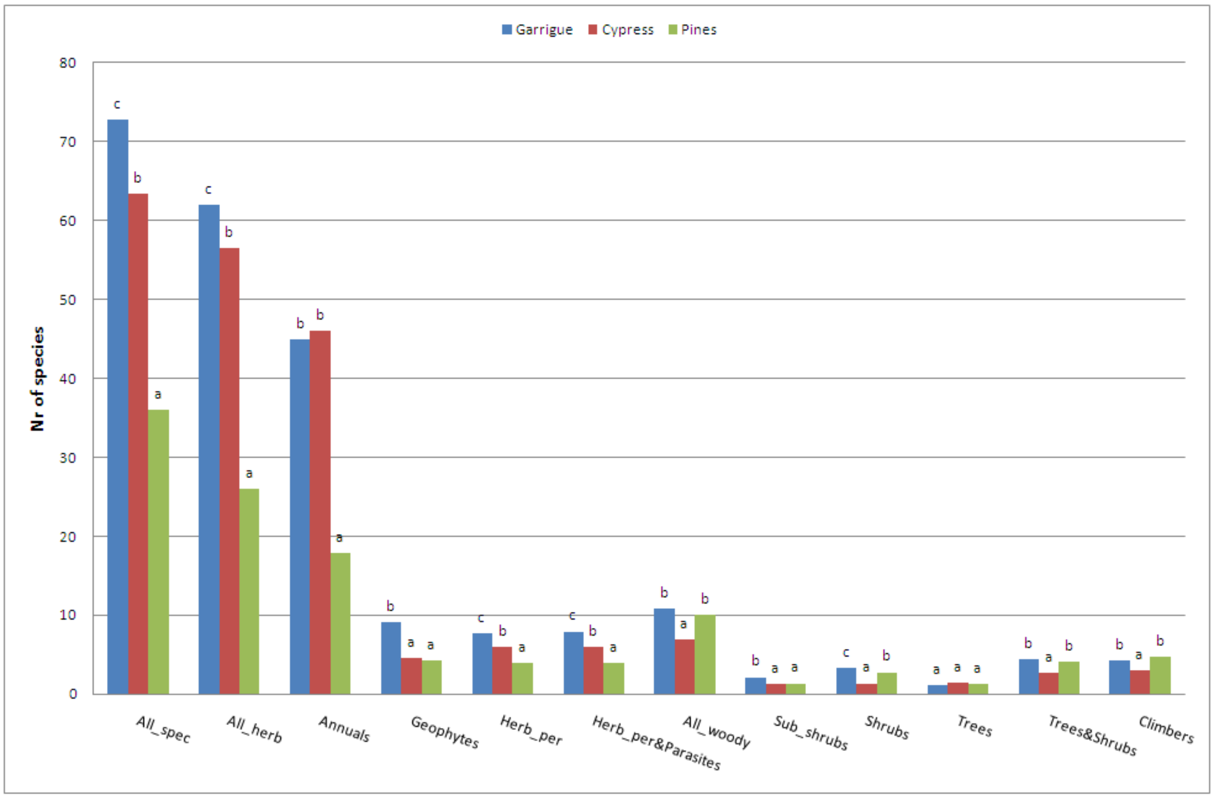

Figure 10 Average species richness within each species growth form on the transect level. The letters show the significant differences between the three main habitats in the LTER areas in Ramat Hanadiv (Tukey Post Doc test in SPSS). Garrigue is a combination of Cabara, Fuel-break and Garrigue.

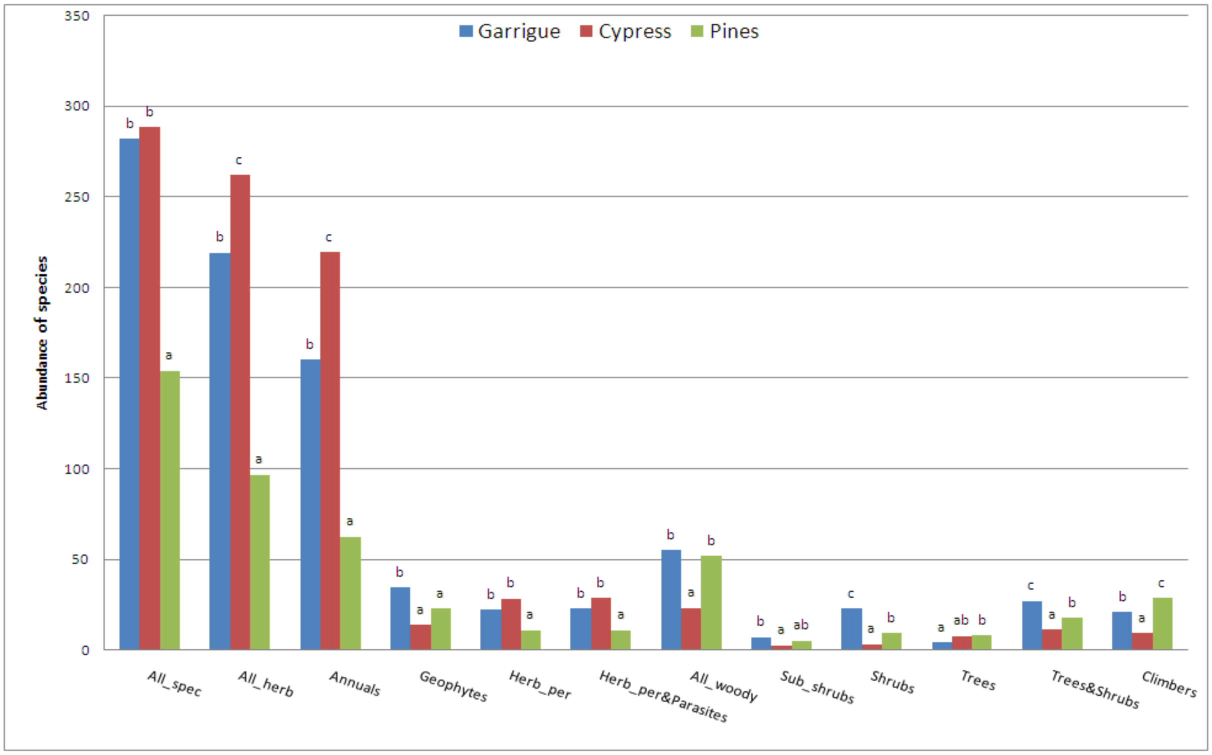

Figure 11 Average abundance of species (sum of positive hits per transects) within each species growth form on the transect level. The letters show the significant differences between the three main habitats in the LTER areas in Ramat Hanadiv (Tukey Post Doc test in SPSS). Garrigue is a combination of Cabara, Fuel-break and Garrigue.

