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NEUTRON PROBE SOIL WATER DATA CORRECTION AND PROBE RECALIBRATION

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ABSTRACT

Soil water at the Pawnee Site has been measured since 1969 using neutron probe subsurface moisture probes. Probes were calibrated at the beginning of the experiment. However, discrepancies in summarized data beginning in 1974 led to the conclusion that the probes needed recalibration and the inconsistent data needed correction. This paper presents the correction techniques and recalibration methods used.

Soil water at the Pawnee Site has been measured with neutron probes since 1969. The Pawnee Site (the northern shortgrass prairie site) is the field research facility of the Natural Resource Ecology Laboratory, Colorado State University, and is located on the USDA Agricultural Research Service Central Plains Experimental Range in northeastern Colorado. The experiment was designed by Galbraith (1969) for use on treatments 1, 2, 3, and 4. Soil water has been measured since 1971 on the environmental stress plots using the same method.

PROBE CALIBRATION

Four Nuclear Chicago neutron probes (Texas Nuclear Corporation) labelled 34, 66, 81, and 86 were calibrated to soil water at the Pawnee Site using two methods (Galbraith 1969). Probe 66 was calibrated directly to soil water by sampling with the neutron probe and gravimetrically. Calibration equations relating neutron counts for probe 66 to soil water were developed with this method. Probes 34, 81, and 86 were calibrated to probe 66 by determining calibration curves with polyethylene standards and by deriving an equation for each probe which converts neutron counts to equivalent counts in terms of probe 66. Soil water can then be determined using the equations for probe 66.

Discrepancies in the Data

Beginning in 1974, sudden increases or decreases occurred in summarized data at the 60 to 120 cm layer on the Environmental Stress Area (ESA) treatments (Fig. 1, 2, and 3). These shifts occurred when natural events could not explain the changes in soil water. Also, the discrepancies were apparent not only on the control and unirrigated treatments, but also on the treatments where soil water is held relatively

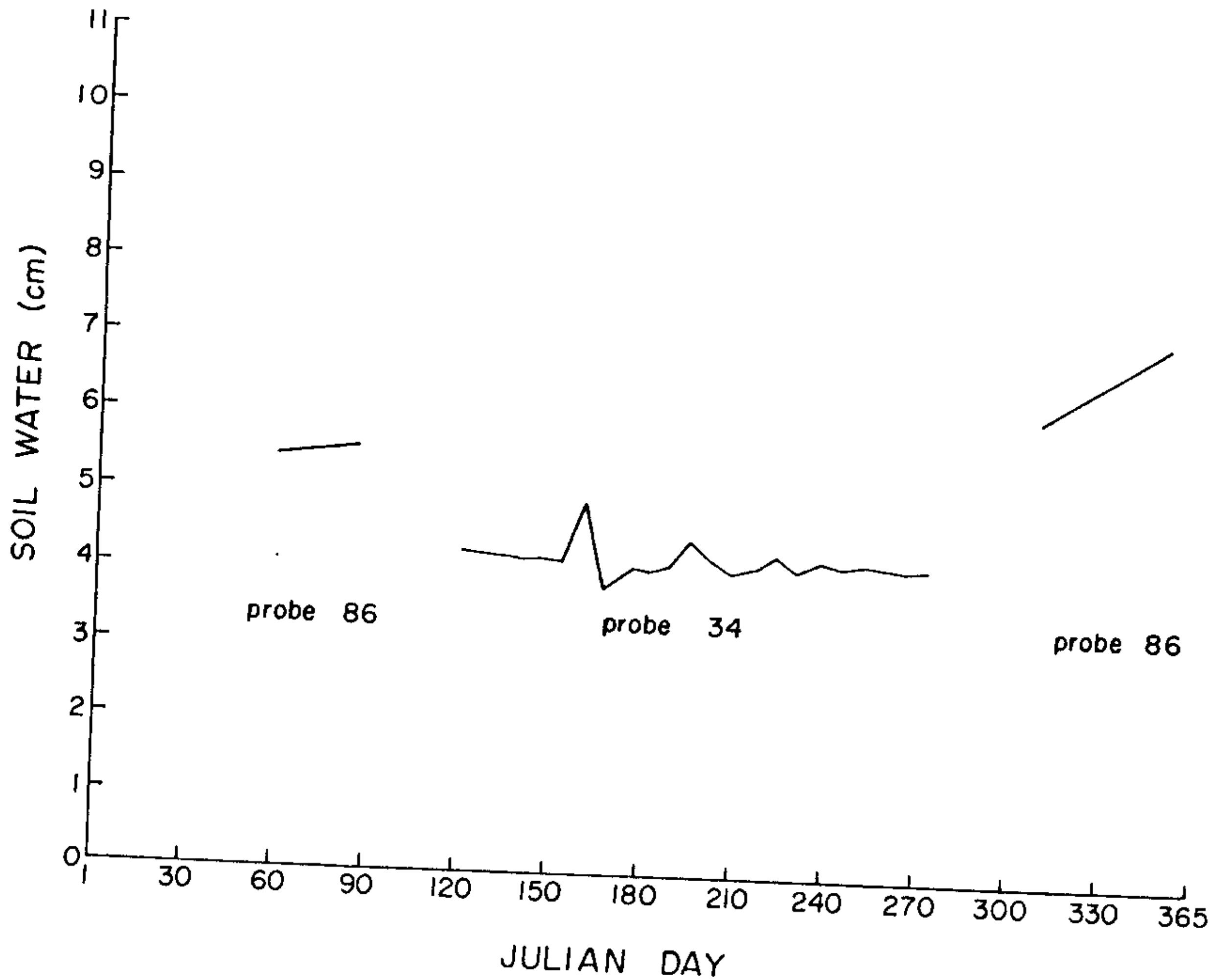

Fig. 1. Uncorrected soil water, 60-120 cm, Treatment D, 1974.

