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La Copita Research Area: 1992 Consolidated Progress Report

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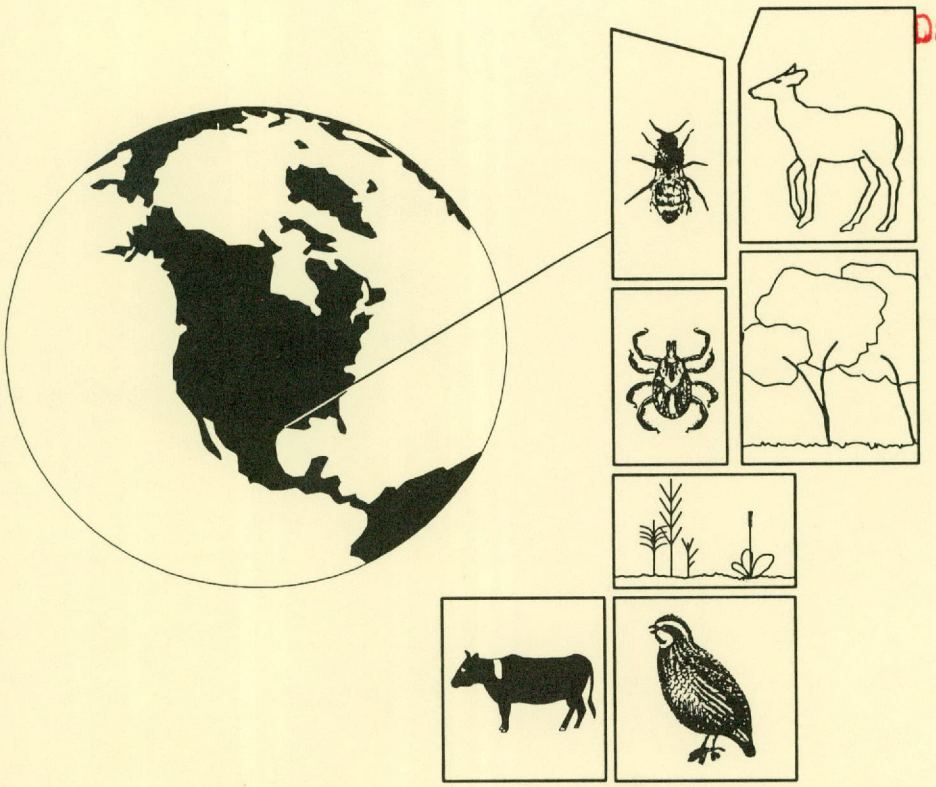

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THE TEXAS AGRICULTURAL EXPERIMENT STATION/Edward A. Hiler, Director/The Texas A&M University System/College Station, Texas

La Copita Research Area:

1992 Consolidated Progress Report

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Foreword

The La Copita Research Area was established to address the multifaceted problems of grazinglands and resource management in South Texas. The research program is designed to expand our knowledge of essential interactions between biotic and abiotic processes impacting production-oriented problems, social issues, and sustainability of South Texas ecosystems. This report outlines the breadth of this research program that is expected to make significant contributions toward the responsible management of more than 15 percent of the State's land area.

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The Impact of Spanish Meat Goats on Range Vegetation in South Texas

J. Ford, W. Hoefler, C. W. Hanselka, and J. Paschal

The next 10 years will be a period of rapid changes to meet increased demands for agricultural production. Ranchers and farmers will be continually seeking alternative production schemes which will improve profit potential. Strategies will include not only improvement of existing enterprises, but the addition of new commodities. This diversification will not only apply to land under cultivation but also to native rangeland. With approximately 47% of the world's land area being classified as rangeland, it becomes apparent that rangeland will and must play an ever-increasing role in feeding the world's growing human population. These rangelands are generally less productive than cultivated cropland and therefore less intensively managed. However, for rangeland to be utilized for maximum production, the level of management will have to be increased.

On a global basis, native ranges are maintaining their current levels of production or are actually declining in production. The major cause of this declining production can best be summed up by mismanagement of livestock grazing. Overgrazing results in the loss of perennial grasses and increased annuals in the plant composition when stocking rates are above acceptable levels. Annual plants are less productive and predictable in their forage production. Shrub plants also increase with overgrazing and are generally less utilized by herbivores.

Moisture is the most limiting resource for most range vegetation production and water use by low producing or non-palatable plants is very inefficient. However, shrubs are very competitive for available precipitation because of extensive root systems. These root systems allow efficient use of both deep and shallow soil moisture, which reduces soil moisture available for herbaceous growth. For maximum forage production, one must either eliminate these ungrazed shrubs or utilize a grazing herbivore that will graze these shrubs. Due to the high cost of control methods for shrub plants, it becomes necessary to develop management systems whereby grazing herbivores will utilize these shrubspecies. It was, therefore, the objective of this study to try and develop goat management strategies on mixed-brush communities.

The objectives of this study are: (1) To determine the effects of goats on the range resources; (2) To determine optimum stocking rates and grazing strategies; (3) To quantify and demonstrate production systems appropriate to South Texas farmers and ranchers.

Procedures

Sixty acres of a honey-mesquite dominated mixed brush community located on the Texas A&I University Farm, South Pasture, were cross fenced into 12, 5-acre plots. Various levels of continuous stocking with Spanish goats were used to determine optimum stocking rates and to help develop grazing strategies. To accomplish this, 63 Spanish goat nannies were randomly assigned to 1 of 4 treatment groups. Treatments consisted of (1) no browsing by goats (control), (2) browsing by goats at the rate of 0.6 goats per acre (light stocking rate), (3) 1.2 goats per acre (moderate stocking rate), and (4) browsing by goats at the rate of 2.4 goats per acre (heavy stocking rate). Each treatment was replicated three times.

The effect of goats on the range vegetation was measured by using three random 36.6 m transects within each study paddock to examine plant composition, basal cover, and aerial shrub cover. Plant composition (%) and basal cover were also examined using the line point method. Points were read at 0.5 m intervals along each transect and records included direct hit, bare ground, and litter. If a point did not fall on the basal portion of a rooted plant, the closest plant to that point was recorded. Aerial shrub cover was determined by measuring the amount of shrub canopy that intercepted the transect.

Six, 1-meter frames were used in each experimental plot to determine phytomass. Herbaceous plants in each frame were clipped at ground level, separated by species, oven dried at 60°C, and weighed. Vegetation sampling was conducted in June, October, and January.

Results and Conclusions

Throughout the 2-year study, there appeared to be a trend in which the overall canopy cover for Texas persimmon, mesquite, lime prickly ash, huisache, white brush, jumping cactus, blackbrush, and prickly pear decreased. This reduction in canopy cover may have been partially attributed to

seasonal changes as well as grazing by goats.

The greatest observed decrease in mesquite canopy cover occurred in the heavy (2.4/acre) stocking rate plots. This is somewhat surprising since past work conducted suggests that goats do not prefer mesquite as a browse species. This decrease in canopy cover indicates that grazing goats at the rate of 2.4 goats per acre may be too high.

Diet composition studies have shown that goats prefer browse even when large amounts of grass are available. This factor, combined with the reduction of canopy cover, provided environmental conditions favorable for the production of Plains bristlegrass in the light and medium stocked paddocks. However, there was a decrease in the production of Plains bristlegrass in the heavy stocking rate plots. This decrease can be explained by the fact that the goats utilized all other available forages and were forced to eat the grass. Shrub and forb production were also lower at the heavier stocking rates.

Stocking goats at the level of 1.2 goats per acre seems to be the ideal level of grazing on a continuous grazing system. The goats were able to supply a measurable amount of brush control, fulfill their nutritional requirements, and never had to be supplemented.

Stocking rates of 2.4 goats per acre completely destroyed all brush and vegetation six months into the project and had to receive supplementation throughout the remainder of the study. During the extremely dry summer months, goats in the heavy stocking rate paddocks had to be supplemented with Coastal hay (2 bales/plot/wk). Fall rains allowed enough plant species to resprout and carry the goats until late November when they had to receive supplementation again. By mid-December the goats had completely removed all available forage and had to be removed from the heavy stocking rate paddocks. During the early winter, as vegetation became less available to the goats, it was not uncommon to find goats 1 to 2 m up in trees eating the foliage. One goat was lost due to tree climbing-grazing when its foot became caught in the fork of a tree, was unable to free itself, and starved to death before it could be located. Unlike the medium stocking rate paddock (1.2/acre), where a large amount of Plains bristlegrass was allowed to grow when brush was removed, the grazing - browsing pressure in the heavy stocking rate plots (2.4/acre) kept Plains bristlegrass from re-establishing.

Very little brush was controlled or removed in the light grazing plots (.6/acre) and goats were unable to keep up with the growth of the brush. It was in these plots where some brush related injuries occurred.

Five goats received brush related injuries primarily from abscesses due to mesquite thorns becoming imbedded in knee joints causing lameness and, in one case, death. Goats with this problem received injections of antibiotic and the abscess was cleaned and drained. However, these animals became easy prey for predators. In view of these problems, brush density should be considered before beginning a goat enterprise. Brush should be present for the goats to feed on, however, extremely thick heavy brush makes management difficult and can cause some injuries to the animals. Roller chopping prior to the stocking of an area with goats may have merit. Brush biomass is decreased after these treatments and the goats will utilize the young tender brush species as they emerge.

A Spanish meat goat industry could be a viable livestock enterprise in South Texas. However, goat production must be an intensely managed operation due to pressures from predators, both animal and human, and parasites. A grazing system must be developed that will utilize the forages available and provide some brush control while maintaining the range at the desired levels. Good management can help insure a successful meat-goat enterprise.

Acknowledgments

This study was partially funded by the Texas Agricultural Extension Service, Texas A&I University, Texas Department of Agriculture (Texas Agricultural Diversification Program), and USDA-Soil Conservation Service. The efforts and cooperation of each is appreciated. This is a contribution of the South Texas Spanish Goat Initiative Project.

The Status of Spanish Goat Production in South Texas

C. W. Hanselka, J. C. Paschal and R. Mercado

The Rio Grande Plains, Coastal Prairies, and lower Post Oak Savannahs of South Texas cover an area of over 22,000,000 acres. More than 13,000,000 acres support a brushy plant complex that lowers cattle carrying capacities to 1 animal unit (A.U.)/25-35 acres. Also, many landholdings are limited resource units that are too small to allow sustainable economic production of beef cattle. Spanish meat goats represent an alternative enterprise to diversify the economy and more efficiently utilize regional resources.

Goats will use marginal lands and forages not fully utilized by other livestock species currently produced in South Texas. Small landowners can graze many goats with proper management and marketing. Larger landowners can more efficiently utilize their total forage resources by use of brush by browsing goats and also use subsequent grass production by grazing cattle. The use of goats in brush management systems will extend the life of the initial treatment, lower mechanical energy inputs, and reduce herbicide applications.

The Texas Agricultural Extension Service, under the auspices of the Comprehensive Ranch Management for Profit (CRMP) program, initiated the South Texas Spanish Goat Initiative Project in 1990 in an effort to organize information, transfer technology, and integrate production, marketing, and processing methods of Spanish goats. The initial phase of this project was to determine the status of Spanish goat production in South Texas by surveying Spanish goat producers in the area. The purpose of the survey was to characterize Spanish meat goat operations, to summarize management practices and procedures, and to determine any opportunities for improvement in production and marketing systems.

Methods and Materials

Spanish goat producers in 33 South Texas counties were identified. A questionnaire was developed and distributed to Soil Conservation Service and Extension personnel in each county and most questionnaires were completed during face-to-face interviews with producers. Sixty-eight useable questionnaires were completed and results entered into a data base file, sorted, and descriptive statistics summarized using SAS-PC.

Results and Discussion

Producer and Ranch Characteristics

The average age of the surveyed producers was 51 years. The survey indicated that over 50% of the ranchers have some post-secondary education: 29% attended college, 25% completed a four-year degree, while 5% completed a graduate or professional program.

South Texas ranches vary greatly in size and production depending upon location. Respondents indicated that 54% of their acreage was brushy rangeland, 22% cleared rangeland, 13% tame pasture, and 11% cultivated crops. A 1989 survey of South Texas ranchers by the CRMP program revealed that only 2% of South Texas ranchers have Spanish goat enterprises but numbers varied depending upon location in the region. Most of these goats were located in the western counties with an average of 4% (5-13% range) of the producers reporting that they raised goats. Only 1% of the producers in the central and eastern counties reported raising Spanish goats.

Although all of the respondents to the present survey raised Spanish goats, only 18% of them reported Spanish goats as their only enterprise. The other 82% have diversified operations. According to the survey, 53% of the ranchers had one other livestock enterprise besides goats, 21% had two, and 9% had three. No one reported more than four livestock enterprises.

There are several reasons for raising goats, but the one most often cited is having meat for personal use and to provide income or as gifts for friends. About one-third of the respondents indicated that they use their goats for brush management while another third use them for utilizing brush as a forage. Income received from goats ranged from 0% to 100% with a mean of 10% indicating diversification of enterprises and off-farm income.

Range Management and Spanish Goats In South Texas

Woody plant species and broadleaf forbs are the primary dietary components of Spanish meat goats. The majority of the Spanish goats in South Texas are pastured on brushy rangeland (Figure 1). An overlap in percentages of land types exists since most ranches have a variety of pasture conditions and forage types. Correspondingly, respondents indicate that brush is the main forage that their Spanish goats consume (Figure 1). Again, an overlap in percentages occurs because some ranchers do not exercise any control on the goats' diet, allowing them to roam freely and feed wherever forage is available.

Stocking Rates

Stocking rates for any livestock enterprise will vary greatly according to range conditions, animal size and species, seasonal trends, and whether or not supplemental feed is being provided. This survey indicates a mean stocking rate of 0.7 goats per acre (2 goats/3 acres) on native rangeland and brush (either natural or regrowth) and a stocking rate of 0.9 goats/acre or approximately 1 goat/acre for tame (planted) pastures. Survey respondents consider range condition, forage quantity, animal condition, and past experience as important factors when making stocking rate decisions for Spanish goats (Figure 2).

Grazing Management Systems

The grazing method most used for Spanish goats is continuous grazing, followed by decision deferred, planned rotation, and short duration methods. More than one grazing system may be used during the year. Conversely, the cow herd will usually remain in one grazing scheme throughout the year.

Brush Management

Spanish goats, at the appropriate stocking rate, are excellent tools for managing brush and optimizing returns from available range resources. The survey indicates that 66.2% of the ranchers use their goats to manage their brush; Spanish goat producers also use other brush management methods such as shredding, root plowing, and discing to maintain the pasture. Goats also readily eat several weed species and 66% of the respondents report using goats as a tool for weed management.

Spanish Goat Management Practices

There are several livestock management practices involving feeding, health, and reproduction management that are practiced by producers.

Drylot Confinement

Some ranchers reported using drylot confinement in their Spanish goat operation. Almost 28% of the respondents use seasonal confinement systems for an average of 54 days (range: 20 - 120 days). Only 7% of the respondents use year-round confinement in their Spanish goat herd and 80% of these owned less than 50 acres.

Supplemental Feeding

The purpose of supplemental feeding is to provide the herd with the nutrients needed to survive a stressful period or season. The survey showed that 71% of the respondents fed supplements on a seasonal basis for an average of 84 days per year. Conversely, 29% of the respondents supplemental feed their goats all year. Smaller land holders feed for longer periods of time. All land holders with less than 50 acres supplemented their Spanish goat herd for an average of 222 days. This may be caused by the lack of range resources that provide the nutrition in a goat's diet or to the need of a rancher to maintain larger herds than the limited land resource will allow. A year round mineral program can help ensure a healthy Spanish goat herd and almost 80% of the respondents indicate that they provide year-round mineral supplementation for their Spanish goats.

Breeding and Kidding Programs

Only 3% of the respondents confine their kidding season to the fall months while 86% of the respondents have two kidding seasons--fall and spring. Their average kidding percentage (139%) indicates that all nannies are not kidding twice a year and that some reproductive failure is occurring.

The survey reported that 11% of the respondents indicated a year round kidding season. Their average kidding percent is 156%. This increased kid crop occurs because billies are not isolated from the nannies, allowing them to mate when the nannies are physiologically ready. A majority of producers (57%) provide supplemental feed to their nannies with smaller numbers evaluating nannies prior to breeding (37%). Only 31% flush nannies prior to breeding to increase kid crop percentages.

An important factor in the success of kidding nannies is knowing when and where nannies are kidding to reduce death loss due to kidding difficulties and predation. Thirty-six percent of the respondents kid their nannies in a pasture, 36% in a small trap, and 28% in a shed or barn. Moving pasture-born kids to a smaller trap or pen helps

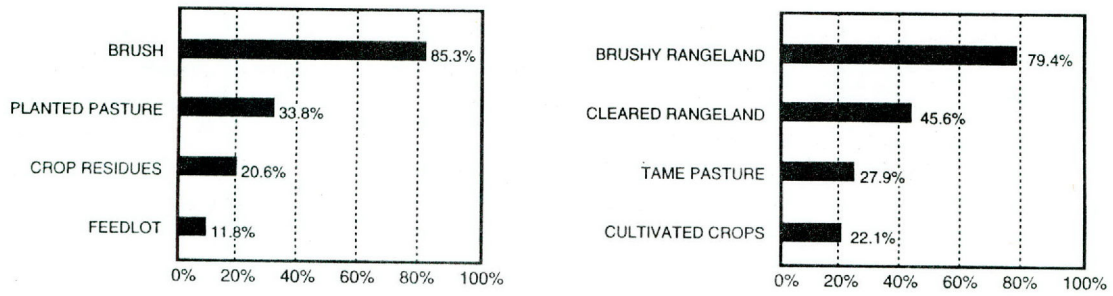

Figure 1. Types of pastures and principal forages consumed by Spanish goats as requested by producers (%)

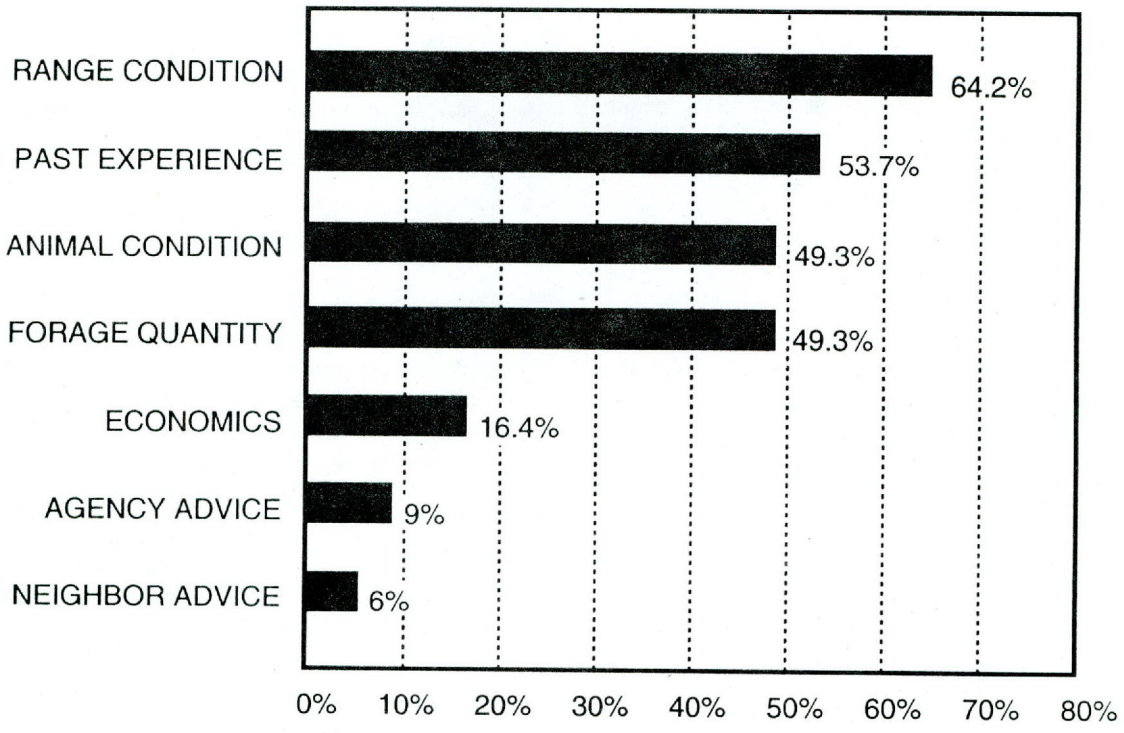

Figure 2.The factors considered important by producers (%) in stocking rate decisions for Spanish goats.

monitor kids and reduces their danger from predation. About three-fourths (75%) of the respondents reported that they moved their kids to a smaller trap.

Herd Health Program

Keeping livestock free of internal and external parasites and diseases aids in reducing death losses and increases profits. Stomach worms are quite common in South Texas Spanish goats and 77% of the respondents reported them in their goats. On an average, the ranchers surveyed will drench their goats two times per year. External parasites also are common and survey respondents indicated that 56% have encountered lice, 35% have encountered ticks, and 22% have encountered mites in their Spanish goat herd.

Common diseases and health related problems included pneumonia (22%) and abortion (29%). However, two-thirds (66%) of the respondents do not vaccinate their goat herd for any disease. Only 16% of those vaccinating will vaccinate for sore mouth while 9% vaccinate for enterotoxemia and anthrax. If the number of ranchers who do not vaccinate could be reduced by half, death loss or morbidity (loss in production due to sickness) could be significantly reduced with a concurrent increase in production.

Predator Control

Predators are a common problem for Spanish goat producers in South Texas. Over half of the respondents indicated that they have lost or had injured an average of 10 goats in the past year because of predators. The most common predators reported were coyotes (60%), neighbors' dogs (32%), bobcats (16%), and feral hogs (10%). Although achieving 100% predator control is usually not possible, implementing predator control practices can significantly reduce predation. Some of the most common predator avoidance strategies include penning at night (63%), using guard dogs (46%), fencing with netted wire (37%), frequent herd checks (37%), and hunting (31%).

Fencing

Another important tool in any livestock operation, and especially for Spanish goats, is fencing. Various factors may influence the type of fence used, including the kind of livestock, the size of the operation, predator pressure, cost of the fence and whether the fence is temporary or permanent. Respondents indicate that 21% use electric fencing with an average of three strands; 49% use barbed wire with an average of six strands; 79% use netted wire; and 9% use some combination of these. Netted wire fencing is most common among Spanish goat producers and may yield the best results but it is the most expensive form of fencing. Electric fencing is showing promising results.

Hired Labor

Spanish goat operations can be labor intensive, requiring a rancher to hire a "pastor" or herder to monitor the goats and perform other required chores, However, only 12% of the respondents employ a pastor. Of those who employ a pastor, 71% employ him full time, 14% employ one periodically during the year, and 14% employ one only during kidding season. A pastor can be an effective tool to control predators; monitor diseases, parasites, and breeding patterns; and most of all to optimize production and profits, depending on the size of the operation and its location. A pastor will also add overhead expenses to a goat operation.

Marketing

The age at which a rancher markets his goats usually depends on the targeted market. Spanish goats are marketed for slaughter purposes anywhere from 2 weeks of age until weaning (3 months). Spanish goats used for replacements or breeding stock will usually be marketed at approximately 1 year of age. The survey indicates that 8% of the ranchers market their goats at 2-4 weeks of age, 55% at 4-6 weeks, 45% at weaning, and 23% at 1 year of age. This means that most of the ranchers are marketing their goats for young milk-fed "cabrito" meat purposes. Since 45% of the goats are marketed at weaning and 23% are marketed at one year of age, a market exists for older meat carcasses and for replacement of nannies and billies.

Marketing of goats is quite different from marketing cattle because of differences in market demand and product availability. However, there are some similarities in that goats may be sold at auctions or directly off the ranch (private treaty). The survey results indicate the majority of producers sold goats by private treaty (70%) or to friends (73%). Others are sold at auctions (34%) or by roadside vending (25%). Very few are sold at wholesale (6%) or direct to packer (5%). Again, the overlap in percentages indicates that most ranchers market their goats using several methods.

Management Implications

Spanish goat production systems can be characterized by survey responses. Various authors have described goat production systems as practiced around the world and these are summarized into

extensive, semi-intensive, and intensive. Extensive systems are usually practiced under semi-desert conditions, primarily on shrub-dominated rangelands. Semi-intensive systems also use rangeland but may have access to crops and crop residues. Intensive systems may include feedlots, improved pastures, or rowcrops. The first two systems basically use Spanish or native meat type goats whereas the latter has more opportunities for a breeding program and selection that will incorporate the use of both hair and milk goats.

Spanish goat production systems in South Texas are essentially semi-intensive systems with a few extensive and a few intensive. Most operations depend upon rangeland brush for forage but do supplement when needed. Some animal health practices are used for parasite and disease control. The main limitations to increased production appears to be lack of herd health practices, overall poor husbandry, the lack of an organized market, the abundance of predators, and, to some extent, the prohibitive cost of fencing and labor.

There is a lack of information for producers. However, interest in production, nutrition, marketing, health, and other Spanish goat production-related topics are overcoming this obstacle. The integration of production-marketing/processing and consumer information show promise in building a viable South Texas Spanish goat industry.