See figure 10 for the species richness within each growth form and figure 11 for the abundance of the species within the growth forms. After narrowing the analysis within the various growth forms it still seemed that Garrigue and Cypress are relatively rich with respect to the herbaceous species compared to Pine. However we see that for example the geophytes are an exception. The same was also found for the woody species, as Garrigue and Pines are stil realtively rich compared to Cypress. However Garrigue and Pines do differ from each other when looking at the shrubs and the climbers. Besides these differences between GHC's there is also differences between the richness and the abundance of species. Garrigue has an higher overall richness compared to Cypress and Pines, but when looking to the abundance of species this tends to be the opposite. When narrowing down it's clear that the same happens with the annuals and the herbaceous perennials. Cypress has less species on the large scale, but the question is whether this is still the case at the small scale as the abundance is slightly higher in Cypress. The same patters are seen when comparing the abundances of the various growth forms (see figure 12 for the abundance of the growth forms)

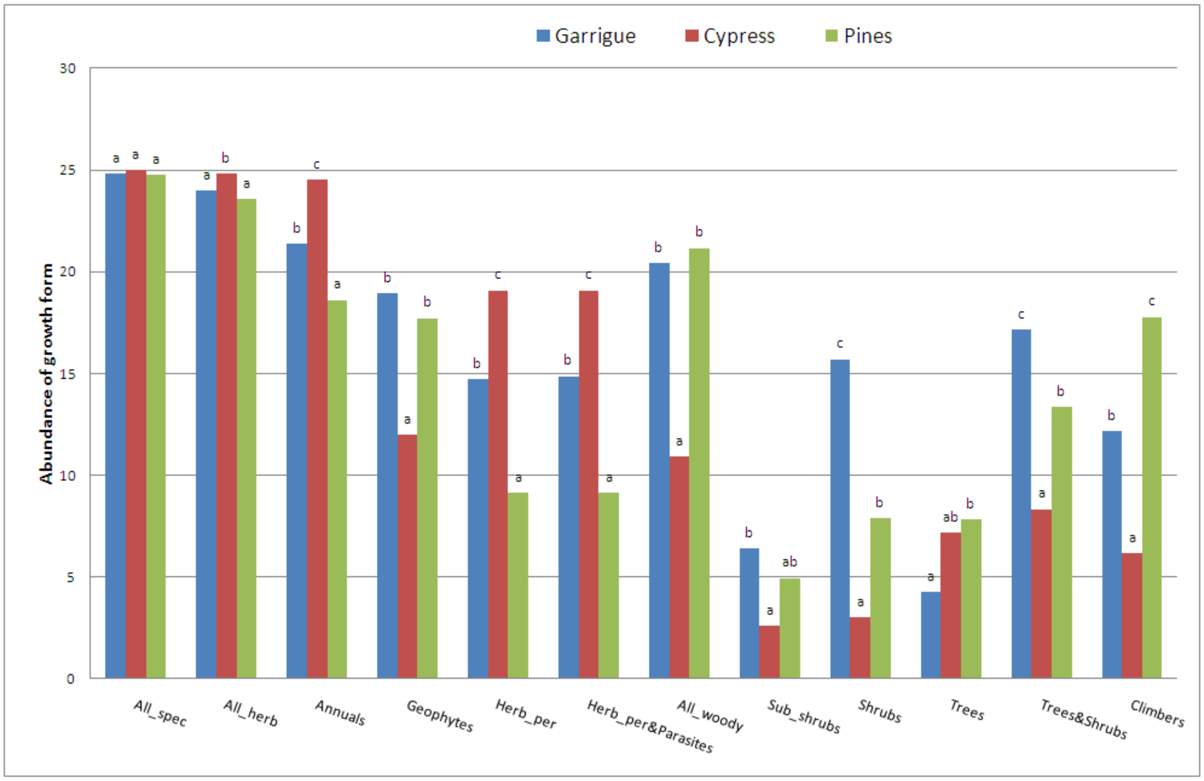

Figure 12 Average abundance of the various growth forms on the transect level (maximum of 25 occurrences as there were 25 quadrates per transect). The letters show the significant differences between the three main habitats in the LTER areas in Ramat Hanadiv (Tukey Post Doc test in SPSS). Garrigue is a combination of Cabara, Fuel-break and Garrigue.

To be able to say something about the patterns in species richness at different scales they are compared between the three GHC's. It appears that Cypress is indeed slightly richer at the quadrate level compared to Garrigue, while this switches at the bigger scale.

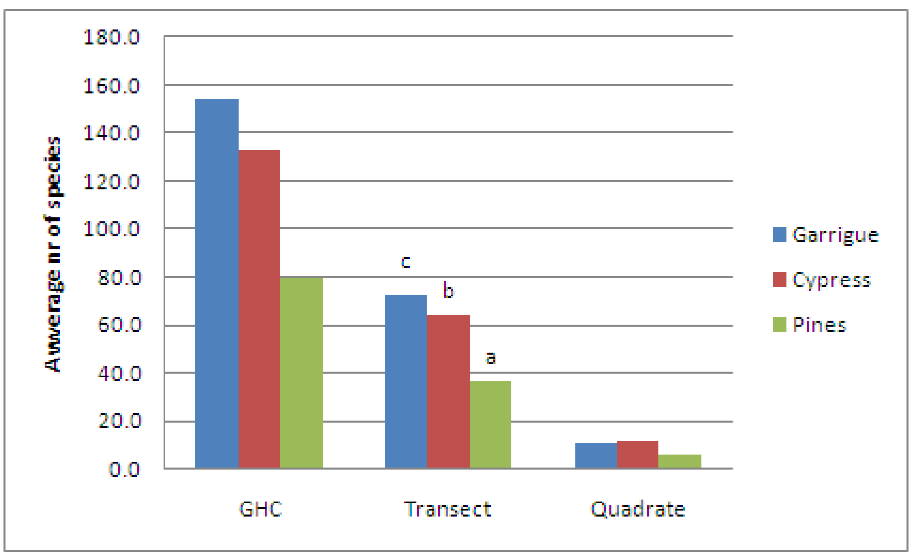

Figure 13 Species richness at different spatial scales: GHC, transect and quadrate scale. The species richness at the GHC level is the average value of the three LTER areas Cabara, Fuel-break and Garrigue. No statistics are done for the GHC and quadrate scale.

