Forest Ecology and Management 419–420 (2018) 160–169

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Cattle foraging in Mediterranean oak woodlands – Effects of management practices on the woody vegetation

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ARTICLE INFO

Keywords:
Animal density
Biomass removal
Cattle foraging
Mediterranean oak woodland
Quercus calliprinos
Sustainable management

ABSTRACT

Vegetation structure and composition of woodlands in the Mediterranean Basin have experienced extensive land-use change during recent decades. Decline in traditional foraging by goats is leading to more closed and spatially homogeneous woody vegetation, reduced plant diversity, and increased fire risk because of accumulation of inflammable material. We studied the use of cattle foraging as an alternative to goat foraging in Mediterranean oak woodlands. Our main goal was to provide basic information on the responses of woody vegetation to cattle foraging intensity, and on the factors affecting spatial patterns of woodland utilization. We conducted the study in the Western Galilee, Israel, in oak woodland dominated by Palestine oak (*Quercus calliprinos* Webb.) interspersed with patches of shrubs and herbaceous vegetation. Effects of two animal population densities, moderate (0.33 cow·ha^{-1}) and high (0.55 cow·ha^{-1}), on the structure, composition, and regeneration potential of dense and of open woody formations were examined. Four consecutive annual seasons of cattle foraging resulted in relatively large amounts of woody vegetation removal, especially under high animal density, but had no negative effects on woody species richness or regeneration potential from saplings. The type of vegetation formation and initial state of the woody vegetation were important factors affecting the degree of change. Woody biomass removal by cattle, as shown in this study, can reduce fire hazards and increase vegetation heterogeneity and plant diversity. These findings support the use of cattle as an efficient alternative tool for multi-purpose, sustainable management of Mediterranean oak woodlands.

1. Introduction

Sustainable utilization of woodlands presents a major challenge worldwide. Mediterranean evergreen oak woodlands have been exploited since historical times for foraging by domestic herbivores, mostly goats (Papanastasis, 2009; Perevolotsky and Seligman, 1998). Browsing has shaped an open structure of the woody vegetation, and contributed to its maintenance, resulting in a more heterogeneous landscape with higher biodiversity (Casasus et al., 2007; Henkin, 2011). In recent decades, however, woodlands worldwide, including those around the Mediterranean Basin, are undergoing extensive land-use transition, which causes large-scale changes in the structure and composition of the vegetation (Lopez-Sanchez et al., 2014; Plieninger et al., 2011; Underwood et al., 2009). In the Mediterranean region, these changes are mainly due to decreases in wood-cutting for firewood and charcoal, and to traditional foraging by goats, which have led to a more closed and spatially homogeneous woody-vegetation structure, thus reducing plant diversity and increasing the risk of fire due to accumulation of inflammable material (Bartolome et al., 2011; Carmel and Kadmon, 1999; Henkin, 2011; Perevolotsky and Seligman, 1998). In parallel, the increasing demand for cattle meat in the region has been constrained by the limited availability of herbaceous rangelands for cattle grazing. This current situation has spurred interest in using Mediterranean woodlands for cattle foraging.

In recent years, traditional goat herding which contributed effectively in shaping oak woodlands have been replaced by cattle herds

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https://doi.org/10.1016/j.foreco.2018.03.017
Received 17 January 2018; Received in revised form 4 March 2018; Accepted 12 March 2018

with the aim of increasing beef production (Bashan and Bar-Massada, 2017; Casasus et al., 2007; Henkin, 2011). However, unlike goats which are adapted to browsing in Mediterranean woodlands, the woody vegetation is considered unsuitable for cattle because of its poor nutritional quality, partly caused by its high tannin content (Papachristou et al., 2005; Perevolotsky et al., 1993). Nevertheless, field observations of cattle foraging in oak woodlands showed that, in addition to herbaceous vegetation, the animals consumed tree foliage and young twigs, as well as oak acorns during fall (October–December) (Bartolome et al., 2011; Brosh et al., 2006). Moreover, a detailed study of diet composition and energy balance of beef cattle foraging in Mediterranean woodland, with moderate supplemental feed during the dry season, showed that their performance was comparable with that of cattle grazing in grasslands in the same region (Brosh et al., 2006; Henkin et al., 2005). However, the low accessibility of the closed woody vegetation to cattle, together with poor productivity of the herbaceous understory vegetation and the generally difficult topographic conditions in woodland areas, make their use for cattle more problematic and less attractive. Moreover, the relationships between cattle foraging intensity and the spatial heterogeneity of the woody vegetation have not been assessed quantitatively. A better understanding of the way cattle consume woody vegetation should contribute to more efficient use and management of Mediterranean woodlands.