Acknowledgments

This study was partially funded by the Texas Agricultural Extension Service, Texas Department of Agriculture (Texas Agricultural Diversification Program), and USDA-Soil Conservation Service. The efforts and cooperation of each is appreciated. This is a contribution of the South Texas Spanish Goat Initiative Project.

Cattle-Rangeland Interactions: An Ecological Basis for Integrated Pest Management

P.D. Teel, J.P. Reynolds, S.R. Archer, O.F. Strey, and T. Longnecker

Cattle are a central feature (Figure 1) in the biological cycles of ticks, horn flies, and woody plants such as mesquite. Ticks residing in litter and on plants will attach to cattle and feed on blood before dropping back onto rangeland. Their chances of survival are increased if they fall near a canopied vegetation community with suitable micro-environment to lay eggs or molt to the next life stage. The cow thus serves as a transport mechanism as well as a blood source.

Horn flies develop in manure and, upon emergence, seek cattle for blood. Unlike ticks, adult horn flies remain on cattle, repeatedly taking blood meals and only leaving the cow to lay eggs in newly deposited manure. If the manure is deposited in uncanopied habitats where soil surface temperatures may be high, fly development may be significantly reduced or even halted, whereas fly development in manure deposited in canopied habitats may produce maximum numbers of flies due to attenuated temperatures.

Long-term vegetation succession also is influenced by the distribution of manure, which may contain scarified mesquite seeds. The establishment of mesquite seedlings and the chronology of woody plant succession ultimately produces canopied vegetation communities with low forage production and optimal environmental conditions for the development and survival of ticks and horn flies.

In recent years, we have demonstrated that prescribed fire or herbicides applied for brush management can reduce tick populations for up to 2 years and reduces the reproductive potential of horn flies from manure in treated habitats. One essential determinant of the duration of effectiveness of brush disturbances on arthropod pest management is the subsequent recruitment of parasites by grazing cattle. Considerations of the role of cattle in the collection and dispersal of ticks and manure, as a medium for horn flies and mesquite seedling establishment, are a potentially important spatial component of brush and grazing management strategy development.

Four interrelated lines of study are being conducted at La Copita to better define how cattle contact and disperse parasites and seeds of woody plants on rangeland landscapes. These lines of investigation are 1) documenting the daily physical position of cattle with respect to brush clusters of different developmental stages; 2) determining manure distribution with respect to canopied vegetation communities; 3) profiling seasonal litter deposition and resident tick distribution under brush clusters of different stages of development; and 4) determining tick attachment rates for cattle visiting brush clusters of different developmental stages. Only the first line of investigation will be discussed here.

To evaluate daily cattle position patterns in brush clusters of different developmental stages, two adjacent plots, approximately 2 hectares each, were selected in the West Deferred pasture. The plots were selected such that they contained comparable numbers of developing and mature clusters and coalesced groves. Each cluster and grove was characterized/defined by size and species composition and located on a grid map of the respective plot. A common water source was provided on the fence line between the plots.

From a group of nine cross-bred cattle, four animals were randomly selected and assigned to each pasture the day before observations commenced. From 6:00 am to 6:00 pm on the following 2 days, an observer recorded the grid location, relative position to nearest cluster or grove and activity of each animal at 5 minute intervals. On the eve of the second day, the animals were moved to the opposite plot and over the succeeding 2 days the respective plot-observers recorded the same information. This sequence provided 32 cow-observation days for analysis. Between the 2 days of observations on each plot the cattle were observed at 2-hour intervals through the night to determine the relative extent of night-time movement.

The cattle were inspected for ticks in a squeeze chute prior to the study period and all ticks removed. At the end of the 4-day study period, the number, species, and stage of ticks attached during the exposure period was recorded. Temperature and relative humidity were recorded constantly during the study. The study will be conducted quarterly and during the respective week of the full moon. Estimates of forage production are made just prior to each observation period to compare the relative

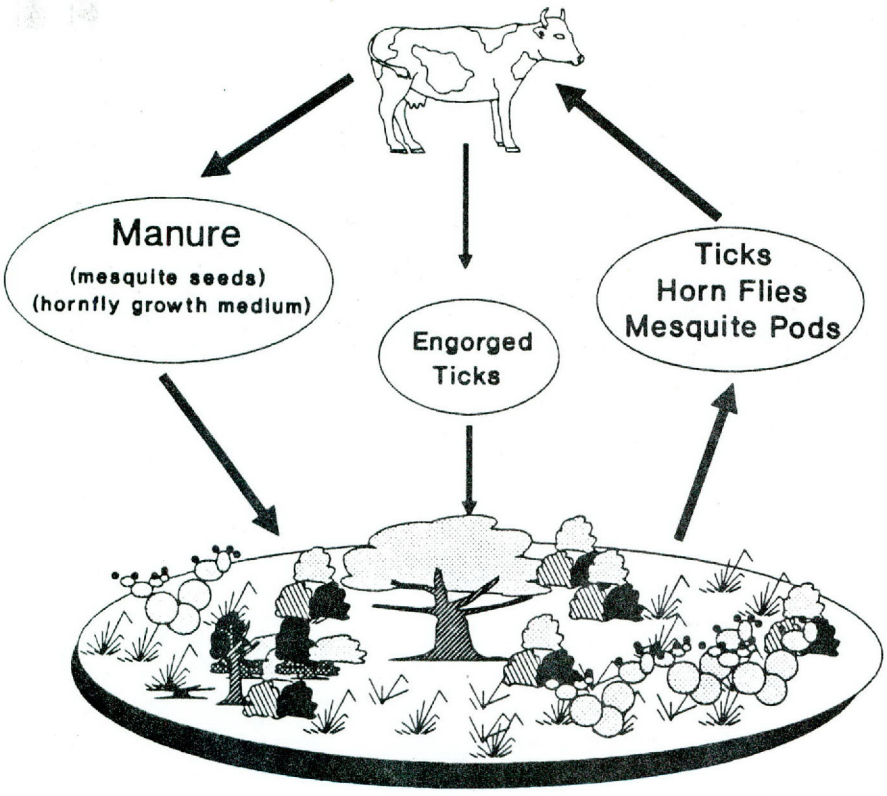

Figure 1. Cow-rangeland interaction in the ecology of ticks, horn flies, and mesquite.

abundance of grasses and forbs between interstitial areas and brush clusters. Following a preliminary study period in June 1991, data sets have been collected in November 1991 and February 1992. Three more data sets will be collected in 1992 to evaluate seasonal influences.

Figure 2 is a partial summary of information obtained from the two, 4-animal groups utilizing developing and mature brush clusters in Plot 2 for 4 days in November 1991. During this period, temperature and relative humidity were quite mild (ave. daily max/min = 27°C, 38%/18°C, 83%). Forage availability was low in developing and mature brush clusters, moderate in groves, and fairly moderate and continuous in the interstitial zones. The animal use pattern for developing and mature brush clusters was bimodal with the highest average number of visits per hour and the longest average stays (<11 minutes) occurring between 6:00 and 9:00 am and from 1:00 to 3:00 p.m. Visitations to the groves, or coalesced clusters, were more variable and showed no discernable pattern.

The preliminary data set (not shown) collected June 1991 was also bimodal, but the hourly distribution of visitations was different and both the number of hourly visitations and average length of stay in each mode were higher, particularly in the mode occurring from 1:00 to 4:00 p.m. when stays exceeded 1.5 hours. Environmental conditions were more stressful during June and forage abundance was lower. Upon completion of all study periods in 1992, a hierarchical statistical analysis will be conducted to more completely evaluate cow utilization of each brush cluster developmental stage across season. A present, the information on duration of stay is being used to design a companion study for 1992 on tick attachment rates from brush clusters of different developmental stages.

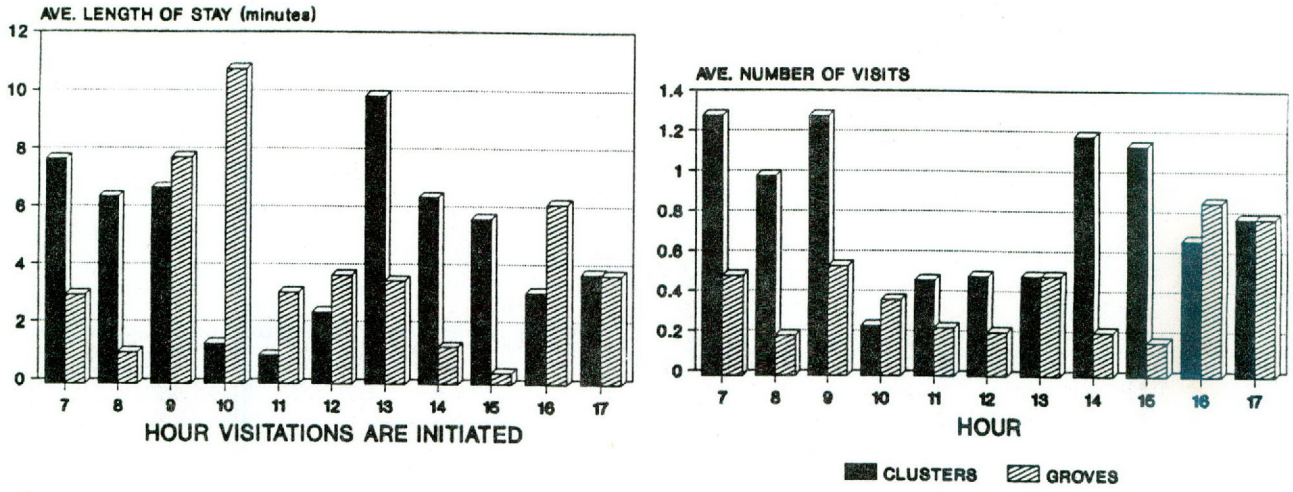

Figure 2. Comparative utilization of developing and mature brush clusters and groves by eight cross-bred cattle from 11-14 November 1991 (Plot 2 - West Deferred Pasture).

Alien Cohabitation vs Temporary Weaning in Estrous Synchronization Schemes Using Syncro-Mate-B

G. L. Williams

Estrous (heat) synchronization and artificial insemination (AI) offer cattlemen the opportunity to breed cattle on a controlled basis. Economically, estrous synchronization and AI are most effective when breeding replacement heifers, seedstock, and embryo transfer recipients. However, under specifically defined conditions, management schemes employing estrous synchronization can also be beneficial in mature, commercial beef cows.

When using Syncro-Mate-B (SMB) synchronization, it is important that calves be temporarily weaned (usually for 48 hours) after implant removal and prior to targeted insemination. This is especially true when synchronization is used with timed AI. Conception rates to timed AI following synchronization with SMB can be effectively doubled by temporary calf removal. However, of all the procedures involved in estrous synchronization and AI, the process of temporary weaning seems to create the greatest concern for cattlemen. This aversion to temporary weaning is not without some degree of justification, since stress and weather conditions can result in sickness in some groups of calves, as well as temporary weight loss.

We now know that calf association and suckling by a calf other than a cow's own calf does not inhibit estrus and ovulation. It appears that the maternal bond must be present in order for a calf to suppress ovarian and sexual activity. Based on this information, we propose that sets of calves can be effectively switched among groups of cows kept temporarily in dry-lot for heat synchronization. We believe this process will not reverse the effect of temporary weaning of "own" calves and may result in some degree of suckling and/or nurturing of alien calves.

The purpose of these trials was to determine the effect of alien cohabitation on estrous synchronization and conception to timed AI. Suckling behavior of cows and calves and weight changes in calves during the 48-hour period of calf removal or cohabitation also were examined.

Procedures

Trial 1

Sixty-three Brahman x Hereford (F_1) cows maintained under South Texas range conditions were used. Cows were stratified by age, weight, body condition score and date of calving, then randomly assigned to one of three groups: 1) SYNCRO-MATE-B (SMB) plus 48-hour calf removal; SMB-W, 2) SMB plus alien cohabitation; SMB-A and 3) SMB-suckled; SMB-S.

Twelve days prior to targeted AI, all cows received the standard SMB treatment.

This included an injection of norgestomet (3 mg) and estradiol valerate (5 mg) plus an ear implant containing 9 mg norgestomet. The implant was removed 9 days later, at which time cows in the SMB-W and SMB-A group had their calves removed for 48 hours. Calves removed from SMB-W cows were placed with SMB-A cows for the 48-hour period. Calves removed from SMB-A cows were placed in a pen approximately 50 yards away. They were fed hay, creep feed and provided with water during this period.

Cows were timed-inseminated at 48 hours with semen from a single collection from one Angus bull. Three experienced technicians inseminated an equal number of cows in each group on a random basis. All calves were returned to their own dams immediately after AI. Pairs were then returned to pasture. Three days after AI, two red Angus bulls of known fertility were placed with the herd for 60 days.

Forty-five days after AI, the reproductive tract of all cows was examined with a transrectal ultrasound scanner to detect conception at timed AI (40 to 45-day pregnancies) and during the subsequent 15-day period (30-day pregnancies). Cows were then palpated per rectum 45 days after bulls were removed to determine final pregnancy rates.

Trial 2

A second trial was performed using 76 Brahman x Hereford cows at Beeville. The trial was identical to Trial 1, except that suckling behavior of cows and calves was monitored for 30 hours: Day 1, 10 hours; Day 2, 16 hours and Day 3, 4 hours. Calves were weighed at the time of weaning and 48 hours later.

Results

Trial 1

Table 1 gives conception rates to timed AI, cumulative pregnancy rates during the first 15 days of breeding and final 60-day pregnancy rates for the trial. Cows in the SMB-W and SMB-A groups exhibited timed-AI conception rates exceeding 50%. However, SMB-S cows had poor conception rates to timed-AI (19%). Cumulative pregnancy rates continued to favor SMB-W and SMB-A through the first 2 weeks of the breeding season. Total pregnancy rates after 60 days did not differ significantly.

Trial 2

Table 2 summarizes the incidence of suckling and suckling duration in alien calves maintained with weaned cows for 48 hours after SMB implant removal. While over 40% of the calves nursed for at least 5 minutes during the 48-hour period, only 24% nursed for 15 minutes or more. Six of 24 cows allowed alien calves to suckle. A further summary of the behavior of cows and calves is presented in Table 3. Due to a scale malfunction, accurate weights were not obtained on the weaned calves before weaning. Hence, the weight change for this group could not be calculated. Table 4 presents weights and weight changes for the other two groups. Calves suckling their own dams gained a small amount of weight, whereas alien calves lost an average of 6.1 lb for the two-day period. As additional trials are conducted, accurate weight change data will be available to compare performance of all groups.

Timed AI conception rates were poor for all groups in Trial 2. Conception rates were: SMB-A, 30.7%, SMB-W, 26.9% and SMB-S, 25%. The cows used in this experiment had previously been used on a nutritional restriction study and were in poor body condition. Hence, poor performance was expected. Our primary interest in Trial 2 was in learning about suckling behavior of alien cows and calves. Additional trials will provide further information concerning these variables as well.

Table 1. Conception rates to timed AI and cumulative pregnancy rates in SMB-W, SMB-A, and SMB-S Cows.

		Percent Pregnant		
Group	No.	Timed AI	15 Days	60 Days
SMB-W	21	57.1[a]	81.0	95.2
SMB-A	21	52.3[a]	76.2	85.7
SMB-S	21	19.0[b]	52.3	90.4

[a,b] $P < .05$

Table 2. Suckling incidence and suckling duration of calves (n=29) in the alien group during the 48-hour cohabitation period, Trial 2.

Total suckling time, min	No. cows allowing suckling ≥ 5 min	No. different calves allowed to suckle ≥5 min	≥ 15 min
402.9	6/24 (25%)	13/29 (44.8%)	7/29 (24%)

Table 3. Behavior of weaned cows (n = 26) and alien calves (n = 29) maintained together in dry-lot during the 48-hour temporary weaning-alien cohabitation period, Trial 2.

Attempts/calf suckling attempts	Attempts/cow Avg	Range	Successful bouts Avg	Range	Total Avg/calf	Range	Avg/cow	Range
269	9.3	0-40	10.3	0-41	5.4	0-19	5.0	0-56

Table 4. Average weight changes of calves in SMB-S, SMB-W, and SMB-A groups during the 48-hour experimental period.

Group[a]	Average wts, lb Initial	Final	Avg. wt. change, lb
SMB-S	223.5	224.8	1.25
SMB-A	214.3	208.6	-6.10
SMB-W	NA	201.9	NA

[a] SMB-S = SYNCRO-MATE-B, suckled by own calves
SMB-A = SYNCRO-MATE-B, maintained with alien calves
SMB-W = SYNCRO-MATE-B, weaned for 48 hours

White-Tailed Deer Harvest Summary (10 Years)

C.D. McKown

The end of the 1991-92 Hunting Season completed 10 years of White-tailed Deer harvest and census information gathered on La Copita. There have been several alterations made in the hunting system during this time to better meet the goals of the Research Area. In 1982 the objectives of the hunting system were defined to: 1) generate revenues from wildlife resources, 2) implement a system that could be planned and controlled within a general ranch operation, 3) provide an attractive hunting-lease package, and 4) improve the quality of the White-tailed Deer herd through controlled harvest.

Short-duration hunts, which included both day and weekend leases, were implemented during the first 5 years. This hunting system charged by the person and fees were based on 1) an access fee, half sent in with a signed lease agreement to confirm a reservation and half collected upon arrival, and 2) a pricing schedule for different game animals harvested. The pricing schedules were designed to give incentive to hunters to harvest game animals in accordance with the harvest recommendation.

The Research Area provided, maintained, and baited hunting stands for clients. Camping was permitted but no facilities were provided until 1986 when a shower/toilet house and trailer pads with electricity and water were constructed. In 1987 a season-long lease was adopted, which consisted of one annual payment based on a per acre basis with a $1000 refund available if the recommended harvest quota was attained. If a reasonable effort was not made to meet the harvest quota, then the refund monies would be used to the cover the cost of implementing a special hunt to harvest the remaining animals. Before the 1991 hunting season, the refund incentive was revoked and became an increase in the cost of the lease. The season lease agreement gives the lessee responsibility of maintaining hunting stands and baiting areas if so desired.

Short-Duration Hunts

In 1982 only deer and javelina hunts were available, no quail hunts were offered. The access fee was $200 for weekend hunts with an additional fee of $100 for does, spikes, and javelina and $200 for forked bucks. Late in the season, one doe was included as part of the access fee, since few does were being harvested. Day leases for quail started in 1983 at $50/day/person. Quail hunts were conducted in November and January, and December was reserved for deer hunts. From 1983-85 the access fee remained at $200 including a free doe or spike, but the pricing schedule was changed to $100 for an additional doe or spike, $100 for a javelina, $200 for a forked buck with less than a 14 inch inside spread, and $300 for a forked buck with a spread greater than 14 inches. In 1986 more incentive to harvest does was essential, therefore the access fee was changed to $250 which included one doe or spike. The pricing schedule then offered a $50 refund for a second doe or spike, $250 for any forked buck, and $50 for a javelina. The doe harvest was short of expectations so $25/day doe hunts were offered with a $50 harvest fee.

During the short-duration hunting period the harvest quota for does and spikes was held at 30 per year. The closest the actual harvest came to the recommended harvest was in 1983 at 73%. The actual number of does harvested totaled 77 and spikes totaled 16 (Table 1). There were a total of 1.88 females harvested per male while using the short-duration hunting system. The sex ratio was holding around 5 does/buck, so the management and research objectives were not being met. The annual income under the this system averaged $8,934, with quail leases accounting for 37.5%.

Season Lease Agreement

The season lease hunting system has been able to meet the management objectives for 4 of the 5 years in use. The average annual income from season leasing was $10,200. The female harvest totaled 115, which is a 49% increase from the short-duration hunts and the harvest ratio was 4.26 females/male (Table 1). The first two years were very successful in fulfilling the objectives originally outlined in 1982. The desired harvest of 30 anterless deer including spikes was easily achieved in 1987. However, the 1988 census indicated that the density of deer had increased, the proportion of does did not change, and that the harvest quota should be set at 40 does. At this time it was decided that until the sex ratio improved, spikes would be considered young bucks and thus would be counted as part of the buck harvest. Male fawns would not count toward the doe quota in 1988, since the objective was to harvest 40 females. The female harvest was allowed to exceed the quota with the anticipation of a major change in the sex ratio. Field dressed weights of mature does

averaged 62.4 pounds and was at an all time low. This corresponded with the highest deer density, of 10 acres/deer, and the second lowest annual precipitation, 15.5 inches, in the 10 year period (Table 1).

The harvest quotas in 1989 and 1990 were not enforced since densities were declining and the drought conditions persisted. The only stipulation was that the proportion of does harvested should equal or exceed the sex ratio from the fall census information. High weights of does in 1989 can be attributed to the cooperation of the hunters in selecting larger does. The 1991 census data indicated that density of deer and the proportion of does in the population had both increased. The actual harvest only reached 80% of the 20 anterless deer in the harvest quota. This is the only year under the season lease agreement that the management objectives were not achieved and that there was no incentive refund.

Census and Check Station Results

The method for censusing the wildlife populations on the Research Area have been modified since 1982. Helicopter counts have been conducted during each of the 10 years. From 1982 to 1988 a non-replicated 25% coverage count was flown both before and after the hunting season. The census area included La Copita and the surrounding 10,000 acres. These counts were done in order to get some understanding of the relationship between the status of the deer populations within and adjacent to La Copita. Spotlight counts were done in conjunction with the helicopter counts and were the primary census used to determine the status of the deer herd on La Copita. Spotlight counts were conducted on 3 to 5 consecutive nights with a route that was equivalent to 4 miles per 1000 acres.

The helicopter census became the primary census method in 1989. The count was modified to include 2 to 3 replications of 50% coverage restricted to La Copita. The Spotlight counts were discontinued at this time. Estimates of sex and age ratios were supported with dashboard observations starting in 1986. Observations from all ranch personnel are taken from the first week of September through the opening day of deer season. The total number of does, fawns, spikes, small forked bucks, and forked bucks with antlers that extend past the tips of the ears are recorded on a weekly basis.

Based on the types of census used, deer density estimates have ranged from 10 acres/deer in 1988 to 21.7 acres/deer in 1984 (Table 2). The average for the 10 year period has been 14.9 acres/deer. Sex and age ratios have improved since the number of does harvested increased in 1987. For the first 7 years the does/buck ratio tended to stay fairly close to 5, but for the last 3 years the ratio has remained around 3. Fawn survival has also increased from an average of .45 fawns/doe (1982-1986) to an average of .65 fawns/doe (1987-1991). A positive indication from the fawn data is that an adequate number of fawns were counted during the severe drought of 1988 and 1989.

Changes in the annual average field dressed weights of mature does fluctuated with the annual precipitation, except in 1989 (Table 2). The averages varied from 62.4 to 72.1 and averaged 66.8 pounds throughout the 10-year period. There was an insufficient number of bucks to look at the data on an annual basis. Combining age classes across years indicated that bucks 3.5 years of age averaged 101 pounds field dressed and 14 inches inside spread. Bucks 5.5 years and older averaged 111 pounds dressed and had an inside spread of 16.5 inches. Yearling bucks ranged from 2 to 5 points with 18 of 23, or 78%, being spikes.

A primary concern since the initiation of hunting systems at La Copita has been "Can wildlife management be used to improve the quality of the deer herd on small land holding?" The indicators used to estimate the quality of the White-tailed deer herd have improved since the project began. Future harvest will continue to adjust deer densities and sex and age ratios with the hope of providing quality deer for clients. Under the season lease agreement, hunters have retained a better understanding of the relationship between the management objectives and the long range outlook. The final outcome on small ranches is influenced by uncontrollable factors, such as harvest practices on surrounding properties and harvest by poaching. These factors may be the difference between producing good and excellent deer.

Table 1. White-tailed deer harvest summary for females and males, percent of anterless deer harvest quota, sex ratio harvest, and gross receipts by hunting system and years on the La Copita Research Area.

Year	Does/buck	Fawns/doe	Deer density (acres/deer)	Doe weights[4] (lb)	Precipitation (inches)
1982	9.25 H[1]	0.46 H	11.3 H	63.7	18.6
1983	4.50 S[2]	0.26 S	13.6 S	67.0	25.4
1984	5.67 H	0.47 H	21.7 S	64.6	20.0
1985	3.78 A[3]	0.58 S	14.9 S	69.7	32.7
1986	4.87 A	0.45 A	11.6 A	67.9	23.6
1987	4.80 S	0.73 A	17.0 S	68.6	28.0
1988	5.00 S	0.52 A	10.0 S	62.4	15.5
1989	2.00 H	0.56 H	15.8 H	72.1	14.5
1990	3.04 H	0.57 H	18.1 H	67.0	22.5
1991	3.28 H	0.85 H	14.7 H	70.1	32.7

[1]H Fall helicopter count.
[2]S Fall spotlight count.
[3]A Average of spotlight and helicopter counts, includes dashboard observations after 1986.
[4]A Average field dressed weights of does, 2.5 years of age and older.

Table 2. Summary of white-tailed deer census and check station information and annual precipitation by year on the La Copita Research Area.