When comparing the average number of rare species at the transect level it is obvious that this is decreasing significantly (Tukey post doc P≤0.001) between Garrigue (53), Cypress (42) and Pines (26). A species was considered to be rare if occurring less than 5 times in atransect.

Besides these comparisons of the growth forms in SPSS we also did an RDA on all species and the various growth forms with the three GHC's as co-variables. With all species you get the ordination graph shown in figure 13.

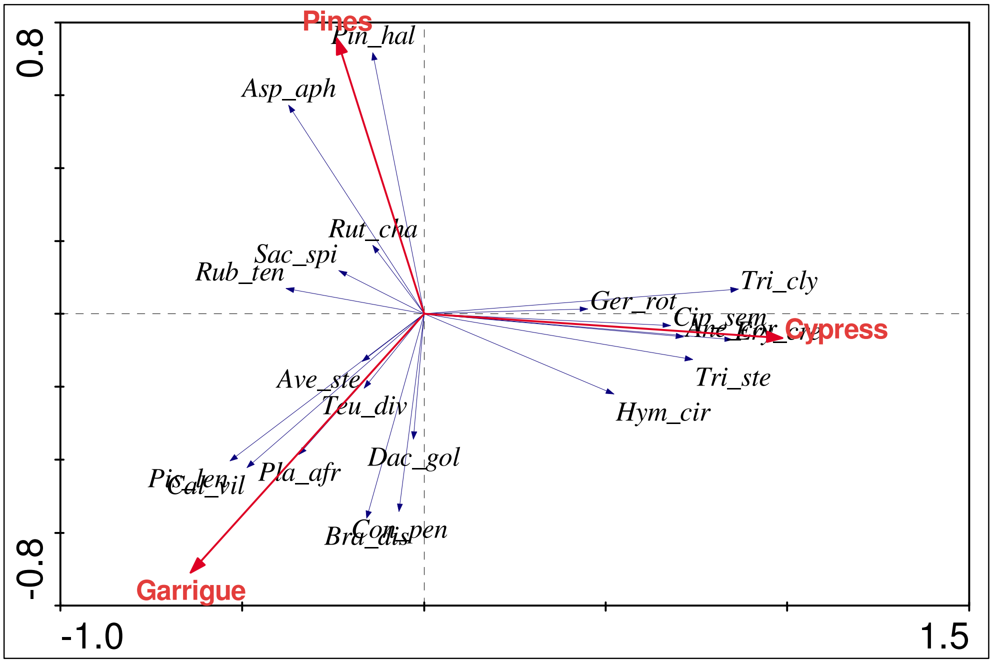

Figure 14 A RDA with covariables on all species with the three main habitat types in the LTER areas in Ramat Hanadiv. Only the most dominant species were shown to keep the figure readable. The species names are the first three letters of the scientific names (both the genus and the species).

For all species together and for the specific growth forms we could clearly distinguish between the three GHC's. Figure 15 is an example of a RDA on one of the growth forms, namely the herbaceous perennials and parasites.

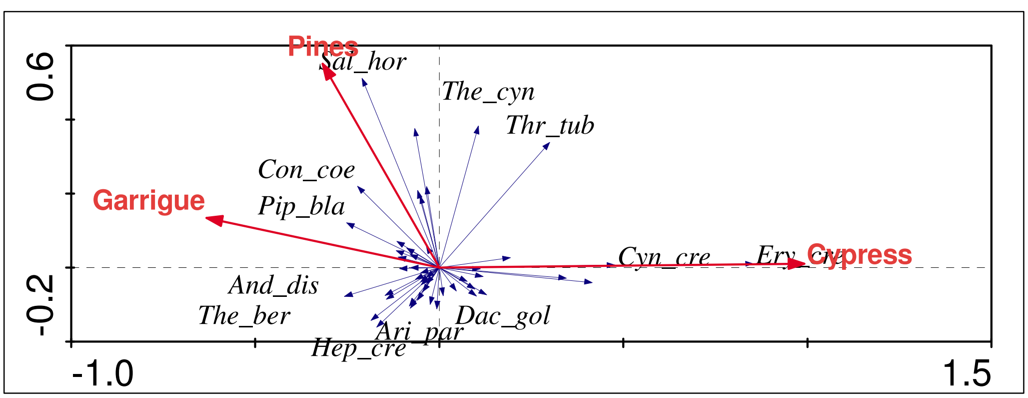

Figure 15 A RDA on herbaceous perennials and the parasites with the three GHC's. The species are plotted in black and the three GHC's are plotted in red as co-variables. The species abbreviations contain the first three letters of the genus and the species name.

