VEGETATION AND LAND USE UNDER DIFFERENT HUMAN IMPACT - A COMPARISON OF NORTHERN MOROCCO AND SOUTHERN SPAIN

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Abstract

Study areas: The Tangier Peninsula in NW Morocco and the Campo de Gibraltar in SW Spain offer identical physical conditions (bedrock, soil and climate), a common flora and shelter endemic plant species. We can study the effects of a different agro-technological management, population density, economic levels, ownership and cultural traditions on the vegetation cover and the plant species diversity.

Methods: The plant species composition was analysed at the habitat level by about 2000 phytosociological relevés. The vegetation mosaic in the landscape dimension was recorded in 75 sample plots of 1 square km. Land use trends in the last decades were analysed by an interpretation of historical and actual air photographs.

Results: The tendencies in maquis and forest are diverging in both areas: In Andalusia, unproductive arable land and pastures are abandoned and spontaneously recolonized by shrub vegetation or reforested with *Pinus* or *Eucalyptus*. Pasture intensity and wood exploitation in forests is decreasing; stem density, timber stock and fire risk are increasing in Spanish Cork Oak forests. In Morocco, there is an on-going reduction of the forested area by illegal clearing, an inner exploitation and degradation of the remaining forests, and an over-aging of the tree stratum by overgrazing. Exceptions are forests around Marabouts and on rural cemeteries. These places, respected for religious reasons, are Sacred Natural Sites. From 86 sites analysed less than 50% conserve near natural,

sustainable Holy Forests. Some stands have an overaged tree layer or are ruderalized by grazing and pilgrimage activities.

SNS are an important element of the natural and cultural heritage of Morocco. They contribute to the conservation of rare plant species and threatened forest ecosystems. SNS make landscapes unique. A national inventory is urgent. Enclosures against pasturing livestock are necessary to guarantee the regeneration and long-term persistence of the Marabout forests.

Weed vegetation in arable land varies strongly according to the agro-technological level. Self-sustaining agriculture still exists in the Outer Rif Ranges. Traditional ploughing methods, shifting cultivation and the intercalation of short-term follow land periods results in species rich Moroccan weed communities. Agro-industrial management as it prevails in Spain, halves species number per field. The anthropogenic transformation of the weed vegetation has a similar tendency in both countries, with a time lag of some decades in Morocco. Heathland is richer in species and endemics in Spain and poorer in Morocco, due to higher grazing impact and fire frequency there. The results confirm the intermediate disturbance hypothesis of diversity.

Conclusions: “Modernisation” of vegetation landscapes results in a more trivial plant canopy. At a finer regional scale, land use trends can be divergent even within both countries, triggered by socio-economic factors such as ownership, infrastructure, accessibility and productivity. Land use types of post-industrial societies (tourism and recreation, nature conservation, wind park installations) lead to re-evaluations of land polygons and can be similar in Morocco and Spain. The evaluation of the sustainability of the land use must take into consideration several independent parameters such as 1- external energy input (fossil carbon or green energy?), 2- external nutrient input (better food supply for the local population or risk of groundwater pollution? 3- Forests managed sustainable and offering ecosystem services (e.g. water retention and prevention of soil erosion).

Keywords:

Landscape succession, biodiversity, natural heritage, cultural ecology, Sacred Natural Site, Marabout, Gibraltar Straits

Abbreviations: SNS = Sacred Natural Sites

Introduction

Archaeobotanical findings like those of Berglund (1991) in southern Sweden show us clearly, that the anthropogenic transformation of vegetation landscapes is going on step by step: The Berglund-model (Figure 1) illustrates the relationship between the agro-technological level and the productivity of husbandry. Innovations such as mechanisation, external energy input, artificial fertilizers, irrigation, breeding of new races of cultivated plants or animals etc. raise the carrying capacity for the human population.

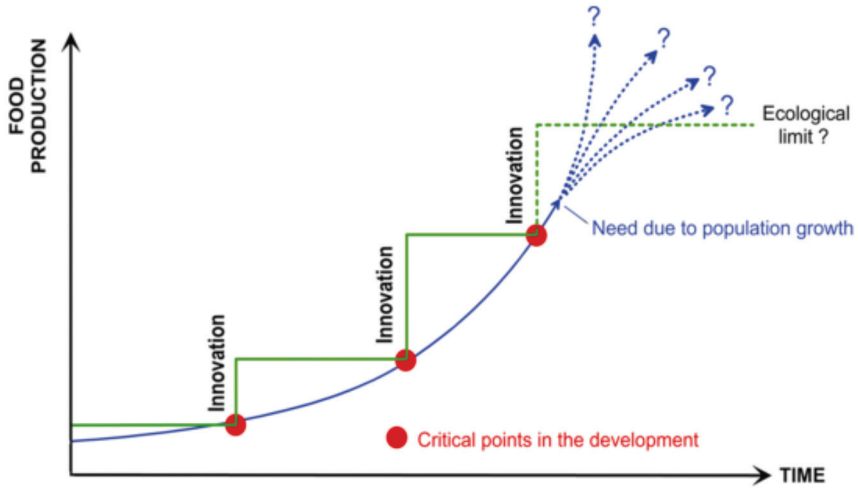

Figure 1: Theoretical model for the development of cultural landscapes (from Berglund 1991, modified)

Important steps in the last decades were the transition steps from self-sustaining to market oriented agriculture and further on to an agro-industrial land management, oriented to international markets. Finally, a post-industrial society will re-evaluate land for new "products" like recreation, tourism, or nature conservation. So, for example, a sandstone ridge in the Outer Rif Ranges, exposed to strong wind and covered with a very unproductive heathland can become a very valuable site for a wind power installation and be very productive for green energy. Or it can be of high conservation value, when it shelters endemic plant species.

