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The relation of certain ecological factors to the inhibition of forest floor herbs under hemlock

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THE RELATION OF CERTAIN ECOLOGICAL FACTORS TO THE INHIBITION OF FOREST FLOOR HERBS UNDER HEMLOCK

By REXFORD F. DAUBENMIRE

In the region of Turkey Run State Park, Parke county, Indiana, there occurs an abundance of Hemlock, *Tsuga canadensis*. In this locality the tree is to be found typically along the upper limits of precipitous creek bluffs and along the rims of the sandstone canyons,—here it is the dominant plant in an edaphic climax. The Hemlock association is a co-dominant climax with the typical Beech-Maple climax of the region.

One of the most notable features of this Tsuga association is the extreme absence of the usual forest floor herbs which are found in the Beech-Maple. Although these two associations occupy fairly comparable topographic positions, the upland Beech-Maple climax extending up to within a few meters of the canyon rims where it is replaced by the Tsuga, there is frequently a rather sharply drawn line between the two associations, so that within a few meters of each other there are two widely different types of forest floors, one (the Beech-Maple) rather rich in mesophytic herbs, the other exhibiting a carpet of leaves rarely interrupted by herbs. The common herbs of the Hemlock association are the saprophytes Monotropa and Epifagus, which at once seem to indicate the possibility of light as a controlling factor in the relative absence of herbs. Little observation is necessary to note, however, that there is a coat of well-dried needles and broad leaves under the Hemlock, while there is but a thin covering of damp, decomposing leaves under the Beech-Maple. This, together with the relative topographic positions of the two associations, suggested a possibility of evaporation as a limiting factor in herb development. Soil conditions, as evidenced by superficial examination alone, seem markedly contrasted in the two forest types. The soil under the Tsuga is of a loose texture, composed mainly of very fine sand of such a dry, non-plastic nature as to seem almost dust-like in comparison to the moist, plastic soil of the Beech-Maple.

A study has been made of four factors: evaporation, light, soil acidity and soil moisture, with an attempt to correlate differences in these respects between the Tsuga and Beech-Maple associations, with the differences in the forest floor herbs. The study includes the summer season, from June 17 to September 1, of 1929.

FLORISTIC DIFFERENCES

A statistical floristic difference between the two associations was obtained by the quadrat method. Twenty-five meter quadrats were plotted at fixed intervals from each other, in both associations, and maps were made showing the distribution and frequency of the plants. It was found that in twenty-five quadrats in the Beech-Maple there occurred: 14 species of herbs, 4 of shrubs and 7 of trees. In the Tsuga there were: 1 species of herb, none of shrubs and three of trees.

There is a wide difference in the relative numbers of herbaceous species as well as in the types of plants encountered. The only herb under the Tsuga was a saprophyte, Monotropa, which, judging from its frequency of appearance in the quadrats, was as dominant in the Hemlock as Sugar Maple was in the Beech-Maple. In October there was a vigorous growth of Epifagus under the Tsuga in as great abundance as was the Monotropa during the summer. All of the Beech-Maple herbs were chlorophyll-bearing.

Breaks in the Tsuga canopy are always oases populated hy Dicranum, Polytrichum, Leucobryum, Cladonia, Mitchella, Polypodium vulgare, Chimaphila and Viburnum acerifolium. While these plants are typical for the more open spaces in the association, they are rarely if ever present in the more dense stand, save as occasional solitary individuals.

EVAPORATION AND LIGHT INTENSITY

Two atmometer stations were maintained during the summer, one in a typical spot in each association. A station consisted of four Livingston clay atmometer cups placed about one meter apart in a square, with the cups about two decimeters above the surface of the soil. Two cups were of the usual white type and two were treated with a black coating Livingston (4). Since the black atmometers differed from the white only in color, the difference in water loss between the two kinds, the black losing more through the greater absorbtion of light, was representative of the evaporative power of the light which penetrated the foliage canopy to the soil beneath. Evaporation from the two black and two white cups at each station was averaged and the results tabulated in Table I.

