Grazing management aimed at producing landscape mosaics to restore and enhance biodiversity in Mediterranean ecosystems

Glasser T.A., Hadar L.

in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 437-452

Grazing management aimed at producing landscape mosaics to restore and enhance biodiversity in Mediterranean ecosystems

T.A. Glasser* and L. Hadar

Ramat-Hanadiv Nature Park. P.O.B. 325, Zikhron Ya'akov, 30900 (Israel)
*e-mail: Tzach@ramathanadiv.org.il

Abstract. This article reviews some of the main effects of livestock grazing on landscape characteristics at different scales, from patch to landscape level. Examples are presented mostly from long-term research conducted in a 500 hectare Mediterranean nature park in Israel. The proposed approach views cattle and goat grazing as management tools targeted at creating a heterogeneous landscape mosaic to enhance biodiversity, restore wildlife habitats and maintain high amenity value for visitors. Managers, researchers, nature conservationists, goat and cattle breeders, and the local community collaborate to maximize the benefits from this relatively small area and create a multi-functional piece of land. Understanding the different factors that influence the way in which grazing affects the natural ecosystem, such as grazing history, grazing pressure, or livestock species, helps us to conduct the most suitable management regime for different areas in the park. Practical examples of grazing plan implementation are presented for cattle and goat herds, which apart from being an agricultural production enterprise, supply grazing as a high quality environmental service.

Keywords. Grazing service – Landscape structure – Multi-functionality – Habitat diversity – Heterogeneity.

Gestion du pâturage visant à produire une mosaïque de paysages pour restaurer et renforcer la biodiversité

Résumé. *Cet article recense certains des principaux effets du pâturage du bétail sur les caractéristiques du paysage à différents niveaux d'échelle, de la parcelle au paysage dans sa globalité. Des exemples sont présentés, issus principalement d'une recherche conduite à long terme dans un parc naturel de 500 hectares en Israël. L'approche proposée considère le pâturage des bovins et des chèvres comme un outil de gestion visant à créer une mosaïque hétérogène de paysages permettant de renforcer la biodiversité, de restaurer les habitats sauvages et de maintenir une haute valeur d'attrait pour les visiteurs. Gestionnaires, chercheurs, écologistes, éleveurs de bovins et de chèvres, ainsi que la communauté locale joignent leurs efforts de façon à maximiser les bénéfices dérivants d'une aire relativement petite et à en faire un espace multifonctionnel. La compréhension des différents facteurs qui influencent la façon dont le pâturage modifie l'écosystème naturel, comme l'historique du pâturage, l'intensité du pâturage ou les espèces animales utilisées, nous aide à mettre en pratique le régime de gestion approprié aux différentes régions du parc. Sont également présentés des exemples concrets de mise en pratique de plan de pâturage pour des troupeaux de bovins ou de chèvres qui combinent entreprise de production agricole et service environnemental de haute qualité.*

Mots-clés. *Service de pâturage – Structure du paysage – Multifonctionnalité – Diversité de l'habitat – Hétérogénéité.*

I – Introduction

Rangelands are of great importance for the quality of life on earth. They provide various goods and services, such as food and fiber, carbon sequestration, genetic diversity, recreational areas, and heritage values. Since the domestication of major livestock species some10,000 years ago, grazing has been the main practice for livestock feeding in most parts of the world. As opposed to modern intensive farming, where feed is presented to animals in pens or feedlots, grazing as a practice has an enormous effect on the spatial structure (Henkin *et al.,* 2007) and hence on ecosystem function, in terms of biodiversity, wildlife habitats (Lunt, 2005), and micro-climate (Yates *et al.,* 2000).

Livestock production is defined as the production of protein (milk and meat) and fiber for human consumption and use. In recent decades, livestock production based on grazing has decreased in many regions of the world (Bouwman *et al.,* 2005). This trend has strongly affected many of the rangeland ecosystems, causing profound changes, some of which, such as shrub encroachment, are considered undesirable (Barbaro *et al.,* 2001). Under these circumstances, the idea of using "grazing services" as a tool for rangeland ecological enhancement has arisen.

Naturally, the main effect of grazing on the landscape is expressed through changes in vegetation pattern and composition. The nature and extent of these changes depend on livestock species (Rook *et al.,* 2004*)*, grazing history (Perevolotsky and Seligman, 1998), vegetation formation and grazing intensity (Coffin *et al.,* 1998), as well as on a-biotic variables such as soil type and precipitation. Global processes such as climate change also play a major role in determining successional trends (Mouillot *et al.,* 2002).

The aim of this article is to propose the use of livestock for the restoration and enhancement of biodiversity, through the creation of landscape mosaics at different scales.

II – Background

1. Spatial heterogeneity and functional heterogeneity

The relationships between landscape pattern and process, as well as the scale at which the landscape demonstrates patchiness, are of major interest in landscape ecology. The term 'spatial heterogeneity' has many different aspects. It can be viewed as a static state or as a dynamic process, as the result of deterministic factors only, or as subject to random or chaotic behaviors. Heterogeneity can be measured by various indices based on the different values of a selected parameter (such as vegetation cover) at different locations. The variable measured (e.g., Shannon's diversity index or the number of different patches) represents the observer's perspective and only a small aspect of the system heterogeneity. This approach, despite its convenience, may have low biological relevance. An alternative approach may be relating to the 'functional heterogeneity,' a more qualitative and multidimensional term, defined by the perspective of the ecological units of interest, e.g., the individual, species, or community (Kolasa & Rollo 1991). Functional heterogeneity is scale-dependent and is most relevant to ecological processes.

Spatial heterogeneity occurs either as a gradient, i.e., gradual variation over space, or as a mosaic composed of patches with distinct boundaries. The term 'spatial pattern' refers to the number, size, and juxtaposition of landscape elements or patches. It has important consequences regarding the effective dispersal of propagules and the spread of disturbance across a landscape (Dunn *et al*., 1990). Substrate heterogeneity, natural disturbance and human activity are three mechanisms that create the spatial pattern.

2. Scale dependency

Mediterranean landscapes are multi-scale mosaics of different vegetation types, associated with high ecological diversity. The recognition of the importance of conserving landscape mosaics has broadened the goals of rangeland management from relatively narrow targets, such as the conservation of a certain species, habitat or pattern, to a multi-scale and multi-purpose perception that identifies the importance of ecosystem structural and functional diversity (Stalmans *et al*., 2001).

Landscape mosaics, and hence grazing effects on them, must be viewed at different spatial scales. A small scale relatively homogenous structure that differs from its surroundings can be defined as a "patch" (Forman, 1997). A wider management unit comprised of many patches is considered a "plot". The largest scale of reference will be the "landscape", which may consist of one or more plots and habitats. These definitions are of course fluent, subjective and interact with each other in many ways. Today the importance of scale in ecological studies is well recognized (Wiens, 1989), and it seems impossible to understand ecological processes without scale determination.

