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NATURAL ECOSYSTEM-UNITS IN ISRAEL AND THE PALESTINIAN AUTHORITY - REPRESENTATIVENESS IN PROTECTED AREAS AND SUGGESTED SOLUTIONS FOR BIODIVERSITY CONSERVATION

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ABSTRACT

The geographic location of Israel and the Palestinian Authorityon the border between Mediterranean and desert climate, and the strong topographic and geomorphological variation resulting from its position on the Great African Rift Valley, combine to sustain a great diversity of landscapes in a very small country. The purpose of this study is to determine whether the protected areas in Israel and the Palestinian Authority adequately represent the range of landscapes and ecosystems in the region.

Altogether, we defined 23 natural ecosystem-units in Israel and the Palestinian Authority, of which 17 are terrestrial landscapes and 6 are aquatic systems. In considering the adequacy of coverage in protected areas, we mapped Israel and the Palestinian Authority landscapes according to a set of environmental factors (climatic, geomorphological, geological and botanical) that we believe most effectively distinguish landscape types in this region. When the separation between adjacent units relies on sharp topographic or edaphic change in the landscape, the mapped units can be separated by a clear and sharp line. When adjacent units are actually a gradient of continuous environmental conditions the separation lines relied mostly on botanic characteristics.

The main land use categories in this analysis were urban areas, agricultural areas, nature reserves, national parks and forest reserves. For the first time in Israel and the Palestinian Authority, we quantified the different landscape types under the different categories of land use. This process, known as systematic conservation planning, allowed us to detect natural landscapes that are underrepresented in protected areas, and can guide decision makers to establish or improve management for the better representation of biodiversity.

Key words: Systematic conservation planning, Ecosystem-units, land use, mapping ecosystems, biodiversity conservation, representativeness in protected areas

INTRODUCTION

Mapping ecosystems or ecosystem-units is a well-known practice around the world (Klijn & Udo de Haes, 1994; Blasi et al, 2000; Davies & Moss, 2002; Comer et al., 2003; Hargrove & Hoffman, 2004). The resolution of the units varies according to the aims of a particular work or research or the questions of the researcher (O'Neill et al., 1986). In many cases the mapping is based on subjective decisions relying on geological, topographic, geomorphology or botanic spatial changes (Bailey, 1985). These changes can be detected on the landscape or by orthophoto or after detailed research or a quantitative mapping procedure. There are many guidelines to draw the correct lines to distinguish between two adjacent ecosystems or ecosystem-units (Bailey, 1985; Hargrove & Hoffman, 1999; Blasi et al, 2000; Post et al., 2007). A simple separation can be drawn between water bodies and terrestrial units, between two different soil units or following topographic lines of foothills and valleys (Strayer et al., 2003). However a researcher can face a challenge trying to draw a line between two units that represent an environmental gradient. The meaning of these lines, aiming to separate adjacent biological or ecological units, is well discussed in the literature (Strayer et al., 2003; Hargrove & Hoffman, 2004). But most writers agree that the lines are artificially drawn, under consistent procedure, in order to face the targets of a particular research.

In order to obtain more objective decisions to define ecosystems, climatic-geographical models were applied (Hargrove & Hoffman, 1999; Trakhtenbrot & Kadmon, 2006). At the base of these models an iterative comparison among adjacent cells, in a continuous grid, is running across a raster-based map resulting in clusters of similar cells (Hargrove & Hoffman, 1999). The resulting maps can vary according to thresholds or the percentage given to each variable (Trakhtenbrot & Kadmon, 2006). The accuracy of the model results depends on the available climatic and geographic data of a particular country. But models usually rely on the one hand on mapped environmental variables that themselves rely on models (for example, continuous spatial information regarding annual precipitation based on an extrapolation of rain gauge data), and on other hand on field observations that contain various biases. The results of these models do not always coincide with the physical or detectable boundaries in the landscape that can ease practical management efforts. Better results can be achieved with data obtained from sophisticated satellite sensors or airborne sensors (Kampe et al., 2010). The variables obtained are continuous sampled data, rather than extrapolation among widely spaced ground sampling sites (Hargrove & Hoffman, 2004; Kampe et al., 2010) and the results are far more accurate.

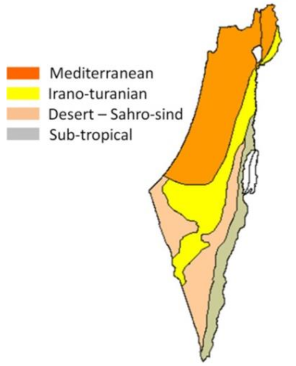
The challenge of delineating a border around habitats or ecosystems stems from the definition of these two terms. The classic definition of habitat is the physical and biological condition allowing a species to exist and to breed successfully, in space and time. More accurately, habitat can be defined as resources and conditions present in an area that produce occupancy-including survival and reproduction by a given organism. Habitat is organism specific; it relates the presence of a species, population, or individual (animal or plant) to an are 's physical and biological characteristics (Hall et al., 1997). An ecosystem is defined as a higher level in the hierarchy of the ecological order. Odum (2001) termed it as every defined life system in a defined geographic area including all living organisms and their interaction with the physical environment which surrounds them. It is a functional unit for which output and inputs can be defined. An ecosystem is more than a delineated geographic unit or region. It can be describe as a hollow hole in a tree or a floating algal surface (O'Neill et al., 1986), or a coral reef or rain forest.

In both cases, habitat and ecosystems, the lines we draw have no realistic meaning, neither for the species nor for most of the physical conditions forming the ecosystem. For example the line of a lake is well defined from the land surrounds it, yet an otter can live outside the lake but get its food in it (Strayer et al., 2003). The line between mountain slopes and valley is well defined in the landscape and in reality we cross from terra-rossa soils to alluvial soils respectively. But landslides or even simple erosion can drift essential elements from the slope ecosystem to alluvium, allowing mountain species to survive or thrive in the alluvial ecosystem. In order to avoid the elusive term 'ecosystem' for mapping procedure we choose to use the term ecosystem-unit which will get it closer to geographic terms and can actually combine the two disciplines.

Defining ecosystems can be done in many objective and subjective methods, depending on budget, data availability and time. Different researchers can get completely different results with the same set of data because of the way they interpret the combination of conditions assembling an ecosystem. Therefore the goal or target of the work is an important starting point.

We take the case of Israel and the Palestinian Authority as an example. The present bioclimatic categories are dividing Israel and the Palestinian Authority into four Phytogeographic regions (Figure 1), which correspond to climatic division made by climate researchers (Braver, 2010). Other current maps are dedicated to other disciplines: geology (Bentor, 1970), soil (Dan et al., 1974), botany (Zohary, 1980).

Fig. 1: Phytogeographic-climatic regions after Waisel (1984)



Kaplan & Salutzki (2000) presented methodology for evaluation of open landscape in Israel. They combined several physical conditions to each landscape unit but eventually those units correspond well to topographic traits other than the combination of traits that corresponds to ecological demands of organisms. The purpose of the present study is to determine whether the protected areas in Israel and the Palestinian Authority adequately represent the range of landscapes and ecosystem-units in the country. Joppa & Pfaff (2009) have shown that protected areas around the world are located in non-favorable landscapes hence high, steep and far from lands suitable for agriculture or large cities. We suggest the partition of the region into ecosystem-units and then exploring its representativeness in protected areas (Scott et al., 2001). The work should serve as guideline for priorities for district ecologists and planners inside Israel Nature and Parks Authority (INPA) as well as for decision makers and stakeholders in Israel and the Palestinian Authority. Priorities for INPA will point at promotion of conservation or management of landscape in ecosystem-units that will define as underrepresented in protected areas. The results of the study are mostly intuitively known but some were unexpected.

