EBONE

European Biodiversity Observation Network:

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

D9.2: Adapting EBONE for use outside Europe: trials and recommendations

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Introduction

The task of WP9 in the EBONE was given in the Description of Work as follows: "WP9 (a pilot monitoring system for global Mediterranean systems) will adapt the system that will be developed for Europe into Mediterranean systems in test areas in Israel and South Africa as representative countries for this biogegraphic zone" (EBONE Description of Work). The present document, D9.2 is the required report on the way the EBONE approach can be extended to the Mediterranean biomes, and also to desert.

In practice, most but not all of the EBONE system was adapted for use in Israel; and some aspects were tested but not adapted for use in South Africa. Hence this report will focus on developments in Israel.

From the beginning, the intention of the Israeli partners has been to put in practice the parts of the EBONE system that proved useful to us, with or without adaptation as necessary. Our focus is in the area of nature conservation. The Israel partner INPA is a governmental authority responsible for 440 nature reserves and 120 national parks covering 16% of the land area of Israel and ranging from montane tundra and mediterranean forest in the north to extreme desert in the south. Hence INPA comes with very real needs for a standardized and cost-effective biodiversity mapping and monitoring program that can be implemented both locally and nationally.

INPA also cooperates with other organizations in Israel to develop an LTER network and a national program for biodiversity monitoring (called the "Maarag" in Hebrew). Our stakeholders mostly have been drawn from our partners in the Maarag, generally with a nature conservation orientation.

Since we are both the researchers and the main stakeholders in our country, INPA has been able to test, evaluate and start implementation of useful aspects of EBONE in a fairly smooth way that would not be possible for most of our partners in EBONE. The details of that process are described in report D9.1 and its appendices (see also Olsvig-Whittaker et al. 2012). The present document D9.2 will summarize our findings, and then give recommendations in a concise way. The reader should refer to D9.1 and other references in the text in order to get our findings in detail.

1 Habitat mapping

1.1 General Principles

EBONE habitat classification is based on structural features of a land unit rather than taxonomic composition. This means that mapping can be done by individuals without extensive taxonomic knowledge, which is an attractive feature in a working conservation organization like ours. It also means that mapping at certain thematic precision can be done at least partly by rapid visual scan or even remote sensing approaches, thus greatly speeding the mapping process in comparison with what we have done in the past. In principle, mapping can be done over a broad period of time, not confined to the very brief spring season when floristic work can be done in mediterranean regions. These are all attractive features. However, the linkages between habitat mapped in this way and species composition or species diversity (critical information for any conservation organization) must be explored. Much of our field work in the EBONE project has been given to testing these linkages.

1.1.1 Habitat distribution as an indicator of biodiversity

Habitat types are recognised as one of the basic parameters which can be used to measure biodiversity because they are the locations (Habitats are not so much locations. I think some other term should be used) upon which species from a range of taxa depend, hence the various definitions of habitat from Hutchinson to that recently used in BioHab and EBONE (Hutchinson 1957, Whittaker 1973 et al, Bunce et al 2011). The assessment of the extent and patterns of habitat distribution within landscapes is also widely used as shown in the BioBio project (see Senn et al 2011, Gomiero et al 2011). Habitats are used in Europe as the basis for nature conservation planning because the list of over 250 habitat types included in the Habitats Directive (Council of the EU 1992) Annex I form (together with species listed in Annex II) the basis for site selection in the Natura 2000 network of protected sites (http://ec.europa.eu/environment/nature/natura2000/index_en.htm).

The availability of a consistent field protocol (Bunce et al. 2011) and relative ease of recording led habitats to be selected as the basic framework for biodiversity assessment within the EBONE project. This selection was confirmed in WP 1 of EBONE (see EBONE Description of Work). The use of habitats to form the framework for statistical analysis of stock and change of different taxa at the species level has been demonstrated in many publications of the GB Countryside Survey.

Recommendation: Habitat distribution and heterogeneity are useful measures of biodiversity which are not used as often as they could be. Since the data are already collected in any landscape mapping, a further analysis of habitat diversity may prove very useful and cost-effective in projects mapping and monitoring for biodiversity.

