STRATIGRAPHY OF A PLAYA-LAKE DEPOSIT WITHIN THE PROPOSED ALIGNMENT OF THE AMARILLO-AREA SUPERCONDUCTING SUPER COLLIDER

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INTRODUCTION

A limited investigation of playa-lake stratigraphy was conducted at a small unnamed playa approximately one mile northeast of Nazareth, Castro County, Texas (figs. 1, 2). This work was done in support of a study of the proposed Amarillo-area site for the Superconducting Super Collider (SSC), and is intended to complement discussion of the areal geology of the Amarillo-area site by Raney and others (1987).

Three shallow boreholes (B6, B6A, and B6B) were drilled in the northeastern quadrant of the playa (fig. 1 inset). Borehole B6 was drilled near the center of the playa basin, B6A approximately half the playa radius to the northeast, and B6B farther northeast, just outside the playa margin. The three boreholes are aligned along a directional azimuth of N68E. Core was collected from each of the boreholes using Shelby tubes. Depth of all three was approximately 70 ft. The playa contained standing water at the time of coring; equipment access was afforded by a narrow levy road constructed across the playa floor. Boreholes B6 and B6A were drilled through the road fill.

Playa deposits are among the most common Late Cenozoic stratigraphic units in the Southern High Plains (fig. 2). The number of playas in the Southern and Central High Plains of Texas may exceed 37,000 (Schwiesow, 1965). Several playas are located near the proposed alignment of the Amarillo-area SSC (fig. 2). Despite their large collective areal extent and a long history of scientific interest in playas in general, the age and origin of deposits filling playa basins in this region remain highly controversial (see brief discussion by Raney and others, 1987).

Playas are ephemeral lakes; their deposits typically include a mix of lacustrine and eolian sediments. Lacustrine silty clay and eolian fine sandy silt deposits of varying thickness are found in playas throughout the study area. Although the composition of playa deposits has been reasonably well characterized, the mechanisms by which their associated basins form and are maintained are not fully understood. At many sites, modern playa basins are inset into older lacustrine deposits, indicating possible genetic cyclicity. A variety of mechanisms may be involved in creating and maintaining playas as a group, and many individual playas may be polygenetic.

TOPOGRAPHIC SETTING OF TEST PLAYA

The test playa near Nazareth lies at an elevation of approximately 3,715 ft within a more extensive basin having more than 20 ft of relief (U.S. Geological Survey, Nazareth, Texas, 7.5-minute quadrangle map). The original extended basin is no longer entirely closed. A northward-flowing tributary of Middle Tule Draw

