Ungulate Foraging Pressures on Riparian Zones Along the South Llano River

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Summary

Riparian ecosystems are vital in stabilizing riverbanks and cut banks as well as providing shade cover to the water. Without healthy riparian zones, the Llano River will change flow patterns more quickly and the water's temperature will rise by as much as two degrees Celsius. An increase in temperature due to shade cover loss will alter the biodiversity within the river itself. Riparian deterioration leads to the overall deterioration of the river ecosystem with the loss of key species and class I macroinvertebrates (most favorable). This study will examine how ungulate herbivory affects riparian ecosystems' health. Due to foraging selectivity, it is expected that ungulates (specifically whitetail and axis deer) are altering the soil composition and species richness within riparian zones. The selected study site receives higher levels of disruption and has many areas with very few young saplings/seedlings outside of the exclosure. In order to determine the impact of ungulate herbivory I will examine the plants within and outside the exclosure and compare richness, maturity of species and browsing pressures. I expect my findings to be similar to other studies showing that young saplings (specifically pecan saplings along the riparian zone of the Llano River) are facing increased mortality and slower nut production/regeneration. With preferred saplings and seedlings reaching maturity, invasives should be outcompeted. The next steps will be to determine how long exclosures must be in place to increase sapling survivability and develop an integrated approach to lessening the deer (especially the invasive axis deer) populations.

Introduction

Riparian ecosystems are crucial in providing anchorage and stability to the rivers' banks and shading the water. However, when introduced to a high density of ungulates, saplings and seedlings are often overwhelmed and cannot reach maturity. Ungulates foraging patterns make pecan (Carya illinoinensis), a key species in healthy riparian ecosystems, especially vulnerable. Whitetail deer's diets are heavily comprised of browse species especially during drier summers. Dillard et al. (2005) in a study throughout northern and central Texas found that whitetail diets were composed of 46% browse species during a drought and 29% in wetter summers. Browse species in this study were defined as the soft tissue components of woody forage (trees, shrubs, vines). Saplings must reach a growing capacity that is not detrimentally affected by excessive forage in order for the riparian ecosystem to remain healthy and intact. In order to help the younger saplings survive and establish their root systems an 8-foot tall game fence was erected along the south Llano River (Broad et al. 2016). This exclosure should allow the protected vegetation to develop, produce seeds and regenerate. Therefore, I predict the initial quantitative analysis of species richness and abundance to show a decrease in preferred riparian species outside the exclosure.

Whitetail herbivory can also affect plant litter composition and change the soil organic matter. Whitetail deer seek out plants of higher importance, plants that increase fitness. As the overall biomass of these species is reduced soil quality decreases (Sirotnak and Huntly 2000). In the

absence of herbivory pressures preferred plants (in the ecosystem) can develop and regenerate, keeping the C:N ratio of soil matter lower and not allowing other plants (some invasive) to monopolize/dominate an area (see Fig. 1). Ungulate selectivity should also show a decreased amount of dry organic matter (litter). With a smaller litter layer, the shallow soil found along the South Llano River is more likely to be washed away and depleted of nutrients during a storm (Reardon and Merrill 1975).

I expect whitetail deer selectivity to negatively impact the riparian area exposed to browsing pressures, enabling the introduction of invasive species and leading to a litter layer indicative of low quality organic matter. The vegetation outside the exclosure perimeters will be in a juvenile state, and if the ungulate population is as dense as predicted, most of the browse species will have been foraged to a height of 1 foot or less or terminated (Travers et al. 1996). Within the exclosure, I expect to observe preferred species (including pecan trees) in greater abundance that are growing taller and showing signs of maturity (nut/seed/fruit production, adult branches). The litter layer within the exclosure will most likely be composed of fast-cycling plant matter. Since the exclosure is rather new, I expect that results will not be as noticeable than in older, more settled exclosures, and some invasive species may still be present in the exclosure and require management. Elephant Ears have been found in continuous strands along the South Llano River and can dominate native riparian ecosystems (Broad et al. 2016). The plant grows either by rhizomes or seed dispersal and a single root system can provide water to several plants. The species greatly exploits water consumption creating an imbalance in the watershed and taking away nutrients from preferred species.