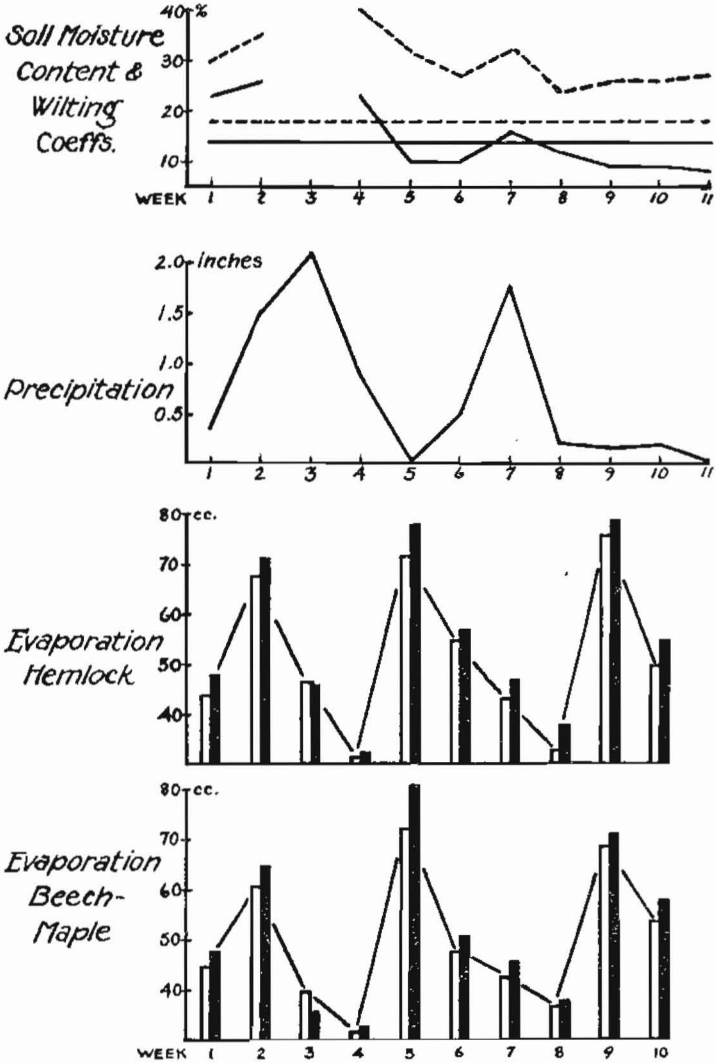
TABLE I. EVAPORATION IN CC WITH THE BLACK AND WHITE ATMOMETERS AVERAGED

WEEK ENDING	EVAPORATION IN CC IN BEECH MAPLE		EVAPORATION IN CC IN HEMLOCK	
	BLACK ATMOMETER	WHITE ATMOMETER	BLACK ATMOMETER	WHITE ATMOMETER
June 24	48.27	45.42	48.00	44.24
July 1	65.93	61.62	70.80	67.94
July 8	35.90	39.89	46.00	47.00
July 15	32.97	31.99	32.40	31.99
July 22	81.24	72.68	78.00	71.89
July 29	51.21	48.58	57.20	55.30
Aug. 5	49.06	43.64	47.20	44.24
Aug. 12	37.28	38.31	37.80	33.37
Aug. 19	71.63	67.94	79.60	76.63
Aug. 26	57.90	54.11	54.80	49.82
Average weekly evaporation	53.11	50.41	55.18	52.24
Average daily evaporation	7.58	7.20	7.89	7.46
Difference in average weekly evaporation: Black minus white	2.70		2.94	

This table shows that evaporation was practically the same in both associations, thereby indicating that it cannot be a critical factor in the inhibition of herb development under the Hemlocks. The situation having the greatest evaporation (as shown by the white atmometers alone) shifted constantly from one station to the other, and within narrow limits. The average daily evaporations were 7.20 cc and 7.46 cc in the Beech-Maple and Hemlock respectively. Figure 1 illustrates the coordination of seasonal fluctuations and types of atmometers in the two associations.

The results from the Beech-Maple evaporation agree with those results obtained by Fuller, Weaver, and Cain and Friesner, as summed up in the works of Cain and Friesner (2). The Hemlock evaporation, however, does not agree quite so well with the results of Moore *et al.* (5), who found that daily evaporation under Hemlock averaged 11.5 cc in four out of five of their stations. Their fifth station, one of a more northern location, and with an average daily evaporation of 7.5 cc, on the other hand, was quite similar to the results of Hemlock evaporation at Turkey Run. When the latter writers compared a different type of hardwood with the Hemlock, evaporation was found to be but little more of a critical factor than here, since the difference between the two types averaged .8 cc daily (.26 cc at Turkey Run).