1.1.2 Links with in situ species data (Ramat HaNadiv, Avdat, Lehavim)

Tests of the correlation between EBONE-defined habitat type and species richness were conducted in the mediterranean forest/maquis/garrigue complex at Ramat HaNadiv (RHN), a private park and LTER site near Haifa. In keeping with the original EBONE concept, we used pre-existing species data to test correlations. We found that this is not a good idea; sampling designs for the species data had not been balanced for habitat, making statistical analysis difficult. We found poor correlation with pre-existing species data. The following year we sampled in situ species data after doing the mapping and got much better (more significant) results.

References: See de Gelder (2011) and Olsvig-Whittaker et al. (2012) for background information.

Recommendation: where possible, collect species-level data after delineation of habitats by mapping, in a statistically valid manner. The use of pre-existing species data is not as promising as we had hoped.

1.1.3 Selection of sites for quality plots (Lehavim)

The problems we experienced in correlating RS images with mapped habitats were studied at Lehavim, where images from three passive sensors of different resolution levels (Modis, LandSat and QuickBird) were compared to habitats checked on the ground from selected RS polygons. Unmixing Classification of the high resolution (2.8-m) QuickBird images proved successful in distinguishing bare ground from herbaceous cover, despite high standard deviation in the values of the images for any given habitat category. Even with selection of sites for RS training, the correlation of RS with mapped areas remains very problematic.

Reference: Levin report 2011, Appendix 1, this document).

Recommendation: If mapping is to be done by remote sensing, the higher the spatial and temporal resolution level, the better, and preferably over the different growing seasons. In desert areas one of the key components is that of non-photosynthetic vegetation (NPV; e.g., shrubs that are mostly dry except following sufficient rainfall, which do not occur every year). Mapping of NPV requires hyperspectral information in the Short Wave Infra Red (SWIR, 2.0-

2.5 μm; Asner and Lobell, 2000; Asner and Heidebrecht, 2002). New satelite hyperspectral sensors planned to be launched in 2013-2014 (EnMap and Prisma) promise to provide the needed spectral resolution with a high signal to noise ratio, presently only available from hyperspectral airborne sensors.

Additional recommendations include:

- Using segmentation techniques to create the polygons from orthophotos/satellite imagery, so they can be derived objectively using predefined parameters of scale, generalization and homogeneity
- Tasking/obtaining national cloud-free imagery every year, representing each season, using a Landsat type sensor.
- Tasking a national LiDAR mapping every two years, for monitoring changes in vegetation height, coastal erosion, built-up areas changes, and other surface processes.
- Using MODIS-type time series for monitoring changes in vegetation cover and wildfires.
- Making all the above imagery and datasets freely available for governmental agencies, environmental NGOs, research institutions and universities.
- Create a national landcover/landuse map for Israel using the CORINE Land Cover classification of the EU every 5 years.

1.2 Habitat mapping importance in Israel

The Israeli team first became interested in the BioHab/EBONE approach to habitat mapping when we realized that five different professional Israeli geographers/botanists mapping the same area could produce five quite different habitat maps. This was recognized as a problem since much of our conservation management and regional planning is based on habitat/vegetation maps.

Our interest in habitat mapping has been on two different scales. First, we need to know what is in the parks and nature reserves for which INPA is responsible, and what changes may take place in them over time. Local changes may infer environmental drivers such as management, or may reflect unexpected drivers. Hence local monitoring of habitat change is desirable.

Second, we are participants in a national network, the Maarag, which combines LTER studies with a national biodiversity monitoring plan. The need for habitat/biome mapping in that work takes place on a very large scale from desert to mediterranean landscapes, especially for issues of national concern such the environmental impacts of climate change or urbanization. We have been intrigued by the EBONE's approach using stratified sampling, which may be done here as well. Indeed we have contributed to the Environmental Stratification work package of EBONE, expanding its range.

I think you should mention also the need of maps as a basis for spatial planning of development/construction vs. different levels of conservation

Hence habitat mapping in Israel takes place on a variety of spatial scales for a range of different purposes. We found that the toolkit of methodology will be different depending on the spatial scales of concern, and whether the objective is monitoring through time or accurate mapping in space (see D9.1)

<u>Recommendations</u>: Based on our experience we suggest that the goals of the mapping drive the tools selected to do it. There is some flexibility in the EBONE approach to mapping (for example primary reliance on in situ data or on remote sensing images) but the selection of the best toolkit should be informed about and oriented towards user goals.