I expect that a greater abundance of plants within the 8-10 and 11-14 stages (see explanation in methods section) will be recorded in the exclosure. Plants in the exposed plots will be smaller and regenerate less effectively due to mowing and browsing. Taller seedlings/saplings that are exposed will experience intense browsing pressures and smaller seedlings/saplings will be mowed down by ungulates.

The significance of this work has 3 parts**.** The Llano River is still in good condition with safe water. However, with 7.4 miles of cut banks along the South Llano River (Broad 2016) threatening bank stability and higher erosion levels, it is imperative that young pecans survive and develop root systems to stabilize the banks.

As preferred native species are depleted, invasive species will be able to develop root systems and take over areas of the riparian zone. China Berry has already invaded a majority of the entire watershed (Broad et al. 2016). If more saplings and seedlings of native species could mature and reach the stage when browsing pressures do not threaten survivability, the riparian zone will be composed of preferred species.

Lastly, Texas Tech University, for safety purposes, does not allow guns on the property. This hinders the ability to mechanically control the ungulate (whitetail and axis deer) populations to a more manageable level. This hindrance forces those on the property to rely on the ungulates to live in equilibrium with their environment (Travers et al. 1996). This also puts an added emphasis on community outreach. It is crucial that private landowners work with the University and Upper

Llano Watershed Coordination Committee to control the ungulate populations and manage riparian areas.

Methods and Materials

Study area

I studied the effects of ungulates foraging habits on riparian ecosystem maintenance and development along the south Llano River in Junction, Texas. The exclosure was placed on a relatively undisturbed area along the river bank. This area of the Llano River has a high density of deer (axis and whitetail) experiencing increased pressures. The whitetail deer population is estimated at 117,534 with one deer/10 acres in riparian zones. Deer densities are higher in cities and riparian zones. The axis deer population is difficult to accurately quantify, but the deer travel in herds of 100 or more (Broad et al. 2016). The high exclosure reaches 8-feet tall not allowing any deer to enter. The exclosure does not exclude smaller herbivores (i.e. rabbit, squirrel, etc.).

Most of the watershed is composed of Tarrant soils that are very swallow, shallow or calcified limestone interbedded with marl and chalk (Broad et al. 2016). Limestone from the Cretaceous age broke down after years of long weathering creating this permeable soil (Broad et al. 2016). The soil is seen at a slope as great as 50% along backslopes or ridges or dichotomized plateaus. The climax community is a tallgrass savannah with oak trees sparsely distributed. Dominant species include little bluestem and sideoats grama (Broad et al. 2016).

The control plots will be directly adjacent to the exclosure to avoid environmental digressions (river flow, bank erosion, etc.) (Opperman and Merenlender 2000).

Sampling

The sampling methods will be modified from Anderson et al. 2004. Using the coordinate system, I randomly placed five quadrats (.25 m x .25 m) throughout the exclosure. Then, on each side of the exclosure two quadrats will be placed at a random length along the exclosure for a total of eight control plots. These control plots will be five meters from the fencing. Within the quadrat, a complete list of species will be compiled and combined with the other species within the other quadrats to get an idea of the overall species richness in either plot. Any species observed throughout the descriptive analysis that were not represented within the plots will be noted. Then, the stem height, length, width of one randomly-selected leaf, number of leaves and flowering status of forbs and weeds will also be recorded (Augustine and deCalesta 2003). I will also record stems/leaves with evidence of browsing. Then, I will follow Augustine and deCalesta (2003) and determine the proportion of browsed stems/total stems; proportion of flowering plants/total plants; mean stem height; and a display of stage-class distributions. Small non-flowering plants, with a 0-6.3 cm^2 leaf area are grouped into stage classes 1-3; mid-size non-flowering plants, 6.3-39.8 cm^2 leaf area 4-7; large non-flowering plants, 39.8-158.5 cm^2 5-10; primarily flowering plants, 158.5-1,000 cm^2 11-14. Then, the same process will be used to analyse sapling regeneration and growth. Size class 1 will include saplings less than 50 cm tall with branching, woody stems or obvious new growth; sapllings between 1-2 meters tall, or with five or more stems and adult branching will be placed into size class 2 (Opperman and Merenlender 2000).