FIGURE 1. SOIL MOISTURE CONTENT AND WILTING COEFFICIENTS, PRECIPITATION AND EVAPORATION, AVERAGED WEEKLY



Moore *et al.* (5) explain their increase in evaporation under Tsuga, at least partially, to the absence of herbaceous and shrub growth there. The situation at Turkey Run is evidently contrasted to the Eastern forests, since here most of the trees are comparatively young and the tenaceous lower branches, although for the greater part dead, persist to retard air currents. The majority of the Hemlock stands are in a fairly young state of development, probably due to previous suppression by giant white oaks, some of which still remain to break the uniformity of the stands. The age of the particular association in which these data were accumulated was unascertained. Selection of this stand, however, was based on average diameter of boles, which ranged from about 3-15 cm. d. b. h.

Figure 1 illustrates an interesting correlation between the depressions in evaporative power of the air and the periods of greatest precipitation. The rainfall peaks precede the evaporation depressions by one week in each case, demonstrating the direct relation of evaporation to relative humidity, which is in turn affected by rain.

Light radiation, as shown by differences between the black and white atmometers, was also practically the same in the two associations. Averaged over the entire summer, there was slightly less penetration in the Hemlock. Although this difference in penetration is quite constant, except for unexplainahle reverses in the data in weeks three and eight, it is far too small to be of any significance as a critical factor of difference in herb development between the two associations.

The results of the black atmometers are not, in the opinion of the writer, successful as a measure of qualitative differences in light penetrating the two forest types. While there can be no doubt but that these cups measure light intensity quantitatively, with respect to its effect on evaporation, they certainly do not express the differences in kinds of light which may exist beneath the two forest types. A deficiency of one kind of light, for example, in the Hemlock, might be balanced in effect by a surplus of other kinds, so that the black atmometers show like light conditions as evidenced by evaporation, and still there may exist at the same time a difference in wave length of light exerting an inhibitive influence on the vegetation for physiological (photosynthetic) reasons. To the observer's eye, it seemed quite evident when the problem was forming itself that there was a considerable light difference under the trees of the two associations, but, from the results thus far obtained, it must be stated that, quantitatively at least, solar radiation (as effecting evaporation on the two forest floors) is practically equal when determined by this method.

SOIL MOISTURE

For soil moisture studies, two series of soil samples were collected in each association weekly during the summer. A series consisted of a sample at each of the: 1", 3", 6", 12" and 18" layers of soil. The soils were collected in air-tight tins and sent to the botanical laboratory at Butler University, where they were weighed, dessicated at 105 C for four or more days and reweighed to obtain the actual moisture content of the soils.

The moisture equivalents of the different soil depths tabulated herein are, with one exception, averages of four tests each on two soil samples of each soil layer selected at random from those used in the determination of moisture content. There was only slight variation in the four moisture equivalent tests of any one sample, and, since the variation between any two different samples of the same layer were also small, it was concluded that these averages are sufficiently accurate. Wilting coefficients of the soils were calculated from these moisture equivalents by the formula of Briggs and Shantz (1).

Soil moisture data are tabulated in Table 11. By checking actual soil moisture with the wilting coefficients of Table III, it is found that in the Hemlock there is a negative amount of growth water from about the middle of July through the summer. The figures which are below the wilting coefficients for those depths, and therefore indicate a negative amount of growth water, are italicised. A two-inch rainfall on August 2 is reflected quite evidently in the upper half of the soil for this particular week. The line of effectual moisture penetration from this rain was between 6" and 12", but the moisture content was effected at least as low as 18". Table IV and Figure 1 sum up the significant conclusions from the foregoing data. There is always an excess of soil moisture over the wilting coefficient, i. e., growth water, in the Beech-Maple, while in the Hemlock half or more of the summer weeks are characterized as extremely xerophytic edaphically, with the available water of most frequent occurrence in the uppermost layers. The absence of growth water in the soils of the Hemlock associations for such a great portion of the growing season is undoubtedly due to the fact that the

TABLE II. SOIL MOISTURE CONTENT AT DIFFERENT DEPTHS

Each figure represents a percentage of total water based on dry weight of the soil; each figure is an average of two different stations; italics signify the absence of growth water, i. e., an amount of water in the soil below the wilting coefficient.