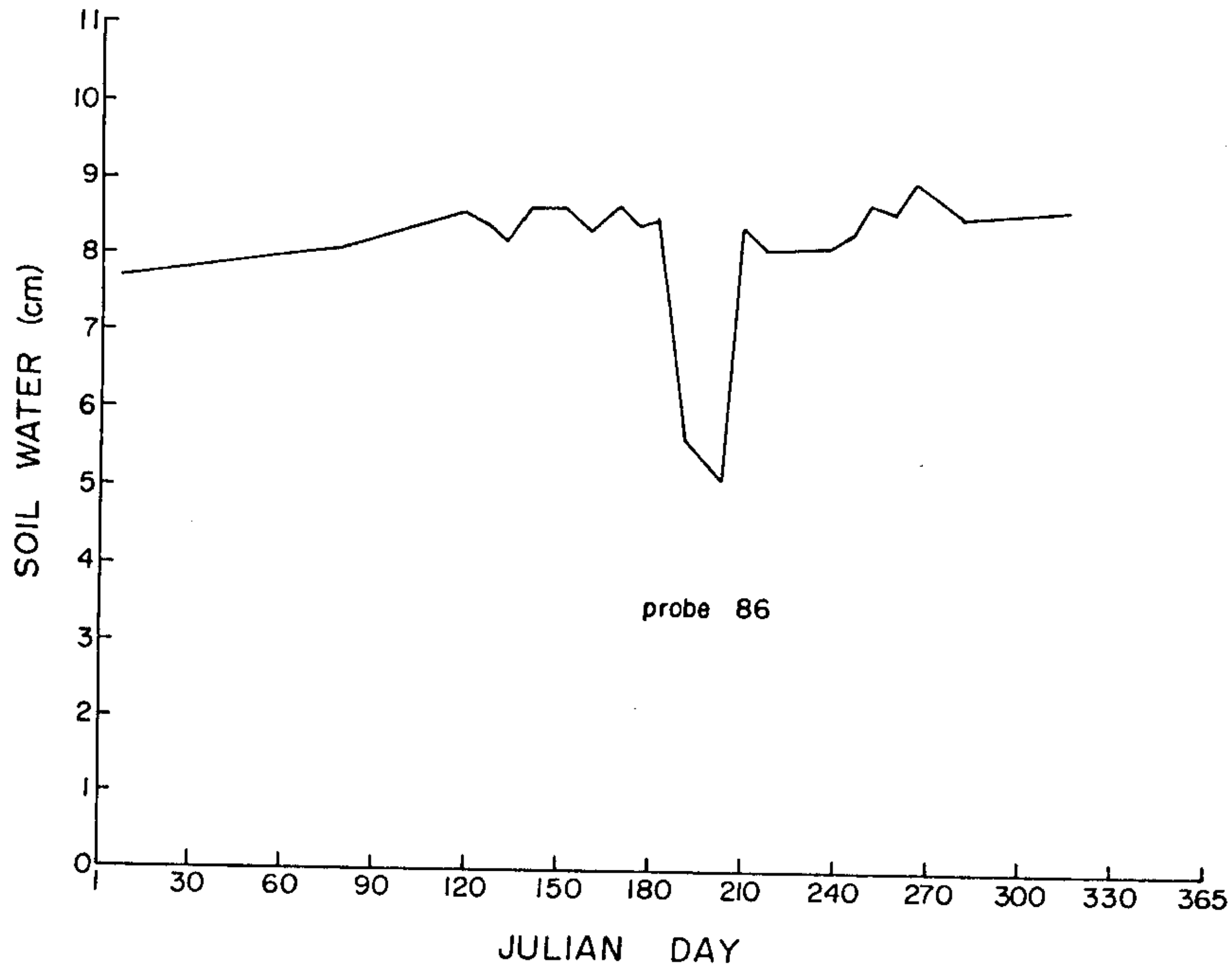

Fig. 2. Uncorrected soil water, 60-120 cm, Treatment D, 1975.

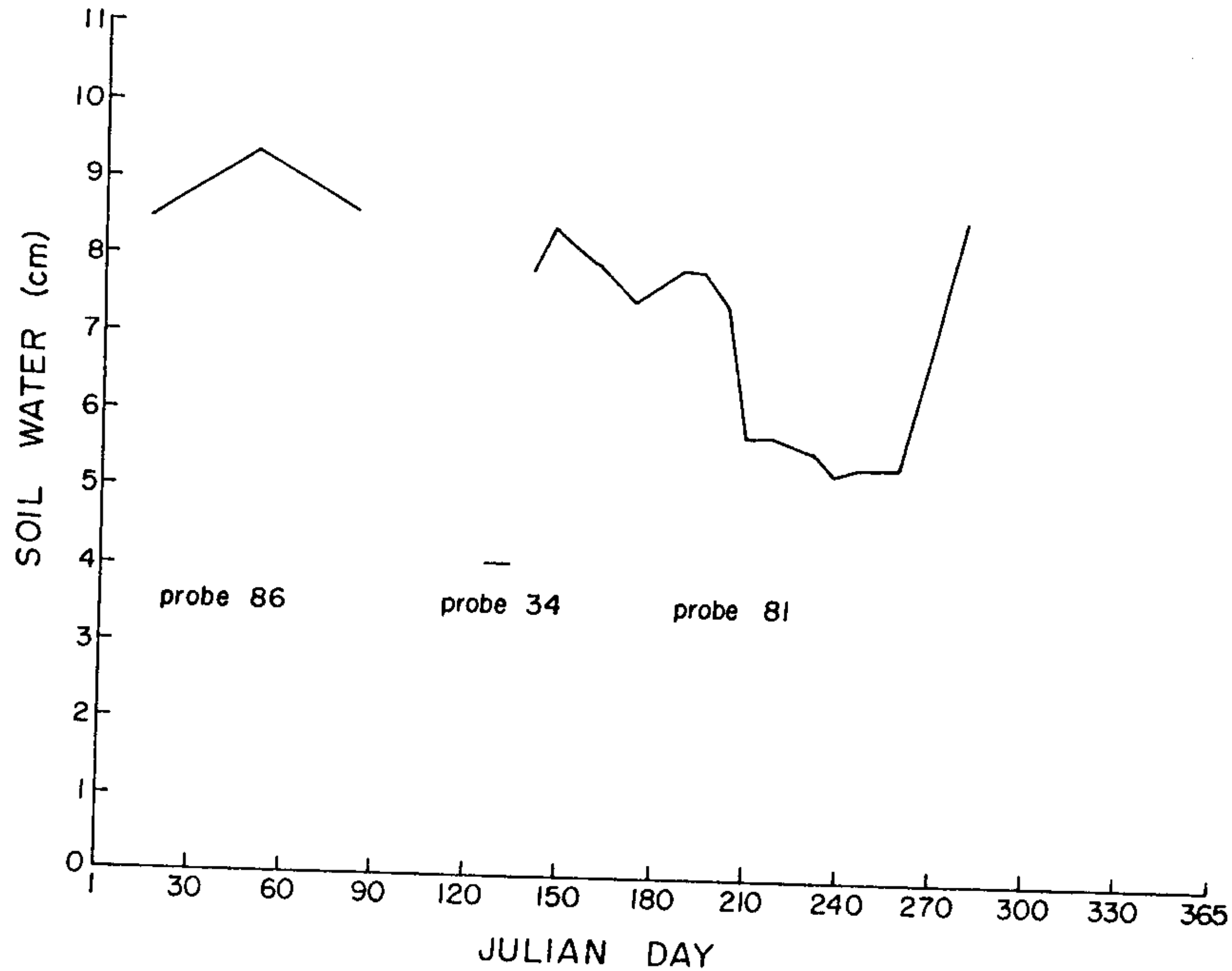

Fig. 3. Uncorrected soil water, 60-120 cm, Treatment D, 1976.

constant by irrigation. Figures 1, 2, and 3 illustrate the fact that soil water changed suddenly not only when probes were changed but also when only one probe was being used.

