PAST AND PRESENT RESEARCH ON THE JORNADA EXPERIMENTAL RANGE AND FUTURE NEEDS

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The Jornada Range was set aside for experimental purposes by presidential proclamation in 1912. From 1912 to 1915 it was controlled by the Bureau of Plant Industry. From 1915 to 1953 it was under the jurisdiction of the Forest Service. In 1953 all range seeding research for domestic livestock and grazing management on rangelands not integrated in use with national forest ranges was transferred to the Agricultural Research Service. So, since 1953, the Jornada has been operated by the Arid Pasture and Range Section, Crops Research Division of the ARS.

The present area is 105,700 acres. An additional 85,000 acres in the San Andres Mountains and foothills, now on lease to the White Sands Missile Range, are available for research but not for grazing.

In 1958 a new livestock agreement was inaugurated, under which the cooperator furnishes the breed and class of cattle in the numbers required and the government handles the cattle and maintenance of improvements. Prior to that time, the cattle were furnished by a cooperator under a system whereby the cooperator had control of the cattle and maintenance of facilities. For the control needed in research, the new arrangement is much better than the old.

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Most of you are familiar with our climatic features but I would like to briefly review them. The average annual precipitation is 9.10 inches (1915-62) while the average July through September precipitation is 4.99 inches. The average temperature is 59 degrees with -20 being the lowest ever recorded and 109 the highest. Wind movement averages 10,759 miles annually with March through May having the highest monthly totals. Average annual evaporation from a free water surface totals 90.18 inches with June having the highest monthly total. Taken altogether, then, the climatic features become favorable for plant growth when the summer rains begin, usually in early July. Conditions remain favorable for established plant growth, depending on available soil moisture, until the early part of October.

Practically all our discussion will be concerned with studies on mesa lands. These are level to gently rolling sands interspersed with old geologic lakebeds. The vegetation on the sandy land consists of black grama, dropseeds, some forbs, and mesquite which has invaded vast areas. The vegetation on the lakebeds consists of tobosa, burrograss, and tarbush which has invaded some areas. Creosotebush has invaded the sandy loams.

Past Work

Approximately 100 publications have been prepared from data collected exclusively on the Jornada and an additional 31 publications were prepared from data collected in part on the Jornada. The great preponderance of this information had to do with grazing management and ecology.

There was essentially no grazing on the mesa lands before 1904, when the first wells were drilled. Grazing of the foothills and mountains date back to at least the mid-1800's. Spring water was available in that part of the Range.

The area was heavily stocked in the early years, but intermittent droughts would either wipe out the herds or force sales en masse. One of these reductions occurred in the drought of 1922-26. About that time concepts of proper use of available forage were being developed, and the Jornada Range was never overstocked after that time.

In 1915 E. O. Wooten pointed out that the stock-raising industry in New Mexico must adjust to the physical environment. He further reported that closely cropped range plants produce less than one-third as much forage than those allowed to make some growth before being grazed. In those days of open range, he redognized the necessity of control over land so that operators could afford to initiate range improvements.

In 1917 Jardine and Hurtt reported that the carrying capacity of the public range was at least 25 percent less than it was originally. They gave the major objective of studies at the Jornada Experimental Range as working out a system of range management and improvement practical for large grazing units, which would build up the depleted areas and insure the maintenance of the whole range in good condition. They showed that a 50 percent improvement of black grama rangeland could be obtained by: (1) reducing the stocking during the growing season to about half the average number the area will carry for the year, (2) not overstocking during the remainder of the year, and (3) better distribution of stock-watering places. Thus we see the development of the concept of deferring black grama range during the summer and grazing tobosa during the summer-early fall growing season.

In 1922 Jardine and Forsling suggested separately fencing grama grass and tobosa types of range, when the two occur together on a ranch, and using the grama in winter-spring season and the tobosa in summer and early fall.