Species ranking

Species ranking within the five LTER areas and within the two treatments

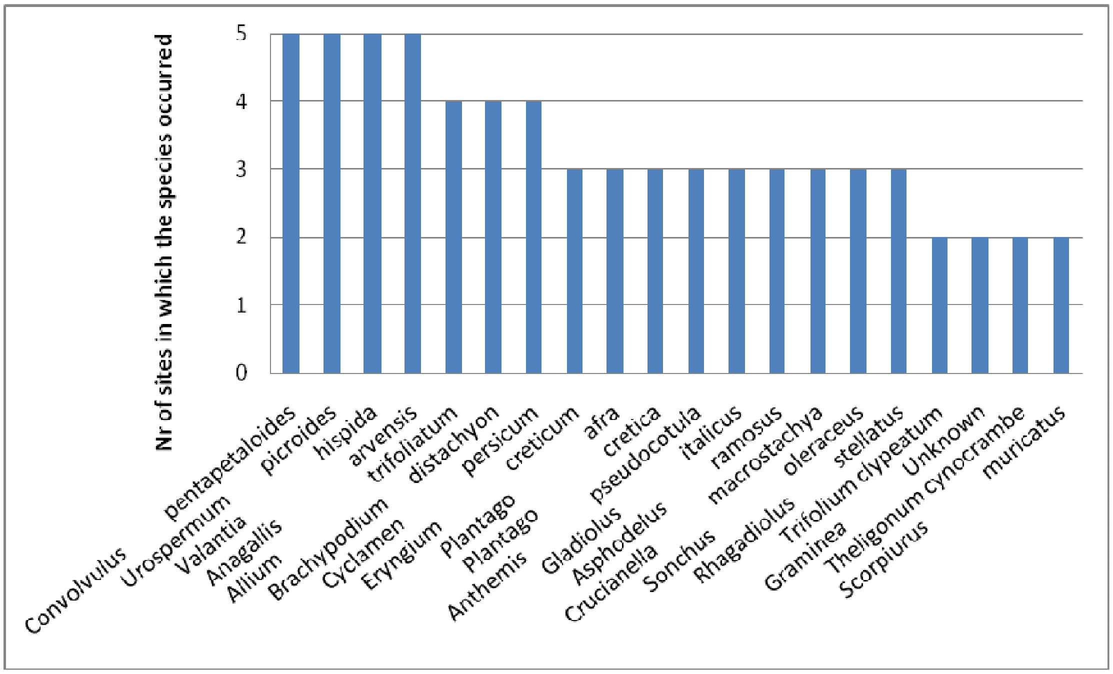

Figure 16 Occurrences of the 20 abundant herbaceous species (out of 332 species) in the various LTER areas in Ramat Hanadiv. Only four species occur in all 5 areas, than 3 species occur in 4 of the areas, etc. In each of these subgroups the most abundant species is plotted first.

When looking at the abundant herbaceous species (see figure 16) we see that only a few species occurred in all areas. However, almost half of the woody species (14 out of 32) occurred in all 5 areas (see figure 17). So the areas seemed to be most distinctive with regard to herbaceous species. Even though a higher variety in herbaceous species might cause the areas to differentiate more, you would not expect this small a number of abundant herbaceous species occurring in all areas.

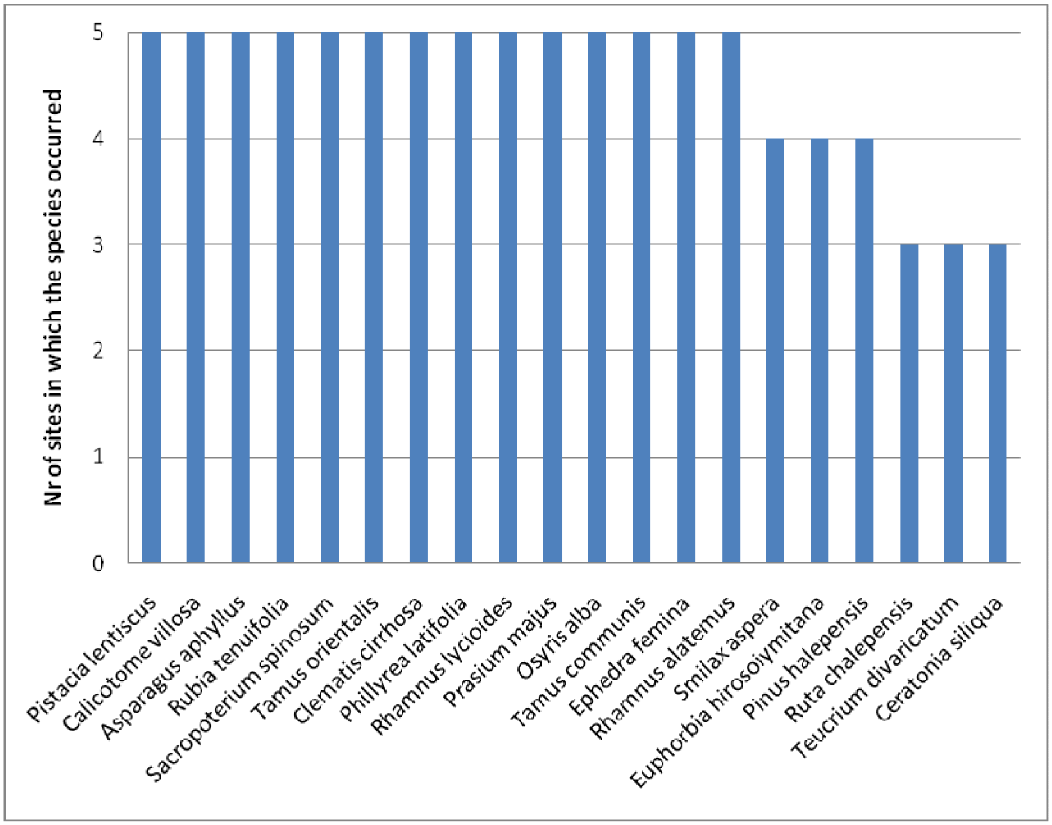

Figure 17 Occurrences of 20 abundant woody species (out of 32 species) in the various LTER areas in Ramat Hanadiv. Fourteen species occur in all 5 areas, than 3 species occur in 4 of the areas, etc. In each of these subgroups the most abundant species is putted first.

When looking at the 20 most abundant herbaceous and woody species (figure 18 and 19 respectively) that 10 of these herbaceous species and 16 of these woody species occurred under non-grazing and grazing. It seemed that the most abundant species are not really affected by grazing, which might explain the nature of these species.

