LEGACY OF CHARLES TRAVIS TURNEY: THE JORNADA EXPERIMENTAL RANGE

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The Jornada Experimental Range (JER) in south-central New Mexico has served as a field research laboratory since its establishment in 1912. The varied scientific activities on the range throughout this century have led to important discoveries about desert ecosystems that have been the basis for principles of land management that have application around the globe. This region is probably the most extensively studied desert on earth, and on-site research activities continue to flourish as we approach the next millennium. From microscopic-scale studies of soil microorganisms to synoptic-scale assessments of vegetation patterns detected from satellite-based sensors, JER is addressing a multitude of research needs relevant to natural resource management issues. One phenomena that we have continually observed in our studies over the years is that small events can have cascading effects on ecosystem structures and functions. A period of drought, an innocuous introduction of an alien species, unmanaged grazing, or dispersal of seed into a new area are examples of events that can have far-reaching effects in subsequent decades. Like these biological events, the inception of JER was based on a relatively small event that has then cascaded into the legacy of scientific discovery that is the Jornada range today. In 1904, Harvey Ringer, a man not particularly interested in the cattle business, sold 16 ha of land in the south-central portion of the 3,000 km^2 Jornada Plain to a man from Texas, Mr. C. T. Turney.

INTRODUCTION

The Jornada Basin in south-central New Mexico is often called the Jornada del Muerto (journey of the dead). It lies to the east of the Rio Grande on a plain 100 m above the river. The San Andres Mountains border it on the east; the Doña Ana Mountains correspond to the southern reaches; and the lava fields adjacent to Frá Cristobals form the northern limits. The plain varies in width from 8–50 km and is about 150 km long. The plain is primarily a closed basin with limited external drainage on the west edge.

Livestock were introduced from Mexico into this region during the early part of the sixteenth century (Hastings and Turner 1965). However, grazing was limited for over 250 years to the Rio Grande valley and adjacent slopes because of lack of surface water in the surrounding basins, including the Jornada. Some water could be found in springs and seeps in the mountains, but supplies were ephemeral and livestock use was sporadic.

The Jornada Plain began to be settled following passage of the Homestead Act of 1862 and the end of the Civil War. The first well on the plain was dug in 1867 at the Aléman Ranch along the southern portion of the Santa Fe Trail north of the Doña Ana Mountains. Yet, it was not until 1888 when the Detroit and Rio Grande Livestock Company pumped water from the river to a tank on the mesa and piped it to troughs 10 km to the western side of the plain that livestock grazing spread into the Jornada grasslands. Originally owned by U.S. Army officers from Michigan, the Detroit Company began to assemble grazing rights across the Jornada Plain during this period, and grazing use increased. In the later part of the century, the Bar Cross brand (and the 20 or so other purchased brands) of the Detroit Company could be found on 20,000 cattle, including 1,000 bulls on the Jornada Plain. The number of other stock, especially horses, is unknown, but is assumed to have been substantial.

Grazing was more limited on the sporadically distributed homesteads based around springs on the east side of the Jornada Plain. At Goldenburg Springs on the west slope of the San Andres, the three Goldenburg brothers reportedly watered 1,800 cows in the very early 1900s. Lack of developed water in the central and eastern regions of the plain limited livestock distribution in the area. The first wells were drilled in 1903 by Harvey Ringer at the current site of the Jornada Experimental Range (JER) Headquarters and at Red Lake and Middle Well (on the current JER). Ringer had begun to purchase portions of the Bar Cross from the Detroit Company as that ranch was dissolved, probably triggered by the severe drought of the 1890-1893 period.