3. Livestock grazing, heterogeneity and biodiversity

As opposed to disturbances, such as wildfire or clearing, which exhibit a pronounced and concentrated effect on the landscape, grazing is usually a continuous process and should be studied accordingly. It may shift vegetation structure in different directions depending on initial vegetation formation, animal species, grazing intensity and the way it is spatially distributed (Adler *et al*., 2001) Many studies demonstrate an increase in spatial heterogeneity under grazing conditions, mainly due to the dynamics between grazed and ungrazed patches, and to other effects of grazing, such as manuring and trampling (Hadar *et al*., 2000). These changes influence ecosystem function, for instance, through changes in the distribution of many species (Christensen,1997). In many cases, an increase in species richness is found under grazing, when many more species are able to maintain themselves in a variety of microhabitats (Whittaker 1977; Lavorel 1997).

In Mediterranean ecosystems, different patch types play different roles as "landscape modulators" (Shachak *et al*.,2008) that filter species composition within the patch. Different woody patches impose different sets of abiotic conditions thus inhabit different plant communities (Blank & Carmel, 2012). The size and shape of a patch also affect the composition, richness and diversity within it (Gabay, 2008). Consequently, many researchers see heterogeneity as the basis for conservation and ecosystem management (Christensen., 1997; Ostfeld *et al*., 1997; Wiens., 1997).

Grazing effects on biodiversity vary widely depending on conditions, such as invasion risk of certain plant species; grazing history; site productivity; plant palatability and plant regeneration requirements (Lunt, 2005). Nonetheless, it is possible to predict or evaluate the expected outcomes under similar conditions or ecosystems. Some examples can be found in species-rich Mediterranean ecosystems (Lavorel, 1999) where successional processes are well determined (Naveh, 1994). Many of these ecosystems have a long history of grazing (Blondel, 2006), and are characterized by a variety of mechanisms against herbivores, such as secondary compounds, high lignin concentration and thorniness, which lead to low palatability for livestock (Hartley & Jones, 1997).

Mediterranean landscapes are characterized by high woody vegetation cover, with patches of herbaceous vegetation and a heterogeneous structure. The introduction of livestock into these ecosystems is considered a disturbance (McIntyre *et al*., 2003), although for ecosystems that had developed under strong human impact, the cessation of grazing is, in fact, the un-natural situation. Natural processes with no interference will lead to dense scrublands and woodlands, with high fire risk, low landscape and habitat diversity, low amenity value (Carmel & Kadmon, 1999, Pausas & Vallejo, 1999), as well as low feed quality for livestock (Kababya *et al.,*1998).

In this paper we address the effects of grazing in which livestock directly affect landscape spatial structure and pattern and leads to changes in plant and animal communities, and we present the use of cattle and goat herds in order to achieve the desired conservation goals.

The cases presented here were studies conducted at Ramat Hanadiv, a 450 hectare privately owned Nature Park, located in the Mediterranean region of Israel (fig. 1). With over 25 years of intensive ecological research, and a long-term base of knowledge, the park serves as a "field lab" for testing conflicts between different parties of interest-managers, researchers, nature conservationists, goat and cattle breeders, and the local community.

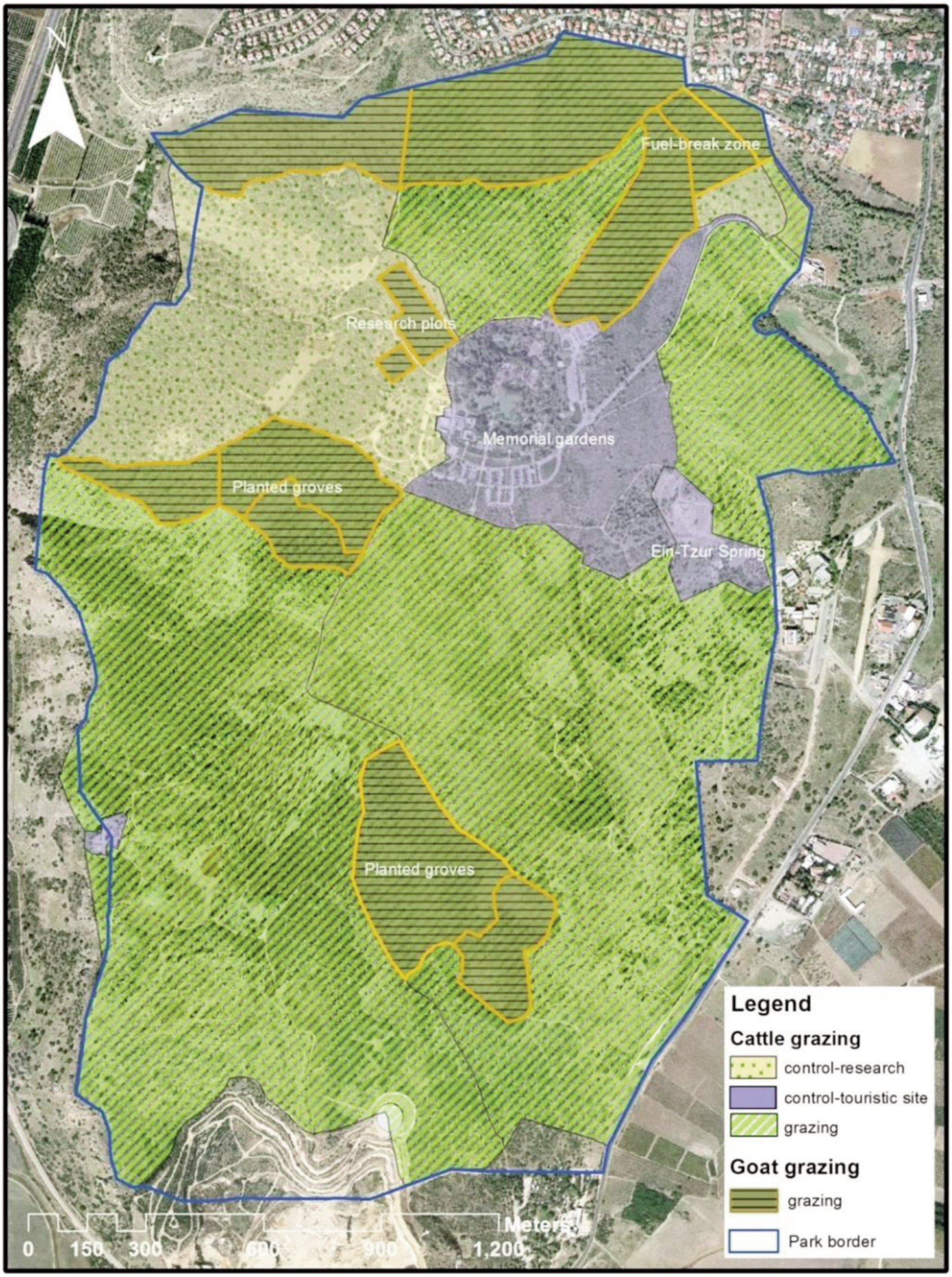

Fig. 1. Ramat Hanadiv Nature Park and the different sites subjected to goat or cattle grazing or not grazed.

