# Leopold Pines. 1972

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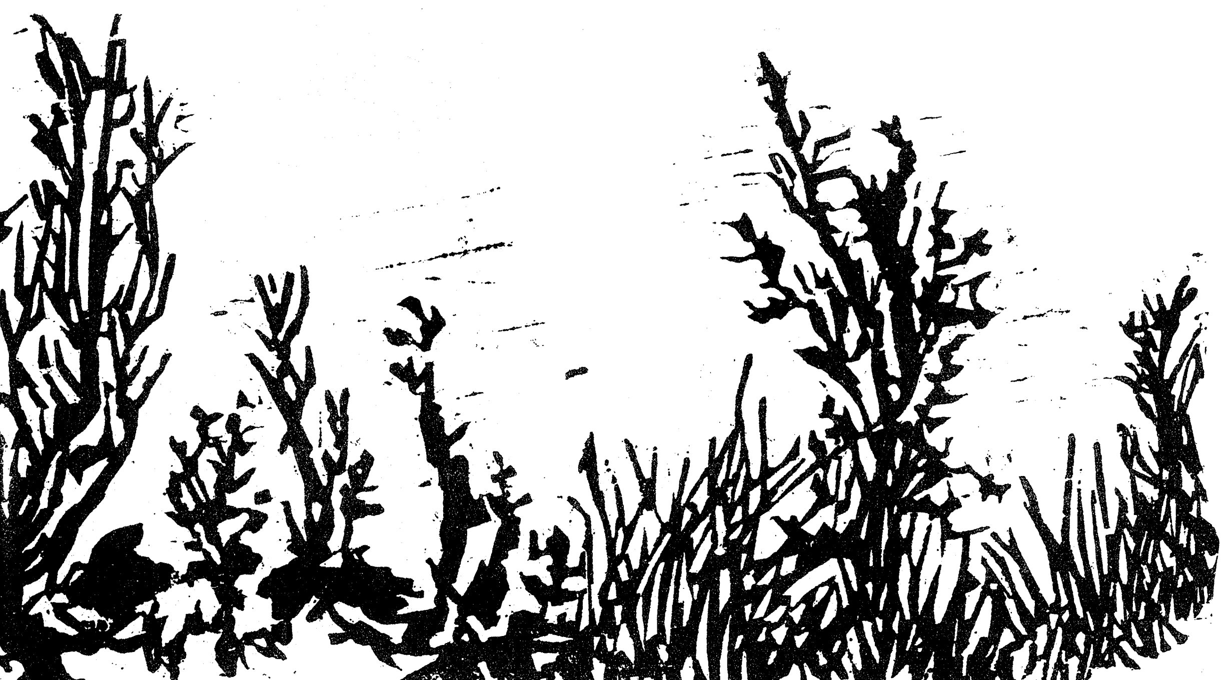
# Leopold Pines



The University of Wisconsin Arboretum

This field book is dedicated to Mrs. Jean Otto who loved the Arboretum and visited it often.

Mrs. Otto had a deep appreciation and understanding for the natural world and readily transmitted it to those who knew her. For her each season brought its own delights; migrating birds, colors of fall, the stark beauty of bare branches against the winter sky, the tender wild flowers poking through soft earth in spring, and lush green of summer—all were part of the rhythm of her life.

We hope that those who use this booklet will gain a deeper feeling and understanding of the natural world thereby making this a suitable memorial for Jean Wilson Otto.

# THE LEOPOLD PINES

The Arboretum is a restoration of the native plant and animal communities of our region, yet all of these communities do not closely resemble their natural counterparts. Prairies, oak forest, and other communities that occurred in this region prior to European settlement simulate their natural states reasonably well. However, those communities which were not part of the native landscape near Madison have been established with less success.

To evaluate the success of the artificially established communities and to provide an inventory of others, information is obtained periodically about the number, size, and kinds of plants and animals in the restoration areas. This article discusses the information gathered about the Arboretum's Leopold Pines, which are dedicated to the famous Wisconsin naturalist, Aldo Leopold. The information we have gathered thus far indicates that the Pines, established in 1933 and 1937, are a long way from becoming a natural pine forest, and perhaps will never be one.