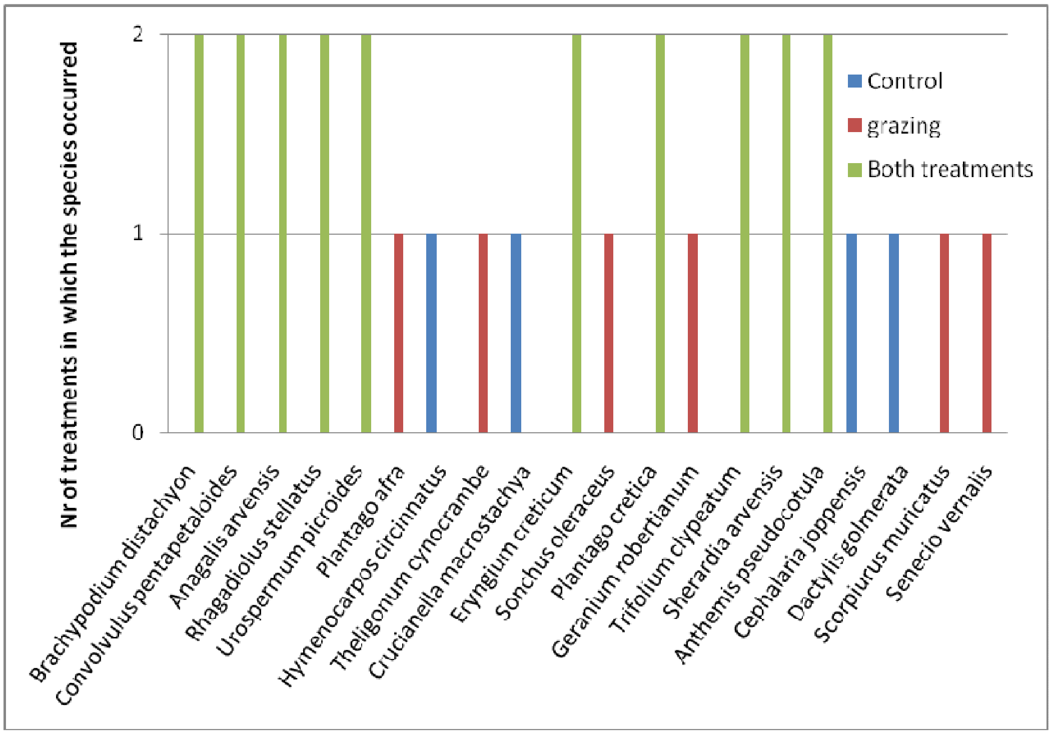

Figure 18 Occurrences of the 20 most abundant herbaceous species (out of 332 species) in the two treatments. Ten species occurred in both treatments, than 4 species occurred in only the control plots and 6 in the grazed plots.

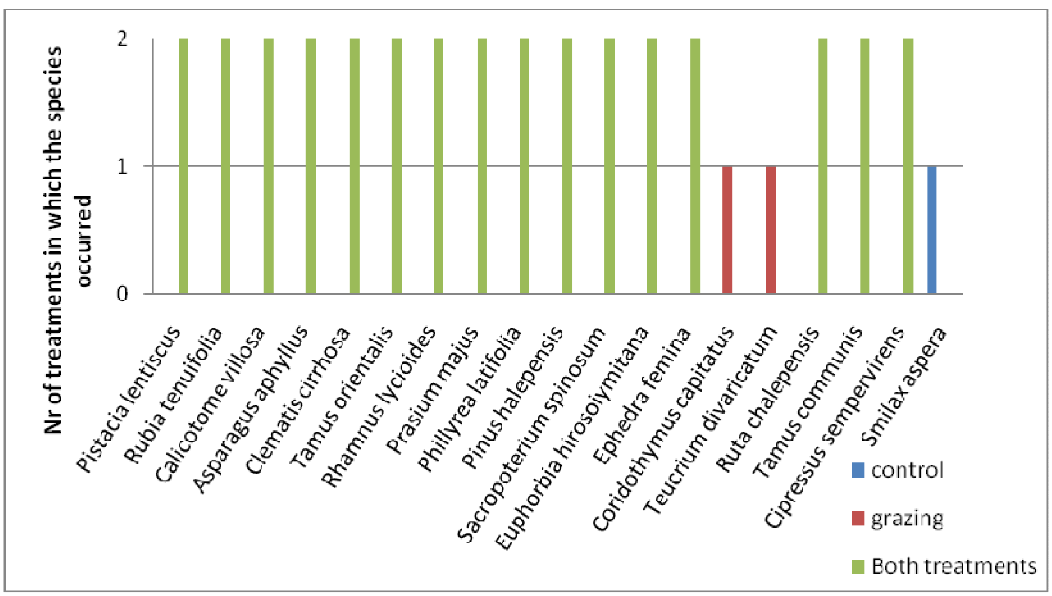

Figure 19 Occurrences of the 20 most abundant woody species (out of 32 species) in the various LTER areas in Ramat Hanadiv. Sixteen species occurred in both treatments, than 1 species occurred in only the control plots and 2 only in the grazed plots.

3.2 Woody vegetation in LTER areas

The data set with of the woody vegetation could have been analyzed the same way as the data set of the understory vegetation, but we decided to only use it to see what was driving the difference between the two forest stands. The hypothesis was that a shade gradient occurs in forest stands with an increase in cover between Cypress and Pines. This shade gradient would cause an inverse relation between the relative tree cover and the richness of the understory vegetation. This was tested by doing a regression on the relative tree cover on the species richness of the understory vegetation. The results are shown in figure 20.

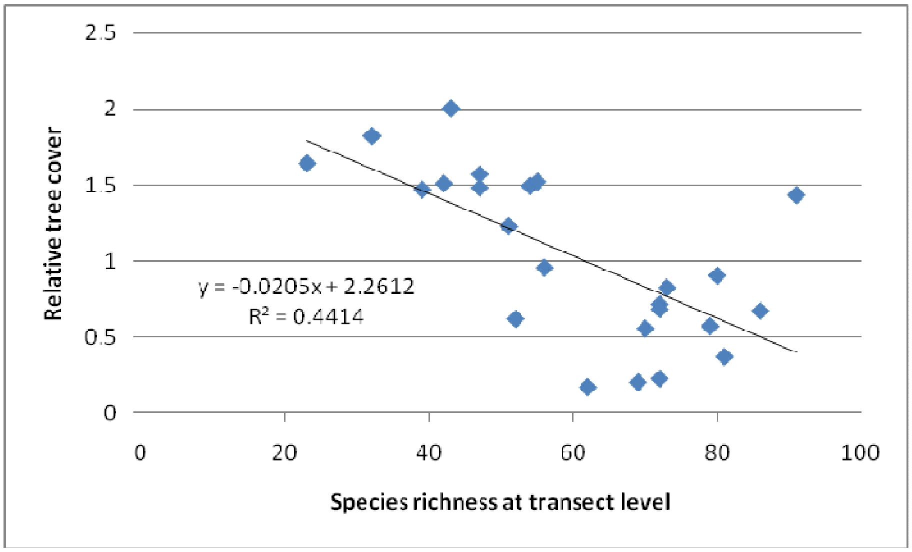

Figure 20 Regression on relative tree cover and the species richness (transect level) in the forest habitats (Cypress and Pines). The regression coefficient is significant (P<0.001). These are only the data of 2008.

There is a clear relation between the relative tree cover and the species richness. However, after discussing this with the staff in Ramat Hanadiv it seems that the Cypress stand is really a unique site. When looking at the soil type (a terarossa soil) and its' historical use as farmland we cannot just extrapolate this site to other cypress stands. The richness in herbaceous species and the lack of woody species is more due to the soil types and the historical management than due to the presence of the cypress trees instead of other tree species.

