Comparison between BioHab mapping and remote sensing

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Abbreviations: FPH- Forest Phanerophytes, TPH- Tall Phanerophytes, MPH- Mid Phanerophytes, LPH- Low Phanerophytes

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Abstract

There is a need for a cost effective data collection system for measuring biodiversity at regional scale. The BioHab is a framework to map and describe habitats. This is done by field recording of General Habitat Categories (GHCs). This project goal is to determine whether remote sensing and image analysis could be combined for automating mapping of GHCs, to complement mapping in situ, which could then be used for evaluation purposes. The overall objective of this project was to compare the BioHab classification conducted in Ramat Hanadiv Nature Park in 2009 with a specific remote sensing product, based on LiDAR. We looked at two structural traits of vegetation, cover and height. Vegetation cover estimated by the BioHab mapping was compared to vegetation cover estimated using two independent remote sensing sources: LiDAR (Light Detection and Ranging) and aerial photo. Grouping vegetation height estimated following the BioHab mapping protocol was compared to vegetation height data derived from LiDAR. Relatively large differences were found in woody cover estimates acquired using remote sensing methods and the BioHab survey product, while smaller differences were found between the two independent remote sensing methods. A large difference was also found between the LiDAR and the BioHab height estimates. Qualitative inspection indicates considerable error in both the BioHab and the LiDAR products. In conclusion, while LiDAR image may yield vegetation maps that are partially compatible to the BioHab product, the currently large gaps between these information sources need to be resolved.

Introduction

The specific objective of the BioHab framework for a European-wide monitoring of habitats, is "…to obtain statistically robust estimates of their extent and associated changes in biodiversity" (Bunce et al. 2005). The BioHab methodology is a system for consistent field recording of habitats and for subsequent monitoring. This is done by field recording of so-called General Habitat Categories, and is based on the hypothesis that habitat structure is related to environmental factors. This is a practical, transmissible, and reproducible procedure for surveillance and monitoring habitats which can produce statistics integrated at the landscape level. The methodology is based on classical plant life forms, used in biogeography since the nineteenth century. The principal advantage of the GHCs is that they enable the primary decision on habitat category to be made in the field without the necessity of subsequent data analysis. Their primary disadvantage is the demanding resources of time, money, and human industry involved, restricting such mapping to relatively small areas.

Height and cover are the most basic and straightforward descriptors of vegetation structure (Tomaselli 1981). Mapping land and vegetation cover is usually carried out by image classification, which in most cases is pixel-based (de Jong et al. 2001). LiDAR was found to be suitable for deliniating vegetation structure units in a Mediterranean landscape (Bar Massada et al. 2012).

It was proposed that remote sensing and image analysis could be combined for automating mapping of GHCs, to complement mapping in situ, which could then be used for evaluation purposes. The major question here is how well could remote sensing products correspond to in situ BioHab vegetation mapping. In this report we focused on comparing vegetation height and cover .Height and cover are the most basic and straightforward descriptors of vegetation structure

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Methods

Study site

The study was conducted at Ramat Hanadiv Nature Park, located at the southern tip of Mt. Carmel in northern Israel (32°30' N, 34°57' E), in an area of 4.5 km^2 surrounded by human settlements and agricultural fields. The area is a plateau with an elevation of 120 m. The climate is eastern Mediterranean, characterized by relatively cool, wet winters and hot, dry summers. The area receives approximately 600 mm rainfall annually, mainly between November and March. The vegetation is mostly eastern Mediterranean scrubland. The area has a very rich, herbaceous flora (Hadar et al. 1999), with 325 plant species recorded in the park area in a recent survey (Blank and Carmel *in press*).

Mapping according to BioHab protocol

In March 2009, an area of 1 km^2 was mapped according to the BioHab protocol (Figure 1). In this report we characterized each polygon using the total woody cover and height. Woody vegetation height was assigned using GHC categories (Table 1).