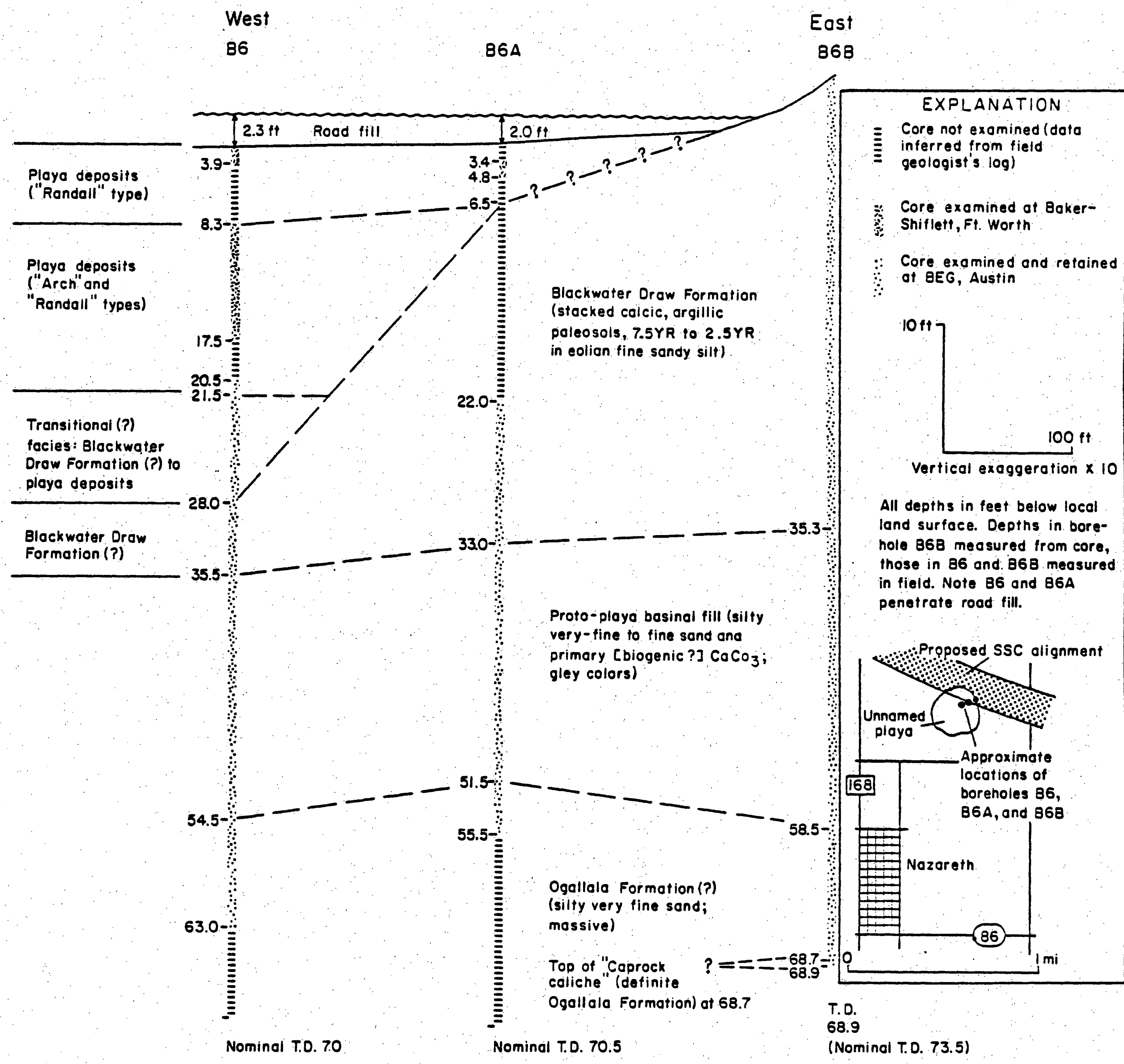

Figure 1. Stratigraphic cross section through northeastern quadrant of unnamed playa approximately one mile northeast of Nazareth, Castro County, Texas.