3.3 Bird observations

The data was collected by going through the area and writing down each observed bird which is also known to be nesting in the area. Only the warbler wasn't written down consistently for various reasons. As we have the coordinates of the observations we know for each observation in which polygon it was situated. So we know in which habitat type the bird species forage, assuming that they show some preference for these areas. Unfortunately we have to be very carefully about making conclusions out of these data due to various reasons:

1. The sampling effort varied over the area and between habitat types.

2. The observations were done in the various habitats recognized by the staff of Ramat Hanadiv. These habitats are based on other features than the structural method of BioHab. Therefore, we can't be sure whether these habitats represent the BioHab polygons entirely.

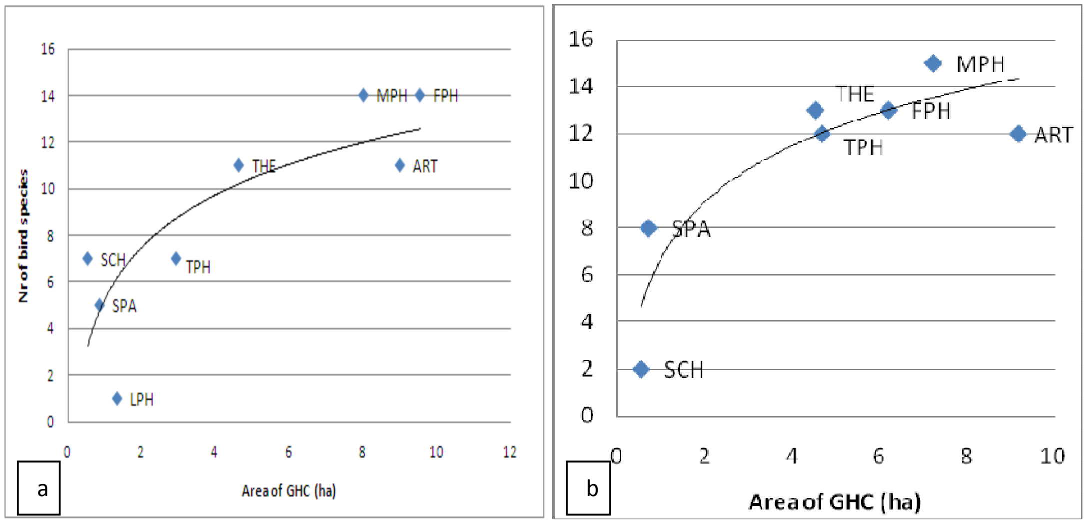

Figure 21 The relation between the number of bird species and the area of the GHC (ha) for a) the bird data of 2001 and 2004 and b) the bird data of 2007. A logarithmic trend line was added through the various GHC's. The abbreviations are given in table 1 at page 6.

There are dozens of species richness parameters. Figure 21 a and b show the relation between the number of species and the area of the GHC (ha).However, we could not use this relation as we can't relate the number of observations to the area of the polygon. The reason is that the sampling effort wasn't constant over the area, so we don't know if it is the habitat type or the sampling which is defining the difference in species richness between the habitat types. Therefore the conclusions can only be a suggestion.

If we compare the number of species divided by the number of observations per General Habitat Category we get the numbers shown in table 8 and 9. We decided to leave out the numbers of the habitat types which were smaller than 2 hectares, as they might give a wrong impression. If these numbers are compared between the habitats which are in total bigger than 2 hectares it seems that the artificial areas attract the most bird species. This was the case for both data sets. The Therophytes (THE) and the Low forest (TPH) are relatively rich as well.

Table 8. Number of individuals, number of species and the ratio between these in the various GHC's. These numbers are derived from the bird data of 2001 and 2004.

GHC	INDIV	NO SPP	RATIO (spec/nr)*100%	total ha
FPH	169	14	8.3	9.6
TPH	28	7	25.0	2.9
ART	21	11	52.4	9.0
THE	38	11	28.9	4.6
MPH	115	14	12.2	8.0

Table 9. Number of individuals, number of species and the ratio between these in the various GHC's. These numbers are derived from the bird data of 2007.

GHC	INDIV	NO SPP	RATIO (spec/nr)*100%	total ha
FPH	52	13	25.0	6.2
TPH	29	12	41.4	4.7
ART	20	12	60.0	9.2
THE	34	13	38.2	4.5
MPH	70	16	22.9	7.2

Discussion

1. Vegetation

BioHab defined two main General Habitat Categories (GHC's) in the five different LTER areas in Ramat Hanadiv: Mid-Phanerophytes in Cabara, Fuel-break and Garrigue, and Forest Phanerophytes in Cypress and Pines. Even within the same GHC, it was clear that the habitat descriptors (the cover of the growth forms present) differed between the LTER areas. With these descriptors there were even differences between the grazed and un-grazed plots.

In contrast, a floristic analysis based on indirect ordination in Canoco (Detrended Correspondence Analysis – DCA) showed us three main vegetation types: 1) Cabara, Fuel-break and Garrigue, 2) Cypress and 3) Pines. This distinction could still be confirmed after separating between the herbaceous and the woody species, though some small differentiation occurred between years (in Cypress) and treatments (Fuel-break). The same patterns could be distinguished after a numerical classification in TwinSpan.

Examination of Raunkiær growth forms gave us the same picture, though it became clear that patterns of species richness tended to change between vegetation types when looking at different spatial scales. The total abundance of species tended to be higher in Cypress compared to Garrigue at the transect level. However, more species occurred in Garrigue compared to Cypress and Pines at transect level. The same was the case with the number of rare species, as confirmed by a higher species richness in Cypress at the quadrate level. When looking to the most abundant species, we see that a relative small number of herbaceous species occur in all 5 LTER areas, while relatively more woody species were in all the areas. The grazing regime did not really show a difference between the most abundant herbaceous and woody species.

The relative tree cover in the forest stands was inversely related with the richness of the herbaceous vegetation (e.g. the higher the tree cover, the lower the species richness). Since these are planted forests, it is reasonable to expect a poor correlation between forest cover and the richness in herbaceous species in the understory, which seems better explained by the soil type and the historical use of the land.Bird assemblages.

2. Bird data

The bird data showed a high species richness in the garden area, followed by the grassland areas (therophytes) and the forest (phanerophytes), but this could not be related to the area of the general habitat categories. This was mainly due to the differences in vegetation versus habitat classification, and inherent problems in the sampling design for the bird assemblages.