Last summer a study was made of the trees and woody understory plants at selected locations in the Leopold Pines. This investigation was a continuation of work begun in 1963-64.[1] By comparing the number and size of trees, at the same location within the Pines, at eight-year intervals, generalization can be made about the growth and survival of the trees. Also, by comparison with expected values obtained from native pine stands, it is possible to see how close restoration has come to approximating natural pine forest conditions.

Sampling a forest community is like taking a political survey. A portion of the plants are measured and then these results are extended to the community as a whole. In the initial survey of the Pines, forty sampling locations were studied. These same points were resampled in the summer of 1971. The forty sampling points were divided into eight units of relatively uniform tree composition called stands. The eight stands were further grouped into three community types based on percentages of white and red pines they contained. There were five red pine stands, two white pine, and one mixed pine stand.

For each of the three community types, the tree density and basal area was determined. Density is the number of trees per acre and basal area is the cross-sectional area of the tree stems at 4½ feet above the ground. These measurements are reported only for trees having 12 sq. in. or greater of basal area. In addition, the density of the woody understory plants, which includes shrubs, vines, and tree seedlings, was also measured.

In mature native pine forests, 200 to 250 trees per acre are expected. It can be seen in Table I that all the community types studied in the Arboretum support many more trees per acre than the native ones. However, the density has been markedly reduced since the initial establishment of about 1,700 trees per acre in the 1930's.

[1] Swain, 1964.

**TABLE I - TREE DENSITY**

| | | Red pine trees | White pine trees | Total for all trees* |
|---|---|---|---|---|
| Red pine community | 1963 | 619 | 24 | 652 |
| | 1971 | 626 | 24 | 656 |
| | Change | +7 | 0 | +4 |
| White pine community | 1963 | 4 | 460 | 484 |
| | 1971 | 4 | 408 | 432 |
| | Change | 0 | -52 | -52 |
| Mixed pine community | 1963 | 280 | 320 | 608 |
| | 1971 | 160 | 280 | 448 |
| | Change | -120 | -40 | -160 |

*Includes pines and other species

Two of the three communities, white pine and mixed pines, decreased in density between 1963 and 1971. However, the red pine stands showed a slight increase in the number of trees per acre during the eight-year sampling interval due to the growth of pine saplings into tree-sized individuals. Since all the communities support more trees than natural pine forests, we can expect that overcrowding will cause additional trees to die in the future as the trees grow larger.

The great reduction in density occurred in the mixed community with a decrease in red pine of 120 trees per acre between 1963 and 1971. During the same time span, white pine density also declined, but at the much slower rate of 40 trees per acre.

A second indicator of tree growth and survival is basal area per acre, the cross-sectional area of the tree stems at 4½ feet off the ground. Albert Swain, working in the northern pine forest, reported that for communities between 33 and 60 years of age there was an increase in basal area as the community became older.[2] Mature native pine forests have 160 to 255 square feet per acre. Table II shows that although the Arboretum pine communities were all below the 160 square foot per acre level in 1963, they were all well above it in 1971. The white pine community had slightly more basal area, 190 square feet, compared with 186 for the red pine and 171 for the mixed pine community.

[2] Swain, pp. 8-9, 1964.

**TABLE II - TREE BASAL AREA (Sq. Ft. Per Acre)**

| | | Red pine trees | White pine trees | Total for all trees* |
|---|---|---|---|---|
| Red pine community | 1963 | 147 | 8 | 156 |
| | 1971 | 175 | 10 | 186 |
| | Change | +28 | +2 | +30 |
| White pine community | 1963 | 1 | 149 | 154 |
| | 1971 | 2 | 182 | 190 |
| | Change | +1 | +33 | +36 |
| Mixed pine community | 1963 | 51 | 102 | 155 |
| | 1971 | 39 | 131 | 171 |
| | Change | -12 | +29 | +16 |

*Includes pines and other species

It is also significant that white pine basal area increased in the mixed community while that of red pine decreased. More sampling of white pine and mixed forest conditions are needed before conclusions can be drawn with reasonable reliability. However, it is suggested from the present data that the mixed community favors white pine growth and survival at the expense of red pine. In addition, the white pine community has become less dense while increasing total basal area per acre. However, the red pine community has essentially retained its 1963 density while increasing its total basal area per acre, although at a slightly slower rate than the white pine community. Thus, the communities are changing from having many small trees to communities with fewer but larger trees.