III – Grazing effects on vegetation structure and ecosystem function

Spatial structure can be viewed in different dimensions, e.g. from the view of the human eye (horizontally) or the wider birds'-eye view (vertically). Spatial patterns are usually viewed and analyzed from the bird's-eye view by aerial photography analysis or other remote sensing techniques. The main advantages of these techniques are that they are easier to quantify, do not necessitate intensive field work, and enable landscape scale analyses. However, when dealing with shrublands or forests, structural changes occur under the canopy and will not be detected by most remote sensing techniques. Bar-Massada and his colleagues analyzed changes in small scale spatial patterns in a Mediterranean garrigue as a result of goat grazing and shrub clearing treatments (Bar-Massada *et al.,* 2008). They used several common landscape ecology indices for the investigation of the structural attributes of patches and landscape patterns. Among them are total woody vegetation cover, patch size, patch density and edge density. They found that the combination of grazing and clearing in small scale plots (0.1 ha) shifted landscape pattern towards higher patch densities, smaller patches with greater distances between them and with significantly longer edges (fig. 2). Similar trends were found in an open rangeland subjected to goat grazing (Glasser *et al.,* 2013). These structural changes have functional ramifications from the patch level to the plot and the landscape levels, as well as on the interaction between patches. Examples of interaction between closed (woody) patches and open (herbaceous) patches regarding plant community diversity following grazing and shrub clearing are changes in seed dispersal ability and patterns (Gabay, 2008), as well as changes in seed bank composition of the different species (Dutoit and Alard., 1995). These changes must be seen at different scales. Gabay (2008) found no significant effects of grazing on plant density or on species richness at the plot scale level (0.1 ha.) under goat grazing. Nonetheless, when analyzed at the patch level, significant differences in species richness and composition were found. Hence, grazing alters the spatial dispersal of species without changing their richness. Due to these results it was concluded that in landscapes exhibiting a mosaic of closed and open patches, separate analyses for the plot scale and for the patch scale is recommended due to the differential effects of grazing on different patch types (closed vs. open).

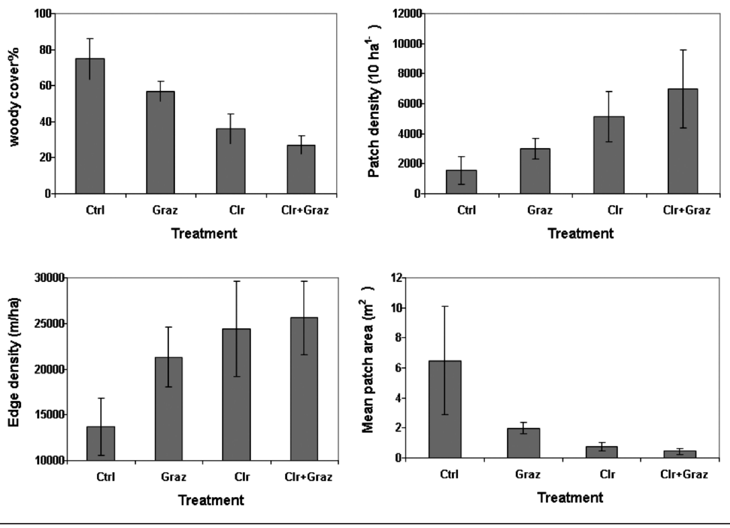

Fig. 2. Average values of landscape metrics for woody patches in the different treatments at the finest scale. The category axis lists the types of treatments: Ctrl–Control, Graz–Goat grazing, Clr–Shrub clearing, Clr+Graz–Clearing with grazing. (adapted from Bar-Massada *et al.*, 2008).

The approach that refers to Mediterranean landscape mosaics as a dichotomy of closed and open patches is argued by Blanc & Carmel (2012), who differentiate among different woody patch types. Woody patches play a major role in the modification of soil temperatures, soil organic matter concentrations, mineralized N, and microbial biomass (Belsky *et al.,* 1989). These changes are of unequal value for different woody patch types created by the different woody species. Different herbaceous species assemblies have affinity to specific woody patches. Species richness and community composition in less dense woody patches were found to be more similar to open patches than to other woody patches (Blank & Carmel, 2012).

Grazing can indirectly affect the expansion of invasive or colonizing species through changes in limiting resources and vegetation structure. An example can be taken from the colonization of *Pinus halepensis*, which is the most widespread pine species in the Mediterranean basin (Osem *et al.,* 2011). The expansion of this species from planted areas to natural shrublands may cause a major landscape change and affect the ecosystem at all levels. *Pinus halepensis* colonization in Ramat Hanadiv Nature Park has increased dramatically in grazed areas in relation to control plots (Osem *et al.,* 2011). Combination of cattle grazing and grazing by goats (which are browsers and can consume large amounts of secondary compounds, (Silanikov *et al.,* 1996) may assist in preventing the expansion of this species by the consumption of pine seedling. This approach has already been presented in controlling juniper encroachment in the southern United States (Ueckert, 1997). The use of livestock in modifying the structure at the landscape level is of great importance not only from a "pure" ecological perspective, but also from the human point of view (e.g. scenery, recreation). As mentioned, in many cases grazing affects landscape structure under the canopy height only. Different livestock species at different grazing regimes will profoundly change this aspect (Fernandez-Lugo *et al.,* 2013). Cattle and goats can exploit shrubs and trees to a height of 1.8-2.0 meters while sheep will utilize the grazing area up to about 1.0 meter. Of course there are differences among livestock species in other parameters, such as browsers vs. grazers, selective vs. more generalist, and other physiological attributes (Hofmann, 1989), These will further affect landscape structure and heterogeneity, important qualities from the human-scale viewpoint, relating to different activities and uses of the area, as well as its aesthetic value (Henkin *et al*., 2007). Cattle and modern goat grazing regimes have been shown to increase the diversity of plant shapes, as well as the landscape accessibility and transparency, by creating a wide diversity of gap shapes and dimensions (e.g. wide and open, narrow and closed) while traditional heavy goat grazing has created only wide and open gaps (Henkin *et al.,* 2007) (fig. 3).

A long-term study conducted at Ramat Hanadiv Nature Park has investigated the relationships between management practices and plant community composition and diversity (Hadar *et al*., 2013; Kent & Carmel, 2011). Data was collected at different sites (garrigue, dense shrubland, cypress grove, pine grove and a fuel-break zone) and treatments (grazed by cattle vs. ungrazed) every second year between 2003-2012. The results of these two studies have shown that cattle grazing alone did not affect plant richness or diversity (Shannon-Weiner and Simpson indices) and caused only a minor change in community composition. Nonetheless, when the cattle grazing was combined with shrub clearing or goat grazing, higher richness and diversity values were found along with a significant change in community composition (Hadar *et al*., 2013) (fig 4).

Another study (Kent & Carmel, 2011) reported that 29%-43% of all species had a significant affinity to a certain treatment (grazing or protection). Among these species, the majority had affinity to the grazing treatment (fig. 5).