1.3 Habitat mapping: extrapolating from mapped squares

One of the basic concepts of EBONE was that sample sites from which in situ data had been recorded could be overlaid with satellite imagery and the relationships established used to extrapolate into adjacent squares. The sample size for estimating habitat extent could therefore be extended without further field work. In Estonia habitats were recorded using the EBONE protocol in eight sample squares. In one of the squares statistical procedures were used to extend the habitats from the central square into the eight surrounding squares. The accuracy of the overlaying varied but was usually over 80% but bearing in mind the other errors in the process, the levels were acceptable. A statistical procedure to allow for autocorrelation of grouped samples is still required. A similarsimilar procedure has been followed in Alterra for a test site in The Netherlands but accuracies have not yet been calculated.

In Israel over 10 squares have been mapped (described above). Noam Levin has overlaid these squares with different satellite images and shown degrees of agreement between 60 and 90 %. These images were presented in the workshop at Ein Gedi and could form the basis for further analysis of the relationships between imagery and in situ data (Noam Levin 2012, Appendix 2). It was difficult to assess the comparisons visually but the satellites with a higher spatial resolution appeared to have better agreement with the in situ data. Sander Mucher showed similar results in EBONE work in Almeria, south east Spain but the full life form composition from column five in the field mapping forms (Bunce et al 2011) may be needed to improve relationships because of the high proportion of bare ground.

Two examples were presented of integrated mapping of General Habitat Categories (GHC) via the FAO Land Cover Classification System (LCCS) Italy and Wales from the work of Richard Lucas in the BIOSOS project. Automated mapping from satellite imagery is carried out using an algorithm which maps LCCS classes. The relationship between these and GHCs, together with ancillary data is then used to produce a map of GHCs for the whole scene (about 20 by 20 km). Experience with local patterns suggests that the map is realistic but further work is in progress to assess accuracy and to calculate the area of habitats.

Recommendations: Two methods seem available for extrapolating. One is to expand by in situ checking of adjacent squares, testing the statistical probability of encountering new habitat types as the area expands. The other is to use correlation with remote sensing images as training to interpret RS over a wider area. The former needs more exploration; the latter seems perfectly feasible and cost-effective, bearing in mind the errors and need for statistically valid sampling.

1.4 Results of habitat mapping trials in Israel: conclusions from presentations and discussions of the Ein Gedi workshop, January 2012

Results: Habitat mapping using GHC's was successfully carried out in a series of test sites in Israel (D9.1) Additional GHC's were developed to enable appropriate habitat mapping for desert biomes (Bunce et al 2011). In the desert, vegetation cover below 10% needed to be recorded as individual percent categories. Sample squares of 0.25 sq km were used when many samples were needed for the same sampling effort. This was particularly the case when sampling was guided by remote sensing, and statistical correlation was the goal.

You haven't mentioned new categories introduced for desert and based on geomorphology

A new mapping system was developed in Israel which was deliberately linked to the EBONE system. Although traditional in nomenclature, it is structural and quantitative in definition and can be matched to the GHC's in the EBONE system, especially when species information is included. The main difference is in the mapping area, with a minimum of 1 ha, rather than 400 sq m.

Recommendations:

- Add GHC's where needed, rather than try to fit a new kind of habitat into existing categories, but use the same logic as in the existing system.
- Scale of mapping squares can be flexible. If more samples are needed and resources of time and labor are limited, scaling down to smaller squares is possible.
- It may be desirable to work out a local mapping system with its own nomenclature. This is not problematic as long as the mapping is based on structure and there is a clear link of local types to the global GHC's for data sharing purposes.

2 Remote sensing in Israel

2.1 General principles

Israel is a very small country, hence it does not share the need for RS-based mapping which is understandable in countries the size of South Africa, for example. We tend to focus on use of orthophotos for mapping purposes, and use of thematic scanning RS systems more for what they can tell us that is not visible to the eye in photographs (such as topography, biomass or phenology). Another important consideration is expense. While high resolution RS has some very attractive features, it is currently outside our budget to be able to use it on a national basis. Hence use of satellite-based remote sensing for mapping habitat in Israel tends to be constrained by cost effectiveness in comparison to other approaches. We currently prefer orthophotos for habitat mapping purposes; while satellite imagery is more effective for mapping wildfires, disturbances, changing productivity in response to climate change, etc. (see Appendix 1).