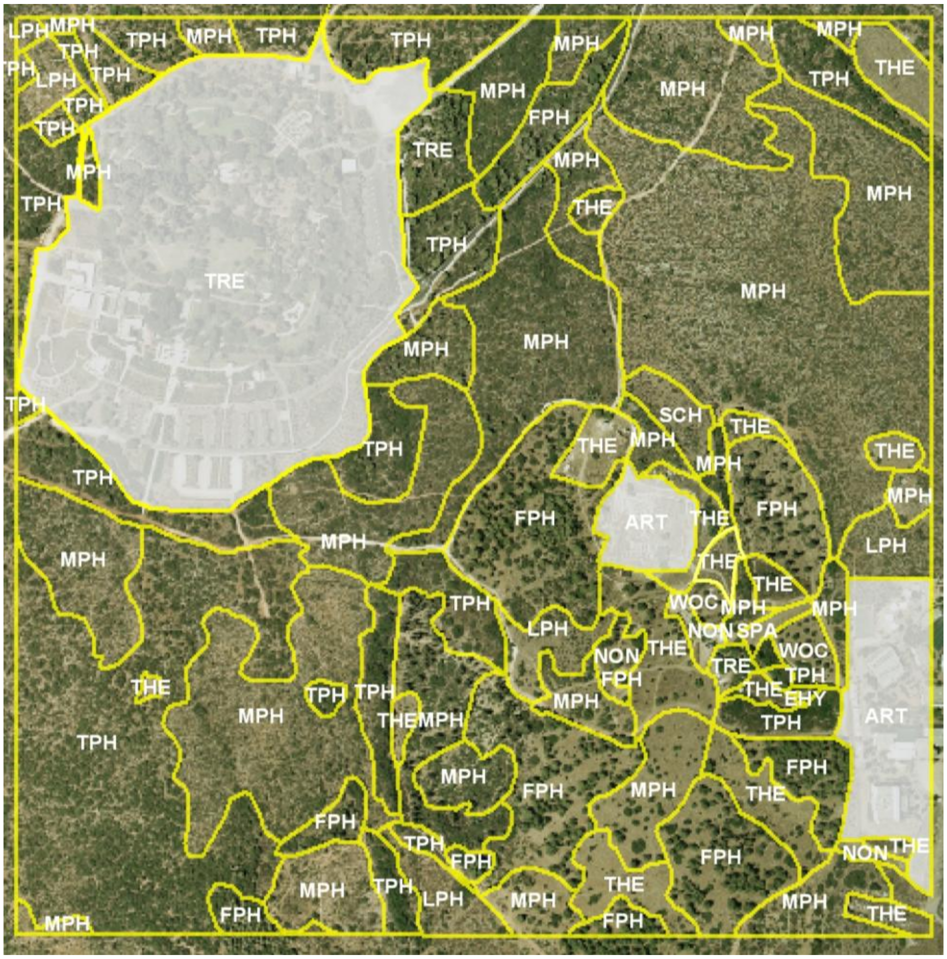

Figure 1- GHCs of the study area. Gray areas represent areas excluded from our analysis. They were calssified as artificial (ART) and as gardens (TRE) according to the BioHab protocol.

Table 1- Woody vegetation height (m) categories according to the BioHab protocol.

FPH- Forest Phanerophytes	**TPH-** Tall Phanerophytes	**MPH-** Mid Phanerophytes	**LPH-** Low Phanerophytes
buds over 5.0 m	buds between 2.0-5.0 m	buds between 0.6-2.0 m	buds between 0.30-0.6 m

Remote sensing

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

LiDAR data

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

LiDAR-based vegetation cover layer

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

LiDAR-based GHC layer

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

Aerial photo image classification

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

Methods evaluation

We calculated the average of absolute differences between the proportion cover estimated by two methods for each polygon that was delineated in the BioHab mapping. In the same way we calculated the differences in cover of each height class in each polygon as estimated by the BioHab protocol and the LiDAR.