MAPPING METHODS

Israel and the Palestinian Authority are characterized by considerable variation in climate, topography, lithology and pedology. Mean annual rainfall ranges from 15 mm in the south to 1200 mm in the north. Elevation ranges from 400 m below sea level at the Dead Sea area to 2200 m above sea level at Mt. Hermon. Variation in topography is associated with related variation in temperature, although other factors such as latitude and distance from the Mediterranean Sea are also involved in determining patterns of variation in temperature and precipitation.

In the present work we used conventional mapping methods as done around the world. We relied on well documented knowledge and draw the lines between ecosystem-units based on expert's opinion. Biotic data were based mostly on botanic maps and literature (e.g. Zohary, 1980; Rabinowitz, 1986; Danin, 1992; Kadmon & Danin, 1999). Abiotic were obtained from standard national GIS layers and literature, including climate (Braver, 2010), geology (Zilberman et al., 2011; Bentor, 1970), geomorphology (Nir, 1989) and soils (Dan et al., 1974; Rabikovitz, 1981). The mapping procedure relayed mostly on 1:50,000 scale data. Several ecosystem borders were extracted from 1:250,000 maps. The shore salines were mapped on the bases of the PEF (Palestine Exploration Fund) map, at the scale of 1:63,000 (1:50,000 inch). In order to map the rocky shores along the Mediterranean coast, we used aerial photographs at the scale of 1:5,000 (Table 1).

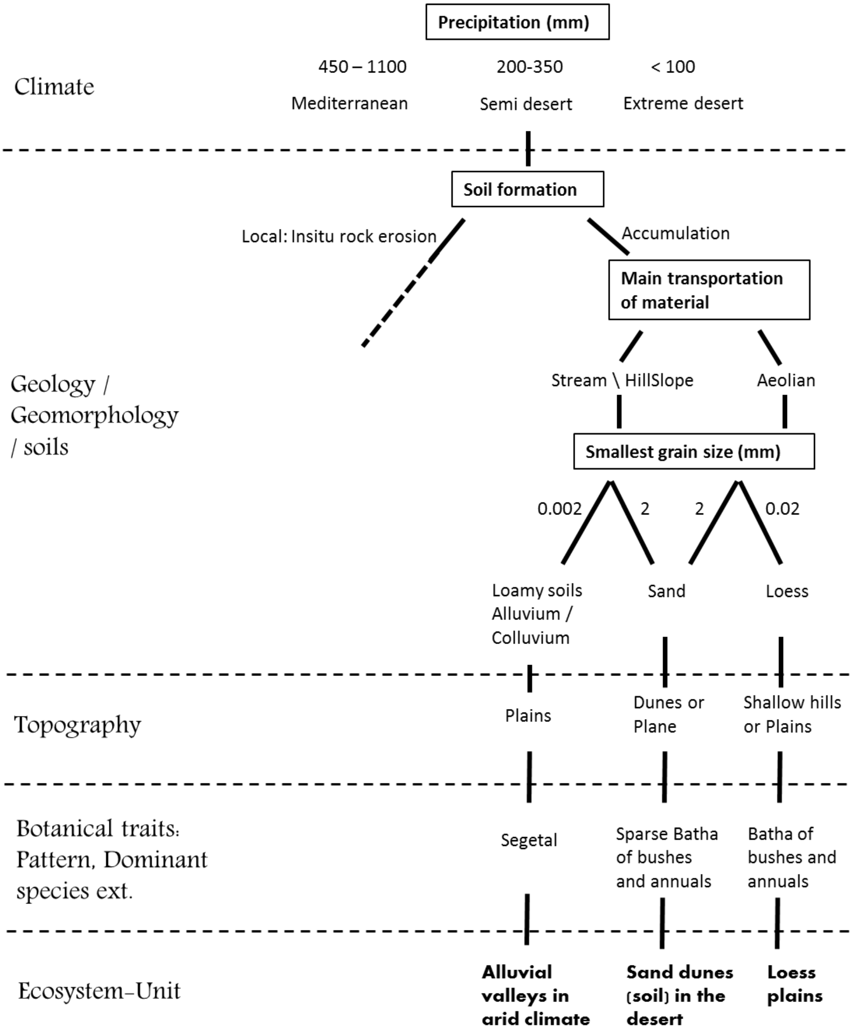
Table 1: Categories list forming Ecosystem-units map

#	Category / layer name	Source	Map / Layer scale
1	Soils map	Minestry of Agriculture	1:50,000
2	Lithology map	Geological Survey of Israel	1:50,000
3	Botanical maps	INPA, Hebrew university, SPNI, Zohary, 1980;Rabinowitz, 1986; Danin, 1992	1:50,000 – 1:250,000
4	Climate map - Precipitation	Hebrew university	1:250,000
5	Streams and Rivers	Survey of Israel, INPA	1:50,000
6	Ortophoto	Survey of Israel	1:2,500

The smallest ecosystem-unit is the rocky shores, with total coverage of less than two square kilometers. That ecosystem-unit is not continuous along the shore. We choose the hierarchal method (Bailey, 1985) where climate is defined as the higher level, followed by geology, geomorphology, topography, pedology and finally vegetation structure, and in some cases also characteristic fauna (Figure 2).

For strict terrestrial ecosystem units the higher level was defined by climate and in particular precipitation. The second level referred to traits stems from geology, lithology, geomorphology and soils, followed by topographic patterns of the landscape, and ending with botanical traits like patterns of plants or other dominant species (Figure 2). For aquatic ecosystem units, the first level referred to the geometry of the unit, followed by chemical or geomorphological traits, and ending with topography, flow pattern and botany.

Fig. 2: Hierarchy scheme to define terrestrial ecosystem-units
The highest level is climate dividing the area into three categories followed by traits or conditions of morphology, pedology and geology. The next level refers to topography or to the main pattern of the landscape. The last level is botany refers to spatial pattern of vascular plants or dominant species.The example is given for three ecosystem-units under semi desert conditions.



In several occasions we could base an ecosystem-unit definition on particular research that revealed ecological interactions among the major organisms of the ecosystem. These interactions dictate plant physiognomy and influence the patchpattern of the ecosystem (Shahak, 2010). Bioclimatic models like Mahalanobis Distance (Mahalanobis, 1936; Farber, & Kadmon, 2003) failed to distinguish between adjacent ecosystems because of poor spatial data and because the assemblage of organisms poorly corresponds to a border that restricts their distribution (Pearson & Dawson, 2003). We did correct the line between two ecosystems: Extreme Xeric Desert and Shrubby Steppes in the Negev Desert after using Mahalanobis Distance based on observations of species that characterize the two ecosystems.

Subsequent decisions to draw lines between ecosystem units relied on intuition (Bailey, 1985; Blasi et al, 2000). This intuition or expert opinion was based on knowledge that stemmed from the combination of environmental physical and biological factors that we delineated as a separate landscape unit or ecosystem-unit.

The area mapped lies within the present international borders of Israel and the Palestinian Authority exclusive of Gaza. While mapping ecosystem units we did not consider existing land use. The ecosystem-units were mapped without existing development constraints. At the first step of mapping ecosystems we excluded very small units like springs, seasonal ponds and caves.

