
SOIL MOISTURE INVESTIGATIONS AT *NEOTOMA*, A FOREST BIOCLIMATIC LABORATORY IN CENTRAL OHIO[1]

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One of the many items of ecological import studied at the *Neotoma* bioclimatic laboratory during the past several years has been the soil moisture relations of opposing slope and ridge top forests and open valley habitats. Since the vegetation of *Neotoma*, as well as the specific sites presently being investigated, has previously been reported (Wolfe et al., 1949; and Wolfe and Gilbert, 1956), the following brief descriptions of the vegetation dominating the habitats in which soil moisture studies have been conducted appear sufficient for the purpose of this paper.

Lower northeast facing slope (*station #1, fig. 1*).—The vegetation of this habitat is a relatively young mixed mesophytic forest (undisturbed at the time of this writing for a minimum of 35 years) with a distinct shrub layer and luxuriant groundcover. The canopy is dominated by a variety of species including Beech (*Fagus grandifolia*[2]), Tuliptree (*Liriodendron tulipifera*), Red Maple (*Acer rubrum*), White Oak (*Quercus alba*), Red Oak (*Q. rubra*), Chestnut Oak (*Q. prinus*), Sugar Maple (*A. saccharinum*), White Ash (*Fraxinus americana*), and Black Cherry (*Prunus serotina*), among others.

Southwest facing slope (*station #3*).—The vegetation of this slope was originally dominated by Oak and Chestnut. With the death of Chestnut and subsequent lumbering there has developed on this site a secondary forest of mixed oak and hickory, also undisturbed for a minimum of 35 years. Dominant canopy species include Chestnut Oak, Black Oak (*Q. velutina*), White Oak, Scarlet Oak (*Q. coccinea*), Sweet Pignut Hickory (*Carya ovalis*), and Pignut Hickory (*C. glabra*).

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[2]Nomenclature essentially that of Gray's Manual of Botany, 8th edition (Fernald 1950).

The shrub layer is poorly developed and is underlain by a depauperate ground-cover and a soil surface approximately 50 percent devoid of leaf litter.

Open valley.—The vegetation of the narrow valley of *Neotoma* was destroyed many years ago, and with subsequent pasturing there has developed the present treeless community dominated by Blue Grass (*Poa pratensis*), Asters (*Aster* spp.), Goldenrods (*Solidago* spp.), and, in slight depressions, Rushes (*Juncus* spp.). A number of common Ohio weeds frequently occur throughout the community. Pasturing was terminated one year prior to these investigations.

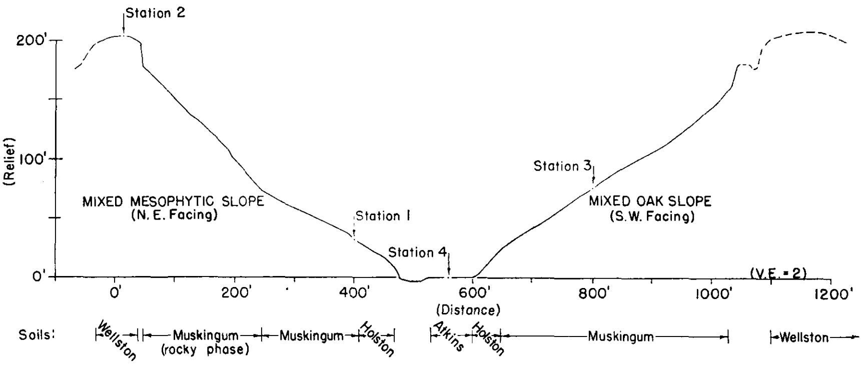

FIGURE 1. Cross section of *Neotoma* valley showing location of bioclimatic stations and distribution of major soil types.