Results

Woody cover

We compared the three methods that were used to calculate the percentage of woody cover: LiDAR-based estimate, air-photo classification and the field mapping done using the BioHab protocol (hereafter referred to as LiDAR, airphoto, and BioHab, respectively). The LiDAR and airphoto approches delivered quite similar estimates of woody cover, with an average difference of about 8.5% when comparing 88 polygons (Figure 2). However,when comparing each of these methods to BioHab we found higher average differences of about 20%. The magnitude of the absolute difference between the three methods was not correlated to polygon size.

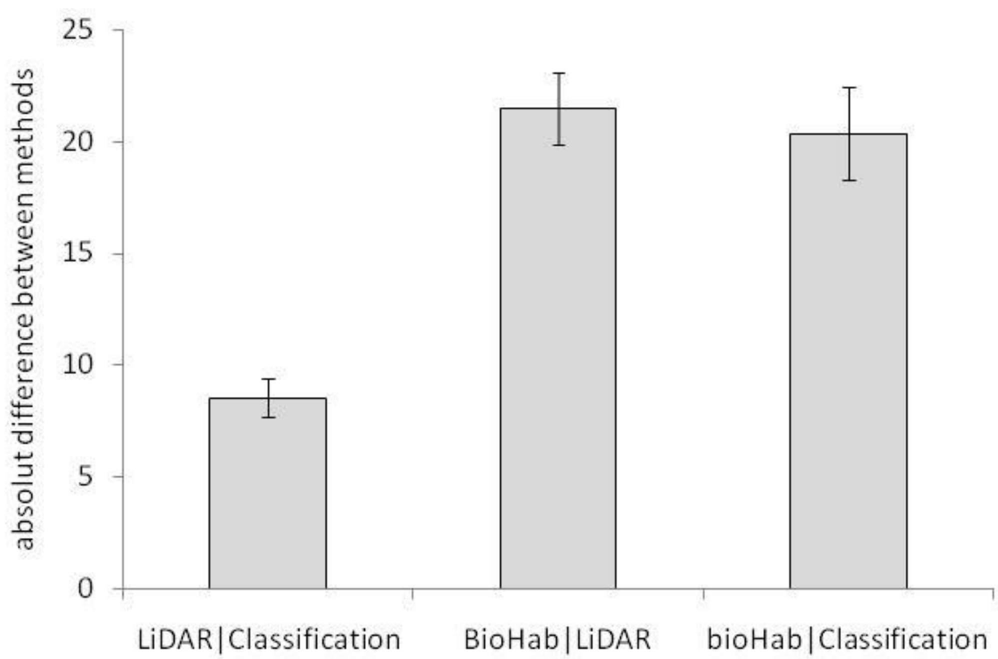

Figure 2- the absolut average difference in estimating the percentage of woody cover between each of the three methods (±SE).

Figure 3 displays an example of the product of two remote sensing methods for polygon #88. This polygon was classified as having 20% woody cover according to the BioHab protocol. Using the LiDAR approach the woody cover was estimated as 54% (B) and using the aerial photo image classification the woody cover was estimated as 64% (C).

