The Occurrence of Hickories in Iowa in Relation to Soil Types

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INTRODUCTION

The data of ecology reveals a very close relationship between soil types and the species of plants which will be normally found on them. Silviculturists have lately applied methods of ecology quite intensively to a study of the habits and associations of trees, and in these studies the physical and chemical properties of soils occupy a position of prominence. Silviculturists recognize some ten or twelve ecological factors influencing the occurrence and distribution of sylva. These are quite commonly known to foresters as the "Silvicultural Characteristics of Trees." Among the most important of these factors is the one of soil quality.

While the ecologists have mapped and described the vegetation occurring on certain more or less striking but limited soil areas or soil formations, and the silviculturists have made an extensive inventory of the gross characters of the soils for which each of the several forest tree species have evidenced a preference, neither of these classes of students has made any definite classification of the soils upon which certain species do occur, based upon the geological origin of the soils in question, and described in the accepted terminology of the United States Bureau of Soils.

The first attempt at such a distribution study was made by R. J. Becraft at Iowa State College in 1922-23, with reference to Quercus velutina along the Skunk River in Hamilton and Story Counties. The present study is a continuation of the work started by Becraft, and relates to the distribution of our native Iowa hickories.

THE PROBLEM OF TREE DISTRIBUTION

Historical

Notes on the distribution of trees in Iowa, and discussions as to the origin of Iowa's treeless prairies date back to a period when the Iowa Geological Survey was commencing its work. In 1870 White stated that "The question of the origin of the prairie has become more hackneyed perhaps, than any other of the spec-
ulative questions which North American geology affords.” Early writers attempted to explain the absence of trees over the greater part of the state, and their prevalence in some few parts, upon the basis of certain meteorological features common to prairie areas. Hence we find Macbride suggested that fires on a soil naturally adapted to gramineous vegetation which furnished fuel in such amounts, and at so frequent intervals, repeatedly destroyed the few tree seedlings that chanced to germinate. Shimek, after considering the factors of fire, the inherent moisture and temperature qualities of prairie regions, and geological formations and soils, pointed out that prevailing winds could greatly affect the presence

Fig. 1. Shag bark hickory and red oak on Clinton silt loam in Mahaska County. In the background may be seen a number of river birch, growing on Wabash silt loam. (Photo by Trenk)

or absence of a forest flora. In a later paper Shimek called attention to treeless openings in otherwise forested areas. The herbaceous vegetation of such areas, he showed, was identical with the more extensive prairie areas, and he ascribed their existence to the same causes which have produced our broader prairies.

Pammel has made a comparative study of the effect of the origin of certain soils upon the native vegetation, both herbaceous and arborescent. In a paper on the Flora of Western Iowa Pammel has discussed the plant formations found, following the classification of Cowles. In this paper a careful analysis is made of the predominating species of plants for each formation, some attention being given to those formations which are distinctly

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A number of papers have appeared describing the forest flora in various parts of the state, but few of these papers contain any ecological notes as to the distribution of the individual species of trees. Notes on forest trees appear with each of the geological descriptions of the various counties in the state, as these geological reports have been published from year to year. Pammel, MacDonald and Clark have made a valuable contribution to the study of trees and shrubs of the Missouri basin. The origin of the tree flora is briefly discussed, as is also the ecological distribution of the component species.

One paper, the contents of which are quite pertinent to the present study, is a report on a very thorough investigation by Salisbury of the Oak-Hornbeam woods of Hertfordshire, England. Particularly valuable are the data resulting from a comparative study of the edaphic conditions prevailing in the Quercus robur-Carpinus woods and the Quercus sessiflora-Carpinus woods, as they are found in southern England.

Some Factors of Distribution

In any discussion of the occurrence of a species of plant, it would appear that at least a review of the factors which have some effect on the observed occurrence is in order. To attempt to relate the distribution of hickories to any one factor as final would be quite misleading. While soil properties may be regarded as of major importance, other factors have been studied in considerable detail by numerous students, and in connection with problems quite similar to the present one.

