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RANGES AND PASTURES OF THE SOUTHERN GREAT PLAINS AND THE SOUTHWEST

THE southern Great Plains and the Southwest often are called "Big Country." This not only refers to the size of individual holdings but the sparseness of urban centers. (See Fig. 46.1.) Annual precipitation averages less than 250 mm in the lower elevations of Arizona, New Mexico, and western Texas. It ranges up to 750 mm in the eastern portions of the southern Great Plains. The precipitation not only varies greatly within and among seasons and years but also among locations separated by only a few kilometers. About 70% of the average annual precipitation occurs during the spring-summer period in the Great Plains. In western New Mexico and southern Arizona the growing season precipitation occurs during the summer, and the spring period normally is very dry. (See Fig. 46.2.) The entire region is frequently plagued by drought. During a prolonged drought, the Great Plains may take on a desertlike appearance. The region may also have high winds during some periods; coupled with a reduction in vegetation and

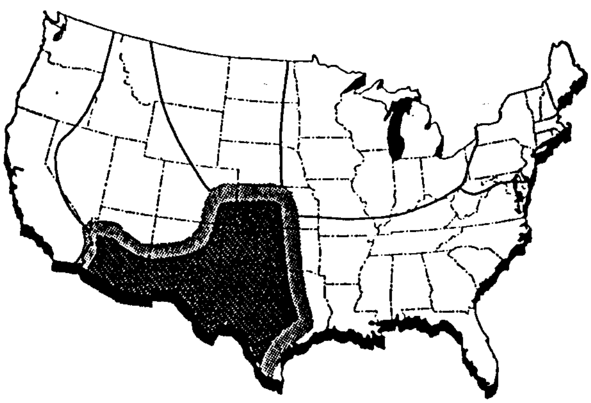

FIG. 46.1. The southern Great Plains and the Southwest.

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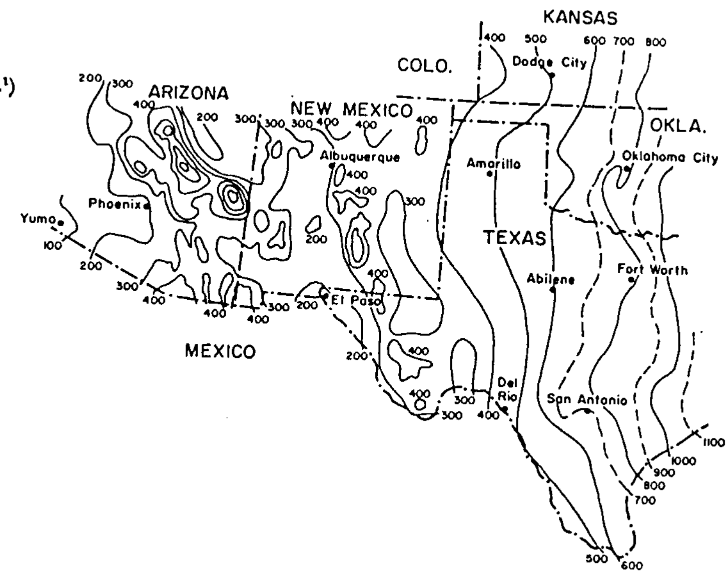

FIG. 46.2. Average annual precipitation in mm. (USDC, 1968.[1])

cover due to drought, this results in considerable wind erosion. The average annual evaporation ranges from 2160 mm at Oklahoma City to 3050 mm at Yuma, Ariz.[1] The frost-free period averages about 180 days in the northeastern part of the region to 340 days in the Yuma area.

Elevations in the southern Great Plains vary from 200 m in southern Texas to 1200 m in northeastern New Mexico. The parts of Arizona and western New Mexico considered in this chapter are desert or desert-like basins interrupted by mountains. The entire region is dissected with rivers and their accompanying floodplains. The soils are highly variable.

Because of the erratic weather conditions dryland farming is high risk in all but the eastern portions of the region. However, because of the favorable temperatures irrigated farming is highly productive where water of good quality is available. A high percentage of the land in the region is used for ranching, a much less intensified operation. Practices common on farmland may not be feasible on rangeland.

1. USDC. 1968. Climate atlas of the United States. Environ. Sci. Serv. Admin.

☙ RANGELANDS

The land used for ranching varies from 50% of the area in the eastern part of the region to more than 95% of the area in Arizona, New Mexico, and the trans-Pecos of Texas. In the latter, farming generally is limited because of low precipitation. Much of the Edwards Plateau in Texas is used for ranching because of shallow and rocky soils and a rolling terrain. Productivity of the rangelands has been greatly reduced by overgrazing, droughts, and an increase in noxious plants. The Edwards Plateau ranches and adjacent areas are stocked with sheep, goats, and cattle. The remaining rangelands of the region are stocked largely with cattle. See Table 46.1.)[2-4]

Much of the rangeland of the region has been invaded by noxious woody plants. An increase of brush is responsible for the loss of grazing lands that formerly made a sig-

2. USDA. 1972. Cattle, sheep, and goat inventory. Crop Rep. Board, Stat. Rep. Serv. LvGn 1 (72).
3. Wooten, H. H., K. Gertel, and W. C. Pendleton. 1962. Major uses of land and water in the United States. USDA Agr. Econ. Rept. 13.
4. USDA. 1972. Crop production, 1971 annual summary. Crop Rep. Board, Stat. Rep. Serv. CrPr 2-1 (72).