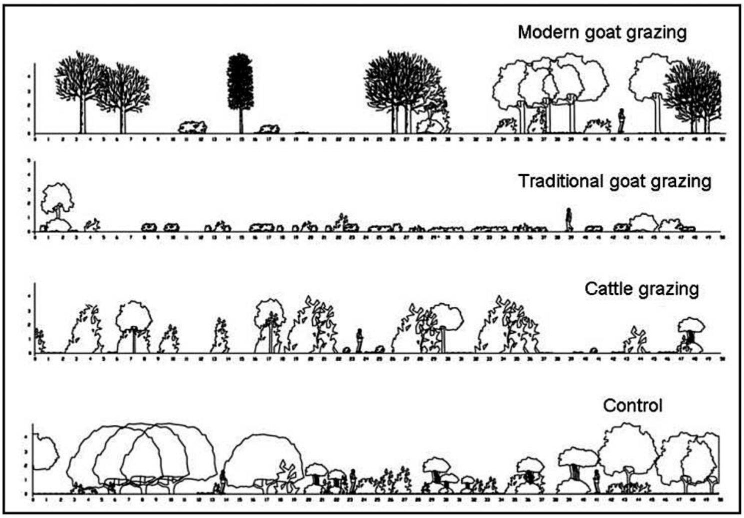

Fig. 3. Drawings that illustrate the structural profiles of the woody vegetation in all four treatments (adapted from Henkin *et al.,* 2007).

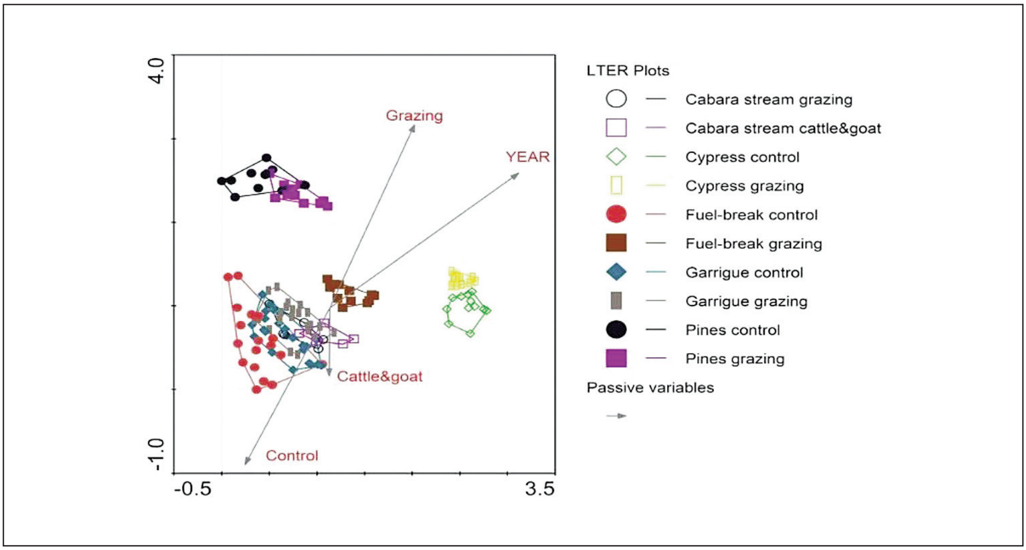

Fig. 4. Site and management effect on species composition. DCA (Detrended Canonical Analysis) on the whole dataset 2003-2008. The passive variables are year, control, grazing (cattle) and cattle & goat grazing. Symbols represent different transects (Adapted from Hadar *et al.,* 2013).

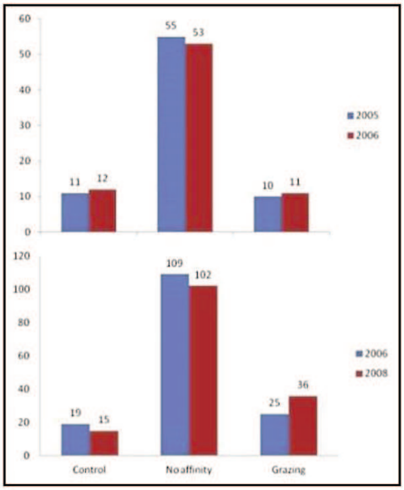

Fig. 5. Number of species found in affinity to a certain treatment compared at different years (2005-2006 top; 2006-2008 bottom). Adapted from Kent and Carmel (2011).

1. Wildlife habitats and diversity

Changes in landscape structure directly affect wildlife habitats at all scales. Arthropod species that need humidity were not found in medium-to-open patches where radiation vaporizes soil moisture (Shure and Phillips, 1991) or where there is increased tree structural diversity that may widen the niches for arboreal arthropods (Lubin *et al*., 2010).

Research conducted at Ramat-Hanadiv has found that shrub clearing reduced the number of spider families, while goat grazing did not have a significant effect on the number of families or on the ground spider community composition. The ground spider community of cut woody patches differed significantly from that of uncut woody patches and was more similar to that of open patches (Lubin *et al*., 2010).

Moderate grazing has been found to positively affect butterfly communities in various habitats around the world (Kirkland, 2002; Krauss *et al*., 2004; Ellis, 2003). In Ramat Hanadiv, research regarding the use of butterflies as bio-indicators has shown that on one hand grazing has positively affected host plants‘ richness, while on the other hand the consumption and trampling of herbaceous vegetation by the cattle has presented a negative trend in their affect on their abundance. This negative trend may have deteriorated the nutritional foundation for butterflies (Schwartz-Tzachor, 2007). One of the management conclusions of this research was that goat grazing, which also contributes to the reduction in woody cover, may assist in retaining butterfly fauna due to minimized trampling effect while expanding the cover of open herbaceous patches (Schwartz-Tzachor, 2007).

Grazing also affects small mammal (i.e., rodent) abundance and diversity (Torre *et al.,* 2007; Jones and Longland, 1999), mainly through a reduction of herbaceous volume, which increases their exposure to predation. (Schmidt & Olsen, 2003; Rosenfeld, 2004) or a reduction of their habitat quality by trampling (Keesing, 1998). Nevertheless, small mammals that depend on rocky refuges would be less susceptible to population changes due to grazing (Rosenfeld, 2004). Interestingly, under moderate cattle grazing small mammal populations have managed to recover by the existing resources, immediately after the cattle has left the area or by the next vegetative growth season (Rosenfeld, 2004).

With regard to ground-nesting birds, cattle grazing, which was assumed to be destructive for this group, was found to positively affect chukars (*Alectoris chukar*) and stone curlew (*Burhinus oedicnemus*) populations, due to a general opening of the dense shrubland. thus providing more sites for nesting (Perelberg 2011; Adar, 2013;). A similar result was found regarding gazelle (*Gazella gazella*) population (Perelberg 2011).

After focusing on the structural and functional effects of grazing from the ecological aspect, we would like to present a practical approach that has been applied at our nature park, which takes into consideration the different aspects, viewpoints and interests.

IV – Implementation of a multi-functional grazing plan

The perception of livestock grazing as a feed source only is limited, and seems irrelevant nowadays. Livestock grazing is increasingly perceived as a tool for landscape and ecosystem management. The vast changes in a range of ecological qualities, such as vegetation structure and biodiversity are only part of the picture. Additional landscape functions and services, such as fuel-breaks or recreation, must be taken into account when introducing livestock to a rangeland. For these reasons we believe that in order to build a good grazing management plan, which maximizes the benefit from this natural resource, all parties of interest (livestock breeders, ecologists, landscape managers and the local community representatives) should work in close collaboration.