THE TURNEY INVOLVEMENT

Charles Travis Turney was from Sutton County, Texas. Born in 1857 and on his own from the age of 8, C. T. Turney had spent his life working as a cowboy. Turney and some of his fellow Texans had decided that land had become too expensive in Texas and that the New Mexico Territory was their land of opportunity. He first traveled into New Mexico in 1900 and registered his t-hook brand. In 1902, he began moving a herd of cattle from Texas to southern New Mexico. He was delayed in the Pecos area for a year because of animal-quarantine restrictions but eventually arrived in Doña Ana County in 1904. In January 1904, Turney purchased the 16-ha lots at the headquarters site, Middle Well, and Red Lake, and $4,000 worth of cattle from Harvey Ringer. Then in February 1904, he moved his family to Mesilla and began building his ranch and farm enterprises. In the following eight years Turney purchased from other homesteaders in the area (including Joe Taylor and Hugo Seaburg) an additional 6 wells on 80 ha and shipped or trailed to the Jornada an additional 3,000 cattle. By 1912, Turney held deed to 120 ha and 9 wells that provided grazing rights to over 80,000 ha on the Jornada Plain for his 4,000-5,000 head of cattle. In fact, by 1912 he had already constructed fence around a portion of the borders of his ranch.

Concurrent with the expansion of livestock grazing in the late 1800s throughout the southwest region was a noticeable decline in rangeland conditions (Smith 1899). In New Mexico, deteriorated rangeland conditions were first documented by E. O. Wooton (1908). Wooton, a professor at New Mexico College of Agriculture and Mechanical Arts in Las Cruces, had spent years documenting rangeland conditions through the state (Allred 1990). In his first thorough report on the subject (Wooton 1908), he included results of a survey of southwestern cattlemen on the condition of regional rangelands. Of the 118 responses, 16 stockmen felt that rangeland conditions had improved in recent years, and 102 responded that there had been significant declines in grazing capacities. Of these 102 responses, 69 attributed the declines to overgrazing, and 33 blamed drought conditions. These observations were fairly universal and led to the first fledgling attempts at range research to develop suitable management and improvement practices by 1890 on small areas in the Texas panhandle (Smith 1899). Wooton had initiated his own experiments by 1904, but he was frustrated by the lack of a suitably large area for research that would have application to the large ranches typical in the Southwest.

Some of Wooton's early experiments were conducted on Turney's ranch on the Jornada Plain. Turney had fairly quickly become one of the prominent ranchers in the area, and it is apparent that he and Wooton established a rapport on the benefits of this research. It is also evident that the creation of a large reserve for research could serve to secure grazing rights for the cooperating rancher. A large reserve, the first of a significant size, had already been established in Arizona south of Tucson. Wooton left the College in Las Cruces in 1911 to serve as an agricultural economist for the U.S. Department of Agriculture in Washington, D.C. From this post he orchestrated the creation of the Jornada Range Reserve in 1912 from withdrawn, public-domain lands surrounding Turney's nine scattered holdings on the Jornada. President Taft signed Executive Order 1526, creating the Jornada Range Reserve 124 days after New Mexico was awarded statehood. Established within the USDA's Bureau of Plant Industry, Wooton returned to New Mexico to oversee the reserve's establishment. One of the first collaborations between Turney and Wooton at the Reserve was the completion of the perimeter boundary fence that secured Turney's sole use of the southeastern portion of the Jornada Plain. This was 22 years before the passage of the Grazing Act in 1934, which would establish grazing rights for ranchers using much of the remainder of the unpatented public domain in the western United States. Wooton's photograph of the fencing crew in 1912 has appeared widely in publications and brochures on western rangelands over the last several decades (Figure 1).

Surprisingly, given his role in establishing the Reserve and his successful collaboration with Turney, Wooton only remained as Superintendent until 1915. At that time, the USDA transferred the Reserve to the Forest Service and appointed a new director, C. Forsling. The U.S. Forest Service had established an in-house research program that was quickly creating a presence throughout the western United States. The research on the Jornada Plain began in earnest under Forsling's direction.

The initial objectives, as detailed in the 1915 Memorandum of Understanding between the Forest Service and Mr. Turney, were to

1. Develop a range-management plan to minimize stock loss during drought;

Figure 1. Dinnertime, just before completing the boundary fence of the Jornada Range Reserve, October 1912. Around the chuck wagon are (left to right): George, the cook; two unidentified laborers; George Lynch, county surveyor; two unidentified laborers; and C. T. Turney. (Photograph by E. O. Wooton).

