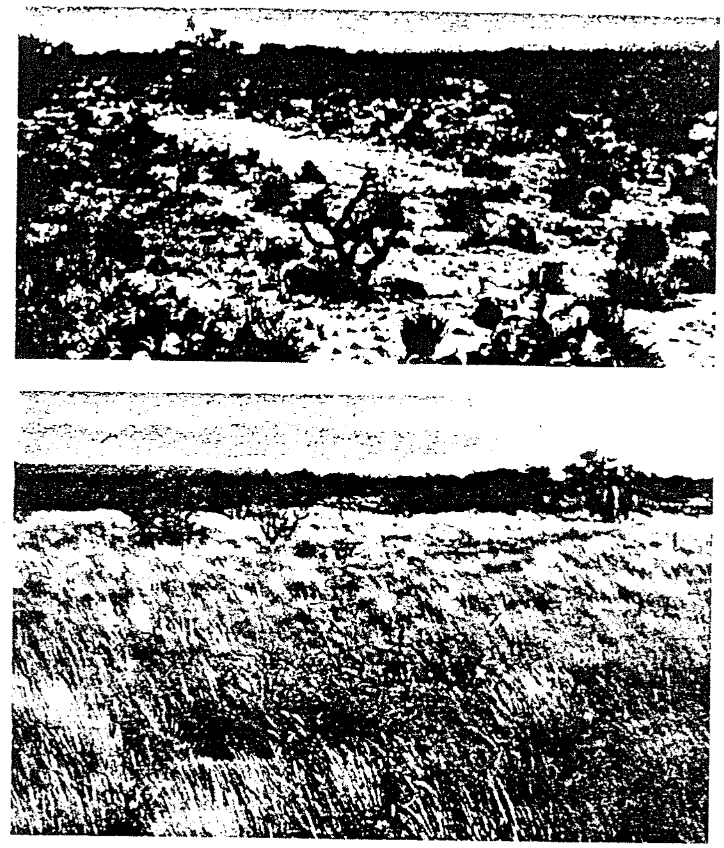
Semidesert rangeland before
and after brush control.



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Reviving Arizona's rangelands

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HISTORICAL records show that southeastern Arizona was a grassland before 1880. Today, shrubby plants dominate the region. From 1880 to 1900, dramatic changes in the composition of vegetation took place along major waterways. Flooding and resulting channelization, plowing of the floodplains, and livestock grazing essentially eliminated the natural process of shallow groundwater recharge. Changes in vegetation on upland range between 1930 and 1980 were gradual but just as destructive. We documented the changes in the region's vegetation between 1880 and 1980, determined why the changes occurred, and determined if the range resource can be reclaimed.

Early descriptions

Spanish explorers and ranchers were active in southeastern Arizona (*3*, *12*, *38*), but it is difficult to correlate their descriptions of land with precise areas. Early American explorers, on the other hand, maintained journals describing vegetation and location. Their records provide descriptions of grazing areas and vegetation in southeastern Arizona prior to 1870:

Santa Cruz Basin. "We were off this morning [from Tucson]...and soon entered a thickly wooded valley of mesquite. A ride of nine miles brought us to San Xavier de Bac...a mile further we stopped in a fine grove of large mesquite trees near the river, where there was plenty of grass. The bottom-lands resembled meadows being covered with luxuriant grass and but few trees. The bottoms [between San Xavier and Tubac] in places are several miles wide...and covered with tall, golden colored grass...divided by a meandering stream a dozen yards wide and as many inches deep, this shaded by cottonwoods, willows, and mesquites" (*4*).

The upland range [south and east of Tucson] provided excellent summer and winter forage of grama grass, indianwheat, and winter annuals in 1900 (*11*). Considering current vegetation and soil conditions it may be difficult to visualize the Santa Cruz Valley near Tucson covered with grass. However, 100 cows continuously grazed a big sacaton pasture of about 100 acres near Tucson between 1868 and 1880 (*38*). Furthermore, some 2,000 cows continuously grazed the Santa Cruz Valley between Sahuarita and Tucson before 1870, and about the same number also grazed the Tanque Verde, Pantano, and Rillito grasslands during the same period.

San Pedro Basin. "The valley of this river is quite wide and is covered with a dense growth of mesquite, cottonwood and willow. The majority of the valley has good grass...the bottoms having very tall grass. There is excellent trout fishing but the grass makes travel by wagon very difficult" (*7*).