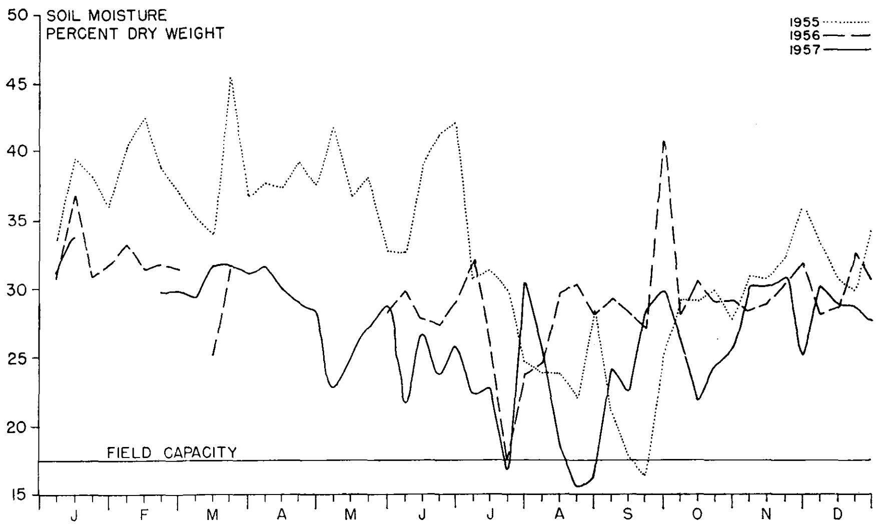

FIGURE 2. Annual soil moisture regimens of the one to three inch depth of Atkins Silt Loam of valley bottom (station #4).

Western ridge top (*station #2*).—A relatively open forest community of Chestnut Oak, with Black Oak as a common associate, dominates the narrow western ridge top of *Neotoma* where a major part of the present bioclimatic studies is being conducted. However, since soil moisture studies at this site at the time of this writing have been underway for only a few months, a discussion of the moisture relations of this habitat must necessarily come at a later date.

CLASSIFICATION OF *NEOTOMA* SOILS

The major soil types transecting the central portion of *Neotoma* valley, where present bioclimatic studies are being emphasized, are as follows (fig. 1).

Wellston silt loam.—A brown, acid, permeable, well-drained soil dominating opposing ridge tops, and believed developed from approximately two ft of loess material overlying an even-textured sandstone bedrock. The general profile and certain horizon characteristics at station #2 are as follows:

Ao. A relatively thick and evenly distributed layer of leaves, largely of Chestnut Oak.

Ao_1. One-fourth to one-half in. in thickness.

Ao_2. A matted complex of roots and well-decayed organic matter ranging from one-half to one and one-half in. in thickness, frequently light gray to near white due to leaching and abundant fungal filaments.

A_2. A pale brown silt loam approximately five in. in thickness and gradually grading into B_1 horizon.

B_1. A yellow-brown fine silt loam approximately six to seven in. in thickness.

B_2. A dark yellow-brown coarse silty clay loam nine to ten in. in thickness, and underlain by a solid floor of even-textured brown sandstone.

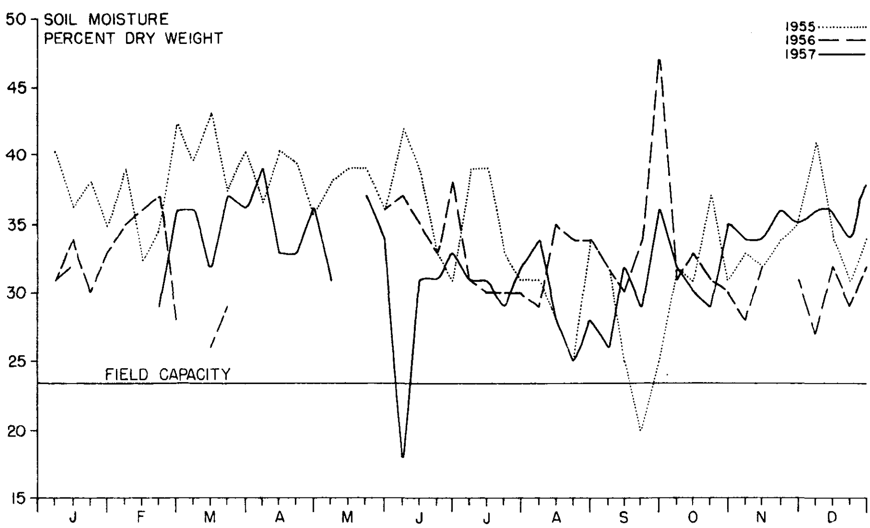

FIGURE 3. Annual soil moisture regimens of the six to nine inch depth of Atkins Silt Loam of valley bottom (station #4).