2. Establish a system of forage utilization consistent with growth requirements of forage species and which will build up depleted range and minimize nonuse losses;

3. Identify advantages of controlling stock and the range for improving stock performance;

4. Quantify carrying capacity of native range under control and comparative capacity of these lands without control;

5. Identify costs of handling stock under controlled conditions compared to uncontrolled conditions;

6. Quantify loss of stock under controlled conditions compared to uncontrolled conditions;

7. Identify number and distribution of stock-watering places necessary to secure proper use; and

8. Examine the possibility of range improvements by introduction of new plants, seed planting, conservation of runoff, etc.

Unfortunately, Turney's tenure on the Jornada was also brief. Success during the early years led to expansion of his farming and ranching enterprises. In fact, in 1919 he bought the Bar Cross ranch from James L.

Hurt. However, extended drought from 1916 to 1919 and a disastrous loss of cattle shipped into Mexico forced Turney to sell his interests in the Jornada in 1925. Yet, the mission of the Reserve had been established, and the legacy of Turney (and Wooton) was secure. C. T. Turney died in 1930.

RESEARCH HISTORY

Obviously, implicit in the original goals of the Range Reserve was to demonstrate the advantages for both stock and the land of controlling the grazing use of the open range. The subsequent record of research on JER provides considerable insight into the developmental history of our western rangelands during the twentieth century. This record can be categorized into six principle themes: range management, husbandry, ecology, improvements, interdisciplinary sciences, and ecosystem science.

Range Management

A key problem for range management was quickly identified as inaccurate judgement of carrying capacity (Wooton 1915). The JER research program focused on quantifying proper utilization levels of the principle species. Jardine and Forsling (1922) established early guidelines for carrying capacities of black grama (*Bouteloua eriopoda*) rangelands. Subsequent research during ensuing decades has reinforced the accuracy of these guidelines, as Campbell and Crafts (1938), Paulsen and Ares (1962), and Holechek and others (1994) have reached strikingly similar conclusions. These authors all conclude that proper utilization of black grama should be less than 40 percent of the current year's growth.

The original philosophy was that proper utilization of the leaves and stems of the main forage plants was the basic principle of range management (Canfield 1939). General-management guidelines published in the 1910s and 1920s are very similar to those promoted today. For example, nearly 80 years ago Jardine and Forsling (1922) recommended the following drought strategies: (1) limit breeding stock to carrying capacities during drought, (2) utilize surplus stock during good forage years depending upon market conditions, (3) adjust range use seasonally depending upon growth characteristics of key species, (4) establish permanent watering points no more than 8 km (5 mi) apart, and (5) establish both herding and salting practices that achieve optimal stock distribution. Similar recommendations for drought conditions are outlined in one of the most current textbooks on range management (see Holechek et al. 1995).

Husbandry

Initial research on livestock production also emphasized strategies for drought. Most of the original efforts focused on supplemental feeding programs, especially those that used locally available feedstuffs such as cottonseed products. For example, general recommendations were for .45 to .9 km (1 to 2 lb) of supplemental protein to augment range forage for maintenance (Forsling 1924), with slightly higher quantities suggested for growth of stockers (Jardine and Forsling 1922). These general recommendations have persisted during ensuing decades. However, more recent research focuses on the use of protein and energy supplements for specific animal-production stages to trigger specific physiological activities (Gambill et al. 1994).

More novel research has emphasized specialized practices for emergency feed conditions and management of poisonous plants. Soapweed (*Yucca elata*) was found to be a palatable emergency feed when fed chopped and fresh (Forsling 1919). Ensiling or preparation was not determined to be necessary. Other plant species were either deemed not suitable as emergency feeds (i.e., *Dasylirion wheeleri* and *Yucca macrocarpa*) or required spine removal (*Opuntia* spp.). Interestingly, burning spines from prickly pear cactus (Forsling [1924] estimated that one person could prepare cactus feed for 200 to 400 head of cattle in a day) was employed during the 1994–1995 drought in the southwestern United States. However, even in the 1910s and 1920s, the use of emergency feed practices was not viewed as responsible management for properly stocked rangelands.