I will integrate methods from Reardon and Merrill (1975) and randomly select 3 quadrats from both the exclosure and exposed plot. These randomly selected plots will be clipped and dried. The recorded weight (grams) will be multiplied by 10 to calculate forage yield in lb/acre. The recorded forage weights can be further categorized to decreasers, increasers, forbs and weeds, and dry organic matter (litter). Decreasers are plants that decrease under excessive browsing whereas increasers increase under browsing pressure. Dry organic matter will leave out twigs and branches but include all other decomposing matter (leaves, weeds, dead grass).

Results and Discussion Ideas

Saplings were almost nonexistent outside of the exclosure. Two stage class 1 pecans were observed, but saplings of netleaf hackberry, American basswood, winged elm, wafer ash or little walnut were not present. Also, the only two saplings observed were being smothered by frostweed and common horehound, receiving inadequate light exposure. Still, chinaberry managed to grow and spread throughout the exclosure—likely the result of aviary consumption and dispersal and not in relation to deer herbivory.

Saplings of all these species were found in abundance throughout the exclosure with a suppressed amount of honey mesquite, frostweed and common horehound in relation to the relative frequencies of preferable species and saplings (pecan particularly). Only a single corner (in the north west) of the exclosure held common horehound. As shown in Graph 4, fewer frostweed plants within the exclosure were in mature stage classes suggesting that frostweed is neither palatable to deer nor preferable to the riparian zone. Notably fewer plants are within the stage classes 8-10 within the experimental plots. Frostweed creates long rhizomatous stands only when preferable plants are not in abundance (likely due to deer herbivory). Because fewer matured plants are within the exclosure, there is evidence that decreasers are present within the exclosure.

Pecan, Virginia wildrye, rescuegrass, netleaf hackberry, common horehound, frostweed, rouge plant and wild four o'clock were recorded throughout the experimental plots. Plants within the exclosure that were not present within the plots included: Texas wintergrass, beggar's tick, saw-toothed green briar, chinaberry, wild petunia, goldenrod, eastern gama grass, indian grass, American basswood, winged elm, cedar elm, poison ivy, wafer ash, broadleaf uniola, honey mesquite, little walnut, rock clematis and heartleaf peppervine. Because deer did not have access to the experimental plots, the browse recorded was only on the leaves and was due to small mammals or insects. However, there are signs of deer herbivory on plants (including smaller frostweed) outside the exclosure. Deer are consuming less preferable plants (frostweed and horehound) due to lack of diversity. Wild four o'clock is extremely palatable to deer as well as butterflies and other insects. Graph 3 shows the relative frequencies of browse on different species throughout the plots. Wild petunia and wild four o'clock were in flower but not recorded. Out of the recorded rouge plants (6 throughout plots) 50% were flowering and one was producing fruit. All of the pecan saplings observed and recorded were within stage class 1. After five years these saplings are still too small to survive deer herbivory. Other tree species including chinaberry, American basswood, wafer ash, netleaf hackberry and winged elm have enough adult branching and new growth to survive herbivory pressures.

Table 2 shows the preferability by deer of certain plants seen inside or outside the exclosure. Class I includes the most preferable plants (browse and forb) that are usually scarce or extinguished from the land. Class IV is the least preferable group and includes plants that are avoided by deer unless more preferable classes are unavailable. However, sometimes lower classes are temporarily moved into a higher class (classes provided by Nelle 2006). This occurs when the browse or forb specie produces seed, flower or bean which the deer prefer. (See table 2) Only plants in class III and IV are present outside the exclosure. The three wild four o'clock plants that spread to outside the exclosure are nearly completely consumed. Increaser plants: honey mesquite, frostweed and common horehound dominated the control plots and remaining riparian zone. These plants were in mature age classes and left little room for other plants to grow. Indian mallow and prairie coneflower were also in moderate abundance. Smaller patches of rescue grass, indian grass and Texas wintergrass were present and showed signed of deer pressures due to mowing. For this reason, the litter layer outside the exclosure was drastically smaller than that of the exclosure. With less preferable plants outside the exclosure and a thin litter layer, the top soil is in danger of being swept away in a flood and the soil is not as nutritious.