The profile is well penetrated with roots ranging from less than one mm to approximately five cm in diameter, many extending to and distributed horizontally upon the sandstone bedrock. Underground stems of *Smilax rotundifolia* are also common throughout most of the profile.

Muskingum fine sandy loam.—The most prevalent soil type of *Neotoma*, dominating most of the opposing slopes and with the following specific profile characteristics at bioclimatic stations #1 and #3.

Station #1, mixed mesophytic forest.

Ao. Well developed and generally distributed leaf litter.

A_1. Zero to five in. Dark, near black, fine sandy loam with numerous fine roots in upper part. Lower two in. with abundant rock fragments of pebble size.

A_2. Five to 12 in. Pale brown fine sandy loam with many roots.

B_1. Twelve to 20 in. Yellow-brown loam with many roots.

B_2. Twenty to 36 in. Dark yellow-brown loam with few roots, and underlain by mottled silty material.

Station #3, mixed oak forest.

Ao. Zero to one-half in. Dark, near black, morlike organic layer.

A_1. One-half to two in. Dark, near black, sandy loam high in organic matter with many fine roots.

A_2. Two to 14 in. Pale yellow-brown loam with abundant roots.

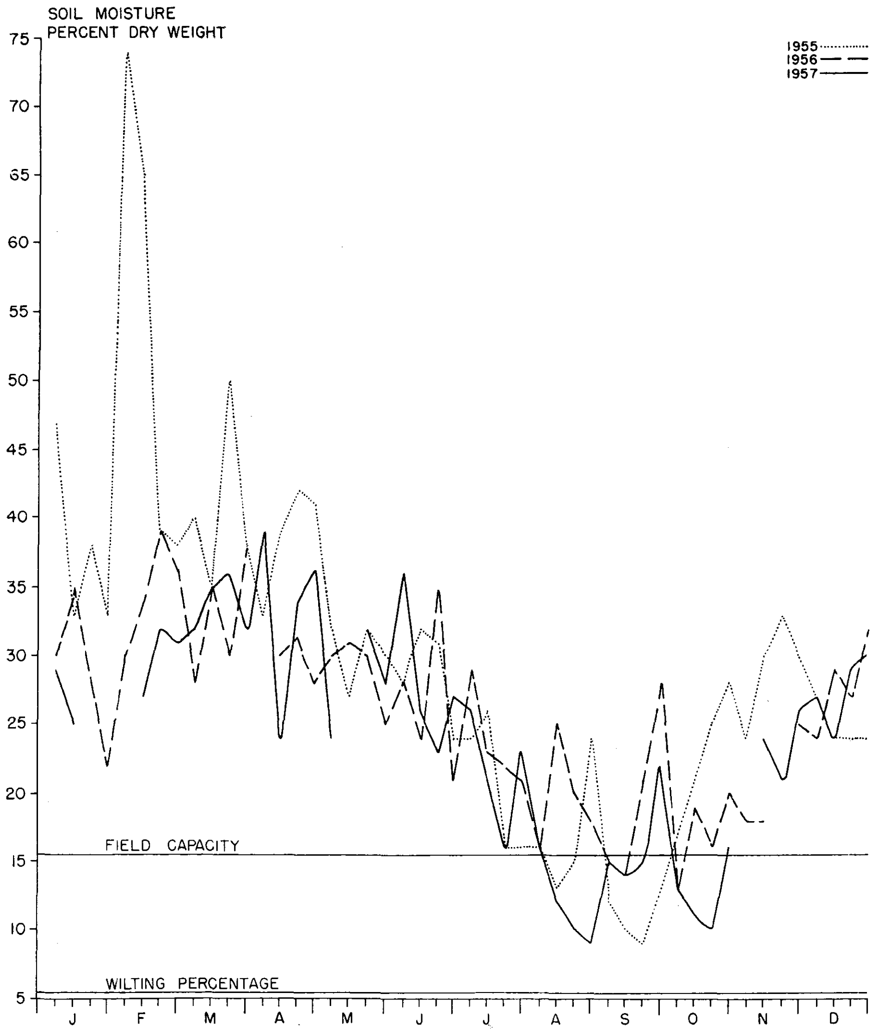

FIGURE 4. Annual soil moisture regimens of the one to three inch depth of Muskingum Silt Loam underlying mixed mesophytic forest at station #1.