As in other western rangeland regions, studies on poisonous plants provided both initial guidelines for livestock management and insight into the difficulties of plant control in a desert environment. For southern New Mexico, drymaria (*Drymaria pachyphylla*) became a problem in response to overgrazing (Little 1937). For clay soils, drymaria was viewed as an early seral or successional species (Campbell 1931). Avoidance of grazing in drymaria-infested areas was the recommended management strategy. Various measures of control (fencing, burning, spraying, and revegetation) were examined and determined to be either too expensive or ineffective. The recommended control practice was hoeing, but eradication was not viewed as a viable possibility. These general characteristics relative to management and control recommendations for poisonous plants persist today (James et al. 1993).

Development of techniques (such as esophageal fistulation) for animal nutrition research led to investigations of the interactions between plants and livestock. Early work identified foraging behaviors of different cattle breeds (Herbel and Nelson 1966), but regardless of breed, cattle are generalists in this environment. A current research emphasis is identification of animal production capabilities most suitable to forage characteristics of desert rangelands (Walker and Winder 1993). Cattle genotypes with relatively modest performance traits, such as milk production, would be more successful in this nutrient-sparse environment. It is possible that some desired characteristics will mirror those inherent to the original cattle breeds introduced to North America in the sixteenth century.

Research on plant-animal interactions now reflects the widespread distribution of shrubs in the Chihuahuan Desert. Foraging behaviors are strongly mediated by secondary plant chemistry (Estell et al. 1994), and chronic ingestion may have post-ingestive consequences that further shape preferences (Fredrickson et al. 1994). Remediation of shrub-dominated rangelands will require cost-effective technologies. The use of livestock as biocontrol agents for remediation will require detailed knowledge of this chemically mediated interaction in order to be an effective technology.

Ecology

One of the early objectives of JER was to understand the role of management in natural revegetation of rangelands (Jardine and Hurtt 1917). By the late 1920s, patterns of succession were described (Campbell 1929, 1931). These observations were generally in areas where livestock numbers had been substantially reduced (or eliminated) and year-long grazing had been adjusted to seasonal use. For example, on sandy soils, five successional stages were described in the natural revegetation of sand dunes: (1) mat stage of low-prostrate annuals, (2) ruderal stage of large annual and perennial forbs, (3) snakeweed (*Gutierrezia sarothrae*) stage (viewed as critical), (4) dropseed (*Sporobolus* spp.) stage (regeneration of perennial grasslands), and (5) grama-grass stage. These observations reflected the succession-and-climax paradigm of the period.

However, these early observations did not portend larger-scale transformations that were documented over ensuing decades. Probably the defining publication from the first half-century of research in the Jornada Basin was Buffington and Herbel's (1965) reconstruction of vegetative changes in the area between 1858 and 1963. The broad-scale encroachment of shrubs was attributed to seed dispersal, heavy grazing, and periodic droughts (Buffington and Herbel 1965).

Concomitant with the vegetation dynamics has been substantial change in surface soils. Gibbens and others (1983) documented effects of wind erosion of soil fractions as an ungrazed landscape changed from perennial grassland to coppice dunes dominated by mesquite. Both soil movement and the redistribution of sand, silt, and clay fractions were substantial.

Emerging from this reconstruction and associated research has been a key postulate regarding changes in ecosystem properties that accompany grassland conversion to shrubland (desertification). The central hypothesis is that the distribution of soil resources is altered from spatially homogenous, as seen in semiarid grasslands, to heterogeneous, as seen in shrublands, with desertification (Schlesinger et al. 1990). Further, these emerging resource islands act as positive feedback to further the invasion and persistence of shrubs. This hypothesis has formed the basis for the research efforts of scientists affiliated with the Long-Term Ecological Research (LTER) program at the Jornada (Figure 2).

This hypothesis counters the earlier observations regarding the potential for disturbed lands in arid environments to naturally revegetate to semiarid grassland conditions. Current research in other arid regions would also support a hypothesis of nonlinear vegetation dynamics in these environments (for example, see Milton et al. 1994).