Year	Females	Males			Quota (%)	Females/Male	Gross Receipts
		Fawns	Spikes	Forked			
				Short-duration leasing			
1982	8		4	10	40.0	0.57	$5.825.00
1983	18	2	2	4	73.3	2.25	$7,950.00
1984	15	1	4	5	66.7	1.50	$10,150.00
1985	19			5	63.3	3.80	$10,375.00
1986	17	1	2	1	66.7	4.25	$7,260.00
Sub-total	77	4	12	25		1.88	$41.560.00
				Season leasing			
1987	28	3	2	3	110.0	3.50	$10,000.00
1988[2]	47	2	4	1	117.5	6.71	$10,000.00
1989	13			3	68.4	4.33	$10,000.00
1990	12			4	66.7	3.00	$10,000.00
1991	15	1		4	80.0	3.00	$11,000.00
Sub-total	115	6	6	15		4.26	$51,000.00
Total	192	10	18	40		2.82	

[1]No quail hunting income.
[2]Spikes included in buck harvest quota.

NIRS Equations for Predicting Diet Quality of Free-Ranging Goats

E.R. Leite, J.W. Stuth, R.K. Lyons, J.P. Angerer, C.D. McKown, and E.D. Kapes

Several methods for predicting nutritional status of livestock have been reported. However, nutritional research concerning grazing ruminants has been limited by the high labor demand and relatively low precision. In recent years, many researchers have indicated that fecal indices may have potential for predicting ruminant diet quality, forage intake, and performance. Consequently, several regression equations have been developed to determine relationships between dietary and fecal parameters. Some investigators concluded that fecal nitrogen and fecal in vitro digestibility appear to be closely related to dietary nitrogen and in vitro digestibility of diet, at least when grasses comprise most of the diet of a ruminant. Other authors, however, have suggested that fecal profiling provides weak correlations to diet quality, which is probably due to the difficulties in seeking wet chemistry techniques.

Near infrared reflectance spectroscopy (NIRS) technology, which is already being used in forage analysis, offers the potential to develop a rapid, reliable, and easy to use method of estimating the nutritional quality of the range animal's diet. Recent studies indicate that NIRS appears to provide superior estimates of diet quality from fecal analysis than wet chemistry methods.

The NIRS analysis method is based on the principle that each major chemical component of a sample has near-infrared absorption properties that can be used to differentiate components from each other. Major advantages of NIRS analysis include speed, ease of sample preparation, multiple analysis performed with one operation, and nondestruction of samples. Disadvantages include instrument requirements, dependence on calibration procedures, complexity of choosing data treatments, and lack of sensitivity for minor constituents. Calibration is necessary for each component analyzed and usually calibration is valid only for the same type of samples. This makes standardization of collection and handling procedures essential.

Procedures

Fecal NIRS equations for predicting nutritional status of cattle are already defined and being successfully used, but equations for other domestic or wild ruminants are still lacking. To define equations for free-ranging goats a study was conducted in College Station and at the La Copita Research Area, in Alice, Texas. In La Copita, extrusa and fecal samples were collected from six, 4.0 acre paddocks, reflecting three levels of available browse, replicated twice and conducted from August, 1990 to August 1991. In College Station, samples were collected from five small paddocks, each one simulating a particular kind of predominant vegetation (native grasses, evergreen shrubs, deciduous shrubs, rye-grass, and a pen with a mixture of grass, forbs and browse).

Analysis were started with both College Station and La Copita's samples together, but the results were discouraging because the R-squares (R^2) were low and the standard errors of calibration (SEC) were higher than an acceptable maximum. Separated analysis were then performed for both College Station and La Copita data sets. Results obtained with La Copita's samples were worse than when its data were analyzed together with College Station's data, while a improvement was found when the College Station samples were analyzed alone. It was concluded that the multiple, 15-minute extrusa samples collected in the large La Copita paddocks were not representative of the nutritional quality of the goat diets integrated over the grazing trial. While in College Station the animals had between 10 and 20 plant species to select in the small paddocks, in La Copita they had around 100 species. Consequently, it was decided to build the initial calibration using only the College Station data set.

The stable equations were determined after the elimination of possible outliers (chemical and laboratory procedures) and data being submitted to various math treatments. For each math treatment, several factors were considered to select the most appropriate equation including R^2 (degree of variation accounted for the independent variables), SEC (repeatability of prediction), the wavelength F-statistics (variation contributed by each wavelength), wavelength coefficient magnitude, identification and avoidance of water related wavelengths, and examination of primary

wavelengths to determine the existence of chemical relationships with the biological parameters studied.

Results

The selected equations in Table 1 met the criteria for stable equations as stated earlier, and were within acceptable and usable limits. To better understand behavior of the spectra, primary wavelengths for both crude protein (CP) and digestible organic matter (DOM) equations were plotted within the spectra of fecal samples representing extreme samples collected in the study (Figure 1). For the CP equation, greater absorbance for the high quality sample was noted for the primary wavelength (2305 nm). This wavelength has been associated with neutral detergent fiber (NDF) of forage samples that have been passed through the gastro-intestinal tract. CP is described as one of the components of NDF in plant cell wall, which is highly related to fecal components. Some authors suggest that the greater absorbance associated with feces from high quality forage may indicate detection of microbial response to diet quality through absorbance associated with chemical bonds in undigested rumen microbial (bacteria) cell walls, whole microbial cells produced in the lower gastrointestinal tract, and aromatic and other by-products of microbial fermentation.

For the spectral region around the primary wavelength (2018 nm) in the DOM equation, absorbance was greater for the low quality sample (Figure 1). This wavelength falls in the range of compounds associated with -OH chemical bonds, which are reported to be in all starch and cellulose containing substances. Digestibility of forages has been reported to decline with maturity, which is associated with increased fiber content.

Analysis of samples derived from the La Copita Research Area indicated that there was no spectral difference between feces collected in this area and feces generated in the Post Oak woodlands near College Station. This indicates a broader applicability of NIRS equation than originally planned.

This research indicates that NIRS is a viable technology for predicting diet quality of free-ranging goats. Our results show that generalized fecal NIRS calibration equations can accurately predict CP and DOM from goat diets on ranges with a wide variation in botanical composition. NIRS shows great potential as a tool to reduce time, labor, and cost inputs associated with nutritive evaluation of range animal's diet, helping to improve nutritional programs in a ranch operation.

Table 1. *In vivo* corrected crude protein (CP and digestible organic matter (DOM) equations for free-ranging goats from College Station calibration set[1].

	Calibration				Validation			
Equation	Wavel.	F	SEC	R^2	SEV(C)	R^2	Bias	Slope
CP	2305	360	1.12	0.94	1.28	0.94	0.16	1.18
	2241	229						
	2027	170						
	2174	332						
	2260	124						
DOM	2143	89	2.02	0.93	2.12	0.92	0.18	0.91
	2018	182						
	2057	111						
	2301	169						

[1]Math treatment for both equations is 2, 10, 10, 1.

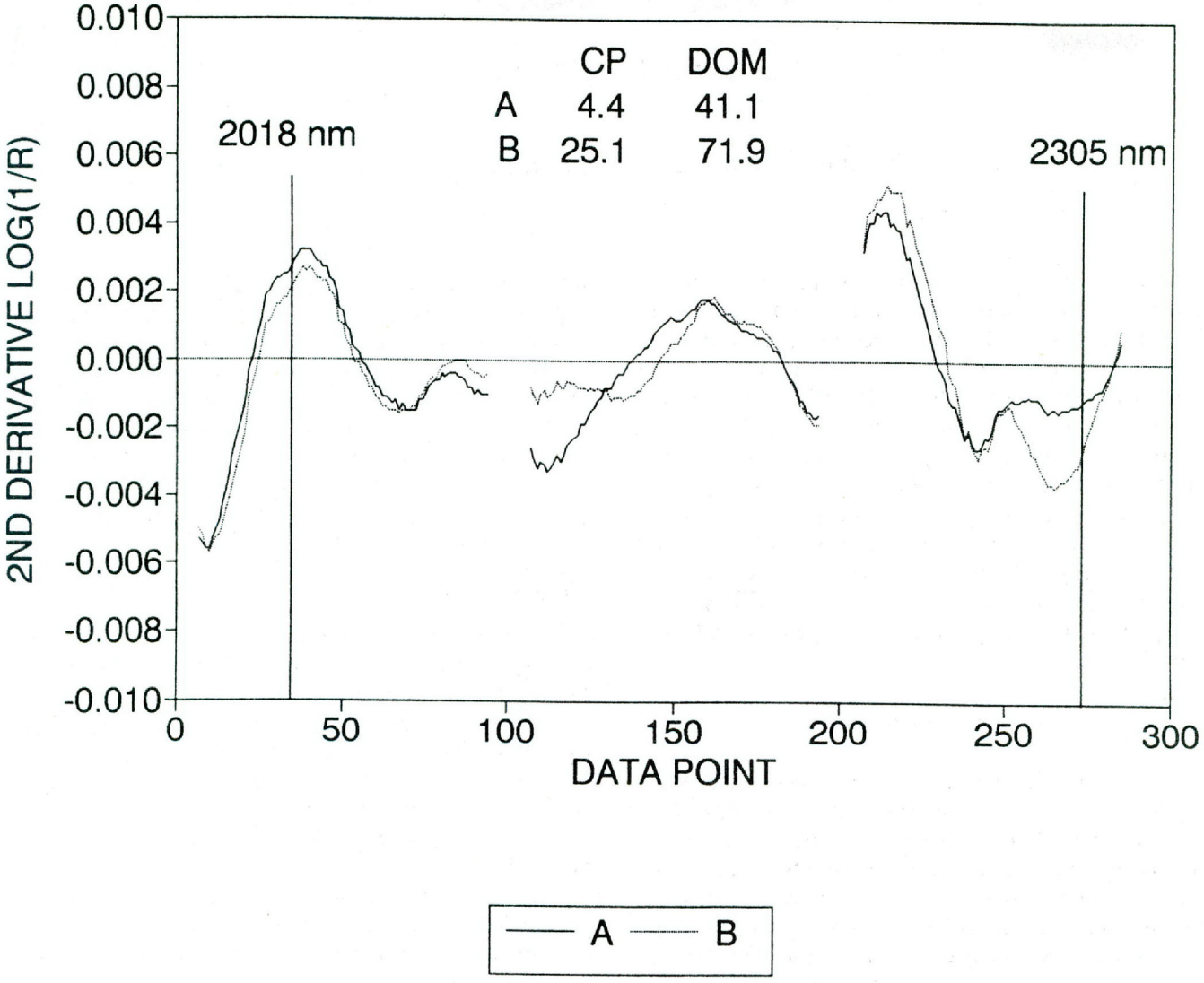

Figure 1. Comparison of second derivative log (1/R) fecal spectra associated with fermentation of low (A) and high (B) quality forages illustrating greater absorbance at most significant estimated wavelengths in the DOM equation (2018 nm) for sample A and in the CP equation (2305 nm) for sample B. Valleys (minima) in second derivative are analogous to peaks (maxima) in log (1/R) spectra. Gaps are indicative of filter changes.

Effects of Brush Level on Diet Quality and Nutrients Balance of Free-Ranging Goats

E.R. Leite, J.W. Stuth, R.K. Lyons, J.P. Angerer, C.D. McKown, and E.D. Kapes

The meat goat industry is growing in the thorn-shrub region of South Texas. To date, the focus has been on marketing, breeding, and general husbandry. However, little is known about the effects of varying brush levels and the nutritional status of goats in the region. Without this knowledge, strategic supplementation will be a long trial and error process. Recent advances in NIRS technology provides goat producers a mechanism of scanning feces to predict dietary protein and digestibility of free-roaming animals. This technology allows assessment of nutritional balance of goats when coupled with nutritional decision support system.

Procedures

Dietary crude protein (CP) and digestible organic matter (DOM) were measured with NIRS equations for Spanish goats grazing pastures with low, moderate, and high amounts of woody plants cover on La Copita Research Area. These data provided nutritional inputs to study the balances of CP (lb/day) and net energy of maintenance (Mcal/day) for mature nanny Spanish goats. Fecal samples were collected from herds grazing the three vegetation conditions every 30 days, from August, 1990 to February, 1992. Seasonal environmental conditions and different physiological states of nannies (dry, open, pregnant, and lactating) were reflected in the accelerated breeding program. The computerized nutritional decision support system, NUTBAL, was used to predict nutrient requirements and intake. Nutrient balance was determined by subtracting the predicted nutrient intake by the requirement of the animals at the current physiological state. The values were corrected for breed characteristics and environmental conditions.

Results

Woody plant cover on the low, moderate, and high brush paddocks was 30.4 %, 39.0 %, and 47.3 %, respectively. The entire study area had been chained in 1978. In 1983 one third was shredded, one third was treated with herbicide, and one third was left untreated. Therefore, the high browse paddocks represent twelve years regrowth following chaining, while the moderate browse paddocks represent seven years post-shredding of a five year old chaining. The low browse plots represent seven years post-spraying of a five year old chaining. Diversity of browse was similar between the moderate and heavy plots but herbicide treatments had considerably reduced species such as honey mesquite, black brush, Brasil, lime pricklyash, and pricklypear.

Generally, the nannies were able to select higher quality diets from the high browse paddocks. However, dietary crude protein (CP) was more sensitive to level of available browse than digestible organic matter (DOM) in the diet. High browse paddocks provided greater CP throughout the growing season, except during the hot, dry periods of mid-summer when little differences were noted between paddocks (Figure 1). Dietary CP during winter periods was below requirements in all paddocks. However, the goats grazing the low woody cover paddocks experienced protein deficits earlier in winter.

Dietary DOM and subsequent net energy of maintenance (NEm) of the goats was more erratic relative to availability of browse (Figure 2). However, the goats grazing the high browse paddocks selected diets greater or equal to the other levels of woody plants. Only in fall, when high soil moisture generated young forbs and fresh grass leaves, did the low browse paddocks provide the nannies with diets higher in DOM and NEm.

Given the accelerated breeding program used in this experiment, the nannies were in a negative plane of nutrition during late lactation for both kidding cycles. However, the animals were able to regain body condition during the latter stages of lactation and during the pre-breeding period.

During the first lactation cycle, only those nannies on the low and moderate browse levels experienced a protein deficit (around 0.05 lb CP/day). However, in

the second lactation cycle the nannies experienced a 0.08-0.12 lb CP/day deficit from late November through late February in the low browse paddocks and 0.02-0.09 lb CP/day during the same period on the moderate browse paddocks (Figure 1).Second lactation nannies grazing the high browse paddocks experienced a 0.1 lb CP/day deficit later in winter, approximately 30 days later than nannies grazing the low and moderate browse paddocks.

NEm balance followed similar trends as CP balance for both lactation cycles. NEm deficits were 0.4-0.5, 0.05-0.4, and 0-0.4 Mcal/day for the first lactation cycle and 0.55-0.6, 0.3-0.45, and 0-0.45 Mcal/day for the second lactation cycle of nannies grazing the low, moderate, and high browse paddocks (Figure 2).

Given the deficits for 60 lb Spanish nannies with peak milk yield of 1.5 lb/day, a potential feeding regime is provided for various feedstuffs in Table 1. Although maximum feeding levels are similar across paddocks, the primary difference was duration of deficit periods. The application of NIRS technology to assist ranchers in monitoring nutritional status of goats on rangelands will help address this issue.

Table 1. Maximum supplemental feeding levels (lb/day) to meet winter deficits of crude protein (CP and net energy of maintenance (NEm) for Spanish nanny goats grazing south Texas shrublands of varying brush levels[1].

	First Lactation			Second Lactation		
Feedstuff	Low	Mod	High	Low	Mod	High
Corn	0.45	0.45	0.45	1.07	0.63	0.89
Grain Sorghum	0.50	0.50	0.50	1.19	0.69	0.99
Oats	0.42	0.42	0.42	1.02	0.59	0.85
Cottonseed meal	0.31	0.25	0.25	0.37	0.28	0.28
Alfalfa pellets	0.42	0.34	0.34	0.69	0.40	0.58

[1]60 lb females with peak lactation of 1.5 lb of milk/day.

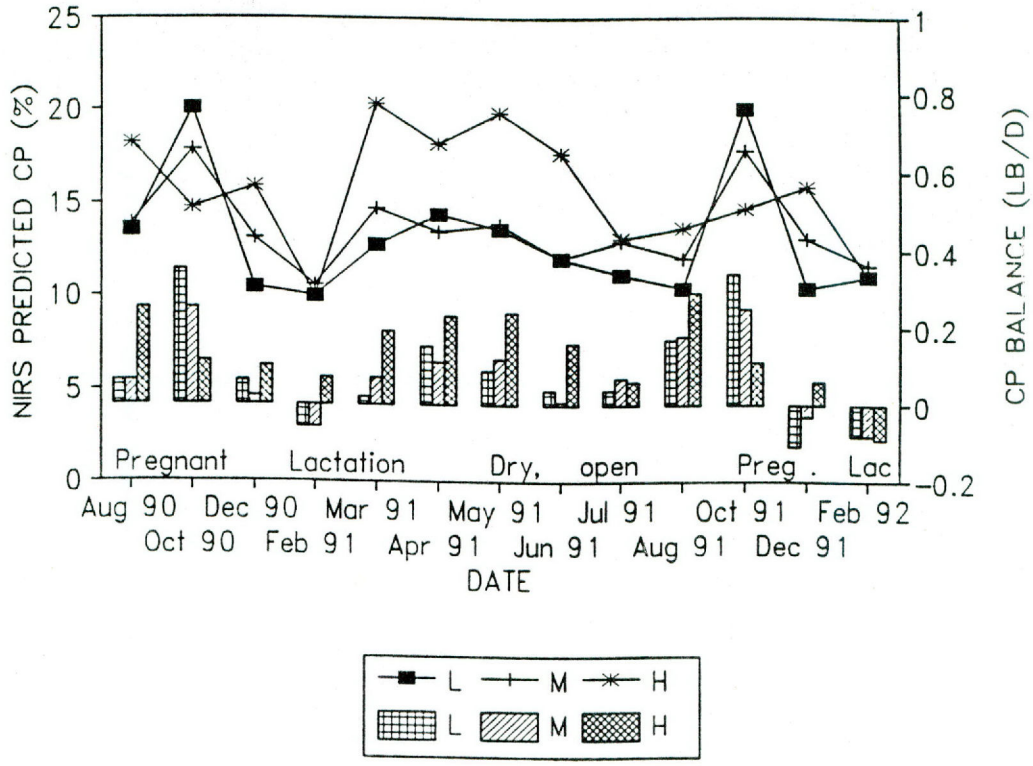

Figure 1. Effects of brush level on crude protein balance (lb/day) of nanny goats under different physiological states and varying seasonal conditions.

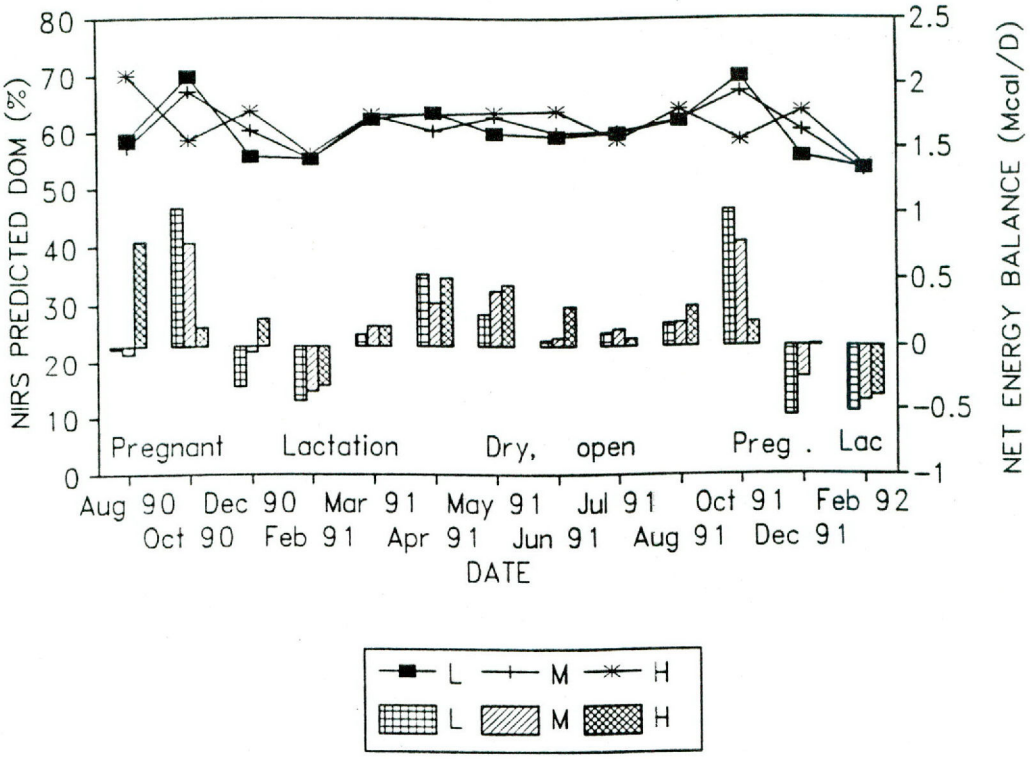

Figure 2. Effects of brush level on NEm balance (Mcal/day) of nannu goats under different physiological states and varying seasonal conditions.

Predicting Range Cattle Diet Quality Using Fecal NIRS Equations

R.K. Lyons, J.W. Stuth, C.D. McKown, and J.P. Angerer

The objective of this study was to investigate the feasibility of using near infrared reflectance spectroscopy (NIRS) to predict forage diet quality of free-ranging cattle from fecal analysis. NIRS is already being used in many agricultural applications including forage quality analysis.

Procedures

Pasture diet samples were obtained using esophageal-fistulated steers. Subsequently, fecal samples were collected from mature cows grazing the sampled areas. Diet samples were analyzed for crude protein (CP) and digestibility (DOM) using conventional laboratory methods to provide reference data for NIRS equations development. Fecal samples were dried, moisture stabilized, and scanned with NIRS to provide spectral data. Diet reference data and fecal spectral data were used to develop NIRS equations using modified stepwise regression.

Results

Initial diet collections at La Copita provided a relative narrow data range for CP (6-12%) and DOM (54-65%) which resulted in lower coefficients of multiple determination (R^2) than desired for both CP (.64) and DOM (.69). Five additional data collection trials were conducted at College Station which expanded both the CP (4-17%) and DOM (54-68%) data ranges. The Combination of the La Copita and College Station data resulted in equations with improved R^2 for both CP (.92) and DOM (.80). Seven validation trials independent of the NIRS equations have resulted in high correlations between conventional laboratory estimates of quality of diet samples obtained with esophageal-fistulated steers and NIRS predicted diet quality from fecal analysis for both CP (r=.99) and DOM (r=.94).

Comparison of fecal spectra from low quality and high quality forage provides some indications of the possible biological basis primary equation wavelength selection. For this comparison, second derivative spectra were used in which valleys indicate greater absorbance. Greater apparent absorbance (Fig. 1) at the primary CP wavelength (2107 nm) for feces resulting from consumption of low quality forage is interpreted to indicate that dietary fiber residues are being detected. For the primary DOM wavelength (2297 nm), apparent absorbance is greater for feces from high quality forage (Fig. 1) which is interpreted to indicate that microbial response to diet quality is being detected.

Results of this study suggest that fecal NIRS analysis can be used to determine forage quality of free-ranging cattle. This information can be used with computer decision support systems to provide ranchers with timely nutritional management information which can improve efficiency and sustainablity of operations.