B. Fourteen to 28 in. Dark brown loam with many rock fragments and few roots.

C. Sandstone bedrock, frequently fragmented.

Muskingum sandy loam (*rocky phase*).—Much the same as Muskingum Fine Sandy Loam, but with extreme rockyness near the surface. Most prevalent on the upper relatively steep north-east facing talus slope.

Holston silt loam.—A yellow-brown, moderately heavy, acid terrace soil developed from laminated silt and clays believed deposited during ponding resulting from damming of local drainage by Illinoian glacial outwash. Occurs sporadically along lower elevations of both slopes.

Atkins silt loam.—A relatively complex soil derived from stratified alluvium and occurring in the poorly drained valley bottom. Profile characteristics of this soil at one site are as follows:

Horizon 1. Sod, from zero to three-fourths in. A matted complex largely composed of stems and roots of Blue Grass, Asters, and Goldenrods.

Horizon 2. A fine silt loam occurring from the above and varying in thickness to a depth of approximately two in. An evenly dark brown soil some

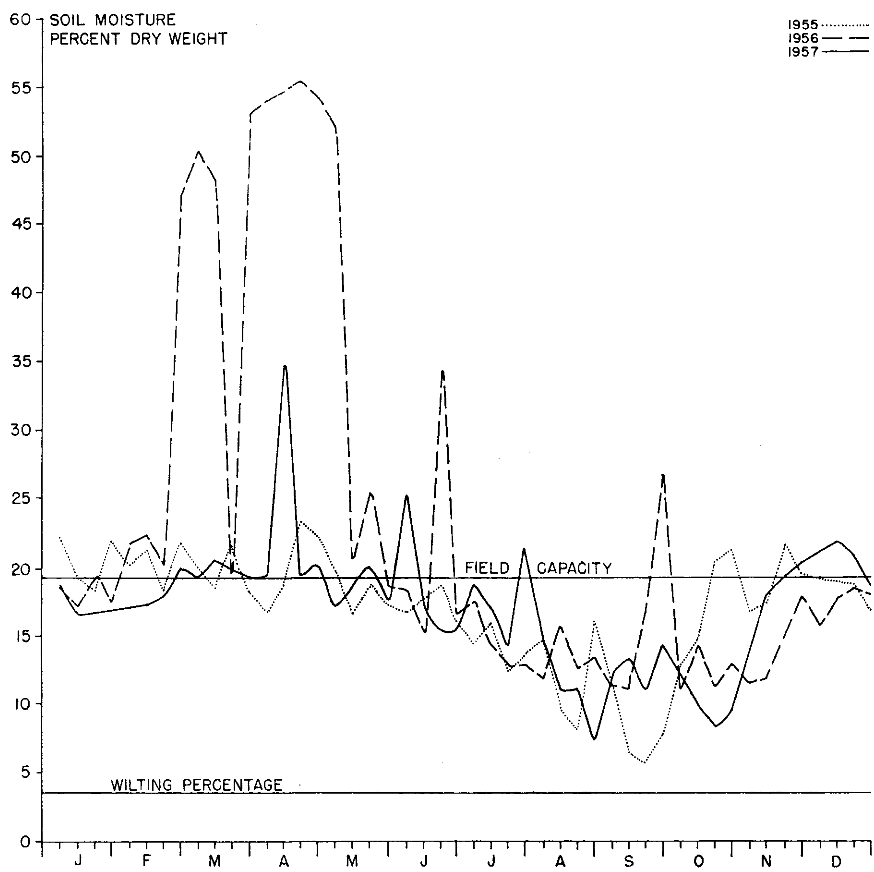

FIGURE 5. Annual soil moisture regimens of the six to nine inch depth of Muskingum Silt Loam underlying mixed mesophytic forest at station #1.

one in. in thickness and abundantly penetrated by roots with maximum diameters of approximately one mm.