Pearson regards the distribution of a forest type as dependent upon four main factors — temperature, precipitation, wind and evaporation, and soils. These he studied in some detail in the San Francisco mountains of Arizona, and in a subsequent paper attempted to determine what part each of these factors played in limiting the distribution of the four chief forest types (associations) in that region.

Bates and Zon working on research methods in forest environment, believe “that from every ecological aspect the important soil condition is the availability of soil moisture.”

A factor in the prevalence, if not in the absolute occurrence, of a species of tree is light. A tree is spoken of as being tolerant or intolerant according as it can withstand great shade, or is readily suppressed by a small amount of shade. Chief among the workers in America on the influence of light upon forest distribution and forest succession is Bates. Burns has pointed
out that not merely light, but whether it is diffuse or direct, affects forest succession, and concludes that foresters use the terms light and tolerance too loosely.

The factors so far touched upon are climatic and edaphic. Related to a study of hickory distribution is the work of Watts in England on the causes of failure of natural regeneration of oak and beech woods. Here is indicated a very pertinent factor — the biotic one. Watts, of course, duly recognizes the climatic and edaphic factors, but in addition has given interesting and valuable data on the effects of plant and animal enemies of the nut prior to germination, and the possible fate of the seedling after germination as it is subjected to the attacks of these same natural enemies. The fruit of most of our hickory trees being highly prized both by man and numerous rodents as food is quite evidently subjected
to the same possibilities of destruction as are the beech nuts, and to a lesser extent the acorns, of British woods.

**The Species of Hickories in Iowa**

Five species of hickory are native to Iowa, as recorded by Fitzpatrick: \(^{17}\) *Carya illincensis* (Wang) K. Koch (Pecan), *Carya ovata* (Mill) K. Koch (common shagbark), *Carya laciniosa* (Michx) Loud. (Big shellbark), *Carya alba* (L.) K. Koch (mockernut, *C. tomentosa* Nutt.) and *Carya cordiformis* (Wang) K. Koch (bitternut or swamp hickory, *H. minima*). The *C. cordiformis* and *C. ovata* are by far the most common. A very few pecan trees are found at Green Island in Jackson County. The State University Herbarium \(^{17}\) contains specimens from Muscatine and Louisa Counties. The big shell bark has been observed by the writer in Fremont, Appanoose and Van Buren Counties; Fitzpatrick \(^{17}\) reports it from Muscantine, Louisa, Wayne, Clinton and Jefferson Counties. The range of the mockernut hickory in Iowa is very limited. Specimens of this species are in the Iowa State College Herbarium from Muscantine County. Dr. Pammel reports having seen it in Scott County.

**The Distribution of Hickories as Related to Iowa Soils**

**Soil Classification**

The United States Bureau of Soils \(^{19}\) recognizes seven soil provinces and six soil regions. A soil province is defined \(^{18}\) as
an area which has the same general physiographic expression and in which the soils were produced by the same forces or groups of forces. A soil region may include several soil provinces which later study may establish. The whole of Iowa falls within the province named Glacial and Loessial, since the origin of practically all Iowa soils can be traced to one or the other of these sources. A more detailed outline for classification of Iowa soils based upon origin, and used by the Iowa Agricultural Experiment Station follows:

I. Uplands — origin being:
   A. Glacial.
   B. Loessial.
   C. Residual — limestone.
   D. Lacustrine.

II. Terraces.

III. Bottomlands.

The last two named are of alluvial origin.

These major groups may be further subdivided. The glacial soils may be divided on the basis of drainage; the loessial soils may be divided on the basis of topography, whether ridges and tops of divides or heads of drainage areas; terraces and bottomlands may be divided on the basis of color, source and texture. The final unit in each of these divisions is the series and it is arrived at by a composite description of the soil texture at the surface, at six or eight inches below the surface (subsurface) and at 30 to 36 inches (sub-soil) below the surface.