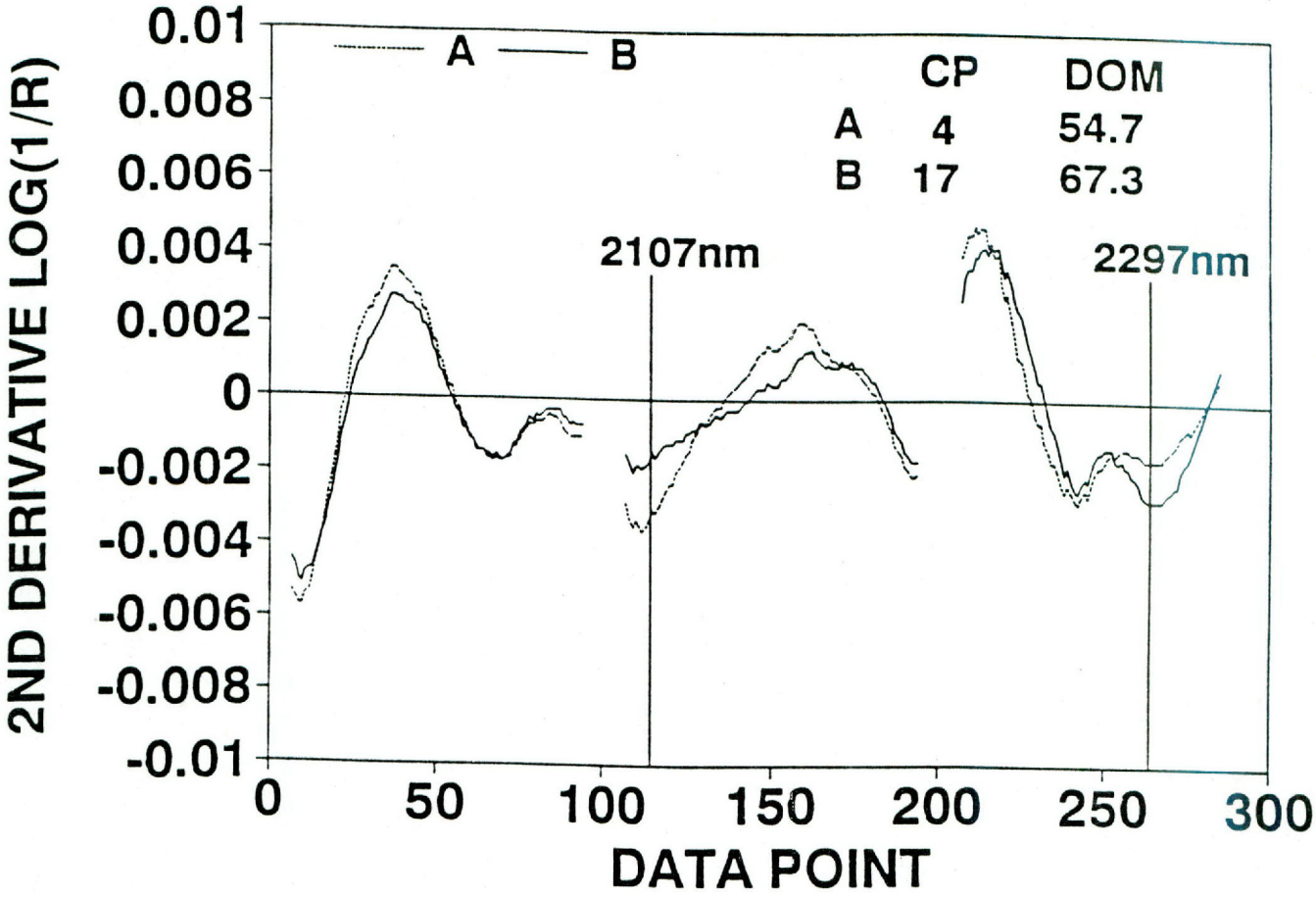

Figure 1. Comparison of second derivative fecal spectra resulting from consumption of low-(A) and high-(B) quality forages. Valleys in second derivative spectra indicate greater absorption. At the primary DOM wavelength (2297 nm), absorption appears to be greater in feces from high-quality forage (B), whereas with the primary CP wavelength absorption appears to be greater in feces from low-quality forage. Adapted from Lyons and Stuth, 1992, J. Range Manage. 45:238-244.

NUTBAL Validation: A Computer Program to Interpret Range Livestock Nutritional Status

R.K. Lyons, J.W. Stuth, and C.D. McKown

The purpose of this study was to validate range cattle performance predictions generated by a computer decision support system (NUTBAL) designed to interpret nutritional status.

A group of eight mature, nonlactating, pregnant, Hereford x Brahman cows was used in this study. Individual fecal samples were obtained weekly from September, 1990 to June, 1991 and forage diet quality predicted using fecal near infrared reflectance spectroscopy (NIRS) equations. Cows were weighed about every 3 weeks. Weather data were collected for the period as well as an estimation of herbaceous standing crop. Descriptive information was entered in NUTBAL relative to the animals in terms of breed, age, physiological stage, travel, weight, and body condition; relative to environmental conditions in terms of current and previous temperatures, night cooling, and mud conditions; and relative to forage quality and quantity in terms of NIRS predicted forage crude protein and digestibility, and quantity of herbaceous standing crop.

In using NUTBAL, information relating to factors affecting forage intake appeared to be most critical in providing accurate predictions of performance.

When these factors were not considered, predictions overestimated performance for almost the entire study period. However, when these factors were included, predicted performance very closely approximated observed performance (Figure 1). Even when predictions were outside the 95% confidence interval built around observed performance, the trend in performance, i.e., gain or loss, was correct. Factors most important in improving accuracy of predicted performance were current temperatures (daily maximum and minimum), forage standing crop, and whether forage crude protein level was adequate for rumen function.

These results suggest that with adequate animal, environmental, and forage quality and quantity information, the NUTBAL model can accurately predict range cattle performance. The linkage of fecal NIRS forage quality predictions and the NUTBAL model could provide a useful tool for making nutritional management decisions, a capability previously unavailable to range livestock producers. This linkage can also be useful to researchers in studying range nutrition concepts on a landscape level as well as identifying knowledge gaps and areas for needed research.

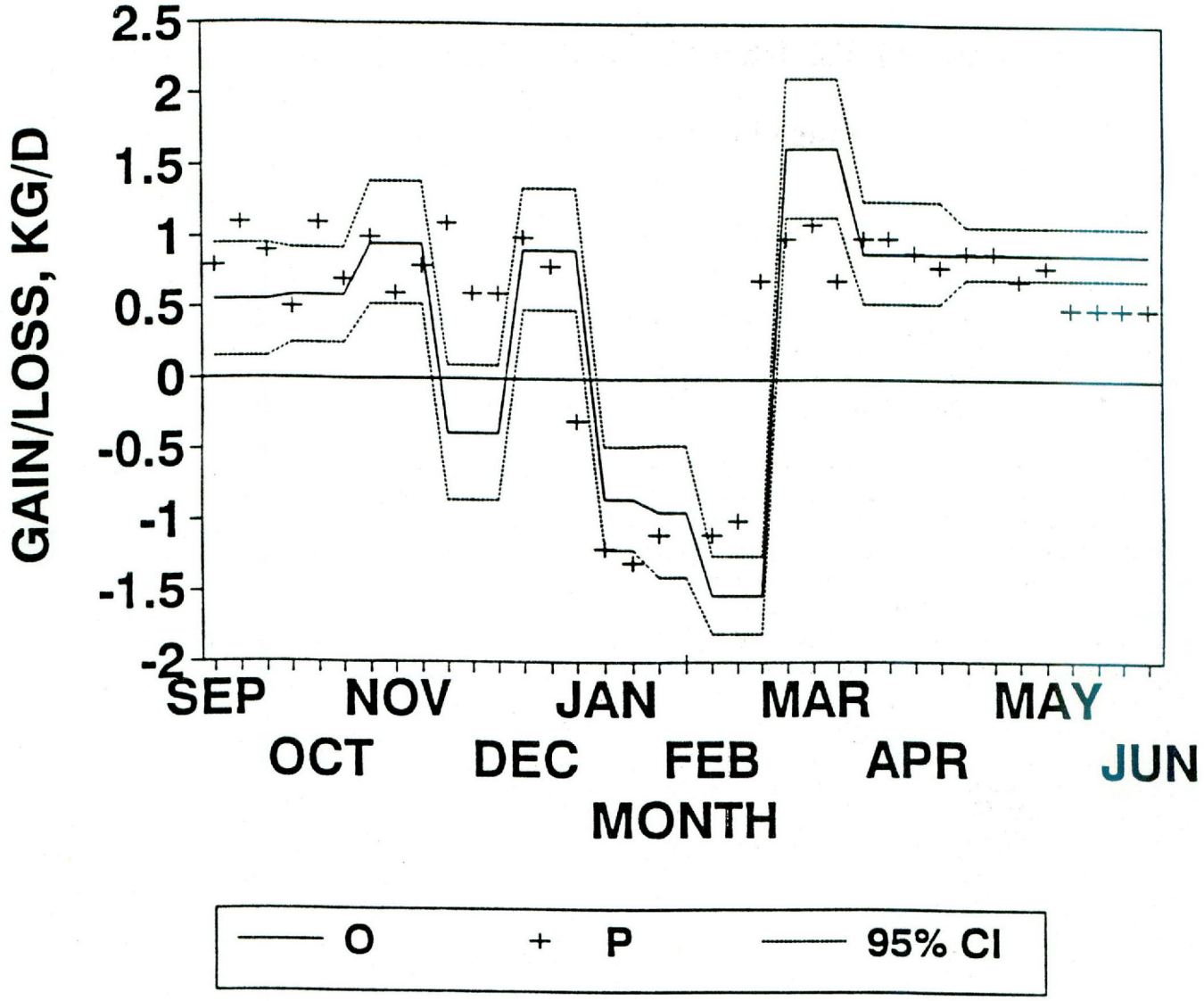

Figure 1. NUTBAL predicted performance (P) of nonlactating cattle over a 10-month period using information related to factors affecting forage intake compared with observed performance (O) with a 95% confidence interval (CL). Even where predictions were outside the 95% CL, the trend (gain/loss) was correct.

Spatial Modeling of Succession in a Subtropical Savanna

Yi-Te Chu, S.R. Archer, and D.K. Loh

The potential natural vegetation of the Rio Grande Plains of southern Texas and northern Mexico has been classified by plant geographers as savanna. In portions of southern Texas, these exist as parklands characterized by a two-phase pattern of discrete clusters of woody plants dispersed throughout a continuous grassy matrix. However, many of the present landscapes in this subtropical region are dominated by thorn woodlands. Archer (1990) has hypothesized that these woodlands may develop or that the shrub clusters in parklands may expand and coalesce. As shrub clusters develop in herbaceous zones, forage production decreases and livestock carrying capacity is reduced. Factors believed to have contributed to and have regulated this phenomenon include climate, soil characteristics, disturbances, and their interactions.

The objective of this study is to develop a spatial model of succession incorporating processes described by Archer et al. (1988) for a savanna parkland in southern Texas. Equations developed by Archer et al. (1988) are adapted to show the relative growth rate of the woody clusters. These equations are integrated with geographic information systems and rule-based reasoning tools to simulate the landscape pattern change. The event probability correlation analysis is used to validate the modeling results. Figure 1 shows the overall design of the system.

Presently, the aerial photographs were successfully digitized and displayed through GRASS (Geographical Resources Analysis Support System). Based on conditions of the study site, the initial landscape was simulated using the Monte Carlo method and a rule-based approach. The preliminary result showed a successful simulation of the initial landscape.

Literature Cited

Archer, S., C. Scifres, C. R. Bassham, R. Maggio, 1988. Autogenic succession in a subtropical savanna: conversion of grassland to thorn woodland. Ecological Monographs, 58: 111-127.

Archer, S., 1990. Development and stability of grass/woody mosaics in a subtropical savanna parkland, Texas, U. S. A. Journal of Biogeography 17, Paper 557.

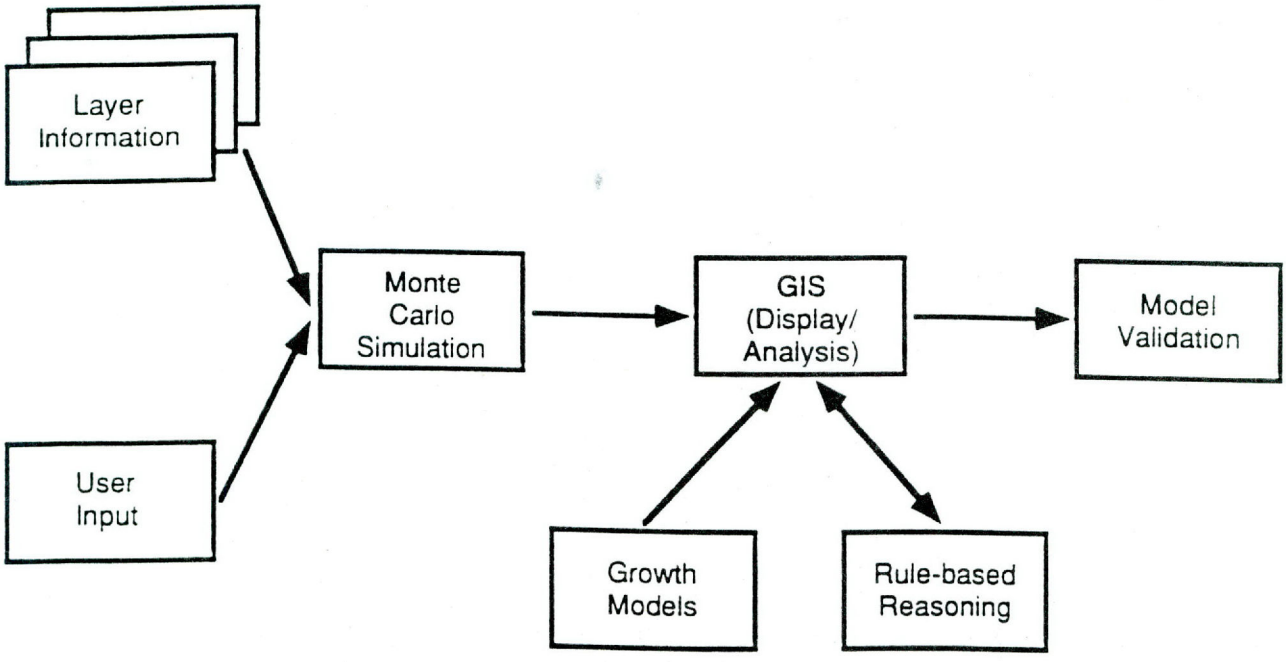

Figure 1. The overall design of the system.

Seed Banks and Current Herbaceous Vegetation Accompanying Succession of a Grassland to a Woodland

R. C. Flinn and S. R. Archer

A two-phase vegetation pattern, consisting of various - sized woody plant clusters dispersed in grasslands, occupies many uplands in south Texas. Woody plant clusters of different sizes/ages represent different levels of woody plant succession. We studied the herbaceous seed bank associated with this successional gradient from grasslands to the largest woody plant clusters. The study addressed two hypotheses: 1) Development of woody plant clusters in herbaceous areas removes higher successional, more productive midgrasses and tall grasses from the herbaceous vegetation and from the seed bank beneath woody plant canopies. 2) Development of woody plant clusters in herbaceous areas reduces herbaceous species richness in both current vegetation and in the seed bank.

Procedures

Sampling was stratified among herbaceous areas, developing and mature woody plant clusters, and groves. We collected 2 soil cores in 10 clusters of each size class and from 9 herbaceous areas in the Fall of 1987 and again in the spring of 1989. We placed soil samples in greenhouses and watered them for 3 months. Seedings that emerged from these samples represented the effective seed bank. We sampled current herbaceous vegetation by estimating foliar cover by species in 12, 0.25 m^{-2} quadrats per woody plant cluster.

Results

Mean species richness of the current herbaceous vegetation ranged from 29 species in herbaceous areas to 9 species for groves (Figure 1). In contrast, seed bank species richness did not differ among habitats. More forb than grass seedlings emerged in samples from all shrub cluster size classes (Figure 2). Equal numbers of forb and grass seedlings emerged from herbaceous zone samples. More forb seedlings emerged in samples from woody plant clusters than in samples from developing clusters and herbaceous areas. More grass seedlings emerged from herbaceous area than from woody plant cluster seed bank samples, yet woody plant clusters mainly produced midgrasses and tall grasses, whereas, herbaceous areas primarily produced shortgrasses (Figure 3). Similarity of total seed bank composition to total extant herbaceous vegetation was less than 24 % for all habitats (Figure 4), but percent similarity between current grasses and grasses emerged from seed banks were greater than 40 % for each habitat.

Woody plant clusters appear to serve as refuges for higher successional and potentially more productive grass species. They may represent not only patches of potentially higher productivity, but also may be reservoirs from which propagules of higher successional grasses are dispersed into adjacent herbaceous areas.

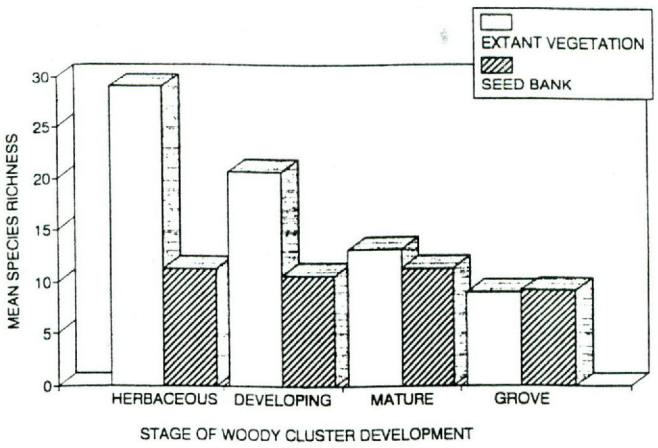

Figure 1. Mean species richness for herbaceous seed banks and extant vegetation of three brush cluster size classes and herbaceous areas, on the La Copita Research Area, in fall 1987 and spring 1988.

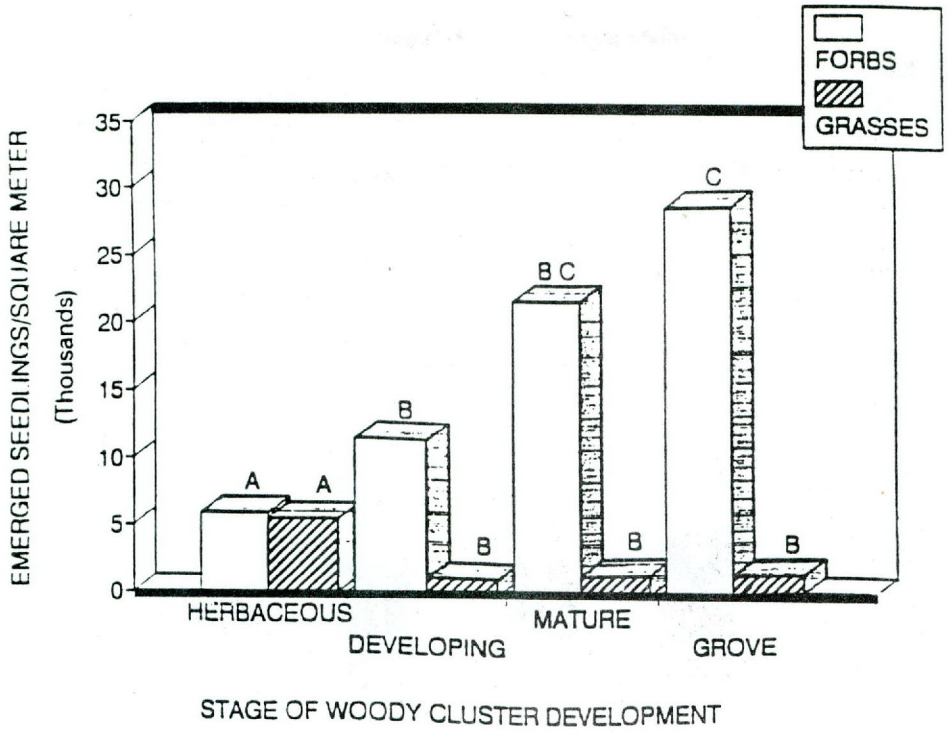

Figure 2. Emerged seedling density for forbs and grasses from three brush cluster size classes and herbvaceous areas, on the La Copita Reseach Area, in fall 1987 and spring 1988.

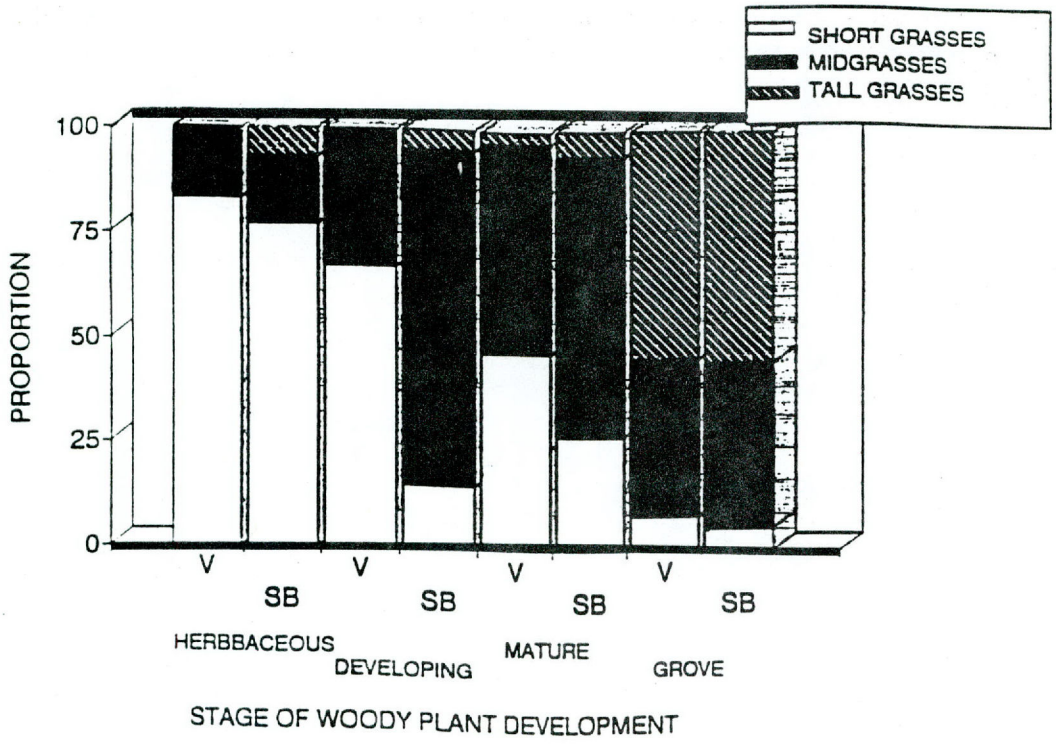

Figure 3. Proportion of emerged grass seedlings in three functional groups for current vegetation and seed banks of three brush cluster size classes and herbaceous areas on the La Copita Research Area, in fall 1987 and spring 1988. V = Current vegetation, SB = Seed banks.

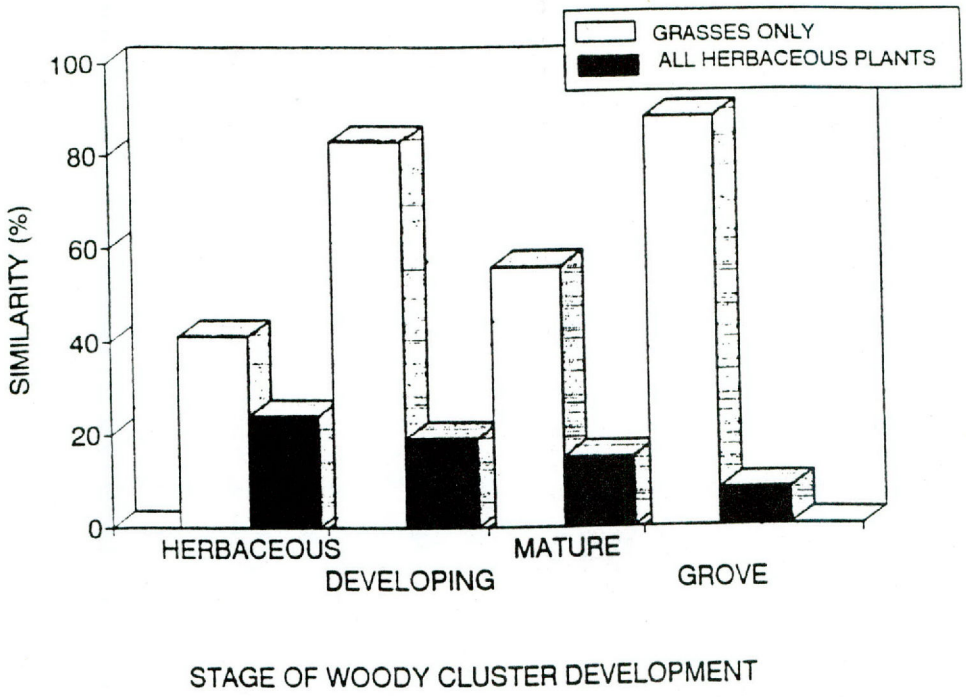

Figure 4. Similarity (%) between current vegetation and seed banks for all herbaceous plants and for grasses only in samples from three brush cluster size classes and herfbaceous areas, on the La Copita Research Area, in fall 1987 and spring 1988.

Plant Communities of the Mesquite Brushland Preserve

R. C. Flinn and S. R. Archer

Federal, State, and private organizations are increasingly concerned with the conservation of native plant communities. Conservation efforts require that plant communities be described quantitatively so their rarity, nearness to pristine conditions, and potential for recovery can be assessed. The Mesquite Brushland Preserve is an 683 acre tract located 2.1 miles south of San Diego in Duval Co., Texas. The Texas Nature Conservancy, a private conservation organization, received interest in the property and was considering the area's potential as a preserve. We delineated and surveyed late successional plant communities on the preserve.

We used aerial photography, topographic maps, and ground reconnaissance to delineate distinct vegetational areas or communities in the spring of 1990. Multiple examples of stands that appeared similar in early reconnaissance were sampled when they existed. Using line and belt transects, we assessed plant canopy cover; woody plant height distribution; density, vigor, and size distribution of honey mesquite; and density of small succulents within the identified communities. Sampled stands separated into distinct groups, when ordinated based on woody and herbaceous plant composition (Figure 1). These groups were then classified as community types based on a framework derived for plant community classification in Texas (Table 1).

Woody plant canopy cover in the mesquite - spiny hackberry communities was about twice that of the mesquite - mixed brush communities, yet woody species richness was the same for both communities (Table 1). Honey mesquite plants were larger (Figure 2) and had more well-filled canopies (Figure 3) in the more mesic woodland communities than in the two drier upland communities. Seventy one percent of standing mesquite plants in the amargosa - brasil community appeared dead (Figure 3). This contrasts markedly with the mesquite - hairyseed paspalum community where only 13 % of mesquite plants appeared dead.