2.2 General conclusions from Remote Sensing in EBONE relevant to Israel

Results: The EBONE project gave us an opportunity to compare several RS methods and explore their potential usefulness. LiDAR trials are reported in Blank and Carmel 2011; thematic mapping trials are reported in Levin et al. 2011 covering a wide range of spatial scales. Results for habitat mapping purposes proved very problematic.

LIDAR has successfully been correlated with GHCs in The Netherlands, Estonia, and Sweden which would be expected because of the height divisions in the TRS categories. However, there are problems with growing crops because the time of the image needs to be precisely linked to the date of the field survey. The correlations in comparable work in Israel were however disappointing but further work is required because (as Dr. Didi Kaplan, Galilee district biologist) stated in the workshop, estimates of height would be useful in maquis and forest habitats. However, there are cost implications because in Israel the price is high whereas in The Netherlands it is negligible. Sander Mucher and Mait Lang have also both shown that integrated mapping using LIDAR and satellite imagery improves relationships.

Extrapolation from central to surrounding squares has been done in Estonia but statistical implications need to be considered (see above).

Currently patches for training for RS are selected after the field work. It would be better to choose the best sites for training whilst carrying out the field work and not subsequently in isolation from the field in the lab. A report has also been produced by Bob Bunce for EBONE showing how additional GHCs from those in the central square from the eight surrounding squares can be recorded relatively quickly. It is also pointed out that different patches within GHCs may have different colours which can be seen in the field e.g. red roofs and black roads within ART. Labelling such different patches within then same GHC would improve relationships and the divisions could then be reunited into GHCs for reporting. A similar suggestion was made by Mait Lang in Estonia for crops because oilseed rape is dark green and barley pale green.

Ancillary data (e.g. DTM – digital terrain model – and shade) are also important to improve the quality of the RS maps as shown by Noam Levin's example from Carmel in his presentation in Ein Gedi. This agrees with work by Richard Lucas and Sander Mucher in Wales and The Netherlands.

LIDAR could be important in Israel to detect changes in vegetation and height but would require repeat flights for monitoring change.

Recommendations: Changing costs of RS may well alter this situation but at present we recommend orthophotos for mapping in the mediterranean, and possibly LandSat for mapping in desert where the habitats are determined by geomorphology rather than vegetation. However, there are some interesting technical options:

The best RS technology for habitat mapping seems to be high resolution thematic scanning (QuickBird, resolution 2.8 meters, or WorldView2 at 1.85 meters); LandSat may be suitable for habitat mapping in desert conditions but not adequate for the high spatial heterogeneity of the mediterranean part of Israel. At present LandSat is free but higher spatial resolution images are very expensive. LiDAR expenses are at present completely out of the range of practical use, and matching with GHC's still problematic.

Change can be detected in some GHC categories in Israel using RS (urbanization) and change in productivity (MODIS) which can be linked to changing habitats (climate change).

Segmentation has potential in assisting GHC mapping in the field, but needs to be further tested. At present the evaluation is subjective. Levels for segmentation produce different results and need further discussion and comparison to automated mapping.

3 Orthophotos and habitat change through time

Orthophotos are used extensively in Israel to produce habitat boundaries as a preliminary to field mapping. In practice this turned out to be the most useful RS tool, given the fact that these data are readily available, and the acquisition of comparable high resolution satellite imagery would have been quite costly.

There is wide experience in using historical maps and historical aerial photos to analyze changes in vegetation cover in Israel (e.g., Carmel and Kadmon, 1998; Kadmon and Harari-Kremer, 1999; Levin and Ben-Dor, 2004; Levin, 2006; Levin et al., 2009).

There is the example of Samar sand dunes to show the interpretation of historical aerial photos to discern changing habitats. This procedure has great potential elsewhere for identification of past changes and for selection of sites for future monitoring in Israel as shown also in Slovakia. The general approach is to convert to raster on GIS and analyze quantitatively there.

Current maps of GHC's can be used to provide assistance for interpretation of historical aerial photos. (Halada et al., 2011). The procedure starts with delineation of GHC boundaries in the same way as used in the preparatory phase of the field mapping in EBONE methodology, but using historical air photos as a background. Visual interpretation of historical air photos is than used for determination of potential GHC category, taking into account also recent GHC map. This method produces simulated GHC map that is more or less close to reality. The precision of estimates produced by this method depends on length of studied time period, quality of historical air photos and the land cover dynamics during studied period. The ancillary data could improve thematic accuracy and increase probability of correct GHC category estimation. Maps produced in the described way could be useful for estimation of past habitat changes.