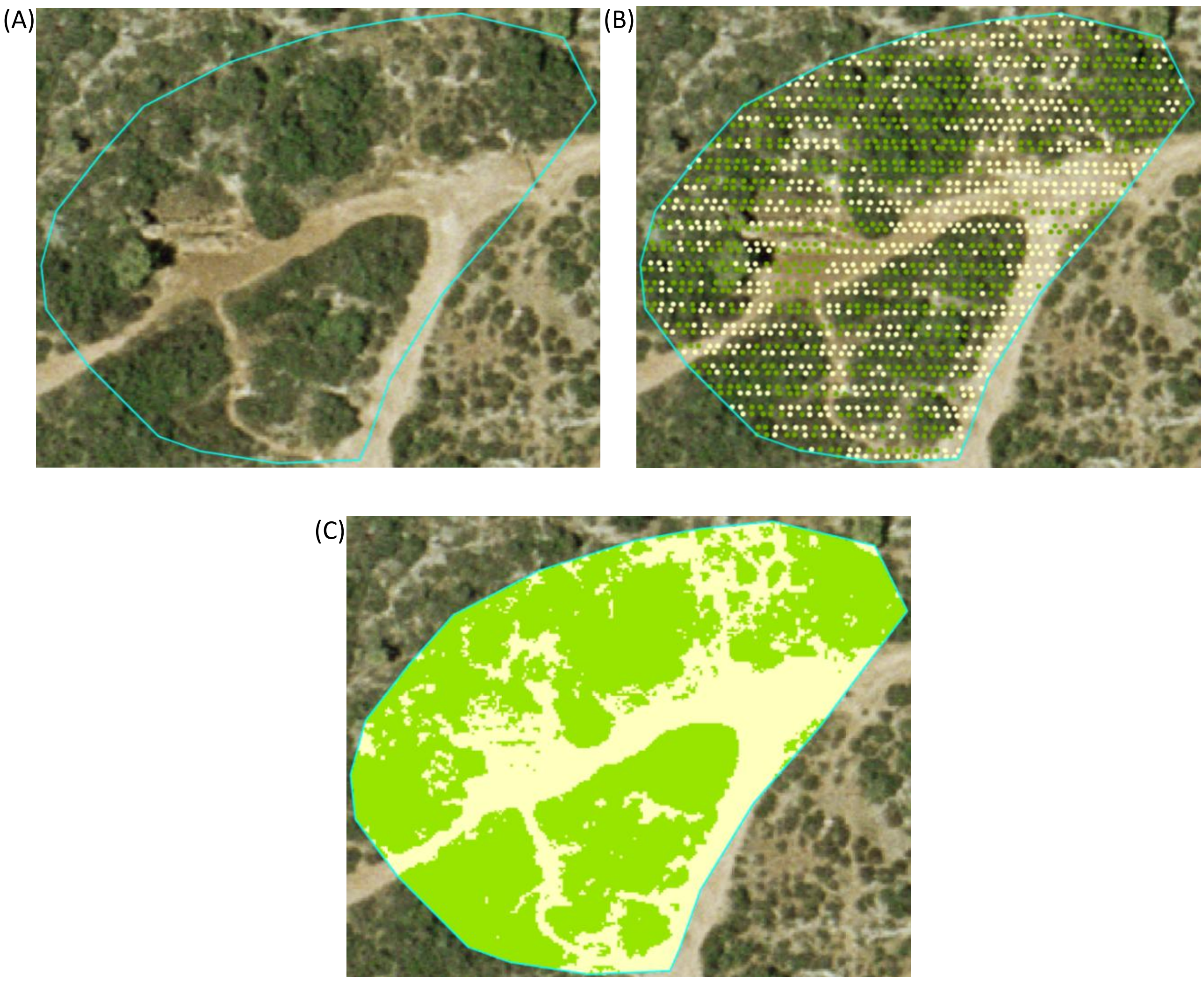

Figure 3- polygon number 88 as an example of woody cover using LiDAR (B) and air photo classification (C): yellow <0.2 m and green >0.2 m.

Vegetation height

The absolute average difference in cover of each height category between BioHab and LiDAR is presented in figure 4. FPH had the least mismatch with about 4.5% average difference in cover while MPH had the largest mismatch with about 15% average difference in cover.