Improvements

The first articles on classic techniques for improving forage production on desert rangelands were published in the 1940s (Cassady and Glendening 1940; Parker 1943). These research efforts primarily focused on reseeding practices and a variety of brush-control methods. With the development of appropriate machinery (i.e., the rangeland drill) and herbicides, examinations of intensive improvement practices were a significant part of the research program for the next 45 years (Herbel and Ares 1961; Herbel and Gould 1970; Herbel et al. 1985; Parker 1949). The principles of these intensive improvements have been well articulated (Herbel 1983); however, more recent economic assessments of these practices have not been wholly favorable. For example, Sherwood (1994) concluded that over 95 percent of the possible reseeding practices suitable for the Jornada Basin would result in a negative economic return. Similar doubts have been raised regarding the cost effectiveness of

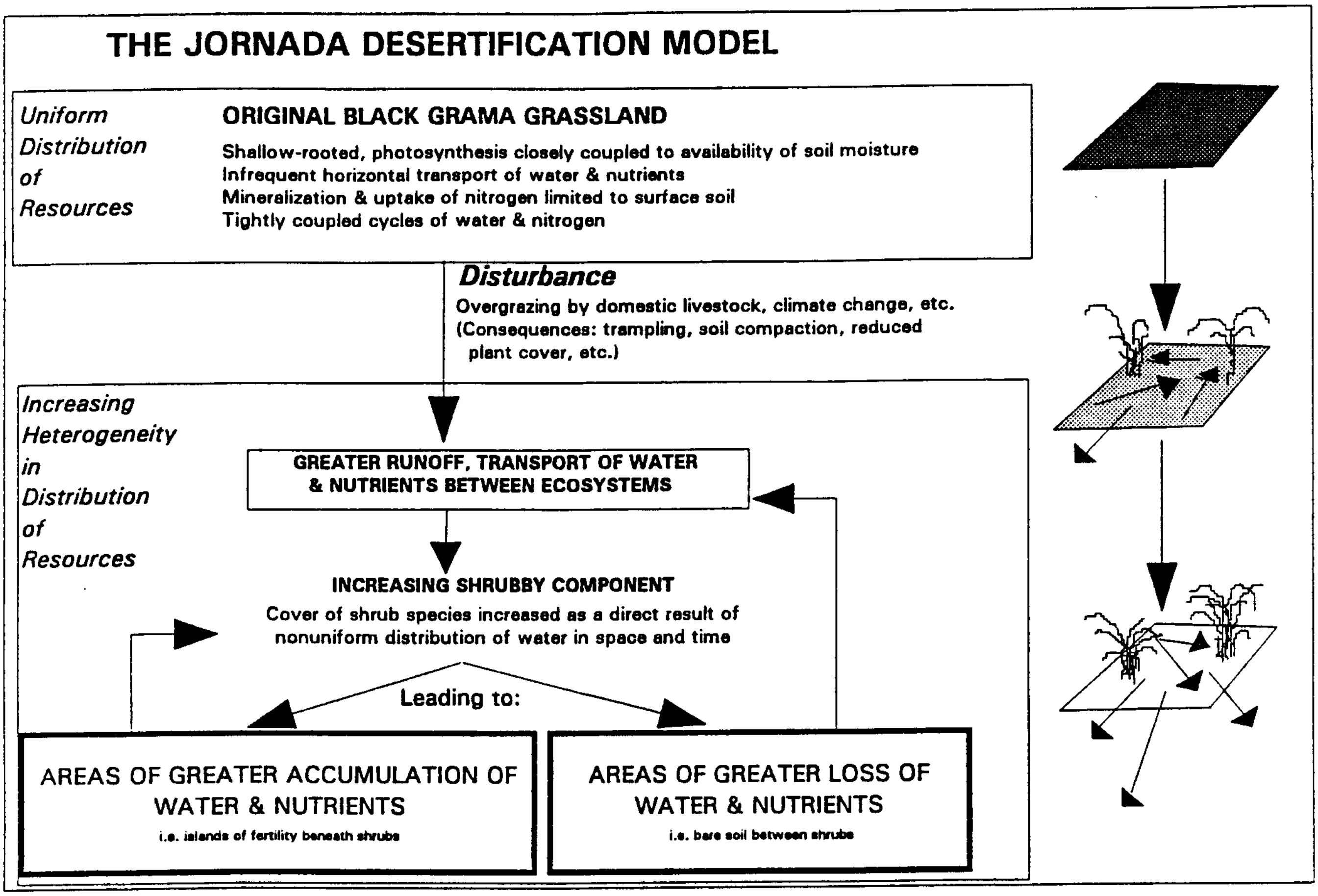

Figure 2. The "Jornada Desertification" model. A central hypothesis of research at the Jornada Experimental Range is that changes in vegetation are accompanied by a redistribution of water and soil resources in the landscape, which act as a positive-feedback mechanism to promote the desertification process.

chemical methods for brush control (Herbel and Gould 1995).