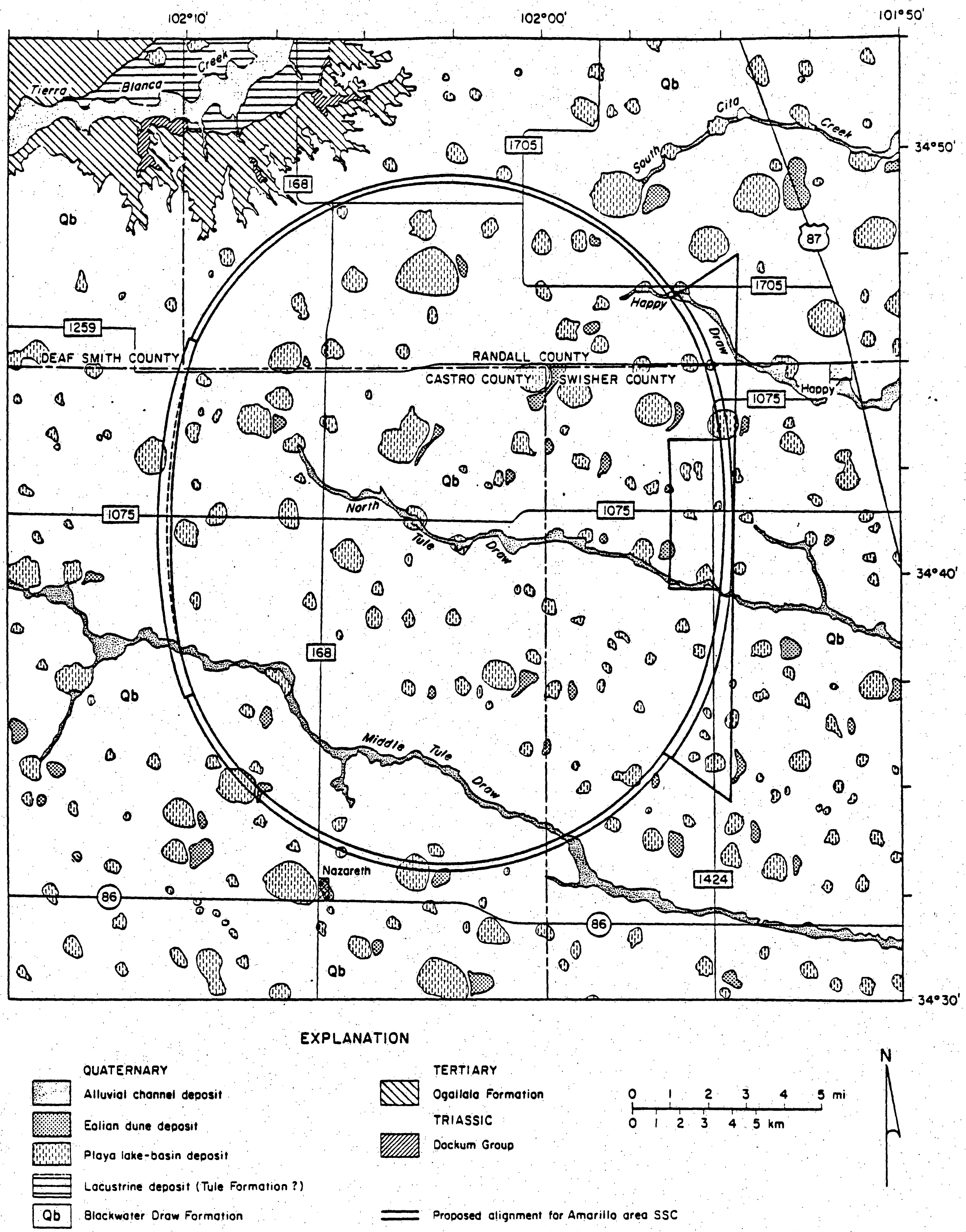

Figure 2. Areal geologic map of the proposed Amarillo-area site for the Superconducting Super Collider.

occupies a breach in the former basin margin. Because of this breach, the closed portion of the modern playa basin has less than 10 ft of total relief.

DATA FROM TEST PLAYA

Core was collected from the three aligned boreholes at the test playa. D. James of Baker-Shiflett, Inc., an engineering testing laboratory in Ft. Worth, examined samples from all three boreholes and prepared a preliminary stratigraphic log for each. The present author examined short sections of the core from boreholes B6 and B6A at the offices of Baker-Shiflett. Part of the remaining core, and all of the core from borehole B6B, was examined and stored at the Core Research Center of the Bureau of Economic Geology in Austin.

Depths reported here for borehole B6B vary from those in the field geologist's log. Reconstruction of the depths in B6B was based on careful measurement of the core, allowance for sediment disturbance and slumping during boring, and interpretation of the field log. These measurements facilitated detailed logging in the laboratory but differ slightly from actual borehole depths measured in the field. Although this discrepancy is small it is additive downhole. The reconstructed total depth of B6B is 68.9 ft, whereas the field measurement of total depth is 73.5 ft.

Borehole B6B

Borehole B6B, the easternmost of the three boreholes, was located just outside the playa floor above water level (fig. 1). As mentioned, almost 69 ft of core was recovered from this borehole (total depth measured in the field was 73.5 ft). Including the modern soil, B6B penetrated more than 35 ft of pedogenically modified eolian sandy clayey silt correlative with the Quaternary Blackwater Draw Formation. This formation is distinguished by a vertical succession of paleosols developed in eolian sediment (silt and rounded, frosted, very fine to fine sand). The degree of soil development is also diagnostic: hues are 7.5 YR to 2.5 YR, argillic horizons are thick, and calcic horizons (approximately Stages I to III in the classification scheme of Machette, 1985, table 1) are common.

Beneath the Blackwater Draw Formation in B6B and the other boreholes is approximately 23 ft of silty very fine to fine and rare medium sand preserving original sedimentary structures. These sediments were penetrated in all three boreholes over approximately the same depth interval. The deposits are clayey in part and have distinctive gley colors indicative of iron reduction (see Soil Survey staff, 1951, p. 180, 184). Concentration of calcium carbonate in this unit is extremely high, but preservation of sedimentary structures indicates the carbonate was deposited essentially at the same time as the silty sand. The carbonate may be biogenic and possibly algal, but detailed examinations required to address this question have not been performed. However, these strata are similar to deposits of algal carbonates and clastic sediments known from existing small lakes in the Pecos River valley of New Mexico (Caran and others, 1986). There is little evidence of pedogenesis in the calcareous silty sands of the test playa, and there is no basis for correlation with the Blackwater Draw. Instead, the calcareous silty sands may represent lacustrine sediments having a large eolian component that were deposited in an early basin or "proto-playa" significantly larger than the modern playa. Whether the areal extent of this basin fill corresponds to that of the extended, partly breached depression surrounding the modern playa is uncertain. Regardless of its origin, this unit clearly predates development of the existing playa basin.