A soil type is characterized by two factors — series and class. Class refers to the predominating size of the individual soil particles at or near the surface — as clay, silt, sand, loam, gravel, etc. A dark brown to black loam surface soil found on a yellow clay loam sub-soil of glacial origin characterizes the Carriington series. The combination of the series name with the name of the class which in this instance was given as loam, constitutes the name of the type — Carriington loam. The nomenclature will be used in the present paper in the naming of the various soils.

Temperature and Moisture Data for Several Representative Soils

The statement of Bates and Zon regarding the availability of soil moisture as a factor in tree distribution has been quoted earlier in this paper. Temperature coefficients, both of the soil and atmosphere, have been shown by the Livingstons to greatly effect the occurrence and distribution of vegetation throughout the entire United States. It seemed advisable in this study to
secure data on a few representative soil types near Ames upon which hickories grow, to determine amounts of soil moisture present, and to compare the temperatures of several soils under varying weather conditions. Soil temperatures were taken at uniform depth of eight inches. Samples for soil moisture were taken at the surface, at six inches below the surface, and at 30 inches below the surface.

Four plots were selected. Plot I was a level area, rather heavily wooded, and the soil was Carrington loam. A point midway between two shag-bark hickories about six feet apart was chosen as the place at which to take soil temperatures, while samples of soil taken from approximately the same place were used in making the moisture determinations.

Plot II was Carrington loam (steep phase) near the base of a heavily wooded, ungrazed hill, sloping toward the north. Soil temperatures were read at a point about five feet from a bitternut hickory, eight inches in diameter; and soil samples used for determining soil moisture were taken from the same place.

Plot III was a Clarion loam (rolling phase) soil, east to northeast exposure, quite heavily wooded. Soil samples for determining soil moisture were taken from a point between a shag-bark hickory and a bitternut hickory, approximately five feet apart. The same place was used for taking the soil temperature readings.

Fig. 4. A nearly pure stand of shag-bark hickory seedlings and saplings on Clinton silt loam in Wapello county. (Photo by Trenk)
Plot IV was Miami sand loam, nearly level, and quite heavily wooded. Soil samples and temperature data were taken at a point about 30 feet from the nearest hickory. This was done in order to secure data from as near the center of this area of Miami sand loam as possible. The hickories appeared to grow near the border of the Carrington loam and of the Miami loam.

TABLE I
SOIL TEMPERATURE DATA

<table>
<thead>
<tr>
<th>DATE</th>
<th>TEMPERATURE READING</th>
<th>WEATHER</th>
<th>ATMOSPHERIC TEMP. (F)</th>
<th>SOIL TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>PLOT I</td>
<td>PLOT II</td>
</tr>
<tr>
<td>5/14/24</td>
<td>9 a.m.</td>
<td>Cold, windy and misting</td>
<td>44.5°</td>
<td>47.5°</td>
</tr>
<tr>
<td>5/20/24</td>
<td>3:30 p.m.</td>
<td>Cloudy and cold in a.m. Clear and warm in p.m.</td>
<td>61.5°</td>
<td>52.0°</td>
</tr>
<tr>
<td>2/27/24</td>
<td>3 p.m.</td>
<td>Clear, light west breeze, following a heavy rain</td>
<td>68.5°</td>
<td>53.5°</td>
</tr>
<tr>
<td>6/6/24</td>
<td>4 p.m.</td>
<td>Clear, a little wind, had been cloudy during a.m.</td>
<td>65.0°</td>
<td>56.0°</td>
</tr>
<tr>
<td>6/9/24</td>
<td>5 p.m.</td>
<td>Clear, heavy rain 20 hrs. earlier</td>
<td>68.0°</td>
<td>56.0°</td>
</tr>
<tr>
<td></td>
<td>AVERAGE</td>
<td></td>
<td>61.5°</td>
<td>43.1°</td>
</tr>
</tbody>
</table>

The results indicate that site, and not the physical properties of the soil, determine the average soil temperature.