The plant cover is an ecosystem parameter quite sensitive to land management and human impact. The question is: Do different agro-technical management and contrasting economic and social conditions result in different vegetation landscapes? What are the characters of a "traditional" respectively a "modern" vegetation landscape?

The economic situation of a society also affects biodiversity patterns. We start with the hypothesis, that within-habitat plant species diversity (alpha-diversity) is maximal under moderate environmental stress and medium intensity of management (Intermediate Disturbance Hypothesis of Grime, 1993). This will be studied 1- by the example of the weed flora in arable land, and 2- by the species richness in heathland plant communities.

To study landscape succession and vegetation changes we can apply two approaches:

1) A retrospective approach by comparing historical and recent documents (e.g. time series of aerial photographs). A profound field analysis of the present landscape allows drawing some conclusion, what have been the earlier land cover, former vegetation types and the historical habitat diversity (diachronic analysis).

2) The location-for-time-substitution-approach: It starts with the following pre-assumptions: The rate, direction and velocity of the stepwise transformation of landscapes depend upon the national economic situation, the regional infrastructure and the individual situation of the landowner. Therefore, two regions might exist side by side, which have arrived today at quite unequal economic levels, and have different ownership structures and agro-technological management. We can study the land use trends by comparing the present vegetation of regions, if one of them still represents the former situation of the other. The different human impact resembles to an "experiment in the landscape dimension", which is already running over decades or centuries.

Areas, suitable for a location-for-time-substitution-approach have to fulfil two conditions: 1) They must offer identical physical and biotic features before human intervention. 2) They must be submitted to different land use systems, cultural traditions and levels of modernisation.

The Mediterranean world, situated in the economic gradient between Europe and Africa is a suitable area for studying the effects of a changing economic situation and of the impact of different societies on land use trends and biotic diversity. The meeting place of the contrast is the Straits of Gibraltar. An agro-industrial landscape on the Spanish coast might exist side-by-side with a self-sustaining farming system in Morocco. The actual Moroccan plant cover could have some features, which are already historic in Spain or in other words: Landscape transformation might be asynchronous. To see whether the trends of land use changes are parallel, divergent or convergent, the location-for-time-substitution approach was applied to the peninsulas at both sides of the Straits of Gibraltar.

The comparison of the plant cover of the Tangier Peninsula in NW Morocco and the Campo de Gibraltar in SW Spain should give answers to the following questions:

1. Do both areas differ in the extension, internal structure and plant species composition of the forests? Is forest management and exploitation by cutting, logging and grazing sustainable, allowing regeneration of the tree layer? A special focus will be laid upon the role of Sacred Forests around Marabout tombs and on rural cemeteries as elements of natural and cultural value.
2. What are the effects of modern respectively traditional land management for the within-habitat plant diversity? Does it confirm the intermediate disturbance hypothesis? This will be tested by the example of weed communities and heathlands.
3. How are the land use trends in both areas? Is there a convergent or a divergent landscape evolution? Or is it parallel, but with time lag in one country?
4. Are these tendencies positive for a sustainable land use or are they threatening the natural heritage?

Study area

Abiotic and biotic similarity

The study areas are the peninsulas at both sides of the Straits of Gibraltar. The African part in NW Morocco is called Tangier Peninsula (Tangérois) respectively "Tingitano" as phytogeographical sector. It includes parts of the provinces Tangier, Tetouan and Larache. The European part is located in the provinces Cadiz and Malaga. This part of SW Andalusia is called Campo de Gibraltar or "Gaditano" in phytogeography. Both peninsulas are part of the Betic-Rifean mountainous arc. Common sedimentation processes and a synchronous orogenetic uplift resulted in identical geological structures, bedrock material, soils and geomorphological features (see geological map in Didon et al., 1973 and geomorphological study by Andre, 1971). The sandstone ridges of the "Unité numidienne" in Morocco are equivalent to the Unidad del Campo de Gibraltar.

A common sub-humid climate of the atlantic-mediterranean type and a land connection between Africa and Europe until mid-Tertiary resulted in an almost identical flora. Valdés (1991) was the first to setup a Gaditanean-Tingitanean phytogeographical sector. The study area is a hotspot of biodiversity in the Mediterranean (Médail & Quézel, 1997) and shelters a large number of vascular plant species, endemic to that area (Galán de Mera & Vicente Orellana, 1997; Molina-Venegas et al., 2013). One example is the Portuguese Sundew (*Drosophyllum lusitanicum*) (Figure 2), distributed over the southwestern part of the Iberian Peninsula, and transgressing to Africa exclusively on the Tangier Peninsula (Garrido et al., 2003).