	JUNE	JULY					AUGUST				SEPT.
Week Ending.	24	1	8	15	22	29	5	12	19	26	2
No. of wk.	1	2	3	4	5	6	7	8	9	10	11
Tsuga....1″	43.0	33.0	......	42.5	*15.5*	*15.0*	22.8	27.4	*12.8*	*13.5*	*11.5*
3″	22.0	32.0	....	22.5	*11.0*	*11.5*	18.0	*10.9*	*11.8*	*10.8*	*8.5*
6″	20.0	30.0	....	21.5	*9.0*	*10.3*	18.3	*10.0*	*10.3*	*9.7*	*9.5*
12″	14.5	21.0	......	17.5	*8.0*	*7.0*	*12.5*	*6.0*	*6.5*	*6.8*	*5.5*
18″	14.0	16.0	.....	12.5	*7.5*	*6.1*	*9.2*	*5.0*	*5.6*	*5.8*	*5.5*
Wkly. Av,	22.7	26.4	......	23.3	*10.2*	*9.9*	16.2	*11.8*	*9.4*	*9.3*	*8.1*
Beech-Maple....1″	35.5	48.5	....	69.5	40.9	33.0	37.0	28.9	34.7	37.5	33.5
3″	35.5	40.5	....	39.0	38.5	31.8	36.0	26.3	28.2	32.0	32.0
6″	27.5	34.0	. .	34.0	29.2	24.7	29.9	22.2	24.7	24.0	26.0
12″	26.5	27.0	....	30.6	24.3	21.1	29.8	21.2	21.8	21.5	20.5
18″	26.5	24.0	.....	26.8	25.6	22.7	25.5	20.2	21.5	15.5	24.0
Wkly. Av.	30.3	34.8	.....	39.9	31.7	26.6	31.6	23.7	26.1	26.1	27.2

TABLE III. AVERAGED SOIL MOISTURE CONTENT, WILTING COEFFICIENTS AND MOISTURE EQUIVALENTS FOR THE DIFFERENT SOIL DEPTHS

ASSOCIATION	DEPTH	AVERAGE S. M. C. 11 WEEKS	MOISTURE EQUIVALENT	WILTING COEFFICIENT
Hemlock	1″	23.7	29.45	16.0
	3″	15.9	30.61	16.6
	6″	14.5	29.32	15.8
	12″	10.5	23.20	12.6
	18″	8.7	20.01	10.8
Beech-Maple	1″	39.9	39.27	21.3
	3″	33.9	34.47	18.7
	6″	27.6	33.80	18.3
	12″	24.4	26.90	14.6
	18″	23.2	28.40	15.3

TABLE IV. SHOWING RELATIVE AMOUNTS OF AVAILABLE WATER DURING THE SUMMER IN THE TWO ASSOCIATIONS

		NO. OF WEEKS THERE WAS UNAVAILABLE WATER	PER CENT. OF SUMMER THERE WAS AVAILABLE WATER
Tsuga	1″	5	50
	3″	6	40
	6″	6	40
	12″	7	30
	18″	7	30
Beech-Maple	1″		
	3″		
	6″	0	100
	12″		
	18″		

roots of the Hemlock are massed in the upper few inches of soil, while in the case of the Beech-Maple no such massing of roots occurs. The fact that growth water was present, in the case of the Hemlock soils, in the upper layers more than in the lower layers, was undoubtedly due to the same reason (massing of roots), coupled with the distribution and extent of the rains which fell. That is, this layer of roots must have intercepted much of the rain which fell, otherwise the layer should, owing to greater water absorbtion, have been the drier and hence have had less growth water than the lower layers. It seems fairly certain that the soils under the Hemlocks were dry because of the presence of Hemlock, with its peculiar root formation, rather than the Hemlock being present where it is because the soil is dry. From these data, it seems that the amount of available moisture bears a direct relation to the richness of forest floor herbs.

Until recently the tremendous importance in some localities of soil moisture as a controlling factor in vegetational development has been underemphasized, especially in sylvicultural practice. The work of Fuller (3) in the dunes of Lake Michigan is an illustration of the relative unimportance of soil moisture, while Toumey (8) found soil moisture of paramount significance. The latter found that the roots of white pine depleted soil moisture progressively during the summer, which is quite in accord with the conditions under Hemlock at Turkey Run. A study of this factor by Thone (7) at Starved Rock, Illinois, brings out another similarity. This writer also found that there was no growth water in July and August, except immediately following periods of rain.

