

## Herbivore species and grazing intensity regulate community composition and an encroaching woody plant in semi-arid rangeland

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### Abstract

Grazing by livestock can influence ecosystems in various ways, including altering plant communities, influencing woody plant encroachment, and determining livestock productivity. Evaluating long term effects of grazing on plant composition is valuable not only to understand herbivory on rangelands but to be able to address the primary factors that can threaten long term livestock productivity. We examined plant species composition and woody plant encroachment 45 years after the initiation of differing grazing treatments within a semiarid savanna of the southern Great Plains, USA. Grazing treatments varied in herbivore type (domestic cattle, sheep, and goats vs. goats only) and grazing intensity (heavy, moderate, and no-herbivory). All individual trees of *Juniperus ashei* Buchholz, the encroaching woody plant of the area, were removed prior to treatment initiation. Moderate and heavy grazing by a combination of species resulted in similar plant communities, while a history of heavy browsing by goats only and no-herbivory resulted in more distinct communities. Cover of *J. ashei* did not differ between mixed grazing and no-herbivory treatments, indicating that grazing was not responsible for woody plant encroachment. *J. ashei* cover within the browsed treatment was a third less compared to other treatments; compositional differences within this treatment are possibly due to reduced cover of woody vegetation. Declines in livestock productivity of the area are likely related to compositional changes resulting from increased woody plants. Livestock production within this semi-arid rangeland is likely unsustainable without management of woody plant encroachment, as communities tend to a closed canopy woodland.

### Zusammenfassung

Die Beweidung durch Viehbestände kann Ökosysteme in verschiedenster Weise beeinflussen, z.B. indem die Pflanzengemeinschaften verändert werden, die Einwanderung von holzigen Pflanzen beeinflusst oder die Produktivität des Viehbestandes bestimmt wird. Die Bewertung von Langzeiteffekten der Beweidung auf die Pflanzenzusammensetzung ist von Wert, nicht nur um Herbivorie auf Weideland zu verstehen, sondern auch um die primären Faktoren ansprechen zu können, die eine langfristige Produktivität der Viehbestände gefährden können. Wir untersuchten die Zusammensetzung der Pflanzenarten und die Einwanderung von holzigen Pflanzen 45 Jahre nach dem Beginn von verschiedenen Beweidungsformen in einer semiariden Steppe der südlichen Great Plains, USA. Die Beweidungsformen unterschieden sich im Herbivorentyp (Hausrinder, Schafe und Ziegen vs. nur Ziegen) und Beweidungsintensität (hoch, mittel und keine Herbivorie). Jeder individuelle Baum von *Juniperus ashei* Buchholz, der invasiven holzigen Pflanzenart in diesem Gebiet, wurde zu Beginn der Untersuchung entfernt. Mittlere und

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starke Beweidung durch eine Kombination von Arten führte zu ähnlichen Pflanzengemeinschaften, während eine anfänglich starke Beweidung durch ausschließlich Ziegen und keine Beweidung zu stärker voneinander unterschiedenen Gemeinschaften führte. Der Deckungsgrad von *J. ashei* unterschied sich nicht zwischen gemischter Beweidung und Ausschluss von Beweidung und zeigte, dass die Beweidung für die Einwanderung holziger Arten nicht verantwortlich ist. Der Deckungsgrad von *J. ashei* war nach der Beweidung durch Ziegen um ein Drittel kleiner als bei anderen Behandlungen und die Unterschiede in der Zusammensetzung innerhalb dieser Behandlung können möglicherweise auf eine verringerte Deckung der holzigen Vegetation zurückgeführt werden. Die Abnahme der Produktivität der Viehbestände in diesem Gebiet ist wahrscheinlich mit den Veränderungen in den Zusammensetzungen verbunden, die aus der Zunahme der holzigen Pflanzen folgt. Die Viehproduktion in diesen semiariden Weideländern ist wahrscheinlich ohne ein Management der Einwanderung der holzigen Pflanzen nicht nachhaltig, da sich die Gemeinschaften zu einem Wald mit geschlossenem Dach entwickeln.