Domestic herbivores vary in their impact on the vegetation, depending on factors related to: (i) animals' characteristics, such as eating technique, food preferences and body size (Arnold, 1981; Rook and Tallowin, 2003), (ii) vegetation structure and composition, nutritional quality, and anti-herbivory defenses (Marquardt et al., 2009, 2010; Provenza, 1995), and (iii) environmental factors, including seasonal conditions and topography (Delcurto et al., 2005; Guevara et al., 1996). These factors have major impacts on the spatial distribution of cattle foraging in the woodland (Schoenbaum et al., 2017) and on the dietary choices of the animals; thus they influence plant growth, sapling establishment, vegetation structure and diversity (Arnold, 1981; Perevolotsky and Seligman, 1998). Livestock can affect woody species by browsing, trampling, fertilizing with excreta, or grazing the herbage and modifying competitive relationships between herbaceous and woody vegetation (McEvoy et al., 2006; Papachristou and Platis, 2011). High foraging intensity, beyond the carrying capacity of the woodland, might damage the woody vegetation, thereby negatively affecting species richness and vegetation composition (Chaideftou et al., 2011; Gill, 1992). Moreover, recruitment failure might threaten the continuity and sustainability of the woodland (Dufour-Dror, 2007; Plieninger et al., 2011; Tyler et al., 2008). Thus, foraging intensity should be adjusted to the availability of tree and shrub species that are of high preference for the cattle, while remaining low enough to allow woodland regeneration, in order to prevent large changes in vegetation composition (Evlagon et al., 2010; Marquardt et al., 2009). Furthermore, appropriate management of the woodland is required to provide other ecological services such as biodiversity conservation, recreation, and landscape diversity, in addition to animal production. Thus, there is an urgent need for better understanding of the impact of cattle foraging on Mediterranean woodlands – which will enable land managers to choose a suitable management strategy for improving cattle performance while minimizing damage to the vegetation; thereby, conflicts between conservation and cattle herding interests should be mitigated.

Thus, the main goal of our present study was to provide essential information on the responses of woody vegetation to cattle foraging in Mediterranean oak woodlands, and on the factors affecting spatial patterns of woodland utilization. Mediterranean oak woodlands are characterized by a complex multilayered structure and consist of a mosaic of various vegetation types, ranging from dense woodland to garrigue formations with low tree densities (Papanastasis, 2009). Cattle that forage in these vegetation formations spend much of their time in woody ranges that provide both food and shade, particularly during the dry season in summer and early fall, when the woody vegetation provides most of the available forage (Schoenbaum et al., 2017). Therefore, in the present study we focused on the impact of cattle foraging on the woody components of both the dense and the open woodland formations. Specific objectives were: 1) to quantify changes in the structure, composition, and regeneration potential of different types of woody vegetation, in response to two animal population densities; 2) to assess the main factors affecting the way cattle utilize the woody vegetation; and 3) to assess the suitability of foraging management for improving both the use and conservation of Mediterranean woodlands.

2. Methods

2.1. Study area

The research was conducted during 2007–2011 at the Hatal Experimental Farm in Western Galilee, Israel (long. 35°15′, lat. 33°01′), described in detail by Henkin et al. (2005). The site is 400–500 m a.s.l. and comprises moderate to steep slopes of up to 40°. Limestone and dolomite rocks form 15–40% of the surface cover; they are interspersed with pockets of terra rossa soil, up to 40 cm in depth. The climate is typically Mediterranean, with mild winters and hot, dry summers. The long-term average (± SD) rainfall during the hydrological year (from October 1st to September 30th) is 796 ± 201 mm, most of which falls from November through March. The annual rainfall during the study period was: 735, 535, 607, 797, and 895 mm for hydrological years 2006/7, 2007/8, 2008/9, 2009/10, and 2010/11, respectively. The average, minimum, and maximum ambient temperatures during the experimental period were 19.5, 8.3, and 35.5 °C in spring (March–April); 27.8, 18.8, and 38.8 °C in summer (July–August); and 23.2, 13.4, and 37.5 °C in fall (October–November).

The dominant vegetation is scrub-oak Mediterranean woodland with dominant species *Quercus calliprinos* Webb, *Phillyrea latifolia* L., *Laurus nobilis* L., and *Rhamnus lycioides* (Boiss. et Reuter) Tutin, interspersed with garrigue vegetation comprising shrubs and dwarf shrubs, mainly *Calicotome villosa* (Poiret) Link, *Sarcopoterium spinosum* (L.) Spach., *Cistus salvifolius* L. and *C. creticus* L. The vegetation structure at the site comprises patches of dense and open woodland. Herbaceous vegetation occurs in open patches within the woody vegetation matrix, and provides three to four months of high-quality herbage during winter and spring (January–April). The area was under very sparse, sporadic foraging before the beginning of the experiment.

2.2. Experiment design and cattle herd

Treatments were two animal population densities, moderate and high relative to common practice, of 0.33 and 0.55 cow·ha^{-1} respectively. The treatments were applied in two separate, fenced adjacent paddocks. Each treatment had a total area of 106 ha with 35 and 59 cows in the moderate and high density treatment, respectively. The animals were a herd of 94 Baladi (local breed × Hereford) cows aged 3–12 years, of average body weight 502 ± 9 kg, and of fair-to-good body condition after calving – at least 2.5 according to the scale (1–5) of Edmonson et al. (1989). The cows were randomly allocated to paddocks for the duration of the experiment, the single constraint being balance according to age. Animals were classified in three age groups (3–4, 5–9 and > 9 years old) and the same proportion of each group was allocated to each treatment. Calving occurred predominantly during November through March, and the calves were weaned in early June. The average annual calving and weaning rates were 85 ± 3% and 76 ± 3%, respectively.

The cattle grazed in the paddocks during four annual seasons (2007–2011). Following early-season grazing deferment, the cows entered the paddocks in spring (mid-March) and foraged through fall (mid-November) in accordance with vegetation conditions; they averaged 260 foraging days per year. They had continuous access to water