One of the original objectives of the Experimental Range was to identify a management system that brings about natural reseeding of desired species (Jardine and Hurtt 1917). With our emphasis on developing specialized intensive technologies, we have not accomplished this original objective. Low-input techniques that are economical and effective are still required. Four premises need to be advanced: (1) biological integrity of both above- and belowground systems in addition to the short-term establishment of desired species is necessary to buffer against future disturbances; (2) resource redistribution over time at the community and landscape levels plays an important role in both desertification and restoration processes; (3) restoration efforts should focus on fertile sites best suited for re-establishment of native species; and (4) planting technologies should be based on readily available "natural" dispersal systems (Herrick et al. 1995).

Interdisciplinary Sciences

Interdisciplinary research began in earnest in the 1960s. Rangeland science has typically been presented as an applied, interdisciplinary field, but involvement of related sciences (other than animal science and other directly related agricultural fields associated with range-livestock production) was slow to develop. The interactions with this new group of scientists occurred in conjunction with an expanding appreciation for the multiple uses and values of desert rangelands.

In the Jornada Basin, these interactions involved both biological and soil sciences. Gile (1966) provided new insights into soil-horizon development processes in arid environments. In particular, descriptions of clay illuviation in high-carbonate sediments greatly revised our understanding of argillic horizons in arid soils (Gile and Grossman 1968; Gile and Hawley 1972). These clay horizons develop slowly in deserts and can be masked by subsequent accumulations of carbonate.

Whitford and others (1983) provided initial insights into the role of decomposers and herbivores on nutrient cycling in the desert. For example, cleverly designed field studies identified the mass of subterranean termites (*Gnathamitermes tubiformans*) in the Jornada at 30 kg/ha (MacKay et al. 1989). Termites were estimated to recycle 11 percent of litter nitrogen and 13 percent of annual and grass standing crops (Schaefer and Whitford 1981).

Hundreds of studies in the past 25 years have expanded our knowledge on a range of topics, including soil biota (Virginia et al. 1992), biogeochemical processes (Schlesinger and Peterjohn 1991), nitrogen fixation (Herman et al. 1993), surface hydrology (Tromble 1988), primary production controls (Cunningham et al. 1979), effects of lagomorphs (Gibbens et al. 1993), and distributions of rodent populations (Hoover et al. 1977).

Although many of these topics require further research, we still have two particular, and different, research needs. First, this body of work lacks effective synthesis. Without complete and detailed synthesis, the application of this information to the management of these desert rangelands is seriously curtailed. Second, there is an overwhelming need for research on the roles of soil biological systems in the recovery of degraded lands (Whitford and Herrick 1995).

Ecosystem Science

The creation of the International Biological Program (IBP) provided the impetus for an ecosystem framework for research. The Jornada Basin was the location for the desert-grassland site within IBP. By the early 1970s, scientists had assessed system variables as a foundation for model development and expanded insight into ecosystem processes. For example, Pieper et al. (1972) quantified that 4 percent of captured energy was transferred from plants to herbivores in the desert.

As the IBP dissolved in the late 1970s, the LTER program emerged in the 1980s as its successor. The LTER, now in its second decade, has five core research efforts: (1) pattern and control of primary production; (2) spatial and temporal distribution of populations selected to represent trophic structure; (3) pattern and control of organic matter accumulation in surface layers and sediments; (4) pattern of inorganic inputs and movements of nutrients through soils, groundwater, and surface waters; and (5) pattern and frequency of disturbances. Research in these core areas has provided a basis for modeling efforts. In particular, modeling has linked transport processes to the spatial and temporal dynamics of soil resources, a key premise of the Jornada model. Based on these efforts, the regional stability of desert ecosystems has been described as a function of resource distributions among smaller scale (patch) mosaics within the larger landscape (Reynolds et al. 1995). Understanding the cascading effects (both positive and negative) of both management and remediation practices in the desert will require the continued development of larger-scale ecosystem models.