When defining a goal for the grazing plan, a multi-functional approach should be implemented that refers to the correct spatial and temporal grazing regime, e.g., in order to avoid flammable dry herbaceous biomass, a fuel-break zone should preferably be grazed by grazers such as cattle or sheep, during a season that will still provide the best nutritional quality. Can this fuel-break zone be simultaneously used for recreational purposes? Should livestock be introduced after flower blooming or even after seed dispersal? Finding this delicate balance is a great challenge for landscape and grazing managers.

In the eyes of a livestock breeder, rangelands provide forage of varying quality. Among his considerations we can identify the importance of feed quality, type of terrain, distance from water resources, management practice (milk or meat production), and location from the farm center or stables. All of these considerations have practical and economic ramifications. Facing the livestock breeder we can find land managers who must take into account ecosystem and natural resources conservation in the rangeland and the wise exploitation of the herd on the premises. Furthermore, many parks, forests and nature reserves under grazing also serve as recreational areas open to the public, and in some cases there are conflicts with certain aspects of the grazing regime (fences, gates, sheds, water troughs, etc.).

1. Management of beef cattle grazing – A test case

Since 1991, a herd of beef cattle has been introduced into the nature park every year to consume most herbaceous biomass, mainly to diminish fire risk and maintain a mosaic of different vegetation structural types. About 30% of the park's area is left as a control without grazing, as wildlife habitats, tourist sites, research plots and for the future. A yearly grazing plan is prepared and takes into account parameters such as rainfall amount and distribution, herbaceous biomass accumulation, and developmental stage. Location of water troughs and feed supplementation points are considered as well. Since the park serves as a recreational area, interaction and potential conflicts with the public (in time and space) must also be considered, particularly the location of electric fences, gates and sheds. Due to fluctuations in precipitation (quantity and timing), a yearly "tentative grazing plan" is prepared in full collaboration with the park manager, other departments staff (visitors, education, research), and the livestock breeder. One of the main factors influencing primary production is precipitation. The amount and distribution of rain is never known beforehand. Research conducted at a climatic gradient in Israel has shown a relation between the amount of rainfall and herbaceous production at different grazing sites, however, in arid areas these relations were stronger (Golodiatz *et al.*, 2013). As part of the adaptive management approach, data regarding precipitation as well as the grazing regime in the park are collected constantly. This data is analyzed on yearly basis in order to learn and improve future management practices. Data collected since 1990 has shown that the minimum precipitation that will provide enough forage for cattle grazing is 300mm. Nonetheless, trying to predict when is the right time for introducing the cattle herd into the park is more difficult due to variation in rain distribution. The average rainfall from October to January is 252 mm. Analyzing past data presents a correlation coefficient of 0.4 for the prediction of date of entry by rainfall amount until January 1st (Fig. 6). In order to get more accurate data regarding the amount of vegetation, direct monitoring of available herbaceous biomass along three fixed 1500meter trails located in different areas of the park is conducted. In each trail, ten 25 x 25 cm samples are measured for vegetation cover and height, harvested, dried at 60ºC for 48 hours and vegetation dry biomass is weighed and recorded. For each harvested sample, nine other estimations are recorded without harvesting. This method produces 300 estimations before introducing the cattle herd, 300 estimation during the grazing season and 300 at the end of the grazing season.

This method enables the estimation of the amount of forage available for the cattle and of the biomass remaining after the herd has left the area. It is important to note that in order to achieve goals such as ecological values, fire prevention, and nature conservation with minimal conflict with other parties of interest, much effort should be invested in every grazing season, both in monitoring and in finding creative solutions that might not be ideal for everyone, but can work for the park as a whole.

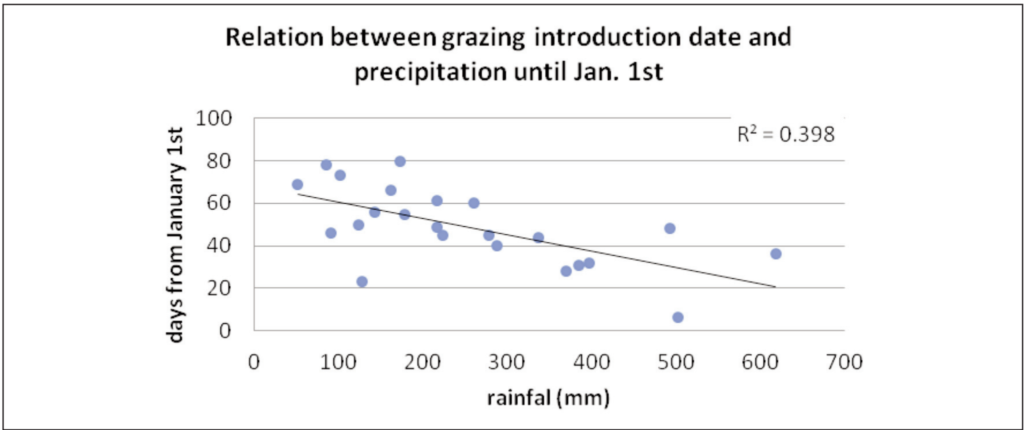

Fig. 6. Relation between amount of rainfall until January 1st and date of grazing introduction into the Ramat-Hanadiv Nature Park. Based on data from 1990-2012.

The main points of conflict are:

Date of entry into the park: Park managers would like the cattle herd to enter the park at a later date, to allow as many species as possible to disperse their seeds, and to minimize conflicts with nature conservationists and hikers, who wish to see the blooming of ornamental plants, especially geophytes. From the livestock breeders' point of view, an early entry of the herd into the area (in most cases before blooming, but only after a minimal biomass value is achieved) will provide vegetation of a higher nutritional quality and allow a longer time of exploitation of this rangeland (on account of other grazing areas).

Date of exit from the park or entry into the firebreak zone: Different targets are set for different areas of the park. When the main goal is fire prevention, park managers would be interested in grazing the area at extremely high pressure to reduce herbaceous biomass to minimum. In this case the farmer must supply the cattle with concentrated food of higher quality (mainly nitrogen). On the other hand, this leads to excessive exertion of nitrogen by the cattle which leads to changes in soil nutrient flows and encourages the development of nitrophyllic plant species, an undesired process from ecological perspective. In other areas, less prone to fire risk, park managers may not insist on having high grazing pressure hence creating a variety of vegetation structural types and habitats. Reducing grazing pressure needs of course to be negotiated with the livestock breeder.