There is such a wide and obvious difference in the soil moisture relations of these two associations that this factor alone might be the decisive one in the development of floral carpets under the two forests.

SOIL ACIDITY

Samples of the soil were taken under typical stands of both associations at Turkey Run. Separated locations were selected under each forest type and at each location a series of ten samples were tested: five of the surface soil (just beneath the duff layer), and five corresponding subsoils (at about a six-inch depth). The soils were tested for their H-ion concentration by the quinhydrone method.

There were three such typical locations selected in the Beech-Maple and four in the Hemlock. The locations cover a four-mile line, extending from Turkey Run Creek to Mill Creek. Three pH readings were made of each sample, and the active acidities of each of the three readings were averaged to obtain an accurate active acidity average for the soil sample (Wherry 9). The results from 15 surface and 15 subsoils in the Beech-Maple, and 20 surface and 20 subsoils in the Hemlock are tabulated in Tables V and VI.

Figure 2 gives a graphic summation of the foregoing tables. The percentage of all samples taken in the particular layer in each association is shown at each pH interval. Thus 22.4 per cent. of the readings of surface soil samples taken under Hemlock had a pH value of 4.4. This table shows that there is a distinct difference in only the surface soil reaction. Although the occurrence of a difference in soil reaction between soils of contrasted vegetational types is not unusual, it frequently happens that when plotted on a scale the acid ranges overlap confusingly so as to render any conclusions only relative. Here, however, the acidity ranges of the two surface soils are separate and distinct, with an appreciable gap on the scale between the two. The difference in reaction of the surface soils alone might prove to be a limiting factor in a vegetational development, since it is the acid nature of this layer with which the seedlings of the association must first cope.

The subsoils prove to be more nearly alike. It is quite interesting and significant to note that the subsoils occupy an intermediate place on the scale, with the surface soils diverging each in an opposite direction, that of the Beech-Maple tending to be more neutral and that of the Hemlock more acid. These relative positions may be explained by

TABLE V. SOIL ACIDITY—BEECH-MAPLE

	SURFACE SOIL				SUBSOIL				
LOCATION	NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY	NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY
West of		6.1	8			4.6	250	
Falls	1	6.3	5	6	2	4.5	315	293
Canyon		6.3	5			4.5	315	
		6.7	1.5			5.0	100	
	3	6.6	2	2	4	5.1	80	101
		6.6	2			4.9	125	
		6.4	4			5.1	80	
	5	6.4	4	4	6	5.2	63	223
		6.5	3			5.1	80	
		5.3	50			4.9	125	
	7	5.4	40	43	8	5.0	100	117
		5.4	40			4.9	125	
		7.0	0			5.5	31.5	
	9	6.7	1.5	1	10	5.7	20	25
		6.6	2			5.6	25	
East of		6.6	12			5.1	80	
Boulder	1	6.8	1	1	2	5.2	63	68
Canyon		6.7	1.5			5.2	63	
		5.9	12.5			5.4	40	
	3	6.1	8	9	4	5.4	40	43
		6.1	8			5.3	50	
		6.9	0.5			5.3	50	
	5	6.8	1.0	0.7	6	5.5	31.5	40
		6.9	0.5			5.4	40	
		6.1	8			5.3	50	
	7	6.2	6	7	8	5.3	50	44
		6.2	6			5.5	31.5	
		6.1	8			5.1	80	
		6.1	8	7		5.1	80	80
		6.3	5			5.1	80	
Summer		6.0	10			5.8	16	
Evap.		6.1	8	9		5.7	20	17
Station		6.1	8			5.8	16	
		6.8	1			4.8	160	
		6.9	0.5	0.7		4.9	125	148
		6.9	0.5			4.8	160	