The dried above-ground biomass collected from both treatment types was weighed and sorted into the four categories: decreaser, increaser, forbs and weeds and litter (dry organic matter). The weight (in grams) of the increaser plants outside the exclosure was 25x larger than that recorded from plots within the exclosure (graph 2). Furthermore, the dry organic matter weighed 44.7% more from the exclosure plots (graph 1). There was an obviously greater amount of decreaser plants throughout the exclosure. Table 3 indicates plant yields throughout the two treatment types.

Discussion

The heavily dense deer populations greatly decreased almost all saplings and preferable forb species. Only eight of the recorded 26 plant species were found within the experimental plots; and only three of those plants (frostweed, rescuegrass, common horehound) were found in abundance. This decrease in species diversity is found in similar studies (Augustine and deCalesta 2003, Opperman and Merenlender 2000, Reardon and Merrill 1976, Travers, Meier and Arbor 1996)). The decrease in species diversity has left soil bare. The bare soil will continue to erode and leech nutrients at the current deer density.

This near monoculture also supports the claim that deer selectivity allows increaser plants to dominate the ecosystem lowering the C:N ratio. With less diversity, the plant biomass that dies and decomposes is altered as well. Different plants hold a different amount of nutrients that are released by decomposers and detrivores. This alters the C:N ratio, which can change the behavior of some plants. Plants that need a high C:N ratio may not sprout and may experience increased fatalities. Pecans grow best in 15:1- 20:1 ratio (Wells 2010) as with many other woody and preferably species; so as the ratio lowers, the abundance of plants decreases and exposed soil increases. The litter layer within the experimental plots is more than twice as small as that within the control plots. The 44.73% difference in litter layer shows that deer browsing exacerbates soil erosion. The river bank continues to erode along with the top soil as storms increase in power and

frequency. The litter layer helps replenish soil nutrients to help future plants grow and diminishes erosion.

Trees grow slowly, and in order for more saplings to reach a point in which they survive herbivory pressures the enclosure will need to be up for several more years. The pecan tree (as well as other species) does not reach sexual maturity for about 8-11 years (Sirotnak and Huntly 2000). However, the tree should be able to survive herbivory before sexual maturity as long as nutrients are available and the tree can still perform photosynthesis and build sugars.

The study showed how deer affected this particular area on the South Llano River; to have results conclusive of a larger area more enclosures would need to be erected. Multiple enclosures would prevent pseudo-replication and show ecosystem succession along the riparian zone and upland. Future research could analyze the chemical properties of the soil within and outside of the enclosure(s) to numerically show the effects of a reduced litter layer. The placement of piezometers would also help scientists determine a difference in water depths at different areas along to river, in the upland and throughout experimental or control plots. By studying the water depths scientists will better understand the health of the ecosystem and be better suited to address the problems.