TABLE 46.1 ❧ Livestock numbers and selected crops in states of the southern Great Plains and the Southwest

Livestock (000 head) Crops (000 ha)	Arizona	New Mexico	Texas	Oklahoma	Kansas	Colorado
Cattle[2]	1,295	1,441	12,829	5,441	6,757	3,716
Sheep[2]	503	742	3,524	123	337	1,114
Goats[2]	*	*	1,500	*	*	*
Range[3]	23,522	26,488	47,355	9,205	7,675	17,324
Pasture†[3]	83	174	3,319	1,047	585	500
Hay[4]	97	117	898	750	1,002	683
Silage[4]	7	14	78	29	263	116
Fodder[4]	2	28	547	150	179	109
Cereal grains[4]	194	244	3,504	2,003	6,160	1,543

* Small numbers, not estimated.
† Cropland used only for pastures.

nificant contribution to the maintenance of domestic livestock. Stands of brush increase the cost of handling livestock, reduce livestock production, increase parasite damage, and require the use of more breeding males. Mesquite, *Prosopis juliflora* (Swartz) DC., competes with range forage for moisture on about 38 million ha in Arizona, New Mexico, Texas, and southwestern Oklahoma.[5] Shinnery oak, *Quercus havardii* Rydb., occurs on deep sandy soils of western Oklahoma, northern Texas, and eastern New Mexico. Sand sagebrush, *Artemisia filifolia* Torr., is a problem on sandy soils of western Oklahoma and northern Texas. Juniper, *Juniperus* spp., dominates large areas in the Edwards Plateau and rolling plains of Texas[6] and at elevations above the semidesert grasslands and below the ponderosa pine zone in Arizona and New Mexico. Small soapweed, *Yucca glauca* Nutt., is a problem in eastern New Mexico and northern Texas. Tarbush, *Flourensia cernua* DC., occurs on 5.36 million ha in western Texas, southern New Mexico, and southwestern Arizona. Creosotebush, *Larrea tridentata* (DC.) Coville, is a serious problem in Arizona, New Mexico, and western Texas. These are only some of the woody plants of concern to ranchers in the region. Snakeweed, *Gutierrezia sarothrae* (Pursh) Britt. & Rusby, and burroweed, *Aplopappus tenuisectus* (Greene) Blake, plus poisonous plants such as loco, *Astragalus* spp.; cocklebur, *Xanthium spinosum* L.; and milkweed, *Asclepias* spp., are also a problem. In many instances, as undesirable woody plants increase, there is a corresponding decline in the protective forage grasses and an increase in wind and water erosion. In this region part of the dust during windstorms and the sedimentation in streams and reservoirs comes from rangelands infested with brush. Certain brush species provide browse for wildlife, but heavy stands of those mentioned above have a depressing effect on wildlife, they reduce the recreational value of the land, and in some cases they constitute a serious fire hazard.

Damage of rangeland by rodents and rabbits is often underestimated. On deteriorated mesquite sand dune sites in southern New Mexico there were 81 kg/sq km of rodent biomass.[7] This, plus rabbit populations that may range up to 250/sq km, exerts as much pressure on desirable vegetation as 1 animal unit/sq km. Rodents and rabbits consume vegetation, destroy roots and aboveground plant parts, and collect seed that would otherwise aid in natural revegetation. Even in good grassland areas the banner-tailed kangaroo rats, *Dipodo-*

5. Platt, K. B. 1959. Plant control—Some possibilities and limitations. I. The challenge to management. *J. Range Manage.* 12:64–68.
6. Gould, F. W. 1962. Texas plants—A check list and ecological summary. Tex. Agr. Exp. Sta. MP-585.

7. Wood, J. E. 1969. Rodent populations and their impact on desert rangelands. N. Mex. Agr. Exp. Sta. Bull. 555.

mys spectabilis Merriam, kept 10% of the area from vegetative production by denuding the ground in the vicinity of their mounds.[7] Rangelands in good condition generally have fewer rodents and rabbits than those in poor condition.