Ecosystem-units definition

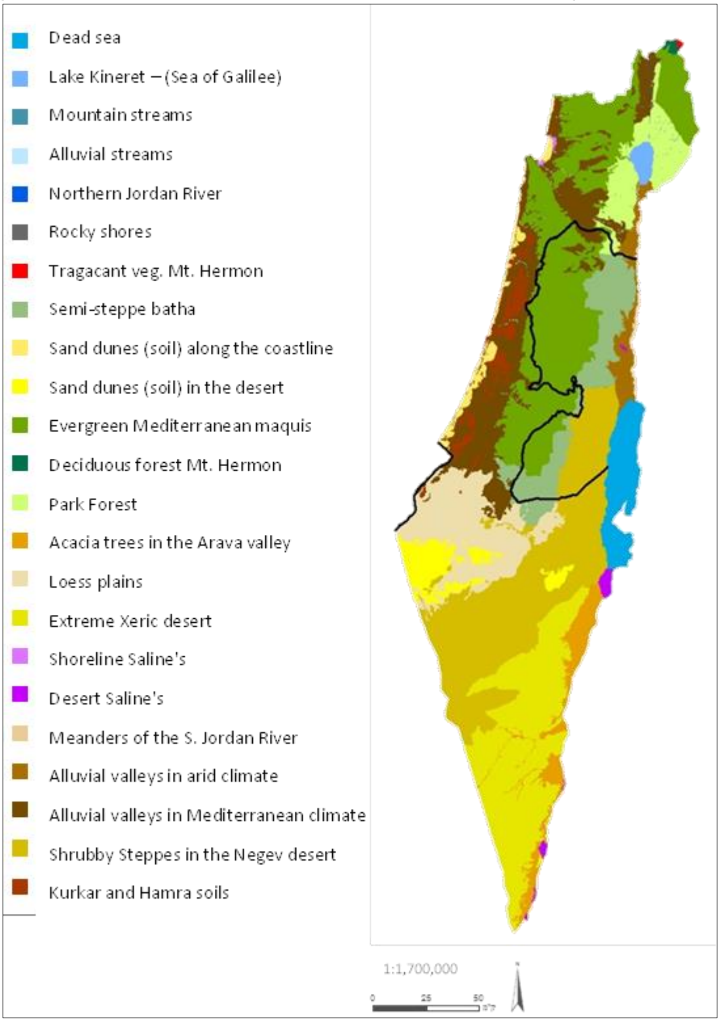
The proposed division to ecosystem-units unifies extensive areas with similar environmental conditions and features or similar phenomena of flora and fauna. For example fast flowing streams are characterized by plants with resistance to flood flows and animals with relatively flat substrate adherence ability. Animals and plants possessing traits to cope with sandy soil will characterize sandy soil ecosystems but not adjacent ones.

Altogether, we defined 23 natural biomes in Israel and the Palestinian Authority (Figure 3), of which 17 are terrestrial landscapes and 6 are aquatic systems. The first step divided the map into terrestrial-waters ecosystems *vs* strictly terrestrial. The humid ecosystems were divided according to their shape, separating lakes from streams. The two lakes of Israel and the Palestinian Authority are well defined by their salinity. The **Sea of Galilee** is a freshwater lake while the **Dead Sea** is a hyper-saline lake. We have delineated the historical sea level (Fig. 3). Although In present days the southern part of the Dead Sea is part of mineral manufacture factory and the actual ecosystem-unit is relevant only in the north part of the lake. Streams were divided by the main soil or rock characterizing their banks and bed: alluvium *vs* rocky or stony. Streams in this region are very narrow entities showing on the maps (and in reality) as single continuous blue lines. Since every stream has a volume of water and it influences several meters of its banks, we decided that on average **alluvial stream** width will be 100 meters. These streams are characterized by a low gradient with laminar flow, canalizing in the coastal low lands of the country. **Wide streams in the north of Israel**, with their riverine forests, and the **lower Jordan River** with its meanders, were defined at 100 meters width as well. Although the lower Jordan River can be considered an alluvial stream, its natural meanders and the soils it canalizing in differs it from the low land alluvial rivers which are mostly artificial canals. **Mountain streams** characterized by steep gradients and turbulent rapid flow were considered 50 meter width. Altogether we have referred to the historical (last 100 years) potential flow of the streams.

The division of the strictly terrestrial ecosystem-units followed a hierarchy procedure, starting with rainfall and ending with floral characteristics. Climate and in particular rain, divides Israel and the Palestinian Authority into three main climatic zones: 450 -1,100 mm, 200 – 450mm and less than 200 mm.

Further steps were parallel for each of the three sections. North and west to the 450 rain isohyet we characterized 10 ecosystem-units. **Mediteranean maquis** develops on mountains and hills characterized by different soil types. Since there is no limitation of precipitation, we predict, according to researches and models (E.g. Kadmon & Harari-Kremer, 1999; Shachak et al., 2008), that most of the areas, without interference, will grow to a continuous closed canopy structure maquis or forests (Davies & Moss, 2002). For that reason we included all the potential succession stages: batha, garigue, maquis and evergreen native forests in the same unit, without reference to the existing vegetation form.

Fig. 3: Ecosystem-units of Israel and The Palestinian Authority



The ecosystem-unit of the **Light soils in the "Sharon" coastal plain** consist three different rock-soil formations: the carbonized-cemented quartz sandstone (Kurkar) ridges, reddish brown loam (Hamra) and Husmas which is a buried Hamra soil with calcareous nodules (Shapiro, 2006). All of the rock-soil formations are stages in a geomorphological process of Pleistocene sand dunes under changing humidity of climate regimes (Nir, 1989; Neev & Ben-Avraham, 1977). In the past the Sharon was covered by maquis or *Quercus ithaburensis* forest, but during the 20^{th} century the fertile soils and the moderate landscape were attractive to new agriculture and settlements respectively, resulting in rare and fragment patches of the original habitat. The rock-soil elements of the ecosystem-unit are unique locally and globally and the annual vegetation has many endemic and endangered species

(Shmida et al., 2011). The unit was mapped from the soil map, and delineated from adjacent units according to changes in soil types surrounds it.

The ecosystem unit of **Alluvial valleys under Mediterranean climate is** characterized by its montmorillonitic clay soil. The soils are well developed and are the outcome of fluvial transportation (Alluvium) or slopes erosion (Colluvium). The relatively deep fertile soils accumulate in large topographic depressions (Rabikowitz, 1981; Shapiro, 2006). We included alluvial depression soils in a single unit because of the clay mineral traits and because most of the ecosystem unit is under intense agriculture regime, leaving only hints of potential native vegetation. The present native vegetation is described as segetal and similar species characterize all valleys (Zohary, 1980). The lines separating between valleys and adjacent units are the topographic-geologic change from the plane alluvial soils into steep slopes constructed of limestone, chalk or basalt rocks of the surrounding mountains. The ecosystem-unit of **coastal sand dunes** gets its uniqueness from the physical traits of the sand grains. Low water availability, high salinity, and high radiation create desert abiotic conditions under 450-800 mm of rain. The unit was mapped from soil maps. Four other ecosystem-units can be distinguished in the Mediterranean climate region. The **Park Forest** unit describes a landscape with scattered trees accompanied by annuals. The main trees are *Quercus ithaburensis* and *Ziziphus spina-christi* and the annuals dominated by Gramineae species. Climatic and topographic gradients (Zohary, 1980) as well as human impacts like cairns (Kaplan & Gutman, 1999) are the main reasons for its appearance. Hence not a single thin line can separate the unit from the Mediterranean maquis unit. The line was drawn according to an acceptable botanic separation in the literature (Zohary, 1980; Waisel, 1984). The ecosystem-units of Mount Hermon, the highest elevations in this classification, were separated upon altitude gradient (Auerbach & Shmida, 1993). **Deciduous forest** was mapped according to topographic altitude 1300 – 1800 m line, while **Taragacanthic spiny shrub batha** covering the peaks of Mt. Hermon were mapped up to 1800-2200m. The ecosystem-unit of the **Rocky shore** appears at the coastline of the Mediterranean Sea. The ecosystem unit is the transition zone between land and sea. Most of the bedrocks are eroded table or rimmed terraces of Pleistocene carbonized-cemented quartz sandstone (Kurkar), (Neev & Ben-Avraham, 1977) that differentiates this unit from the adjacent Coastal Sand Dunes unit. It was mapped from orthophoto. **Shoreline saline flats** were described at the estuaries of the Na'aman River and the Kishon at the Haifa bay. The ecosystem-unit soils are salty because of seawater rising during winter storms, or driven by western winds. Mapping the ecosystem relied on old topographic map (PEF 1880, Palestine Exploration Fund) and upon vegetation descriptions of the present work. Today only remnants of the ecosystem can by seen due to high development pressure on the Haifa-Acre metropolitan area.