Horizon 3. A silt loam occurring from the above to a depth usually varying from five to six in. Color is dark brown with occasional gray areas and abundant rust-brown mottling. Horizon is well penetrated by fine roots.

Horizon 4. A coarse clay occurring from the above to a depth usually varying from 11 to 14 in. Color is dark blue-gray with occasional rust-brown mottling especially along root channels. Horizon is well penetrated with fine roots, and with occasional roots of approximately one mm diameter.

Horizon 5. A light gray loam occurring from above to a depth of approximately 20 in. and with occasional rust-brown mottling. Roots rare.

Horizon 6. A gray coarse clay loam occurring from above to a depth varying from 26 to 29 in., and with abundant rust-brown mottling. Roots rare.

Horizon 7. A pale brown coarse sand occurring from above to an unknown depth and with occasional gray streaking and orange mottling. Roots absent.

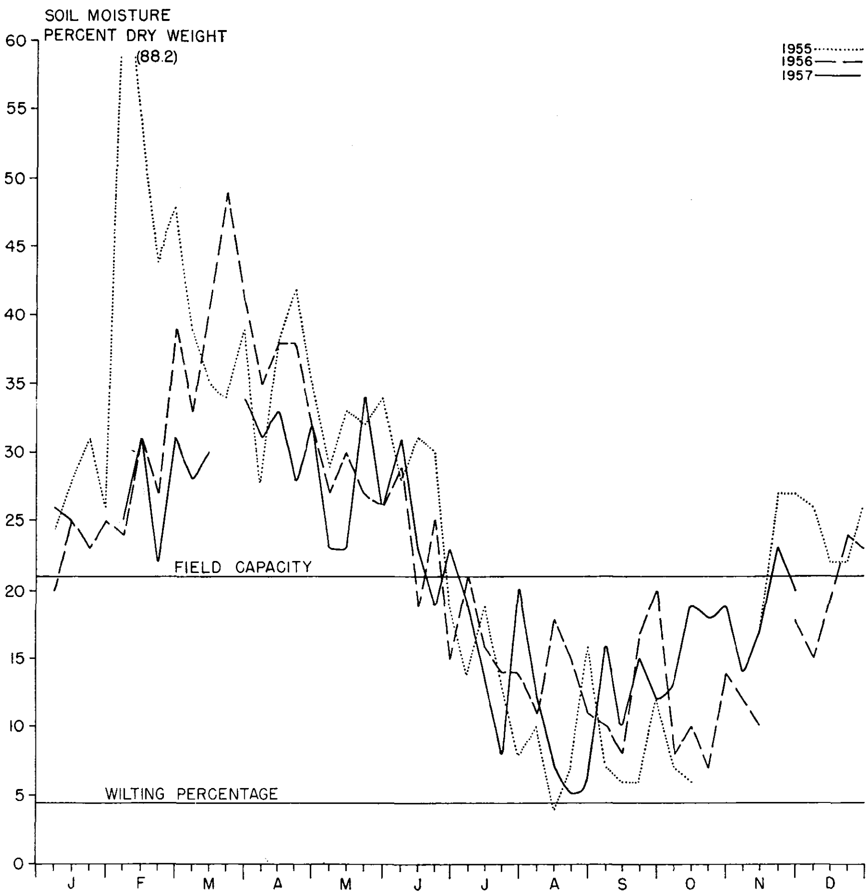

FIGURE 6. Annual soil moisture regimens of the one to three inch depth of Muskingum Silt Loam underlying mixed oak forest at station #3.

SOIL MOISTURE STUDIES

Weekly, occasionally twice weekly, soil moisture sampling was initiated in November, 1954, a minimum of three and a maximum of five random samples being collected at both one to three and six to nine in. depths within the mixed mesophytic and mixed oak transects (station #1 and #3) as well as the valley bottom (station #4).

Individual samples were obtained by a soil tube, usually weighed between 150 and 200 gm, and were dried for a minimum of three days at 105° C. Both plant and pressure membrane tests were utilized in obtaining permanent wilting percentage data; however, since resultant averages were much the same, results of the pressure membrane tests (15 atm) were chosen to represent wilting percentage. Approximate field capacity values of the same soils and depths were obtained by determining moisture retention of samples subjected to a tension of one-third atm. Results of the membrane tests are included in table 1.