Vast range areas in the region are sometimes heavily infested with grasshoppers. Even in a light infestation on a range, with an average of 6 grasshoppers/sq m, those on 4 ha consume grass at about the same rate as a cow.[8] During periods of heavy infestation when there may be 30–60/sq m, all the grass may be destroyed. Like rabbits and rodents, grasshoppers do damage beyond that caused by actual feeding. They cut plant parts and eat only part of them; prevent natural revegetation; eat the grass closer than livestock; and when extremely abundant, sometimes injure the crowns so that growth is reduced for several years. Other insects sometimes causing damage are the New Mexico range caterpillar, *Hemileuca oliviae* Cockerell; armyworms, *Pseudaletia, Laphygma* and *Prodenia* spp.; harvester ants, *Pogonomyrmex* spp.; and thrips, *Frankliniella* and *Thrips* spp.[9]

Control of Noxious Plants

Trends toward dominance by noxious plants can be halted or reduced by judicious use of mechanical and chemical control methods, revegetation of forage species, and control of the numbers of grazing animals and their seasons of use. Sound management principles are essential to the use of any control method on rangeland infested with brush. Once established, woody plants such as mesquite, juniper, oak, and sagebrush cannot be eliminated by good grazing practices alone. On rangelands dominated by brush, control measures are essential before achieving benefits from other improvement practices such as a grazing system, seeding, or water spreading.

The most effective control measure may vary for each particular site, specific vegetation, and degree of infestation. Brush control generally is less costly when invasion is just beginning and the brush plants are small and scattered. In this situation a method should be employed that will not destroy the residual forage plants. On sandy soils heavily infested with brush a broadcast chemical method may provide control of the undesirable plants and result in an increase in forage plants. On medium- to heavy-textured soils with a heavy infestation of brush and a poor stand of desirable plants, a mechanical method accompanied with seeding may be required. Broadcast mechanical methods generally are avoided on sandy soils because of the wind erosion hazard. Fortunately, natural revegetation often is quite rapid on sandy soils following chemical control of the brush. Conversely, natural revegetation following brush control often is very slow on medium- to heavy-textured soils.

CHEMICAL CONTROL. It is often difficult to chemically control stands of mixed brush species with a single application because of different herbicide requirements for various species or a different time of peak readiness among various species. To be effective, foliage applications of herbicides must be applied at the proper stage of growth. Treating mesquite even one week too early drastically reduces the effectiveness of 2,4,5-T treatments.[10] Plants generally are most sensitive to foliage sprays of growth-regulator herbicides when they are actively growing. In dry years herbicide treatments should not be made since plants under moisture stress do not readily translocate phenoxy herbicides.

To achieve adequate initial control of many woody plants, two or more herbicidal applications are necessary. Two aerial spray applications of 0.56 kg of 2,4,5-T/ha from one to three years apart killed 23–64% of the mesquite on sand dunes in southern

8. Parker, J. R. 1954. Grasshoppers, a new look at an ancient enemy. USDA Farmers' Bull. 2064.
9. Randolph, N. M., and C. F. Garner. 1961. Insects attacking forage crops. Tex. Agr. Ext. Serv. Bull. B-975.
10. Valentine, K. A., and J. J. Norris. 1960. Mesquite control with 2,4,5-T by ground spray application. N. Mex. Agr. Exp. Sta. Bull. 451.

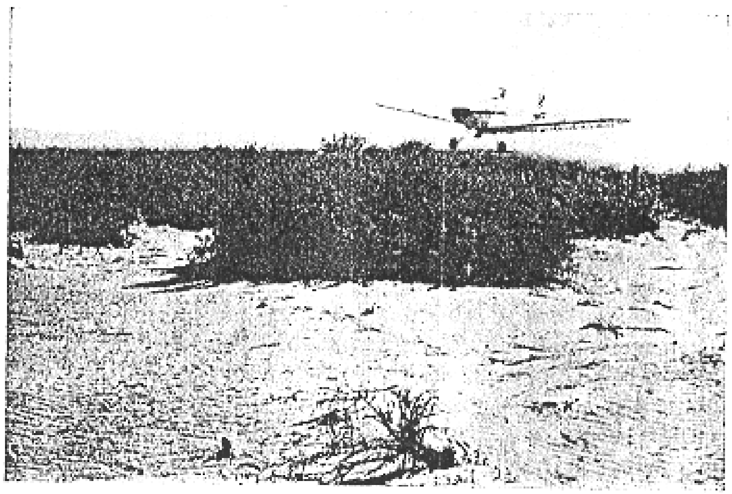

FIG. 46.3. *Leveling of sand dunes . . . less wind erosion on sprayed areas.* Aerial spraying of mesquite sand dunes in southern New Mexico. Controlling the mesquite increases forage production.

New Mexico.[11] Perennial grass yields on areas sprayed twice in 1958–61 averaged 234 kg/ha during 1963–68. On an adjacent unsprayed area the perennial grass production averaged 39 kg/ha. There have been a leveling of the sand dunes and less wind erosion on the sprayed areas. (See Fig. 46.3.)