TABLE II
SOIL MOISTURE DATA

<table>
<thead>
<tr>
<th>PLOT No.</th>
<th>DEPTH</th>
<th>ORIGINAL WT. GR.</th>
<th>AIR DRY WT. GR.</th>
<th>OVER DRY WT. GR.</th>
<th>(BASE-OVEN DRY) PRECENT HYDROSCOPIC MOISTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface</td>
<td>75</td>
<td>61.3</td>
<td>60.0</td>
<td>2.16%</td>
</tr>
<tr>
<td></td>
<td>Sub-surface</td>
<td>75</td>
<td>65.0</td>
<td>62.7</td>
<td>3.66%</td>
</tr>
<tr>
<td></td>
<td>Sub-soil</td>
<td>75</td>
<td>66.5</td>
<td>64.5</td>
<td>3.10%</td>
</tr>
<tr>
<td>2</td>
<td>Surface</td>
<td>75</td>
<td>66.9</td>
<td>61.9</td>
<td>8.07%</td>
</tr>
<tr>
<td></td>
<td>Sub-surface</td>
<td>75</td>
<td>63.5</td>
<td>60.2</td>
<td>5.48%</td>
</tr>
<tr>
<td></td>
<td>Sub-soil</td>
<td>75</td>
<td>64.8</td>
<td>63.8</td>
<td>1.52%</td>
</tr>
<tr>
<td>3</td>
<td>Surface</td>
<td>75</td>
<td>65.5</td>
<td>64.4</td>
<td>1.71%</td>
</tr>
<tr>
<td></td>
<td>Sub-surface</td>
<td>75</td>
<td>64.1</td>
<td>62.65</td>
<td>2.31%</td>
</tr>
<tr>
<td></td>
<td>Sub-soil</td>
<td>75</td>
<td>64.3</td>
<td>62.7</td>
<td>2.54%</td>
</tr>
<tr>
<td>4</td>
<td>Surface</td>
<td>45</td>
<td>34.42</td>
<td>32.94</td>
<td>4.59%</td>
</tr>
<tr>
<td></td>
<td>Sub-surface</td>
<td>45</td>
<td>39.43</td>
<td>39.12</td>
<td>0.80%</td>
</tr>
<tr>
<td></td>
<td>Sub-soil</td>
<td>45</td>
<td>38.65</td>
<td>37.36</td>
<td>3.45%</td>
</tr>
</tbody>
</table>
Detail of Occurrence of Hickories Over Principal Soil Areas

The whole of Iowa, with the exception of a narrow strip bordering the Mississippi River in the northeast corner of the State, has been glaciated. Some parts of the State have been visited by several glaciers, the last of which occurred in the late Cenozoic. Upon the basis of the glaciers which have passed over Iowa, and their subsequent influence on the topography and drainage of the State, geologists recognize five main soil areas which are known as the Southern Iowa Loess, the Missouri Loess, the Mississippi Loess, the Iowan Drift and the Wisconsin Loess, the

Iowan Drift and the Wisconsin Drift. As the names indicate, the soils in three of the areas were deposited chiefly by wind, in the other two by glaciers. The geology of each of these areas, and its influence upon the soil, will be discussed presently.

In this distribution study it seemed desirable to consider the occurrence of hickories in relation to the predominating soil types in each of the soil areas. An attempt has been made to determine for each of the areas those soils upon which hickories most universally occur, those upon which they occur just occasionally, and those which rarely support hickory. Distinction has been made of course, as to which species of hickory were observed. Data have also been taken determining the relative percentages of each species of tree found on a plot of a specified soil type 60 feet in radius. Notes on the associated vegetation, of both shrubs and herbs, are included, since there is frequently a marked
relationship between the herbage found on certain soils and the arborescent plants found on these same soils.

(Note: For the purpose of reducing the length of this paper, census data and notes on the ecology of thirty-nine sample plots, distributed throughout the five soil areas of the State, will be omitted.)