Annual patterns of soil moisture on a weekly, occasionally twice weekly, basis for the one to three and six to nine in. levels of the Muskingum Fine Sandy Loam of the sites investigated (stations #1 and #3) and the Atkins Silt Loam of the valley bottom have thus been obtained for the years 1954 to, and including, 1957 and are graphically presented in figures 2 to 7.

TABLE 1

Permanent wilting and field capacity percentages of certain Neotoma *soils as derived by pressure membrane tests*

Type and Location	Depth(in.)	Perm. Wilt.	Field Cap.
Muskingum F. S. Loam			
1. Mixed Oak Slope	1–3	4.5	21.0
(Station #3)	6–9	3.0	18.9
2. Mixed Meso. Slope	1–3	5.5	15.5
(Station #1)	6–9	3.6	19.4
Atkins Silt Loam	1–3	8.4	17.5
(Station #4)	6–9	13.3	23.6

Atkins Silt Loam of Valley Bottom

The major control of soil moisture of this habitat throughout most, frequently all, of the year is an elevated water table which usually occurs at a depth ranging from a few inches to approximately three ft from the soil surface. The near presence of such a saturated soil condition results in soil moisture values usually well above corresponding field capacity values throughout the year (fig. 2 and 3). However, during late summers characterized by relatively little rainfall, lowering of the water table may be sufficient to result in occasional soil moisture values of the sampled levels slightly less than field capacity. However, it appears that during most years rainfall frequency and amount is sufficient to maintain above field capacity values throughout most of the summer, and a drouth of considerable degree would be necessary to reduce soil moisture values to permanent wilting levels.

Muskingum Silt Loam of Mixed Mesophytic Slope at Station #1

1. One to three in. level. With the return of relatively frequent rainfall, usually during October, soil moisture of this layer rapidly increases to and beyond the corresponding field capacity and remains well above this level during the following fall, winter, and spring months (fig. 4). In late May or early June a general decrease in soil moisture usually commences, culminating in minimum values which are usually attained during late August or September. However, these minimum values are well above the permanent wilting percentage and, consequently, little precipitation is required to return the moisture of this level to and above the field capacity level.

2. Six to nine in. level. Weekly soil moisture values of this layer usually increase rapidly during late October or November to field capacity levels and generally remain at this level until the latter part of May or the middle of June, depending upon the amount and distribution of winter precipitation (fig. 5). At this time a marked decrease in weekly soil moisture values begins and usually continues until the latter part of August and September at which time minimum values for this level for the three years here reported were well above the corresponding permanent wilting percentage, indicating an ample plant supply of soil moisture. With the reoccurrence of relatively frequent rainfall, usually during the latter

part of September and October, soil moisture values rapidly return to or near field capacity values.

Muskingum Silt Loam of Mixed Oak Slope at Station #3

1. One to three in. level. With the return of relatively frequent rainfall during October and early November, soil moisture values of this level rapidly increase and by mid or late November have usually not only attained but surpassed corresponding field capacity, and usually remain well above this level until early summer of the following year (fig. 6). A general decrease in weekly soil moisture values of this level usually initiates during mid or late April and by late June or early July has resulted in a reduction of soil moisture to field capacity values. Drying of this soil continues and yearly minimum or near minimum values are usually first attained in mid August, usually being at or within several percentage units above permanent wilting percentage. During most summers