Underlying the calcareous silty sand unit in all three boreholes is a massive, silty, very fine to fine sand generally brown in hue that is here tentatively correlated with the Ogallala Formation. Concretions of calcium carbonate are present but are small and discontinuous throughout the section. This eolian sediment lacks the characteristic pedogenic signature of the Blackwater Draw Formation. The brown silty sand is most similar to eolian facies of the Ogallala Formation (see Gustavson and Holliday, 1985). However, recognizable "Caprock caliche," the calcrete typically found at the top of Ogallala sections (see discussion by Raney and others, 1987), occurs beneath the brown silty sand in B6B. Gustavson and Holliday (1985) showed that prominent calcretes occur in several positions within some Ogallala sections examined in outcrop. It is not unreasonable to suppose that at this site, either the uppermost Ogallala deposits were not well cemented or the calcrete originally present was removed by erosion or leaching of this interval. The preponderance of available data supports correlation of the brown silty sand unit with the Ogallala Formation.

At the base of the core recovered from B6B is a laminated calcrete (at least Stage IV in the classification scheme of Machette, 1985, table 1). It is fortunate that any of this calcrete was recovered because the Shelby tubes used in coring could not penetrate more than a few inches into this resistant material. Although there are rare examples of Stage IV calcretes developed in the Blackwater Draw Formation under special conditions, it is far more reasonable to correlate the calcrete in B6B with the Ogallala.

Borehole B6A

Borehole B6A, the middle borehole, was located on the levy road within the playa (fig. 1). At this site, the playa floor was below water level at the time of drilling. Total borehole depth measured in the field was 70.5 ft. Depth was measured from the surface of the road through 2 ft of road fill. B6A penetrated 4.5 ft of organic-rich silty clay containing isolated grains of eolian fine sand. This clay is similar to that of most playas in the region. The soil series typically developed on this sediment is the Randall, and Holliday (1985, p. 350) has informally described the lacustrine deposits themselves as "Randall-type" deposits. It is in this sense that the term "Randall type" is used here in reference to these organic silty clays.

Beneath this lacustrine clay, the section at B6A is very much like that at B6B. Borehole B6A penetrated approximately 26.5 ft of the Blackwater Draw Formation, 18.5 ft of the "proto-playa" basinal sediments, and 19 ft of presumed Ogallala Formation. "Caprock caliche," if present under the playa, either was not recovered or was not reached in B6A, although this borehole attained a depth comparable to that of B6B. Slight discrepancies in depths to the top of the Ogallala Formation (?) in B6A and B6B (fig. 1) may reflect the difference in the way depths are reported for these two boreholes.

Borehole B6

Borehole B6, the westernmost borehole, was located on the levy road near the center of the playa (fig. 1). The playa floor was completely submerged at the time of drilling. Total borehole depth measured in the field was 70 ft. Depth was measured from the surface of the road through 2.3 ft of road fill. B6A penetrated 6 ft of Randall-type organic-rich silty clay containing isolated grains of eolian fine sand. Beneath this clay is a 13-ft interval of Randall-type clays interbedded with a highly calcareous silty sandy clay, here informally referred to as "Arch type" after the Arch soil series characteristically developed on playa sediments of this composition (Holliday, 1985, p. 350).

Underlying the interval of interbedded Randall- and Arch-type lacustrine sediments is a zone having complex stratigraphy. Deposits composing this zone are 7.5 ft thick and probably include both lacustrine silty clays (mostly Randall-type) and eolian very fine to fine sandy silts with a pedogenic overprint. Pedogenesis appears to have weakly overprinted some beds of silty clay as well, such that boundaries between the lacustrine and eolian depositional units are indistinct. The sandy silts probably represent tongues of the Blackwater Draw Formation interbedded with the lacustrine deposits. This zone was penetrated only in B6; it appears to represent a transitional facies that existed near the margin of the modern playa early in its history.

