Examination and Classification of Ecosystem Vegetation and Ecosystem Services in Messinia, Greece.

Fig. 1. *Picture of the vegetation type Garrigue/Woodland on Proti Island, Greece. (Frisk, 2014)*

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Abstract

Many ecosystems and the ecosystem services they provide have deteriorated markedly in recent times. Rainforests are being cut down, sand scattering contributes to desertification and biodiversity decreases slowly but surely. The Millennium Ecosystem Assessment has examined the status of ecosystem services around us and has concluded that 15 of 24 are heading in a negative direction, five were stable and 4 could not be determined. One area where the ecosystems and ecosystem services are unstable is in the Mediterranean Basin. To investigate this, the study is based on identifying, classifying and analysing natural Mediterranean ecosystems in Messinia, Greece. This was done with the help of aerial photographs, surveys, vegetation classification, ecosystem services classification and GIS tools on the sites of Proti Island and Maglavas Mountain. Ecosystem service classification showed that many of the 24 ecosystem services that MEA used are classified in a positive direction because of the ecosystems which were investigated are natural and basically without human interference.

The results showed that Proti Island consists mostly of open vegetation types but also some woodland and partly shrubland, which is largely caused by the sheep that live in the context of the island's monastery. This allows the pollination ecosystem services to be of great importance here. It also showed that the monastery contributes to two ecosystem services by itself although not counted to the rest of the vegetation. The vegetation on Maglavas Mountain showed that the succession is of great importance for the development and future of this ecosystem. Almost the entire mountain's vegetation consisted of a mixture of forest and shrubland while only a small portion consisted of either forest or shrubland by itself. This makes the ecosystem services timber and fuel wood important here, but also biodiversity. It is clear that more research is needed and that natural ecosystems are very important in an aspect of ecosystem services.

Sammanfattning

Många ekosystem och de ekosystemtjänster de bidrar med har försämrats märkbart på senare tid. Regnskogar huggs ner, sandspridning bidrar till att öknar ökar i storlek och biodiversiteten minskar sakta men säkert. Millennium Ecosystem Assessment har undersökt hur ekosystemtjänster runt omkring oss mår och har för status och har kommit fram till att 15 av 24 är på väg i negativ riktning, 5 var stabila och 4 kunde inte fastställas. Ett område där ekosystemen och ekosystem tjänsterna är ostabila är i länderna kring Medelhavet. För att undersöka detta är studien baserad på att identifiera, klassificera och analysera naturliga medelhavsekosystem i Messinia, Grekland. Detta gjordes med hjälp av flygfoton, inventeringar, vegetationsklassificering, ekosystemtjänst klassificering och GIS verktyg på platserna Proti Island och Maglavas Mountain. Ekosystemtjänst klassificeringen visade att många av de 24 ekosystemtjänsterna som MEA använt klassas i positiv riktning eftersom att ekosystemen som är undersökta är naturliga och utan mänsklig påverkan.

Resultatet visade att Proti Island består till största del av öppna vegetations typer men även en del skogslandskap och mindre buskområden, som till stor del orsakats av får som bor i samband med öns kloster. Detta gör att ekosystemtjänsterna pollination har stor betydelse här. Det visade också att klostret bidrar till två ekosystemtjänster av sig självt även om det inte räknas till resten av vegetationen. Vegetationen på Maglavas Mountain visade att succession har stor betydelse för utvecklandet och framtiden för detta ekosystem. Nästan hela bergets vegetation bestod av en blandning av skog och buskområde medan bara en mindre del bestod av antingen skog eller buskområde. Detta gör att ekosystemtjänsterna timmer och bränsle av trä har stor betydelse här, men också biodiversitet. Det är tydligt att mer forskning behövs och att naturliga ekosystem är väldigt viktiga för ekosystemtjänsterna.

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Introduction

All over the world today we are experiencing loss of ecosystems and ecosystem services, not only in quantity but also in quality (IPCC, 2014; MEA, 2005). The ecosystem quantity misbalance is caused by desertification, deforestation and agriculture, among other, all of which is not entirely negative, and results in homogenisation of the landscape with fewer and smaller natural habitats to sustain populations (IPCC, 2014). The ecosystem quality misbalance results in population decrease in species, extinction of species and lower genetic intra-species variation, which in the long term is permanent loss of biodiversity (IPCC, 2014; Ricklefs, 2009). Disturbance of ecosystem quantity and quality loss is not distributed evenly in the world because neither the species richness nor the intensity of how the nature resources are used is evenly distributed. One of the well-studied ecological theories is concerning the loss of species richness with increase of latitudes, Latitudinal Diversity Gradient (LDG) (Mora & Robertson, 2005; Ricklefs, 2009). Logically follows that at the 0°N, the equator, the rainforests of Congo have more species diversity than at the 60°N, the pine forests of Sweden, which indicates that there is a higher chance of biodiversity loss when there is a local disturbance in Congo than in Sweden, but there are also other factors that determine species richness.

One of the relationships could easily be reviewed by looking at the correlation between the rate of biodiversity loss and endemic species (Malcolm *et al.*, 2006). Endemic species are species which distribution is only located in one specific place on earth and nowhere else, which is creating a higher biodiversity index because their extinction from this area is the extinction of the species in total (Dallman, 1998). Areas of high amount of endemic species are often rainforests, islands, Mediterranean areas and remote locations (Dallman, 1998). There by follows that loss of ecosystem quantity in these areas has higher chance to extinct endemic species and by that also follows a higher loss of biodiversity. The ongoing loss of species diversity is more problematic when its concerning isolated endemic species than wild spread global species (Malcolm *et al.*, 2006). Another factor which we are unable to dodge anymore is the global warming (Malcolm *et al.*, 2006). The temperature rise, even as low as 2°C is of great concern, mostly because the expanding properties of water, which will devour several islands and make coastal areas all around the world inhabitable. Though the 2°C to 4°C increase is a general increase, some parts will experience up to 6°C increase, while others will experience a cooling effect (IPCC, 2014). This means some parts of the world will gain longer growth periods and more agricultural importance, while other parts will get to hot in the summers and actually destroy old plant communities and create entirely new ones, with loss of biodiversity as a result (IPCC, 2014).