Sulphur Springs Basin. "This vast area is without either running streams or timber, but covered to a great extent with fine grass. Approaching Sulphur Springs from the East, the road lies for miles through a dense growth of sacaton grass" (*16*). This area was particularly adapted to grazing because of climate, abundance of alkali sacaton and salt grass in the playas, and grama grass on the uplands (*11*).

San Simon Basin. "The valley of the San Simon is...25 miles in width, and contains much fine grazing and some agricultural land. It is covered with grama grass. Mesquite is most conspicuous and abundant from the base of the mountain [Graham]...and sparse on the mesa...the sacaton and grama cover the plain.... The county

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abounds in game, such as deer, antelope, wolf, wild turkey, duck and quail" (*16*).

The livestock industry

With the completion of southwestern railroads and dangers from Indian raids reduced, stockmen from Texas and investors from England and the eastern United States moved large herds of cattle and sheep into southeastern Arizona in search of "free grass" (*11, 38*). The winter of 1888 and summer of 1889 were wet and forage was abundant. More cattle and sheep were shipped from the Great Basin the following winter. By 1891 there were an estimated 1.5 million cattle in Arizona's southeastern counties (Table 1).

Summer and winter rains were well below normal in 1891, and by June 1892 cattle began to die. The governor of the Arizona Territory estimated losses at 50 to 75 percent (*11, 18*). Another report noted, "In my past trip [Vail, Arizona, to Nogales, Mexico] beef carcasses were so numerous that they dotted the landscape... it is not possible to travel more than a stones throw without seeing bones or decaying bodies of cattle" (*28*).

Historians generally assume that livestock populations before 1900 were equally distributed throughout southeastern Arizona. Livestock no doubt followed minor drainages and grazed the uplands in wet years. But upland water development and fencing began after 1930 (*38*), and livestock grazing was likely limited to areas near major drainages and playas in the 1890s. If this assumption is true, livestock use was limited to about 20 percent of the land area (3.6 million acres), and livestock grazing was concentrated in sacaton bottoms and on nearby grama uplands.

Alkali sacaton (*Sporobolus airoides*) and big sacaton (*Sporobolus wrightii*) were common before 1900. The plants covered alluvial floodplains and nearby uplands in southern Arizona and New Mexico (*17*). Could these grasses, covering 20 percent of the land, support 1.5 million cattle?

In a wet summer, when rainfall exceeded 10 inches, both sacaton species produced up to 3 tons per acre of green forage. But in a dry summer, when rainfall was less than 5 inches, sacaton produced less than 1 ton per acre of green forage. In wet years, or those before 1891, 20 percent of the land area might have supported more than 1.5 million cattle. However, in dry years (1891 to 1893), the same area would support 500,000 head or less.

Annual precipitation varies greatly in southeastern Arizona, adding to the complexity of estimating forage production in wet and dry years. In fact, annual variations in precipitation were greater in southeastern Arizona than in any other part of the contiguous United States (*13*). The variability of individual storms and total annual rainfall was illustrated at the Walnut Gulch Experimental Watershed in 1967 (*23, 24*). Annual rainfall was 10 inches at one location and 16 inches at another. The distance between the locations was less than 10 miles. Thus, a wet year and a dry year occurred in the same general area.

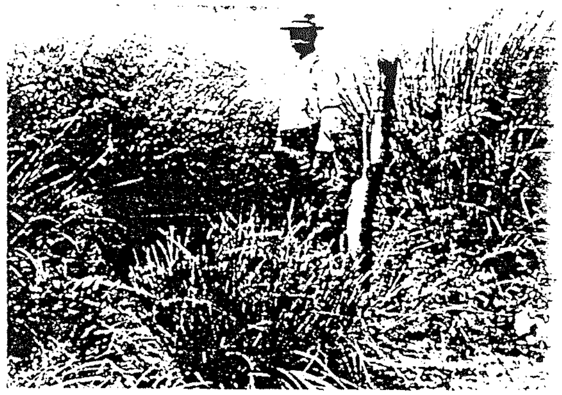
Total annual rainfall on upland range would directly affect forage production. However, runoff from locations where rainfall was above average would accumulate in lowlands every year and forage production would remain relatively stable. Before channelization in lowlands occurred, water entering major channels was naturally spread over large areas by dense stands of sacaton. As a result, water moved slowly in channels, shallow aquifers were likely replenished each year, and discharge occurred over months rather than hours.