At the 200-400 mm of rain we described four ecosystem-units. The **Semi steppe batha** surrounds the Mediterranean maquis unit from east and south. The climatic conditions governing the unit are a combination of local and global phenomena. The north-east part of the unit is influenced by topographic steep change in elevation from the top of the Samaria ridges at 800 m in average, to –200m towards east in the Dead-Sea Rift valley. The phenomenon is termed 'rain shadow-desert' since the clouds dropping through the steep topographic gradient lose their precipitation (Kutiel et al., 1995). In the south part of the unit the climate conditions resemble the transition zone between the Mediterranean climate and the global northern desert belt. The ecosystem-unit is represented by small thorny shrubs with no trees (Danin, 1992). Since it is a transition zone the border lines are hard to draw. We drew these upon vegetation maps (Zohary, 1980; Danin, 1992).

Alluvial valleys in arid climate were determined upon the union of various types of alluvial soils along the Jordan valley from the Dead-Sea in the south up to Beit-Shean Valley, south of the Sea of Galilee, in the north. We distinguish this unit from the Mediteranean alluvial valleys because the soils have developed under arid climate conditions. The arid semi desert climate with a high evaporation/wetting ratio causes the soil to become more salty. High carbonated and high-gypsum soils called Serozems soils develop on old lake-marl (Shapiro, 2005). Large portions of the ecosystem-unit are under an intense agriculture regime.

The ecosystem-unit of **Sand dunes or sandy soils in the desert** is a type governed by the sand grain physical traits. The water availability at the upper parts of the ground is low and the grains drift in the wind preforming dunaric landscape. In one place the sand covers vegetation and in another place roots are exposed. The ecosystem unit is scattered and consists of large sand fields under the 200 mm isohyet, containing manly quaternary Aeolian sand. It was mapped from soil map.

The **loess plains** ecosystem-unit differs from other units by the physical characteristics of the loess particles and the landscape it forms. The loess plain soils are an accumulation of dust particles drifting by storms from the Sahara and Sinai desert. Only the tiny grains reach the region through the atmosphere, sinking and accumulating by shrubby vegetation in desert edges (Yaalon & Dan, 1974; Tzoar & Pye, 1987).The tiny clay minerals causing a poor water regime. The moderate landscape and the semi fertile but friable soil are intensively settled and cultivated.

The ecosystem-unit of **Shrubby steppe of the Judean desert and the Negev Mountains** is separated from other neighboring ecosystem-units by the two-phase patch habitat of scattered shrubs (Zohary, 1980; Danin, 1987; Shahak, 2010), without annuals between the shrubs. The vegetation pattern described is changing on a gradient from south west to north east. The peaks of the Negev Mountains (up to 1000 m) experience numerous night of dew, hence dense and uniform slopes cover by shrubs, while moving north east the pattern and the uniformity are less pronounced. To the north the ecosystem-unit is topographically higher than neighboring topographic depressions of the loess plains and the desert sand dunes. To its south a sharp topographic gradient occurs, hence the precipitation and climatic gradient changes the vegetation pattern, turning it to a distinct ecosystem-unit.

South and east of the 100 mm of rain, we described three more ecosystem-units. In the ecosystem-unit of the **Extreme xeric desert** in the southern Negev, vegetation is contracted to wadis. The ecosystem-unit covers a variety of rock formations like granite and metamorphic rocks in Eilat Mountains as well as limestone and chalk. Since the limiting factor is the unpredictable rain regime, the soil or the rock type has a limited impact on vegetation type. Yet, inside this previous ecosystem-unit we can separate extremely **wide wadis** and the **Arava valley** as a distinct unit. The unit is notable for a scattered but dense population (compared to the surrounding extreme desert) of Acacia trees. The long topographic depressions of the wadis and the Arava are filled by conglomerate, pebbles and gravel (Zilberman et al., 2011), which significantly improve the underground water regime enabling the trees to thrive, attracting a highly diverse micro and macrofauna. The geologically very active Rift valley caused the emergence of undrained topographic depressions. Flood water accumulates and seeps but high solar radiation causes fast evaporation and the soil becomes saline (Nir, 1989; Franzen, 2013). The **Desert saline** ecosystem-units have pronounced vegetation belts. The outer most belts can support Acacia trees, replaced by Tamarix spp. or *Nitraria retusa* in the inner belts then a bare salty ground in the middle of the saline. The ecosystem-unit is scattered in a few fragment patches along the Arava valley and in the lower Jordan valley.

Land use Map

In order to perform spatial analysis of the ecosystem-units map we, carried out a parallel process of creating a continuous national land use map. We have selected GIS layers of several sources. The national master plans number 8 refers to nature reserves and national parks (Ministry of interior, 1981; Tal, 2008). Forest and afforestation derived from national master plan No. 22. Out of these master plans, the Israel Nature and Parks Authority and the KKL-JNF (Jewish National Fund actually are the managers of planted forest and large native landscapes in Israel) respectively, can promote, through rural to national planning committees, declaration of protected areas. Other land use layers were military zone, agriculture, built area, roads and railway infrastructure.Since the aim of the land use map is to intersect with the ecosystem-units map we decided to avoid parallel land uses e.g. military zones that overlap nature reserves, agriculture inside nature reserves or longitudinal infrastructures (roads, and railways) that overlap built areas. We used a methodology that ranks land use factors and prioritizes them (Table 2). The categoriesare listed according to overlapping priorities. The first categories will encompass lower categories. Encompassed portions of lower categories were not included in the final map. The GIS layers were converted into raster format and the final combined layer was obtained through a sequence of logical conditions, favouring priorities for conservation, among the land use layers. In order to avoid large areas that have no land use definition we use a wide range of sources from various ministries and layers for the Survey of Israel (Table 2).

Table 2: Categories list forming the land use map

The categories are listed according to overlap priorities. The first categories will overlay lower categories. Overlaid portions of lower categories will not include in the final map.

#	Category / layer name	Source
1	Declared Nature reserves	INPA*
2	Declared National Parks	INPA
3	Approved nature reserves according to detailed plans derivate from master plan # 8	INPA
4	Approved national parks according to detailed plans derivate from master plan # 8	INPA
5	Native forest for conservation according to master plan #22	KKL-JNF**
6	Native forest for cultivation and care according to master plan #22	KKL-JNF
7	planted non-native forest according to master plan #22	KKL-JNF
8	Proposed nature reserves and national parks	INPA
9	Transportation infrastructure	Survey of Israel
10	Built area	Survey of Israel
11	Aquaculture - Fish ponds	Survey of Israel
12	Water bodies	Survey of Israel
13	Agriculture (fields and plantation)	Survey of Israel
14	Agriculture (greenhouses)	Survey of Israel
15	Military zones	IDF***

*INPA – Israel Nature and Parks Authority. **KKL-JNF - Jewish National Fund actually are the managers of planted forest and large native landscapes in Israel. The forest division of the JNF follows the instructions of Israel master plan # 22. Native forest for conservation according to master plan #22" may include areas which are not forests at all and that this class corresponds to land use and not to land cover. ***IDF – Israel Defense Force.

Analysis of Ecosystem-units *vs* Land-use

The last step of the project was to intersect between the two maps. The output points to ecosystem-units that are underrepresented in natural protected areas based on the CBD, Aichi Biodiversity Targets category c Target 11 recommendations. The convention recommends the conservation of 10% of each type of coastal and marine areas and 17% of each type of terrestrial ecosystem. We emphasize the natural protected areas because under master plan No. 22 there are vast areas of non-native planted forest. Therefore while calculating percentage of natural protected areas we considered all declaration stages (proposed, approved and declared) in master plan No. 8. For master plan No. 22 we have chosen only the native types of forests Natural forest for conservation and Existing or proposed forest park (Kaplan, 2011).