Previous phytosociological maps can be converted to GHC maps and compared to current EBONE mapped areas to study changing landscapes thought time (de Gelder 2011).

4 Habitats correlated to species diversity

4.1 General principles

The EBONE project is aimed at establishing a biodiversity monitoring system; hence biodiversity parameters are central to the project. The measurement of biodiversity in Europe is primarily guided by the SEBI2010 (Streamlining European 2010 Biodiversity Indicators). SEBI2010 is the set of biodiversity indicators developed by the European Environmental Agency (EEA) that represents the EU effort to make the CBD recommendations practical. It includes an overwhelming 26 headline indicators of biodiversity, some more practical than others.

Israel has a somewhat different history on biodiversity measurement. Our biodiversity parameters were selected according to the needs of practical application. We focused on the measures of biodiversity commonly used by conservation managers in our country, specifically species richness and species composition. Other measures may prove useful (for example, functional trait diversity (de Belo et al 2006), Ellenberger values (when we have them), but species richness and species composition are the most basic possible biodiversity parameters, and we began there.

4.2 Results of field trials in Israel

In Israel habitats were successfully correlated to species composition (beta diversity), but not successfully to species richness. Several taxonomic groups were used (reptiles, invertebrates and plants) and composition proved successfully correlated to habitat.

EBONE has not gotten sufficient data to fully analyze at a national level the core procedure of collecting vegetation data linked to habitats (plant composition correlated to habitat). The demonstration of integrated statistical analysis of such data is CS2007. Linkage of animal assemblages to habitat structure is much less known, and has mainly been studied with birds (see for example Sabo 1980).

We should emphasize that detailed vegetation data from stratified random samples are integral to the EBONE approach, and are ideal for detecting critical species such as invasives and include nested quadrates such as done in Avdat. (En Afeq also demonstrated the value of detecting changing species composition through time using the EBONE approach – all EBONE vegetation plot plots should be permanently marked.)

There is potential for individual case studies in Israel to utilize existing species level data. Caveat on this from Ramat HaNadiv where sampling differences limited their use.

Once sample sites have been set up in the Israeli monitoring program then records can be made of other taxa such as birds, butterflies, reptiles etc. Habitat level parameters such as diversity of habitats, structural diversity, heterogeneity, etc. should also be done at this stage. This sampling should be done AFTER the sites are mapped, for statistical reasons.

<u>Recommendations</u>

- First determine which parameters of biodiversity are most needed for practical application, and why.
- Most likely, data on the biodiversity parameters must be collected only after the habitats are mapped. Use of pre-existing biodiversity data has been disappointing
- Sampling should be simple and basic in order to have statistically valid sample sizes, and be repeatable in a monitoring framework.

- Biodiversity at the species level (whether functional groups, Ellenberg values, or simply species diversity) should encompass more than vegetation. There is circularity in correlating plant species diversity with habitats based on vegetation structure. Including animal taxa in analysis of patterns will to some extent ameliorate this circularity in analysis and enhance results by adding a new dimensions to the "biodiversity space"..
- Richness is the most widely used diversity parameter but we find it less useful and interpretable than changing composition. (This may not be true in very large scale geographic frameworks, but seems true within a biome.) At minimum, both should be analyzed.

5 Experiences outside Israel

For correlating biodiversity with remote sensing data, in a first approach in South Africa an assumption was made that there were linear relationships between biodiversity and three spectral, structural and textural measures derived from LANDSAT TM and SPOT 5 imagery. These relationships were used to develop a gradual biodiversity or ecosystem intactness index within a test region around Elandsbay, Western Cape Province, South Africa. The correlation with data derived from a practise-based ecological field assessment system was reasonably high (for details refer to CSIR's EBONE Deliverable Report D5.3.2).

The principle of mapping with life forms was also tested in South Africa. Additional life form categories from the European list were required and also a further division of the TPH (tall Phanerophytes) category to express variation within the Fynbos. The coverage of mosses and lichens on bare rock was also important and these have been included as optional life form qualifiers in the most recent manual. Also included in the manual are additional lists of life forms required for South Africa based on the field work carried out in EBONE. These lists are however provisional and they need to be tested by actual field mapping and some more classes may need to be added e.g. creeping fleshy leaved plants.