Correction of the Data

In April 1977 probes 34, 81, and 86 were recalibrated. Shield counts (Texas Nuclear Corporation) were taken at various voltages and the points plotted. Figures 4, 5, and 6 illustrate the voltage vs. shield count curves. Probes 34, 81, and 86 are operated at 1400, 1200, and 1200 volts, respectively. A plateau exists for each probe in which a substantial change in operating voltage will not cause a corresponding significant change in neutron counts. The operating voltage for probes 81 and 86 of 1200 volts is located at the edge of their respective voltage plateaus. In this situation, a small increase in operating voltage could substantially change the neutron count response of the probe and consequently the estimate of soil water. We feel that incorrect voltage settings of probes 81 and 86 are the major cause of errors in soil water data. It became apparent that voltage errors were probable when the field technician related that the voltage setting for each probe is obtained by the coarse adjustment on the instrument and that the fine adjustment may have been ignored. The fine adjustment could increase voltage as much as 100 volts. Also, on at least one occasion when the probes were brought to the lab, the fine voltage adjustment on the scaler was set at 80 volts which would not have been correct for any of the probes.

Calibrations at several voltages using polyethylene standards were taken for each of the probes. Although the voltage vs. neutron counts curve is nonlinear at the edges of the voltage/counts plateau

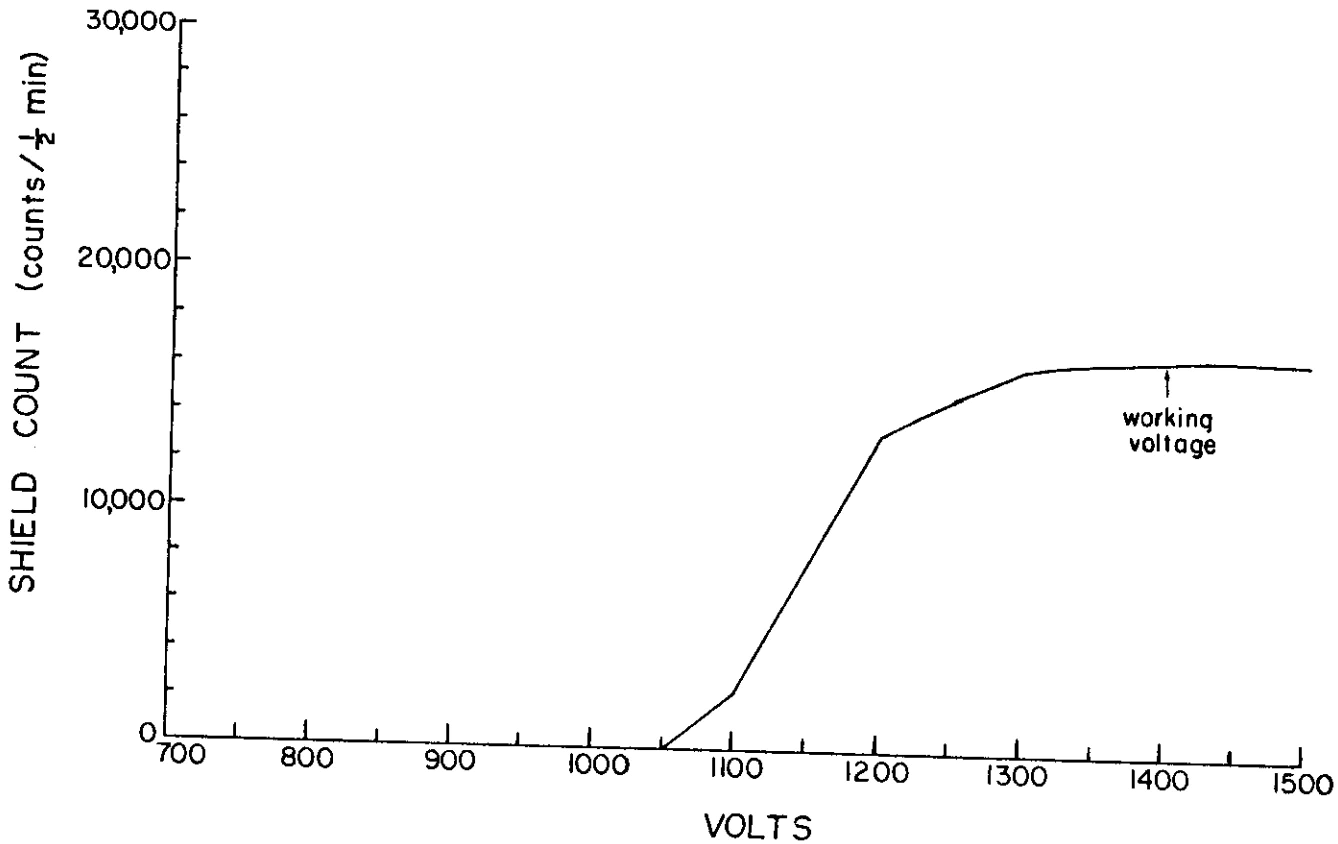

Fig. 4. Probe 34, shield count vs. voltage.