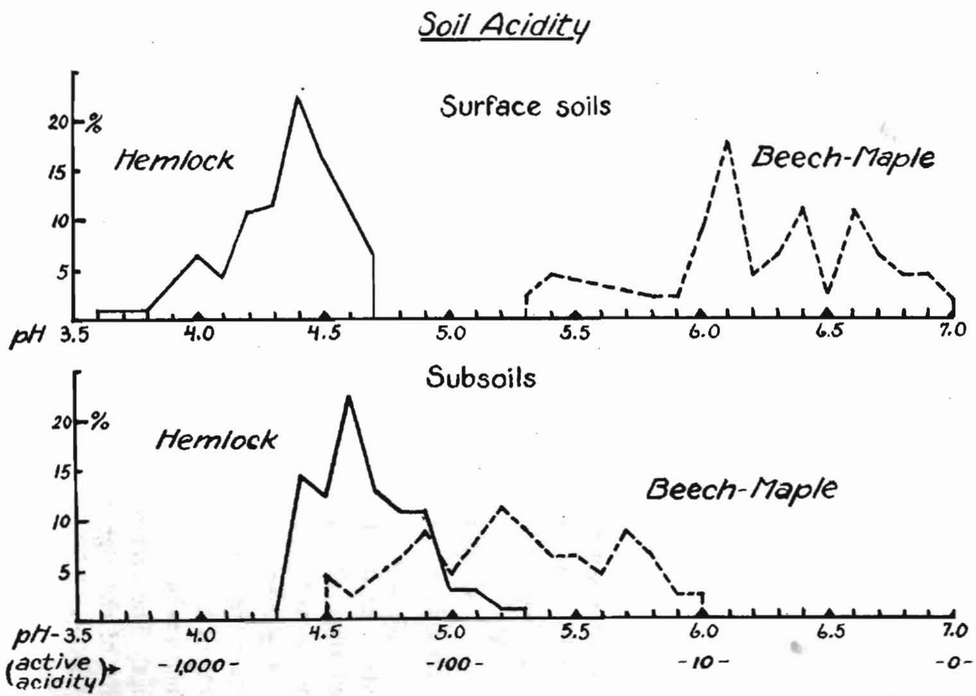
LOCATION	SURFACE SOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY	SUBSOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY
Summer		6.4	4			5.9	12.5	
Evap.		6.8	1	3		5.7	20	14
Station		6.4	4			6.0	10	
		6.0	10			5.6	25	
		6.4	4	5		5.7	20	20
		6.6	2			5.8	16	
		5.8	16			5.2	63	
		6.0	10	12		5.2	63	95
		6.0	10			4.8	160	

TABLE VI. SOIL ACIDITY—HEMLOCK

LOCATION	SURFACE SOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY	SUBSOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY
Summer		4.3	500			4.8	160	
Evap		4.6	250	417		4.9	125	116
Station		4.4	400			5.2	63	
		4.3	500			4.9	125	
		4.1	800	643		4.9	125	117
		4.2	630			5.0	100	
		4.4	400			4.4	400	
		4.4	400	400		4.4	400	400
		4.4	400			4.4	400	
		4.0	1,000			4.5	315	
	9	4.0	1,000	1,000		4.5	315	343
		4.0	1,000			4.4	400	
		3.6	2,500			4.4	400	
	7	3.8	1,600	2,033		4.4	400	400
		3.7	2,000			4.4	400	
East of		4.6	250			4.7	200	
Boulder	1	4.3	500	355	2	4.8	160	187
Canyon		4.5	315			4.7	200	
		4.2	630			5.1	80	
	3	4.2	630	553	4	5.3	50	70
		4.4	400			5.1	80	
		4.1	800			4.8	160	
	5	4.3	500	700	6	4.8	160	160
		4.1	800			4.8	160	

LOCATION	SURFACE SOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY	SUBSOIL NO.	pH	ACTIVE ACIDITY	AV. ACTIVE ACIDITY
East of		4.3	500			4.9	125	
Boulder	7	4.2	630	710	8	4.9	125	117
Canyon		4.0	1,000			5.0	100	
		4.6	250			4.7	200	
		4.7	200	317		4.8	160	173
		4.7	200			4.8	160	
West of		4.4	400			4.5	315	
Falls	1	4.4	400	433	2	4.5	315	315
Canyon		4.3	500			4.5	315	
		4.6	250			4.6	250	
	3	4.5	315	293	4	4.6	250	250
		4.5	315			4.6	250	
		4.6	250			4.3	500	
	5	4.5	315	322	6	4.4	400	433
		4.4	400			4.4	400	
		4.5	315			4.6	250	
	7	4.4	400	343	8	4.6	250	233
		4.5	315			4.7	200	
		4.5	315			4.9	125	
	9	4.2	630	525	10	4.9	125	167
		4.2	630			4.6	250	
Mill		4.2	630			4.6	250	
Creek	1	4.3	500	543	2	4.5	315	272
		4.3	500			4.6	250	
		4.4	400			4.7	200	
	3	4.4	400	400	4	4.6	250	217
		4.4	400			4.7	200	
		4.4	400			4.6	250	
	5	4.6	250	350	6	4.6	250	250
		4.4	400			4.6	250	
		4.6	250			4.5	315	
	7	4.7	200	650	8	4.5	315	293
		4.7	200			4.6	250	
		4.5	315			4.7	200	
	9	4.5	315	315	10	4.7	200	217
		4.5	315			4.6	250	