This gives the grama an opportunity to build up its root reserves and also permits maximum use of tobosa, which is relatively unpalatable in the winter-spring period. Paulsen and Ares (1962) illustrated the benefits from this kind of management on two adjacent and once comparable black grama ranges. One area was grazed principally from October to July and the other yearlong at approximately the same intensity. After 20 years, plant composition on the range grazed October to July was 72 percent black grama, 20 percent other grasses, and 8 percent snakeweed. The other area's composition was 69 percent snakeweed, 9 percent black grama, and the remainder other grasses and weeds. For ranches not having a large enough area of tobosa to carry the livestock during the summer period, Jardine and Hurtt suggested that one-third of the ranch unit be deferred or have no more than light use for 2 years in succession. This system was to be rotated so that each third would be at least partially deferred during the growing season for 2 years of 6.

Proper distribution of stock over the large pastures prevalent in the area is another point that received early attention. Jardine and Hurtt in 1917 recognized that it was impossible to secure reasonably efficient, even utilization of rangeland where cattle had to travel over 2 1/2 miles to water. They suggested constructing temporary watering places such as tanks to supplement permanent water developments. Jardine and Forsling in 1922 reported that salt should be placed out away from water to draw cattle to areas otherwise lightly grazed or ungrazed. Ares (1953) showed that placing meal-salt mix away from water greatly reduced the area of overutilization in a pasture.

Jardine and Hurtt in 1917 also pointed out that calf crop percentages could be increased by not overstocking the range. They also showed that flexibility in herd management could be obtained by having one-third steers

during the average years. It would then be possible to reduce the number of stock, when necessitated by drought, by selling steers and thus reducing to a minimum the forced sale of breeding stock.

Jardine and Forsling in 1922 further emphasized the necessity of flexible stocking in the Southwest. A fluctuating forage crop is a fact-of-life in this area. To assume that a range unit can be stocked at a constant level based on average years is inviting catastrophic destruction of the range resource. If a range unit must be stocked at a constant level it must be at a low enough level that forage species are not extensively overgrazed during the inevitable drought periods. This, of course, would result in a waste of forage during average and above-average years. Thus, to make maximum use of the forage resource without inflicting irreparable damage, it becomes necessary to have some form of flexible stocking.

An examination of precipitation records on the Jornada Range shows it to be quite variable from year to year. During the period of 1916 through 1962, 47 years, there were 28 years with below-average July-September precipitation and only 19 years with above-average seasonal precipitation. Of the 28 years with below average precipitation, 22 were low enough to greatly reduce forage production. On the other hand, of the 19 years with above average July through September precipitation, 13 years were sufficiently above to give forage production considerably above average. Thus, in a 47-year period, 22 years had below average production, 13 years had above average production, and 12 years had about average production.

Paulsen and Ares in a bulletin published in 1962 compared seasonal precipitation and herbage production from 1939 through 1953. During this 15-year period, there were only 2 years that had above-average seasonal

precipitation; another 6 years had approximately average precipitation; and 7 years that had below average precipitation. Because of favorable rainfall distribution, 7 of the 15 years had forage production ranging from about 25 to 75 percent above average. Three years had about average forage production while 5 out of the 15 years had production ranging from 15 to 75 percent below average. This means that if a rancher had a 1000 cow outfit his stocking based on proper utilization of forage each year would have varied from 278 to 1579 cows. We don't expect the catastrophic drought conditions of the early 1950's to be repeated very frequently. So our recommendations for a flexible stocking plan are to have the herd composed of no more than 55 to 60 percent breeding animals during average years. The remainder of the herd is composed of yearlings and replacement heifers. Flexible herd management, as applied to this area, begins with an appraisal of forage production each fall after the growing season. In years of low forage production, adjustments in the size and composition of the herd are planned for the winter-spring season to bring the herd within the capacity indicated by the forage appraisal. Adjustments are made in this manner: (1) weaner calves are sold; (2) holdover yearlings are marketed; and (3) a heavier than normal culling of the cow herd is made and, when necessary, even some of the replacement heifers are sold.

In the years of above-average forage production, additional stock are added to the herd carried through the winter-spring period. All the natural increase from the breeding herd can be held over until spring and additional weaner calves can be purchased for winter pasturing. Depending upon the market and forage conditions, these yearling animals are sold in the spring or the next fall when forage production is appraised again and the herd adjusted to meet the new situation.