This problem expresses natures stability to inner and outer turmoil caused by human interference and the ignorance of how to strengthen nature's own values and instead to weaken them. This is the main cause of the degradation of natural ecosystems. One of the ways to see this is with the concept of ecosystem services and the loss of these, which will be reviewed in the next chapter.

Ecosystem Services

Ecosystem services are services which are provided for free from the ecosystems, while the official definition for ecosystem services from The Millennium Ecosystem Assessment is "benefits people obtain from ecosystems" (MEA, 2005). These are quite necessary for us because without them we could not possible survive and prosper. They have been around ever since the earth was created and is the foundation of which all life on earth is built upon. In the year 2005, The Millennium Ecosystem Assessment (MEA), composed of more than a thousand scientists, were to investigate which ecosystem services that nature were providing, their health and future propositions which could strengthen these (MEA, 2005). The initiative for the assessment came from the report *“We the Peoples: The Role of the United Nations in the 21st Century”* written by the current United Nations Secretary-General Kofi Annan (MEA, 2005). They identified 37 different ecosystem services in four different categories; Provisioning Services, Regulating Services, Cultural Services and Supporting Services. Two examples in each category are: *Food-Crops* and *Fiber-Timber* in Provisioning Services, *Air quality regulation* and *Water purification and waste treatment* in Regulating Services, *Spiritual and religious values* and *Inspiration* in Cultural Services and last but not least, *Soil formation* and *Photosynthesis* in Supporting Services (MEA, 2005). Of the total of 37 ecosystem services that they found MEA investigated 24 of these in greater depth. MEA concluded that the status of 15 of the 24 was declining, 5 were stable and 4 were inconclusive. The 4 that were inconclusive was hard to determine because of differences between locations (MEA, 2005). It is in this spirit that a new system has come into play, the virtual price tag of specific ecosystem services if we were to make it in an artificial fashion. It is quite clear that some ecosystem services cannot be made in an artificial manner, for example photosynthesis, some it would be very impractical to make, for example pollination, and some we actually do make to some degree today, like water purification and waste treatment (Daily, 1997). What this means is that if the ecosystem services does not begin to recover soon, we will have to create the equivalent services ourselves and the price tag will not be cheap (IPCC, 2014). The way this works is to force the decision makers to realize that there will be consequences if we do not respect the limitations of nature resources and ecosystem stability (Daily, 1997), because before the ecosystem services just appeared to be free of charge, which they are, if we were to respect nature. One could argue that it is impossible to put a price tag on clean air and photosynthesis, but it is irrelevant for this paper.

One way to secure our ecosystems future production of ecosystem services is to enhance our ability to manage them in an environmental friendly and sustainable way (MEA, 2005). It is hard to pinpoint the different factors which come into play, but the most central one is to only use the interest rates of the ecosystem and not the capital itself. Simple examples are to cut down less trees than the ones that grows back, or to release less pollutants that the ecosystem could process back into the environment, or to never exhaust an entire population to the brink of extinction, which makes it almost impossible for it to recover, as with the cod in the Alaska (Ricklefs, 2009) or if a religious site is abandoned because the natives to the region moves away from the location. Ecosystem services as worldwide phenomena are evenly distributed all over the earth, even though some of them have, because of species, geographical or climate differences, different difficulties to re-cultivate certain areas. One of the most known examples is the Easter Island in the Pacific Ocean (Ricklefs, 2009). The island was once populated completely by trees, which the natives used to make items they required, one of which was boats. Because of the small size of the island, there were also a finite amount of trees. All the trees were eventually cut down without the chance to grow back which lead to the demise of the natives, in a way, they painted themselves into a corner because the trees could not re-cultivate the island. This is not a unique feature but exists all over the world, in more or less progressive ways. This is partly true to the Mediterranean Basin, due to the specific climate and weather conditions the forests in this area are having trouble to re-cultivate to their former glory of vast continuous forests (Dallman, 1998). Instead they are scattered in remote locations and on mountains.

One of the climates which are threatened by ecosystem and ecosystem services changes, have large amounts of endemic species, have strongly shifting yearly weather cycles and are experiencing global warming first hand is the Mediterranean Climate zone. In the next chapter we will review the Mediterranean climate and vegetation types in its natural form.

Mediterranean Climate and Vegetation types

According to the Köppen climate classification there are two climate zones (Csa and Csb) which are "dry-summer subtropical" climates, also known as Mediterranean climate zones (Peel *et al., 2007)*. There are six of these areas located on our planet. These are, by the biggest size, Mediterranean Basin, south-west Australia, South Australia, California, central Chile and Western Cape in South Africa (Dallman, 1998). There are many similarities but also many differences between them. One of the biggest differences between them, except the size, is temperature, which has a tremendous effect on weather conditions from site to site. The temperature difference is causing a great difference in plant community composition, and thereby also dominant ecosystem services. All the areas share dry-hot summers, wet-mild winters and that all are located on the western or south-western coasts of continents, often with cold, offshore ocean currents (Dallman, 1998). One other thing they have in common is the summer drought. The summer is the most problematic period for both plants and animals alike, in terms of water scarcity for survival purposes, but also in the terms of the likeliness of wildfires, due to dry vegetation, which has the potential to eliminate whole ecosystems. Wildfires are a natural occurrence in these areas and the understanding of them as important features in nature provides us with the knowledge to understand the entire plant communities of the Mediterranean climate zones and the succession of the whole ecosystem (Dallman, 1998; Ricklefs, 2009).

Normally the natural Mediterranean vegetation is split into four different categories, or four different vegetation types or ecosystems on local level. These are Coastal scrubland, Shrubland, Woodland and Forests (Dallman, 1998). All of the four vegetation types have different names according to where they are located in the world because of small differences in function and big ones in species composition, even though they are basically the same vegetation type. All of these are distributed more or less in all of the Mediterranean areas over the globe, there are of course exceptions, and one of these is that California has lots of forests while the forests of Western Cape are limited at most (Dallman, 1998). None the less, all the areas have all of the vegetation types, even though they are different in their composition, but basically same in function. There is a simple reason for this equality in function and the theory for this is called convergent evolution (Ricklefs, 2009). Different plants have evolved in similar fashion because of similar climate and weather phenomena, some to withstand drought, some to withstand predation and some to withstand heat among other adaptions that are common in the Mediterranean areas (Ricklefs, 2009). One of the most common adaptions is called drought-deciduous (Dallman, 1998). In comparison to the deciduous trees of the northern hemisphere they drop their leaves, but instead of dropping them to save water from the cold weather of winter, they drop their leaves to save water from the dry-hot weather of the summer (Dallman, 1998). Some adaptions are more common in some vegetation types than other, while drought-deciduous adaptions are more common in the coastal scrubland, adaptions that maximize solar absorption; like big leaves, are more common in forests.