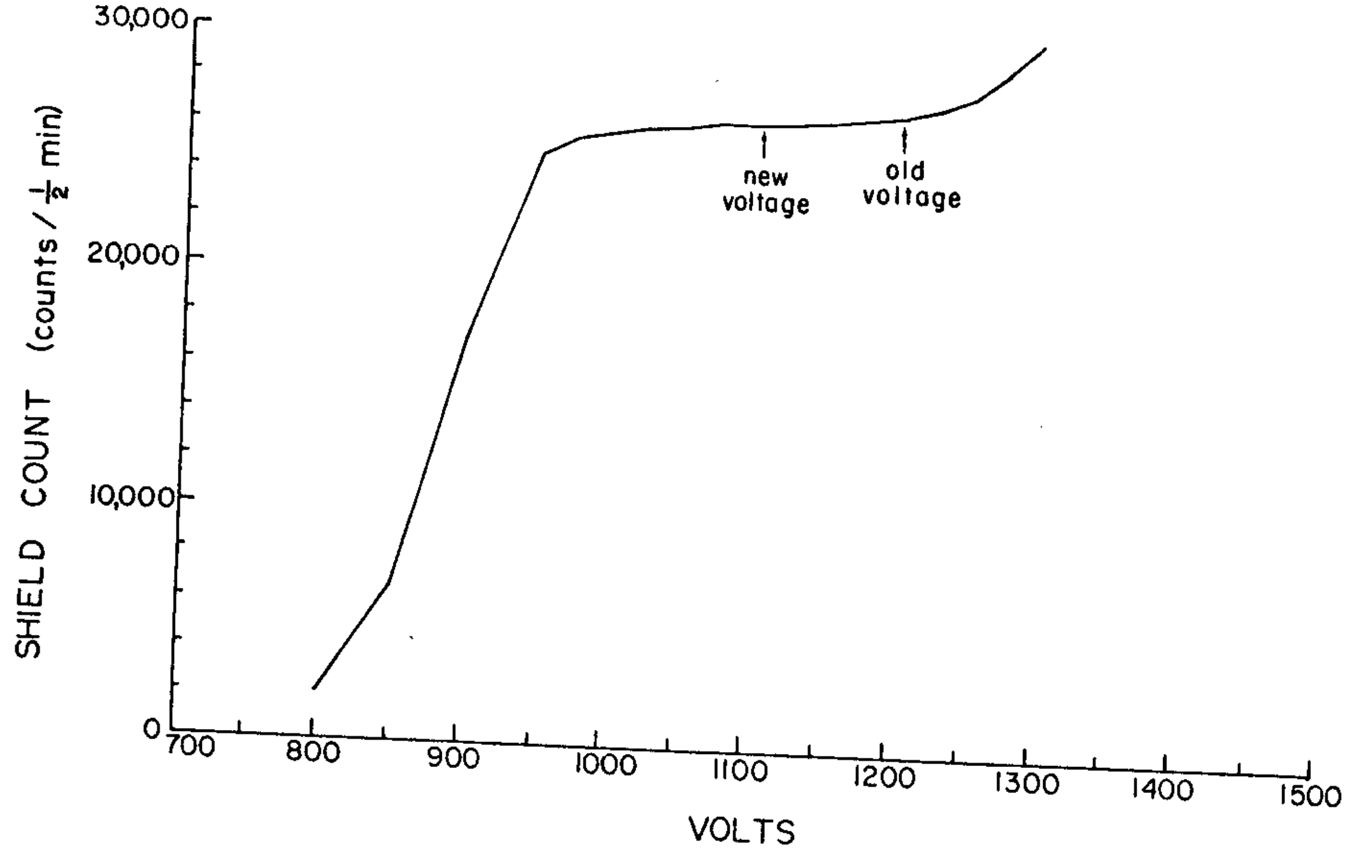

Fig. 5. Probe 81, shield counts vs. voltage.

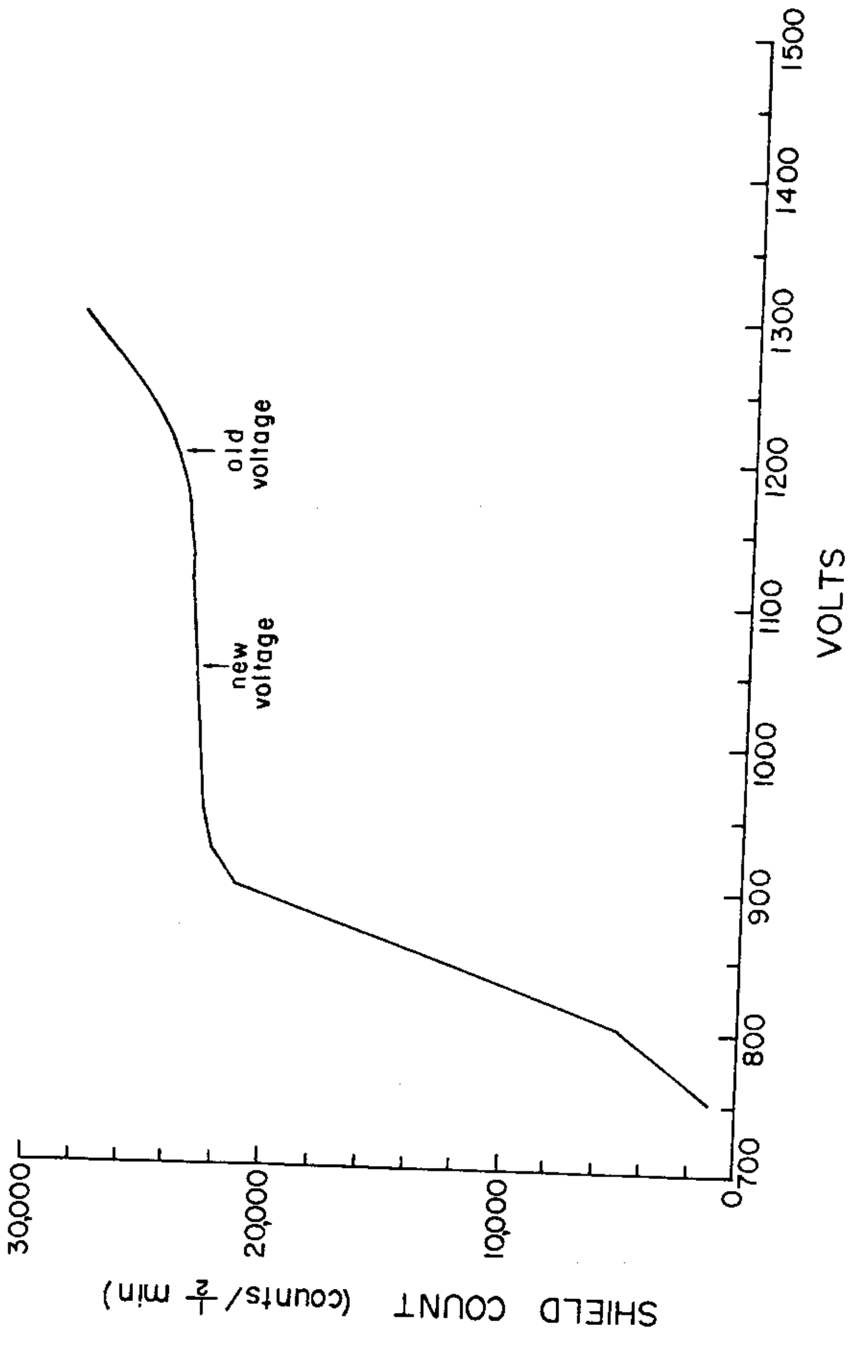

Fig. 6. Probe 86, shield count vs. voltage.