Between 1904 and 1914, summer rainfall was apparently above average (*40*), forage was abundant, cattle prices were high, shipping costs declined, and ranges were overstocked. A brief dry period occurred in 1917. There was severe drought in 1920. In the summer of 1933, southeastern Arizona counties were classified as emergency areas, and the Bureau of Animal Industry condemned and slaughtered range cattle (*38*).

Passage of the National Industrial Recovery Act and implementation of the Work Progress Administration and Civilian Conservation Corps in the 1930s led to the opening of new grazing land. Federal and private groups developed water on upland range, and fencing was used to divide land into grazing units (*19*). Range livestock populations that were previously confined to lowlands were then moved to upland range.

From 1890 to 1980, wet periods with abundant forage were followed by overstocking, and drought periods were followed by livestock reductions. With each successive cycle, perennial grass productivity declined, and the rangeland supported fewer livestock. Excessive and continuous use of perennial grass slowed plant recovery and favored invasion of woody plants. Semidesert grassland became semidesert shrubland (*10, 11, 12, 18*).

If livestock populations have declined 88 percent over the past 90 years and if reduced forage production caused channelization, then one might logically assume that cattle grazing caused the decline in forage production and is responsible for



A sacaton stand near Tucson in 1902.

A typical overgrazed hillside in southeastern Arizona in 1933.

A retake of above scene in 1980, showing increase of brush, cactus.

Recent photo of a productive sacaton meadow with trees.

channelization. Unfortunately, overgrazing continues to occur in southeastern Arizona, but it is incorrect to infer that the livestock industry is solely responsible.

Irrigated agriculture

Farming in southeastern Arizona was concentrated initially near major lowland drainage areas. Water was taken directly from rivers. This practice was hazardous on the San Pedro River because beaver would build dams in irrigation ditches at night and limit water flow to cropland. During the floods of 1895 and 1900, channel cutting resulted from the combination of farming, wagon trails, and grazing rather than grazing alone. The soils associated with lowlands were extremely rich, and farming began after removal of the sacaton bunchgrasses (*11*).

Sacaton had slowed floodwater, trapped sediment, and enhanced soil fertility on the floodplains (*39*). Once removed, whether by burning, grazing, or plowing, there was nothing to slow water movement in the lowlands. The result was channelization.

From 1930 to 1960, irrigated agriculture expanded rapidly in the southeastern counties (Table 2). Decades of peak acreages were the 1940s in Cochise, 1950s in Pima and Pinal, and 1960s in Graham and Santa Cruz Counties. During periods of maximum cultivation (by county), about 2.6 million acres were cultivated in the five southern counties; and if the areas farmed in 1980 are subtracted from the peak acreages, then 2.2 million acres of farmland have been abandoned in the past 40 years.

Urban growth and water use in urban areas will increase dramatically to the year 2030 (*2*). As urban demand for water increases, water will be diverted from agricultural uses, which have lesser value. This means the abandonment of more of the region's farmland, a phenomenen occurring nationally at an average rate of 3 million acres per year (*25*).

Effects of development

A majority of the population in southeastern Arizona between 1890 and 1930 was rural and dispersed. Populations in Cochise and Pima Counties were relatively even until 1940. From 1940 to 1980, the population increased gradually in all counties except Pima. Today, more than 70 percent of the region's people live in Pima County, most in and around Tucson.

As population increased, so did demands for water and space. The fertile lowlands, previously sacaton bottoms and farmland, were easy to develop, and housing quickly covered prime agricultural land.

Agricultural water use declined rapidly in the 1970s and early 1980s, but mining and urban uses are accelerating in Pima County (*2*). Agriculture, mining, industry, and urban concerns are depleting groundwater at an alarming rate.

Arizona legislators have recently passed legislation to limit groundwater removal. We estimate that 283 million acre-feet of water were pumped from shallow water tables in the past 80 years, while the Arizona Water Commission (*2*) estimated that 265 million acre-feet of water were available in 1972 to a depth of 700 feet. In 80 years, therefore, assuming minimal recharge after 1895, residents of southeastern Arizona have removed more than half of all the stored water in shallow aquifers.

Public concern for water conservation is genuine, but people continue to overgraze rangeland, build on floodplains, straighten channels to accelerate runoff, abandon farmland, fill swimming pools, and drive recreational vehicles in washes and on upland range. These activities continue to degrade land resources.