The Coastal scrubland is mainly composed of low shrubs that are adapted to wind and sea salt from the ocean and the plants community are of geophytes, succulents, annuals and drought-deciduous species. Common species are Greek spiny spurge (*Euphorbia acanthothamnos)* and Thorny burnet (*Sarcopoterium spinosum)(Blamey & Grey-Wilson, 2004; Dallman, 1998)*. In the Mediterranean Basin the coastal scrubland is called Garrigue. The shrubland is mainly composed of short to tall evergreen shrubs with sclerophyll leaves, to withstand drought (Ricklefs, 2009), and sometimes also small trees. Common species are Myrtle (*Myrtus communis)* and Strawberry tree (*Arbutus unedo)(Blamey & Grey-Wilson, 2004; Dallman, 1998)*. In the Mediterranean Basin the shrubland is called Maquis. There are also two subcategories in the maquis class, low maquis and high maquis. While high maquis contain both tall shrubs and small trees, the low maquis only contain tall shrubs. The woodland is mainly composed of trees with an open canopy, which makes room for a variety of plants, such as shrubs, grasses and herbs. Common species are Holm oak (*Quercus ilex)* and Kermes oak (*Quercus coccifera)(Blamey & Grey-Wilson, 2004; Dallman, 1998).* The woodland in the Mediterranean Basin is often called Oak woodland. The forests is mainly composed of trees with a closed canopy which does not allow much vegetation beneath the trees, only the most shadow resistant species can survive on the forest floor. Common species include the Woodland species but also conifers to some degree such as Umbrella pine (*Pinus pinea)* and Aleppo pine (*Pinus halepenis)(Blamey & Grey-Wilson, 2004; Dallman, 1998)*. The forests in the Mediterranean Basin are often called Oak and/or Pine forests. Some ecosystems share ecosystem services while some others differ and this makes them unequal in the aspect of function and distribution (MEA, 2005). In the next chapter we will discuss the issue of how to investigate Mediterranean ecosystems and their relationship to ecosystem services.

Issue

To understand which of the ecosystems that are contributing to which ecosystem services it is crucial to investigate how the ecosystems, and thereby the ecosystem services, is located in the terrain. Therefore the aim of this study is: Which type of natural Mediterranean ecosystem is providing the most ecosystem services?

Area Description

To investigate the difference between natural Mediterranean ecosystems it is of great importance to find a location which provides great diversity and recognizable differences between the ways vegetation types appear in nature. The study chose the region of Messinia (Also spelled Messenia), which is located on the peninsula of Peloponnese in Greece *(37°8’31.21”N, 21°57’7.96”E)(G.E.P., 2014)*. Messinia is located on the south-western coast of Peloponnese and experiencing direct contact with the Mediterranean Basin. Due to its general climate and all the year temperature it is a region which is favourable to the growing of olives (Giourga & Loumou, 2002), tomatoes and citrus fruits like lemon and orange. The capital and biggest city in the region is Kalamata, and is famous for its world-known olives.

The area is mountainous with valleys of flatter areas in between the mountain ranges. Most of the land-use consists of olive groves, citrus fruit trees and villages; leaving mountains, smaller and inaccessible areas with the natural vegetation. It is up to debate if the olive groves, which have been cultivated in the area for thousands of years, are part of the natural vegetation or not (Giourga & Loumou, 2002), but for the simplicity this paper considers them a part of the anthropogenic ecosystems and not natural in that sense that they would probably not existed here without the help of humans. In the next chapter we will review the restrictions of the study area.

Area Restrictions

Since the study is seeking to investigate natural ecosystems in the region these areas should be restricted in the sense that they should be considered as separate units. It would also be preferred if these units were different in composition and location in order to compare them in function and stability. This does not mean that they are not affected by humans, but to a minimal degree, in order to stay in their natural conditions (Daily, 1997). Two of these areas have been found that are separate units, not too small to be considered part of another unit and not too large to be considered unspecific. These two are Proti Island and the mountain of Maglavas. In the next two chapters these units will be described in detail.

Proti Island

The island of Proti is located just off the west coast of Messinia, outside the town of Marathopoli *(37°3'3.60"N, 21°33'14.22"E)(G.E.P., 2014)*. It is a long but thin island, stretching from north to south, with the length of 3.67 km, width of 1.97 km and an approximate area of 3.33 km^2 (G.E.P., 2014). At the moment the only standing buildings is a monastery with a small harbour. The monastery is habited most of the time and they also have sheep on the island to ensure their independence. Except from the monastery there is a ruin of a former watchtower, which has presumably been used during one of Greece's many wars (IDAITDP, 2014). The only way to get to the island without private boat is by the tourist company called "Proti Cruises" from Marathopoli (Proti Cruises, 2014). The island consists of a larger round mountainous area to the north and a small long flatter area to the south. The highest area of the northern part of the island is approximately 180 m.a.s.l. while the highest area of the southern part of the island is approximately 45 m.a.s.l. (G.E.P., 2014).

Maglavas Mountain

The mountain of Maglavas is located in the middle of Messinia, just south of the town Vlachopoulo *(37°0'42.29"N, 21°47'15.82"E)(G.E.P., 2014)*. It is an oval mountain, stretching from north-north-west to south-south-east, with the length of 3.89 km, width of 2.1 km and an approximate area of 7.49 km^2 (G.E.P., 2014). There are two building located on top of the mountain, to the north it is a wooden tower, and in the middle a church called Panagitsa church (Panagitsa, 2014). The top of the mountain, where the tower is located, is at 706 m.a.s.l., while the surrounding area outside of the mountain is approximately at 400 m.a.s.l. (G.E.P., 2014), which puts the mountain at a height of 300m above the rest of the region. The mountain itself is filled with ridges and valleys, making it differ in composition and height conditions. It has a steeper height gradient to the north and a less steep gradient to the south, making it appear like a slope leaning to the south. The surrounding area is composed entirely of olive groves, making the appearance of Maglavas as a separate unite quite clear. There are several roads up the mountain, making it more accessible than Proti Island.