SUMMARY OF OBSERVATIONS ON THE OCCURRENCE OF HICKORIES IN RELATION TO SOIL TYPES

<table>
<thead>
<tr>
<th>Soil Area</th>
<th>Loess</th>
<th>Drift</th>
<th>Terrace</th>
<th>Bottom-land</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Iowa</td>
<td>Clinton silt loam (1) (2)</td>
<td>Shelby loam (1) (2)</td>
<td>Calhoun silt loam (1)</td>
<td>Waubash silt loam (3)</td>
<td>Union silty clay loam (3)</td>
</tr>
<tr>
<td>Iowa loess</td>
<td>Marion silt loam (1)</td>
<td>Lindley loam (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missouri Loess</td>
<td>Marshall silt loam (1) (2)</td>
<td>Shelby silt loam (1) (2)</td>
<td>Waukasha silt loam (1)</td>
<td>Waukasha silt loam (3)</td>
<td></td>
</tr>
<tr>
<td>Missouri Loess</td>
<td>Clinton silt loam (1)</td>
<td>Lindley silt loam (1) (2)</td>
<td>Waukasha silt loam (1)</td>
<td>Waukasha silt loam (4)</td>
<td>Dubuque silt loam (3)</td>
</tr>
<tr>
<td>Mississippi</td>
<td>*Fayette silt loam (1)</td>
<td>*Thurston loamy sand (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loess</td>
<td>*Lindley loam (1)</td>
<td>*Carrington silt loam (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa Drift Sheet</td>
<td>Clinton silt loam (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Carrington loam (steep phase) (1) (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift Sheet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) = Carya ovata
(2) = Carya cordiformis
(3) = Carya laciniosa
(4) = Carya illinoensis
* = Occurrence of hickories reported in Iowa Soil Survey Reports, but not observed by the writer.

While it is not intended to report these findings as final in all details, an examination of the tabular summary reveals several interesting observations. When one considers that there are over 115 recognized soil types in Iowa, it is noteworthy that such a relatively small percentage of the total number support a growth of hickory.

In the Wisconsin Drift sheet hickories occur only on drift soils. Carya ovata and Carya cordiformis are the species.

Clinton silt loam is the important hickory-bearing type in three
soil areas — the Southern Iowa Loess, the Mississippi Loess, and the Iowan Drift.

Drift soils bearing hickories were observed in all of the five soil areas, and exhibit a wider variation in types than any other group of soils.

Three terrace types supporting hickories were found. One, the Calhoun silt loam, is limited to the Southern Iowa Loess area; another, the Chariton silt loam, is limited to the Mississippi Loess area; while the Waukasha silt loam is common to both the Mis-

![Image](https://example.com/image.jpg)

Fig. 6. A view showing how completely the young tree growth and ground cover were destroyed by a ground fire in this stand of shellbark hickories and white oaks, on Marion silt loam, in Wapello county. (Photo by Trenk)

sissippi Loess area and the Iowa Drift Sheet. The Calhoun was found to support only *Carya ovata*, as did also the Chariton silt loam. In the Mississippi Loess only *Carya ovata* was observed on the Waukasha silt loam, while on the same type, in the Iowan Drift sheet, *Carya cordiformis* was the only species.

Two bottomland types support hickories. The Wabash silt loam, common to the Southern Iowa Loess and Missouri Loess areas has a limited occurrence of *Carya laciniosa*, while on the Wabash silty clay loam in the Mississippi Loess was found a few *Carya illinoensis*.

The Union silty clay loam and Dubuque silt loam were the only residual soils found supporting hickory. *Carya ovata* was the only species.

**CONCLUSIONS**

The results of this investigation hardly warrant the drawing
of any conclusions as to the absolute factors determining the occurrence of the several species of hickories in the state. As was mentioned earlier in this paper, soil qualities is but one of a number of factors which influence tree distribution. With the definite information, however, of the specific types of soil upon which hickories do occur, and upon which they never occur, a future study dealing in more detail with analyses of the soil types involved is suggested as a means to enable one to draw more definite conclusions concerning the occurrence of hickories in Iowa.

Fig. 7. White oak and shag-bark hickory on Miami silt loam in Webster county (Photo by Trenk)

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HICKORIES AND SOIL TYPES


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Iowa State College.

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