Herbicides such as 2,4-D, 2,4,5-T, silvex, dicamba, and picloram control many species. Applied as broadcast sprays, they may be used on dense stands of weeds or brush. Individual plant treatments of dry herbicides are an effective and economical method of controlling sparse stands of brush. Monuron, fenuron, picloram, and other herbicides are applied as powder, granules, or pellets around the bases of target plants.[12]

MECHANICAL METHODS. Bulldozing and mechanical grubbing, rootplowing, disking, and cabling or chaining are the major mechanical methods of rangeland brush control.

Bulldozing is effective on sparse stands of many species. Bulldozer blades or front-end loaders may be fitted with a stinger blade which is pushed under the crown of the plant to ensure uprooting of the bud zone. Experienced operators can lift and push over a tree in one smooth operation.[12]

A rootplow is a horizontal blade attached to a track-type tractor. Rootplowing cuts off the brush, generally at depths of 38 cm for mesquite or other resprouting species and at lesser depths for nonsprouting species. Rootplowing kills 90% or more of all of the vegetation growing on the area. The method is best adapted to dense brush areas having little or no residual grass and where seeding of desirable grasses is possible.[13]

Disking is done with a large disk plow or tandem disk which uproots the brush. It is limited to small shallow-rooted plants like sagebrush, creosotebush, and tarbush. It also destroys grasses growing on the area. Thus disking, like rootplowing, should only be done in areas where forages can be established.[12]

Chaining and cabling involve the dragging of a 90–120 m anchor chain or heavy-duty cable in a loop behind two track-type tractors.[14] The method is effective in controlling nonsprouting species like one-seeded juniper, *Juniperus monosperma* (Engelm.) Sarg., and Utah juniper, *J. os-*

11. Herbel, C. H., and W. L. Gould. 1970. Control of mesquite, creosotebush, and tarbush on arid rangelands of the southwestern United States. Proc. 11th Int. Grassl. Congr., pp. 38–41 (Surfers Paradise, Queensland, Aust.).
12. National Research Council Subcommittee on Weeds. 1968. Weed Control. Nat. Acad. Sci. Publ. 1597.
13. Rechenthin, C. A., H. M. Bell, R. J. Pederson, and D. B. Polk. 1964. Grassland restoration. II. Brush control. SCS, Temple, Tex.
14. Fisher, C. E., C. H. Meadors, R. Behrens, E. D. Robison, P. T. Marion, and H. L. Morton. 1959. Control of mesquite on grazing lands. Tex. Agr. Exp. Sta. Bull. 935.

teosperma (Torr.) Little. It also is useful in knocking down mesquite trees previously killed by aerial spraying, thereby reducing the cost of working livestock.

BURNING. Results of burning vary greatly and depend on the susceptibility of a species to fire and the availability of enough fuel. Several range shrubs and weeds are ideally controlled by burning at the proper season if moisture conditions are good and precautions are observed. An example of using fire in range management is the burning of vegetation infested with shinnery oak. Its growth is suppressed for several years and forage production is substantially increased. Summer burning is effective in controlling burroweed in southern Arizona.[15] Burning also is useful in removing old stemmy forage growth from species such as sand bluestem and tobosa.

GRAZING METHODS. Sheep and goats are utilized to control some plants. The animals select the more palatable plants or plant parts and are effective in controlling seedlings and young sprouts. However, continuous heavy utilization of the desirable forage species must be avoided.

SEEDING

In this region the soil surface is infrequently moistened and the evaporation rate is high. Establishing seedlings often is difficult because of an adverse microenvironment (rapid drying, unfavorable temperatures, and crusting of the soil surface). The primary objective in seedling establishment is to place the seed in a favorable environment for germination. Establishment methods vary with site conditions.

Under rangeland conditions most grasses should be seeded 0.7–2 cm deep. In the southern Great Plains sufficient moisture for seedling emergence and establishment cannot be maintained on level bare surface soil except with very favorable weather.[16] The average annual precipitation in that area ranges from 350 to 600 mm. Establishment is a greater problem in the more arid areas of the Southwest. The use of mulches and land-forming procedures increases the chance of successful seedling establishment under difficult environments.

STUBBLE MULCHES. In forage establishment, plant residue improves soil moisture and protects the soil surface against wind and water erosion.[17] Stubble mulching is being used for seeding grasses in the Great Plains.[18] It consists of planting a residue-producing crop like sorghum a year before the grass is seeded. Sorghum is seeded in mid to late summer to prevent seed formation before frost but in time to make 15–20 cm growth. Grasses are seeded the following spring. Residue from the sorghum improves the microenvironment for the grass seedlings.