(Fig. 4, 5, and 6), the difference in counts response between two fixed voltage settings throughout the water range represented by polyethylene standards is constant (Fig. 7, 8, and 9). Therefore, a correction factor can be introduced into the calibration equations to adjust neutron counts when an incorrect voltage has been used. The correction factor (CF) is defined as follows:

$$CF = S_A - S_S,$$

where S_A = actual shield count read for the probe at the time the data were taken, and

S_S = standard shield count determined for the probe from data taken during the years 1971-1973 when inconsistent data did not occur.

The actual counts can then be adjusted before conversion to probe 66 counts by the following equation:

$$\text{Counts} = \text{Actual counts} - CF$$

The correction factor is applied to a sample when the actual shield count deviates from the standard shield count by more than 5%. Data summaries were run at values of 3%, 4%, and 5% with the latter value chosen as the cutoff point. The operating manual for the neutron probe suggests a cutoff value of 3% when counting time is one minute (Texas Nuclear Corporation 1968). However, 5% was chosen as the cutoff point because of the greater variability in neutron counts taken in the field as the result of a 0.5 minute counting time. Figures 10, 11, and 12 represent 60 to 120 cm soil water corrected and uncorrected for 1974-1976.

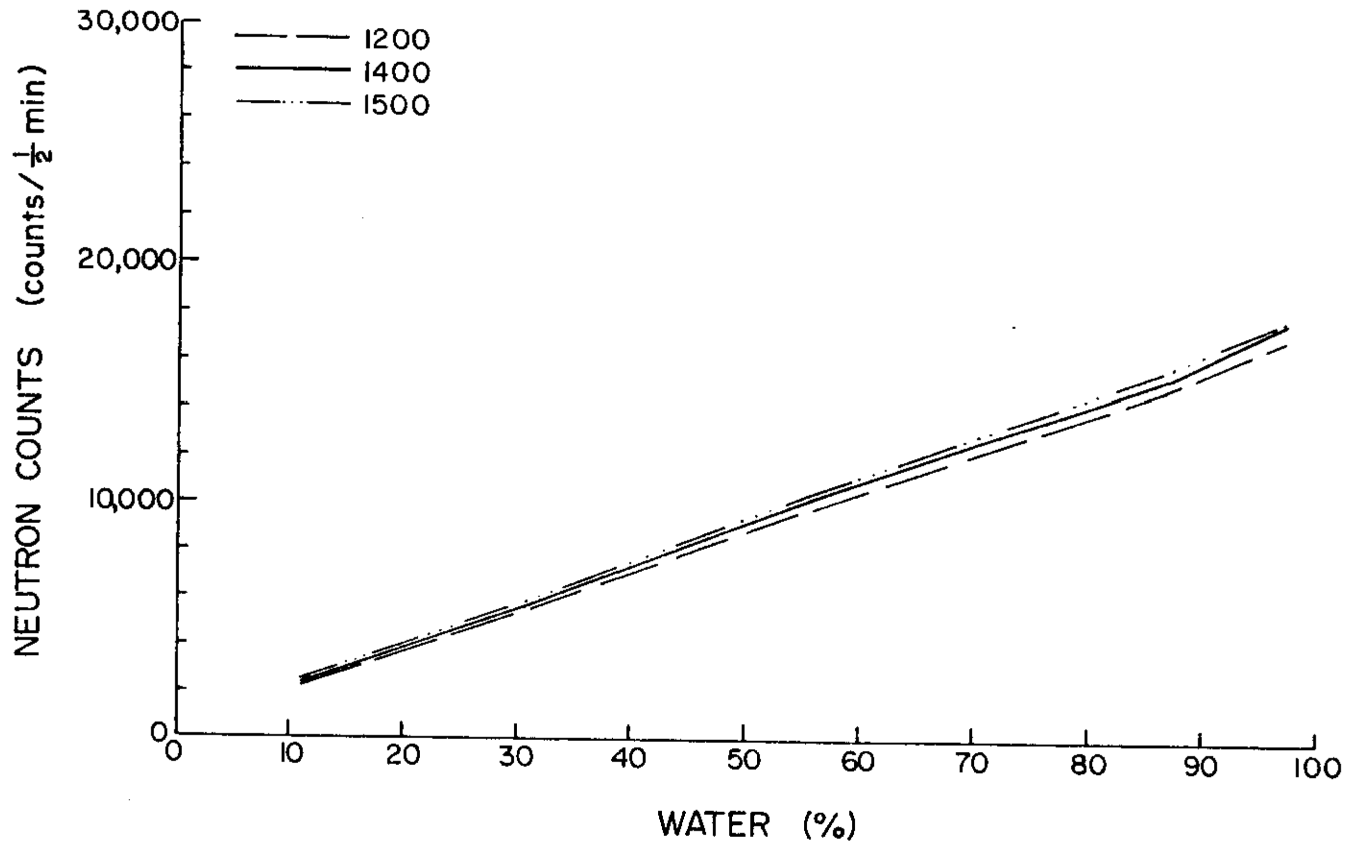

Fig. 7. Neutron counts vs. percent water represented by polyethlene standards, probe 34.