Although the Leopold Pines are far more dense than natural pine forests, the apparent tendency of white pine stands to have lower density and higher basal area than similarly aged red pine stands is consistent with natural pine forest conditions.

Two other factors to consider are the relative number of the most characteristic tree and the other kinds of tree species present. The tree composition of the Leopold Pines demonstrates why a pine plantation is not a realistic simulation of a natural pine forest. Native pine forests have been considered to be red pine communities if 40 percent or more of the trees are red pines. Similarly, white pine forests contain about 60 percent white pine trees. Observed values in the Leopold Pines are 95 percent red pine trees in the red pine communities and approximately 75 percent white pine in white pine communities. Thus, there is presently an overabundance of the most characteristic tree species in each of the respective communities.

Other tree species of the native pine forest include jack pine, balsam fir, trembling aspen, white birch, red maple, and red oak. Of these, only white birch and red maple trees were found in our studies. Other trees occurring in the Leopold Pines are black cherry, white spruce, box elder, hawthorn, apple, and chokecherry. Thus, the Leopold Pines have a very sparse occurrence of deciduous trees and an inappropriate representation of those that would be expected.

Density values represented in Table III are for woody understory plants sampled in the Leopold Pines in 1963 and 1971. Substantial increases in density were recorded for the five most abundant species. In addition, the total number of stems increased from 2,558 per acre to 20,553. Of the five most abundant species (see Table III), only black cherry is listed by Curtis as being native to the northern red or white pine forests. Tartarian honeysuckle and bittersweet nightshade, the woody understory species with the highest density values in 1963 and 1971, respectively, are both European plants which have escaped from cultivation. Gray dogwood and wild grape are natives of the southern Wisconsin deciduous forests.[3]

**TABLE III - WOODY UNDERSTORY DENSITY**

| | Bittersweet Nightshade | Black Cherry | Honey-suckle | Gray Dogwood | Wild Grape | Other | Total |
|---|---|---|---|---|---|---|---|
| 1963 | 168 | 405 | 1,480 | 0 | 126 | 405 | 2,558 |
| 1971 | 12,800 | 2,480 | 2,140 | 1,220 | 513 | 1,400 | 20,553 |
| Change | +12,632 | +2,075 | +660 | +1,220 | +487 | +995 | +17,995 |

Competition from native vegetation of the Madison area is an important limitation to successful restoration of the Leopold Pine communities. Of the 35 species of woody understory plants identified in the Leopold Pines in 1971, only nine are listed by Curtis as being native to the red or white pine forest. Of these nine, seven are representative of southern deciduous forests and, therefore, may be more indicative of deciduous forest understory invasion than of the establishment of typical pine forest understory.[4]

In a natural pine forest, there are many small openings in the forest that permit light and moisture to reach understory plants. However, the Leopold Pines are nearly planted in rows. See how many trees you can line up in rows the next time you are in the pines.[5] As a result of their spacing, the tree crowns are essentially continuous with few openings for light and moisture to penetrate to the forest floor. Because the pine trees have grown so well they have greatly reduced the success of plants that live under their crowns.

On several occasions, northern pine understory herbs such as bluebeads, partridge berry, northern star flower, trailing arbutus, bracken fern and others have been planted in the Leopold Pines. However, the success in establishing these species has been very limited. We might have better success if openings were created in the pines and the appropriate northern species planted in these openings. Unfortunately, these openings would also be more suitable for the growth of the southern oak forest shrubs and they in all probability would crowd out the northern plants.

The addition of tree species other than conifers such as red maple, aspen, white birch, and red oak is also desirable. The crown of these deciduous species are less dense than the coniferous crown and as a result they allow more light and moisture to reach the forest floor.[6] A combination of creating openings, the addition of deciduous species, and removal of weedy European and southern deciduous forest invaders should be effective management procedures to hasten the Leopold Pines on their way to becoming more representative of natural pine forests.

[3] Curtis, pp. 520-528, 1971.
[4] Curtis, pp. 520-528, 1971.
[5] Swain, p. 14, 1964.
[6] Anderson, pp. 46-47, 1965.