RIPPING, PITTING, AND FURROWING. Pitting followed by cultipacker seeding has been the most consistent method of successfully seeding ranges in Arizona.[19] Ripping and contour furrowing have also been good methods of seedbed preparation on fine-textured bottomland soils. Broad shallow pits generally last longer than conventional pits made with a pitter disk. The four-year average annual production of seeded buffelgrass was 773 kg/ha on an area with broad pits and 283 kg/ha on an area with conventional pits.[20]

PLOWING AND SEEDING. Broadcast-seeding native grasses at the time of rootplowing for control of mesquite failed to

15. Tschirley, F. H., and S. C. Martin. 1961. Burroweed on southern Arizona rangelands. Ariz. Agr. Exp. Sta. Tech. Bull. 146.

16. Army, T. J., and E. B. Hudspeth, Jr. 1960. Alteration of the microclimate of the seed zone. *Agron. J.* 52:17–22.

17. Duley, F. L. 1953. Relationship between surface cover and water penetration, runoff, and soil losses. Proc. 6th Int. Grassl. Congr., 2:942–46 (State College, Pa.).

18. Anderson, K. L. 1959. Establishing and reseeding grassland in the Great Plains and western Corn Belt. Proc. Amer. Grassl. Council, pp. 30–36.

19. Anderson, D., L. P. Hamilton, H. G. Reynolds, and R. R. Humphrey. 1957. Reseeding desert grassland ranges in southern Arizona. Ariz. Agr. Exp. Sta. Bull. 249.

20. Slayback, R. D., and D. R. Cable. 1970. Larger pits aid reseeding of semidesert rangeland. *J. Range Manage.* 23:333–35.

provide satisfactory stands at several locations in the high plains of Texas.[21] Loss of seedlings after emergence was attributed to rapid depletion of soil moisture from the loose seedbed after rootplowing and to severe weed competition. Broadcasting is generally a poor method of seeding.

Equipment has been developed for successfully seeding areas infested with brush in the arid Southwest.[22] The brush and other competing vegetation are controlled with a rootplow. The seed are placed in a V-shaped press-wheel groove. Drag chains cover the seed with loose soil to a depth of about 1.3 cm. A conveyor picks up the brush behind the rootplow and deposits it behind the seeder, and a hydraulically operated bulldozer blade in front of the seeder forms basin pits. Thus in a simultaneous operation the competing vegetation is killed; the seed is placed in a firm seedbed; the dead brush is used to partially shade the seeded area, thereby substantially reducing summer soil temperatures; and water is concentrated near the seed.

SPECIES TO SEED. Species for range seedings vary with climatic and site conditions and management of a specific range unit. A species may only be adapted to sandy soils in a fairly small area; other species may have wider adaptation. Considerable use is made of seed harvests of native species. It is important to choose native cultivars or ecotypes of local origin, generally within 300 km north and 450 km south of the area to be seeded. Many native and introduced species are used for seeding in the region.

Big bluestem, little bluestem, switchgrass, and indiangrass are important native species in the eastern part of the southern Great Plains; sand bluestem is adapted to sandy soils. Blue grama and sideoats grama are widely adapted throughout the region except for the most arid portions of the Southwest. Black grama, Lehmann lovegrass, and Boer lovegrass are some of the major species used in the more arid portions of the Southwest. Blue panicgrass and buffelgrass commonly are used for seeding in Texas. Weeping lovegrass has been seeded in Oklahoma, northern Texas, and the foothills of Arizona.

Seeding rates generally are 100 pure live seed/m of seeded row. Most of the native grass seed is harvested from native stands on rangeland. There is some seed production, particularly of introduced species, under irrigated conditions. Many grass plantings have been ruined by grazing before the seedlings were well established since newly seeded plants must not be grazed until they are well rooted. Severe infestations of rodents, rabbits, and insects are sometimes responsible for seeding failures.

RANGE FERTILIZATION

In some parts of the region low amounts of N in the soil limit plant growth. Fertilizer N is economical only where there is adequate moisture and plant species that give N response.

In Oklahoma, forage yields of weeping lovegrass increased about 50% with 34 kg N/ha.[23] A single application in April increased yearling steer gains 10%; carrying capacity, 25%; beef production per ha, 31%; and profit per ha, 36%. Weeping lovegrass fertilized with N was more palatable, stayed green longer at the beginning of droughts, regrew faster after grazing, and produced more seed. Nitrogen available for plant growth on grazed pastures after a few years of fertilization may amount to 50% of the annual requirement due to recycling through the grazing animal.[24]

In a 380-mm precipitation area in New Mexico, blue grama range fertilized with 45