The preserve supports four distinct plant communities representative of the general region. It does not contain any significant areas of the quajillo - blackbrush acacia community type described by Scifres and Koerth on the La Copita Research Area, but does contain small areas resembling the mesquite - whitebrush drainages they described. The herbaceous component of the preserve's vegetation is in a low to mid-successional state, except for the mesquite-hairyseed paspalum communities. Nevertheless, the remnant patches of higher successional herbaceous species that occur on the preserve hold the potential for succession toward more pristine conditions. With judicious grazing, installation of a prescribed burning program and similar stewardship practices, the preserve should provide a valuable long term resource for biological conservation and research.

We used the herbarium and other facilities of the La Copita Research Area during this study. Ben Koerth and David McKown, of the La Copita staff, provided technical help with sampling and plant identification. The plant community descriptions of Scifres and Koerth, in their bulletin on the vegetation and soils of the La Copita Research Area, served as a basis for identification of communities on the preserve.

Table 1. Classification (based on Diamond et al., 1987) and salient attributes of plant communities identified on the Mesquite Brushland Preserve, Duval County, Texas.

Association	Subclass	Class	Topography	Surface soil texture	Acre.	No. of stands	Avg. canopy of woody plants	Species richness: Woody plants	Species richness: Herb. plants
Mesquite-hairyseed paspalum	Mainly deciduous	Woodland	Playa	Clay	7	2	74	6	17
Mesquite-spiny hackberry	Mainly deciduous	Woodland	Drainage	Clay loam	216	6	126	18	34
Mesquite-mixed brush	Mainly deciduous	Shrubland	Convex upland	Sandy loam	269	9	60	18	46
Amargosa-brasil	Mainly deciduous	Shrubland	Convex upland	Sandy loam	20	1	45	17	26

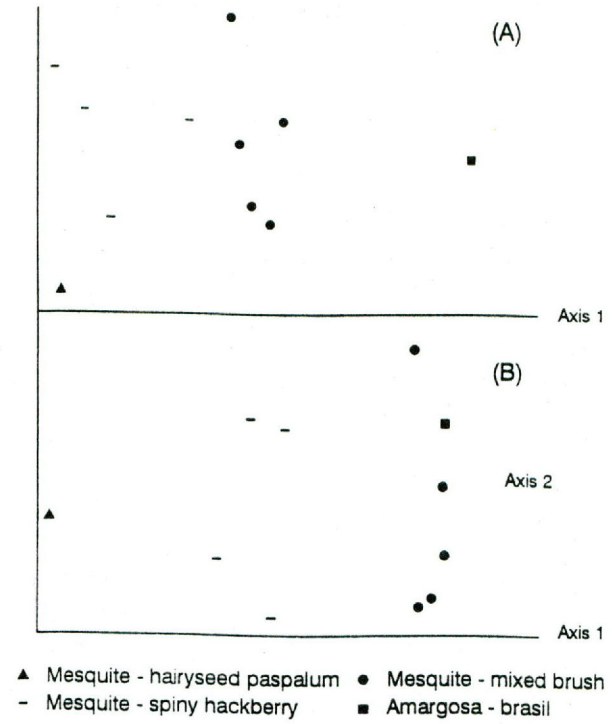

Figure 1. Ordination of undisturbed vegetation stands on the Mesquite Brushland Preserve, based on (A) woody plant composition and (B) herbaceous plant composition, summer 1990. Symbols indicate community type.

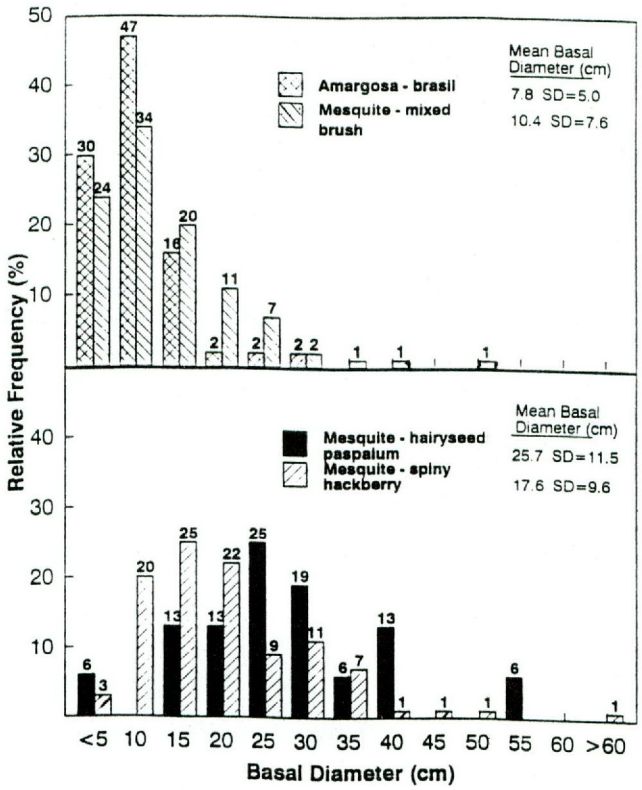

Figure 2.Size class distribution of mesquite plants occurring in two upland and two lowland plant communities in summer 1990 on the Mesquite Brushland Preserve.

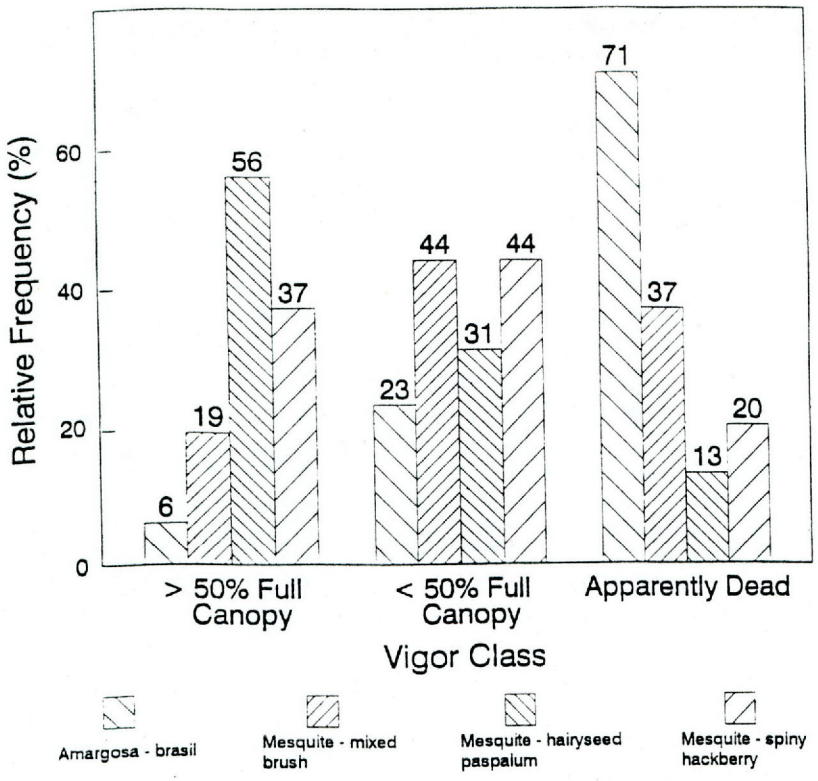

Figure 3. Relative frequency in three canopy vigor classes for all mesquite plants in four plant community types in summer 1990 on the Mesquite Brushland Preserve.

Variations in Basal Sprouting in Five Co-occurring Shrubs: Implications for Stand Dynamics

R. C. Flinn, C. J. Scifres, and S. R. Archer

Most woody plants in south Texas sprout from the base following disturbances such as frost or brush management treatments that involve top removal. We hypothesized that woody plant species of the area varied in their sprouting characteristics, and thus would respond differently to various intensities of top removal.

We quantified sources of basal sprouting for five shrub species representing five plant families common to the Tamaulipan biotic province, following four intensities of top removal. Top removal intensities were: (1) none recorded for 20-30 yr, (2) all aerial stems removed to ground line in 1979, (3) stems removed to a 5 cm residual above ground in January 1984, and (4) all tissues (stem bases and root crowns) removed to below the first woody lateral root in March 1984. The schema and terminology used to describe the structural characteristics of shrubs is presented in Figure 1.

Among undisturbed shrubs, *Celtis pallida* and *Zanthoxylum fagara* were somewhat arborescent, with one or two dominant primary stems per plant. *Aloysia gratissima, Ziziphus obtusifolia* and *Schaefferia cuneifolia* were fruticose in architecture, with more (Figure 2.) and smaller stems. Following top removal, each species exhibited a distinct regenerative hierarchy, whereby shoot production following disturbance was primarily from structures immediately subtending the removed tissues, even though more distal tissues had the capacity for shoot production. Thus, removal of stems to a 5 cm residual increased the contribution of primary stems from stem bases, whereas stem removal to ground line typically induced regeneration from root crowns (Figure 3). *Schaefferia, Zanthoxylum* and *Ziziphus* were capable of producing shoots from root tissue, yet regeneration from roots was not stimulated until tissues were removed to below root crowns.

Field observations indicate most woody species in the subtropical thorn woodlands of southern Texas are highly persistent in the face of natural and anthropogenic disturbance, owing to their ability to regenerate vegetatively. Alternative sources of stem replacement contribute to the high resilience of these shrubs following disturbance and may help explain patterns of secondary succession and plant persistence following various intensities of disturbance.

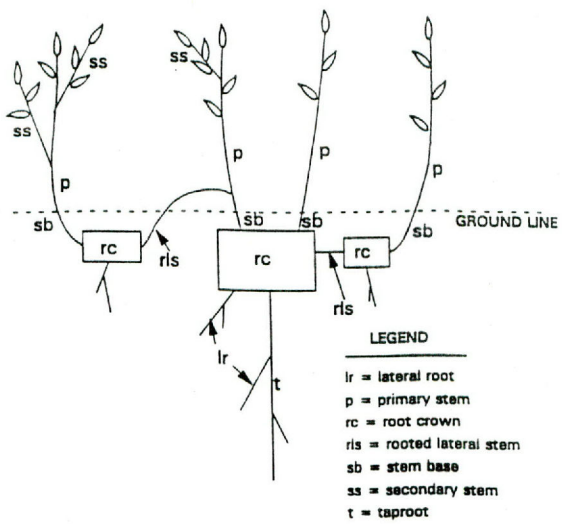

Figure 1. A schema based on form and function for characterizing regenerative structures of shrubs examined in this study.

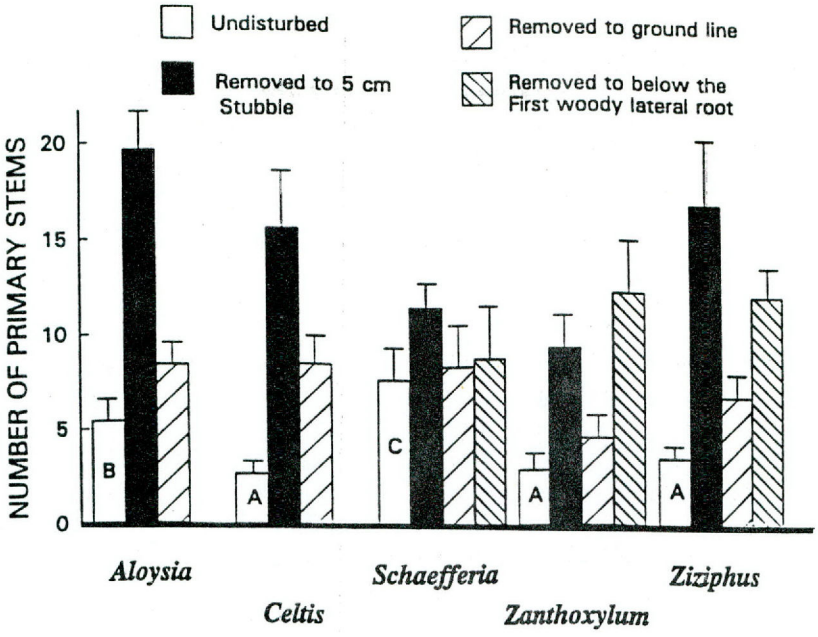

Figure 2. Mean (+SE) number of basal stems per plant in August 1984 for *Aloysia gratissima*, *Celtis pallida*, *Schaefferia cuneifolia*, *Zanthoxylum fagara*, and *Ziziphus obtusifolia*, following various intensities of top removal. Species means for the undisturbed treatment marked with the same uppercase letter were not statistically different ($P \leq 0.05$). Statistical comparisons between treatments were not made because of differences in time since disturbance.

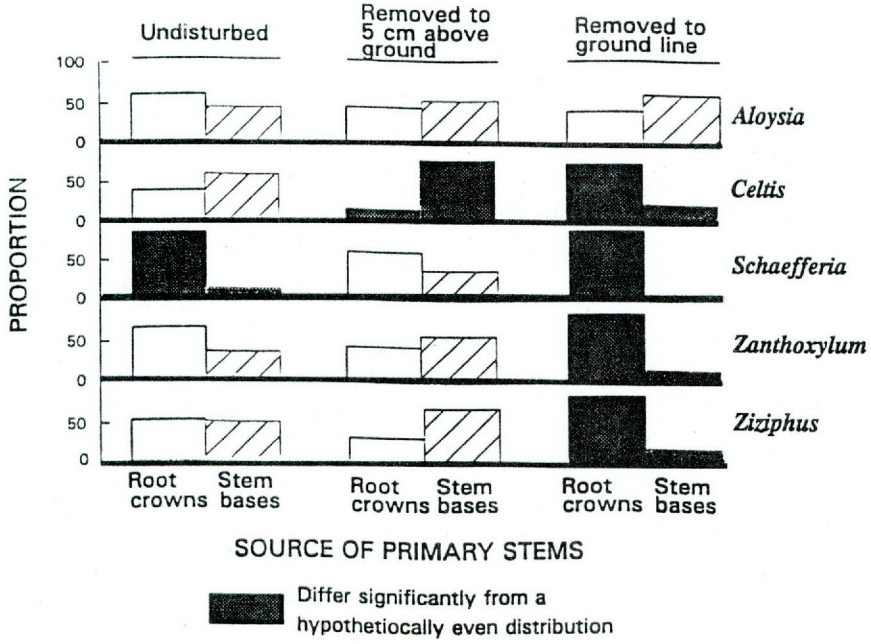

Figure 3. Proportion of basal stems originating from root crowns and stem bases, for *Aloysia gratissima*, *Celtis pallida*, *Schaefferia cuneifolia*, *Zanthoxylum fagara*, and *Ziziphus obtusifolia* in August 1984. Plants had been subjected to either no top removal, removal to a 5 cm residual above ground or removal to ground line. Based on X^2 comparisons with untreated plants, relative contributions of root crowns and stem bases were different ($P \leq 0.05$) for all species following both treatments except for *Schaefferia cuneifolia* removed to ground line. Shaded bars indicate that source of stems differed significantly from a hypothetical even distribution for that species/treatment combination.

Carbon 14 Ages of Honey Mesquite Trees on the La Copita Research Area

Steve R. Archer and Robert C. Flinn

The potential natural vegetation of southern Texas and northern Mexico has been classified by plant geographers as savanna. Nevertheless, much of the region is presently dominated by subtropical thorn woodlands. The thorny shrubs and small trees which characterize this region have counterparts throughout much of the world's tropical and subtropical zones. Many people think these vegetation types have replaced grasslands and savannas, yet such contentions are controversial and based largely on historical accounts, many of which are conflicting (Table 1).

Table 1. Historical observations on woody plant abundance in Texas.

MARCCY EXPEDITION (1854) across north-central Texas (from Malin, 1953):

"...nothing could be seen but one continuous mesquite flat, dotted here and there with small patches of open prairie..."

"The country we are now passing is gently undulating and covered with mesquite trees."

"a broad level plain...covered with buffalo grass and mesquite trees, and extending as far as the eye could reach..."

"[Mesquite often grew] upon the most elevated arid prairies, far from water courses..."

DESCRIPTIONS OF SOUTHERN TEXAS VEGETATION (from Inglis, 1964):

Borders of creeks were well supplied with timer but there was "scarce a brush on uplands"- Lundy (1833), Jim Wells County

"The prairie was now dead level, the grass short...Not a bush or tree was to be seen....thousands of antelope..." - Fremantle (1863), Nueces County

"high rolling prairie covered with fine mesquite grass and interspersed with mesquite trees..." - Michler (1849), Nueces County

"open country with mesquites"- Bollaert (1843), Frio County

Landscapes at the La Copita Research area in southern Texas are characterized by woodlands and savanna parklands. Previous research on this site has shown that honey mesquite facilitates the ingress and establishment of subordinate woody species following its establishment in uplands. Discrete woody plant clusters, with a single, central mesquite plant, characterize portions of the uplands where an argillic (clay-pan) horizon in well-developed. Where the argillic horizon is absent, mesquite groves form. Field observations indicated that mesquite plants in groves are substantially larger than plants in discrete clusters. We hypothesized that mesquite plants in groves may have been constituents of the landscape throughout much of the Holocene, whereas mesquite plants of discrete clusters have appeared since European settlement (Figure 1). To test this hypothesis, we used dendrometer bands, annual ring counts, and carbon 14 dating to estimate growth rates and ages of mesquite plants on uplands. Knowledge of the history of vegetation change on these landscapes should help place efforts at resource management and biological conservation into a clearer ecological and historical context.

Procedures

Twelve well-developed discrete clusters (those with large mesquite plants and diverse shrub understory) and four groves were surveyed to quantify maximum mesquite plant sizes. Canopy and basal stem diameters and height were measured. Basal portions of mesquite trunks in discrete clusters (n = 18) and groves (n = 46) were instrumented with dendrometer bands and trunk growth was measured monthly from October, 1989 through June 1990. Stem cross-sections were obtained from the largest mesquite plants in each of seven discrete clusters and five groves. Stems were cut at ca. 15 cm above ground level. Cross-sections were sanded and stained and annual rings counted. As another assessment of plant ages we excavated mesquite root crowns and obtained a wood sample from the center of this subterranean tissue, which is the junction between the root and shoot systems. Geochron Laboratories of Cambridge, Massachusetts analyzed the samples for Carbon 14 age.

Results

The largest mesquite plants in discrete clusters were smaller than the largest mesquite plants in groves in terms of height, basal diameter and canopy diameter (Table 2). The larger size of plants in groves was a combination of their higher growth rate and their greater age. The largest plants in groves were, on average, 25 years older than the largest mesquite plants in discrete clusters. Maximum stem age was 81 years. Based on carbon 14 age estimates, plant ages can be regarded as "modern" on 4 of the 5 groves (Table 3). Within the limits of statistical error associated with the carbon 14 estimates, stems were generally comparable in age to the tissues which gave rise to them. The one exception was the plant in Grove 5, whose stem of 77 years was subtended by root crown tissues estimated at 510 years by carbon 14 dating.

The hypothesis that mesquite plants in groves have been long-term constituents of the landscape relative to mesquite plants of discrete clusters (Figure 1) was not supported by direct dating techniques. Establishment of the current population of mesquite plants on non-argillic soils in uplands appears to have occurred only slightly earlier than on soils with the argillic horizon.

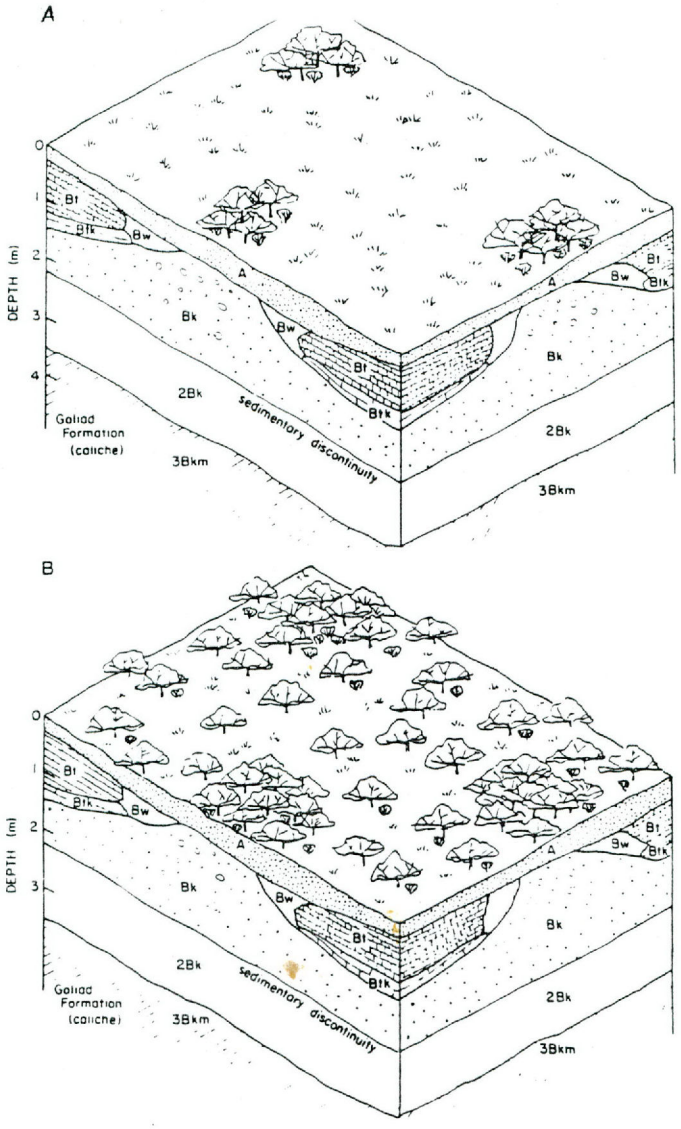

Figure 1. Hypothesized changes in vegetation on uplands at the La Copita Research Area in southern Texas. TOP: Soils with argillic horizons were historically dominated by grasses, whereas non-argillic inclusions supported mesquite groves. BOTTOM: Changes in grazing, fire and/or climatic regimes in recent history have enabled mesquite to establish on argillic soils.

Table 2. Mean (± SD) size and age of *Prosopis glandulosa* stems on upland landscapes in southern Texas. *Prosopis* plants in well-developed discrete clusters occurred on soils underlain with a distinct argillic (clay) horizon. This horizon was absent within groves (Figure 2).

	Discrete clusters	Groves
Canopy Diameter (m)	6.5 (1.1)	7.2 (2.2)
Basal Diameter (cm)	15.7 (2.4)	24.1 (6.2)
Height (m)	3.7 (0.6)	5.8 (0.7)
Monthly Radial growth (mm)	0.04 (.03)	0.10 (.07)
Age*		
Mean	43.3 (11.9)	74.6 (5.5)
Max	64	81
Min	39	67

*From annual ring counts. Ages are not adjustsed for the time required for seedlings to produce annual rings at the height at which stsems were cut (15 cm).

Table 3. Estimated ages of the largest *Prosopis* plant in each of five groves. Main stem ages were determined from annual ring counts. Ages of the stru ctsures (crowns) giving rise to stems was determined by ^{14}C-dating.

	Estimated age (y)	
Plant/Grove	Crown (genet)	Stem (ramet)*
1	190 ± 75	73 ± 1
2	210 ± 80	81 ± 1
3	50 ± 115	73 ± 6
4	185 ± 75	79 ± 6
5	510 ± 75	67 ± 3

*Mean (± SD) annual ring count along three radii per stem cross-section. Ages are not adjusted for the time required for seedlings to produce annual rings at the height at which stems were cut (15 cm).

Assessing the Influence of Subsoil Heterogeneity on Vegetation Patterns in the Rio Grande Plains of Southern Texas Using Electromagnetic Induction and Geographic Information Systems

James Stroh, Steven R. Archer, Larry P. Wilding, and James Doolittle

Research in the Rio Grande Plains of southern Texas has provided evidence that suggests a physiognomic conversion of grasslands and savannas to woodlands in recent history (Archer 1990). The process of this conversion centers on the ability of honey mesquite (*Prosopis glandulosa*) to successfully invade grasslands. Mesquite trees facilitate the colonization of trees and shrubs beneath their canopies that eventually leads to discrete clusters of woody plants forming on the uplands of the landscape (Archer et al. 1988). Inferences of successional processes for this region suggest that upland portions of the landscape may eventually develop a woodland physiognomy in the absence of soil or fire constraints.

A possible constraint for woody plant density on upland sites could be related to the presence of a claypan or argillic (clayey) horizon. Data from study sites in this region indicated that soils from upland sites which supported herbaceous vegetation and small clusters of shrubs were characterized by a well developed argillic horizon, whereas soils that supported groves of large trees had no argillic horizon (Loomis 1989). If inherent subsoil characteristics (e.g. argillic horizon) regulate woody vegetation development, then the density and distribution pattern of woody groves on the landscape would be determined by the availability of non-argillic microsites. If the majority of non-argillic microsites are presently occupied by groves, then the present pattern of discrete woody groves scattered throughout a grassland matrix may be relatively stable.

Procedure

With this study, we will map the distribution of non-argillic inclusions and various physical and chemical properties of the soil using surficial bulk soil conductivity readings obtained with electromagnetic induction (EMI). A geographic information system in conjunction with a historical sequence of aerial photos will then be used to determine the extent to which spatial variability of soil properties is related to past, present,and future patterns of vegetation distribution.