Figure 2: The Portuguese Sundew (*Drosophyllum lusitanicum*), a SW-Mediterranean endemic species occurring in open heathland on the Tangier Peninsula

The study area became part of the Intercontinental Biosphere Reserve of the Mediterranean (IBRM), designated by UNESCO in 2006 (Abdul Malak et al., 2017) because of its floristic richness (about 1700 plant species) and high rate of endemism (about 5%) (Arroyo 1997).

Without human intervention, the altitudinal sequence of potential natural vegetation would be forests with Wild Olive Tree (Tamo-Oleetum sylvestris) on black cotton soil respectively Wild Olive and Cork Oak (Oleo-Quercetum suberis) on sandy soils in the thermomediterranean lowlands, a pure Cork Oak forest (Teucrio baetici-Quercetum suberis) on acid soils and with Kermes Oak (Rusco hypophylli-Quercetum cocciferae) on schist and marl in subhumid, mesomediterranean bioclimate at mid altitude, and a forest with deciduous oaks (Rusco hypophylli-Quercetum canariensis) in perhumid mountainous areas and on northern slopes (see Figure 3 in Deil, 2003). Clearing and pasturing resulted in a great variety of maquis and heathland plant communities.

An important cultural difference is the existence of Holy Forests in the Moroccan part. Sacred sites, sheltering remnants of vegetation in the surroundings of Marabout tombs and on Muslim rural cemeteries are called Sacred Natural Sites (= SNS). They have often been considered as primeval forests (Quézel & Barbero 1990, Benabid 1991). Such elements are part of the cultural as well as biological heritage of Morocco.

Cultural and economic contrasts

Man's influence on the vegetation cover is quite different on the European and African side. In general human pressure in Morocco is higher. The density of the rural population is three to four times higher in Morocco than in Spain. In spite of a considerable urbanisation in northern Morocco (see some contributions in Berriane & Laouina, 1998), the rural population is still increasing. In Andalusia there has been a strong decline of the rural population in recent decades. The role of agriculture for the GDP and the number of employees in that sector has decreased enormously in the last few decades (Prados de la Escosura & Sanchez-Alonso, 2020). A strong contrast between both countries can also be stated in mean income (GDP per capita is 4,600 USD in Morocco, 33.700 in Spain) and in average farm size (2-3 ha in Morocco, 35 ha in Spain) (Aldul Malak et al., 2017).

Arable land in Spain is the property of big land owners, who produce for the market of the EU in a biennial crop rotation and with a considerable amount of capital. Characteristics of this agro-industrial system are the application of modern ploughing techniques and of chemicals for weeding. Unprofitable soils have been abandoned in recent years. In the Rifean part of Morocco, self-sustaining small holder farming still exists in remote areas. Rainfed agriculture of durum wheat, superficial ploughing without harrowing, manual weeding, and the intercalation of fallow land periods (shifting cultivation) are characteristics of this traditional agricultural system. In both countries, the irrigated agricultural area is increasing. In the western Rif Mountains, the cleaning of maquis and the cultivation of new agricultural land even on steep slopes is still going on (Ben Salah et al., 2018). In the Spanish mountainous regions the setting aside of pastures and fields is frequent, favoured by subsidies of the European Community.

Pastures: In the Andalusia, large areas in private ownership are used for cattle breeding with the Retinto race in a rotation system with enclosures. Medium sized farms and latifundia predominate. In Morocco, we find an unregulated grazing system on common ground with local cow races and predominant small animal breeding. Stocking rate and – in consequence – pasture intensity are higher in Morocco.

In both countries, urbanization, industrialization and tourism are concentrated on the coastal regions. Many sensitive dune ecosystems of the Gaditanean coast are protected from touristic impact. At the coast east of Tangier near Ksar Kbir, camping and permanent settlement take place in a more or less unregulated fashion. Hunting and ecotourism are important activities in the National Park "Los Alcornocales", situated in the Campo de Gibraltar. Such activities are of minor economic importance in northern Morocco at the moment.

Conclusion: An agro-industrial system with some elements of post-industrial character (tourism, nature conservation) on the Spanish coast exists side-by-side with a system in Morocco, based mainly on smallholder preindustrial farming with remnants of a self-sustaining agricultural system. First transitions to agroindustry take place in Morocco. The Peninsulas offer the possibility of studying the effects of different human impact on the plant cover, because population density, ownership, and economic framework are different and the land is used and managed differently.

Methods and data set

The vegetation was analysed at the habitat level by sampling of floristic data on more than 2000 plots. Vegetation types were defined on the basis of repetitive species composition (phytosociological approach). The vegetation mosaic in the landscape dimension was recorded in 75 sample plots of 1 square km and by an analysis of Catenae along altitudinal and edaphic gradients. The plant cover was mapped in three corresponding pairs of eco-regions on both peninsulas (for location of the perimeters see Figure 2 in Deil, 2003). Land use trends in the last few decades were analysed by an interpretation of historical and actual air photographs.