Conclusion

The main conclusion is that by only using the General Habitat Categories (GHC's), we cannot make a clear distinction between the habitat types. In the case of Ramat Hanadiv especially the planted forests seem to be problematic, as these were given the same GHC while the species composition is very different. This difference between the cypress and pine stand confirmed what we know about them from the field.

1. In general the General Habitat Categories can predict patterns in biodiversity, but problems appear when planted forests are considered as the understory vegetation is not taken into account sufficiently for these categories. Though it seems likely that the tree cover can tell us more about the richness of the understory this should be tested for more areas as the areas used were not that representative.
2. However, when using also the habitat descriptors we see clearly differences between all habitats (even grazing patterns are obvious in some cases).
3. When describing the species diversity it seems to be valuable to distinguish between the herbaceous and woody vegetation as they react differently to grazing.

The relative tree cover in the forest stands was inversely related with the richness of the herbaceous vegetation, but the soil type and the historical land use seemed to explain better the difference in species richness.

The bird data showed a high species diversity in the artificial area, followed by the therophytes and the forest phanerophytes, but this could not be related to the area of the general habitat categories due the unsuitable sampling design.

Recommendations

Based on the findings we would like to do a few recommendations for the EBONE project and future data research

Recommendations for the EBONE project

It's important to take into account the soil type, the management and the history of a site. Lacking field knowledge of a site can lead to misleading explanations of the species composition. Therefore it is important that these descriptors stay in the classification system

It seemed that especially forest stands might give problems as the BioHab mapping puts more emphasis on the dominant tree and shrub species, while the small species tell us also a lot about the site conditions. The main reason is that the trees are often planted, while the understory vegetation is mostly part of the natural vegetation. Therefore it can be recommended to leave the Raunkiær plant growth forms also in the classification system, as it helps us to distinct different forest types.

Recommendations for future research

If further data is to be collected it should be considered that the various habitats are covered in order to test whether the habitats are indeed representing the patterns in the understory vegetation.

It's important that the sampling effort is spread evenly over the area, so that the observations done can be linked to the area of the habitats. This is important as the various habitat types (GHC's) are not equally covering the area. A straight forward comparison might give an unrealistic picture.

References

Bunce, R.G.H., Groom, G.B., Jongman R.H.G., Padoa-Schioppa E., (Eds.) 2005. Handbook for surveillance and monitoring of European habitats; First Edition. Wageningen, Alterra, Alterra-rapport 1219. 107 pp. Weblink: http://www.ebone.wur.nl/NR/rdonlyres/37915034-990B-4EEB-BBE9-493F68BB75E6/82312/AlterraRapport1219.pdf

ter Braak, C.J.F. 1987. CANOCO – a FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principal components analysis and redundancy analysis (version 2.1) Agricultural Mathematics Group, Wageningen, 95 pp.

ter Braak, C. J.F. and Smilauer, P. 2002: CANOCO Reference manual and CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power (Ithaca, NY, USA), 500 pp.

Fragman O., Plitmann U., Heller D. and Shmida A. 1999. Checklist and ecological data-base of the flora of Israel and its surroundings. Department of evolution, systematic & ecology. The Hebrew University of Jerusalem, Giv'at Ram, 91904, Jerusalem, Israel.

Halada L., Jongman R.H.G., Gerard, F., Whittaker, L., Bunce, R.H.G., Bauch, B. and Schmeller, D.S. 2009. The European Biodiversity Observations Network – EBONE. European conference of the Czech Presidency of the Council of the EU towards environment, 12 pp.

Hill M.O. and Šmilauer P. 2005. TWINSPAN for Windows version 2.3. Centre for Ecology and Hydrology & University of South Bohemia, Huntingdon & České Budějovice.

Jongman R.H.G., ter Braak C.J.F. and Van Tongeren O.F.R. (Eds.) 2005. Data analysis in community and landscape ecology. Cambridge University Press, 299 pp.

www.ebone.wur.nl/UK EBONE. Framework for a European Biodiversity Observation Network ad Research Hierachy. 2009, 2 pp. Accessed on 11-08-09.

www.nbu.ac.uk/biota/biohab_page.htm BioHab. A framework for the coordination of Biodiversity and Habitats. 1 pp. Accessed on 11-08-09.

Annex I. Numerical classification

Table 10 Results from a numerical analysis in TWINSPAN. Only the species occurring in more than 5 quadrates are included in this analysis. The numbers give the average counts of the transects within each group.

		# transects	24	90	12	12		
Life form	Taxa	Species	Pines	Garrigue	Cypress 2008	Cypress 2006	1st cut level	2nd cut level
C	Sacropoterium	spinosum	1.4	1.3	0.3	0.3	0	0
V	Asparagus	aphyllus	3.4	2.2	0.8	0.6	0	0
G	Arum	dioscoridis	1.0	0.3	0.2	0.0	0	0
S	Ephedra	femina	1.0	0.7	0.8	0.0	0	0
A	Avena	sterilis	0.6	1.4	0.8	0.3	0	0
A	Mercurialis	annua	2.7	0.4	0.1	0.1	0	0
T	Pinus	halepensis	2.6	0.1	0.0	0.0	0	0
H	Aristlchia	parvifolia	1.5	0.5	0.1	0.0	0	0
V	Clematis	cirrhosa	2.3	1.2	0.4	0.0	0	0
A	Crepis	bulbosa	1.0	1.1	0.1	0.2	0	0
G	Cyclamen	persicum	4.1	3.1	0.0	0.0	0	0
A	Euphorbia	arguta	0.0	0.9	0.0	0.1	0	0
A	Plantago	lapopus	0.0	0.7	0.2	0.0	0	0
H	Salvia	horminum	0.0	1.0	0.0	0.2	0	0
A	Calendula	palaestina	0.0	0.7	0.0	0.0	0	0
G	Asphodelus	ramosus	0.2	3.0	0.0	0.0	0	0
A	Plantago	afra	0.0	2.0	0.2	0.0	0	0
A	Biscutella	didyma	0.0	1.3	0.0	0.0	0	0
A	Helianthemum	saliciflium	0.0	0.9	0.0	0.0	0	0
A	Scorpiurus	muricatus	0.1	2.0	0.4	0.3	0	0
A	Catananche	lutea	0.0	0.7	0.0	0.0	0	0
A	Linum	strictum	0.0	1.2	0.0	0.0	0	0
A	Geropogon	hybirdus	0.0	0.6	0.0	0.1	0	0
G	Gynandriris	sisyrinchium	0.0	1.2	0.0	0.0	0	0
A	Synelcosciadiun	carmeli	0.1	0.6	0.0	0.0	0	0
A	Stachys	neurocalycina	0.0	0.8	0.2	0.0	0	0
H	Piptatherum	blacheanum	0.1	1.4	0.0	0.0	0	0
A	Linum	corymbuloum	0.1	0.7	0.0	0.0	0	0
A	Linum	nodiflorum	0.0	1.7	0.1	0.3	0	0
A	Cephalaria	joppensis	0.0	1.2	0.0	0.0	0	0
C	Euphorbia	hirosoiymitana	0.0	1.2	0.2	0.0	0	0
H	Andropogon	distachyos	0.3	1.5	0.0	0.0	0	0
A	Crepis	palaestina	0.3	0.9	0.2	0.0	0	0
A	Nigella	ciliris	0.3	0.7	0.1	0.0	0	0
S	Calicotome	villosa	0.9	2.9	0.2	0.2	0	0
G	Gladiolus	italicus	0.8	1.4	0.2	0.1	0	0
G	Allium	trifoliatum	1.1	2.6	0.2	0.2	0	0
A	Phalaris	paradoxa	0.1	0.6	0.2	0.0	0	0
S	Pistacia	lentiscus	1.8	3.5	0.4	0.6	0	0
T	Phillyrea	latifolia	0.2	1.7	0.3	0.2	0	0
G	Arisarum	vulgare	0.3	0.6	0.1	0.2	0	0
A	Daucus	bicolor	0.0	0.7	0.0	0.4	0	0
G	Ranunculus	asiaticus	0.0	0.6	0.3	0.1	0	0
A	Crucianella	macrostachya	0.1	2.2	0.2	0.8	0	0
A	Crupina	crupinastrum	0.0	0.7	0.3	0.0	0	0