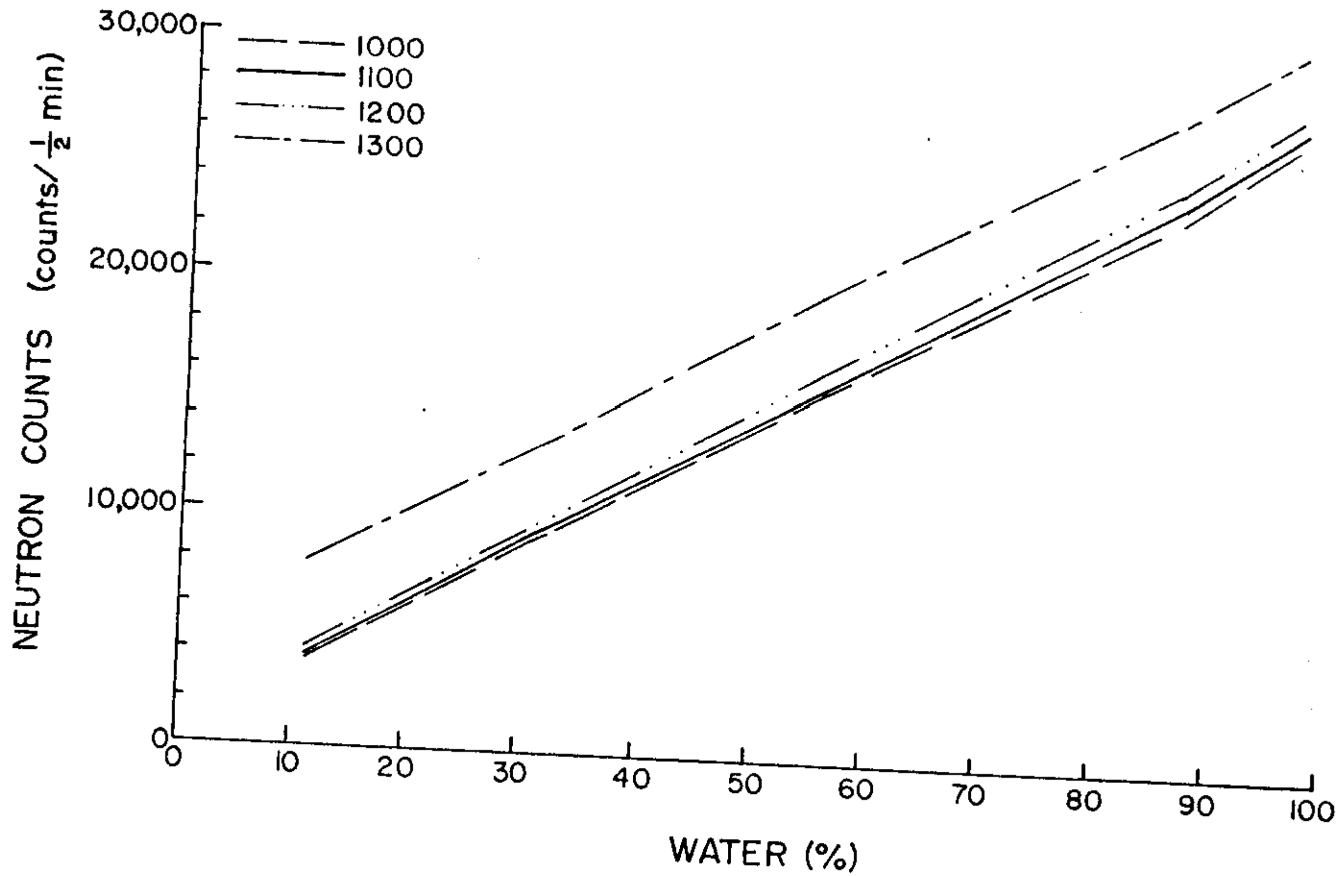

Fig. 8. Neutron counts vs. percent water represented by polyethlene standards, probe 81.

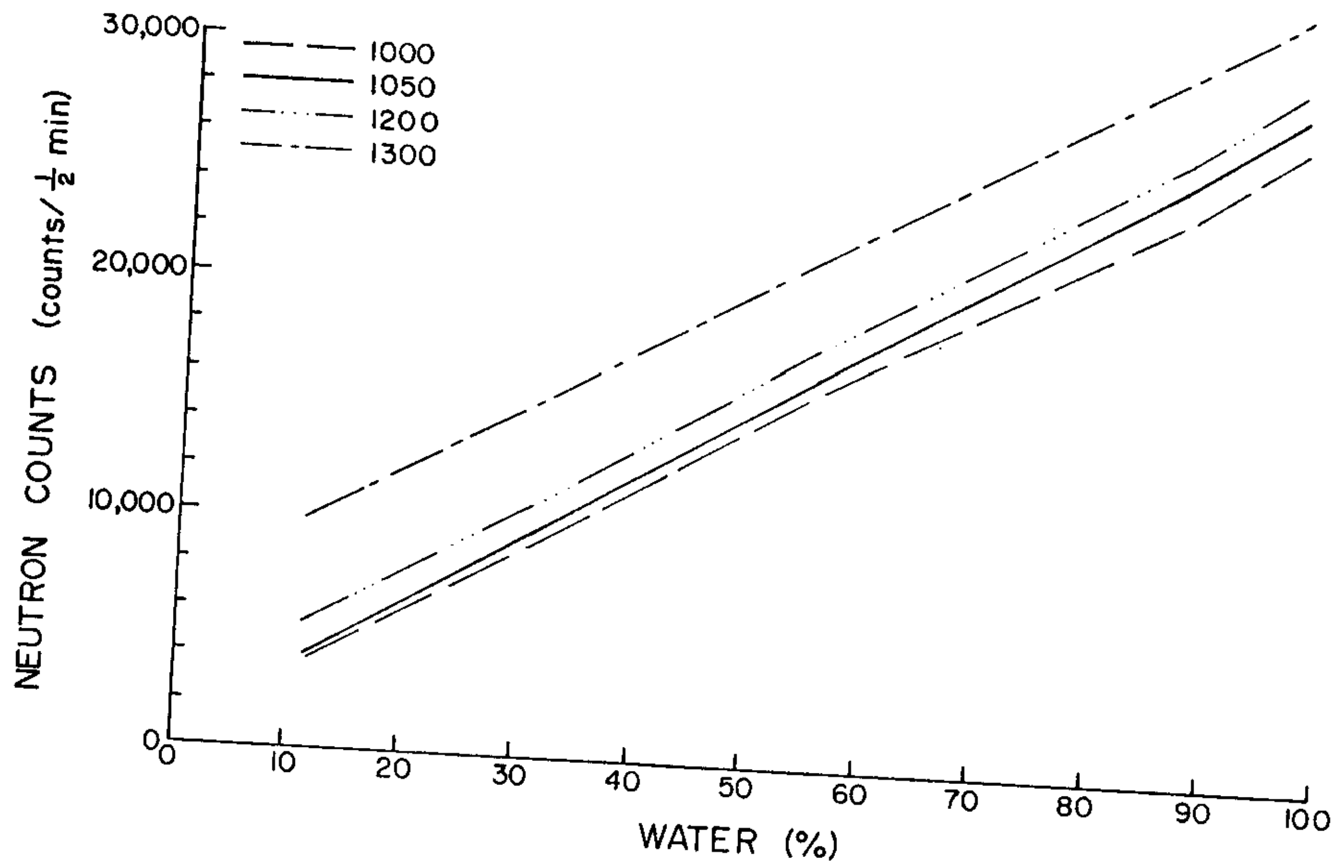

Fig. 9. Neutron counts vs. percent water represented by polyethlene standards, probe 86.