Material and Method

The main method of doing this study is by classification. The classification process could be split into several different steps, the first one is vegetation classification, the second one is ecosystem services classification, the third one is to GIS-polygon identification and the fourth and final step is to integrate them all into one complete ecosystem evaluation. But first, let's review the restrictions of the basic understanding of the study.

Restrictions

There are several restrictions in this study to consider. It is of course an impossibility to not have any restrictions but the irony is that one must be restrictive about restrictions. One of the basic restrictions is in the vegetation type classification; only the vegetation that is considered natural in the sense that it grows without human assistance in the Mediterranean areas is considered relevant, this goes without saying that olive groves unfortunately must be excluded. Another restriction is the size of the research area. Since it is bigger than just one vegetation type and local it is not possible for it to be as specific as it could have been, making variation in different locals with the same vegetation type lose its value. Therefore all locals with the same vegetation type are considered the same quality, even though quantity and area differences remain separate.

It is also important to realize the width of separate ecosystem services and the borders between them. Too much diversity and degree of abstraction is not able to provide a definite result, this applies for services like photosynthesis and soil formation, which are nonetheless completely priceless in count of ecosystem value (Daily, 1997). Therefore there will only be a finite number of ecosystem services that are accountable for which are measurable in terms of progress. The boundaries of the study itself reflect the field of information in which the study is relevant. Since it is an approximate understanding of how ecosystems correlate to ecosystem services and to paint a bigger picture, most of the details are lost due to the complexity of the whole.

Vegetation Classification

In order to identify vegetation one must first make sure what one is looking for, and that is why the classification of vegetation types is essential. To create these folders of classification the Mediterranean Basin neutral vegetation types were used with some modification, instead of using the classic coastal scrub, shrubland, woodland and forest the classification was changed to be adapted to the specific Greek environment (Dallman, 1998). The classification that was used were mainly composed of five different classes of vegetation and three miscellaneous classes which are not considered natural vegetation; **Garrigue** (I)**, Low maquis** (II)**, High maquis** (III)**, Woodland** (IV)**, Forest** (V)**, Urban, Rocky coast** and **Plantation**. To make it simple later they are given roman numerals from I (1) to IX (9).

There is one more thing to consider while making the vegetation classification: there is almost never a clean-cut between two different types. What this means is theoretically it is easy to distinguish between high maquis and forest, but practically it is not because they often coexist in the same location, and even have a gradual change between the two (Ricklefs, 2009). This is why there also are some extra vegetation classes which are not part of the main classification; these are **Garrigue/woodland** (VI)**, Low maquis/garrigue** (VII)**, High maquis/woodland** (VIII) and **Forest/high maquis** (IX)**.** The problems that occur when having several gradual change classes will be discussed more in detail later on. There are several ways to identify the vegetation while having the classifications; two of these are with aerial photographs and in-field study.

Vegetation Classification; Aerial photographs

The aerial material that was used was composed of three different photos. The first was a satellite material from Google earth pro, taken in 9th November, 2013 (G.E.P., 2014). It is also possible to measure the area, length and width of a unit with Google earth pro, which were used in the area description chapter (G.E.P., 2014). The second was a black/white aerial photo from Hellenic Military Geographical Service, taken in 1945 (HMGS, 2014). The third was a colour aerial photo from Hellenic Military Geographical Service, taken in 2007 (HMGS, 2014). The connectivity between the three photos increased the exactness of the evaluation. The first step to identify the vegetation was to investigate the aerial photographs of the locations in order to know what to look after and where to look when arriving at the locations. The simplest of ways to do this is to seek similar vegetation and make distinctive polygons containing the same vegetation type from the classes described above. In order to identify the right polygon as the right vegetation type one must carefully look for different characteristics that overlap with the main types; amount of trees, canopy-cover, relative height, absence of plants and gaps between plants. If these characteristics are considered while keeping the classes separate, the classification will be almost complete. The last step is to search for characteristics that overlap several classes, and identify these as the gradual change classes, this is the hardest part. While using aerial material one must keep in mind that often it is only possible to view the objects from above, which is making it difficult to be positively sure about the exactness of your assessment, this is why the aerial classification is a compliment to the next part of the classification, the in-field part.

Vegetation Classification; In-Field study

With polygons from the aerial classification done the next step is to confirm the vegetation type identification in the field. The simplest way to do this is to travel to the location and then investigate all the virtual polygons one by one, either by distance or upfront. While being at the locations it has several pros and cons. The pros are that it is possible to see the vegetation and the separate species one by one but also to get a better feeling of the undergrowth which is not visible in the aerial photos. The cons are that the eyesight is blocked by the topography but also to some extent the vegetation itself, making it hard to see the vegetation type as one unit, and instead gives the view of separate trees and landscape elements. The elements of vegetation that are important in the identification process are mainly height of trees and shrubs, species and moisture, but also to some degree topology, elevation and distance to the ocean. Mainly the identification is composed of seeing if the aerial classification was correct, if not, what is the correct vegetation type, and then switching to the right one.

Ecosystem Services Classification

The next step in the classification process is to investigate which ecosystem services that should be accounted for and to which vegetation type they are relevant. In order to present an exact relation of ecosystem services and their definition the 24 ecosystem services which were investigated by the MEA (MEA, 2005) is used in this study. These are 24 services split into three different categories. To make it simple later they are given numerals from 1 to 24. In the category of Provisioning Services there are five in the service of Food: **crops** (1), **livestock** (2), **capture fisheries** (3), **aquaculture** (4) and **wild foods** (5), there are three in the service of Fiber: **timber** (6), **“cotton, hemp and silk”** (7) and **wood fuel** (8), there are also **Genetic resources** (9), **“Biochemical, natural medicines and pharmaceuticals”** (10) and **Fresh water** (11). In the category of Regulating Services there is **Air quality regulation** (12), in the service of Climate regulation: **global** (13) and **“regional and local”** (14), **Water regulation** (15), **Erosion regulation** (16), **Water purification and waste treatment** (17), **Disease regulation** (18), **Pest regulation** (19), **Pollination** (20) and **Natural hazard regulation** (21). In the category of Cultural Services there are **Spiritual and religious values** (22), **Aesthetic values** (23) and **Recreation and ecotourism** (24) (MEA, 2005).

