THE INFLUENCE OF TWO JUNIPERUS SPECIES ON SOIL REACTION[1]

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That the soil reaction is influenced by vegetation is well recognized. Various European investigators (3, 4, 5, 8, 9, 12, 14, 15) have shown that both the composition of the forest stand and the cultural operations in the stand affect the pH of the soil.

It is reasonable to assume that a plant may influence the reaction of the soil beneath it by any or all of three means: first, by changing the chemical composition of the soil through withdrawals of substances by the roots; second, by changing the chemical composition of the soil through additions of substances from the decomposition of litter; and third, indirectly through modifying soil structure, shading the surface, intercepting rainfall, etc.

Koslowska (6), working with 39 plant species, showed that "plants possess in their underground organs the property of changing the reaction of the medium." That the decomposition of litter affects soil reaction has been demonstrated and at least partly explained by Nemec and Kvapil (8, 9), Stepanof (12), Waksman (13), and others.

EXPERIMENTAL

In order to measure the influence of vegetation on soil reaction, experiments were carried on in the vicinity of New Haven in the fall and winter of 1939–40, Red cedar, *Juniperus virginiana*, and ground juniper, *Juniperus communis*. growing on old field soils were chosen for this purpose; and on three divisions of the Eli Whitney Forest of the New Haven Water Company, blocks were laid out, in each of which a series of random samples was taken. Four paired samples were taken at each location, two under the plant at depths of 1 inch and 6 inches in the mineral soil and two at a distance of 5 feet from the plant at the same depths. At the latter position, that is, in the open, the vegetation throughout consisted of pasture grasses.

The red cedars and one block of the ground junipers studied were growing on Gloucester sandy loam. The blocks on this brown glacial till soil, derived

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from granite and gneiss material, were on high, rocky, and well-drained land. The ground juniper was also studied on Cheshire sandy loam and on Holyoke loam (7). The block on Cheshire sandy loam, a soil derived from red Triassic sandstone, was situated on a moderate slope, low in a small stream valley but well drained and almost free from rocks, whereas that on Holyoke loam, derived from traprock, was near the top of a moderately high traprock ridge.

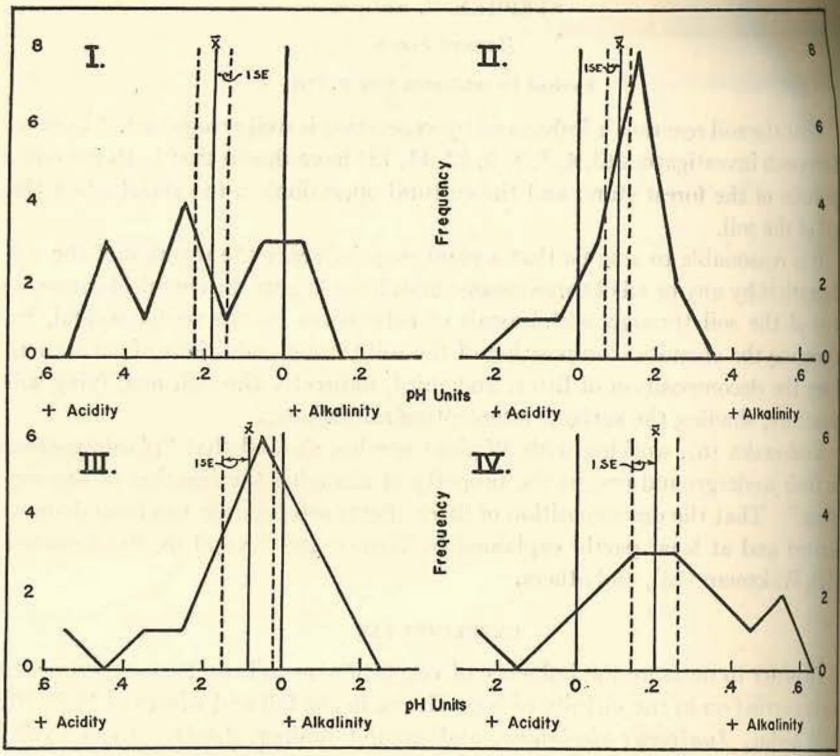

FIG. 1. COMPARISON OF pH VALUES FOR JUNIPERUS VIRGINIANA SAMPLES SHOWING FREQUENCY CURVES FOR EACH PAIR COMPAIRED, MEAN DIFFERENCES ($\bar{X}$), AND RANGE OF INDIVIDUALLY COMPUTED STANDARD ERRORS (SE)

I. 6-inch depth under plant cf. with 1-inch depth under plant.
II. 6-inch depth in open cf. with 1-inch depth in open.
III. 1-inch depth in open cf. with 1-inch depth under plant.
IV. 6-inch depth in open cf. with 6-inch depth under plant.