In the last decade (2007 to 2017) we studied and analysed the vegetation around the tombs of local saints ("Marabout") and on graveyards on the Tangier Peninsula (NW Morocco), a region, known for its Maraboutism (Berriane, 1989). These sacred groves were studied intensely in the last decade, with a regional focus on the Tangier Peninsula. Naturalness and conservation value have been investigated in detail (Deil et al., 2005 2009; Frosch & Deil, 2011; Jäckle et al., 2013; Deil & Mhamdi, 2015; Frosch et al., 2016; Jäckle, 2017) and by a working group of Tetouan University (Demdan et al. 2008; Taiqui et al., 2009; Ben Salah et al., 2018).

Total number and size of the SNS in the study area were analysed from topographic maps and verified by field studies in 8 landscape sections (36 km^2 plots), randomly located in the major ecoregions after a pre-stratification according to bioclimate and geology (see Figure 1 in Jäckle 2017). The vegetation mosaic was recorded on 86 SNS: Frequency,

spatial extension and naturalness of the habitats were analysed. The habitats were classified based on physiognomic characters of the plant cover and dominating woody species, and grouped according to naturalness. To analyse the conservation value for rare or vulnerable plant species, 203 phytosociological relevés have been sampled in the forested parts of the SNS and were clustered according to floristic similarity. The resulting forest associations are discussed in a broader geographical context (SW Mediterranean) and compared with data from non-sacred forests (Frosch & Deil, 2011). Vascular plants were classified according to pre-defined risk factors like stenochory or grazing sensitivity. Naturalness index and refugial value were calculated for each site (Frosch et al., 2016). Deil & Mhamdi (2015) give a synopsis where in Morocco SNS have been studied.

Results

Contrasting processes in forests and maquis

Maamora was the largest Cork Oak forest in the world (300.000 ha in 1939), before it was reduced by clearing and internal exploitation by illegal cutting in the last few decades to actual 50.000 ha open degraded forest (Rejdali, 2004; Fennane & Rejdali, 2015). Now the largest Cork Oak forest in the Mediterranean Biome occurs in the Campo de Gibraltar (82.000 ha), colonising the Aljibe and other mountain ridges over Numidian sandstone (Figure 3). It is protected as part of the Natural Park Los Alcornocales (170.000 ha), designated in 1989. 25% of the area is in public ownership (Alvarez de Sotomayor, 2002). Private owners are big fincas (< 100ha). Dominating vegetation types are Cork Oak (*Quercus suber*), Holm Oak (*Quercus rotundifolia*), deciduous Oak forests (*Quercus canariensis*, *Q. faginea, and Q. pyrenaica*), maquis and heathland. Reforestations with *Pinus* or *Eucalyptus* are of minor importance.

Figure 3: A closed Cork Oak forest covers the Sandstone Ridges of the Sierra del Niño, part of the Natural Park Los Alcornocales in SW Andalusia

The tree layer in the Spanish forests became closer in the last few decades, stem number and basal area increased (Alvarez de Sotomayor 2000). In *Quercus suber* forests, low and middle diameter classes are dominating, favoured by forest management. These diameters are easier to handle for cork exploitation, which was in the last 150 years the main economic objective of land use (beside charcoal production and extensive grazing). *Quercus canariensis* has a certain percentage of very large trunks with diameters > 60 cm (Jurado, 2002a, 2000b). Nowadays, hunting for red deer, roe deer, and wild boar creates the main income from the Park. Ecotourism is also relevant. Further forest ecosystem services are water storage, reduction of erosion, and protection of water reservoirs from sedimentation.

The extraordinary conservation status of the forests in the Aljibe Mountains is due to their position in a no man's land with extreme low population density, located in the Middle Ages in a frontier situation between reign of the Caliph of Grenada and the Empire of the Kings of Castillia (Marañon & Ojeda 1998). Strict regulations and supervision with forest guards since 1748 by the Ministry of Sea protected the forests later on. Actual management according to the Plan Forestal Andaluz is sustainable.

The Tangier Peninsula also shelters large Cork Oak forests in the Outer Rif range, for example between Chaouen and Jebel Bouhachem, and on the Numidian sandstone ridges further westwards like Jebel Kerchichane near Moulay Abdesselam. Palynological data (Muller et al., 2014) document that human impact in the Pre-Rif Mountains was low in Roman times. Opening of the forests started 900 years ago and increased strong in the last 400 years. Forest quite well conserved still existed in the colonial period.

Actually the remaining forests are submitted to strong deforestation and degradation processes like reduction of the forest area by clearing (Chabbi, 1994; Taiqui, 2005, Taiqui et al., 2008, Ben Salah et al., 2018), internal exploitation and opening of the tree canopy by illegal cutting of low and middle diameter classes. Intensive browsing with small animals (sheep and goats) prevents the regeneration of the tree layer. Forest use is not sustainable, even not in the SIBE site of Jebel Bouhachem, where illegal logging and clearing for *Cannabis*-cultivation reduces the closed *Quercus suber* and *Q. canariensis* forest. (Chabbi, 1994; Gatchui et al., 2014). Illegal logging of low diameter classes of *Abies maroccana* occurs even in the National Park Talassemtane (Linares et al., 2011).