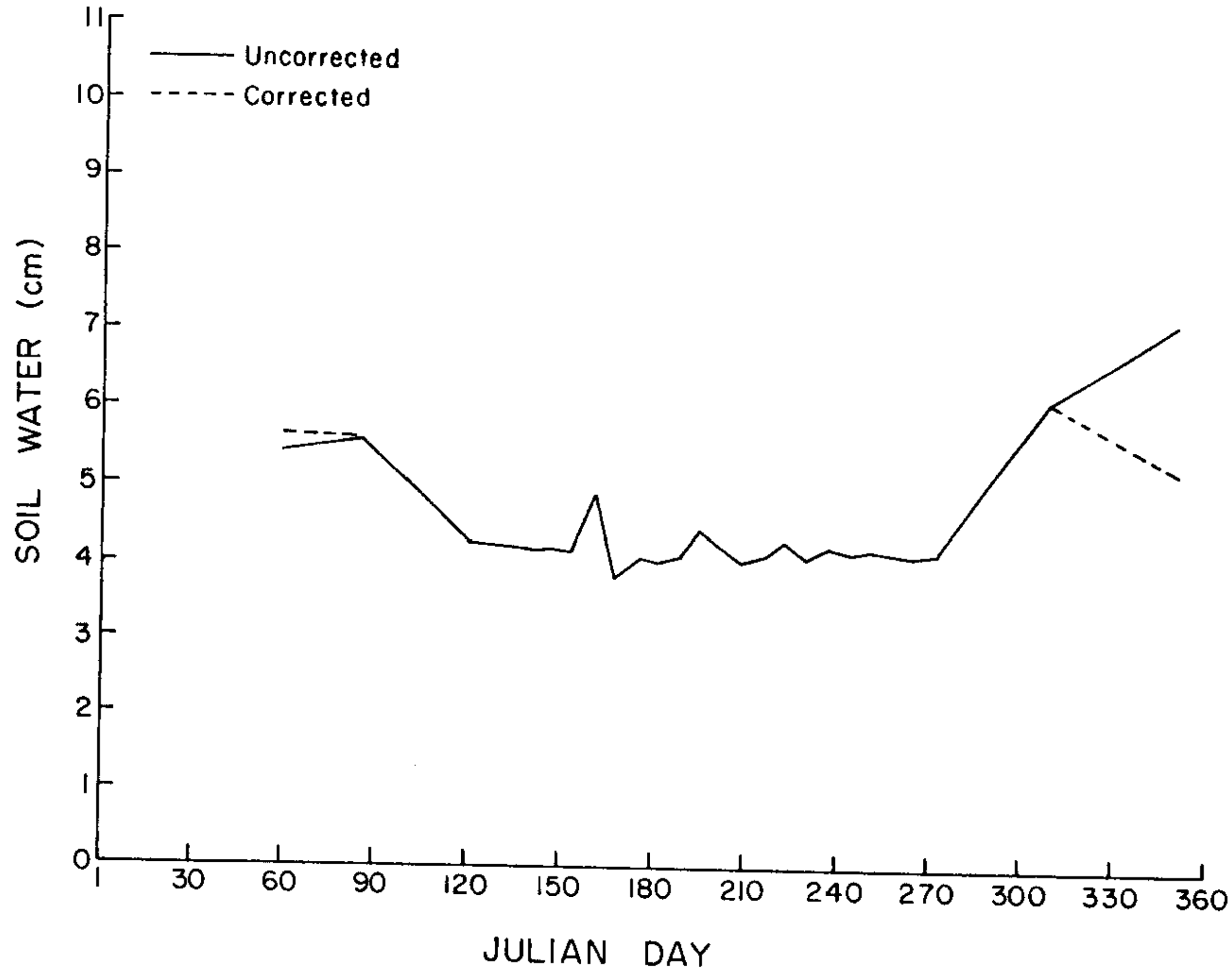

Fig. 10. Corrected and uncorrected soil water, 60-120 cm, Treatment D, 1974.

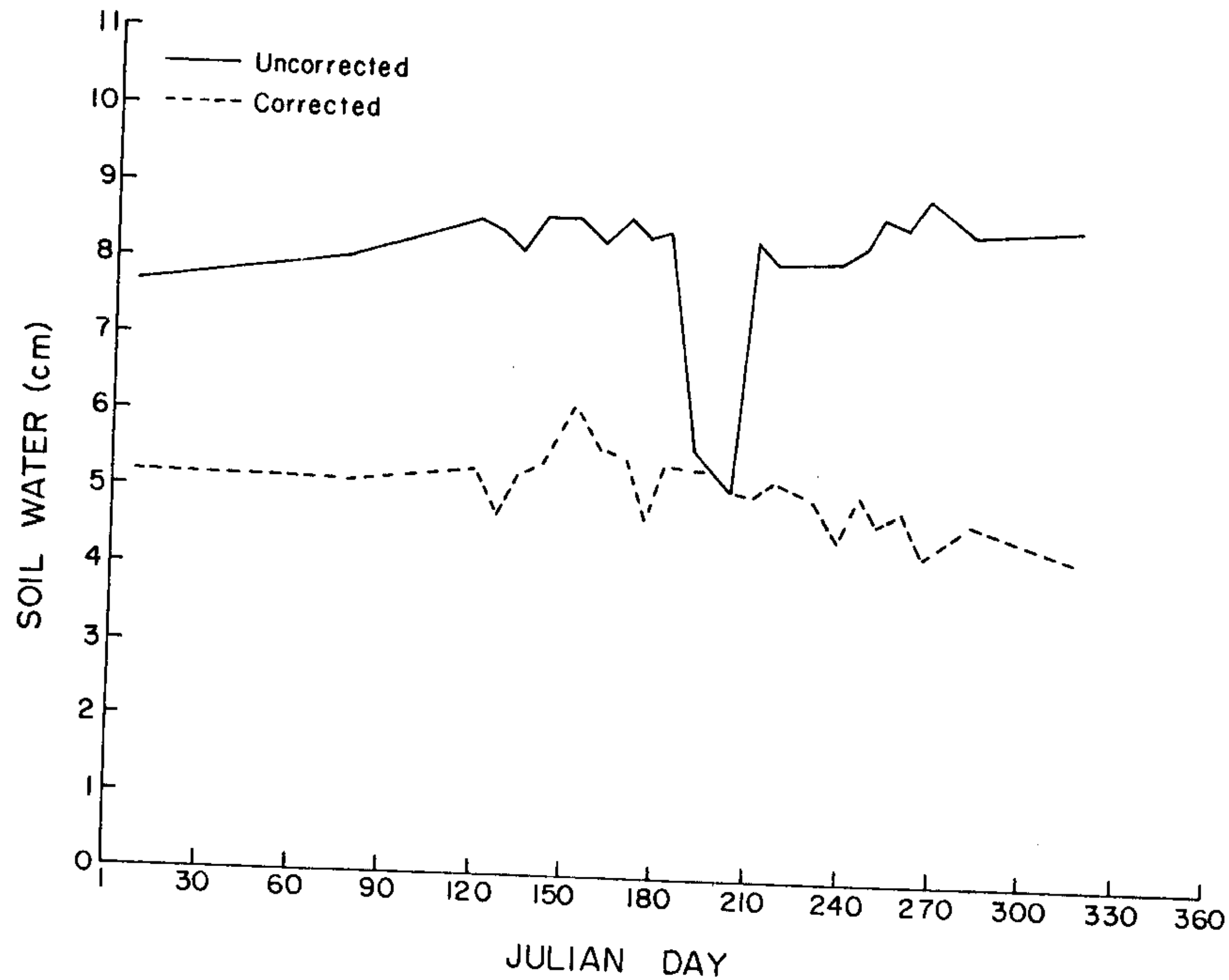

Fig. 11. Corrected and uncorrected soil water, 60-120 cm, Treatment D, 1975.