CONTEXT OF RESEARCH HISTORY

Two prevailing themes arise from an analysis of the history of research conducted in the Jornada Basin. These themes are degradation and utilitarian environmentalism. JER has its roots in the deteriorated range conditions of the region during the later decades of the nineteenth century. Much of its research effort throughout the twentieth century was devoted to developing range-management practices suitable for degraded lands or intensive technologies for their improvement. Even today a central postulate of research is based upon a hypothesis of degradation processes (the Jornada model). Yet, if there is one key deficit to these research accomplishments, it is the failure to identify usable technologies for remediation of degraded conditions.

This failure is probably more a function of the dynamics of our environment, our economy, our attitudes, and our expectations than from an inefficient use of the scientific method. We now believe that remediation has to be accomplished in a more extensive fashion and based on a more complete knowledge of the basic ecological processes that occur in desert rangelands.

Since its establishment, JER's research program has included a significant element devoted to ecological studies. Livestock production and an understanding of the principles for managing the forage on which the range-livestock industry is based was the initial emphasis. However, the emerging principles have an ecological basis. Though an increasing emphasis is now placed on the study of ecological principles, livestock grazing as a viable use and tool for landscape management is still central to the research. This can best be labeled as utilitarian environmentalism, a concern for the long-term capacity to harvest food and fiber from a highly variable (transient) environment. Our terms for this goal, such as "proper use" and "sustainability," have not withstood rigorous examinations. The theme, though, has been and will continue to be how to use this resource based on a thorough understanding of our surroundings and our interactions with those surroundings.

HISTORY AS ANALOG

The history of research results from JER supports three emerging postulates from the broader body of rangeland science in recent years. These postulates are (1) many ecological processes have thresholds below and above which they become discontinuous, chaotic, or suspended; (2) ecological character is reflected by dominant species;

and (3) species are interdependent and many of these interdependencies form highly specialized interactions.

Many of the observations in the Jornada Basin during this century have documented surprisingly rapid changes across the landscape. Yet, our frustrations in effecting change, even with intense inputs, supports the second postulate. Remediation within this ecosystem will require specific knowledge of species interactions, which may have to be regenerated before corrective management actions will be effective. Needless to say, we can predict from our observations that simply abandoning the landscape will not promote recovery or prevent further deterioration.

Within this context, livestock grazing must be managed so as to neither disrupt species interactions or drive impacted processes beyond the thresholds. The average annual carrying capacity for this hot desert is 9.5 animal units/section. This would require the annual harvest of approximately 10-20 g of forage per m^2 with even distribution of grazing use. We have the basic management techniques for controlling grazing for this level of defoliation. However, we still need the ability to effectively monitor that use over large areas, detect impacts of use on key processes, more rapidly recognize seasonal forage dynamics, and develop methodologies for using the animal to effect desired changes.

CONCLUSIONS

Much of the research conducted during the early twentieth century is still applicable to today's management issues. Though the experimental designs employed in the 1910s, 1920s, and 1930s might not entail the sophistication serviceable by current statistical analyses, the thoroughness and detail of the early field research more than compensate. In addition, the length of the research record itself becomes a powerful tool for insight and scientific speculation.

One perception that surfaces from a review of the research record of the Jornada Basin is the complexity of this arid ecosystem. This complexity cannot be easily communicated. Yet, these desert rangelands will continue to provide critical resources to a significant portion of the human population. It is important that we not oversimplify our understanding of this system in our attempts to communicate our knowledge to interested segments of our society. Solutions to today's management problems are generally not simple, and we should not create false expectations. We need to use the full scientific history of experimental stations like the Jornada to create more complete understanding. This should be a prominent objective within our research programs. In fact, using the Jornada Experimental Range as a demonstration for our knowledge of desert rangelands was an original objective of C. T. Turney and E. O. Wooton, and it is still valid today.

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