A more detailed study of the forests in the summit area of the Aljibe Mountains in Spain and the Jabal Kerchichane in the Beni Aros tribal area on the basis of 146 relevés gave the following results (Benzler et al. 1998): Two forests communities (Teucrio baetici-Quercetum suberis and Rusco-Quercetum canariensis) occur in both countries. Their spatial distribution is triggered by aspect and soil water capacity. Herbs like *Luzula forsteri* and *Brachypodium gaditanum* characterize closed forests with intact topsoil. When these forests are opened by selective felling, pollarding, fire and grazing, the ombrophilous herbs are disappearing and shrubs are dominating the understorey. The invading woody plants are different in both countries: In Spain, this regressive succession results in the dominance of Ericaceae and Genisteae (e.g. *Erica scoparia* and the Gaditanean endemic *Ulex borgiae*). In Morocco, Rock Rose species (*Cistus crispus* and other *Cistus* spp.) characterize the ground floor. The higher fire frequency and stronger grazing impact in

Morocco might cause this shift from resprouters (Ericaceae with lignotuber) to reseeders (Cistaceae with a fire stimulated seed bank).

The role of Sacred Natural Sites (= SNS) for forest conservation and natural heritage

Intact Cork Oak forests on fertile soils in Morocco are restricted to small plots. They are sheltering Marabout tombs or covering rural cemeteries (Figure 4). These SNS are numerous in NW Morocco (mean value is about 26 per 10x10 km perimeters), but small in size (in mean 0.7 ha) (Figure 5). Jäckle et al. (2013) estimate about 2100 sites for the Tangier Peninsula. 67% are documented on the topographical maps 1:50.000.

In a broad scale analysis which compared forests in the SW-Mediterranean inside and outside SNS, forests on SNS were in better condition (Frosch, 2010; Frosch & Deil, 2011). Some forest types are exclusively found around Marabout tombs and on cemeteries like Wild Olive groves on sand and marls in the thermomediterranean lowlands and the Kermes Oak plant community (Rusco-Quercetum cocciferae) (Figure 6) on marl and schist in the subhumid bioclimate. Near natural forests shelter true forest species in the ground floor, with a high constancy and abundance of ombro- and mesophilous taxa. These well conserved Holy Groves are restricted to certain ecoregions, with preference in mid altitude and in remote areas of the Outer Rif Ranges (Figure 7) (Jäckle, 2017; Ben Salah et al., 2018). They represent the potential natural vegetation of the mesomediterranean bioclimatic belt.

Figure 4: A small patch of a Cork Oak forest around a Marabout tomb, located in the Beni Ider tribal area, Outer Rif Ranges

Figure 5: Sacred grove Sidi el Mokhfi near the village Er Rhorba in the tribal area of Beni-Ider in the Outer Rif Ranges. The holy forest is a mixed stand with Kermes Oak and Wild Olive Tree

Figure 6: Near natural forest with arborescent individuals of Kermes Oak (*Quercus coccifera*) and Mock Privet (*Phillyrea latifolia*) around Marabout 'Sidi Arabi' in the Western Rif Mountains. Due to opening of the canopy around the qubba, grasses dominate the foreground

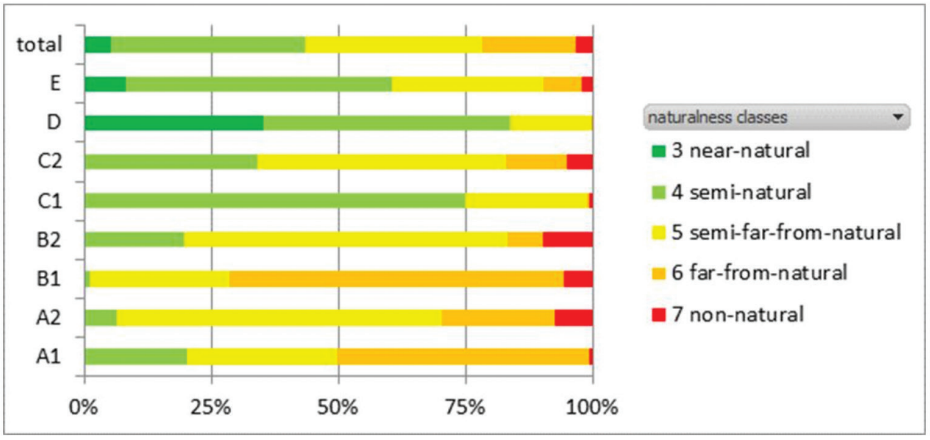

Figure 7: Pattern of naturalness of the SNS vegetation in the landscape sections A to E (from Jäckle, 2017)

However: Near-natural and semi-natural vegetation covers less than 50% of the surface of the 86 SNS mapped by Jäckle (2017). Anthropo-zoogenic impact (burial activities, burning, grazing) on SNS can create a fine scale vegetation mosaic (see Figure 4 in Deil, 2001 and vegetation maps in Deil et al. 2005). Many forests on SNS have an overaged tree layer like on Jabal Habib (Figure 8). Regeneration of the dominating tree species is missing for decades due to overgrazing. The tree canopy is "sub-fossil". In sacred groves with Wild Olive, located near villages or in Cork Oak groves submitted to strong pilgrimage activities (both are sites with high nutrient input), the typical forest floor vegetation has disappeared and is replaced by nitrophilous and ruderal annuals in the process of therophytisation and ruderalisation (Figure 9). About half of the SNS are strongly degraded and far from natural conditions. A greater conservation effort with exclosures of pasturing livestock is necessary to ensure the conservation of these forests.