We explored the land use of all ecosystem-units in order to understand better the possible steps that can be taken to improve conservation or biodiversity representation in non-protected areas. Moreover we calculated the natural area left for each ecosystem-unit. That procedure was possible due to new layer that separates native areas from non-native ones: built areas, infrastructures, agriculture ext.

RESULTS AND DISCUSSION

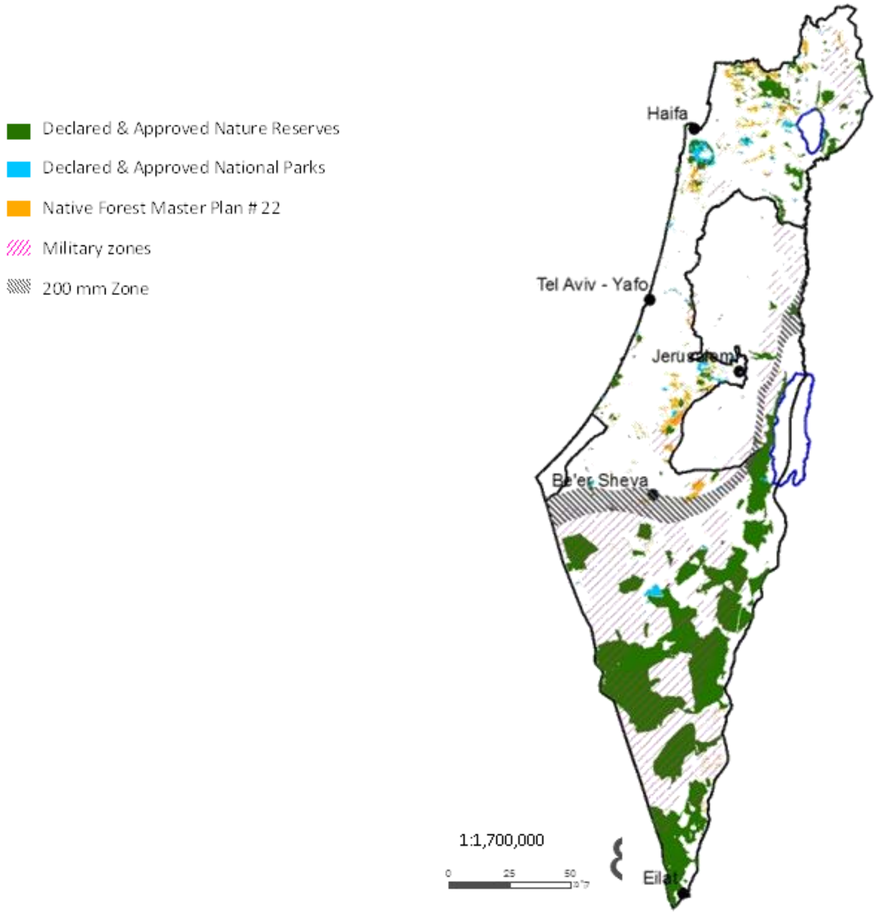
Ecosystem-units representation in protected areas

Nature reserves and national parks are spread from north to south along the whole region. But the spatial distribution of nature reserves is uneven among the different ecosystem-units and especially north and south of the 200 mm isohyet. While north of that line there are numerous small nature reserves, south of it, under the desert climate, there are few but very large nature reserves (Figure 4). Since each ecosystem-unit has its own uniqueness in biodiversity we assume that good representation of all ecosystem-units in protected areas will represent the overall biodiversity in the region. In principal larger areas can support more species (MacArthur & Wilson, 1967). However in the aridity gradient of the region, we need less Mediterranean or sub-Mediterranean area to represent its biodiversity in comparison to the arid ecosystems of the desert area. Apparently because of productivity that stems from climatic-physical condition, the desert ecosystems will support fewer individuals per unit area, especially of closely related species with the same body mass, compared to Mediterraneanareas (Huenneke & Noble, 1996).

The human population distributions of Israel and the Palestinian Authority are uneven over their territories. In Israel most of the human population lives north of the 200mm isohyet and along the coast line. In The Palestinian Authority the population is concentrated along and west of the Samaria-Judean ridges and north of the 200 mm annual precipitation isohyet.

In both cases the terrestrial ecosystem-units overlapping these areas are under-represented in protected areas. These ecosystem-units are: Loess plains, Sandy dunes or soils along the coast line, Coast line saline, 'light soils' (Hamra Husmas and Kurkar) in the Sharon, and alluvial valleys in both arid and Mediterranean climate. The Dead Sea and the Sea of Galilee are not represented satisfactory in protected areas as well. Surprisingly even the Mediterranean maquis, one of the largest ecosystem units definednorth of the 400mm isohyet, is not well represented in strict nature reserves. Adding national parks and native forests of master plan No. 22 the protected areas reach the 17% destination (Figure 5).

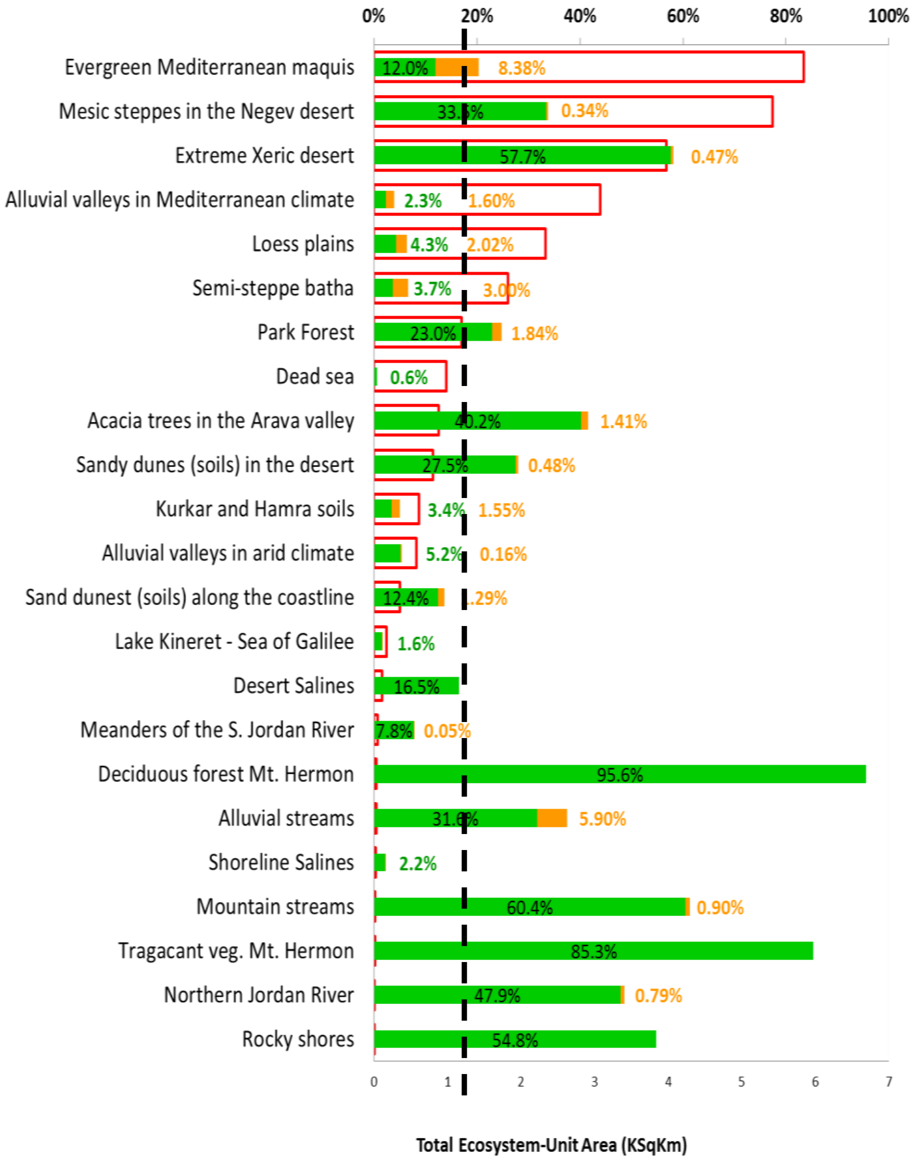
Fig. 4: Protected areas in Israel and the Palestinian Authority
South of the 200 mm zone large areas where declared and serves as nature reserves and military zones. North of the 200 mm line the protected natural areas are small and scattered. Source INPA GIS unit.