Is restoration possible?

Mechanical treatment (physical modification of the soil surface) of vegetation on uplands was common until the oil shortages of 1970. Such treatment normally alters soil structure, requires seeding to restore productivity, and often succeeds only in years with above-average rainfall (*8*).

Chemical treatment to control shrubs began in the 1920s (*27*). New pelleted herbicide formulations are less dependent on time of application, have no liquid drift, and effectively control brushy plants (*22*).

To estimate potential forage production in the region, we selected a mixed brush site at an elevation of 3,100 feet. Annual precipitation in the area is generally less than 12 inches, and reseeding at such locations is not recommended (*20*). Brush species were treated with a combination of two pelleted herbicides, and we fenced the area to exclude livestock. Forage production on treated and ungrazed verses untreated and ungrazed was 400 and 200 pounds per acre in 1979, 900 and 350 pounds per acre in 1980, and 1,500 and 500 pounds per acre in 1981. Similar forage responses on creosotebush sites at locations in southeastern Arizona, southern New Mexico, and northern Mexico have been observed.

One of the most difficult tasks associated with water management is to control floodwater after it enters a channel. The dense stands of sacaton and beaver dams controlled water speed in primary channels before 1890 (*11*). Restoration of

Table 1. Cattle populations in southeastern Arizona counties between 1890 and 1980. Range cattle populations were determined by using published estimates, or by subtracting estimated dairy and feedlot cattle from estimated county populations.

	Counties						Range Cattle	
Year	*Cochise*	*Graham*	*Pima*	*Pinal*	*Santa Cruz*	*Total*	*Populations*	*Reference*
1890						1,500	1,500	(18)
1900	172*	85	98	42	43	440	438	(29)
1910	150	98	43	42	44	377	375	(30)
1920	84	47	64	45	27	267	263	(31)
1930	91	42	88	21	30	272	268	(32)
1940	91	33	58	53	26	261	250	(33)
1950	65	51	41	38	27	222	210	(34)
1960	71	74	83	64	33	325	250	(35)
1970	68	60	72	221	24	445	240	(1, 36)
1980	67	35	40	207	16	365	188	(1, 37)

*1,000 head.

Table 2. Acres of irrigated agriculture in southeastern Arizona between 1900 and 1980 and estimates of abandoned farmland in 1980 (abandoned farmland obtained by subtracting 1980 estimates from peak production years).

	Counties						
Year	*Cochise*	*Graham*	*Pima*	*Pinal*	*Santa Cruz*	*Total*	*Reference*
1900	4,990	18,300	8,620	11,300	2,560	45,770	(29)
1910	4,900	38,820	10,160	25,430	4,770	84,080	(30)
1920	12,980	32,400	16,880	28,650	2,610	93,520	(31)
1930	377,010	136,410	280,550	75,740	4,990	874,700	(32)
1940	907,700	210,130	293,660	593,930	168,610	2,174,030	(33)
1950	359,120	405,610	353,330	871,690	126,210	2,097,960	(34)
1960	637,620	492,000	312,520	730,670	185,780	2,358,590	(35)
1970	90,920	51,850	50,030	260,110	2,100	455,010	(36)
1980	88,630	45,900	47,280	221,610	3,970	407,390	(37)
Acres of abandoned farmland	819,000	446,100	288,050	509,060	181,810	2,244,090	

stream channels and riparian zones is possible when the rainfall is readily absorbed by the upland portions of the watershed, reducing overland flow (*6*).

Runoff potential can be reduced on uplands after shrubby species are replaced with grass (*15*); however, clean water entering the channel will have a greater erosive potential. Therefore, any efforts to control water speed must be initiated where channels begin. Water control systems usually consist of large dams designed to hold water. A more ideal situation is to reduce water speed with vegetation and a series of alternating, open-ended spreader dams in riparian areas. As sediment is deposited, the height of dams is increased.

It may not be possible to seed big sacaton directly into stream channels or riparian zones because soils are high in silt and clay, but clumps from existing stands can be removed, potted, and transplanted at field locations, or supplemental irrigation can be used.

Recommendations

As a supplement to recent groundwater legislation and plans for water importation into southeastern Arizona, we recommend that restoration of the semidesert grassland also be considered. Historical documentation suggests that if watersheds were returned to grass the following conditions might occur:

► Rainfall infiltration might increase, thereby reducing the probability of downstream flooding (*9, 17*).