FIGURE 2. SUMMATION OF FOREGOING TABLES



the nature of the substratum. Mansfield sandstone, which is quite soft and easily decomposing, underlies most of the soil at Turkey Run. The soil is quite thin and is presumably affected by the silicious substratum which on decomposing produces acid conditions. The divergent types of leaves which are shed on the two types of forest floors evidently tend to alter the reaction of the upper soil layers in a similar divergent manner. Although the proximity to a precipitous bluff or canyon rim is at Turkey Run inevitable with a Hemlock stand, it is evident from the nature of the water relations of the Hemlock soil, as shown above, that the leaching out of bases is not entirely responsible for such a difference in acidity. The soil is always quite dry, and the soil moisture data show that precipitation only slightly affects the moisture content of the soil and that very little water gets beyond the reach of the roots.

It is of common occurrence that, as any condition of environment extends itself in either direction from the optimum, the numbers of species decrease. The conditions of soil reaction and statistics of vegetational frequency in the two associations at Turkey Run coincide remarkably with Olsen's (6) concept, but whether or not acidity is the principal factor inhibiting herbs under the Hemlock cannot be empirically stated; however, the increase in acidity between the two associations and the decrease in species are at least concomitant phenomena.

That acidity does play a part in the vegetational development under the Tsuga may be demonstrated by a review of the plants which first inhabit this forest floor under a break in the foliage canopy. Since Monotropa, Epifagus and Viburnum acerifolium grow in both associations, it may be concluded that they are tolerant of quite a range of acidity,—from 3.7 to 7.0. Cladonia, Leucobryum, Dicranum, Polytrichum and the ericads, Gaylussacia and Chimaphila, are uotoriously plants of acid soils, and it is naturally expected that they are to be found in relative abundance only under the more acid conditions of the Tsuga. The presence of these plants rehabitating Tsuga soil is indicative of the high acidity acting at least as a contributing factor in vegetational development.

SUMMARY

1. The purpose of these investigations was to correlate, if possible, differences between Hemlock and Beech-Maple forest types in four factors of the habitat (evaporation, light intensity, soil moisture and

soil acidity) with the differences in forest floor herbs,—the Hemlock being quite barren of herbs, while the Beech-Maple, in a comparable topographic situation, has a rich carpet of forest floor herbs. This study included the summer weeks, from June 17 to September 1, of 1929.

2. Evaporation results indicate an equal degree of mesophytism in the two associations, in contrast to the work of Moore *et al.*, who found Hemlock forests to be slightly more xerophytic in respect to evaporation than hardwood.

3. Light intensity, as measured by difference in evaporation between black and white atmometers, was practically equal, quantitatively at least, in its effect upon water loss in the two associations.

4. Soil moisture studies showed a lack of growth water in the Hemlock soil from about the middle of July through the summer, except for a short period immediately following a heavy rain. The lower layers of soil under Hemlock are more constantly lacking in growth water, due to the slight penetration of rainfall. Growth water was always present in all soil layers studied in the Beech-Maple.

5. Soil reaction varies widely between the two forest types in only the surface soils. The surface soil in the Hemlock ranges from superacid (pH 3.6) to mediacid (4.7), and this layer in the Beech-Maple ranges from subacid (5.3) to circumneutral (7.0).

6. It is concluded, therefore, that, of the factors studied, soil moisture conditions exerted the most inhibitive influence on vegetational development under Hemlock, while the greater acidity of the surface soil in the Hemlock is probably a contributing factor in the inhibition of forest floor herbs.

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