The effect of the two species on the soil profile was similar on all soil types. In contrast to the A_1 profile of the soil in the open, which tended to have little structure and to be compact and poorly aerated, the A_1 profile under the plants was characterized by a highly developed crumb structure coupled with considerable earthworm activity. Although a layer of raw humus was commonly found under other woody plants on the same soils, this layer was completely absent under the two *Juniperus* species. Below the A_1 horizon, there was no observed difference between the soil profiles in the open and those under the canopy.

The soil samples taken were stored in paper bags until dry; pH determinations were then made by the quinhydrone method (16). In this determination, the apparatus was checked every half day with a standard buffered solution. The soil samples were found to be well suited for determination by this method, having small drifts and pH values between 4.4 and 5.6. The soil-liquid ratio

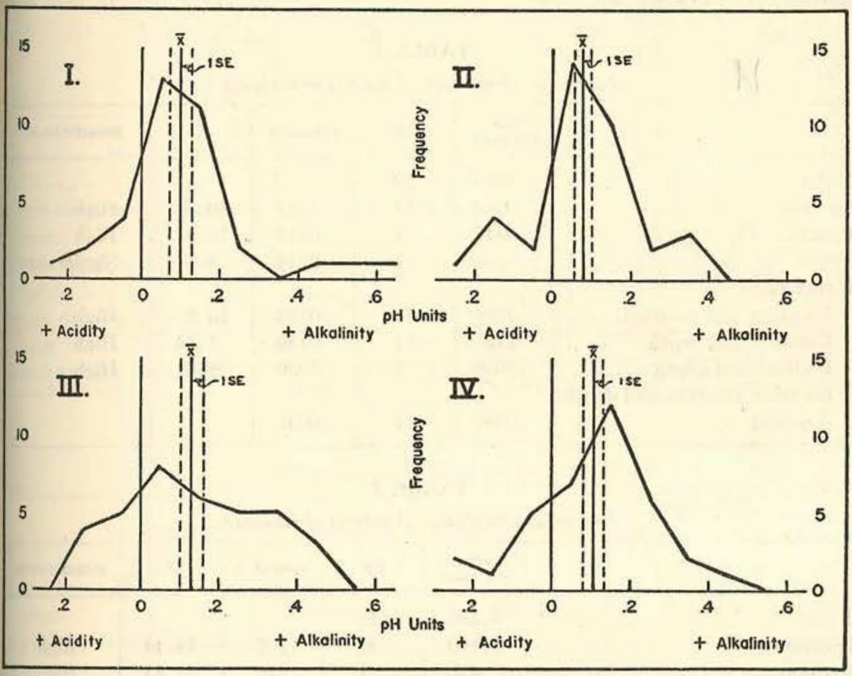

FIG. 2. COMPARISON OF pH VALUES FOR JUNIPERUS COMMUNIS SAMPLES SHOWING FREQUENCY CURVES FOR EACH PAIR COMPARED, MEAN DIFFERENCES ($\overline{X}$), AND RANGE OF INDIVIDUALLY COMPUTED STANDARD ERRORS (SE)

I. 6-inch depth under plant cf. with 1-inch depth under plant.
II. 6-inch depth in open cf. with 1-inch depth in open.
III. 1-inch depth in open cf. with 1-inch depth under plant.
IV. 6-inch depth in open cf. with 6-inch depth under plant.

used was that of 1:2.5. The soil and water were shaken together for approximately 30 seconds and the quinhydrone stirred in for 10 seconds. The potential was measured at 60 seconds.

A preliminary analysis of variance was made to determine whether the effect of ground juniper on the soil reaction varied with the soil type. A significant difference was found to exist between the blocks, but inasmuch as this significance was of a low order and the same general relationships were found to occur on each soil type, soil types were disregarded in subsequent analyses. Figures 1 and 2 show the distribution of differences of paired samples for each comparison made. The standard errors of the difference indicated in these figures were derived separately for each comparison and not by analysis of variance as is done below.