Paulsen and Ares (1962) studied the economics of flexible herd management by comparing two periods on the Jornada Range. During 1927-34 an average of 1,110 animal units grazed on the range, and 377 pounds of beef per animal unit were sold. Under the flexible system of management, an average of 780 animal units grazed the Range from 1940 through 1951 and produced an average of 495 pounds of beef. When the same prices are used for comparing the 2 periods, there was a slightly higher income during the 1940-51 period (Table 1). This was despite the fact that there were 330 fewer animal units per year grazing during the latter period because of drier conditions. The major difference in the sale animals was in the numbers of weaner calves and yearlings sold.

Table 1. Economics of flexible herd management (from Paulsen and Ares, 1962).

Date	Average stocking	Beef sold per animal unit	Gross return using same prices
1927-34	1,110 AU	377 lb.	$50,048.77
1940-51	780 AU	495 lb.	$50,320.53

During the first period, before flexible herd management, weaner calves made up 36.5 percent of the beef sold and yearlings 30.8 percent. During the latter period, weaner calves made up only 10.0 percent while yearlings made up 56.4 percent of the beef sold.

Flexible herd management has resulted in these added advantages: (1) more uniform annual sales, (2) a higher percentage calf crop, and (3) lower losses.

The key in implementing a program of flexible herd management is keeping records - records of stocking by pastures, records of precipitation, records of forage conditions in the fall, and records of degree of grazing use actually obtained on the pasture before the next growing season begins.

Collection of such data for several years builds up records that may be used for appraisal purposes and for developing future plans. Longtime records let the manager know how the forage plants respond to fluctuating weather conditions and how management can be adjusted to fit the environment prevailing in the arid Southwest.

Nelson (1934) reported on a 13-year study of the influence of precipitation and grazing on black grama range. He pointed out that black grama survived and recovered from the droughts of 1916-18 and 1921-26. One favorable growing season was necessary to restore the vigor of drought-weakened plants before improvement in stand began. Black grama was found to compete successfully with associated species after depletion of stand by drought and to withstand conservative utilization by livestock. Heavy grazing resulted in deterioration of the stand. Considering the severe drought of the 50's, it is interesting to note that the drought of 1921 resulted in an 89 percent reduction in stand of black grama, even on ungrazed areas.

Paulsen and Ares, 1962, point out that precipitation records for the area show no general long-time upward or downward trend and at approximately 20-year intervals, rainfall was alternately about 10 percent above and 10 percent below average. They found that black grama density was reduced to about the same point during extended droughts irrespective of grazing use. Density during years of more abundant rainfall is greater on areas conservatively grazed than on areas heavily grazed or ungrazed. Paulsen and Ares report also that forage grasses are unable to persist under the severe climatic regime when handicapped by shrub competition.

To be able to make full use of the abundant tobosa was early recognized as a problem. Ares, 1939, suggested making hay when it was more nutritious

and palatable. Paulsen (1953) reported that more use could be made of tobosa in the winter by spraying with molasses.

The early workers also realized that the predominant grass species could not consistently be grazed down to ground level and survive. To obtain data on proper use of black grama and tobosa, a clipping study was initiated in 1925 and continued through 1936. In 1939 Canfield published results of this study. Clipping black grama at a height of 2 inches or less prevented reproduction, reduced the yield by half in 3 or 4 years, and destroyed the stand in 10 years. Clipping tobosa at a height of 2 inches did not destroy the stand, but reduced yields to 9 percent of the production on plots clipped at the 4-inch height.

Campbell and Crafts in 1939 stated that the grazed stubble should be cropped not closer than 2 to 3 inches above the surface of the ground by the end of the grazing season in June whether grazing is yearlong or only during the winter-spring season. In addition, one-fifth of the flower stalks and most of the runners should be ungrazed.

The early workers also recognized the importance of improving the grade of stock. Jardine and Forsling (1922) suggested using purebred bulls, culling the poorer grade cows, and replacing them with the best grade heifers obtained from the use of the good bulls. They also pointed out the advantages of keeping the breeding animals in good condition and having good distribution of the bulls throughout the herd.

There have been a number of publications on the basic ecology of the area, on the taxonomy of the plants, on early attempts at reseeding, and on controlling poisonous plants and snakeweed.