A	Briza	maxima	0.0	0.6	0.4	0.2	0	0
S	Rhamnus	lycioides	1.5	1.9	0.9	0.8	0	1
V	Rubia	tenuifolia	3.1	2.7	1.3	1.8	0	1
V	Tamus	orientalis	2.0	2.0	0.3	0.8	0	1
A	Medicago	coronata	0.0	0.7	0.4	0.3	0	1
A	Geranium	robertianum	2.6	1.0	1.8	0.8	0	1
A	Tetragonolobus	palaestinus	0.2	1.0	1.2	0.8	0	1
A	Urospermum	picroides	1.1	3.0	2.7	1.8	0	1
A	Anagalis	arvensis	1.9	2.7	3.3	2.8	0	1
A	Hippocrepis	unisilliquosa	0.2	1.3	0.6	1.0	0	1
A	Senecio	vernalis	0.3	1.3	1.7	2.1	0	1
A	Convolvulus	pentapetaloides	1.0	2.9	2.7	2.8	0	1
H	Dactylis	glomerata	0.5	1.7	1.7	1.6	0	1
A	Lagocia	cuminoides	0.0	0.8	1.0	0.7	0	1
G	Ornithogalum	narbonense	0.1	0.9	0.3	1.1	0	1
A	Brachypodium	distachyon	0.7	3.2	3.6	0.3	0	1
V	Prasium	majus	0.2	1.1	1.7	1.5	0	1
A	Linum	pubescens	0.0	1.1	1.3	1.4	0	1
A	Carduus	argentatus	0.1	0.5	1.1	0.3	0	1
A	Plantago	cretica	0.0	2.0	2.3	3.2	1	0
A	Catapodium	rigidum	0.0	0.5	1.2	0.2	1	0
A	Scabiosa	prolifera	0.0	0.6	1.3	0.5	1	0
A	Sonchus	oleraceus	1.0	1.7	2.8	1.4	1	0
A	Trifolium	scabrum	0.2	0.5	0.8	0.7	1	0
H	Pallenis	spinosa	0.0	0.8	1.6	1.9	1	0
G	Bellevalia	flexuosa	0.0	0.5	0.0	2.1	1	0
A	Vicia	plaestina	1.6	1.2	1.9	1.3	1	1
A	Trigonella	monospeliaca	0.8	0.3	0.3	0.7	1	1
H	Theligonum	cynocrambe	1.7	1.2	1.9	1.5	1	1
A	Valantia	hispida	1.1	1.8	3.4	3.2	1	1
A	Galium	divaricatum	0.6	0.5	1.0	0.5	1	1
A	Bromus	alopecuros	0.0	0.6	2.1	0.3	1	1
H	Thrincia	tuberosa	0.0	0.4	0.7	1.5	1	1
A	Crepis	sancta	0.0	0.7	1.7	1.3	1	1
A	Rapistrum	rugosum	0.0	0.4	0.2	2.2	1	1
A	Filago	pyramidata	0.0	0.7	2.4	2.7	1	1
A	Hymenocarpos	circinnatus	0.1	1.2	3.3	2.7	1	1
A	Rhagadiolus	stellatus	0.7	1.7	3.2	3.7	1	1
A	Anthemis	pseudocotula	0.2	1.8	4.0	3.4	1	1
A	Trifolium	campestre	0.7	0.5	2.9	1.9	1	1
A	Sherardia	arvensis	0.8	0.6	4.0	4.1	1	1
A	Lolium	rigidum	0.0	0.5	1.9	0.0	1	1
A	Geranium	molle	0.5	0.3	1.2	2.5	1	1
H	Eryngium	creticum	1.3	1.5	3.7	4.3	1	1
A	Graminea	Unknown	1.5	0.4	0.9	2.9	1	1
G	Anemone	coronaria	0.8	0.7	2.6	3.5	1	1
A	Lotus	peregrinus	1.0	0.8	2.5	1.5	1	1
A	Trifolium	clypeatum	1.6	0.8	4.8	3.8	1	1
A	Onobrychis	squarrosa	0.0	0.3	2.0	2.3	1	1
A	Trifolium	pilulare	0.0	0.5	2.8	2.3	1	1
A	Trifolium	stellatum	0.0	0.5	3.0	2.9	1	1
A	Medicago	polymorpha	0.1	0.5	3.2	2.1	1	1
A	Trifolium	resupinatum	0.0	0.4	2.8	1.3	1	1
A	Bromus	lanceolatus	0.2	0.2	0.0	2.9	1	1

A	Picris	altissima	0.1	0.2	2.3	0.9	1	1
	1st cut level		0	0	1	1		
	2nd cut level		0	1	0	1		