TABLE 1. Abundance of *Astronium graveolens* and other tree species in canopy and understory of four 40 x 50 m transect plots in tropical dry forest.

Tree species	Numbers		
	canopy	understory	total
A. graveolens	13 (65%)	7 (35%)	20 (11%)
Other	44 (28%)	110 (71%)	155 (89%)
Total	57 (33%)	117 (67%)	174 (100%)

TABLE 2. Number and frequency of trees by "species" and height strata containing active termite trails or no active trails in 25 x 25 m quadrats.

	Number of Trees		Total
	With no active trail	With active trail(s)	
Canopy (total)	12 (21%)	45 (79%)	57 (100%)
A. graveolens	5 (38%)	8 (62%)	13 (23%)
Other	7 (6%)	37 (84%)	44 (77%)
Understory (total)	1 (1%)	116 (99%)	117 (100%)

est floor and access to nearby trees. Furthermore, the relative importance of these factors could change from the dry season to the wet season. We noted that some termite nests located at or near ground level were unoccupied, which might be explained by termites shifting from high nests in the dry season to lower nests in the wetter parts of the year. Further studies of termite nests during the wet season could provide evidence for such seasonal migrations. Such changes in termite distribution, if they occur, have the potential to affect other aspects of the tropical dry forest. For example, the abundance of dead wood and distribution of termite predators could change depending on where termites locate their nests.

In addition to a preference for canopy trees, termites also seemed to show a preference for building trails on *A.graveolens* (Fig. 2). There are several possible explanations for this preference. Since *A.graveolens* make up a substantial portion (23%) of the canopy trees and since 65% of *A.graveolens* reach the canopy, termites looking for a high nest site would do well to utilize this species of tree. A selection bias of *A. graveolens* by the termites would increase the colony's probability of colonizing a canopy tree if high nest sites are more successful or survive longer. *A.graveolens* trees could also be especially susceptible to insect invasion or have extra dead tissue or other characteristics that benefit termites. Alternatively, the abundance of termite activity on *A.graveolens* trees could be a result of avoidance of other trees with insect defense systems or peeling bark and not a direct preference for *A.graveolens*. Further studies are needed to evaluate the causes of preferential nesting and activity of termites among tree species and strata in tropical dry forests.

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Effects of Cattle Grazing on Plant Communities in a Tropical Dry Forest

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Abstract: Cattle grazing is known to significantly alter plant community composition in temperate forests, but its effects have not been thoroughly studied in Neotropical systems. We tested the hypothesis that community structure would vary significantly between grazed and ungrazed areas in tropical dry forest. We found that herbaceous plants were significantly more abundant in grazed areas than in ungrazed areas, but the relative abundances of seedlings, saplings, lianas and trees did not differ between the treatments. Although we found few significant differences between grazed and ungrazed areas, qualitative observations suggest that such dissimilarities do exist and that further research is required to quantify these patterns.

Key Words: forest composition, forest disturbance, grazing pressure, herbivory

Introduction

Cervid and bovid grazing is prevalent throughout the Neotropics and has been shown to have dramatic effects on the distribution and abundance of woody and herbaceous plants (Stuart 1995). While cattle prefer herbs to woody plants, cattle grazing tends to increase the herbaceous plant cover in an area over time. This apparent contradiction arises because it is more costly for woody plants to replace lost tissue and they are thus slower to regenerate than herbaceous plants. The ability to regenerate under grazing pressure allows herbaceous plants to increase relative to woody plants in grazed areas.

In this study we examined the relative abundances of woody and herbaceous plants in grazed and ungrazed areas in a tropical dry forest in Costa Rica. We hypothesized that the relative abundances of plant functional groups would vary with the grazing history of the plot. Specifically, given the observations above, we predicted that the number of herbs and amount of herb cover would be higher in grazed than in ungrazed areas. We also predicted that seedlings would have higher abundance in grazed areas than ungrazed areas for two reasons: first, intensive grazing had ceased several years ago, allowing the seedlings time to colonize and grow since then; and second, in ungrazed areas, seedlings would be less successful under the closed canopy. We predicted that saplings, trees and lianas would have lower abundance in grazed areas because of both direct grazing and relatively slow recruitment of new plants.