A preliminary survey of a 120- X 140-m grid on a upland site at the La Copita Research Area was conducted with EMI meters capable of scanning 0-1.5 meters (EM-38) and 0-6 meters (EM-31) of soil. Two-dimensional contour plots constructed from systematic point samples of EMI measurements within the grid are shown in Figures 1 and 2. In both of these figures, several zones of higher electrical conductivity readings were apparent. One is located near coordinates X=60, Y=120.

The second area extends from the upper right to the lower left hand corners. This diagonal zone is more obvious on measurements taken with the EM 31 meter.

Results

Sample profile descriptions within the grid indicated that higher EMI readings corresponded to areas with higher clay contents in the argillic horizon or areas that lacked vertical profile development (Bw soils). The lowest EMI readings generally occurred in regions of soil with a sandy, clay loam argillic horizon that supported herbaceous vegetation and small shrubs. These results suggest that EMI meters may be useful for mapping the non-argillic inclusions on upland soils.

An initial investigation of the spatial dynamics of six mesquite groves located on a upland site at La Copita was conducted with a historical sequence of black and white photographs. Photographs were classified with TERRAMAR software and the spatial extent of each mesquite grove was calculated (Figure 3). Results indicated an increase in spatial extent of four of the six groves (1, 2, 7, and 21). Expansion of each grove varied from what appeared to be a steady increase (grove 2), an initial increase followed by a period of no expansion (grove 1), to exponential expansion (grove 21). Fluctuations of spatial extent of groves between photo dates may have been the result of precipitation anomalies (e.g. drought) or a result of the season in which the photos were taken (e.g spring vs. winter). If grove expansion is constrained by the presence of an argillic horizon, then the different growth rates or lack of growth (grove 23) may be the result of the size of the non-argillic inclusion each grove occupies.

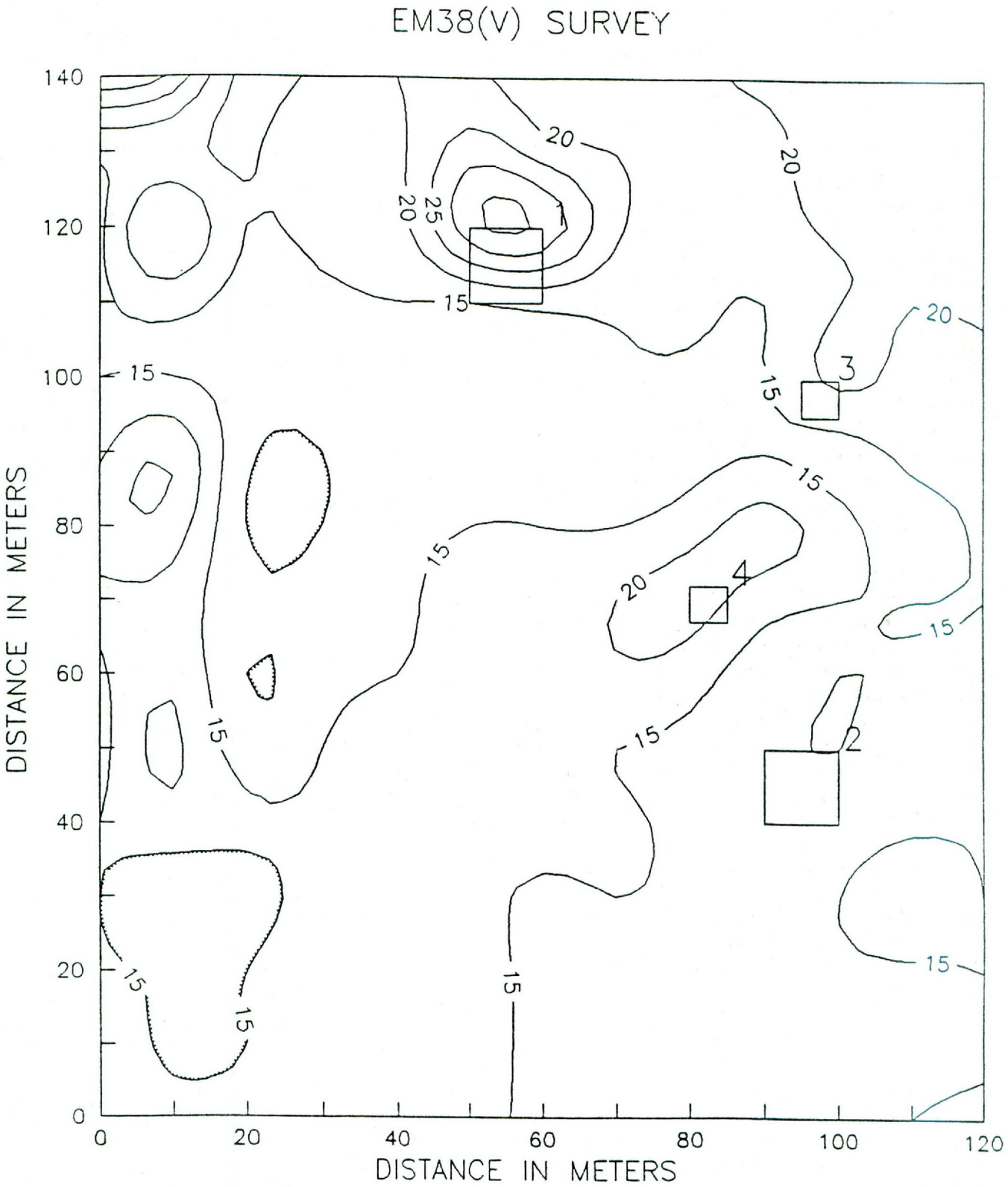

Figure 1. Two-dimensional contour plot of apparent electrical conductivity within the sample grid site as measured by a EM-38 meter. Contours represent conductivity readings in milliSiemens per meter. Areas subsampled with the EM-38 meter are delineated by numbered boxes.

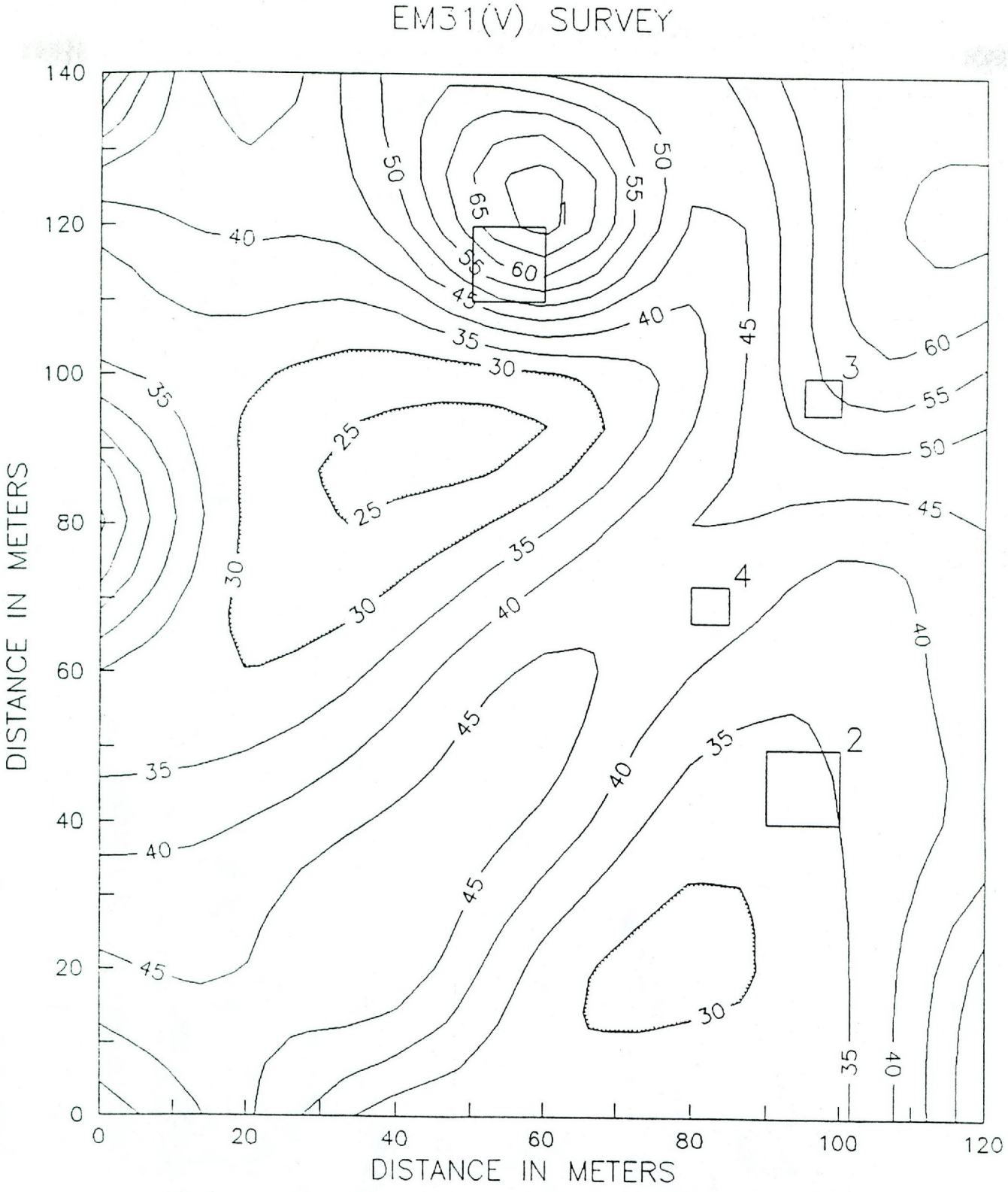

Figure 2. Two-dimensional contour plot of apparent electrical conductivity within the sample grid site as measured by a EM-31 meter. Contours represent conductivity readings in milliSiemens per meter. Areas subsampled with the EM-38 meter are delineated by numbered boxes.

In this study we will use high altitude black and white aerial photos (c.a. 1:20,000) from 1941, 1955, and 1969 along with 1990 color IR transparencies (c.a. 1:6,600). To reduce the amount of seasonal variability in aerial canopies of woody vegetation winter photography will be use for all dates except 1990. The photos will be referenced with a global positioning system, classified with ERDAS software, and entered into the GRASS geographic information system. Data entered into the GIS will be used to: 1) locate the rate and direction of expansion of groves and woodlands in areas sampled with electromagnetic induction; 2) provide vegetation overlays for the maps of subsoil heterogeneity; and 3) reconstruct the vegetation history of as many portions of the landscape as possible to determine the type, rate and magnitude of woody vegetation change since the 1940's.

This will be the first study designed to combine aerial and subsurface remote sensing techniques with GIS technology as a means for evaluating plant/soil relationships. These methods should provide insights into the stability of the existing vegetation pattern on the uplands and possibly identify areas where future establishment of woody plants is most likely to occur. Additionally, the use of EMI may supply information that could be used to determine the origin of the unique subsoil patterns that appear to be characteristic of this region.

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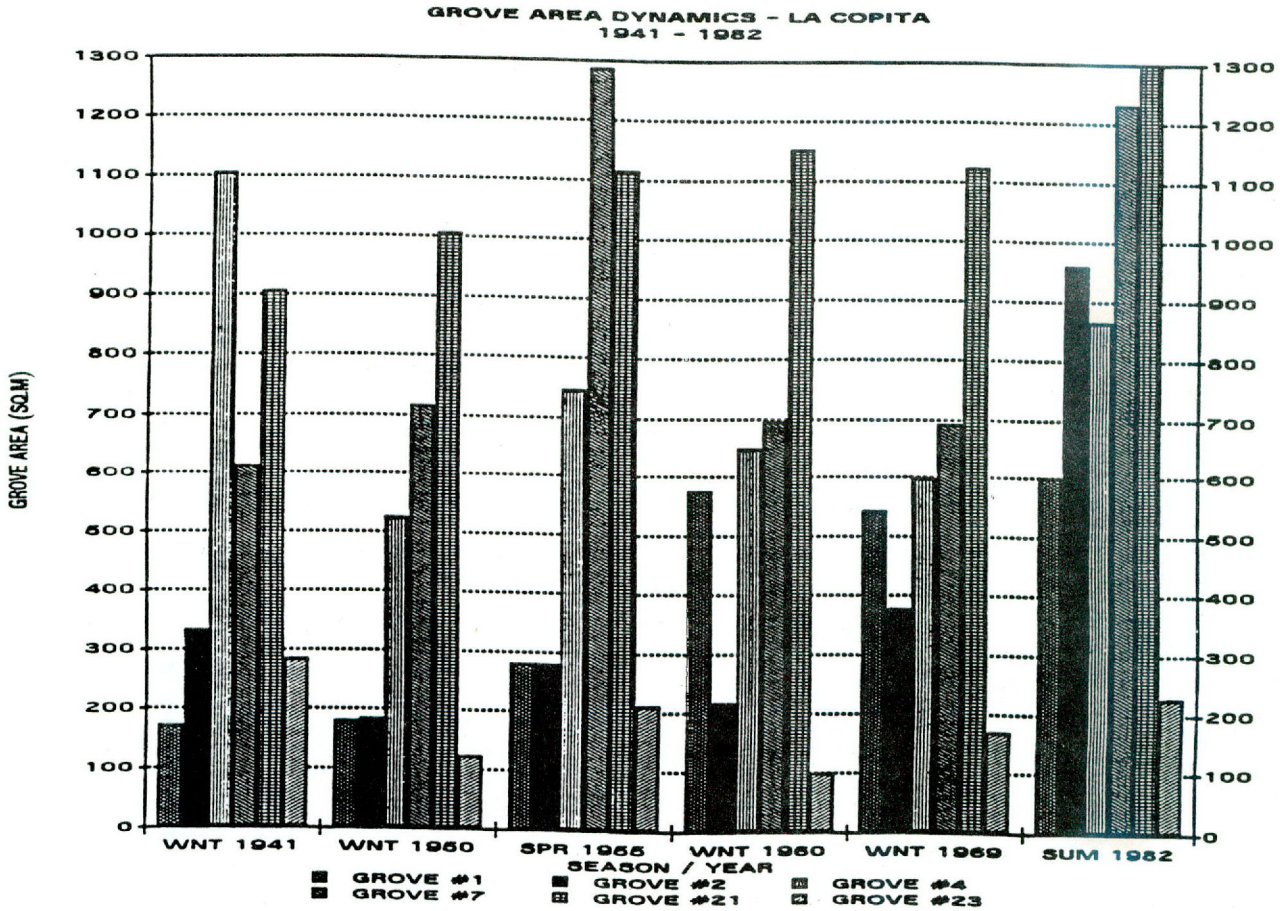

Figure 3. Documentation of the change in spatial extents of six mesquite groves from an upland sitse at the La Copita Research Area.

Africanized Honey Bee Monitoring at La Copita

E. A. Sugden

The United States Department of Agriculture, Agricultural Research Service (USDA,ARS) Africanized honey bee (AHB) program has been maintaining 10 bait hives at La Copita Research Area since April, 1989. A progress report of honey bee swarm collecting at La Copita was presented in poster form at the La Copita Field Day in May of 1990. At that time, data from one full year and about 1 1/2 swarm seasons (Spring) were available. Although possibly not significant, the swarm catch at La Copita appeared to be greater than at other brush country sites, possibly because of the "magnet" affect of bait hives placed in an environment with few natural nesting cavities, especially few large, old trees and associated hollows.

At this writing, data from another 1 1/2 years and 1 1/2 swarm seasons have been collected. A compilation of this data appears in Figure 1.

Naturally dispersing Africanized honey bees were first detected in the United States in Hidalgo County on October 15, 1990 in an ARS bait hive. The next captures took place the following April. Since then, AHBs have steadily increased in number and total proportion of swarms collected in the Rio Grande Valley (ca. 60% by Fall, 1990). At the same time, the range of this sub-population of feral honey bees has spread north and westward in Texas-more-or-less as predicted. By the end of 1991, the first year of Africanization, 17 South Texas counties had been declared Africanized and quarantined against inward movement of domestic honey bees.

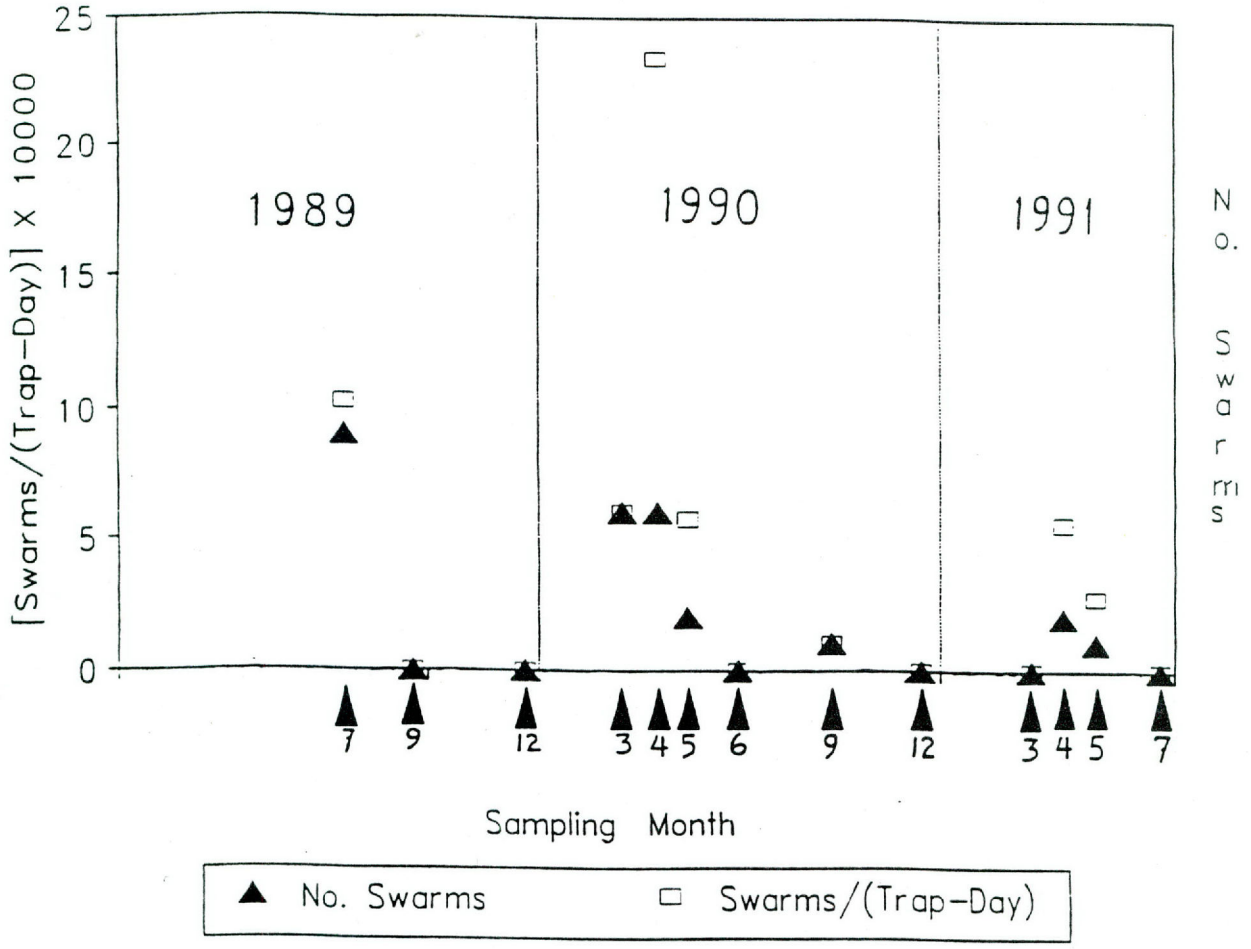

Figure 1. Swarm and trap data for 2 1/2 years at the La Copita Research Area.

The western most detection was in Val Verde County and the detection front had moved as far north as Nueces County on the Gulf Coast. The quarantine line currently extends from Maverick to Nueces County. Jim Wells County was quarantined on September 30, 1991, although there have been no AHB detections in that county as of this writing.

Abundant rainfall throughout South Texas during the latter part of 1991 will translate into many swarms during 1992. I expect swarm captures at La Copita to be greater than the 3 previous years. There is little doubt that AHBs are in the region and it is reasonable to expect that our bait hives will be collecting 50% AHBs by Summer. Based on previous years data from S. Texas and Northeastern Mexico, swarming will likely continue through October or November, with an accentuated fall peak incidence.

Honey bee forager traps have been concurrently run at La Copita and have indicated a low but persistent resident feral honey bee population. During 1991, bait stations were placed at several sites along the main service road and beelines established to at least two feral colonies on the property. These colonies have yet to be found. Pollen from bait hives throughout S. Texas, including La Copita, is being analyzed for species composition by Gretchen Jones, Texas A & M University. Results may indicate whether honey bee diets differ significantly between study sites, between years, between different times of the year and between pre- and post-Africanization.

Collection of Natural Enemies on the La Copita Research Area for Control of Weeds in Australia

W. A. Palmer

The North American Field Station is an overseas unit of the Queensland Department of Lands. Its purpose is to find natural enemies of various weeds of North American origin and ship them back to Australia where they are used in biological control programs. It is presently investigating the weeds *Parthenium hysterophorus, Lantana camara,* and *Ambrosia artemisiifolia.*

The La Copita Research Area has provided the North American Field Station with a very convenient base for its south Texas investigations during the past 6 years. Not only are the plants under investigation found on the property itself but insects and plants found by surveying the roads throughout south Texas can be prepared or otherwise investigated in the laboratory facilities available on the property. The La Copita Research Area is particularly suitable for our purposes as it is a large area of relatively untouched rangeland, free of insecticide usage.

Lantana Project

One of the three *Lantana* spp. found on the La Copita Research Area. was again surveyed for its insect fauna this year. This plant is a *L. urticoides* x *L. camara* hybrid and is common throughout the area. Following the good rains in the early part of the year, the plant was quite abundant and persisted well into the year with a second flowering. Insects collected in the survey were sent to the Systematic Entomology Laboratory, ASDA-ARS for expert identification. The results obtained this year will be incorporated into a general account of the insect fauna found on *Lantana.*

This year's work concentrated on biology and host specificity studies of three lepidopterous insects.

1. *Cremastobombycia lantanella*

This gracillarid moth oviposits on the lower surface of the leaf and the resultant larvae mine into the mesophyll tissue of the leaf to form a characteristic blotch mine which is eventually visible from both leaf surfaces.

The insect was collected in south Texas in the spring of 1991 by collecting leaves containing mature mines. Although this insect occurs throughout the south Texas area, it is rarely found in abundance and much of the collected material was obtained from *Lantana* growing in two gardens in the town of George West and from the La Copita Research Area. The leaves were placed in plastic bags until the moths emerged.

A laboratory colony was established without undue difficulty by using potted plants in cages covered with a fine mesh gauze placed in an air conditioned greenhouse. In host specificity tests, the mines indicative of *C. lantanella* attack were seen only on *L. camara* and *L. montevidensis* and not on 20 other plant species that were selected primarily from the Verbenaceae and Lamiacae families. On the basis of these tests, the insect was considered to be sufficiently host specific for importation into Australia. This will be recommended.

2. *Anoncia diveni*

Anoncia diveni is a moth of the family Cosmoptergidiae that has been collected from both *L. camara* and *L. urticoides*. The moth oviposits on the underside of *Lantana* leaves. Emerging larvae burrow into the mesophyll of the leaf and form a characteristic mine. As the larvae develops, the mining increases so that one larva can destroy more than half of the leaf. Late instar larvae emerge from the mine to tie the leaf over; presumably to provide a pupation site. The insect is quite destructive to the plant, both in the field and in the laboratory.

Material with which to start a laboratory culture was obtained from south Texas, including the La Copita Research Area. Infested leaves were collected and placed in plastic bags. Adults that emerged from these bags were placed on potted plants in cages held in an air conditioned glasshouse. By this method, a laboratory culture was established. However, the insect proved difficult to rear because of its feeding habit. On potted plants, a significant proportion of the infested leaves would fall from the plant before the larva had completed its development. Attempts to transfer the larvae to new leaves were only partially effective. This

problem prevented the build up of a sufficient population for experimental purposes.

One host specificity trial was conducted. In that trial, *A. diveni* attacked only *L. camara* and not five other closely related plants. There is no record of its having hosts other than *Lantana* so there is every indication that further research will prove this insect to be sufficiently specific to be imported into Australia.

3. *Pseudopyrausta santatalis*

The larvae of this pyralid moth are leaf webbers. After emergence, the larvae feed firstly on the underside of the leaf and then feed on the upper surface under a protective web they construct. They have the potential to be very destructive and on occasions have been known to defoliate the plant.

This year this insect was not abundant in south Texas and only a few infested plants were found on La Copita Research area and the surrounding districts. These larvae were collected and utilized to develop a suitable method for culturing this species in the laboratory.

Parthenium Project

Two species of *Parthenium* are found on the La Copita Research Area and in the surrounding district. *P. hysterophorus*, which is the weed in Australia, is an annual plant that is found particularly in disturbed areas such as around cattle yards, along roadsides, in cultivated fields etc. *P. confertum* is a perennial plant that is more likely to be found in the undisturbed pastures. A similar insect fauna is found on both plants.