By identifying these and combining them with the vegetation types it is possible to make a diagram of them in order to get an overview of their relationships. The connection itself between the ecosystem and ecosystem service was created by searching the available literature for correlation which fits the specific service and thus revealing how the two fits together like a puzzle; certain ecosystem service connections only exists in certain ecosystems. The literature in question is represented at the end of this paragraph. Since both the units, and also all the nine vegetation types are natural to the region and basically unaffected by humans many of the ecosystem services gives a positive correlation because of the nature of the concept of natural ecosystems (Daily, 1997). These ecosystem services are **Wild foods** (5), **“Biochemical, natural medicines and pharmaceuticals”** (10), **Air quality regulation** (12), Climate regulation: **global** (13) and **“regional and local”** (14), **Erosion regulation** (16), **Water purification and waste treatment** (17), **Disease regulation** (18), **Pest regulation** (19), **Pollination** (20), **Aesthetic values** (23) and **Recreation and ecotourism** (24). There are also some ecosystem services which are have a natural correlation, this is because it either does not have the specific vegetation type connected to this ecosystem service like **Capture fisheries** (3), **Fresh water** (11), **Water regulation** (15) and **Natural hazard regulation** (21) or that it is manage by humans **Crops** (1), **Aquaculture** (4), **“Cotton, hemp and silk”** (7), **Genetic resources** (9) and **Spiritual and religious values** (22). At last but not least there are also some ecosystem services which are positive or neutral when considering the difference between vegetation types; **Livestock** (2), **Timber** (6) and **Wood fuel** (8) (Daily, 1997; Huntsinger & Oviedo, 2014; MEA, 2005; Ricklefs, 2009).

This relationship is shown in detail with the tags ‘*pos*’, as positive correlation to the ecosystem service, ‘*neu*’, as a neutral correlation and ‘*neg*’ with a negative correlation (**Table. 1.)**. An example is vegetation type IV (Woodland) has a pos (positive correlation) with the ecosystem service 2 (livestock), because the livestock in the area has an advantage in the woodland because of its herbivorous edible vegetation.

Table.1. *A graphical correlation between the 9 different vegetation types and the 24 different ecosystem services. The tag ‘pos’ stand for positive correlation to the ecosystem service, ‘neu’ for a neutral correlation and ‘neg’ for a negative correlation.*

			Vegetation		**Types**					
		Garr-igue	Low-Maquis	High-Maquis	Wood-land	For-est	Garri/Wood	L.M/Garri	H.M/Wood	H.M/Forest
	Crops	neu	neu	neu	neu	neu	neu	neu	neu	neu
E	Livestock	pos	neu	neu	pos	neu	pos	pos	pos	neu
c	Capture Fisheries	neu	neu	neu	neu	neu	neu	neu	neu	neu
o	Aquaculture	neu	neu	neu	neu	neu	neu	neu	neu	neu
s	Wild Foods	pos	pos	pos	pos	pos	pos	pos	pos	pos
y	Timber	neu	neu	neu	pos	pos	neu	neu	pos	pos
s	"Cotton/Hemp/Silk"	neu	neu	neu	neu	neu	neu	neu	neu	neu
t	Wood Fuel	neu	pos	pos	pos	pos	pos	pos	pos	pos
e	Genetic Resources	neu	neu	neu	neu	neu	neu	neu	neu	neu
m	"Biochem/nat/med"	pos	pos	pos	pos	pos	pos	pos	pos	pos
	Fresh Water	neu	neu	neu	neu	neu	neu	neu	neu	neu
S	Air Quality regl.	pos	pos	pos	pos	pos	pos	pos	pos	pos
e	Climate regl. Global	pos	pos	pos	pos	pos	pos	pos	pos	pos
r	Climate regl. Reg/Loc	pos	pos	pos	pos	pos	pos	pos	pos	pos
v	Water regl.	neu	neu	neu	neu	neu	neu	neu	neu	neu
i	Erosion regl.	pos	pos	pos	pos	pos	pos	pos	pos	pos
c	Water pur. and Waste	pos	pos	pos	pos	pos	pos	pos	pos	pos
e	Disease regl.	pos	pos	pos	pos	pos	pos	pos	pos	pos
s	Pest regl.	pos	pos	pos	pos	pos	pos	pos	pos	pos
	Pollination	pos	pos	pos	pos	pos	pos	pos	pos	pos
	Natural haz. regl.	neu	neu	neu	neu	neu	neu	neu	neu	neu
	Spiri. and Relig. Values	neu	neu	neu	neu	neu	neu	neu	neu	neu
	Aesthetic values	pos	pos	pos	pos	pos	pos	pos	pos	pos
	Recreat. and Ecotour.	pos	pos	pos	pos	pos	pos	pos	pos	pos

Garrigue (I) has 13 pos and 11 neu, **Low maquis** (II) has 13 pos and 11 neu**, High maquis** (III) has 13 pos and 11 neu, **Woodland** (IV) has 15 pos and 9 neu, **Forest** (V) has 14 pos and 10 neu, **Garrigue/woodland** (VI) has 14 pos and 10 neu, **Low maquis/garrigue** (VII) has 14 pos and 10 neu, **High maquis/woodland** (VIII) has 15 pos and 9 neu and **High maquis/forest** (IX) has 14 pos and 10 neu. There is no neg correlation between any vegetation type and ecosystem service.

GIS-Polygon Identification

The virtual vegetation type polygons were only a model to the real polygons which were to be created in a GIS-based system. The system used in this study is arcGIS and the complementary programs arcMAP and arcCATALOG. In order to create GIS-polygons one must first create the geodatabase to define all the processes, laws and categories which are needed to process the information of polygons, lines and dots. Then background maps were imported and georeferenced to make a proper sizing and placement in the preferred coordinate system. The drawing of polygons then proceeded with comparing the three aerial photos, the virtual polygons and also the in-field assessment. When compiling this data the next step is to put the pieces together and make the polygons. One of the fields of information one gets from this polygon dataset is ‘SHAPE_Area’ which is the area of each polygon, this could be used to compare the area of different vegetation types in the whole unit in order to access the vegetation types important considering size, not importance per se.