Methods

The study was conducted on 8 - 9 January 2002 at Palo Verde National Park, Guanacaste Province, Costa Rica. We sampled 20 plots along a transect in grazed forest and ungrazed forest. The transects were parallel to and 3 m away from a barbed wire fence separating the two areas. Each of the 20 plots contained a series of 5 quadrats, one for each functional group: herbs < 1 m, seedlings < 1 m, saplings 1 - 4 m, lianas > 1 m in length and trees > 4 m (Fig. 1). Only plants rooted in a quadrat were counted. The herb and seedling quadrats were each 1 x 1 m, while the sapling, liana and tree quadrats were each 1 x 3 m. The quadrats were each separated by 3 m. In each herb plot we counted number of herb stems and estimated percent herb cover. In the remaining 4 quadrats of each plot, we recorded only the number of stems of seedlings, saplings, lianas and trees. Along the transects, we also noted the presence of canopy gaps at least 5 x 5 m and clearings surrounding ant-acacia trees. Mean abundances of each functional group in grazed and ungrazed areas

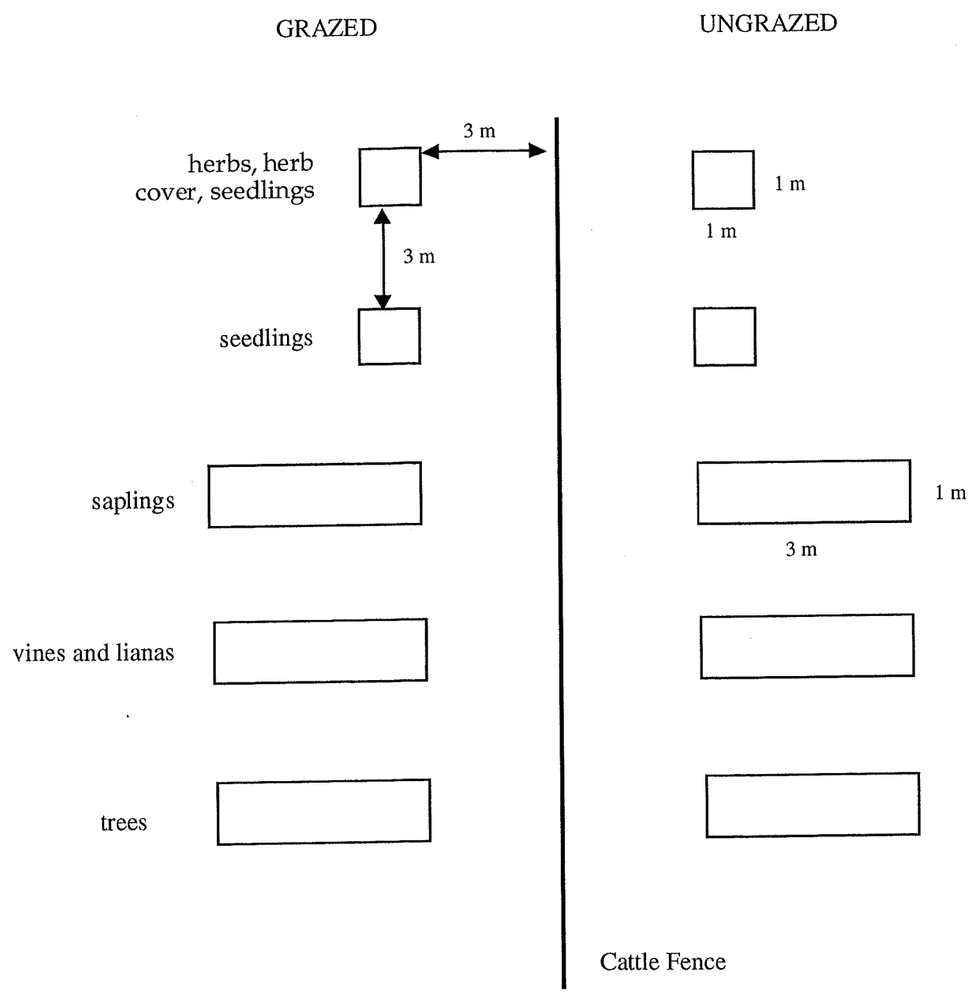

FIG. 1. Diagram showing quadrat layout in each plot along the transect. This plot design was repeated 20 times along the transect.

were compared using a Mann-Whitney U-test.

Results

We found significantly more herb cover (U = 483.5, df = 20, P = 0.04) and herbaceous stems (U = 491, df = 20, P = 0.03) in the grazed area than in the ungrazed area (Table 1). There were no significant differences in seedlings (U = 429, df = 20, P = 0.62), saplings (U = 381.5, df = 20, P = 0.44), lianas (U = 412, df = 20, P = 0.97) or trees (U = 405, df = 20, P = 0.87) between grazed and ungrazed areas.

We observed more ant-acacia clearings in the grazed area than in the ungrazed area, though we did not quantify this trend. We also observed that 8 quadrats in the grazing treatment fell within canopy light gaps, while no gaps were observed in the sampled ungrazed area.

TABLE 1. Percent cover of herbs and number of stems per square meter (mean ± SE) of herbs, seedlings, saplings, lianas and vines and trees found in grazed and ungrazed areas at Palo Verde (n = 20 for each treatment). Asterisks indicate means that differed significantly between grazed and ungrazed areas (P < 0.05).

Treatment	Herbs*	Herb Cover*	Seedlings	Saplings	Lianas/Vines	Tree
Grazed	7.30±2.08	3.30±1.00	7.75±0.87	0.58±0.12	0.92±0.12	0.08±0.03