21. Jaynes, C. C., E. D. Robison, and W. G. McCully. 1968. Root-plowing and revegetation on the rolling and southern high plains. Tex. Agr. Exp. Sta. Rept. 2585.
22. Herbel, C. H. 1972. Environmental modification for seedling establishment. *In* Biology and Utilization of Grasses. Academic Press, New York.
23. McIlvain, E. H., and M. C. Shoop. 1970. Fertilizing weeping lovegrass in western Oklahoma. Proc. 1st Weeping Lovegrass Symp., pp. 61–70 (Noble Foundation, Ardmore, Okla.).
24. Davidson, R. L. 1964. Theoretical aspects of nitrogen economy in grazing experiments. *J. Brit. Grassl. Soc.* 19:273–80.

kg N/ha produced gains of 54 kg/ha, while unfertilized range produced gains of only 26 kg/ha.[25] The increase was due mainly to the greater number of cattle that could be grazed on the fertilized range. Even in more arid areas, some possibilities exist of increasing production on sites that are flooded occasionally.[26]

GRAZING MANAGEMENT

Manipulation of the season of use and intensity of grazing is an important way of increasing range productivity. A decline in grazing capacity has occurred due to overgrazing during droughty periods and a rapid increase in noxious shrubs.

On the Edwards Plateau near Sonora, Tex., average annual net returns for 1959–65 were $1.78, $2.91, and $1.63/ha with light, moderate, and heavy yearlong continuous stocking. The average net return for the same period with a rotation scheme was $4.15/ha.[27] In a four-pasture rotation system each pasture is grazed 12 months then rested 4 months. Thus during a four-year cycle each pasture is deferred once during each of the four-month periods.[28]

Further west on the Edwards Plateau near Barnhart, average annual net returns for 1959–65 were $3.06, $3.90, and $4.17/ha for yearlong continuous use, four-pasture rotation, and two-pasture rotation, all stocked at a moderate rate.[29] At Barnhart a combination of cattle and sheep was more profitable than grazing either alone. At Sonora, combination grazing with cattle, sheep, and goats or cattle and goats was more profitable than using sheep alone or cattle alone. Combination grazing is successful because of differential use of species and plant parts.

In the southern rolling plains near Throckmorton, Tex., calf production per animal unit averaged 200, 208, and 221 kg/year for moderate continuous use, two-pasture rotation, and four-pasture rotation for 1960–68.[30]

In studies at Woodward, Okla., continuous yearlong grazing has been equal or superior to several rotation schemes.[31] Major reasons for the success of continuous yearlong grazing in the southern Great Plains are:

1. Forage production is primarily dependent upon summer rainfall, and monthly forage production during the summer can vary from 20 to 670 kg/ha.
2. Most species are grazed by cattle at one time or another.
3. Many "increaser" species are excellent grazing plants, and they are very productive under certain conditions.
4. Cattle compete with natural losses of forages and with other consumers (rodents, rabbits, and insects).
5. Young and regrowth forage is more palatable and more nutritious than mature forage.
6. Grazed plants do not deplete soil moisture as rapidly as ungrazed plants.
7. Favorable seasons combined with proper management allow ranges to recover a desirable species composition.
8. Utilization during the growing season is light.
9. Lighter stocking per unit area means less soil compaction by livestock during wet periods.

Using weather and plant information and considering livestock needs, the "best pasture grazing system" has been developed

25. Dwyer, D. D., and J. G. Schickendanz. 1971. Vegetation and cattle responses to nitrogen-fertilized rangeland in south central New Mexico. N. Mex. Agr. Exp. Sta. Res. Rept. 215.
26. Herbel, C. H. 1963. Fertilizing tobosa on floodplains in the semidesert grassland. *J. Range Manage.* 16:133–38.
27. Merrill, L. B. 1969. Grazing systems in the Edwards Plateau of Texas. Abstr. 22nd Ann. Meet., Amer. Soc. Range Manage., pp. 22–23.
28. Merrill, L. B. 1954. A variation of deferred rotation grazing for use under Southwest range conditions. *J. Range Manage.* 7:152–54.
29. Huss, D. L., and J. V. Allen. 1969. Livestock production and profitability comparisons of various grazing systems, Texas range station. Tex. Agr. Exp. Sta. Bull. B-1089.
30. Kothmann, M. M., G. W. Mathis, P. T. Marion, and W. J. Waldrip. 1970. Livestock production and economic returns from grazing treatments on the Texas experimental ranch. Tex. Agr. Exp. Sta. Bull. B-1100.
31. McIlvain, E. H., and M. C. Shoop. 1969. Grazing systems in the southern Great Plains. Abstr. 22nd Ann. Meet., Amer. Soc. Range Manage., pp. 21–22.

in the Southwest.[32] The system consists of defining an objective relative to the desired species composition for each pasture and then stocking accordingly. The system is opportunistic in that the use of forbs and short-lived grasses is maximized. They are of little value to the permanent range resource but contribute much to livestock nutrition.[33] No set stocking plan is used for a specified time period because great variations in weather affect plant growth. Livestock are moved when vegetation in another pasture can be grazed to the advantage of both plants and animals. In large pastures in the Southwest, periodic opening and closing of watering places is used to rotate grazing pressure to different areas within a pasture.[34]

