Notas Técnicas

How do monitoring cattle movement in a mosaic of wooded and open areas using GPS in conjunction with GIS?

¿Cómo monitorear el movimiento del ganado en un mosaico de áreas boscosas con GPS en combinación con SIG?

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Resumen

El manejo de bosques de Piñon-Juniper (PJ) ocupa más de 30 millones de hectáreas en el oeste de Estados Unidos. Este ecosistema constituye un importante recurso para la producción y conservación de vida silvestre. Sin embargo, estos han cambiado considerablemente los últimos 30 años, principalmente para manejar ganado en pastoreo. El objetivo fue determinar la cobertura de dosel (TCC) y monitorear, durante la primavera, el uso del ganado del paisaje arbolado. El estudio se realizó en una pastura de 146 ha de la zona central de Nuevo México. La TCC de PJ se determinó a partir de ortofotos digitales recientes usando Feature Analyst® para ArcGIS® 9.1. El sitio de estudio fue segmentado en celdas de 1 ha para mapear cobertura arbórea. Ocho vacas, equipadas con GPS, fueron rastreadas durante 31 días a intervalos de 5 min. Una sección de la pastura con cobertura arbórea mayor que 30 % se utilizó para describir la relación distribución de pastoreo y cobertura de dosel. Se encontró una relación exponencial negativa significativa entre TCC y el uso relativo del ganado (y = 450,41e-12,329x). La cubierta arbórea explicó 50,1 % de la variación en la utilización relativa por el ganado de las celdas. La mayoría de las posiciones animales registradas en áreas dominadas por PJ ocurrieron en celdas con 30-50 % de TCC. Una cobertura del dosel de 50 % podría proporcionar un equilibrio adecuado entre la permanencia y el consumo de forraje para el ganado durante la primavera.

Palabras clave: biodiversidad, dosel, comportamiento animal, ganadería, refugio.

Abstract

Management of Piñon-Juniper (PJ) woodlands occupies more than 30 million ha in the USA. This ecosystem constitutes important resources to production and wildlife conservation. However, they have changed considerably during last 30 years, mainly to handle cattle in grazing systems. The aim of this study was to determine canopy cover (TCC) and monitor, during the spring, livestock use of woodland landscapes. The study was conducted on a pasture of 146 ha ocated in central New Mexico. PJ TCC was determined from recent digital orthophotos using Feature Analyst® for ArcGIS® 9.1. The study site was segmented into a 1 ha grid cell lattice and canopies within grid cells were mapped. Eight cows equipped with GPS collars were tracked during 31 days at 5-min intervals. The number of cow GPS positions in each grid cell was counted. A subset of intact woodland grid cells containing cow locations (approximately 62% of these occurred in wooded areas) was used to describe the relationship between cattle spatial distribution and PJ canopy cover. We found a significant negative exponential relationship between TCC and relative use of grid cells by cattle (y=450,41 e -12.329 x). Tree cover explained 50.1% of the variation in relative use by cattle of the 1 ha woodland grid cells. Most cow positions recorded in PJ-dominated areas occurred in grid cells with 30-50% TCC. Our data suggest that PJ woodlands with up to 50% canopy cover could provide an adequate balance of shelter and forage for cattle during spring.

Keywords: biodiversity, canopy, animal behavior, livestock, shelter.

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Cattle move to graze selectively when confront environments that differ in plant species composition and preference. According to the "satiety hypothesis" (Provenza et al., 2007) the selection for complementary pasture items is consequence of sequential hunger-satiety events to specific nutrients (i.e. too high or low energy or protein) or plants (i.e. behavioral satiety). Cattle seek for plants that nutritionally complement and move between distant feeding sites of a pasture when familiar choices are available (Bailey and Provenza, 2008). Indeed, managing grazing-distribution patterns require knowledge of pasture characteristics and animal behavior patterns (Launchbaugh and Howery, 2005). In addition, behavioral patterns result from recognizable processes that include inherited attributes, individual and social learning systems, cue-consequence specificity, predispositions toward novel stimuli, and spatial memory. Cattle develop temporal patterns of preferences and use spatial memory (Launchbaugh and Howery, 2005; Chapman et al., 2007).