The life form approach has also been tested and shown to be workable in Western Australia, provided that further categories are added e.g. grass trees and megaphanerophytes. A PhD thesis will be available in due course to describe this work.

6 Selecting strategies for implementing EBONE

We found in Israel that EBONE may be applied to needs at different spatial scales and the strategies of implementing EBONE must be adapted accordingly.

On the local scale the main need seems to be for mapping and monitoring nature reserves for conservation management purposes. In the meetings the example cases using GHC's and orthophoto RS tools were generally accepted and found helpful for this purpose.

The involvement of stakeholders has been a key to the success of EBONE in Israel, but the further involvement of the public is problematic. Right now the main interest is indicated by expert groups.

Although unexplored, we also see the application of larger scale EBONE tools at a national scale together with a national LTER network. Again partnership will be critical to success.

7 International links

The extension of GHC categories into desert which was developed in Israel is a major contribution to habitat mapping in deserts outside Europe. These desert GHCs will also be applicable to cold deserts.

The general habitat categories have been shown to work in Israel and can therefore be used as a standard system of habitat recording at a national level in Israel. The international advantage is that within EBONE project these categories are also shown to be practical. In the future therefore results from Israeli change analysis can integrated at least with findings from Europe.

If future Israeli work uses LCCS, (which is likely to be used in EBONE II on a global scale) the Israeli integration can occur on a global scale as well. This is in our interest as drivers of habitat change such as global warming can be compared with similar trends outside Israel.

8 Environmental stratification

Twelve environmental zones are generally accepted in Israel. These zones will be used for the new National Biodiversity Monitoring Program. They would be appropriate for the statistical design of dispersed random sampling developed in EBONE as Environmental Stratification (Metzger et al 2005)).

If these samples selected according to strict random procedures are adequate for probability sampling, they can subsequently be reallocated to the global strata (Metzger, in press 2012). The most recent statistical advice is that a rolling sampling program should be used, linked to sites from the 12 environmental zones, for a balance annual sampling rolled over in a 5 year program. This enables constant sampling by a consistent smaller team and will assist planning and aid quality control and assurance, as well as a steady well trained team.

9 Summary, synthesis and listed recommendations for best practice

Israel has been a continuing laboratory for EBONE, testing the methodology, adapting it, and finally implementing it in national projects under our own volition. If EBONE is to take root, it must have this "bottom up" approach as well as a "top down" approach from regional and global authorities. Above all, it must be practical, and aimed at widespread application in land management of all kinds.

The INPA team found conservation-oriented "stakeholders" very quickly and brought them into the EBONE program from the beginning as participants in field work and students in field exercises. Early-stage English instruction was followed by Hebrew-language workshops and field exercises where stakeholders absorbed and later modified EBONE approaches to their own needs. This led to a creation of a national structurally-based habitat classification system, new EBONE habitat categories based on field experience in Israel's deserts, and a few applications to conservation problems. This process of adapting EBONE methods is ongoing. It risks a mutation of the methods to the point where they might not be translatable to international standards, but without this process, EBONE approach would end in Israel when the EBONE project ends. That does not seem to be happening.

The key is a delicate balance between fixed standard methods and flexibility in adaptation to local needs, always with an eye to the goals of the work. Local projects manage quite well with in situ data and orthophotos to delineate habitats. National projects will need approaches based in remote sensing and statistically valid stratified sub-sampling in order to be practical.

In contrast to the Israeli experience, the perception of stakeholders in South Africa was quite different. Here, EBONE's GHC approach was considered only of limited value, given that the ecosystem and biodiversity management goals in South Africa are different from Europe and Israel. Here, the enormous biodiversity richness and the huge size of the country has led conservationists and planners to focus more on ecosystem functionality and intactness with biodiversity (species richness) seen as a function thereof. Species richness as such is not focussed on in monitoring assessments (would be too costly, given that per sq km up to 1,000 different plant species can occur).

While stakeholders admitted that the EBONE method has its merits in its standardised sampling schemes and categories, the information which would be derived from this exercise would not meet the national requirements. Therefore, South Africa might be one of the (few?) countries where the implementation of the EBONE biodiversity monitoring system is rather unlikely to be successful.

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11 Appendices

11.1 Levin, N., R. Harari-Kremer, and Y. Carmel 2011 Remote sensing of Israel's natural habitats

11.2 Levin, N. 2012 Mapping general habitat categories using QuickBird and LiDAR data – Ramat Hanadiv as a case study