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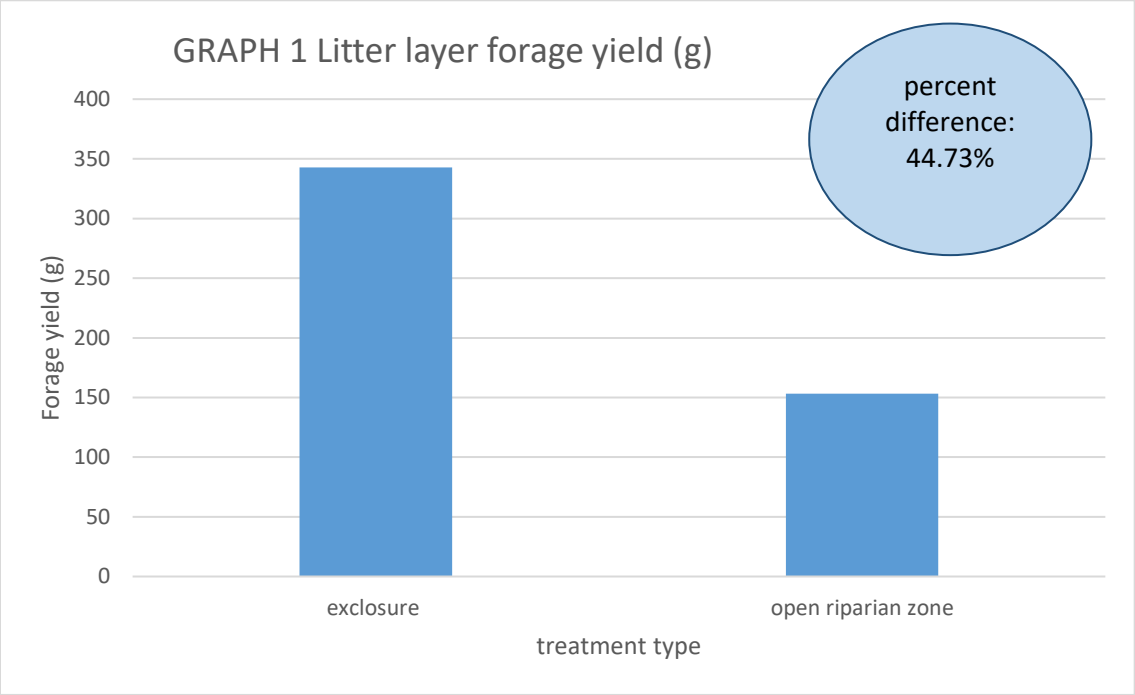
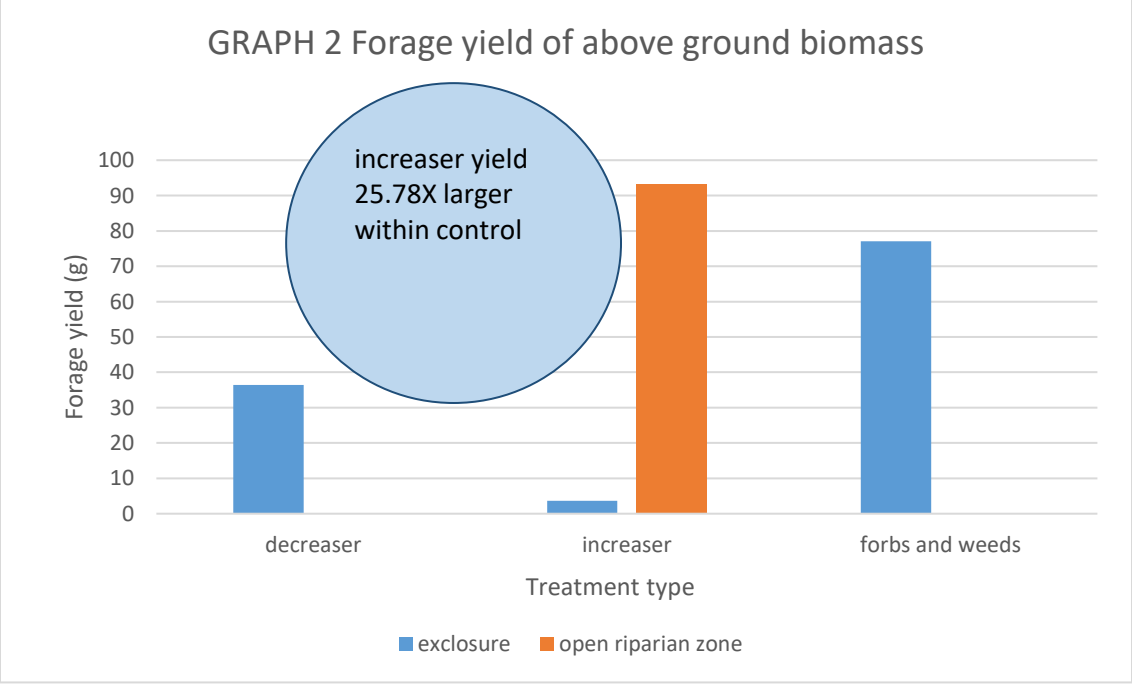