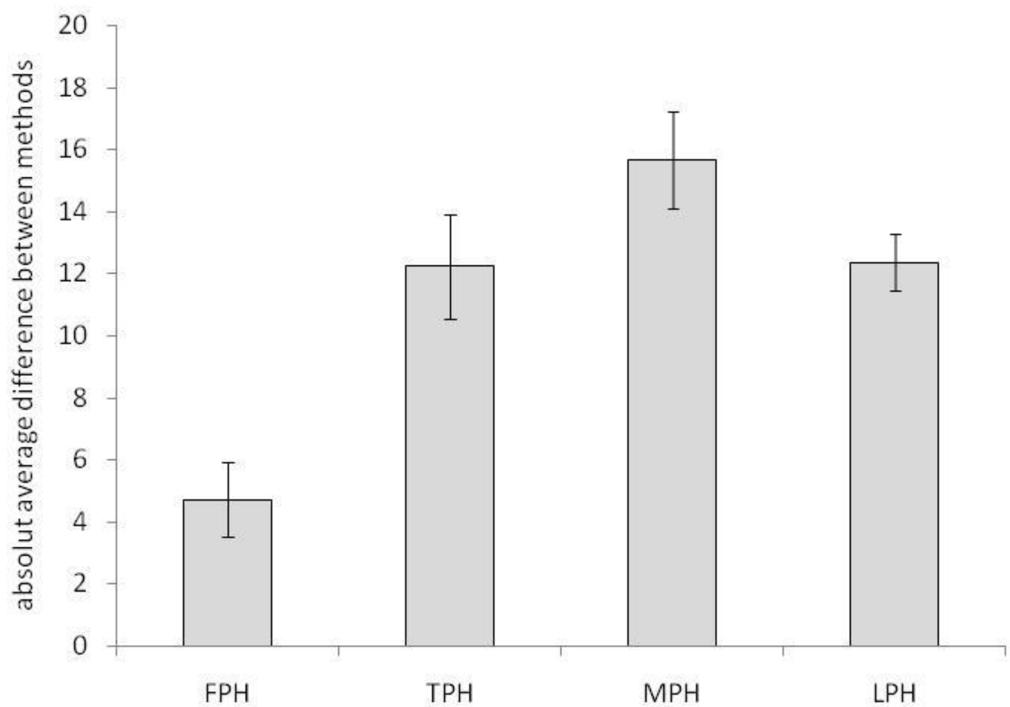

Figure 4- The absolute average difference of the cover for each woody height category between BioHab and the LiDAR (±SE).

There was relatively low correlation between the average difference of the cover for each woody height category between the methods and the polygon area.

Figure 5 and table 2 display an extreme example of the LiDAR method for polygon number 11. This polygon was classified as having 90% woody cover of FPH according to the BioHab protocol while using LiDAR the woody cover of FPH was about 25% (B).

Table 2- polygon number 11 as an example for differences in percent cover of woody height categories in the two methods.

	FPH- Forest Phanerophytes	**TPH-** Tall Phanerophytes	**MPH-** Mid Phanerophytes	**LPH-** Low Phanerophytes
BioHab	90	0	0	10
LiDAR	24.81	10.04	19.30	11.68