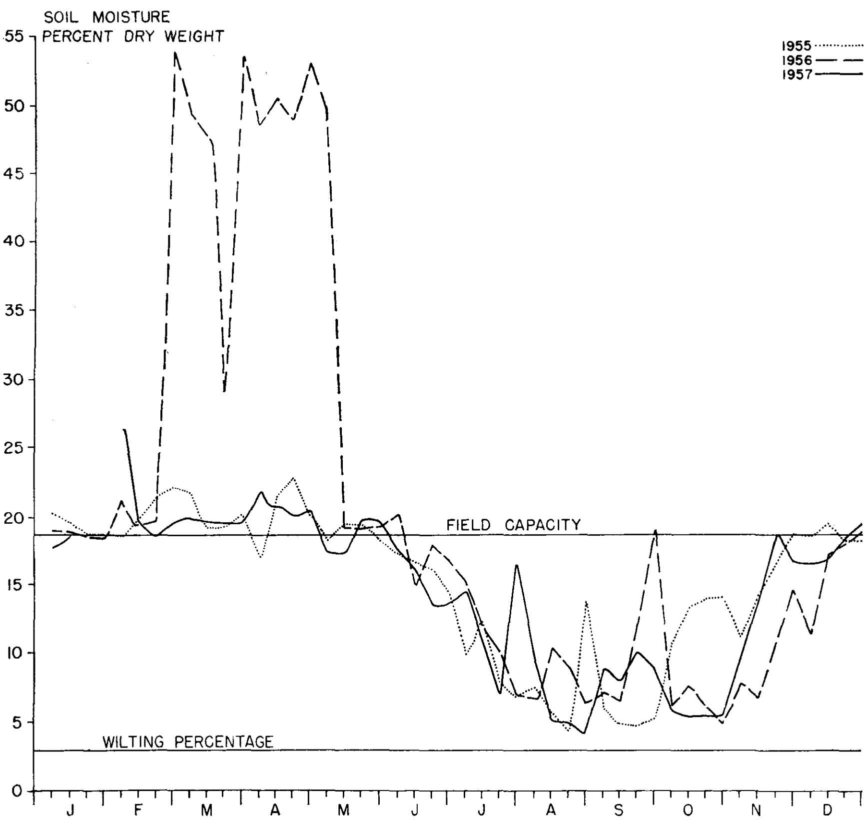

FIGURE 7. Annual soil moisture regimens of the six to nine inch depth of Muskingum Silt Loam underlying mixed oak forest at station #3.

thundershower activity results in at least one marked soil moisture recovery, usually lasting for a period of one week to ten days. A marked increase in weekly soil moisture of this level usually begins by the first or middle of September, and by the first of December soil moisture values usually approximate or exceed field capacity.

2. Six to nine in. level. The reoccurrence of relatively frequent rainfall during October and November results in a relatively rapid increase in soil moisture at this level and field capacity values are usually attained by early December (fig.

7). Weekly soil moisture values then generally remain at this level until approximately the first of May at which time a marked and consistent decrease in weekly soil moisture begins and continues until the latter part of August and September, at which time minimum values, usually several units above corresponding wilting percentage, occur. A relatively rapid increase in soil moisture of this level then generally occurs early in October.

During years characterized by relatively great amounts of precipitation occurring in late winter and spring months, such as 1956, the soil moisture content of the entire profile of both slope soils is considerably above field capacity due to the relatively great amount of downslope seepage and impenetrability of the underlying bedrock. However, this relatively high moisture content rapidly decreases during the latter part of the spring season due to a complex of factors which includes (1) closing of the forest canopies and a corresponding marked increase in rainfall interception, (2) marked increase in atmospheric vapor pressure deficits of lower forest air levels, and (3) rapid increase in removal of soil water by increased transpiration rates.

SUMMARY

1. General profile descriptions of the soils occurring on the opposing slopes, ridge top, and valley bottom sites of *Neotoma* where present ecological investigations are being conducted are here presented.

2. Yearly soil moisture regimens of the one to three and six to nine in. levels of the above sites are graphically presented and generally described.

3. The major control of soil moisture of the open valley habitat is an elevated water table which results in soil moisture values considerably above field capacity throughout most, or all, of the year.

4. Soil moisture values of the south-east facing slope, dominated by a young mixed oak forest, are at or above field capacity throughout the winter and spring periods. A marked decrease in soil moisture usually begins during early summer and generally continues until late August or September, at which time minimum values either at, or extremely near, wilting percentage are attained.

5. Soil moisture values of the north-east facing slope, dominated by a young mixed mesophytic forest, are at or above field capacity throughout the winter and spring periods. A rapid decrease in soil moisture here also begins during early summer and similarly continues until late August or September, at which time minimum values are attained. However, these minimum values are significantly above corresponding permanent wilting percentages.

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