Figure 8: Over-aged Cork Oak forest of Sidi Habib. Grazing, trampling and camping during the annual pilgrimage period prevented any regeneration of *Quercus suber* in the last few decades

Figure 9: Sacred site 'Sidi Amour Al Hadi' in Douar Swahal with Wild Olive trees. The forest floor under the overaged tree layer is ruderalised by heavy grazing, by defaecation of resting animals and by seasonal pilgrimage activities

Species diversity at the habitat level (alpha-diversity): The example of arable land

This parameter was studied by the example of weed communities in arable land. Winter crops on black cotton soil (tirs = vertisols) are characterized on both sides of the Gibraltar Straits by weed communities with *Ridolfia segetum*. They shelter rare and also endemic species like the Bindweed of the Gharb (*Convolvulus gharbensis*). Based on 112 randomly distributed samples on both peninsulas, we stated a mean species number of 48 per field in the Tangier region, 22 in the Campo de Gibraltar. Modern tilling techniques, the application of herbicides and artificial nutrients halve species diversity. But not all species are affected in a similar way. The rhizomes of perennial herbs and shrubs such as *Dittrichia viscosa* and the rosettes of biennial weeds like *Ammi visnaga* are not completely eliminated by the traditional ploughing methods. A focus upon grasses in agricultural land gives the following result: Some annual weedy grasses like *Avena sterilis* and *Hainardia cylindrica* resist the modern agricultural practices and occur in similar frequency on both sides. Perennial grasses like *Cynodon dactylon* and *Phalaris caerulescens* become rare in arable land under modern agriculture practises (Sundermeier & Deil, 1992; Deil & Sundermeier, 1992, Figure 7 in Deil, 2003). The high species number in Morocco results from the additional appearance of annual pasture grasses and of oldfield species whose seed bank is filled up during the fallow land period.

Between-stand diversity and landscape diversity are enhanced in Moroccan agricultural areas by three effects: 1) *Chamaerops humilis*-patches as the last remnants of the original vegetation are scattered all over the arable land. These hummocks shelter maquis species inside the dwarf palm and are surrounded by a tall forb edge community. 2) A broader spectrum of soil types is used for agriculture. 3) The shifting cultivation system creates a considerable variety of succession stages, so gamma-diversity increases.

In the 70ies small holder farmers in the Campo de Gibraltar used the same traditional tilling methods as they are used at the moment in marginalized regions of the Outer Rif Ranges, where self-sustaining agriculture is still applied. Nowadays Rifean weed communities represent former Spanish ones which have been transformed to pure weed communities. The anthropogenetic transformation of the weed communities has a similar tendency in both countries, with a time lag of some decades in Morocco. At the moment, the pattern of Dwarf palm tuffs scattered over traditional managed arable land is disappearing by modern tilling methods. The transition to „modern" weed communities happened already in the Rharb plain and in the Saïs around Meknes. In the surroundings of Tangier (Les Fahs de Tanger), where large properties occur (Guich ownership), tendencies towards agro-industrial land management (cattle breeding for fresh milk production) can be observed. Grazed fallow land has been transformed to hay meadows. In general, high soil productivity, good accessibility to the fields and big ownership speed up modernisation.

Species diversity at the habitat level (alpha-diversity): The example of grazed heathland

Heathland vegetation in Morocco is submitted to a higher fire frequency and a stronger pasture pressure than in Spain. The effects on *Erica umbellata*-communities have been studied in the Sierra del Aljibe and in the Western Rif Mountains. Mean species number for all heathland types is 29 in Spain, 18 in Morocco (see Figure 9 in Deil, 2003). The stronger anthropo-zoogenic stress in Morocco results in a lower floristic diversity and in mono-dominated stands. The higher burning pressure in Morocco favours Cistaceae. In Spain, the heathlands are dominated by Ericaceae and Genisteae.

When we compare species diversity of heathland and arable land, we find an inverse situation: In Spain human pressure is very high and uniformising in arable land and less intensive in forests and shrubland. In Morocco anthropo-zoogenetic pressure is constantly high in maquis and lower (intercalated fallow periods!) in cultivated land. Alpha-diversity in weed communities and in heathland reflects this situation very well. The results are in accordance with the intermediate disturbance hypothesis (Grime, 1993).