2. Management of goat browsing – a test case

A herd of goats owned by the park authorities has been browsing the park since 2004. The herd consists of 200 goats of local breeds (Damascus, Mamber) and local breeds crossed with Alpine bucks, which exploit the park all year round. The management of the goat herd is aimed at the inhibition of shrub encroachment and the conservation of landscape diversity. The main purpose of the goat herd is to supply grazing services as one of the parks management tools. In addition, the herd is milked daily and produces about 60,000 liters of milk and sells about 200 kids a year. This herd is also routinely monitored and supports the conduction of various research projects related to agricultural and ecological issues. As opposed to the cattle herd, which grazes on large and fenced areas of the park, the goats graze in unfenced polygons with a very focused target (termed “targeted grazing”) with a herder on site at all times. The goat grazing plan is built for the long term and is accompanied by a monitoring plan, mainly aimed at detecting desired or undesired changes at the landscape level. Since goats rely mainly on woody plant foliage, which is mostly evergreen, the plan is based on seasonal preferences and availability of the different woody species and the different goals at each site. This plan is not limited by yearly variance in precipitation and is re-opened for discussion every 3-4 years according to monitoring results or when new areas need specific treatment that goats can assist in achieving. A classic example of this kind of treatment is when new areas are cleared of trees and shrubs (e.g., creating a fuel-break, restoration of ancient olive orchards). The browsing of goats is a useful tool for the maintenance of these areas by the suppression of new regrowth of shoots. Goats’ diet selection is also affected by season, due to differences in abundance, phenology and palatability of the different species (Glasser *et al*., 2008). They also increase dry-mater intake rate when planning the grazing rout considering these issues (Meuret, 1997). Goats must be directed to the different areas taking into account these issues in the grazing plan. Goats can also be very useful for the eradication of specific unwanted plant species (Goehring *et al.,* 2010). There are several very useful methods for increasing specific plant consumption by grazing goats, such as pre-conditioning (Richman, 1993), feed supplementation (Campbel *et al.,* 2007,) or supplementation of Poly-ethylen Glycol (PEG) (Silanikov *et al.,* 1996). A monitoring protocol accompanies the grazing plan. The main objective of the monitoring protocol is to estimate spatial and temporal effects of goat browsing on vegetation and landscape properties. Several methods are used, each being conducted at different intervals. These methods include daily monitoring of the herd‘s route by GPS, ground surveys and aerial photo analysis. A GPS collar is put on one goat in the herd and supplies data regarding the time and location of the herd at all times (1 min’ intervals). Data from this device are downloaded into a GIS map and database and enables calculation of the accurate grazing pressure at every location in the rangeland. Figure 7 demonstrates a processed grazing pressure matrix which is composed of a 10x10 meter grid (Segal *et al.,* 2014). The outcome of this processing procedure enables the coupling and exploration of various interactions and relations such as biomass removal at each pixel, temporal and spatial grazing patterns at the polygon or landscape level, interactions between grazing intensity and landscape appearance as

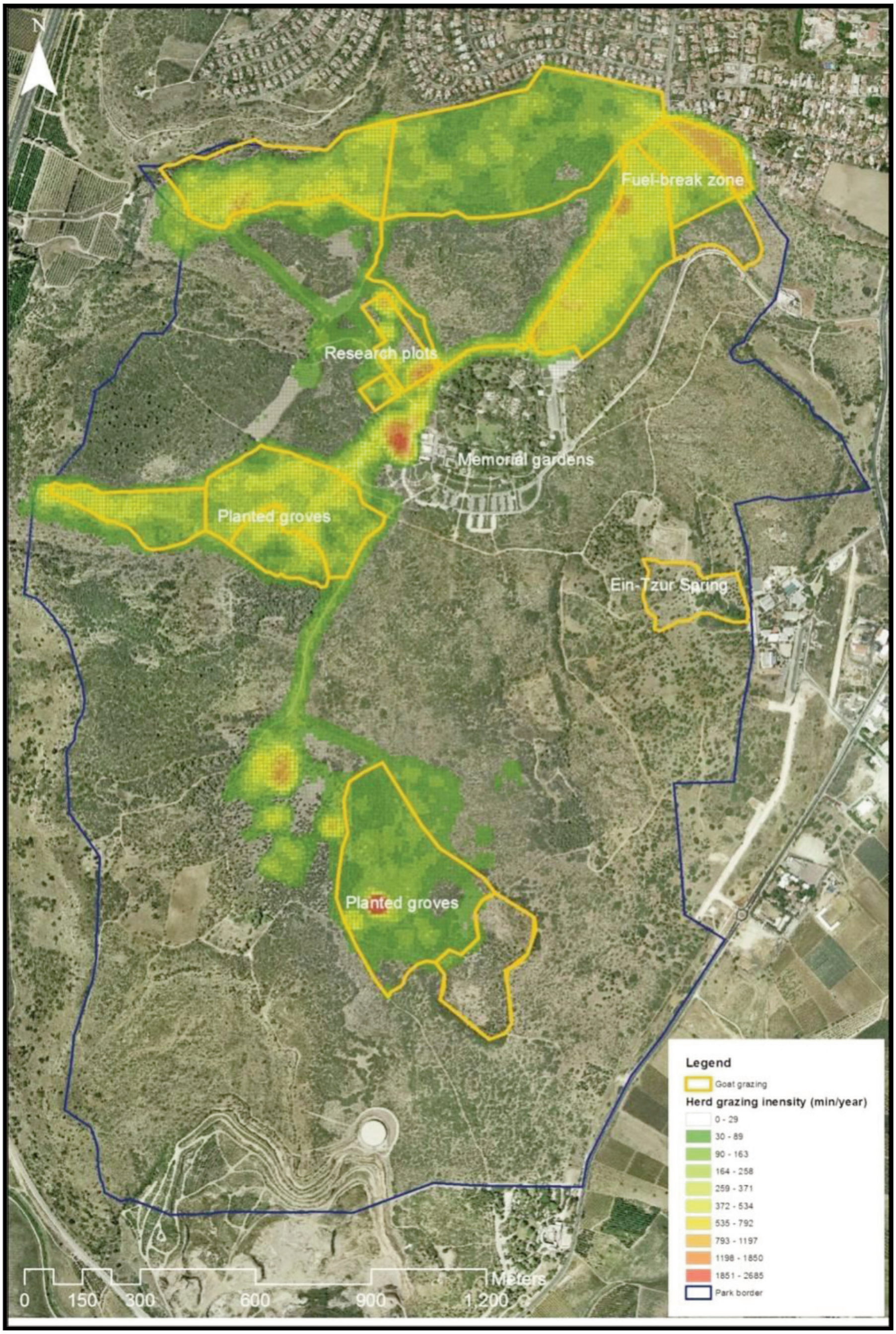

Fig. 7. Goat grazing intensity (min/year) in a 10x10 grid after GPS data analysis.

well as interactions between grazing location, intensity and livestock production. Ground surveys are conducted as well and include field transects where parameters such as defoliation, browsing line intensity and debarking are indexed (BLD index; Glasser *et al.,* 2013). Along these transects vegetation structure and dimension of gaps between shrubs are documented by graphic means (Henkin *et al.,* 2007). Aerial photos are classified and parameters such as woody cover, woody patch area, woody patch density and edge density are measured and analyzed.

V – Conclusions

We believe that grazing must be perceived from the broad perspective of its effects on and benefits to the natural ecosystem, and not only from its agricultural aspect as feed for livestock. Good collaboration between all stakeholders and profound understanding of the effects of different grazing regimes on the ecosystem is an important key for success. Understanding and taking into account the livestock breeders' interests will help promote the use of livestock for production of healthy food for human consumption while at the same time managing grazing for a healthy ecosystem with high diversity of habitats, species and landscapes. Knowledge-based management practice is crucial in this case. Good acquaintance with the different habitats, ecological processes, wildlife species, as well as the needs of livestock and livestock breeders, will not only reduce potential damage but rather enable the utilization of the cattle herd to enhance ecosystem function.