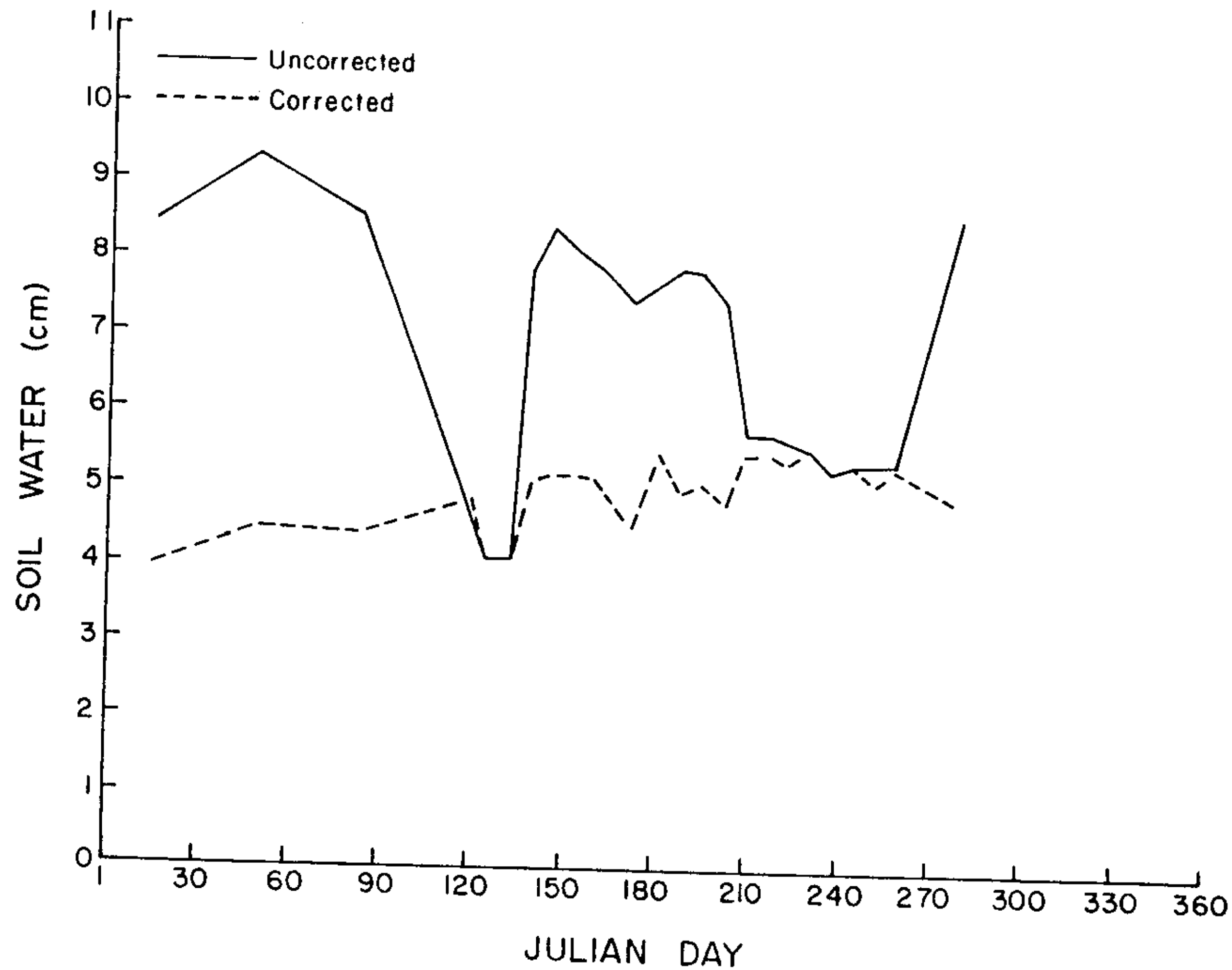

Fig. 12. Corrected and uncorrected soil water, 60-120 cm, Treatment D, 1976.

Recalibration of the Probes

Since the shield counts for probes 81 and 86 were located at the edge of the voltage/shield count plateau, it was evident the probes should be recalibrated at a voltage centered in the plateau.

Probes 81 and 86 were calibrated at 1100 and 1050 volts, respectively; probe 34 remained at 1400 volts. Counts were taken using polyethylene standards and equations derived converting counts to equivalent counts in terms of probe 66. Probe 66 was irreparably damaged in 1971. Gravimetric calibration of one of the remaining probes would involve much time and expense. Therefore, we feel the calibrations to probe 66 gravimetric equations should be used. The equations are as follows:

Probe 34

Old: $C_{66} = C_{34} * 1.587 + 193.$

New: $C_{66} = C_{34} * 1.5344 + 56.$

Probe 81

Old: $C_{66} = C_{81} * 1.005 - 134.$

New: $C_{66} = C_{81} * 1.005 - 818.$

Probe 86

Old: $C_{66} = C_{86} * .97 - 276.$

New: $C_{66} = C_{86} * .9559 - 536.$

Comparison of the new and old calibration equations shows that they changed very little. Statistical comparison of the coefficient terms using neutron count responses from the five polyethlene standards showed no significant differences between the old and new coefficients. The major adjustment is the intercepts for probes 81 and 86 which are due to the new operating voltages specified for these probes.

Data collected from 1974 to March 1977 will be corrected using the correction factor method described on page 12 of this report. Data collected after 1 April 1977 will be summarized using new calibration equations. Correction factors based on standard shield counts determined when the probes were recalibrated will adjust the data if any errors occur. The error will be flagged so a close inspection may be made of the raw data.

The correction to neutron probe soil water data has been done only on data collected on the environmental stress plots at the Pawnee Site. Since the same methods and instruments are used to collect data for treatments 1, 2, 3, and 4 at the microwatersheds, it is probable a correction of these data will also be needed. The correction technique presented in this paper will also be used for these treatments.

LITERATURE CITED

Galbraith, A. F. 1969. Soil water study of a shortgrass prairie ecosystem, Pawnee Site. US/IBP Grassland Biome Tech. Rep. No. 6. Colorado State Univ., Fort Collins. 51 p.

Texas Nuclear Corporation. 1968. Operation and maintenance manual, Nuclear Chicago Model 5810 subsurface moisture probe. Texas Nuclear Corp., Austin. 21 p.