Results

The Ecosystem of Proti Island

The vegetation types of Proti Island are graphically represented in **Fig. 2.**. The area calculations based of the vegetation identification is sorted from biggest to smallest amount of vegetation type in the unit**; Low maquis/garrigue** (VII) 27.50 %, **Garrigue** (I) 17.90 %, **High maquis/woodland** (VIII) 15.84 %, **Rocky coast** 15.10 %, **Garrigue/woodland** (VI) 12.02 %, **High maquis** (III) 8.47 %, **Low maquis** (II) 2.87 % and **Urban** 0.26 %.

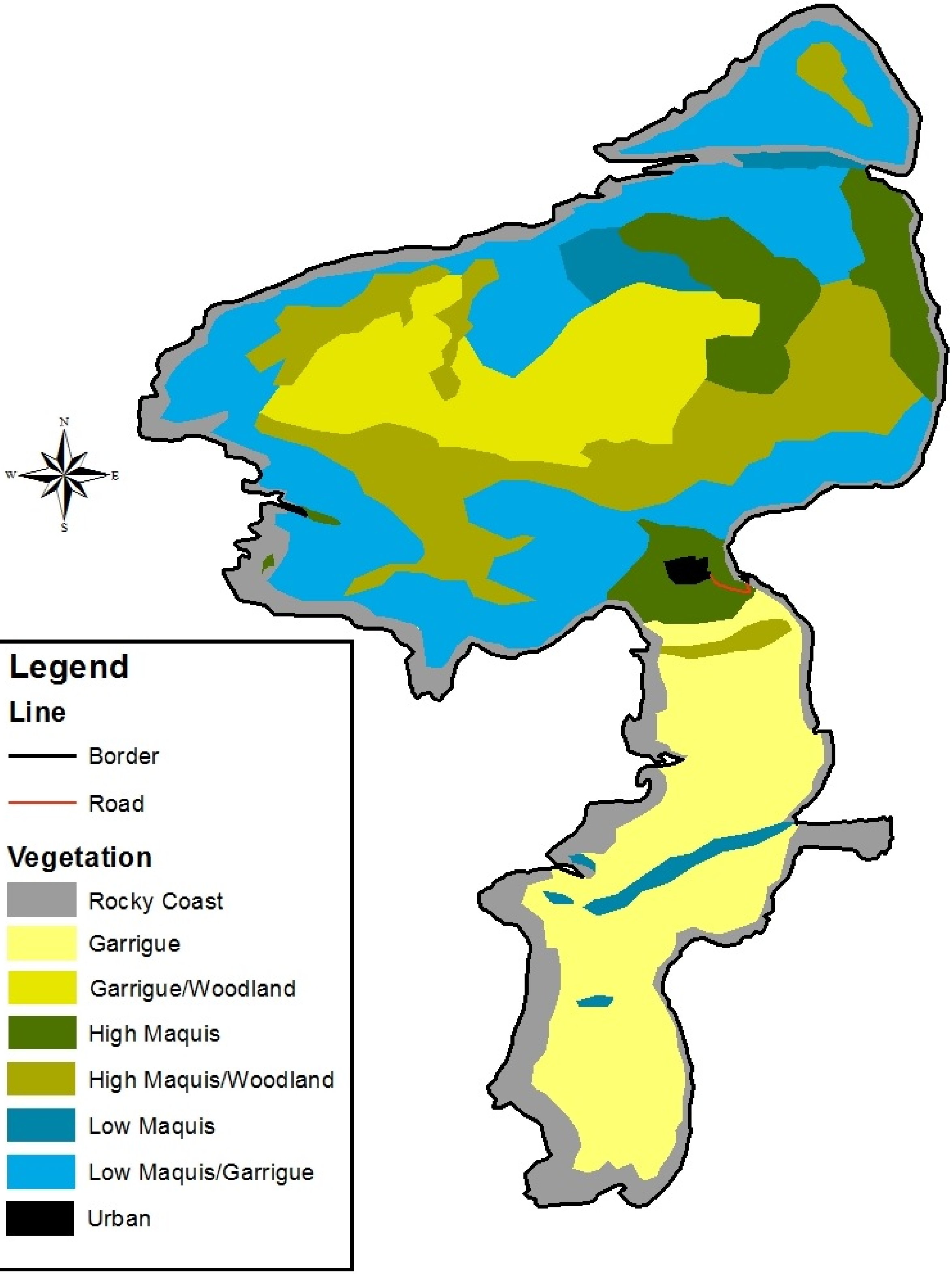

Fig. 2. *Graphical representation of the vegetation types and their distribution on Proti Island.*

The Ecosystem of Maglavas Mountain

The vegetation types of Maglavas Mountain are graphically represented in **Fig. 3.**. The Area calculations based of the vegetation identification is sorted from the biggest to smallest amount of vegetation type in the unit; **Forest/high maquis** (IX) 70.16 %, **Forest** (V) 20.02 %, **Plantation** 7.35 %, **High maquis** (III) 1.63 %, **Woodland** (IV) 0.68 % and **Urban** 0 % (Even though there actually are Urban areas in the map).