References

Adar M., 2013. Breeding bird populations dynamics at Ramat Hanadiv: The effect of habitat, anthropogenic activity and regional change. In: *Conserving and Managing Mediterranean Ecosystems: The Ramat Hanadiv Case Study and Beyon*d. (Ed. Perevolotsky, A) p. 116-127. (In Hebrew).

Adler P.B., Raff D.A. and Lauenroth W.K., 2001. The effect of grazing on the spatial heterogeneity of vegetation. *Oecologia*. 128: 465-479

Bailey D.W., Dumont B. and Wallis DeVries M.F., 1998. Utilization of heterogeneous grasslands by domestic herbivores: Theory to management. *Annals of Zootechnology* 47: 321-333.

Barbaro L., Dutoit T. and Cozic P., 2001. A six-year experimental restoration of biodiversity by shrub-clearing and grazing in calcareous grasslands of the French Prealps. *Biodiversity and Conservation*. 10: 119-135.

Bar-Massada A., Gabay O., Perevolotsky A. and Carmel Y., 2008. Quantifying the effect of grazing and shrub-clearing on small scale spatial pattern of vegetation. *Landscape Ecol*. 23: 327-339.

Belsky A.J., R.G. Amundson, J.M. Duxbury, S.J. Riha, A.R. Ali, and S.M. Mwonga., 1989. The effects of trees on their physical, chemical and biological environments in a semi-arid savanna in Kenya. *J. Appl. Ecol*. 26: 1005-1024.

Blank L. and Carmel Y., 2012. Woody vegetation patch types affect herbaceous species richness and composition in a Mediterranean ecosystem. *Community Ecology* 13(1): 72-81.

Blondel J., 2006. The 'design' of Mediterranean landscapes: a millennial story of humans and ecological systems during the historic period. *Human Ecology*. 34: 713-729.

Bouwman A.F., Vand der Hoek K.W., Eickhout B. and Soenario I., 2005. Exploring changes in world ruminant production systems. *Agricultural Systems,* 84, (2), p. 121-153.

Campbell E.S., Taylor C.A., Walker J.W., Lupton C.J., Waldron D.F. and Landau S.Y., 2007. Effects of Supplementation on Juniper Intake by Goats. *Rangeland Ecology & Management*: 60: (6), p. 588-595.

Carmel Y. and Kadmon R., 1999. Effects of grazing and topography on long-term vegetation changes in a Mediterranean ecosystem in Israel. *Plant. Ecol*. 145, p. 243-254.

Christensen N.L., 1997. Managing for heterogeneity and complexity on dynamic landscapes. Pages 167-186 in Pickett STA, Ostfeld RS, Shachak M, Likens GE, eds. The Ecological Basis for Conservation: Heterogeneity, Ecosystems, and Biodiversity. New York: Chapman and Hall.

Coffin D.P., Laycock W.A. and Lauenroth W.K., 1998. Disturbance intensity and above- and belowground herbivory effects on lont-term (14y) recovery of a semiarid grassland. *Plant ecology* 139: 221-233.

Dunn C., Sharpe D., Guntenspergen G., Stearns F. & Yang Z. 1990. Methods for analysing temporal changes in landscape pattern. In: *Quantitative methods in landscape ecology*, Turner & Gardner (eds), Springer-Verlag, New-York, p. 173-198.

Dutoit T. and Alard D., 1995. Permanent seed banks in chalk grassland under various management regimes: their role in the restoration of species-rich plant communities. *Biodiversity and Conservation* 4: 939-950.

Ellis S., 2003. Habitat quality and management for the northern brown argus butterfly *Aricia artaxerxes* (Lepidoptera: Lycaenidae) in northeast England. *Biological Conservation*, 113: 285-294.

Fernandez-Lugo S., Arevalo J.R., de Nasciment L., Mata J. and Bermejo L.A., 2013. Long-term vegetation responses to different goat grazing regimes in semi-natural ecosystems: a case study in Tenerife (Canary Islands). *Applied Vegetation Science* 16: 74-83.

Forman R.T.T., 1997. *Land mosaics. The ecology of landscapes and regions*. Cambridge University Press.

Gabay O., 2008. Woody Plants as Landscape Modulators in Mediterranean Woodland. Thesis submitted for the degree of PhD. to the Senate of Ben-Gurion University of the Negev.

Glasser T., Landau S., Ungar E.D., Perevolotsky A., Dvash L., Muklada H., Kababya D. and Walker J.W., 2008. A fecal near-infrared reflectance spectroscopy-aided methodology to determine goat dietary composition in a Mediterranean shrubland *J. Anim. Sci*. 86: 1345-1356.

Glasser T.A., Hadar L., Navon Y. and Perevolotsky A., 2013. Innovative monitoring of goat grazing effects on landscape structural properties. Proceedings of the 17th Meeting of the FAO-CIHEAM Mountain Pasture Network. Trivero, Italy.

Goehring B.J., Launchbaugh K.L. and Wilson L.M., 2010. Late-Season Targeted Grazing of Yellow Starthistle (Centaurea solstitialis) with Goats in Idaho. *Invasive Plant Science and Management* 3: 2, p. 148-154.

Golodiatz C., Sterenberg M., Kigel J., Bouken B., Dolev A., Hadar L., Henkin Z., Za'adi E., Betzalel Y., Arnon A., Zeligman N., Ungar E.D., 2013. Relation Between rain and primary production in rangelands along a precipitation gradient in Israel considering expected climate change. *Israel Journal of Ecology and Environment* 4(2), p. 148-159 (In Hebrew).

Hadar L., I. Noy-Meir and A. Perevolotsky, 2000. Scale dependent effects of fuel-break management on herbaceous community diversity in a Mediterranean garrigue. *Journal of Mediterranean Ecology* 1: 237-248.

Hadar L., Jobse D., Ungar E.D., 2013. Ramat Hanadiv plant community – dynamics in time and space. In: Conserving and Managing Mediterranean Ecosystems: The Ramat Hanadiv Case Study and Beyond. (Ed. Perevolotsky, A), p. 277-288 (In Hebrew).

Hartley S.E., Jones C.G. (1997). Plant chemistry and herbivory, or why is the world green? In: *Plant Ecology* (Ed. M Crawley), p. 284-324.

Henkin Z., Hadar L. and Noy-Meir I., 2007. Human-scale structural heterogeneity induced by grazing in a Mediterranean woodland landscape. *Landscape Ecol*. 22: 577-587.

Hofmann R.R., 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 78: 443-457.

Jones A.L. and Longland W.S., 1999. Effects of cattle grazing on salt desert rodent communities. *The American Midland Naturalist*, 141: 1-11.

Kababya D., Perevolotsky A., Bruckental I. and Landau S., 1998. Selection of diets by dual-purpose Mamber goats in Mediterranean woodland. *The Journal of Agricultural Science*, 131(2), p. 221-238.

Kareiva P. and Andersen M., 1988. Spatial aspects of species interactions: the wedding of models and experiments. In: *Community Ecology* (ed. A. Hastings), pp. 38-54. Springer-Verlag, New York.

Keesing F., 1998. Impacts of ungulates on the demography and diversity of small mammals in Central Kenya. *Oecologia,* 116, p. 381-389.