Besides the published work there is a large volume of material that has not been published. A study was initiated in 1938 to evaluate the effects of clearing, rabbit-proofing, seeding, and furrowing on a creosotebush type. When resurveyed in 1956, clearing in conjunction with rabbit-proofing resulted in the greatest grass density. Seeding and furrowing had nothing to do with the results obtained.

Perhaps the foregoing seems like a lengthy presentation, but I believe it is worthwhile to point out that some of the concepts of proper grazing management were developed over 40 years ago.

Present Work

In the present work, an attempt is made to achieve a balance between basic and applied research. Sometimes it is difficult to pin-point the objectives of basic research but it leads to the major break-throughs. Our rocket program would still be on the ground if it hadn't been for basic research in fuels, metals, and many other items that have made it possible to circle the earth 22 times in the same length of time it took Lindberg to fly from New York to Paris just 36 years ago. Another example closer to home is the screw-worm program. Basic research led to the discovery that the female fly mated only once in a lifetime. Other basic work showed that a certain dosage of radio-active material sterilized the male fly without reducing its vigor. When this information was put together we have the highly satisfactory screw-worm eradication program.

Perhaps those are more sensational developments than we have had in range management but we also have had some important findings. Some of the research relating precipitation to production will help in developing better grazing management in some areas. Other research relating plant growth, terminal

bud development, precipitation, and root reserves will assist in developing better systems of grazing. There are others that time will not permit us to mention.

The ultimate objective of the research program on the Jornada Range is to develop methods of obtaining maximum livestock production consistent with maintaining the resource or improving the range land where necessary.

One of the more basic studies has to do with environmental effects on native vegetation. In one phase of the study we are taking detailed estimates of the microclimate on various range sites. By microclimate, I mean the climate where the plant is growing. The data collected include precipitation and soil moisture at various depths, evaporation at the plant level, air and soil temperatures, relative humidity, and wind movement. This study, initiated in 1957, has already given some interesting information.

If we have much precipitation on the sandy soils in October or November we can expect some growth on some of the perennial grasses and weeds in March and April even though the winter-spring period is entirely lacking in effective precipitation. On our creosotebush sites it takes 2 rains within 3 or 4 days of each other to have much penetration. The first rain moistens the surface soil and makes it receptive to the next rain. Another interesting finding is that on all the sites the initial period of rainfall in the growing season, usually early in July, contributes little to available soil moisture. On the burrograss sites, water infiltration is quite slow and we rarely get penetration beyond the 10-inch depth.

Since 1957 we have been taking about 1,200 estimates of cover each year on the grassland type. The data are stratified according to soil type. Yields are also taken on selected sites. The yield and cover data are related to the environment.

Vegetation, weather, and cattle-stocking records date back to 1915. The vegetation is charted annually on about 200 quadrats, most of which were set up around 1915. Since about 1939 a forage inventory has been taken each fall. The major perennial grasses on 4-inch by 50-foot belt transects are clipped and weighed. The stocking rate from November through the next June is based on these yield estimates. A utilization survey the next June shows the degree of utilization obtained by that stocking rate and thereby establishes the current carrying capacity.

The vegetation data collected in the forage inventory are also being used to study the effects of the great drought of 1951 through mid-1957. Records would indicate that this drought was the most severe in this area since the drought of 1275 to 1300. The loss of major perennial grasses was much more severe on deep sandy soils than on shallow sandy soils (see Table 2 and Figure 1). Yields of tobosa were greatly reduced during the drought but the stand was little affected.

Table 2. Drought effects on black grama.

	COVER		YIELD	
	1941-51	1952-57	1941-50	1951-57
Deep Sands	0.86%	0.11%	359 lb.	64 lb.
Shallow Sands	1.10%	0.56%	549 lb.	203 lb.

We have recently come upon some interesting information regarding our original vegetation. When the General Land Office surveyors laid off the township and section lines, they made general comments on the nature of the vegetation. This was done in 1858 on the Jornada Range. With but few exceptions there was little mention of shrubs on our mesa lands. The foothill areas also had excellent stands of grass but there was considerable mention of creosotebush, mesquite, and other shrubs. An interesting point mentioned

by the surveyors was that the foothill areas of the San Andres Mountains were grazed by herds and flocks owned by the farmers in the Rio Grande Valley. They would drive their livestock to these foothill areas in the spring and leave them until fall because their farms were unfenced.