► Water movement below 10 inches might eventually recharge subsurface aquifers (*5, 26*).

► Perennial forage production might increase (*21*).

► Ephemeral streams might become perennial streams (*14, 26*).

► The resulting environmental diversity might enhance wildlife habitat as well as recreational and aesthetic values (*26*).

The question of whether these conditions would follow cannot be answered because existing watershed data were collected on degraded rangelands and do not represent grassland conditions. An entire watershed is needed where large-scale manipulation of vegetation can take place. The effects of these vegetation changes must be monitored to determine (a) herbicide residues, (b) forage and livestock production, (c) erosion, (d) runoff, (e) infiltration, (f) wildlife populations, and (g) possible groundwater recharge over time. Planning, implementation, and review of this watershed research should be accomplished by city, county, state, and federal agencies and private organizations.

Rangelands in southeastern Arizona have been and continue to be abused by ranchers, farmers, miners, and urban residents. The resource should be returned to its original state and be managed properly for all user groups. However, a major question remains: Are people socially, politically, and institutionally mature enough to work together to make the necessary changes?

REFERENCES CITED

1. Arizona Crop and Livestock Reporting Service. 1981. *Arizona agricultural statistics, historical summary of county data 1965-1980.* Bull. S-16. Phoenix, Ariz. 140 pp.
2. Arizona Water Commission. 1975. *Phase I—Arizona State Water Plan. Inventory of Resources and Uses.* Phoenix, Ariz. 37 pp.
3. Bahre, C. J. 1977. *Land-use history of the research ranch, Elgin, Arizona.* J. Ariz. Acad. Sci. 12(2): 3-32.
4. Bartlett, J. R. 1854. [Personal narrative of explorations and incidents in Texas, New Mexico, California, Sonora and Chihuahua. Volumes I and II]. The Botanical Rev. 24: 193-252.
5. Cable, D. R. 1977. *Seasonal use of soil water by mature velvet mesquite.* J. Range Manage. 30: 4-11.
6. Carlson, C. W. 1963. *Drainage density and stream flow.* Paper 422-C. U.S. Geol. Surv., Washington, D.C. pp. 36-42.
7. Cooke, P. G. 1938. [Journal of the March of the Morman Battalion, 1846-1847]. The Botanical Rev. 24: 193-252.
8. Cox, J. R., H. L. Morton, T. N. Johnsen, Jr., G. L. Jordan, S. C. Martin, and L. C. Fierro. 1982. *Vegetation restoration in the Chihuahuan and Sonoran Deserts of North America.* ARM-W-28. Agr. Res. Serv., Western Region, Oakland, Calif. 37 pp.
9. Dixon, R. M., J. R. Simanton, and L. T. Lane. 1978. *Simple time-power functions for rainwater infiltration and runoff.* Hydro. and Water Resources in Ariz. and the S.W. 8: 79-89.
10. Gardner, J. L. 1951. *Vegetation of the creosotebush area on the Rio Grande Valley in New Mexico.* Ecol. Monograph 21: 379-403.
11. Griffith, D. 1901. *Range improvement in Arizona.* Bull. 4. Bur. Plant Industry, Washington, D.C. 12 pp.
12. Hastings, J. R., and R. M. Turner. 1965. *The changing mile.* Univ. Ariz. Press. Tucson.
13. Hershfield, D. M. 1962. *A note on the variability of annual precipitation.* J. Applied Meterol. 6: 575-578.
14. Hibbert, A. R. 1969. *Water yield changes after converting a forested catchment to grass.* Water Resources Res. 5: 634-640.
15. Hibbert, A. R., E. A. Davis, and T. C. Brown. 1975. *Managing chaparral for water and other resources in Arizona.* In Proc., Watershed Manage. Symp. Am. Soc. Civil Eng., New York, N.Y. pp. 445-469.
16. Hinton, R. J. 1878. [The handbook to Arizona]. The Botanical Rev. 24: 193-252.
17. Hubbell, D. S., and J. L. Gardner. 1950. *Effects of diverting sediment-laden runoff to range and cropland.* Tech. Bull. 1012. U.S. Dept. Agr., Washington, D.C. 83 pp.