The behavior of cattle, as to the location near or far away in distance relative to trees, possibly is related to the available food, but also it could be influenced by the shade provided by the canopy (Zuo and Miller-Goodman, 2004; Nielsen, et al., 2009), however, under others weather conditions that behavior could vary. Others authors report a preference selection patterns differed markedly between the landscape and plot scales. At the landscape scale, forage use was related to abiotic factors, primarily slope but also distance to water and a preference for grasslands with little tree cover (Tomkins and Filmer, 2007; Nielsen et al., 2009; Kaufmann et al., 2013).

Global Positioning System (GPS) tracking collars have been incorporated in research on the ecology and management of grazing systems using cattle (Turner et al., 2000; Ganskopp, 2001). In addition, using GPS units in conjunction with Geographic Information Systems (GIS), grazing distribution and animal movement can be related to landscape features (Ungar et al., 2005), also the improved GPS-based animal tracking system has been used to conduct ecological research, range livestock production, and natural resource management (Klarck et al., 2006).There are different studies to evaluate the potential of Lotek GPS collars to predict activity of beef cattle on extensive rangeland in contrasting foraging environments (Ganskopp 2001; Rubio et al., 2008; Ungar et al., 2005). Based on these studies, we conducted a study to determine tree canopy cover (TCC) and monitored cattle use of PJ woodland during spring in a 146 ha pasture at a site in central New Mexico (USA), using GPS units in conjunction with Geographic Information Systems (GIS).

Materials and Methods

The use of GPS and activity sensors to discriminate foraging activities of cattle grazing a rangeland was used to understand relationships among tree canopy cover (TCC) and cattle use of Piñon-Juniper (PJ) woodland during spring in a 146 ha pasture at a site in central New Mexico. Analysis were conducted at the New Mexico State University in the spring of 2008, using the data base of monitoring of tree canopy cover (TCC) and cattle use of PJ woodland on Corona Range and Livestock Research Center (CRLRC) in the spring of 2004 and 2005. The CRLRC (lat 34u159360N, long 105u249360W) has an average elevation of 1.900 m and is located approximately 22,5 km east of the village of Corona, New Mexico. Mean annual precipitation is 400 mm, most of which occurs in July and August as high-intensity, short duration, convectional thunderstorms (Rubio et al., 2008).

The pasture were used for this study had an area of approximately 146 ha consisting of 55% open shortgrass steppe with interspersed juniper saplings and 45% PJ woodland (piñon pine (Pinus edulis Engelm) and one-seed juniper (Juniperus monosperma Engelm Sarg) woodland. The predominant understory grasses are blue grama (Bouteloua gracilis Willd. ex Kunth Lag. ex Griffiths), wolftail (Lycurus phleoides Kunth), threeawns (Aristida spp. L), sideoats grama (B. curtipendula Michx Torr.), and sand dropseed (Sporobolus cryptandrus Torr A. Gray) (Rubio et al., 2008). Topography was flat to gently sloping. There was one drinking water location on the far west end of this pasture, with no other ephemeral water sources.

Piñon-Juniper TCC was determined from recent digital orthophotos QuickBird using Feature Analyst® for ArcGIS® 9.1. Estimation of the tree cover was made with Feature Analyst ® for ArcGIS ® 9.1 by mean polygons, after that, polygons were represented by points (1x1 m) made with Hwths Tools for ArcGIS ® 9.1. Thus, study site was segmented into a 1 ha grid cell lattice and all tree and sapling canopies within grid cells were mapped. It was a facility to estimate tree cover per ha counting points in each cell.