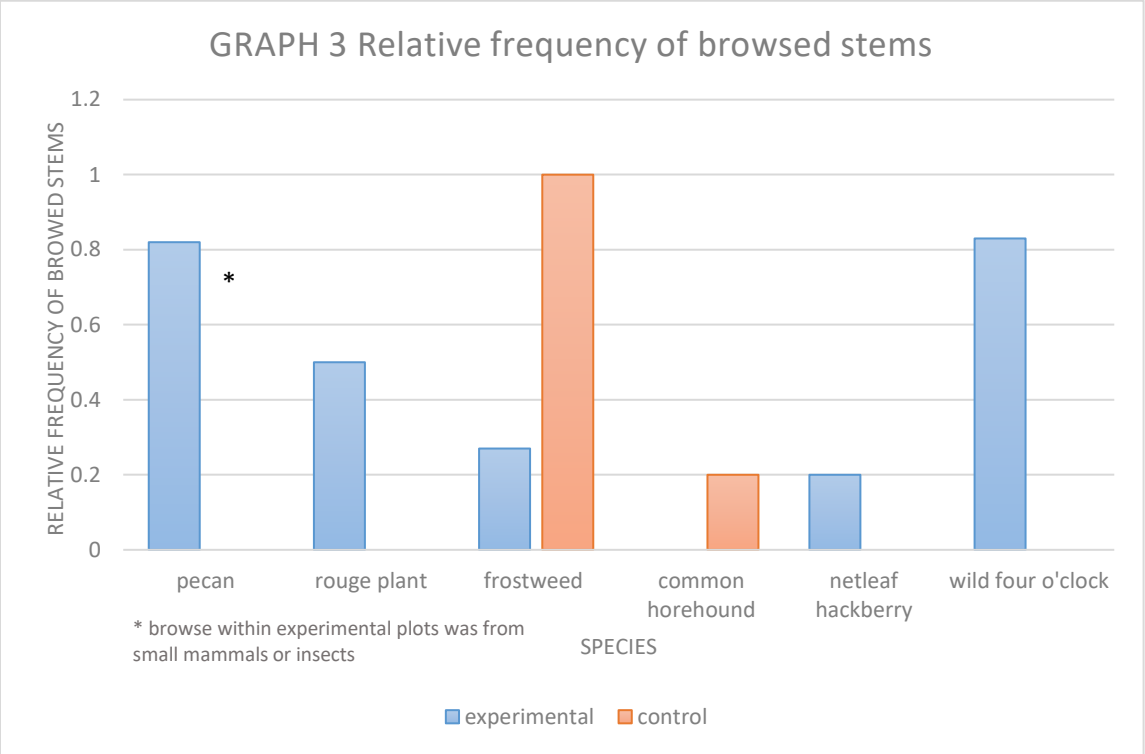
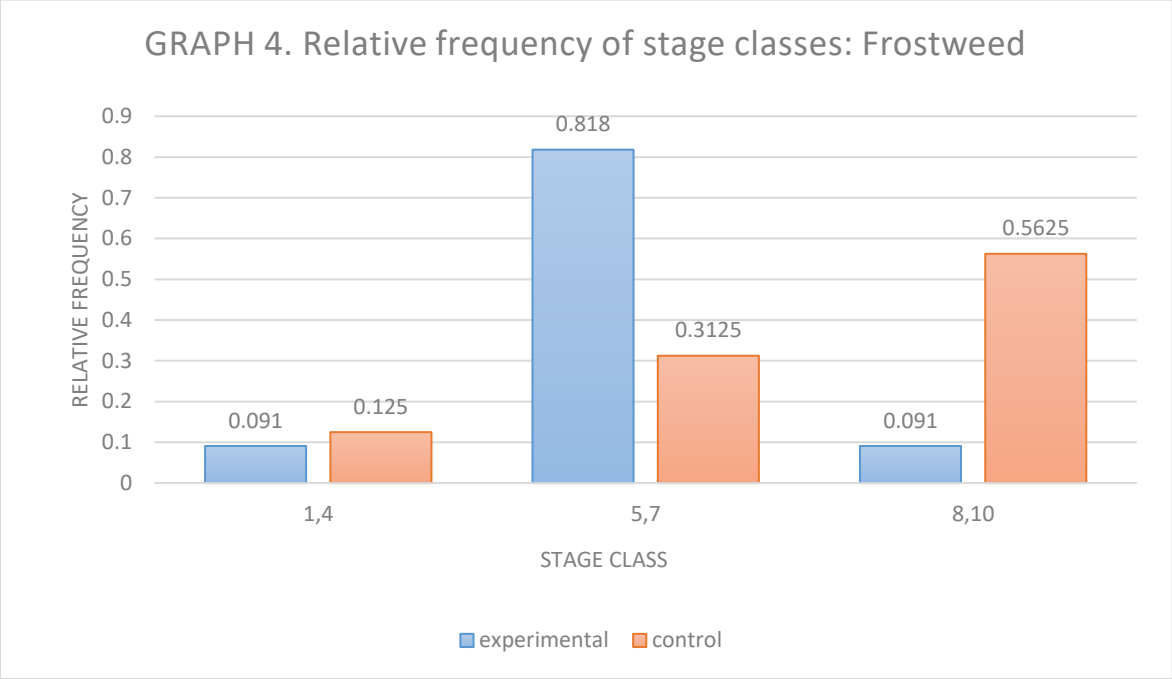
Graphics, Figures and Tables