Kirkland P.H., 2002. Endangered butterflies and moths of Scottish woodlands. *Scottish Forestry*, 56: 21-28.

Kolasa J. and Rollo C.D., 1991. The heterogeneity of heterogeneity: a glossary. In: *Ecological Heterogeneity*, Kolasa & Pickett (eds), Springer-Verlag, New-York, p. 1-23.

Krauss J., Steffan-Dewenter I. and Tscharntke T., 2004. Landscape occupancy and local population size depends on host plant distribution in the butterfly *Cupido minimus. Biological Conservation*, 120: 355-361.

Lavorel S., 1999. Ecological diversity and resilience of Mediterranean vegetation to disturbance. *Diversity and Distribution* 5:3-13.

Lubin Y., Angel N. and Assaf N., 2010. Ground spider communities in experimentally disturbed Mediterranean woodland habitats. *Arachnologische Mitteilungen* 40: 85-93.

Lunt I.D., 2005. Effects of stock grazing on biodiversity values in temperate native grasslands and grassy woodlands in SE Australia: A literature Review. Technical Report 18. Environment ACT, Canberra.

McIntyre S., Heard K.M and Martin T.G., 2003. The relative importance of cattle grazing in subtropical grasslands – does it reduce or enhance plant biodiversity? *Journal of Applied Ecology*. 40: 445-457.

Meuret M., 1997. How do I cope with that bush? Optimizing less palatable feeds at pasture using the MENU model. *Options Méditerranéennes* : Série A (34), p. 53-57.

Mouillot F., Rambal S. and Joffre R., 2002. Simulating climate change impacts on fire frequency and vegetation dinamics in a Mediterranean-type ecosystem. *Global Change Biology*. 8: 423-437.

Naveh Z., 1994. The role of fire and its management in the conservation of Mediterranean ecosystems and landscapes. In: *The Role of Fire in Mediterranean-type Ecosystems*, J.M. Moreno and W.C. Oechel (eds). Springer-Verlag, New York.

Osem Y., Lavi A. and Rosenfeld A., 2011. Colonization of *Pinus halepensis* in Mediterranean habitats: consequences of afforestation, grazing and fire. *Biol. Invasions*. 13: 485-498.

Ostfeld R.S., Pickett S.T.A., Shachak M. and Likens G.E., 1997. Defining scientific issues. Pages 3-10 in Pickett STA, Ostfeld RS, Shachak M, Likens GE, eds. *The Ecological Basis for Conservation: Heterogeneity, Ecosystems, and Biodiversity*. New York: Chapman and Hall.

Pausas J.G. and Vallejo R., 1999. The role of fire in European Mediterranean ecosystems. In: Chuvieco, E. (Ed.), *Remote Sensing of Large Wildfires in the European Mediterranean Basin*. Springer Verlag, New York, p. 3-16.

Perelberg A., 2011. Data Analysis of Chucker and Gazelle surveys at Ramat Hanadiv between 2003-2009 by distant sampling method. Internal report. Ramat Hanadiv Nature Park (In Hebrew).

Perevolotsky A. and Seligman N.G., 1998. Role of grazing in Mediterranean rangeland ecosystems – Inversion of a paradigm. *BioScience*. 48 (12): 1007-1017.

Richman L.H., 1993. Diet selection by conditioned and unconditioned goats in the Sagebrush steppe of Eastern Oregon. A thesis submitted to Oregon state university.

Rook A.J., Dumont B., Isselstein J., Osoro K., Wallais DeVeries M.F., Oarente G. and Mills J., 2004. Matching type of livestock to desired biodiversity outcomes in pastures – A review. *Biological Conservation* 119: 137-150.

Rosenfeld A., Haim A., Perevolotsky A. and Yonatan R., 2004. The importance of grass height to hiding small mammals in Mediterranean habitat, preliminary results. Proceedings 10th MEDECOS – International conference on Ecology, Conservation and Management of Mediterranean climate ecosystems, Rhodes Island, Greece, 2004.

Schmidt N.M. and Olsen H., 2003. The response of small mammal communities to cattle grazing on a coastal meadow. *Polish Journal of Ecology*, 51, p. 79-84.

Schwartz-Tzachor R., 2007. Multi-factorial analysis of a butterfly community used as a bioindicator for anthropogenic activity and habitat quality in Ramat Hanadiv Nature Park. Thesis submitted for the degree of PhD. University of Haifa Faculty of Sciences and Science Education Department of Evolutionary and Environmental Biology.

Segal E., Carmel Y., Unger E.D., Landau S.Y., 2014. Modeling spatial distribution of goat grazing as a fuelbreak management tool in Mediterranean ecosystems (in publication at this meeting).

Shachak M., Boeken B., Groner E., Kadmon R., Lubin Y., Meron E., Ne'eman G., Perevolotsky A., Shkedy Y. and Ungar E.D., 2008. Woody Species as Landscape Modulators and Their Effect on Biodiversity Patterns. *BioScience*, 58(3): 209-221.

Shure D.J. and Phillips D.L., 1991. Patch Size Of Forrest Openings And Arthropod Population, *Oecologia*, 86 (3): 325-334.

Silanikov N., Gilboa N., Nir I., Perevolotsky A. and Nitzan Z., 1996. Effect of a Daily Supplementation of Polyethylene Glycol on Intake and Digestion of Tannin-Containing Leaves (Quercus calliprinos, Pistacia lentiscus, and Ceratonia siliqua) by Goats. *Agric. Food Chem., 44* (1), p. 199-205.

Silanikov N., Gilboa N., Pervolotsky A. and Nitzan Z., 1996. Goats fed tannin-containing leaves do not exhibit toxic syndromes. *Small Ruminant Research* 21: 195-201.

Stalmans M., Balkwill K., Witkowski E.F.T. and Rogers K.H., 2001. A landscape ecological approach to address scaling problems in conservation management and monitoring. *Environmental Management* 28: 389-401.

Torre I., Dias M., Martinez-Padilla J., Bonal R., Vinulea J. and Fargallo J.A., 2007. Cattle grazing, raptor abundance and small mammal communities in Mediterranean grasslands. *Basic and Applied Ecology* 8: 565-575.

Turner M.G., 1989. Landscape ecology: the effect of pattern on process. *Annu Rev Ecol Syst* 20: 171-197.

Ueckert D.N., Whisenant S.G. and Owens M.K., 1997. Juniper control and management.1997 Juniper Symposium Proceedings. College Station, TX: Texas Agricultural Experiment Station. Vol. 5. No. 5.34. 1997.

Wiens J.A., 1974. Habitat heterogeneity and avian community structure in North American grassland birds. *American Midland Naturalist* 91: 195-213.

Wiens J.A., 1997. The emerging role of patchiness in conservation biology. In Pickett, S.T.A., Ostfeld, R.S., Shachak, M., Likens, G.E. eds. *The Ecological Basis for Conservation: Heterogeneity, Ecosystems, and Biodiversity*. New York: Chapman and Hall.

Wiens J.A., 1989. Spatial scaling in ecology: Essay review. *Functional Ecology* 3: 385-397.

Yates C.J., Norton D.A. and Hobbs J., 2000. Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology*, 25, p. 36-47.