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## Introduction

While grazing can be important in shaping and maintaining grasslands and savannas (van Langevelde et al. 2003), the type, intensity, and impact of herbivory can differ across ecosystems and management approaches (Milchunas, Sala, & Lauenroth 1988). Grazing by domestic livestock for agricultural purposes can affect an ecosystem in many different ways, including altering plant community composition and diversity (Belsky 1992; Augustine & McNaughton 1998). Though often studied as a binary response (grazed vs. ungrazed), grazing effects are not exclusively regulated by simple defoliation, but influenced by many factors, including number of animals, species, and resource availability (Allred, Fuhlendorf, & Hamilton 2011). For example, vegetation composition and diversity are influenced by differences in dental and digestive anatomy, as well as body size, among types and breeds of livestock (Rook, Dumont, Isselstein, Osoro, & WallisDeVries 2004). In addition to changes in species composition, grazing can also alter the spatial heterogeneity of vegetation (Adler, Raff, & Lauenroth 2001), which is critical for biodiversity and ecosystem function (Wiens 1997). Selective or patch grazing by moose in boreal forest (Pastor, Dewey, Moen, Mladenoff, & White 1998) and domestic livestock in tallgrass prairie (Fuhlendorf & Engle 2004) resulted in greater spatial heterogeneity of vegetation.

In many grazing ecosystems around the world, the dominance of woody plants is increasing (Scholes & Archer 1997). These changes have consequences for plant composition, forage production, biodiversity, soil erosion, and hydrologic and carbon cycle impacts (Jackson, Banner, Jobbagy, Pockman, & Wall 2002). Though grazing by domestic livestock is an often presumed mechanism of woody encroachment (Archer 1994), variable grazing pressures, woody plant longevity, and lack of long term manipulations or observations make it difficult to evaluate the effect of livestock grazing on woody plant encroachment (Browning & Archer 2011). Accounting for these factors will aid in understanding the effects of grazing on woody plant abundance.

Livestock production is a common and important economic practice on rangelands worldwide. Changes in plant

communities and woody plant abundance can ultimately regulate livestock productivity (Burrows, Carter, Scanlan, & Anderson 1990). Examining grazing effects on plant composition and, in turn, the consequences of these changes for livestock productivity, is necessary in evaluating the long term sustainability of livestock production. The Edwards Plateau, located within the southern Great Plains, USA, is well suited to assess the influence of grazing on vegetation dynamics in light of livestock productivity. Since the early 1900s, livestock production within areas of this region has steadily declined from 0.67 animal units (AU) ha<sup>-1</sup> in 1903 to 0.10 AU ha<sup>-1</sup> in 1997 due to reduced carrying capacity (Appendix A, Fig. 1; Smeins, Fuhlendorf, & Taylor 1997; Walker, Johnson, & Taylor 2005). Evaluating long term changes in vegetation resulting from grazing may identify mechanisms that contribute to the decline of livestock productivity.

In this paper we test the assumptions that grazing intensity and herbivore species alter plant community composition and determine the extent of woody plant encroachment. Our overall objective is to determine the long term effect of grazing on vegetation dynamics in the absence of fire. To do so, we analyze vegetation data collected in 1993, 45 years after the establishment of mixed species grazing treatments. We show that in the semiarid savannas of the Edwards Plateau, heavy and moderate mixed species grazing does not increase woody plant abundance and that the direct effects of grazing on plant composition are dependent on herbivore species and grazing intensity, and are primarily through the regulation of woody plant encroachment.

## Methods

We conducted this study at the Texas A&M Sonora Research Station (30°16'0.1992" latitude, -100°33'55.1052" longitude), located within the Edwards Plateau of the southern Great Plains, USA. Annual precipitation averages approximately 600 mm; it is bimodal with largest amounts occurring in the spring and fall. Dominant herbaceous species include *Hilaria belangeri* (Steud.) Nash

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