## APPENDIX I

Leopold Pines: Trees Identified in 1963 & 1971

| | |
|---|---|
| Acer negundo | Box elder |
| Acer rubrum | Red maple |
| Betula papyrifera | White birch |
| Crataegus sp. | Hawthorn |
| Picea mariana | White spruce |
| Pinus resinosa | Red pine |
| Pinus strobus | White pine |
| Prunus serotina | Black cherry |
| Prunus virginiana | Chokecherry |
| Pyrus malus | Apple |

## APPENDIX II

Leopold Pine Woody Understory Plants Identified in 1971

| | |
|---|---|
| Acer negundo | Box elder |
| Acer rubrum | Red maple |
| Amelanchier humilis | Juneberry |
| Cornus racemosa | Gray dogwood |
| Juglans cinerea | Butternut |
| Lonicera tartarica | Honeysuckle |
| Morus alba or rubra | Mulberry |
| Parthenocissus inserta | Woodbine |
| Populus tremuloides | Quaking aspen |
| Pinus resinosa | Red pine |
| Prunus serotina | Black cherry |
| Prunus virginiana | Chokecherry |
| Pyrus americana | Mountain ash |
| Pyrus iowensis | Wild crab |
| Quercus velutina | Black oak |
| Rhamnus cathartica | Buckthorn |
| Rhamnus frangula | Alder buckthorn |

| | |
|---|---|
| Rhus radicans | Poison ivy |
| Rhus typhina | Staghorn sumac |
| Ribes americanum | American black currant |
| Ribes cynosbati | Prickly gooseberry |
| Ribes missouriense | Missouri gooseberry |
| Rubus ideaus | Red raspberry |
| Rubus occidentalis | Black raspberry |
| Sambucus canadensis | Common elder |
| Sambucus pubens | Red-berried elder |
| Solanum dulcamara | Bittersweet nightshade |
| Taxus canadensis | Canadian yew |
| Ulmus americana | American elm |
| Viburnum dentatum | Southern arrowwood |
| Viburnum lantana | Sweet viburnum |
| Viburnum lentago | Nannyberry |
| Viburnum opulus | European snowball tree |
| Vitis riparia | Wild grape |

## BIBLIOGRAPHY

Anderson, Roger C. "Light and Precipitation in Relation to Pine Understory Development." Master Thesis, Univ. of Wis., 1965.

Anderson, Roger C., O. L. Loucks, and A. M. Swain. "Herbaceous Response to Canopy Cover, Light Intensity, and Throughfall Precipitation in Coniferous Forests." Ecology 50: 256-263, 1969.

Curtis, J. T. "The Development of Pine Forest Communities in the Arboretum." *Arboretum News,* Univ. of Wis., Madison, Vol. 4, No. 2, 1955.

Curtis, John T. *"The Vegetation of Wisconsin."* Univ. of Wis. Press, Madison, 1971.

Rees, Colin P. "The Effects of Three Red and White Pine Stands of Differing Ages on the pH, Litter Depth, and Nutrient Content of the Underlying Soil." *Arboretum News,* Univ. of Wis., Madison, Vol. 16, No. 3-4, 1967.