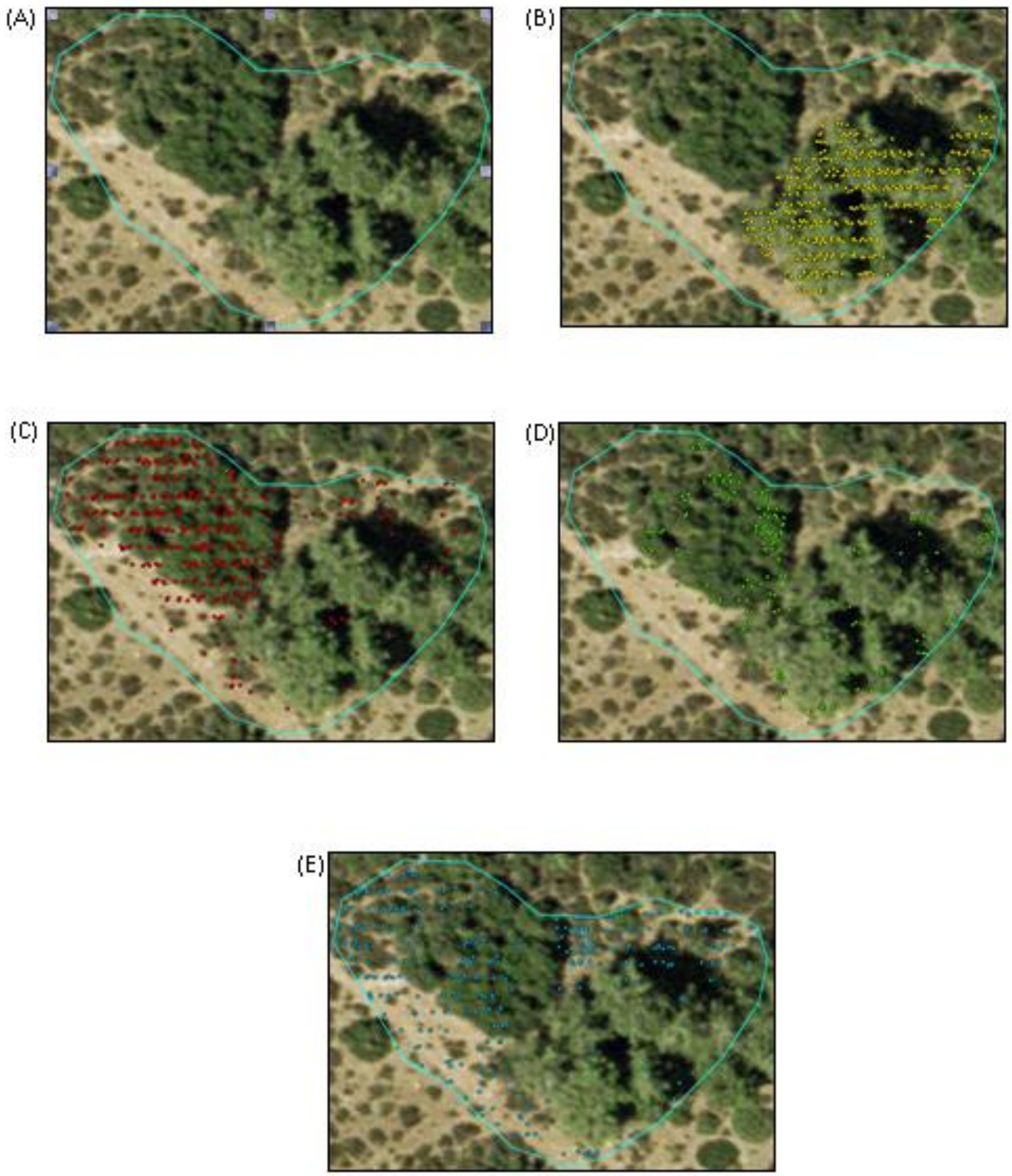

Figure 5- polygon number 11 as an example of woody height using LiDAR: yellow dots >5 m (B), red dots <5 m & >2 m (C), green dots <2 m & >0.6 m (D) and blue dots <0.6 m & >0.3 m (E).

Discussion

Relatively large differences were found in woody cover estimates between each of the two remote sensing products and BioHab product, while smaller differences were found between the two independent remote sensing products. In addition to the formal accuracy assessment, we evaluated the products qualitatively, based on inspection of the air photos and our acquaintance with the area. We noticed incidences where LiDAR apparently erred, possibly because the inherent error in LiDAR scanning hardware and the four years difference between the time the image was acquired and the BioHab mapping. Another source of error could be that DEM, representing ground height, was generated by overlaying the LiDAR on a colour orthophoto and identifying LiDAR hit-points that were located on the ground, and interpolating the data from these points. Thus, there could be a bias in the error of such interpolation depending on the density of the vegetation. In other cases BioHab estimates were mistaken. Presumably, the reasons for BioHab error can be misidentification of locations on the air photo or error in estimating cover and height by the surveyors.

LiDAR image may be used to construct a vegetation map which is partially compatible to the BioHab product. However, some info which derived from BioHab can not be gained by LiDAR such as identification of the dominant species, vertical and sub canopy elements and the management regime in the area.

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

We also propose that future mapping will integrate field survey and remotely sensed mapping components so that the strengths and weakness of each approach will be fully exploited. For example, remote sensing methods are recommended for estimating overall vegetation cover while the BioHab protocol is preferred for identifying vegetation life forms and management regimes.

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