GRAPH 3 Relative frequency of browsed stems
RELATIVE FREQUENCY OF BROWED STEMS
1.2
1
0.8
0.6
0.4
0.2
0
*
pecan
rouge plant
frostweed
common horehound
netleaf hackberry
wild four o'clock
* browse within experimental plots was from small mammals or insects
SPECIES
experimental
control


GRAPH 4. Relative frequency of stage classes: Frostweed
RELATIVE FREQUENCY
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.091
0.125
0.818
0.3125
0.091
0.5625
1,4
5,7
8,10
STAGE CLASS
experimental
control

Type of Plants	Species	Preferability	Stage Class Distributions	TABLE 2
BROWSE	Winged elm	class I	inside: stages 1 and 2 observed	
	Netleaf Hackberry +	class II	inside: 25% recorded as stage class 2	
	mallow --	class III	exclosure	
	frostweed --	class IV	inside: 82% 4-7; 9.1% 1-3 and 8-10. outside: 56.3% 8-10; 41.3% 4-7; 12.5% 1-3	
	prairie coneflower	class IV	outside: already lost flowers and some leafs, tall stalk	

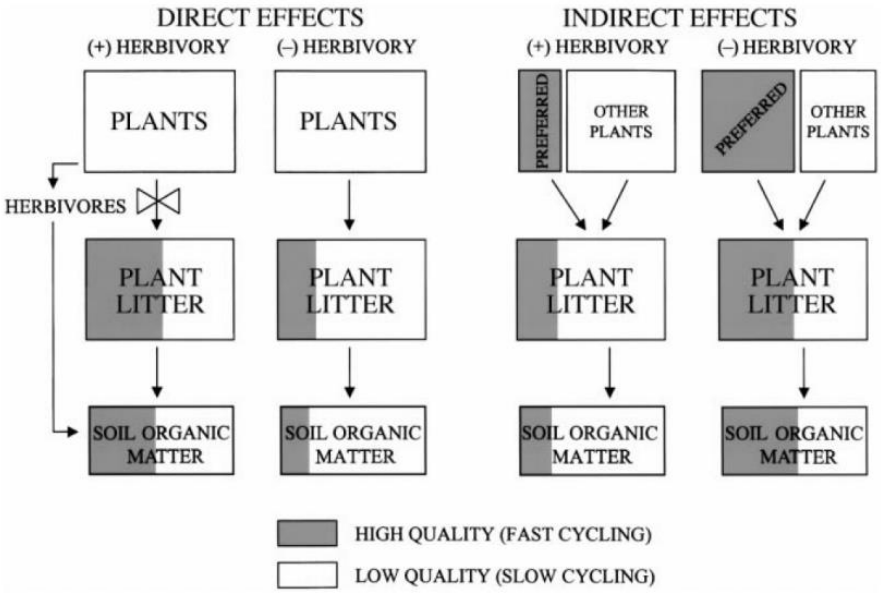


FIGURE 1. Effects of selective herbivory by ungulates. (FROM SIROTNAK, HUNTLY 2000).