Beneath this transitional facies are 42 ft of deposits very similar to those encountered at comparable depths in the other two boreholes. At the top of this interval is a 7.5-ft thickness of clayey fine sandy silts probably correlative with the Blackwater Draw Formation. These sediments have most of the textural and pedogenic properties of the Blackwater Draw but with more clay than is typical. Some of this clay may have been translocated from lacustrine sediments higher in the local section. The probable Blackwater Draw deposits in B6 overlie 19 ft of "proto-playa" basinal sediments, which in turn overlie 15.5 ft of the Ogallala Formation (?) without the "Caprock caliche." Discrepancies in the depths at which these units were penetrated in B6 and the other boreholes (fig. 1) may in part be an artifact of the methods used to determine depth. This discrepancy increases with depth.

SUMMARY AND CONCLUSIONS

Three shallow boreholes drilled at the unnamed test playa approximately one mile northeast of Nazareth, Texas, provide an excellent stratigraphic record of this and, by inference, other playas. The Miocene-Pliocene Ogallala Formation appears to have been penetrated in all three boreholes at depths ranging from 50 to 60 ft. In one borehole, B6B, the "Caprock caliche" was found within the presumed Ogallala section. Overlying the Ogallala Formation (?) is a highly calcareous gleyed silty sand that is most likely an early basin fill (associated with a "proto-playa") into which the modern playa is inset. Depths of first penetration of this unit are relatively constant (33 to 35.5 ft) with perhaps a slight basinward dip. Higher in these sections is the Blackwater Draw Formation, the thickness of which varies from more than 35 ft outside the modern playa to 7.5 ft under the playa center.

Within the area covered by the modern playa, a series of lacustrine and transitional facies were penetrated in boreholes B6 and B6A. A 7.5-ft zone of Blackwater Draw (?) and lacustrine deposits was encountered in B6. In this same borehole, Arch- and Randall-type lacustrine sediments are interbedded through 7.5 ft of section. Randall-type deposits 4.5 to 6 ft thick were cored in B6 and B6A. The Randall- and Arch-type sediments are the true lacustrine facies associated with the modern playa.

The boreholes provide a detailed representation of the playa and its stratigraphic history. Unfortunately, the available data do not permit a clear interpretation of the mechanisms responsible for development and maintenance of the playa as a depositional setting. The relatively constant thickness and depth of the "proto-playa" fill in all three boreholes may indicate that the modern playa is inset within an older, larger basin possibly coincident with the breached topographic depression. This would seem to require influence of a continuing or cyclical process such as shallow-focused subsidence. Alternately, deflation could account for thinning of the Blackwater Draw prior to deposition of the true lacustrine facies. This uncertainty could be resolved through additional coring at this playa, perhaps extending to the edge of the surrounding topographic depression.

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REFERENCES

Caran, S. C., McGookey, D. A., and Neck, R. W., 1986, Ground-water lakes--modern and Pleistocene examples from New Mexico and Texas (abs.): Geological Society of America Abstracts with Programs, v. 18, no. 3, p. 214.

Gustavson, T. C., and Holliday, V. T., 1985, Depositional architecture of the Quaternary Blackwater Draw and Tertiary Ogallala Formations, Texas Panhandle and eastern New Mexico: The University of Texas at Austin, Bureau of Economic Geology Open-File Report OF-WTWI-1985-23, 60 p.

Holliday, V. T., 1985, Holocene soil-geomorphological relations in a semi-arid environment--the Southern High Plains of Texas, in Boardman, J., ed., Soils and Quaternary landscape evolution: New York, John Wiley, p. 325-357.

Machette, M. N., 1985, Calcic soils of the southwestern United States, in Weide, D. L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21.

Raney, J. A., Gustavson, T. C., and Caran, S. C., 1987, Geologic review of proposed Amarillo-area site for the Superconducting Super Collider (SSC): The University of Texas at Austin, Bureau of Economic Geology, 22 p.

Schwiesow, W. F., 1965, Playa lake use and modification in the High Plains, in Studies of the playa lakes in the High Plains of Texas: Austin, Texas Water Development Board Report 10, p. 1-8.

Soil Survey Staff, 1951, Soil Survey manual: Washington, D. C., U.S. Department of Agriculture, Soil Conservation Service, 503 p.