Brush has rapidly invaded on most areas of the Jornada. Creosotebush has taken over most of the gravelly foothill areas. Tarbush has taken over some of the heavier soils. Mesquite has rapidly invaded the sandy land areas. For the past 30 years we have been losing 1 percent of our total area, or 1000 acres, to mesquite dunes each year. It becomes rather obvious that if something isn't done, the entire sandy land area soon would be converted to sand dunes. The capacity of our grassland areas is about 8 to 10 head per section yearlong while on sand dune areas it is 1 or 2 head per section yearlong. Once mesquite plants become established in an area, the grass can't compete for soil moisture, and eventually the area is completely invaded by mesquite. Rabbits and rodents are a complicating factor. They make their homes in brush-infested areas and work out into adjacent grasslands, thus accelerating the takeover by brush.

We are using four methods of controlling mesquite: handgrubbing, use of fenuron pellets, and ground and aerial spraying. Handgrubbing sparse stands of small mesquite is by far the most economical method of control (Herbel et al, 1958). The root must be completely severed below the budding zone, about 4 to 6 inches below the surface of the ground. Good supervision of labor is important to avoid missing plants and keep down costs.

Both 25% fenuron pellets and 80% monuron powder have been found effective in controlling mesquite. Because of the present cost of these materials, use

is limited to relatively sparse stands. High plant kills have been obtained with 1 gram active ingredient per foot canopy diameter (see Table 3).

Table 3. Results of treating mesquites with 25% fenuron pellets or 80% monuron powder.

	PLANT KILL			
1958 Fenuron	1959 Fenuron	1960 Fenuron	1960 Monuron
83.8%	80.3%	94.4%	94.7%

These materials must be applied just before or in the early part of an expected rainy season, about June 15 to August 15 in our area.

With any of the spray programs, the mesquite plants must be fully leafed and growing vigorously. This generally occurs when winter-spring precipitation is at least average. There should be some available soil moisture at the time of spraying. The proper time of the year for spraying is when the plants come into full leaf until seed pods are elongated but not filled, about May 20 to June 20 in our area.

We have been evaluating two types of ground equipment. High kills can be obtained in the good spray years when individual plants are sprayed to the point of drip with a mix containing 1¼ lbs. of 2,4,5-T in 100 gallons of water. (The equipment has been described by Herbel and Ares, 1961.) Labor costs make this method rather expensive. A broadcast ground sprayer with a 50-foot boom was developed and costs were reduced to less than 50 percent of the costs of the 2-gun sprayer. Final results from broadcast spraying have not been obtained.

Experiments on aerial spraying of mesquite are designed to study total volumes, rates of herbicide and diesel oil, period of lapsed time required for resprays, and new herbicides. Fair results can be obtained in the good spray years with 1/2 lb. 2,4,5-T in a 1:7 diesel oil to water emulsion in a total volume of 5 gallons per acre with 0.2 percent emulsifier added.

Both fenuron pellets and monuron powder have been found effective in basal applications on individual creosotebush and tarbush plants. On creosotebush the rate of application should be 1 gram of active ingredient for each 1½ feet canopy diameter. On tarbush 1 - 2 grams have given a high rate of plant kill. Here again, cost of material would limit this method to sparse stands.

In 1961 we started a spray program on creosotebush and tarbush. Plots are sprayed at frequent intervals during the growing season with various herbicides. Very preliminary results on creosotebush indicate that it will take a minimum of 1 pound per acre of 2,4-D, 2,4-DP, or 2,4,5-T during September. On tarbush, very preliminary results indicate that 1/2 to 1 pound per acre of 2,4-D from mid-August to mid-September may be effective.

Rootplowing, disking, and bulldozing have been found to control brush effectively. However, costs seem excessive unless at the same time an excellent stand of grass can be obtained. We have studied other methods of seeding such as drilling, press-wheel, furrows, and in conjunction with pitting. Many seedlings are lost because of high temperatures in the surface soil as well as poor moisture conditions. For example, on a rootplowed area daytime soil temperatures at the 1/2-inch depth under a brush cover averaged 92 degrees in a summer period while in an open area it averaged 119 degrees. During an 80-day period during the summer there was available soil moisture at the 1/2-inch depth for 29 days under brush and only 9 days in an open area. This kind of information leads us to believe that seedings will be more successful when seedlings are protected in some manner. We also feel that seedings should be made after the first summer rains to take advantage of more moderate temperatures and better soil moisture. Weed competition is a problem at times. On heavier soils crusting can be a problem. In fact, there are a lot more problems than answers at this time.