Human impact on age structure in Drosophyllum lusitanicum populations

Apart from the analysis of diameter classes (as proxy for age structure) in the common tree species, there are only very few studies from the Gibraltar region available which analyse how different land use and human impact affects the regeneration of plant species. One exception is the study of the population structure of *Drosophyllum lusitanicum* (Figure 2) by Garrido et al., (2003). The authors studied age classes of this SW-Mediterranean endemic species in Portugal, Spain and Morocco. The Portuguese Sundew is a character species of dwarf *Erica umbellata* heathland (Drosophyllo-Stauracanthetum). It regenerates after fire, needs open patches and has a mean life span of about 10 years. Its strategy is stress tolerance. It can resist high surface temperatures, cope with low nutrient content (by carnivory), shallow soil, and it uses dew as additional water supply. It is a slow growing species. The competition of higher growing shrubs in its surroundings must be reduced from time to time by fire or mechanical disturbance. Populations in SW Andalusia have

a balanced structure, due to fires of mean frequency. Populations in *Eucalyptus* forests in Portugal are overaged except on fire strips, where mechanical disturbance is stimulating regeneration. On the Tangier Peninsula, populations are regressing due to strong grazing and trampling.

Discussion

Land use change (from forest and maquis to arable land) and increasing intensity of land management (from rainfed agriculture to irrigation e.g.), are the main threats for biodiversity in the Mediterranean (Blondel & Médail, 2009). Landscape transformation is going on stepwise and is linked to economic and social changes. The comparison of the Peninsulas on both sides of the Straits of Gibraltar confirms in principal the model of Berglund (1991) (Figure 1): In agricultural land we can state a similar tendency in both countries. A transformation and modernisation from self-sustaining via market oriented agriculture to agro-industrial management. Trends are parallel, with a time lag in Morocco.

Some important modifications respectively alternatives from the Berglund model however are obvious in the study area:

1) Trends can be divergent between countries of different economic conditions. This is obvious in forests and maquis in Morocco and Spain. At a finer regional scale, trends can also be divergent within the same country. This was documented in a Portuguese mountain area, the Serra de Monchique in the Hinterland of the Algarve, where vegetation and land use changes of easy accessible valleys differ considerably form remote valleys (Krohmer & Deil, 2003). Triggering socio-economic factors are ownership, infrastructure, accessibility, and productivity. On the Tangier Peninsula, the marginalized mountainous areas of the Outer Rif Ranges are conservative (= traditional) landscapes: They have relicts of self-sustaining agriculture and shifting cultivation. The contrast between traditional Hinterlands and marginalized mountainous areas on the one side and "modern" and productive lowland and coastal areas on the other side is a general pattern in many Mediterranean countries (Mazzoleni et al., 2004). Regional disparities increase by abandonment of farmland and declining population in the mountains, and intensification of farming and urbanisation by population growth in the lowlands.

2) Trends in landscape transformation are scale dependent. International political framework, national economic conditions, regional development and local social constraints affect the decisions of the landowner: A Spanish farmer, who has access to the subsidies of the EU, can pursue the aim of maximum economic profit from his land. A small-holding Moroccan farmer has to minimize the ecological risk of crop failure. These farmers are more depending on the natural resources than the big landowners in Spain. Vulnerability to climate change effects is therefore higher in Morocco (Aldul Malak et al., 2017).

3. Innovations are not applied and implemented to a "landscape as a tabula rasa", but to a landscape with physical, biotic and social structures (e.g. ownership) dating from

historical times. Landscapes of the past are important for processes in the future (Antrop, 2005). Landscape is more like a palimpsest, conserving some memories of past land use. In Spain for example long distance farming systems evolved after the Reconquista and have been fixed by the Royal Mesta rules. The transhumance is no longer practised in the Campo de Gibraltar, but the pasture routes, the Cañadas and their vegetation complex, do still exist. This is one example of a historical component in the vegetation cover. The vegetation cover is an important element of the cultural heritage and one of the factors that make landscapes unique (Deil, 2001).

4. Landscape elements can exist and persist, which are more or less independent from the economic development of a country, but linked to specific cultural tradition: SNS and their biotic and cultural values are linked to the traditions of Maraboutism in Morocco.

The divergent tendencies in forests and shrublands, as described by Barbero et al. (1990) and by Quézel & Barbero (1990) for the Northern and Southern rims of the Mediterranean Basin, are confirmed by the detailed studies focussing on the Gibraltar areas (Benzler et al., 1998, Marañon et al. 1999, Deil 2001, 2003). In Spain, stocking rate and browsing intensity have decreased in all non-agricultural areas, while tree densities and tree cover value have increased in the last decades. The general tendencies are diverging in both areas (Tab. 1): In Andalusia arable land on slopes and unproductive pastures are abandoned and spontaneously recolonized by shrub vegetation or reforested with *Pinus* or *Eucalyptus*. Pasture intensity and wood exploitation in forests is decreasing, stem density, timber stock and fire risk are increasing in Spanish cork oak forests. On the Tangier Peninsula, the tendencies in oak forests are similar to Moroccan forests in general (UICN, 2015): There is an on-going reduction of the forested area by illegal clearing, an inner exploitation and degradation of the remaining forests, and an over-aging of the tree stratum by overgrazing and a therophytisation of the ground flora. Maquis are reduced by clearing and shifting cultivation or degraded by cutting of firewood and browsing. The higher slashing and browsing pressure and higher fire frequency in Morocco results also in a shift of species composition in the understorey of oak woodlands, with a dominance of Cistaceae in Morocco, and of Ericaceae and Genisteae in Spain (Benzler et al. 1998). Species richness, endemic species richness and taxonomic singularity are higher in Spain. Morocco has a greater abundance of widespread generalist species (Marañon et al., 1999).