Scott et al. (2001) described similar results concerning the biodiversity representation of species in nature reserves in the United-States ecoregions. Species of lowland fertile soils and fertile soils ecosystems in valleys were poorly represented in nature reserves. Troupin & Carmel (2014), have found the same underrepresentation phenomena for birding bird species in Israel. Joppa & Pfaff (2009), have shown that the underrepresentation of ecosystems of fertile soils or lowlands is a worldwide phenomenon. Devillers et al. (2014), have pointed a bias while deciding on Marine Protected Areas (MPA) around the world. They claim that nature protection organization are "favouring ease to establish MPAs on need for protection areas" hence continuing the 'business as usual' processes of establishing protected areas that fail to well represent and defend local biodiversity.

Fig. 5: Representativeness of the Ecosystem-units in native protected areas in Israel and the the Palestinian Authority

Total ecosystem-unit area, Nature reserves & National Parks, Declared & Approved (%), Native Forest types of Master Plan # 22(%). The dashed line is the 17% recommendation for terrestrial protected are according to the CBD Aichi convention.



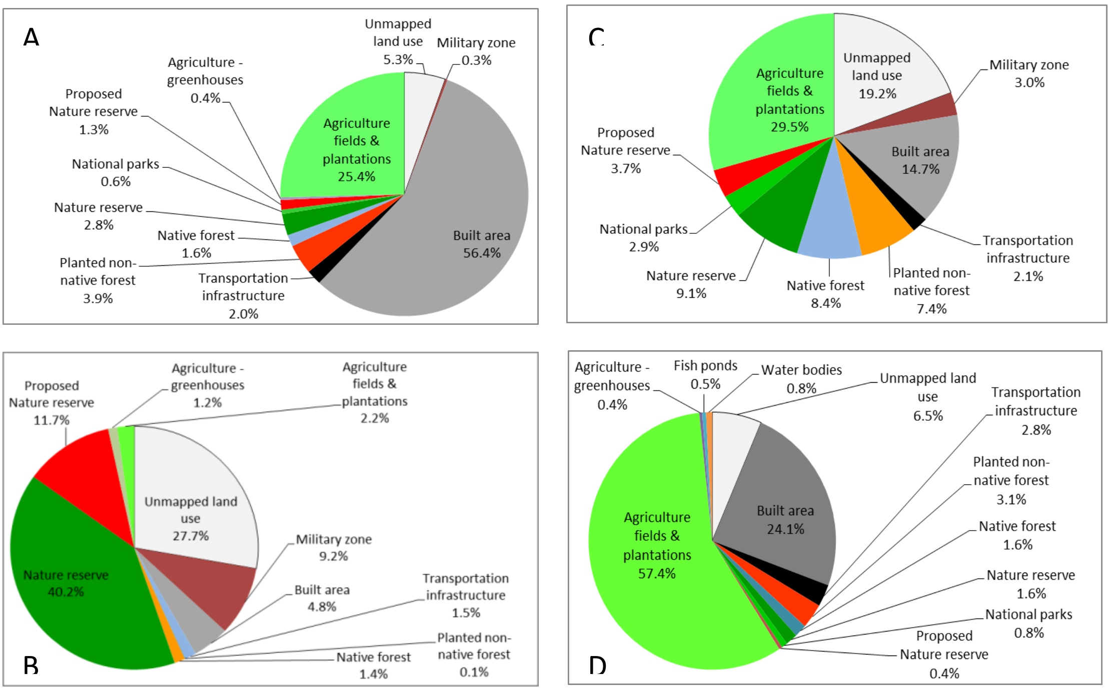
Land-use analysis

Overlaying the ecosystem-units map with the land use map in GIS, allowed us to identify possible solutions or acts that can improve biodiversity representativeness. Figures 6A-D are an example of that analysis of four selected ecosystem-units.The proposed nature reserve segments (red color), in all pie charts are the next step of actual protection of more landscape in a particular ecosystem-unit. It is notable that future addition of nature reserves in the alluvial valleys in the Mediterranean climate (Figure 6D) and in the Light soils in the Sharon (Figure 6A) is less than 1.5% and 0.5% respectively.

Further steps for locating possible landscapes for conservation in these two ecosystem-units will be done by investigating the unmapped segments. The protected areas in the Mediterranean maquis (Figure 6C) seem sufficient but in reality there are three large protected areas of maquis, separated by tens to hundred kilometers: Judean Mt. National Park, Mt Carmel National Park and Nature Reserve and Mt. Meron Nature Reserve. All other reserves are small and fragmented by settlements and roads. Future declaration of reserves can improve the connectivity in that ecosystem-unit.

Fig. 6: Land use analysis of four selected ecosystem-units. In brackets the total area of the unit is given:

A.' Light soils' in the Sharon, (607 Km^2) B. Accacia trees in the Arava valley (875 Km^2), C. Mediterranean maquis (5,838 Km^2) and D. Alluvial valleys in Mediterranean climate (3,077 Km^2).

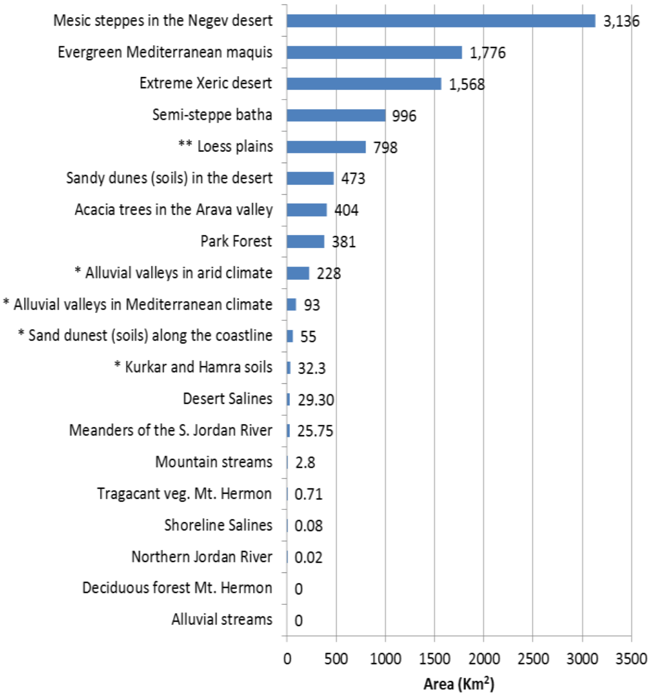


In order to have sufficient biodiversity representation in the southern xeric ecosystem large areas are needed. The ecosystem-unit of the Acacia trees in the Arava valley and in wide wadis (Figure 6B) are well represented in protected areas, but the pie chart does not show the whole picture. Most of the protected areas are within the wide wadis like Paran, Ketzev and Hayun (Figure 3), whereas areas in the Arava valley are not protected. The unmapped land uses and the military zones segments (in the pie chart) in those areas are the next challenge of adding more protected areas to the ecosystem-unit. In our region, under political complexity, the combination of military zones and nature reserve (Oren, 2007), had proved as conceivable under collaboration between the Ministry of Defense and INPA.