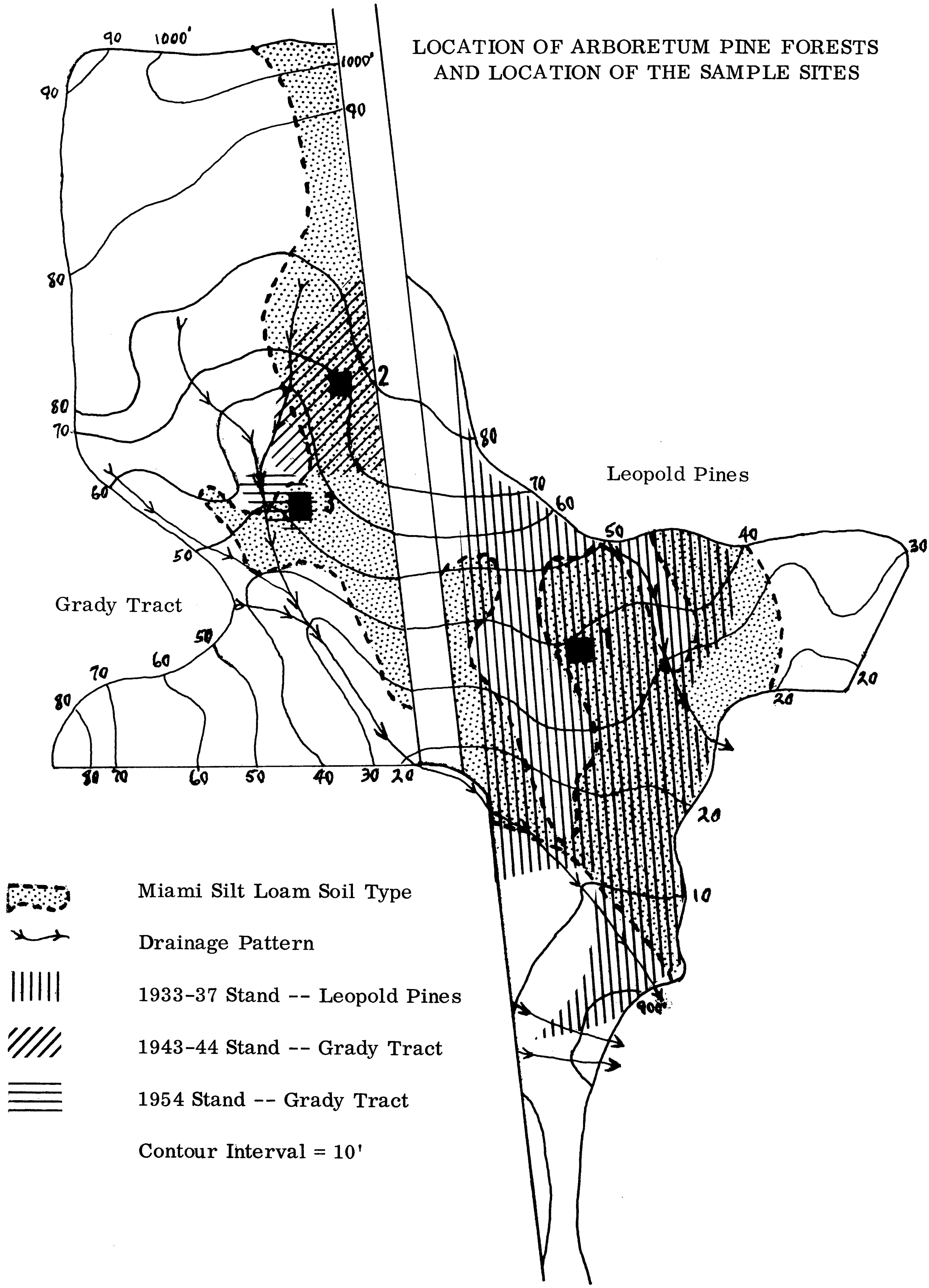
Swain, Albert M. "Relationships of Understory Plants to Age and Density of Conifer Forests." Master Thesis, Univ. of Wis., 1964.

David Schwehr
Roger C. Anderson 1972

## THE EFFECTS OF THREE RED AND WHITE PINE STANDS OF DIFFERING AGES ON THE pH, LITTER DEPTH, AND NUTRIENT CONTENT OF THE UNDERLYING SOIL

The artificial plantings of conifers in The University of Wisconsin Arboretum provide an opportunity to study the effects of vegetation on soil development. Very commonly the soils beneath natural conifer stands are strongly "podzolized," which means that a nearly white (leached) layer, very acidic and almost devoid of nutrients, is present beneath a mat of decaying needles. Such soils are called podzols. The natural soils of the Arboretum developed beneath a mixed deciduous forest and grassland and are more alkaline. They are only mildly podzolized, and referred to as gray-brown podzolics. Considering this, the question which arises is whether or not the pines planted on gray-brown podzolic soils will cause these soils to become more like the podzols of the northern coniferous forests by altering the chemical nature of the materials percolating through the soil.