Eight cows (predominantly of Angus breeding with some Hereford and Simmental influence) equipped with GPS collars (Lotek 3300, Newmarket, ON, Canada) configured to record and store position, were tracked during 31 days at 5-min intervals

(Figure 1). All collared cows grazed together with a herd of young mother cows (77 in 2004 and 88 in 2005). Thus, pastures were moderately stocked (4,5 ha /AU/ 60 d) in both years (Rubio et al., 2008).

Figure 1. Cows Angus breeding x Hereford and Simmental equipped with GPS collars (Cibils, 2008).

The number of cow GPS positions in each grid cell was counted. A subset of intact woodland grid cells containing cow locations was used to describe the relationship between cattle spatial distribution and PJ canopy cover.

Data analysis

The relationship between tree cover and animal movement was examined with multiple regression analysis using Infostat (Di Rienzo et al., 2008)

Results and discussion

The tree canopy cover oscillated in a gradient between <10% and >80%, where 61% had more than 30% of tree cover (Figure 2).

A total amount of 71.242 positions of cows were recorded with GPS, approximately 62% of these occurred in wooded areas (Figure 3). At respect, Tucker et al., (2008) showed that cows were more likely to use shade that provided more protection from solar radiation. They found a positive relationship between shade use and ambient solar radiation. However, others studies suggest a marked preference for grasslands with little tree cover, because the cattle select habitats that provide greater availability of biomass (Kaufmann et al., 2013).

We found a significant negative exponential relationship between TCC and relative use of grid cells by cattle (y=450,41 e -12.329 x). Tree cover explained 50,1% of the variation in relative use by cattle of the 1 ha woodland grid cells (Figure 4b).

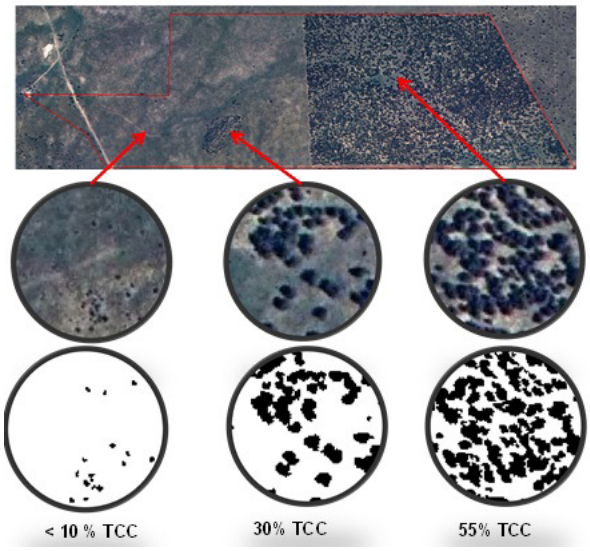

Figure 2. Different Tree Cover Canopy (TCC) modeled with Feature Analyst® based on digital orthophotos of Horse pasture, Corona Ranch, New Mexico. (Source: this research orthophotos QuickBird)

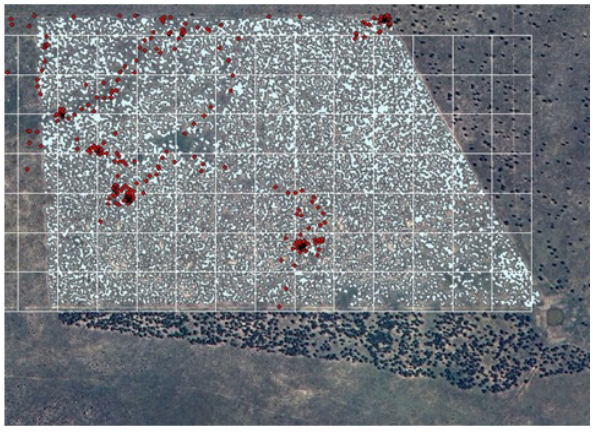

Figure 3. TCC modeled and animal positions per ha on wooded grid cells of Horse pasture, Corona Ranch, NM. (Source: This research based on orthophotos QuickBird)

Most cow positions recorded in PJ-dominated areas occurred in grid cells with 30-50% TCC, possibly it is related to the available food (Zuo and Miller-Goodman, 2004), because intermediate cleared areas constitute an ecotone, it represent an intermediate disturbance, where habitats have maximal species richness and diversity. Thus, richness of species could be attractive for the cows. On the contrary, on totally cleared areas (intensive disturbance) may results in patches that are initially occupied by a few low-successional plant species (Connell, 1978).