The Ranch As a System

Ranches differ in the amount of water development, fencing, and equipment improvements; the proportion of various soil and vegetation types; wildlife values and recreational opportunities; kinds, breeds, and classes of livestock; supplemental feeding practices; and management objectives of the operator. These factors must be collectively considered to maximize production while maintaining the resource. When a variable is introduced, it affects the entire system. For example, in northwestern Oklahoma clearing of brush, seeding, and fertilizing may be used to substantially alter the stocking pattern on a ranch.[35] In that instance only about 10–15% of a ranch should be used for seeded and fertilized weeping lovegrass. Its productivity and season of use dictate this, or a rancher must resort to more intensive management practices than most prefer.

Similarly, a southwestern rancher with a brush problem may want to initiate a program of deferred-rotation grazing. Later, when the brush in a pasture has been controlled, the grazing could be deferred during the growing season for one to three years to allow for a quicker recovery of desirable vegetation. After the brush on a major part of the ranch has been treated, it may be necessary to change to another grazing system to maximize profits.

IRRIGATED PASTURE AND HAY

Alfalfa, sorghums, and a number of grass species are the most important pasture and hay crops produced under irrigation. (See Fig. 46.4.)

Alfalfa

Alfalfa, the most important irrigated forage crop, is adapted to a wide variety of climatic and soil conditions; however, it requires a large amount of water for maximum production. Under irrigation, yields range from approximately 19 to 27 t/ha. On highly productive soils in southern New Mexico light and frequent irrigations using up to 190 cm of water resulted in higher yields and good water-use efficiency.[36]

Irrigation water is usually applied using the border method; however, other methods such as sprinkling, flooding from contour field ditches, and flooding by basins are used. Care should be taken in designing and constructing the system since alfalfa stands are usually maintained for three or more years. Stands are sometimes reduced or lost by excess surface water caused by poor leveling or poor soil drainage.

Alfalfa is moderately tolerant to salts;[37,38] however, special management is required when salts become excessive. Excessive concentrations of either soluble salts or ex-

32. Herbel, C. H., and A. B. Nelson. 1969. Grazing management on semidesert ranges in southern New Mexico. Jornada Exp. Range Rept. 1.
33. Nelson, A. B., C. H. Herbel, and H. M. Jackson. 1970. Chemical composition of forage species grazed by cattle on an arid New Mexico range. N. Mex. Agr. Exp. Sta. Bull. 561.
34. Martin, S. C., and D. E. Ward. 1970. Rotating access to water to improve semidesert cattle range near water. *J. Range Manage.* 23:22–26.
35. McIlvain, E. H., and M. C. Shoop. No date. Grazing weeping lovegrass. Okla. State Univ. Ext. Facts 2558.
36. Hanson, E. G. 1967. Influence of irrigation practices on alfalfa yield and consumptive use. N. Mex. Agr. Exp. Sta. Bull. 514.
37. Bernstein, L. 1958. Salt tolerance of grasses and legumes. USDA Inf. Bull. 194.
38. U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Agr. Handbook 60.

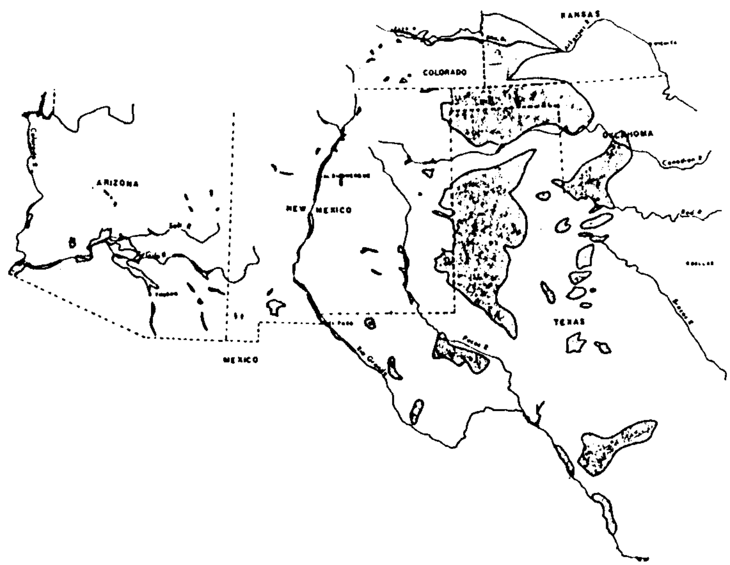

FIG. 46.4. Principal irrigation areas, 1972. Within large blocks shown in Texas, Oklahoma, and Kansas there are significant hectares of nonirrigated land.

changeable sodium or both often cause reduced production. Leaching is the process of dissolving and transporting salts downward through the soil, and is commonly used to help alleviate problems with soluble salts. Productivity of sodium-affected soils has been improved by a combination of leaching and treatment with gypsum and sulfur.[39]

Alfalfa and perennial grasses are well adapted for the improvement of desert and semidesert soils for irrigated agriculture. These forages improve permeability and aeration of soils if managed for high productivity. Alfalfa is especially valuable in crop rotation systems in the irrigated parts of the region.