As in previous years, these *Parthenium* spp. were again surveyed and collected insects sent to the Systematic Entomology Laboratory.

Visitors

Two visitors from the Lands Protection Branch of the Queensland Department of Lands were taken to the La Copita Research Area so that they could discuss methods of brush control with resident staff. Dr. Bruce Wilson from the Tropical Weeds Research Centre, Charters Towers, visited La Copita in May during his Churchill fellowship study tour. Mr. Ed Carroll, from the Charleville district, visited in June. Both officers were very appreciative of their visits.

Root Distribution Patterns of Co-occuring Woody Plants in Southern Texas

S.E. Watts, S.R. Archer, and T.W. Boutton

Little is known about the root systems of woody plants in the subtropical savanna landscapes of southern Texas. Study of the root systems of woody plants will improve our knowledge of ecosystem function and dynamics. Our overall objectives are to: (1) Document horizontal and vertical root distribution patterns in coexisting woody plant species, (2) Relate root distribution patterns of woody plants to patterns of secondary succession, (3) Quantify the influence of soil texture and structure on rooting patterns, and (4) Estimate root biomass associated with woody plant assemblages.

Procedures

Two distinct types of woody plant clusters occur on upland areas in the Rio Grande Plains of southern Texas. Small, discrete clusters have one central honey mesquite (Prosopis glandulosa) surrounded by numerous subordinate species and occur on soils with an argillic horizon. Large clusters or groves consist of multiple discrete clusters which have coalesced with each other as a result of lateral growth and occur on soils without an argillic horizon. Groves contain multiple honey mesquite trees which served as the focal points for development of once-distant clusters.

In the summer of 1991, four trenches (1 m wide and 2 m deep) were excavated with a backhoe. Two of the trenches extended completely through two discrete clusters, while the other two trenches extended into the center of two groves. Root density on the trench faces was quantified by species for roots larger than 1 mm using a grid system of 20 X 20 cm cells. Coarse root (> 1 mm diam.) biomass was quantified by weighing the roots obtained from a series of 20 X 20 X 20 cm blocks. Fine root (< 1 mm diam.) biomass was quantified by weighing the roots obtained by sieving (760 m screen) a 300 cm^3 subsample of soil from each of the blocks through a hydropneumatic elutriation system.

Results

Figure 1 shows the average coarse (> 1 mm diam.) root density (roots / m^2) counted on trench faces for discrete clusters and groves increments. The root density is higher for discrete clusters than for groves (753 vs. 467) in the 0-40 cm depth increment. In the 40-80 cm depth increment, the root densities of discrete clusters and groves are nearly equal (232 vs. 223). At depths below 80 cm, however, the root density for groves is more than twice that of the discrete clusters (227 vs. 106). This pattern may reflect the role of the argillic horizon in limiting root penetration in the discrete clusters. Edaphic impediments to root development may be a primary reason for the reduced canopy area, basal diameter, and height of honey mesquite plants occurring in discrete clusters relative to those in groves.

Honey mesquite appears to be the deepest rooting woody plant occurring in the study area, while cacti (Opuntia spp.) have the shallowest root systems. Roots of lime pricklyash (Zanthoxylum fagara), a dominant understory shrub, dominate the upper 40 cm of the soil profile. Average density and biomass of honey mesquite roots is higher in the groves than in the discrete clusters. Root density and biomass of all species is sharply reduced outside the cluster canopy.

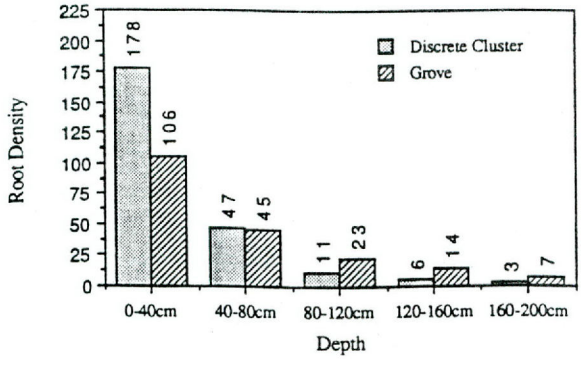

Figure 1. Average coarse (> 1 mm diam.) root density (roots/M^2) counted on trench faces for discrete clustsers and groves at five depth classes.

Acute and Chronic Impacts of Prescribed Fire on Ticks and Mesquite Seeds

P.D. Teel, J.P. Reynolds, S.R. Archer, O.F. Strey, and M.T. Longnecker

The majority of tick species attacking livestock in South Texas are referred to as 3-host ticks, so named because these parasites obtain a bloodmeal from a separate host for each of their three post-embryonic stages. These stages are six-legged larvae (sometimes referred to as seed ticks) which feed for about 3 days, eight-legged nymphs (slightly larger) which feed for about 6 days, and eight-legged adults which feed 10-14 days. Upon completion of feeding, ticks drop from their host to find a suitable microenvironment in vegetation to molt to the next stage or lay eggs. The off-host phase of the tick life cycle may total 98% of time required to produce one generation.

Survival of ticks in the off-host environment is largely dependent upon conditions of temperature and relative humidity. Teel and Pickel (1988) reported that herbicide applied for brush control on the La Copita substantially suppressed resident tick populations in treated areas through reduction of shrub canopies, which increased soil surface temperatures and decreased relative humidity. Prescribed burns, conducted on small plots near Sinton, Texas, which consumed the litter layer and/or achieved a temperature threshold for tick mortality (90-125°C for 30 s) were found to reduce tick populations and alter the woody plant community so that post-treatment conditions may temporarily be less suitable for tick survival (Scifres et al. 1988).

Procedures

In February 1991, fires were initiated on a series of plots at the La Copita Research Area (West Deferred Pasture) which had received aerial herbicide treatment in May 1986 followed by retreatment or clear cutting of selected brush clusters in September 1986. The fire was conducted to 1) determine uniformity of distribution of minimal threshold temperatures for tick mortality, and 2) establish a site to evaluate tick survival and activity during the post-fire recovery period.

The lack of continuous fine fuel required that the plots be artificially loaded with hay to provide a moderate level of continuous fuel. Adhesive-backed heat temples (93°C/200°F) (Omegalabel Bulls-eye Monitors, Omega Engineering, Inc.) on glass microslides were placed at cardinal loci in two concentric rings about each brush cluster. An inner ring of temples was placed approximately 0.3 m from the epicenter of each cluster and an outer ring was placed inside the canopy dripline. Figure 1 shows the environmental conditions, direction of the fire front, and ground level temperatures achieved by the fire in each plot. Threshold temperatures of 93°C were not uniformly reached across brush clusters. Five of the 17 clusters (29%) had surface temperatures >/=93°C, while 12 (71%) had one or more indicators showing temperatures <93°C. Of the total temples in the inner ring, 31% failed to reach the threshold, versus only 14% of temples located at the cluster dripline.

The heterogeneity of temperatures generated by fire passage across brush clusters is influenced by the interactions of fine fuel dispersal within clusters and the physical nature of the cluster structure. Temporal and spatial characteristics of litter turnover and tick and mesquite seed dispersal in brush clusters, currently under study at the LCRA, will help us determine how important the uniformity of lethal threshold temperatures are for control of ticks and mesquite seeds in controlled burns. Separate studies were conducted measuring time-temperature relationships generated in fires produced by different levels of fine fuel and the corresponding mortality of ticks and germination of mesquite seeds. As the level of fine fuel increased, germination of scarified and non-scarified mesquite seeds decreased and mortality of adult cayenne ticks, Amblyomma cajennense, increased (Table 1). Further evaluation of these responses may help us determine the impact of fire on mesquite seed banks and tick populations at the landscape level.

The post-burn environment of the La Copita plots was used to evaluate survival and activity of the cayenne tick, a common pest species of cattle and wildlife in South Texas and the most prevalent species on the La Copita. On July 17, groups of 20 male and 20 female laboratory-reared flat adult ticks 6 weeks of age were released into nine field observation chambers. The observation chambers were cylinders 0.5 m in diameter by 0.65 m tall, with the walls and top of the chamber constructed of synthetic cloth mesh fitted with plastic observation windows. Three chambers were placed in the fire treated interstitial zone and three under the driplines of fire treated brush clusters having also received the 1986 herbicide treatment. The

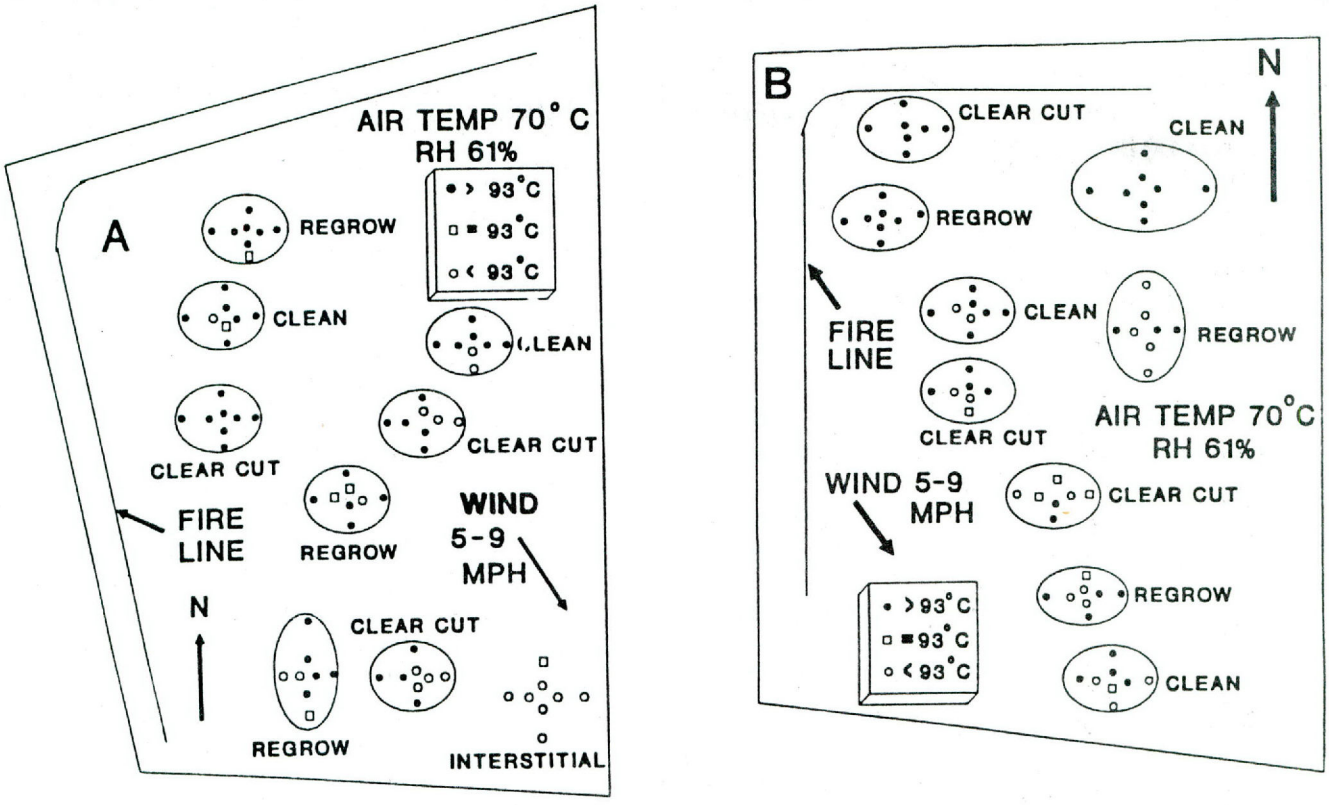

Figure 1. Environmental conditions of prescribed fires for plots A and B (West Deferred Pasture) installed February 1991, and ground-level temperatures achieved across brush clustsers. Cluster names refer to 1986 treatments.

remaining three chambers were placed in nearby brush clusters that had received neither fire nor herbicide treatments. The predominant difference among habitats was the gradient of canopy cover. Each series of 20 males and females were paint-marked on the dorsum to enable monitoring of individuals. Temperature and relative humidity at the soil- vegetation interface and rainfall were continuously monitored. Tick activity data were collected during morning, midday, and afternoon periods on sunny days at approximately 2-week intervals.

Results

Table 2 summarizes the average number of ticks active at observation times nearest 5:00 pm. The term "active" is defined here as the number of individuals on leaf litter and standing vegetation responding to host (observer) breath stimulus. Data show that 65% (interstitial females) to 85% (untreated cluster females) of ticks were active four days after release. By late August the numbers of active ticks had diminished in both interstitial and treated cluster habitats, relative to untreated clusters.

The comparatively high degree of variation among active ticks in interstitial observation chambers after September is due, in part, to physiological stress. In December the chambers were opened and a census of live ticks was taken (Table 3). These data show that tick survival is related to canopy induced environmental conditions. Ticks in the interstitial zone were exposed to the highest daily temperatures and lowest relative humidities. Environments in untreated clusters were least stressful and treated clusters were intermediate. Based upon the December census data, the proportion of live ticks which were active across habitats remained high (from 60 to 70% in November). Ticks will be monitored through the 1992 growing season to determine the proportion of individuals surviving into the second year in each vegetation community.

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Table 1. Average mortality of cayenne ticks and germination of scarified and non-scarified mesquite seeds exposed to fire generated in five replicates of four levels of fine fuel*.

Fine fuel Load (kg/ha)	% Seed germination Non-scarified	Scarified	%Tick mortality
	---Fire treatment---		
1000	43.8	61.2	88.00
1500	44.0	55.0	93.0
3000	12.2	15.6	99.0
4500	2.8	10.8	100.0
	-----Controls-----		
1000	41.5	95.0	28.9
1500	45.0	91.5	0.0
3000	15.5	96.5	0.0
4500	48.5	90.5	0.0

*Each replicatae exposed 100 non-scarified and 100 scarified mesquite seeds and 40 pair of adult cayenne ticks to the fire treatment level.

Table 3. December 1991 census of live adult cayenne ticks in observation chambers in postburn regrowth brush clustesrs, interstitial grass, and untreated clusters, following release of 20 ticks/sex in each of 3 chambers per vegetation community of July 17, 1991.

Habitat	Mean Male	Female	Standard error Male	Female	% survival Male	Female
Interstitial	5	7	1.7	2.0	25%	35%
Trt Clusters	10	11	2.2	2.7	50%	55%
Cnt Clusters	14	14	1.7	3.3	70%	70%

Table 2. Mean numbesrs of adult cayenne ticks active in late afternoon in postburn regrowth brush clusters, interstitial zones, and nontreated clustsers following release on July 17, 1991.

Date	Treatment	Mean Males	Females	Standard error Males	Females
Jul 21	Interstitial	15	13	3.8	4.0
	Trt Clustesrs	15	16	2.0	1.2
	Cnt Clusters	15	17	0.7	0.7
Aug 5	Interstitial	14	12	1.7	0.7
	Trt Clusters	16	15	1.5	0.3
	Cnt Clusters	17	19	0.6	0.9
Aug 24	Interstital	6	10	0.3	3.0
	Trt Clusters	12	11	1.9	0.3
	Cnt Clusters	16	15	0.6	1.3
Sep 1	Interstitial	7	10	3.0	4.2
	Trt Clusters	12	12	1.5	0.3
	Cnt Clusters	16	17	1.7	0.9
Sep 16	Interstitial	5	8	0.9	2.3
	Trt Clusters	11	14	1.0	1.7
	Cnt Clusters	13	14	1.8	1.9
Oct 10	Interstitial	5	5	2.2	2.9
	Trt Clusters	5	7	0.9	1.7
	Cnt Clusters	8	10	1.8	1.5
Nov 1	Interstitial	2	1	3.6	0.3
	Trt Clusters	6	9	0.6	1.5
	Cnt Clusters	10	10	1.8	1.5
Nov 18	Interstial	3	4	2.3	3.0
	Trt Clusters	9	10	0.3	2.1
	Cnt Clusters	9	10	1.2	1.5

Carbon Isotope Ratios of Soil Organic Matter Indicate Vegetation Change in the Rio Grande Plains of Southern Texas

T.W. Boutton, A.J. Midwood, S.R. Archer

The upland vegetation of the Rio Grande Plains in southern Texas has been described as a two-phase pattern consisting of discrete tree/shrub clusters containing 1-15 species embedded in a grassland matrix. Recent studies based on present vegetation patterns and a 50 year sequence of aerial photographs suggests that both the number and size of woody plant clusters in upland areas have increased since 1941, and that the present vegetation may represent an intermediate stage in the conversion of relatively open grassland and savanna to closed-canopy subtropical thorn woodland. In addition, the areal extent of woody vegetation associated with mesic, low-lying landscape positions has also increased during this same time period. However, there is still no direct evidence to indicate whether the trends observed since 1941 represent relatively short-term fluctuations of a stable and persistent plant community, or whether a directional succession from open grassland to closed-canopy woodland is in progress.

The use of stable carbon isotope measurements of soil organic matter can provide direct chemical evidence to evaluate the hypothesis that subtropical thorn woodland is replacing relatively open grassland in this region. All woody plant species in this area are C_3 plants with $\delta^{13}C_{PDB}$ values of approximately -26 ‰, while all major grasses are C_4 plants with $\delta^{13}C_{PDB}$ values near -12 ‰. The $^{13}C_{PDB}$ of soil organic matter records the relative contribution of C_3 (trees/shrubs) vs. C_4 (grasses) plants to site productivity integrated over a length of time approximately equal to the mean residence time of organic carbon in the soil. If woody species have been a long-term component of these landscapes, then the $\delta^{13}C_{PDB}$ values of soil organic matter beneath woody plant assemblages in the uplands and lowlands should bear a C_3-like isotope signature throughout the soil profile. However, if woodland vegetation developed only recently on C_4 grassland, then the $\delta^{13}C_{PDB}$ of the soil organic matter should still bear a C_4-like value similar to that found in the grassland matrix, particularly at depth in the profile where organic matter is oldest.

Procedures

The purpose of this study was to test the hypotheses that: 1) woodland vegetation has replaced relatively open grassland in the Rio Grande Plains of southern Texas; and 2) the progression of woodland formation in this region is from low-lying mesic drainages to uplands. Soil cores (10 cm diameter x 1.5 m length) were taken at La Copita Research Area along two transects in upland grassland, upland mottes, woodlands associated with drainages, and in landscape positions transitional between lowlands and uplands. Cores were divided into 6 depth increments (0-15, 15-30, 30-60, 60-90, 90-120, 120-150 cm); roots and particulate organic matter were removed from each increment by flotation in saturated NaCl. Soil and root samples were treated with 1N HCl to remove inorganic carbon associated with $CaCO_3$. $\delta^{13}C_{PDB}$ values were determined by isotope ratio mass spectrometry.

Results

Analyses have been completed only for upland grassland and drainage woodland. Stable carbon isotope ratios of litter and roots in upland grasslands were near -20 ‰ (Figure 1), suggesting a plant community comprised of 50% C_3 and 50% C_4 biomass. In the upland grasslands, the C_3 component is comprised primarily of forbs. Roots between 90-150 cm had $\delta^{13}C_{PDB}$ values near -24 ‰, perhaps indicating a higher proportion of forb roots deeper in the profile. $\delta^{13}C_{PDB}$ values of soil organic matter in the grasslands were higher than those for litter and roots, ranging from approximately -18 to -15 ‰ (Figure 1). This lack of agreement between isotope ratios of soil organic matter and the current organic matter inputs (i.e. litter and roots) indicates that the upland vegetation once had a much larger C_4 component. It seems likely that years of grazing at this site have resulted in a decrease in C_4 grass biomass and an increase in the biomass of less palatable forbs.

As expected, $\delta^{13}C_{PDB}$ values of roots (-25 ‰) and

litter (-26 ‰) in the drainages indicated a plant community comprised exclusively of C_3 plants (Figure 1). However, $\delta^{13}C_{PDB}$ values of soil organic matter in the drainages are nearly identical to those obtained in the upland grassland (-18 to -15 ‰, Figure 1), suggesting that even these low-lying landscape positions were once dominated by C_4 grassland. Since aerial photographs and tree ring analyses indicate that woody plants have occupied these drainages for at least 60 years, the large isotopic difference between current organic matter inputs and the soil organic matter is difficult to reconcile. It is possible that soil organic matter turnover is slow in this region, and that there has been only limited incorporation of current organic matter inputs from the woodland vegetation into the soil organic matter pool. Alternatively, more labile soil organic matter fractions may have been extracted by soil pretreatments with NaCl and HCl, leaving only the more recalcitrant organic matter for isotopic analysis. Regardless of the actual reason for the large discrepancy between current organic matter inputs and soil organic matter, the conclusion that drainages were once occupied by relatively open C_4 grassland remains unavoidable.

Results of this study indicate that both upland and lowland landscape positions at La Copita Research Area were once dominated by relatively open C_4 grassland, in agreement with previous assessments based on aerial photographs, present vegetation patterns, and estimates of woody plant age based on tree ring analyses and radiocarbon dating. At present, the $\delta^{13}C_{PDB}$ values do not indicate when this vegetation change occurred. However, the large discrepancy between the isotopic composition of the current organic matter inputs (litter and roots) and the soil organic matter pool suggests that the change was recent. Chronological aspects of this vegetation change will be sought through radiocarbon dating of soil organic matter at different depths in the soil profile, and by determination of $\delta^{13}C_{PDB}$ values of soil organic matter pools with different turnover rates.

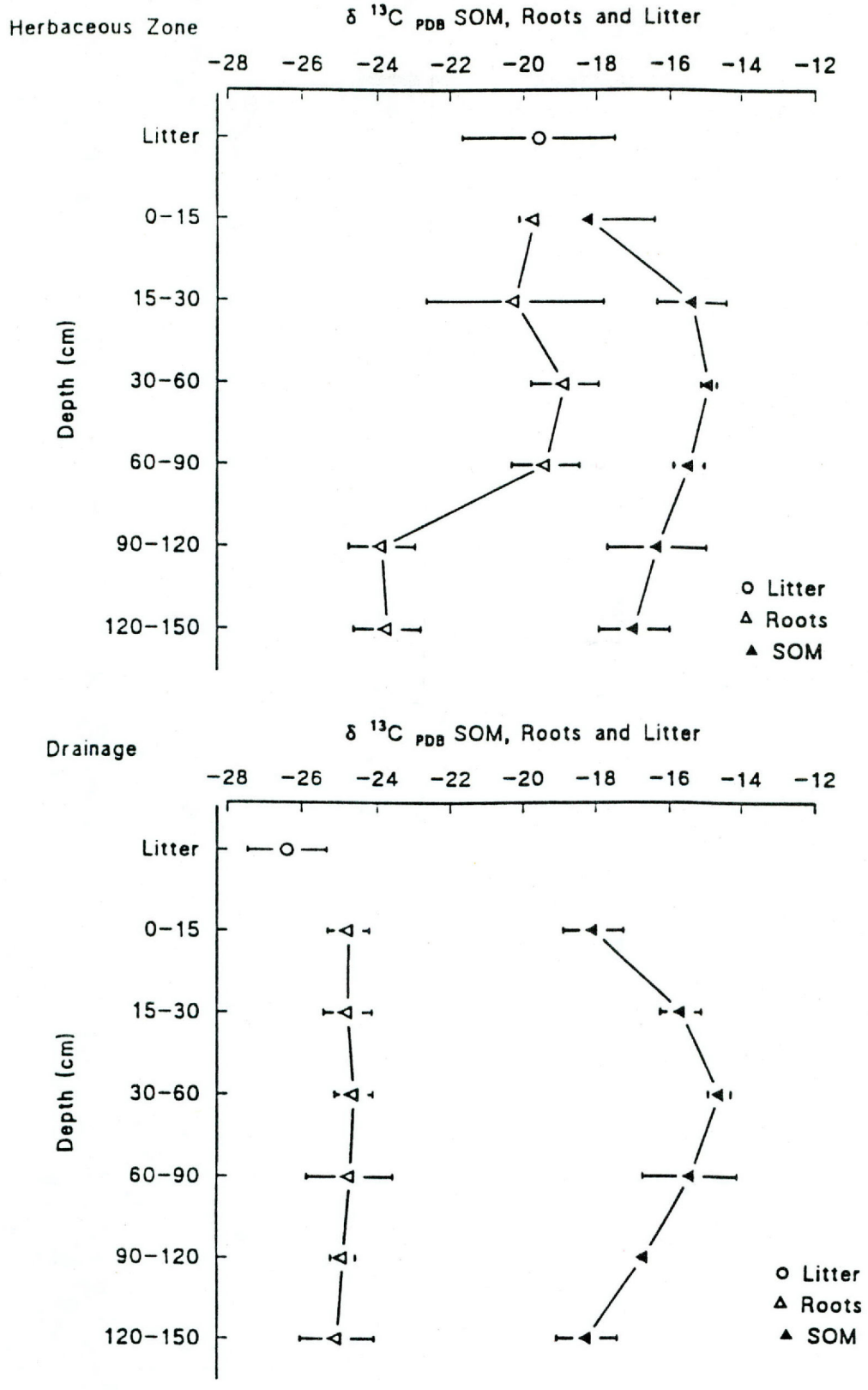


Figure 1. $\delta^{13}C_{PDB}$ values of litter, roots, and soil organic matter (SOM) from upland grasslands (top) and lowland woodlands (bottom) at La Copita Research Area. Error bars are ± 1 standard deviation.