In order to understand how much natural landscape of each ecosystem is still available, we have reduced the protected areas from the total natural area of an ecosystem-unit (Figure 7). Although it seems that previously stated non-represented ecosystem-units still have large natural area for conservation. These areas are very small highly fragmented or under anthropogenic pressure like illegal cultivation of the landscape. For example Kurkar and Hamra ('Light soils' in the Sharon) and the two types of the alluvial valleys are highly fragmented while the loess plains suffers from seasonal cultivation regime cause by the local Bedouins as part of their struggle over land ownership.

Fig. 7: Analysis of the natural area left in each ecosystem-unit

* These ecosystem-units are highly fragmented hence the actual size of relevant areas for conservation are very small. ** The loess plains ecosystem unit is under high pressure of illegal seasonal cultivation. Lakes and Rocky Shore ecosystem-units were excluded from the analysis.



Possible solutions for biodiversity representation

The under-representation of ecosystem-units under dense populated and cultivated areas presents a great challenge for native biodiversity conservation. The vulnerability of ecosystem-units stems from their nature. A closed ecosystem like the fresh water lake of the Sea of Galilee is highly vulnerable due to anthropogenic factors occurring in its basin: intensive grazing, fish ponds aquaculture and intensive agriculture. Nevertheless it became a water supply reservoir with huge water levels difference between winter and summer and was deliberately or unintentionally populated by non-native fishes and organism. Restoration or even preservation of that ecosystem is complicated and demands great efforts among many stakeholders across the whole basin.

Alternatively open ecosystems like the mediterranean maquis can recover fast while reducing anthropogenic impact. Hence in that sense its vulnerability is low. Promoting declaration of more areas as protected areas is nearly impossible in the crowded parts of

Israel and under the present political situation in Israel and the Palestinian Authority. Scott et al. (2001) had pointed at the need of collaboration with private property owners in order to better represent the biodiversity in the ecoregions that were found underrepresented. In our region most of the land is owned by the government, hence the collaboration must run through many stakeholders including farmers, ministries and municipalities prior or in parallel to NGO initiatives. Further more Soulé & Sanjayan (1998), have questioned the need for conservation targets claiming that globally and locally success is achieved only for 'non-commercial' ecosystems or landscape.

Understanding the obstacles in declaration procedure, other options of biodiversity conservation are applicable. In the ecosystem-unit area of the Sharon light-soils and in the alluvial valleys under mediterranean climate several agri-environmental initiatives are taking place. In all cases the initiatives stem from a combination of a local situation like soil erosion or drainage solutions or even consideration of losing the last traditionally cultivated valley, converting it into intensive agriculture like all others. The INPA helps promoting these projects using biodiversity considerations in order to better represent the native biodiversity of a particular ecosystem-unit. For example local flora, instead of wheat, is used to prevent soil erosion in the Light soils of the Sharon. Giant reed *Arundo donax* is used to prevent the distribution of *Ambrosia confertiflora* along alluvial streams preventing it from spread into near by alluvial fields. Other ways of strengthening native biodiversity in non-representative ecosystem-units are by including instruction in rural or even national plans that supports local biodiversity, by direct planting local herbs or by instructions that aim to eliminate or prevent invasive species. But even inside protected areas the INPA is implementing management that aims to restore or preserve local biodiversity. In coastal sand dune reserve the INPA exposed sand dunes covered by natural woody vegetation, which had been losing many sand dwelling organisms (Bar, 2013). In maquis and even in small reserves in the Sharon INPA's rangers reduce mechanically (not only be grazing) woody vegetation in order to gain more native species in the same protected landscape. Trupin & Carmel (2014), pointed out that nesting bird species are poorly represented in protected areas in the north part of Israel (without the the Palestinian Authority and the Golan heights). They concluded that the combination of the two strategies of land sparing and land sharing will achieve the best biodiversity representation.Tear et al. (2005), suggested using Marxan procedure to identify important areas containing large number of species while Pfab et al. (2011), demonstrated an interesting way of combining threatened species habitat and distribution in consideration of regional planning. Altogether in our region in order to represent the natural biodiversity several strategies should be adopted. Management inside protected areas but also improve natural and semi natural condition in open non protected areas like agriculture and planted forests. It can be achieved through collaboration in regional planning involving stakeholders. The framework for regional planning should base on biodiversity data, achievable goals, review of existing conservation areas and on the action and monitoring that should be taken in order to accomplish the plan goals (Margules & Pressey, 2000).

In future work we plan to define sub units of the ecosystem-units presented here. We will try to implement the methods of the IUCN CEM group (Rodrigue et al., 2011) and are considering of writing the red book for ecosystems in the region.

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REFERENCES

Auerbach, M, Shmida, A.V.I., (1993). Vegetation Change Along an Altitudinal Gradient on Mt Hermon, Israel--No Evidence for Discrete Communities. *Journal of Ecology*, 25-33.

Bailey, G.R., (1985). Delineation of Ecosystem Regions. *Environmental Management* Vol 7 No 4 pp 365-373

Bar, P.K., (2013). *Restoration of Coastal Sand Dunes for Conservation of Biodiversity*: The Israeli Experience, Springer Series on Environmental Management, pp 173-185

Bentor, Y.K., (1970). *Geological map of Israel* 1: 250 000. Survey of Israel.

Blasi, C., Carranza, M. L., Frondoni, R., Rosati, L., (2000). Ecosystem classification and mapping: a proposal for Italian landscapes. *Applied Vegetation Science* 3 233–242

Braver, M., (Ed.) (2010). *The New Israeli University Atlas*. Orenstain Y, Yavne Publishing house LTD Tel-Aviv. (in Hebrew).

Comer, P.J., Faber-Langendoen, D., Evans, R., Gawler, S.C., Josse, C., Kittel, G., Menard, S., Pyne, M., Reid, M., Schulz, K., Snow, K., Teague, J., (2003). *Ecological Systems of the United States:* A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia.

Dan, J., Koyumdjisky, H., (1963).The soils of Israel and their distribution1. *Journal of Soil Science*, 14(1), 12-20.

Dan, J., Yaalon, D.H., Koyumdji, H., Raz, Z., (1972). Soil association map of Israel (1-1,000,000*). Israel Journal of Earth Sciences*, 21(1), 29

Danin, A., (1987). *The vegetation in the Golan in Golan Height Ariel Publishers and the institute to the Golan research*, Katzerin (in Hebrew)

Danin, A., (1992). Flora and vegetation of Israel and adjacent areas. *Bocconea*. 3 : pp. 18-42

Davies, C.E., Moss, D., (2002). *Eunis habitat classification 2001 work programme final report*, European topic centre on Nature protection and biodiversity, European Environment Agency

Devillers, R., Pressey, R, L., Grech, A., Kittinger, J.N., Edgar, G.J., Ward, T., Watson, R., (2014). *Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection?* Aquatic Conservation: Marine and Freshwater Ecosystems.

Farber, O., Kadmon, R., (2003). Assessment of alternative approaches for bioclimatic modeling with special emphasis on the Mahalanobis distance. *Ecological Modelling*, 160, 115–130

Franzen, D., (2013). *Managing saline soils in North Dakota*. NDSU extension services SF1087 pp. 1-12

Hall, L.S., Krausman, P.R., Morrison, M.L., (1997). The Habitat Concept and a Plea for Standard Terminology Wildlife Society Bulletin, Vol. 25, No. 1, *International Issues and Perspectives in Wildlife Management*, pp. 173-182

Hargrove, W.W., Hoffman, F.M., (1999). Using multivariate clustering to characterize ecoregion borders. Computing in Science & Engineering, 1(4), 18-25

Hargrove, W.W., Hoffman, F.M., (2004). Potential of multivariate quantitative methods for delineation and visualization of ecoregions. *Environmental Management*, 34(1), S39-S60ţ

Huenneke, L.F., Noble, I., (1996). Ecosystem function of biodiversity in arid ecosystems. Scope-scientific committee on problems of the Environment International Council of Scientific, *UNIONS*, 55, 99-128

Joppa, L.N., Pfaff, A., (2009). High and far: biases in the location of protected areas. *PLoS One, 4*(12), e8273.