In analyzing the data, analysis of variance was adopted, following the standard methods as laid down by Snedecor (11) and Paterson (10). The results are shown in tables 1 and 2. In the analysis of variance in table 2, the individual interactions were found to be of no significance and were grouped together to serve as the error.

TABLE 1

Juniperus virginiana: Analysis of variance

	SUM SQUARES	*DF*	VARIANCE	*F*	SIGNIFICANCE
Total	3.9988	59			
Location	2.6364	14	.1883	60.8	High
Position	.0510	1	.0510	16.5	High
Depth	.0244	1	.0244	8.1	Significant
Interactions					
Location and position	.7286	14	.0520	16.8	High
Location and depth	.2105	14	.0150	4.84	High
Position and depth	.3039	1	.3039	98.0	High
Location, position, and depth (error)	.0440	14	.0031		

TABLE 2

Juniperus communis: Analysis of variance

	SUM SQUARES	*DF*	VARIANCE	*F*	SIGNIFICANCE
Total	9.480	143			
Location	7.190	35	.205	14.14	High
Position	.476	1	.476	32.83	High
Depth	.277	1	.277	19.10	High
Interactions (error)	1.537	106	.0145		

The analysis of variance was followed by t tests comparing the average values for each position and depth (2). The results are presented in tables 3 and 4. The analysis showed a highly significant difference (P less than 0.01) in each case between the two depths at each position and between the two positions at each depth.

In the case of red cedar, measurements taken in the open showed the surface soil to be the more acid, the average pH at the 1-inch depth being 4.88 and that at the 6-inch depth, 4.98. Under the cedar, the pH gradient is reversed, the pH at the 1-inch depth being 4.96 and that at the 6-inch depth, 4.78. This is in agreement with the observation of Coile (1). The increase in the pH value of the surface soil under the cedar is clearly attributable to the incorporation of the decomposition products of litter. The pH of red cedar litter, as determined from the plants studied, averaged 5.57. At the 6-inch depth under the cedar, a decrease in the soil pH as compared to that in the open occurred, a decrease very likely attributable to the withdrawal of calcium and other basic salts by the roots in that region. This decrease at the 6-inch depth was definitely greater than the increase at the 1-inch depth.

In the case of the juniper, the typical pH profile is again found in the open, the surface soil being the more acid. At the 1-inch depth, the pH was 5.05, and that at the 6-inch depth, 5.13. Under the juniper, a highly significant

TABLE 3

Juniperus virginiana: t-tests

AVERAGE VALUES COMPARED	DIFFERENCE (pH UNITS)	$SE_{Diff.}$	t	SIGNIFICANCE
1-inch depth under cedar and 6-inch depth under cedar	.1827	.00203	9.00	High
1-inch depth under cedar and 1-inch depth in open	.0840	.00203	4.13	High
6-inch depth under cedar and 6-inch depth in open	.2007	.00203	9.86	High
1-inch depth in open and 6-inch depth in open	.1020	.00203	5.02	High

TABLE 4

Juniperus communis: t-tests

AVERAGE VALUES COMPARED	DIFFERENCE (pH UNITS)	$SE_{Diff.}$	t	SIGNIFICANCE
1-inch depth under plant and 6-inch depth under plant	.099	.0284	3.48	High
1-inch depth under plant and 1-inch depth in open	.127	.0284	4.47	High
6-inch depth under plant and 6-inch depth in open	.103	.0284	3.63	High
1-inch depth in open and 6-inch depth in open	.076	.0284	2.68	High

drop in pH was observed at both depths, the pH at the 1-inch depth being 4.92 and that at the 6-inch depth being 5.02. At the surface, a striking similarity was noted between the pH of the litter, which was determined as 4.91, and that of the mineral soil, which was 4.92. Again, the changes that were found to have occurred under the plant can probably be attributed largely to the addition of litter at the 1-inch depth and to root action at the 6-inch depth.

SUMMARY

Both *Juniperus virginiana* and *Juniperus communis* alter the pH of old field soils in the vicinity of New Haven. The first species raises the pH of the upper part of the mineral soil and lowers it at a depth of 6 inches. *Juniperus*

communis, on the other hand, lowers the pH at both depths. Tentatively, it may be concluded that the addition of litter is a highly important factor influencing the pH of the upper part of mineral soil and withdrawal of soluble substances by the roots appears to be of similar importance at a 6-inch depth.

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