The diverging tendencies in both Peninsulas are also visible in fossil pollen record of the last 400 years (Muller et al. 2014). The actual degradation processes in Moroccan forests and maquis by local people (illegal cutting, clearing and fruit tree planting to create and establish private ownership, overgrazing on communal and governmental ground) are similar to those carried out by the Spanish rural population during the “Ordenación de los Montes” in Andalusia in the 18th and 19th century (Ortega Santos, 2000).

Tab 1: Tendencies in forests and maquis in Morocco and Spain

Morocco	Spain
Woodland	**Woodland**
reduction of forest area by illegal clearing	timber exploitation decreasing
inner exploitation of remaining forests	increasing stem density and tree cover
therophytisation by intensive pasturing	moderate pasture intensity by game
over-aging of tree layer	regeneration of tree species
Exception: Sacred Natural Sites = well conserved Marabout forests	increasing fire risk (*Pinus, Eucalyptus* plantations)
Maquis	**Maquis**
reduction by clearing, shifting cultivation	abandonment and succession to forests
degradation by cutting and browsing	clearing, transformation into herbaceous pastures

The forests on SNS in Morocco are an exception from this general pattern, sheltering – at least in some of the sites – well conserved stands in near natural conditions (Figure 7). Such Marabout forests are relevant for the protection of intact forests and for plants, vulnerable to opening of the tree layer and to intense grazing. Certain formerly widespread plant communities like Kermes Oak forests survived exclusively on sacred sites (Figure 6). Naturalness and occurrence of vulnerable plants are positively correlated (Frosch et al. 2016). Wild Olive trees on SNS in the Rif and Prerif Mountains can serve as a valuable genetic resource for Olive breeding (Aumeeruddy-Thomas et al. 2017).

Modernisation of the society is linked to a declining respect vis-à-vis the protection of SNS (Taiqui et al. 2009, Ben Salah et al. 2018). Many SNS are threatened by overgrazing, resulting in over-aging of the tree layer or direct destruction of the plant cover (Figure 8, Figure 9).

The SNS around Marabouts and on rural cemeteries are a very important element of the natural and cultural heritage of Morocco. The sites are important for the identity of the local population and are a characteristic feature of the landscape and of high aesthetic value (Figure 10). They are threatened by population growth, land use pressure and decreasing spiritual value. Reduction in size and total destruction occur. A national inventory is urgent. Only known and documented SNS can be protected and monitored.

To guarantee the regeneration and persistence of Marabout forests in the long run, they should be included into the national program CFACG compensating local communities when forest and maquis areas are closed to grazing (Moukrim et al. 2019a, 2019b). This program must be modified to fit to the small size of SNS.

Figure 10: Sacred grove with Dwarf Palm (*Chamaerops humilis*) in arborescent form on a cemetery near Basra, Province Ouezzane, NW Morocco.

Within-habitat diversity is reflecting the intensity of human impact. It has its maximum under intermediate disturbance regimes. Intensification as well as abandonment can result in a decline of habitat diversity. On the European side human impact is strongest in arable land. Other land use types are submitted to extensification, to set aside programs, or dedicated to nature conservation, a post-industrial "non-land-use" type (e.g. dunes in the Campo de Gibraltar). On the Moroccan coast the perennial dune vegetation – sensitive to trampling - will be destroyed in the near future by not-regulated camping activities, practised by "modern" social groups.

In the landscape dimension every technological and economic level creates a specific vegetation mosaic. Characteristic vegetation types exist for Northern Africa respectively Southern Europe (see Tab. 1 in Deil 2001). Culturally indifferent vegetation units are roadside verges and other ruderal communities. "Modernisation" of vegetation landscapes results in a more trivial plant canopy (see Figure 3 in Deil 2001) and in mono-functional land units, following the segregation model of land use. Land use types of post-industrial urban societies (tourism and recreation, nature conservation, wind park installations) lead to re-evaluations of land polygons and can be similar in Morocco and Spain.

When evaluating the land use changes for their sustainability, this must be done separately for several parameters. Just to mention three: 1) External energy input is to be evaluate differently when based on fossil carbon or on green energy from wind power. 2) External

nutrient input increases productivity and food supply for the population, but has the risk of groundwater pollution when applied too intensely. 3) Beside production of timber and conservation of biodiversity, the ecosystem services of forests (e.g. water retention and prevention of soil erosion) must be taken into consideration. In the Outer Rif Ranges, soil erosion increases from 4.5 tons/ha/y under forest to 18-36 tons/ha/y in arable land (Cheddadi et al. 2015).

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