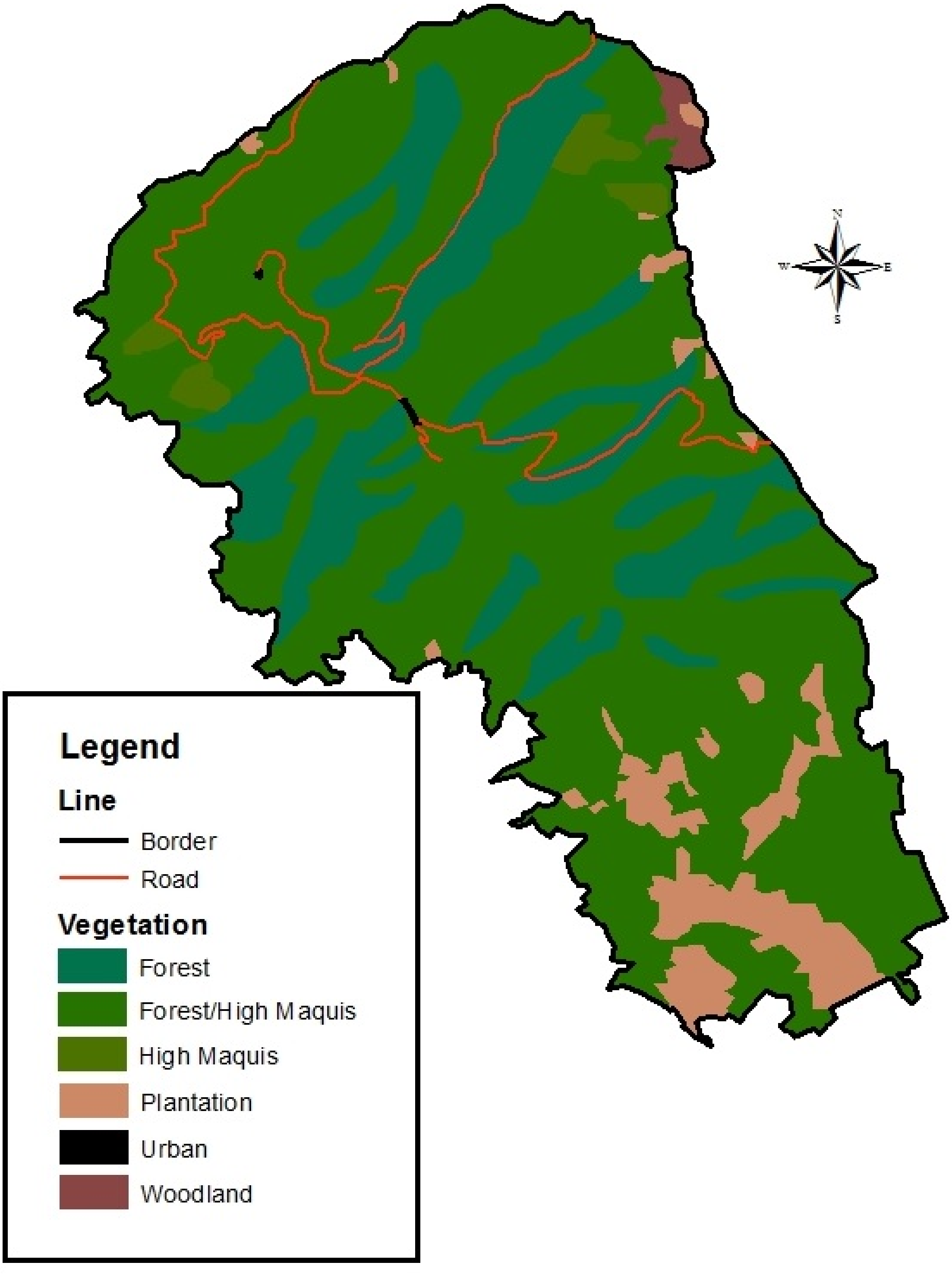

Fig. 3. *Graphical representation of the vegetation types and their distribution on Maglavas Mountain.*

Discussion

To access the full potential of the field of ecological research one must be able to see the glimpses of connections that are ever present in nature, and then explore them to its fullest to be sure that the visions and theories are not clouded by uncertainty; this is the basics of ecological knowledge (Ricklefs, 2009). The reason this is important in this paper is by understanding how to connect different entities to its rightful counterpart, and in this case it is ecosystems and their corresponding ecosystem services. There are of course several different ways to go about this, to view the ecosystem on separate levels, one of its own patch, one of its own vegetation type and one of the whole ecosystem where it is present. The concept which will be in focus is the one of the whole ecosystem and will be reviewed for both Proti Island and Maglavas Mountain, but first we shall try to get a deeper understanding of the gradual change vegetation types.

Succession is a subject that have been reviewed in parts earlier in the paper but to understand these ecosystems it is important to have a deeper understanding of the phenomena. Because of wildfires, drought, vegetation removal and human intervention the ecosystems are in constant change (Daily, 1997; Ricklefs, 2009) and this makes it appearance in the difficulty to identify vegetation types in its full potential and to make a classification to a specific class and instead it becomes to a mixture of classes (Ricklefs, 2009). This succession and mixture concept becomes the reason to why the gradual change classes exist. These classes are not this and not quite that either, it is a mix between them, and sometimes it is more than the other but still got some parts of the first one, still making it a mix. This is the basic reason to why most of the vegetation types in both units are considered to belong to the gradual change category, and this is especially true to the Maglavas unit because of the slow succession of trees and the vegetation type known as forest. It is known that maquis is an earlier succession stage of forest (Dallman, 1998), making the appearance that Maglavas Mountain probably were totally forested in earlier times, before it was cut down and left to find its own way back to the forested ecosystem. The reason to why this is important is because the forest/high maquis vegetation type is not in the middle of forest and high maquis, but a mixture that could just contain one or a few elements of either forests or maquis and the rest of the elements to the other class. Only a smaller percentage of the total unit is either considered forest or maquis, while the majority is the mixture. One other thing which to relate to succession is biodiversity, due to the nature of the concept of succession it is part of several different vegetation types (Ricklefs, 2009). The reason for this is because it has favourable conditions for species from more than one vegetation type, and therefore often contains higher biodiversity. Biodiversity is not connected in this study to ecosystem services but it gives a prospective of the areas relative importance considering the possibility of future values (Ricklefs, 2009). Now let’s get back to the units in question.

The results that the vegetation identification of Proti Island yielded was more or less expected, in the way that the initial aerial classification were close to the in-field classification. Considering the distribution of the vegetation types, the amount of which they are found and how they are located in the terrain it gives the impression both in aerial view, in the field and from the results that the ecosystem of Proti Island is quite open. The low maquis/garrigue which composes 27.50 % of the island is creating an open environment around the slopes of the higher parts, while the garrigue/woodland with 12.02 % creates an open environment on the top of the mountain and the garrigue of 17.90 % creates the open patches of the southern part of the island. This open area is combined with the semi-open area of high maquis/woodland of 15.84 % and low maquis of 2.87 % with the semi-closed areas of high maquis of 8.47 %, which together makes the island more heterogeneous. The rocky coast, which surrounds the entire island, also increases the heterogeneous appearance but is more of a buffer zone (Ricklefs, 2009) from the destructive forces of water and salt.