Kadmon, R., Harari-Kremer, R., (1999). Studying Long-Term Vegetation Dynamics Using Digital Processing of Historical Aerial Photographs, *Aerial Photographs and Vegetation Dynamics*, Volume 68, Issue 2, Pages 164–176

Kadmon, R., Danin, A., (1999). Distribution of plant species in Israel in relation to spatial variation in rainfall. *Journal of Vegetation Science*, 10: 421–432

Kampe, T.U., Johnson, B.R., Kuester, M., Keller, M., (2010). NEON: the first continental-scale ecological observatory with airborne remote sensing of vegetation canopy biochemistry and structure. *Journal of Applied Remote Sensing*, 4(1), 043510-043510

Kaplan, D., Gutman, M., (1999). Phenology of *Quercus ithaburensis* with emphasis on the effect of fire. *Forest Ecology and Management*, Volume 115, Issue 1, 8 March, Pages 61–70

Kaplan, M., Salutzky, M., (2000). *Metodology for the evaluation of open landscape*. Israel Ministry of Environment (in Hebrew)

Kaplan, M., (2011). *National Outline Plan for Forests and Afforestationn* NOP 22, Policy Document. KKL-JNF Jerusalem

Kutiel, P., Lavee, H., Shoshany, M., (1995). Influence of a climatic gradient upon vegetation dynamics along a Mediterranean-arid transect. *Journal of Biogeography*, 1065-1071.

MacArthur, R.H., Wilson, O.E., (1967). *The Theory of Island Biogeography*, Princeton University Press.

Mahalanobis, P.C., (1936). On the generalized distance in statistics. *Proceedings of the National Institute of Sciences (Calcutta)*, 2, 49-55ţ

Margules, C.R., Pressey, R.L., (2000). Systematic conservation planning. *Nature*, 405(6783), 243-253

Ministry of Interior, (1981). *Master plan No. 8 Nature reserves, National parks and Landscape reserves*. Retrieved March 30, 2013, from: http://www.mmi.gov.il/iturtabot/tochmitararzi.asp (in Hebrew).

Neev, D., Ben-Avraham, Z., (1977). *The Levantine Countries*: The Israeli Coastal Region, The Ocean Basins and Margins. pp 355-377

Nir, D., (1989). *Geomorphology of the land of Israel*. Akademon Publishing House of the Students Union at the Hebrew University (in Hebrew)

Odum, E.P., (2001). Concept of Ecosystem. Pp. 205-310. In: Levin, S. (Editor-In-Chief), *Encyclopedia of Biodiversity*, Volume 2. Academic Press

O'Neill, R.V., DeAngelis, D.L., Waide, J.B., Allen, T.F.H., (1986). *A hierarchical concept of ecosystems.* Monographs in population biology, vol. 23. Princeton University Press, Princeton, New Jersey. 253 pp

Oren, A.. (2007), Shadow lands: the use of land resources for security needs in Israel. *Israel studies* 12 (1): 149-170

Pearson, R.G., Dawson, T.P., (2003). Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global ecology and biogeography*, 12(5), 361-371ţ

PEF – Palestine Exploration Fund (July, 2013). Retrieved July 30, 2013, from: http://nla.gov.au/nla.map-rm1949

Pfab, M.F., Victor, J.E., Armstrong, A. J., (2011). Application of the IUCN Red Listing system to setting species targets for conservation planning purposes. *Biodiversity and Conservation* 20 (5): 1001-1012

Rabikowitz, S., (1981). *Soils of Israel formation, nature and characteristics*, AM-OVED Publishers (in Hebrew)

Rabinowitz, A., (1986). *Rock soil and vegetation in the Galilee*. AM-OVED Publishers and INPA (in Hebrew)

Rodríguez, J.P., Rodríguez‐Clark, K.M., Baillie, J.E., Ash, N., Benson, J., Boucher, T. & Zamin, T., (2011). Establishing IUCN red list criteria for threatened ecosystems. *Conservation Biology*, 25(1), 21-29.

Shapiro, M.B., (2006). Soils of Israel. *Eurasian Soil Science*, 39(11), 1170-1175

Scott, J.M., Davis, F.W., McGhie, R.G., Wright, R.G., Groves, C., Estes, J., (2001). Nature reserves: Do they capture the full range of America's biological diversity? *Ecological Applications*, 11(4), 999-1007

Shachak, M., Arbel, S., Boeken, B., Segoli, M., Ungar, E., & Zaady, E.. (2010). The role of plants as ecosystem engineers in resilience to climate change. In EGU *General Assembly Conference Abstracts*Vol. 12, p. 1695

Shachak, M., Boeken, B., Groner, E., Kadmon, R., Lubin, Y., Meron, E. & Ungar, E.D., (2008). Woody species as landscape modulators and their effect on biodiversity patterns. *BioScience*, 58(3), 209-221

Shmida, A., Pollak, G., Frankenberg, E., Levin, N., Nisanhols, N., Walzcak, M., Rotem, D., Zalutzki, M., (2011). Country report & case study Israel Section 3: In Radford EA, Catullo G, de Montmollin B (eds) (2011). *Important plant areas of the south east Mediterranean region, priority sites for conservation* (108 pp.), IUCN, Gland, Switzerland and Malaga, Spain. Gland, Switzerland and Malaga, Spain: IUCN. VIII.

Soulé, M.E., Sanjayan, M.A., (1998). Ecology: Conservation Targets: Do They Help? *Science*, 279(5359), 2060-2061

Strayer, D.L., Power, M.E., Fagan, W.F., Pickett, S.T.A. & Belnap, J., (2003). A classification of ecological boundaries. *Bioscience* 53 (8), 723–729

Tal, A., (2008). Space matters: Historic drivers and turning points in Israel's open space protection policy. *Israel studies*, 13(1), 119-151.

Tear, T.H., Kareiva, P., Angermeier, P.L., Comer, P., Czech, B,, Kautz, R. & Wilhere, G., (2005). How much is enough? The recurrent problem of setting measurable objectives in conservation. *BioScience*, 55(10), 835-849.ţ

Tsoar, H., Pye, K., (1987). Dust transport and the question of desert loess formation. *Sedimentology*, 34: 139–153

Trakhtenbrot, A., Kadmon, R., (2006). Effectiveness of Environmental Cluster Analysis in Representing Regional Species Diversity. *Conservation Biology*, 20: 1087–1098

Troupin, D., Carmel, Y., (2014). Can agro-ecosystems efficiently complement protected area networks? *Biological Conservation*, 169, 158-166

Waisel, Y., (Ed.), (1984). *The fauna and flora of the Land of Israel*, Encyclopedia 8, Minstery of defence publishers & SPNI (in Hebrew)

Yaalon, D. H., Dan, J., (1974). Accumulation and distribution of loess-derived deposits in the semi-desert and desert fringe areas of Israel. *Z. Geomorphol. Suppl*, 20, 91-105

Zohary, M., (1980). *Scenic vegetation of the land*. AM-OVED Publishers (in Hebrew)

Zilberman, A., Edelman, A., Avni, Y., Ginat, H., (2011). *Geology and the development of the landscape in the Negev*. Geological survey of Israel, INPA, Ramat-Negev And Ministry of environmental protection(in Hebrew)