Intermediate disturbance may provide a conceptual model on which to plant woody control in a manner that maintains or results in an increase in plants and vertebrate species richness and diversity, while increasing forage for livestock and wild ungulates (Fukbright, 1996).

A sharp decline in woodland use occurred beyond an apparent threshold of 55% TCC. Our data suggest that PJ woodlands with up to 50% canopy cover could provide an adequate balance of shelter and forage for cattle during spring at our site (Figure 4a).

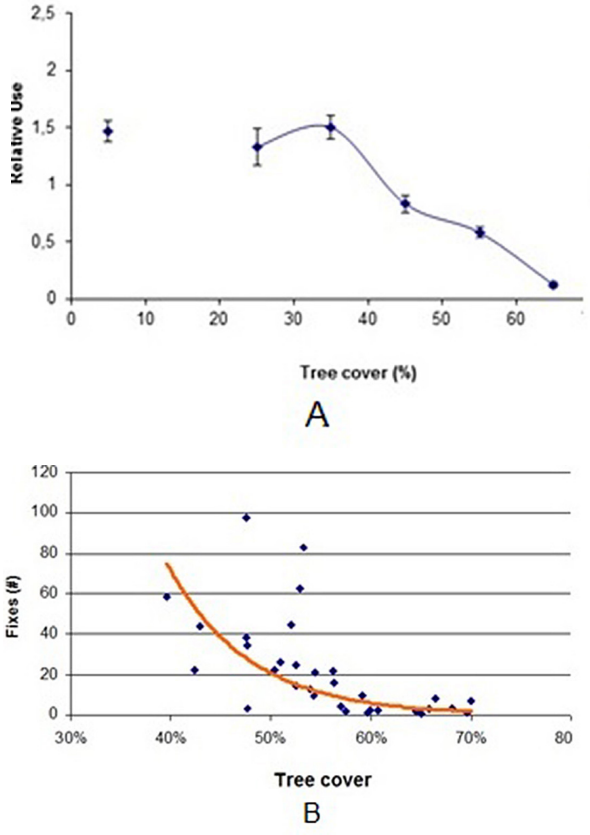

Figure 4. Use related to tree cover (a) and relationship between animal fixes and TCC (b)

The studied cow behavior is consistent with that expressed in different studies (McNaughton, 1983; Tomkins and Filmer, 2007; Nielsen et al., 2009; Kaufmann et al., 2013) which argue that in habitats for grazing and browsing by large herbivores have a predilection for areas with scattered trees in relatively open landscapes.

By observations, we detect in sprint 2008 dominance of Aristida spp and Bouteloua gracilis in cattle diets. It was confirmed by Rubio et al. (2008). Others studios have reported a wide species diversity in range and wooded lands, 138 species we observed across all study sites, 14 were perennial grasses representing 10 genera; 27 shrub species we encountered represent nine families and 16 genera and forb species richness was more variable among shrubland sites than among woodland sites (Kitchen et al.,1999)

Conclusions

An improved GPS-based animal tracking system is needed to meet quickly evolving demands of ecological research and range livestock production. PJ woodlands appear to play an important role in providing shelter for cattle, particularly in areas with 30-50% TCC where forage availability is well supplied. Further research is needed to determine the agroforestry design that would provide the optimal mix of forage and shelter conditions. In addition, the hypothesis that a mosaic of wooded and open areas constitutes a plant community mix able to provide forage and thermoregulation needs of cattle in rangelands should be addressed in future studies.

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