We also maintain a small nursery to determine adaptability of various introductions. Of all the accessions studied to date, El Kan bluestem seems the best adapted.

We have a study in cooperation with the Animal Nutritionists at New Mexico State University entitled, "Grazing habits, relationship between blood composition and nutrient intake, and yields of Hereford and Santa Gertrudis cattle." Utilization checks on perennial grasses are made at approximately 6-week intervals to determine grazing distribution patterns of the two breeds. Monthly observations of all the cow's activities and species preference are recorded for each breed for a 24-hour period. Preliminary results indicate that the cattle prefer perennial grasses the entire year except during the spring when forbs and shrub-like plants are used. The Santa Gertrudis have spent slightly more of their grazing time at a greater distance from water than the Herefords. The Santa Gertrudis have spent a little less time than the Herefords grazing and rubbing and a little more time walking, watering, and salting.

Blood samples are taken each 56 days and related to forage samples collected at the time the cattle are observed. Feces and rumen samples are collected every 28 days in an attempt to determine intake and also are related to chemical constituents of the blood and forage.

The cows are weighed every 28 days throughout the year. Cows weights are generally at their lowest points during May and June. Accurate records are kept of calving dates and weaning weights. Milk production estimates are also obtained every 28 days. The Santa Gertrudis have produced somewhat heavier calves which is apparently due to higher milk production in late summer. It should be kept in mind that this information applies specifically

to these two herds, which are grade animals. We do not propose to make any recommendations from these limited data.

We have recently completed a 5-year study on fertilizing tobosa flood plains (Herbel, 1963). Even though tobosa yields were greatly increased in some years with nitrogen fertilization, it would be uneconomical on most ranches except those having a limited amount of tobosa (see Table 4).

Table 4. Tobosa response to fertilizer (from Herbel, 1963).

	1957	1958	1959	1960	1961
Growing season precipitation (in.)	4.60	6.20	7.83	3.55	7.03
Check					
Yields (lb.)	2207	2071	2791	1489	4381
Protein (%)	4.4	4.2	4.8	4.0	4.8
60# N + 13.1# P					
Yields (lb.)	3511	3308	6363	2175	4105
Protein (%)	6.1	5.0	6.0	4.4	7.6
Cost of additional herbage ($/T.)	17.91	14.47	6.16	--	--

Any fertilizing should be done on areas likely to be flooded. The protein content of the herbage is also increased somewhat by fertilizing.

Future Needs

Even though a lot of work has been done in the past and we have an active research program at the present, many problems are still facing the ranchers of this area. We badly need basic studies on the relations of growth initiation, vegetative production, and root development of the major forage species to weather conditions. We need information on response of plants to grazing at various stages of growth. This type of information could lead to developing a better system of grazing management.

We need to develop methods of obtaining increased utilization of tobosa.

We need studies on the effects of supplemental feeding on the cow herd, particularly from April 15 to June 15.

We still have a long way to go in finding satisfactory and economical methods of brush control. We need more emphasis on the development of herbicides for our noxious brush species. We need more detailed studies on the herbicides we have available to determine whether additives or better methods would give better results.

In many instances just controlling the brush solves nothing because there is no residual grass stand. Thus we need to develop a reseeding program. We need studies on seed germination, methods of seeding, controlling weeds and rodents where necessary, and many others. We also need information on how to handle livestock on reseeded ranges so as to obtain maximum production and yet maintain the stand.

We could go on and on discussing research needs. I am sure that all of you realize that the three villians of high range production - overstocking, drought, and brush invasion - are still rampant and creating more and new problems each year. We can't prevent drought but we can manage our ranges to minimize its effects. We can and must prevent overstocking and brush invasion to maintain our ranges in a state of maximum production. We have some guns in our arsenal but we need more to meet the increasingly complex problems.

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