LOCATION OF ARBORETUM PINE FORESTS
AND LOCATION OF THE SAMPLE SITES



With the discovery of the wide occurrence of strongly podzolized soils that are not acid, the purely chemical concept of podzolization has been broadened. According to Wilde[1] (1958), podzolization proceeds largely under the influence of microorganisms and the by-products of their metabolism where decomposition of forest litter tends to be retarded. Iron and aluminum oxides, as well as the bases, are leached from the surface layer of soil and are deposited at a lower level. This is brought about as a result of absorption of mineral salts by the microorganisms, by the action of reducing agents, and by the formation of complex organic compounds. Podzolization in a mild form can be a most beneficial process, immensely increasing the productivity of some forest soils, particularly those of sandy texture.

Three areas in the conifer forest of the Arboretum were chosen in which to investigate the effects of red and white pine stands of differing ages on the pH, litter depth and nutrient content of the underlying soil. One study was made in a portion of the Leopold Pines planted from 1933-37; two studies were located in the Grady Tract, one planted from 1943-44 and the other in 1954.

Choice of these areas can be explained by reference to the following rationale: (a) the areas were planted at about 10-year intervals; (b) they have a red pine to white pine ratio of about 1:1; (c) the three areas have the same soil type—Miami silt loam; (d) all had been farm land at one time; (e) they are free of trails, fire lanes, and major drainage courses, and are at approximately the same elevation with a slight easterly slope.

Soil samples were collected on April 29, 1967. A forty-foot quadrat was used for each study area, and each quadrat was divided into 9 sections, making 16 intersecting corners. Sample stations were located at each intersection.

After removal of the litter layer at each station, a soil core was obtained by means of a soil auger. Samples were taken at depths of one inch and six inches. The litter depth was measured at each station to the nearest quarter inch. The samples were stored overnight in a cooling device held at a temperature approximating that of the soil conditions in the pine stands.

Less than twenty-four hours after collecting the soil samples, pH was determined with the aid of a Beckman Zeromatic pH meter. Nurtient content was estimated using a La Motte Combination Soil Testing Kit, Model STH-14. Tests were made for nitrate nitrogen, available phosphorus, and replaceable calcium.

Statistical analyses of the data show that the three stands differ significantly with respect to pH values at the depths tested. The following table provides a general comparison of pH averages:

| | Planting Date | pH at 1" Depth | pH at 6" Depth |
|---|---|---|---|
| (1) | 1933-37 | 6.15 | 5.24 |
| (2) | 1943-44 | 6.32 | 5.54 |
| (3) | 1954 | 6.49 | 5.73 |

A calculation of the average litter depth from the data obtained yields the results presented in the table below. The data suggest a correlation between litter depth and pH of the soil.

| | Planting Date | Average Litter Depth in Inches |
|---|---|---|
| (1) | 1933-37 | 1.561 |
| (2) | 1943-44 | 1.250 |
| (3) | 1954 | 0.660 |

[1]Wilde, S. A. 1958. *Forest Soils. Their Properties and Relation to Silviculture.* Ronald Press Co., New York. 537 p.

The tests on available soil nutrients show the 1954 stand contains appreciably more nitrate nitrogen and replaceable calcium than the 1933-37 stand. The 1943-44 stand is intermediate between the other two stands, as would be expected. Tests for phosphorus are not as clear in the results obtained, but show a trend toward a decrease in phosphorus as the age of the pines increases. Results show definitely greater amounts of calcium in the 1" layer than in the 6" layer of soil for all three ages of pine stands.

The estimate of soil nutrients by the La Motte method leaves much to be desired however, and only broad, qualitative trends may be cited with any confidence. From these trends it appears that there is a loss (leaching) of nutrients from the 1" and 6" levels of the soil with time. This loss is probably associated with the rise in acidity and is likely due to the presence of the conifer litter. Somewhat podzolic conditions have evidently been produced in the Arboretum pines.

Assuming that the decay of the pine needles gives rise to the complex organic acids that favor podzolization, it would be anticipated that the longer a pine forest stays on the soil, the greater would be the amount of decay and leaching leading to a lowering of the pH. This is borne out by the data obtained. The youngest stand (1954) has less than an inch of needles and the pH is the highest (most alkaline) of the three stands. The intermediate age (1943-44) has intermediate pH values and less than an inch and a half needle layer. The oldest stand (1933-37) proved to have the deepest layer of needle litter, as well as the lowest (most acid) pH values.

—Colin P. Rees 1967

RED PINE

WHITE PINE

Leach