If a thick stand is maintained, weed control is not as serious with alfalfa as with many other crops. Fall seeding has been popular in much of the region, partially because of fewer weeds compared to spring seedings.

Cultivars have been developed for this region to fit specific insect, disease, and environmental conditions.[40,41] Examples are 'Mesa Sirsa,' 'Sonora,' 'El Unico,' and 'Sonora 70' for Arizona; 'Zia,' 'Mesilla,' 'W.L. 306,' and 'A.S. 13' for New Mexico and western Texas; and 'Kanza' and 'Danson' for the northern states of the region. Cultivars vary considerably in degree of dormancy. A number have been developed with less dormancy to take advantage of the longer growing season in much of the region.

SORGHUMS

Many different sorghum types and hybrids are used for silage, pasture, and hay under irrigation. Sudangrass and sudangrass hybrids commonly are used for summer pasture and less frequently for hay. Forage sorghum hybrids and hybrids between grain and forage types are used for silage. In parts of the region corn also is important.

Sorghum is a drought-tolerant crop but responds strikingly to irrigation in the arid and semiarid portions of the region. Water requirement ranges from 41 to 61 cm/year.[42] Sorghum is moderately tolerant to salts; however, special management may

39. Chang, C. W., and H. E. Dregne. 1955. Reclamation of salt- and sodium-affected soils in the Mesilla Valley. N. Mex. Agr. Exp. Sta. Bull. 401.
40. Dennis, R. E., et al. 1966. Alfalfa for forage production in Arizona. Ariz. Coop. Ext. Serv. & Agr. Exp. Sta. Bull. A-16.
41. Melton, B. A., N. R. Malm, C. E. Barnes, H. D. Jones, D. H. Williams, P. M. Trujillo, J. E. Gregory, and R. E. Finker. 1971. Performance of alfalfa varieties. N. Mex. Agr. Exp. Sta. Bull. 583.
42. Quinby, J. R., and P. T. Marion. 1960. Production and feeding of forage sorghum in Texas. Tex. Agr. Exp. Sta. Bull. 965.

be needed in the drier portions of the region where salts are excessive. Sorghums do well on a variety of soils but yield best on soils with good tilth and drainage and relatively high fertility. A forage sorghum crop producing 70 t/ha of silage contains about 125 kg of N; therefore, large amounts of N are removed from the soil and must be replaced. The depressing effects sorghum sometimes has on crops that immediately follow may be partially reduced by applying fertilizer N. Choosing forage sorghums resistant to lodging is important for use under irrigated, high-fertility conditions.

Other Grasses

A large number of grasses including bermudagrass, tall fescue, blue panicgrass, tall wheatgrass, and intermediate wheatgrass provide a significant amount of pasture and some hay under irrigation. These grasses require about as much water as alfalfa for maximum production. However, if less water is available, they can be maintained satisfactorily at a lower productivity. Under irrigated conditions these grasses respond to high N levels if other fertilizer elements are adequate.

NONIRRIGATED FORAGES OTHER THAN RANGE GRASSES

In the drier parts of the region, particularly in the lower elevations of the Southwest, tame pastures generally cannot be established or maintained without irrigation. In the eastern part, small-grain pasture is one of the most important forages. Wheat, oats, barley, and rye often are grazed if there is sufficient moisture. It is common practice to harvest grain from these crops, and careful grazing management must be practiced if optimum grain yields are to be realized.

Perennial grasses like bermudagrass, johnsongrass, buffelgrass, several wheatgrasses, and legumes supply considerable forage without irrigation. Generally, their productivity is limited by moisture; however, soil type, fertility, and physical condition may also be limiting.

QUESTIONS

1. How is annual precipitation related to the occurrence of warm- and cool-season forage species on rangeland?
2. What are some of the major brush problems of the region? How does this affect ranch operations? What are the two major methods of controlling noxious brush species? What are three factors governing the selection of control methods?
3. What are the problems associated with seeding rangelands? What seeding procedures are used to help alleviate these problems?
4. List several reasons for the success of continuous yearlong grazing in the southern Great Plains. What classes of livestock have been found to be most profitable in the Edwards Plateau? Why is it important to have flexibility in stocking ranges of the Southwest?
5. What are the major problems associated with irrigated forage production in the region?
6. Contrast the management of sorghums for forage under irrigated versus nonirrigated conditions.
7. List and discuss the most important tame forage species of the region.