18. Humphrey, R. R. 1958. *The desert grassland.* The Botanical Rev. 24: 193-252.
19. Johnsen, T. N., Jr., and J. W. Elson. 1979. *Sixty years of change on a Central Arizona grassland—juniper woodland ecotone.* ARM-W-7. Sci. and Educ. Admin., Agr. Res., Oakland, Calif. 28 pp.
20. Jordan, G. L. 1981. *Range reseeding and brush management in Arizona rangelands.* Bull. T81121. Ariz. Agr. Exp. Sta., Tucson. 88 pp.
21. Martin, S. C. 1963. *Grow more grass! by mesquite control.* Progressive Agr. in Ariz. 15: 15-16.
22. Morton, H. L., E. L. Smith, M. Oliveira, and H. M. Hull. 1978. *Soil applied herbicides for brush control in Southwestern United States and Northeast Brazil.* In D. H. Hyder [ed.] Proc., First Int. Rangeland Cong. Soc. of Range Management, Denver, Colo. pp. 647-650.
23. Osborn, H. B., and K. G. Renard. 1973. *Management of ephemeral stream channels.* J. Irrigation and Drainage 99: 207-214.
24. Renard, K. G., and D. L. Brakensiek. 1976. *Precipitation on intermountain rangeland in the Western United States.* In Proc., Fifth Workshop, U.S./Australia Rangeland panel. Utah Water Res. Lab., Logan. pp. 39-59.
25. Sheets, K. R. 1981. *Is U.S. paving over too much farmland?* U.S. News and World Rpt. 2: 47-48.
26. Sosebee, R. E. 1980. *Water: a precious commodity to everyone.* In Res. Highlights—Noxious Brush and Weed Control; Range and Wildlife Management. Texas Tech Univ., Lubbock. 2 pp.
27. Streets, R. B., and E. B. Standley. 1938. *Control of mesquite and noxious shrubs on Southern Arizona grassland ranges.* Tech. Bull. 74. Ariz. Agr. Exp. Sta., Tucson. 29 pp.
28. Thornber, J. J. 1905. *Range improvement.* Agr. Exp. Sta. Ann. Rpt. 16: 17-22.
29. U.S. Bureau of the Census. 1902. *Twelfth census of the United States taken in 1900.* Population - part I, p. 64; agriculture - part I, p. 418; agriculture - part III, p. 825. Washington, D.C.
30. U.S. Bureau of the Census. 1913. *Thirteenth Census of the United States taken in 1910.* Supplement for Ariz., pp. 32, 606-607, 621-622. Washington, D.C.
31. U.S. Bureau of the Census. 1922. *Fourteenth Census of the United States taken in 1920.* Volume III, pp. 78-79; volume VII, pp. 116-117; volume VI, part 3, pp. 134-135. Washington, D.C.
32. U.S. Bureau of the Census. 1932. *Fifteenth Census of the United States taken in 1930.* Volume I, p. 92; volume II, part 3, pp. 349-350; irrigation of agricultural lands, pp. 74-75. Washington, D.C.
33. U.S. Bureau of the Census. 1942. *Sixteenth Census of the United States taken in 1940.* Volume II, part 1, p. 370; volume I, part 6, pp. 404-405; irrigation of agriculture lands, pp. 111-113. Washington, D.C.
34. U.S. Bureau of the Census. 1952. *Census of population and agriculture taken in 1950.* Volume II, part 3, pp. 40-42; volume II, part 30, pp. 215-216; volume III, pp. 1-11. Washington, D.C.
35. U.S. Bureau of the Census. 1960. *Census of population and agriculture taken in 1959. Arizona counties.* Washington, D.C.
36. U.S. Bureau of the Census. 1972. *Census of population and agriculture taken in 1969-1970.* Volume I, part 4, pp. 4-14; volume I, part 43, pp. 268-270. Washington, D.C.
37. U.S. Bureau of the Census. 1981. *Census of population and housing taken in 1980.* A Preliminary Report. Washington, D.C.
38. Wagner, J. J. 1952. *History of the cattle industry in Southern Arizona, 1540-1940.* Social Sci. Bull. 20. Univ. Ariz. Press, Tucson. 132 pp.
39. Wooten, E. O., and P. S. Standley. 1911. *The grasses and grasslike plants of New Mexico.* Bull. 81. New Mex. Agr. Exp. Sta., Las Cruces. 174 pp.
40. Wooten, E. O. 1916. *Carrying capacity of grazing ranges in Southeastern Arizona.* Bull. 367. Bur. Plant Industry, U.S. Dept. Agr., Washington, D.C. 40 pp. □