Ungrazed	3.25±1.29	1.35±0.39	7.15±0.74	0.72±0.12	0.90±0.16	0.12±0.05

Discussion

There were significantly more herbs and a greater percent herb cover in the grazed plots than in the ungrazed plots, supporting our first prediction. However, there was no significant difference in the numbers of seedlings between treatments. It is possible that the recent low-level grazing was sufficient to suppress seedling growth. Similarly, we found no difference in numbers of saplings, lianas or trees between treatments. Based on our qualitative observations, however, there appeared to be differences in the plant communities that were not captured by our experimental design. An accurate measure of the relative abundance of trees would require larger quadrats and perhaps another measure of abundance such as basal area. Liana cover might be a better indicator of liana abundance than number of rooted stems. We believe that a different experimental design involving larger quadrats and other measures of abundance would more accurately characterize the differences between grazed and ungrazed areas.

The observations we made concerning the number of canopy gaps and ant-acacia clearings in grazed and ungrazed areas raised further questions. For example, are these gaps and clearings important factors in determining plant distribution and how are they related to grazing disturbances? An alternative hypothesis for the differences we observed in herbaceous plant abundance is that the presence of gaps, and not the history of grazing, is primarily responsible for the difference in herb distribution. The relationship between grazing and gap formation, and the relative contributions of grazing and gaps to plant distribution patterns, should be further investigated.

The use of forestlands for grazing remains prevalent in Neotropical forests (Kricher 1997). Our results and qualitative observations suggest that grazing suppresses woody plants while increasing the relative abundance of herbaceous plants in Neotropical systems, as in temperate forests. However, it is evident that numerous factors work together to determine the effects of grazing on the richness and diversity of plant communities in the Neotropics. It is important to further investigate these patterns in order to make informed decisions for the management of tropical resources.

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