Table 1. Effects of nodulation on growth of 8-week-old seedlings.

Species	Nodules /Plant	Nodule wt (mg)	Plant wt (mg)	Shoot/Root ratio	Height (cm)	N_2 Fixed (mg)[a]
Mesquite	43.1*	19.8*	696*	1.99*	16.75*	0.6*
with nodules	±18.6	±7.0	±192	±0.24	±2.68	±0.2
Mesquite	0	0	188	1.27	8.00	0
without nodules	±0	±0	±40	+0.52	±1.17	±0
Huisache	20.8*	23.0*	882*	2.33*	22.45*	1.2*
with nodules	±3.6	±4.0	±147	±0.34	±2.49	±0.4
Huisache	0	0	166	1.06	10.12	0
without nodules	±0.1	±0	±6	±0.14	±0.12	±0

*Significantly different than non-nodulated seedlings of the same species, alpha =0.05, n=20.
[a] Milligrams N_2 per gram dry nodule hour.

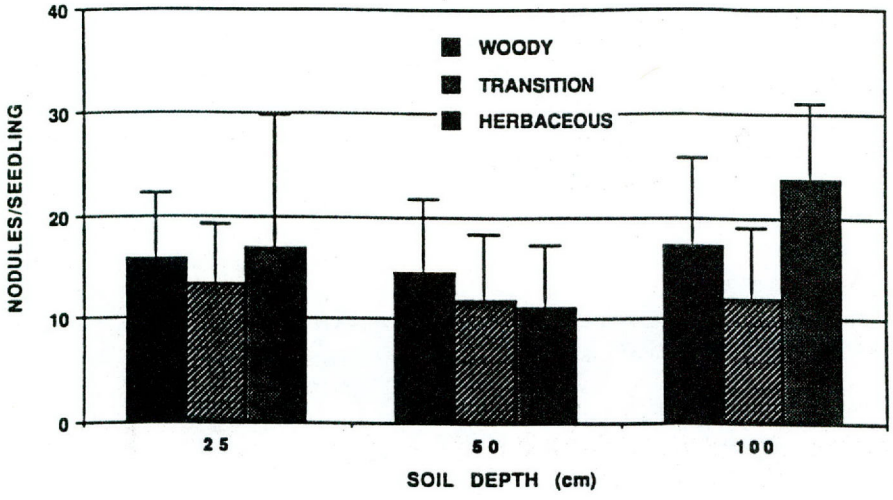


Figure 1. Effect of plant cover type and soil depth onb nodulation of mesquite.

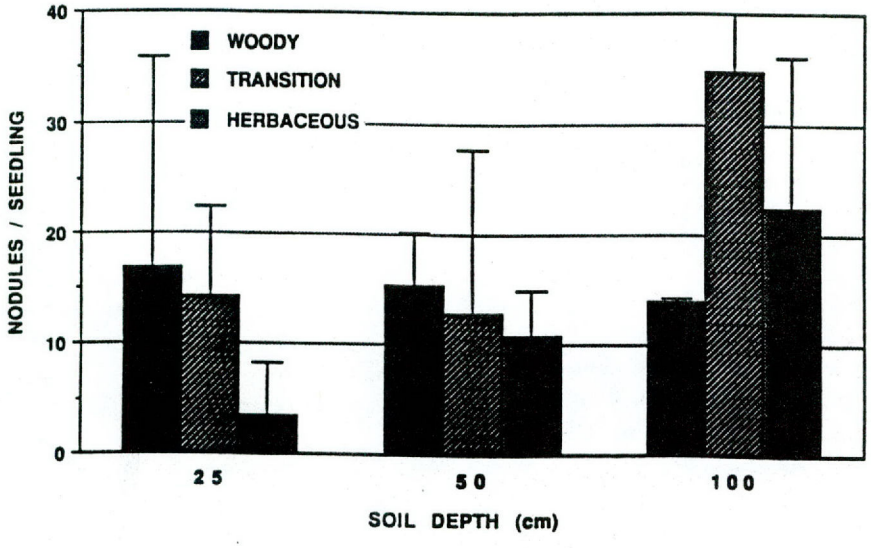


Figure 2. Effect of plant cover type and soil depth on nodulatin of huisache.

Tracing Water Uptake in Woody Plants in a Subtropical Savanna Using Natural ^2H Levels Measured in Environmental Water

A.J. Midwood, T.W. Boutton and S.R. Archer

Natural deuterium (^2H) levels in environmental water have been used to identify sources of water utilized by plants. This is possible because the ^2H concentrations in precipitation, soil water, and groundwater often differ. These differences arise through isotopic fractionations associated with precipitation and evaporation of water. Groundwater appears to represent an integrated average of the δ^2H of precipitation at a given site, while soil moisture in the unsaturated zone has δ^2H values which fluctuate in response to recent precipitation events and evaporative losses. Because plants do not alter the isotopic composition of water during uptake by the roots, it is possible to identify sources of plant water if the different sources (e.g. groundwater vs soil water) are isotopically distinct.

We have initiated studies of natural ^2H levels in soil moisture and plant water to examine water uptake patterns by woody plants at the La Copita Research Area. At this location, the groundwater is 30 to 60 m below the soil surface and may be inaccessible to most plants. Therefore, soil moisture in the unsaturated zone is likely to be the most important water source for plants in this area. Since the ^2H content of soil water varies with depth, it may be possible to determine whether a particular plant species acquires its water from the upper profile, the lower profile, or a combination of both.

Procedures

In October 1991,soil cores (10 cm x 1.5 m deep) and vegetation samples were taken from three sites at La Copita. Samples were taken from woody plants in upland grasslands, from newly formed woody plant clusters, and from mature groves. These sites represent a chronosequence in the succession from open grassland to subtropical thorn woodland. Water was extracted from the soil and plant samples by toluene distillation, reduced to H_2 by heating over zinc, and analyzed for δ^2H by isotope ratio mass spectrometry. All δ^2H values are expressed relative to Vienna - Standard Mean Ocean Water (V-SMOW) and normalized against Standard Light Antarctic Precipitation (SLAP). Precision of δ^2H measurements was better than 2 ‰.

Results

In the woodland grove site, soil water δ^2H values ranged from -5 to -25 ‰, decreasing exponentially with depth in the profile (Figure 1). High values near the soil surface have been shown to be due to evaporation, which causes isotopic enrichment of the residual water. Values for soil water of -25 ‰ deep in the profile are identical to those obtained for groundwater at La Copita. Stem water from all woody plants sampled at this site ranged from -26 to -34 ‰, and was more negative than water in the upper 150 cm of the soil. These results suggest that woody species in the grove site are all acquiring water from the same portions of the soil profile, and this water must be derived from an isotopically more depleted source region below 150 cm. Soil water from portions of the profile at the herbaceous grassland site had δ^2H values as low as -37 ‰, indicating that such a depleted source is reasonable at La Copita. Although the bulk of the root mass in woodland groves is in the upper 150 cm of the soil profile (see summary by Watts et al.), these results suggest that roots below that depth may be functionally significant.

In the woodland cluster site, δ^2H values for soil water ranged from approximately -5 ‰ at the surface to -27 ‰ at depths below 1 m (Figure 1). Stem water from *Zanthoxylum fagara*, *Schaefferia cunefolia*, and *Acacia greggii* were between -25 and -28 ‰, suggesting that these plants were acquiring much of their water from the 50 to 100 cm depth interval. In contrast, stem water δ^2H values for *Prosopis glandulosa* (-34 ‰) and *Condalia obovata* (-35 ‰) were lower than any of the soil water values in the upper 150 cm of the soil profile, suggesting for these two species the possibility of an isotopically depleted water source below 150 cm.

Both the pattern and absolute magnitude of δ^2H values of soil water differed between the herbaceous grassland site and the two wooded sites (Figure 1). Soil water δ^2H values ranged from -18‰ near the surface to approximately -37 ‰ lower in the profile;

δ^2H of soil water declined rapidly in the upper 40 cm from -18 ‰ to a minimum of -37 ‰, and then increased to -22 ‰ at 60 cm before declining again through the remainder of the profile. This difference between herbaceous grassland and wooded sites cannot be explained at present, but may be related to: 1) Differences between life forms (herbaceous vs. woody) that could influence rates of evapotranspiration through leaf area, leaf physiology, root distribution patterns, and/or shading of the soil surface; 2) Possible differences in soil physical properties that could influence plant rooting patterns, evapotranspiration, infiltration, or other aspects of the water-soil-plant-atmosphere continuum. The presence of an argillic horizon beginning at 30-60 cm in the herbaceous grassland zone may be significant in explaining the observed grassland-woodland differences.

Prosopis glandulosa has been shown to be the first woody plant species to colonize open grassland sites in upland areas in this region, and appears to initiate the successional sequence from grassland subtropical thorn woodland. δ^2H values of stem water for recently established *Prosopis* plants in the herbaceous grassland site were approximately -29 ‰, well within the range of δ^2H values in the upper 150 cm of soil. Thus, it appears that recently established *Prosopis* plants in the grasslands may be obtaining most of their water from the upper 150 cm of the soil profile, while older *Prosopis* plants in the wooded areas seem to be acquiring their water below 150 cm. Alternatively, root distribution patterns of *Prosopis* plants in the grasslands may be depth-limited by the presence of an argillic horizon, constraining water acquisition to upper portions of the profile.

These preliminary results suggest that the natural abundance of hydrogen isotopes in plant and soil water may contain information that is useful in elucidating key features of ecosystem structure and function in this savanna/woodland environment. Additional research using this methodology may identify patterns of water acquisition and partitioning between woody plant species, and may be useful in understanding successional processes underway in this region.

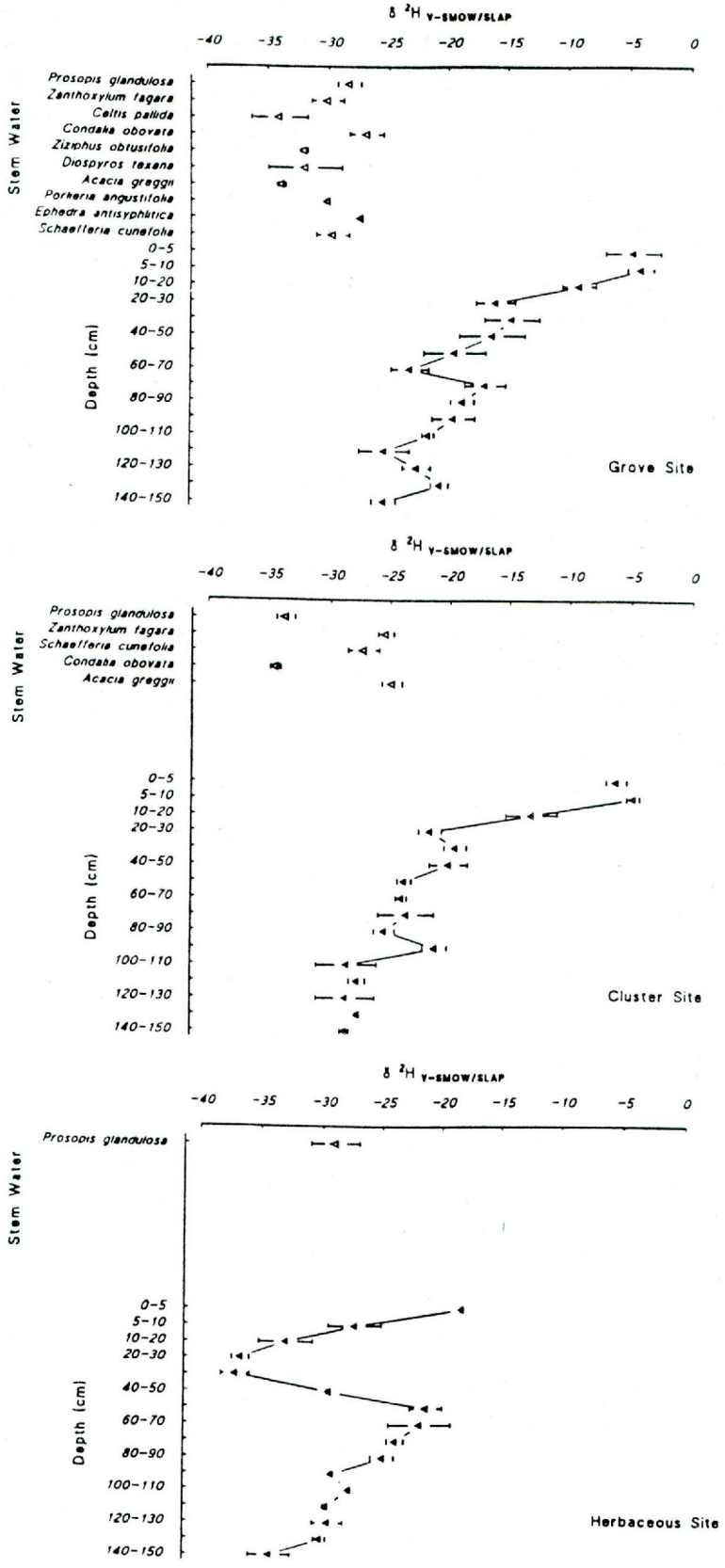


Figure 1. δ^2H values of soil water and stem water from woody plants at La Copita Research Area, October 1991. Error bars represent ± 1 standard deviation.

Nitrogen Fixation by Woody Plants in a Subtropical Savanna: Evidence Based on Natural Abundance of Nitrogen-15

T.W. Boutton, S.F. Zitzer, S.R. Archer, L.A. Cifuentes, J.P. Angerer

Recent studies have shown that mesquite (*Prosopis glandulosa*) and huisache (*Acacia farnesiana*) possess root nodules inhabited by nitrogen-fixing bacteria throughout their geographic range. These data suggest that both species are fixing atmospheric nitrogen, but do not indicate the quantitative significance of this process at either the whole plant or ecosystem level. Since these species are important components of woodland, grassland, and desert ecosystems throughout the southwestern U.S. and northern Mexico, it is critical to determine the extent to which they contribute nitrogen to these systems.

The primary reason for our lack of understanding of nitrogen fixation by woody plants has been lack of appropriate methodology. Techniques developed for assessing nitrogen fixation by crops and forages cannot be applied to woody perennials. However, recent developments in stable isotope biogeochemistry have demonstrated that the natural abundance of nitrogen-15 (^{15}N) in plant tissue indicates both the presence and quantitative significance of nitrogen fixation by woody plants. The basis of this technique is the fact that atmospheric nitrogen has a $\delta^{15}N$ value of 0 ‰, while total soil nitrogen has $\delta^{15}N$ values ranging from +5 to +10 ‰. Thus, plants which rely on the atmosphere for nitrogen can be distinguished isotopically from those that rely on soil nitrogen. Furthermore, the $\delta^{15}N$ value of a plant indicates the relative proportions of nitrogen derived from atmospheric vs. soil sources.

Procedures

During November 1991 at La Copita Research Area, we found that $\delta^{15}N$ values of leaves from mesquite (+2.0 $\pm$ 1.1 ‰, n = 64) and huisache (+0.3 $\pm$ 2.1 ‰, n = 7) collected from four upland woodlands were uniform across age classes and through a growing season, and were significantly lower than values obtained for non-fixing woody plants (+4.0 $\pm$ 1.6 ‰, n = 27) and for total soil nitrogen (+7.3 $\pm$ 0.6 ‰, n = 54) (Figure 1). These results confirm our previous experiments on nodulation potential, and indicate that both mesquite and huisache are incorporating nitrogen derived from the atmosphere.

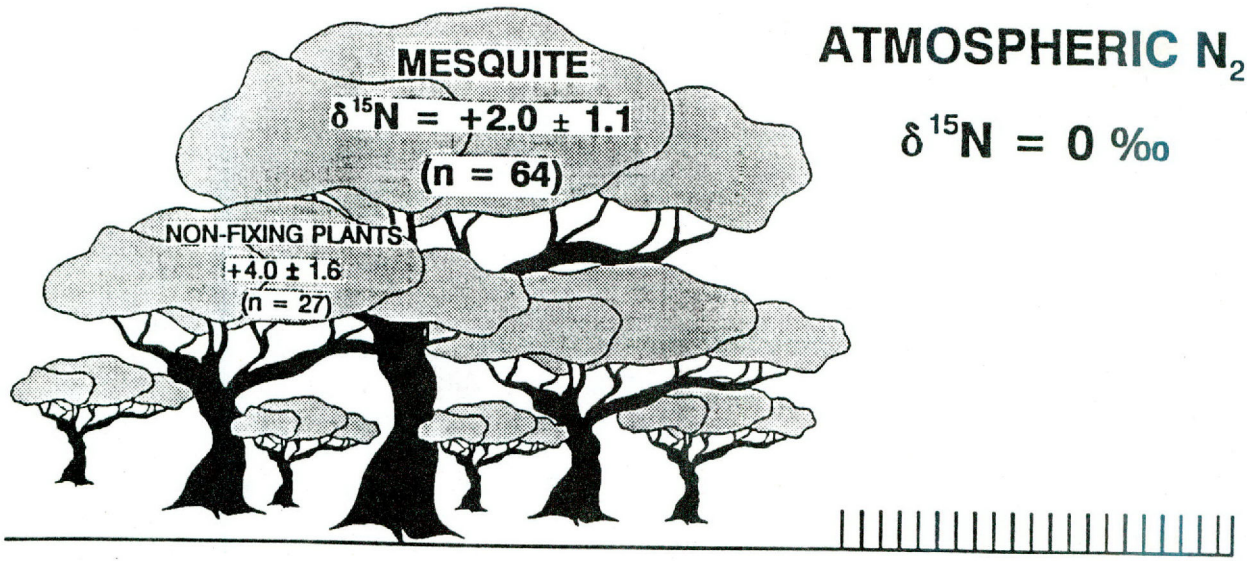
Results

The accumulation of fixed nitrogen in upland soils at La Copita is seen readily in the decrease in $\delta^{15}N$ values along the chronosequence from open grassland to woodland edge to woodland center (Figure 1). Several plant species which we demonstrated earlier to be incapable of nodulation had $\delta^{15}N$ values more similar to mesquite than to soil total N, indicating that fixed nitrogen mineralized from mesquite litter during decomposition is readily available to neighboring plants, and may represent a more available pool of nitrogen to these plants than nitrogen derived from the soil organic matter pool. The accumulation of a readily available pool of soil nitrogen beneath mesquite canopies may be one reason why mesquite facilitates the ingress and establishment of other woody plant species during the successional sequence from open grassland to subtropical thorn woodland in upland landscape positions in this region.

^{15}N mass balance calculations indicate that mesquite acquires 36 to 49% and huisache 63 to 70% of its nitrogen from the fixation process. Production of leaf litter beneath mesquite canopies in the uplands at La Copita is approximately 1010 kg ha^{-1} yr^{-1}, and 2.3% of this litter mass is nitrogen. Therefore, the annual input of fixed nitrogen in litterfall beneath upland mesquite is approximately 8.4 to 11.4 kg N ha^{-1}. This estimate does not include storage of fixed nitrogen in wood, or below-ground inputs of fixed nitrogen via root production and turnover. Since below-ground productivity of trees and shrubs in semiarid ecosystems is at least as large as above-ground production, we conservatively estimate an annual input of fixed nitrogen of 16 to 22 kg ha^{-1} beneath mesquite canopies in upland areas at La Copita. By comparison, estimates of nitrogen fixation by legume crops throughout the world range from 13 to 287 kg ha^{-1} yr^{-1}; for woody plants in forest and woodland ecosystems throughout the world, values range from 1 to 200 kg ha^{-1} yr^{-1}.

These results demonstrate that symbiotic nitrogen

fixation represents a significant nitrogen input for subtropical thorn woodland ecosystems dominated by mesquite in southern Texas. This annual input of fixed nitrogen may play an important role in influencing ecosystem structure by affecting species interactions and successional processes, and may also influence ecosystem function by altering rates of other nutrient cycling processes, especially nitrogen transformations (e.g. mineralization, nitrification, denitrification), in this region.



SOIL $\delta^{15}N$

SOIL DEPTH (cm)	CENTER	EDGE	GRASSLAND
0-25	+6.2 ± 1.0	+6.9 ± 0.5	+7.5 ± 1.0
25-50	+6.1 ± 0.5	+7.6 ± 0.4	+8.5 ± 0.3
50-100	+6.2 ± 0.8	+7.7 ± 0.3	+7.9 ± 0.2
MEAN	+6.2 ± 0.7 (n = 18)	+7.4 ± 0.5 (n = 18)	+7.9 ± 0.7 (n = 18)

Figure 1. $\delta^{15}N$ values for mesquite, for other non-nitrogen fixing woody plants, and for total soil nitrogen. All $\delta^{15}N$ values have units of ‰ (per mil), and are relative to atmospheric N_2.

Land Cover Change and Regional Tropospheric Chemistry

S. R. Archer , M.C. Wildermuth, A.B. Gunther, E.A. Holland, and D.S. Schimel

The accuracy of estimates of stratospheric ozone depletion and estimates of global warming potential attributable to the accumulation of tropospheric greenhouse gases are presently constrained by an incomplete understanding of complex tropospheric chemical processes involving methane, CO_2, and non-methane hydrocarbons (NMHCs = terpenes, isoprene, and various aromatics). Research initiated in June of 1991 at the La Copita research area has focused on NMHCs, since emissions from vegetation are the most important source of non-methane hydrocarbons (NMHC) to the global atmosphere. For example, estimated annual global emissions of isoprene, a common NMHC produced from vegetation is comparable to the estimated natural methane emissions. We generally know that rates of NMHC emissions are affected by environmental conditions and that they differ among plant species. Our investigations seek to (1) quantify seasonal fluxes in this southern Texas environment and (2) compare and contrast emissions among plant species. Our ultimate goal is to evaluate the historical significance of changes in vegetation structure on atmospheric inputs of NMHCs. We hypothesize that the grasslands and savannas which characterized these landscapes at the time of settlement were dominated by species with low concentrations of secondary compounds and hence low NMHC emissions; whereas, the woody plants that have increased in abundance in recent history are species with high levels of secondary compounds and hence high NMHC emission potentials.

Measurements from June 1991 revealed that NMHC emissions from shrub branches of seven species ranged from very high (>60 ug/g/h) to very low (<1 ug/g/h) (Table 1). Ambient isoprene concentrations were similar to those which have been reported from forest ecosystems with known high emission rates. Ambient concentrations of isoprene and monoterpene increased 2X from night to day, suggesting light-stimulated production. Sampling conducted in November 1991 under cold, overcast conditions showed similar patterns among species, but rates were about 50% those observed in June. Additional species screened in November with significant isoprene emission rates (ug/g/h) were Coyotillo (Karwinskia humboldtiana) (30.4), Lotebush (Ziziphus obyusifolia) (8.5) and Texas Kidneywood (Eysenhardtia texana) (3.5). Whitebrush (Aloysia lycioides) had very high monoterpene emission rates (146.3 ug/g/h). Salvia, Colubrina, Guajillo (Acacia berlandieri), Catclaw Acacia (A. greggii, and Blackbrush Acacia (A. rigidula) emissions were <1 ug/g/h.

Additional seasonal measurements will eventually be used in conjunction with ecosystem models (which quantify vegetation dynamics, stand architecture, biomass and leaf area) to evaluate the potential magnitude of past, present and future NMHC emissions from vegetation. Calculation of NMHC emissions over large areas is essential to understanding the role of these chemical species in regional and global atmospheric chemistry. Current regional estimates rely on definition of emission rates for a 'typical' tree of a given species, and then mapping of these rates based on biogeographic data bases. This approach is cumbersome in that data must be obtained for all species and differences in emission rates within a species's due to changing resource availability are difficult to incorporate. We are exploring mechanistic, physiologically-based approaches to measuring and modeling NMHC emission rates to enable pooling of species into broad categories of functional similarity.

Ongoing research seeks to (1) characterize abiotic controls over NMHC emission from contrasting shrub growth forms, focusing on light, temperature, moisture; and (2) refine and parameterize physiologically-based models developed at the National Center for Atmospheric Research and estimate plant NMHC emissions under different or changing environmental conditions. Field surveys, coupled with a mechanistic understanding of process controls, will enable us to begin evaluating the significance of these vegetation-troposphere linkages in a dynamic simulation setting.

Table 1.Biogenic non-methane hydrocarbon emission rates from shrubs at the La Copita Research Area (June 1991).

Species	Common Name	Emission Rates (ug/g/h)		
Acacia farnesiana	Huichache	0.0	0.1	0.1
Celtis pallida	Spiny hackberry	0.0	0.1	0.2
Condalia obovata	Brasil	62.1	0.1	62.2
Diospyros texana	Texas persimmon	0.0	17.1	17.8
Mahonia trifoliolata	Agarito	59.8	0.6	60.4
Prosopis glandulosa	Honey mesquite	0.3	0.3	0.6
Zanthoxylum fagara	Lime prickly ash	0.0	0.7	0.9

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