The three biggest vegetation types, low maquis/garrigue, garrigue and high maquis/woodland composes more than 60 % of the islands surface and has 14, 13 and 15 positive ecosystem services correlations respectively. While most of these are the same it does not change the fact that the islands neutrality in terms of exploitation is providing nature with the ability to recover from stress, at least on a local level (Daily, 1997). One thing though that does influence is the urban area of the island; the monastery. The monastery does not only have special species which is not normal to the vegetation to this island but also sheep. The sheep are wondering around the island, which influences the vegetation in both positive and negative ways (Ricklefs, 2009). The positive aspects are that they have an influence over the openness of the island, which both benefit pollinators, herbs and biodiversity (Huntsinger & Oviedo, 2014). The negative aspects are that they are keeping the vegetation types from expressing their full potential of becoming specific classes; instead they are kept at the gradual change stadium (Ricklefs, 2009). This grazing could even hinder the potential creation of forest on the island, which in itself has both positive and negative aspects, one of which the absence of timber and wood fuel. One could question if the sheep have a positive influence of the ecosystem services of the island, and most likely they have because of their natural ability to create openness in favour for especially pollinators (Huntsinger & Oviedo, 2014), but also to the fact that they are in fact an ecosystem service themselves, livestock. Though the monastery also have two other ecosystem services which are not related to the vegetation of the island; Genetic resources (9) and Spiritual and religious values (22). It is well established that monasteries try to be independent and grow their own food in many cases, and because it has been cultivated for some time they often have species of food which are rare to the rest of the food industry (Åsen, 2009), making it a genetic resource. It is also known that they possess religious values by the simple fact that it is a monastery.

To summarize the island as a whole one could say that it is a relatively undisturbed natural ecosystem of open environments with many ecosystem services which could buffer the world’s already broken ecosystem. The fact that it is an island and is located of the coast is making it a safe zone for plants from the mainland but also a potential stepping stone for populations which could colonize smaller islands farer of the coast.

When coming to the analysis of Maglavas Mountains it is a little bit harder to see the whole picture because of the vast majority of differences from Proti Island; the whole area is a mountain, it is mostly populated by trees and tall shrubs, it is located on the mainland, it is surrounded by olive groves and towns and the simple fact that it has several roads which could influence the vegetation. As mentioned before the mountain is in a great succession phase when the majority of its vegetation is composed of forest/high maquis of 70.16 %, while forest cover 20.02 % and high maquis only 1.63 %. There is a simple reason for this. The Mediterranean forest often grows in locations with more moisture than the rest of the vegetation; this is why the forest which now grows on Maglavas is located in the valleys between the ridges (Dallman, 1998). The high maquis on the other hand grows on the locations where it is dryer and hotter, because of the adaptations of the species associated with maquis (Dallman, 1998). Between the dry and hot areas and the moister areas it is a conflict based on succession and conditions which fits both classes, and that is why forest/high maquis grows there. If the area is continued to be relatively undisturbed and if the climate and weather phenomena does not shift to rapidly the trees in most of these areas will conquer the taller bushes and the vegetation will become more like the forest which now is located in the valleys (Ricklefs, 2009).

As with Proti Island a lot of ecosystem services have positive correlations with the vegetation types in Maglavas because of the fact that they all are neutral ecosystems which are relatively undisturbed with 14, 14 and 13 positive correlations respectively. But there are four major differences one should consider; trees, canopy, moisture and shadow resistance caused by the closed-canopy. The sheer amount of trees located on Maglavas right now and possibly in the future, creates a vast amount of timber and wood fuel which is becoming rarer and rarer in Greece today because of the slow regeneration of forests. The canopy, moisture and shadow resistance creates an entirely different microclimate from place to place on Maglavas, making it a very complex and heterogeneous environment (Daily, 1997). Even though there are a lot of open patches, both in the vegetation but also created by the roads vicinity to the vegetation, which in beneficial to flowers and pollinators, this ecosystem is basically a closed one. This partial distance to the open environment does, instead of benefit livestock, benefit wild animals which have vast areas to use as habitat (Ricklefs, 2009) in otherwise heterogeneous areas of olive groves. In this way the mountain also works as a stepping stone to populations and species which are adapted to this specific environment or is just seeking a refuge from an otherwise hostile environment with pesticides, herbicides and other poisons (Ricklefs, 2009). This has great connection with the surrounding olive groves. Both pollinators and species which are considered pests by some have a refuge in the forest and could even benefit the groves in ways of ecosystem services as pollinators, disease regulation and pest regulation (Daily, 1997; Giourga & Loumou, 2002).

To summarize the mountain; it is a heterogeneous area of high biodiversity and many ecosystem services in contrast to the otherwise homogeneous area surrounding it. It works both as a refuge and stepping stone for species which are unable to survive otherwise (Ricklefs, 2009). In the long term it could also serve as a great resource of timber and wood fuel, even though it right now has a considerable amount of both of the resources.

It is hard to compare the two units with each other because of their differences. One could argue if an open ecosystem is more important or provides more ecosystem services than a close one, if an island off the coast is more important than a mountain on the mainland or if pollinators prefer trees over bushes when choosing their home. The differences between them are not as important as the similarities they share; they are both natural Mediterranean ecosystems, they both provide many positive correlations between their vegetation types and ecosystem services and they both serve as refuges and stepping stones in the favour of biodiversity.

The question at large is how this is relevant in an ecological landscape aspect. It is true that most of the region is made up of olive groves, but there are also areas of natural vegetation in which the condition of nature is at its most undisturbed and finest quality. The other natural vegetation areas of Messinia are not included in this study but if one were to investigate their connectivity it is easy to see the proximity of distances in satellite images (G.E.P., 2014). Areas of similar conditions create connectivity between each other and make the stepping stones which impact the Meta population networks between the ecosystems (Ricklefs, 2009). What this means on the larger scale is that Proti Island and Maglavas Mountain could, and probably do, connect to these other areas and creates a web of patches in which the biota flourishes and further increases the ecosystem services positive influence.

It is clear that more extensive research have to be done, both in more detail to understand how smaller parts of the same ecosystem provides the ecosystem services and brings pieces to the whole, but also in greater extent, in order to understand how surrounding ecosystems interact and influence each other.

Conclusion

When investigating how ecosystems and ecosystem services interact it is important to not only to search for the disturbed ecosystems and point out how they are non-functional, but also to search for the functioning and understand how they provide the solution and future buffer for nature. Biodiversity indicates more than just the sheer number of species on one location; the condition and health of the ecosystem itself. Natural ecosystems are more valuable than just its material components; the whole is more than the sum of its pieces.

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