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Contrasts in certain physical factors in Fagns-Acer and Quercus-Carya communities in Brown and Bartholomew counties, Indiana

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The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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CONTRASTS IN CERTAIN PHYSICAL FACTORS IN FAGUS-ACER AND QUERCUS-CARYA COMMUNITIES IN BROWN AND BARTHOLOMEW COUNTIES, INDIANA

By RAY C. FRIESNER *and* J. E. POTZGER

Oak-hickory forests occur in Indiana under three sets of ecological conditions. First, in the northern fifth of the state, roughly north and west of the Tippecanoe river (except for the northeast corner, i. e., Steuben and part of Lagrange counties), they are the most mesophytic type of forest that will be permanently maintained by the general climate of the area and, therefore, become the climax association. Second, in the southern four-fifths of the state the general climate is such as to support beech-maple as the most mesophytic forest-type capable of permanent maintenance and they there become the climax. However, within this area where beech-maple is climax, oak-hickory occurs on sites where edaphic and physiographic conditions combine to render the areas more xeric, and oak-hickory is the most mesophytic forest community capable of being maintained under the present environmental conditions. Under these conditions there will be an indefinitely prolonged period during which oak-hickory is the end of ecological succession. Since this end of succession will be due to edaphic and physiographic reasons and not by reason of the general climate, oak-hickory becomes subclimax on these sites.

The third set of conditions under which oak-hickory occurs in Indiana is on sites which in every way are capable of supporting beech-maple communities but where forest succession has not progressed to the final or climax stage. Such sites show oak-hickory predominating so far as crown-coverage and density of mature stems are concerned, but the reproduction as shown by density of younger stems is mostly beech and maple and the ultimate end of succession will be beech-maple unless general climate conditions are changed. Under such conditions oak-hickory is preclimax.

The transition from beech-maple climax of the southern four-fifths of the state to oak-hickory climax in the northern fifth is coincident with a change in average annual rainfall from 38 inches to 35 inches, the latter soon followed by a further drop to 33 inches.

With a view to analyzing some of the factors concerned in differentiating and determining the beech-maple climax and the oak-hickory subclimax, studies were carried on from the following standpoints: available soil moisture, evaporation demands, soil acidity relation, floristic composition, and character of herbaceous flora. Data obtained from the first three of the above standpoints are brought together under the present heading, while data from the last two standpoints will be presented in a subsequent paper.

AVAILABLE SOIL MOISTURE

Three of our areas were so situated and showed the necessary floristic composition to be used as direct contrasts between beech-maple and oak-hickory communities. These areas gave a total of five beech-maple communities to be contrasted with a similar number of oak-hickory communities. A brief explanation of these areas follows.

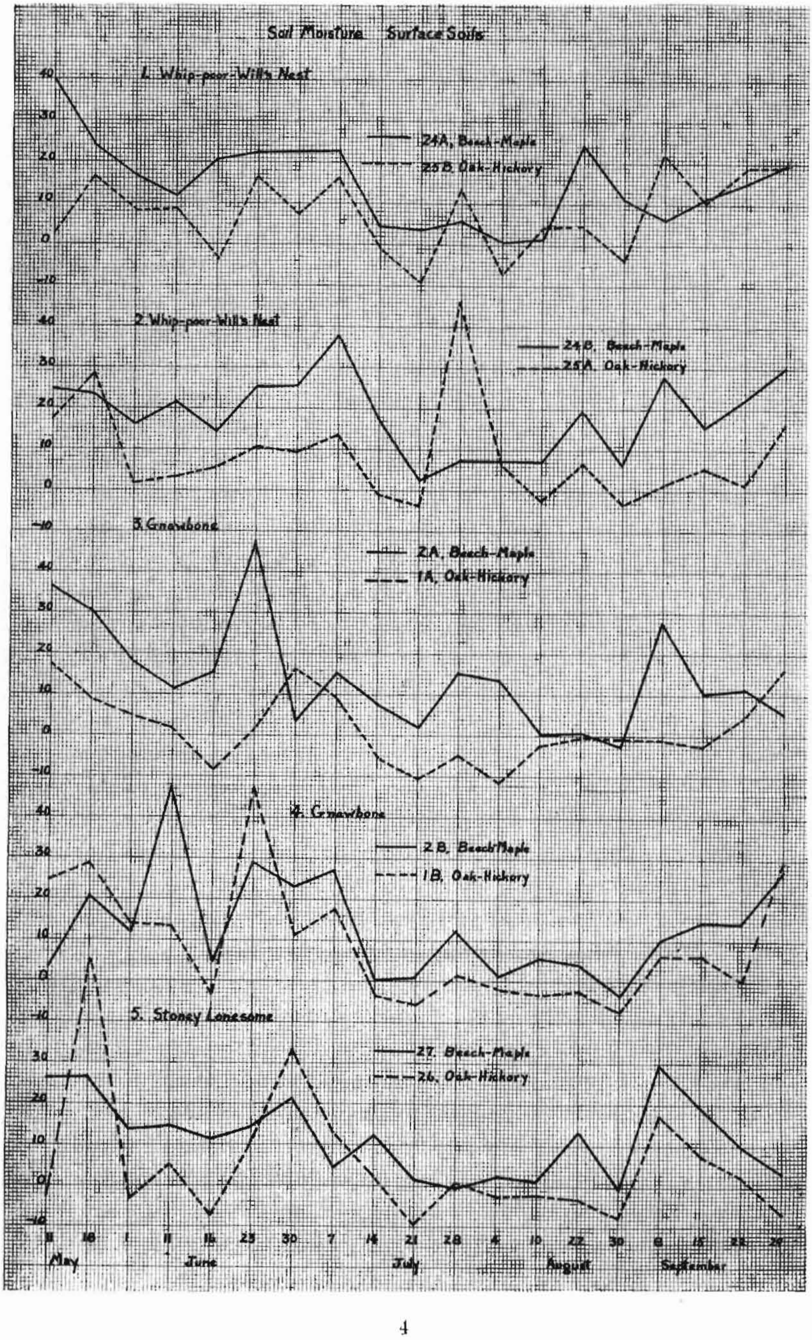
Whippoorwill's Nest. This area comprised a very narrow-topped east-west ridge in Brown county, locally known by the above name, with heavily wooded steep north-facing slope (Area 24 A, B) and somewhat less heavily wooded south-facing slope (Area 25 A, B). The north-facing slope comprised chiefly beech-maple with some Liriodendron and *Quercus borealis maxima,* while the south-facing slope contained primarily *Quercus velutina, Q. coccinea, Q. alba* and *Q. montana,* with some *Carya glabra.* Each slope was divided into upper and lower portions: 24 A and 25 B comprising lower portions of their respective slopes and 24 B and 25 A comprising upper portions.

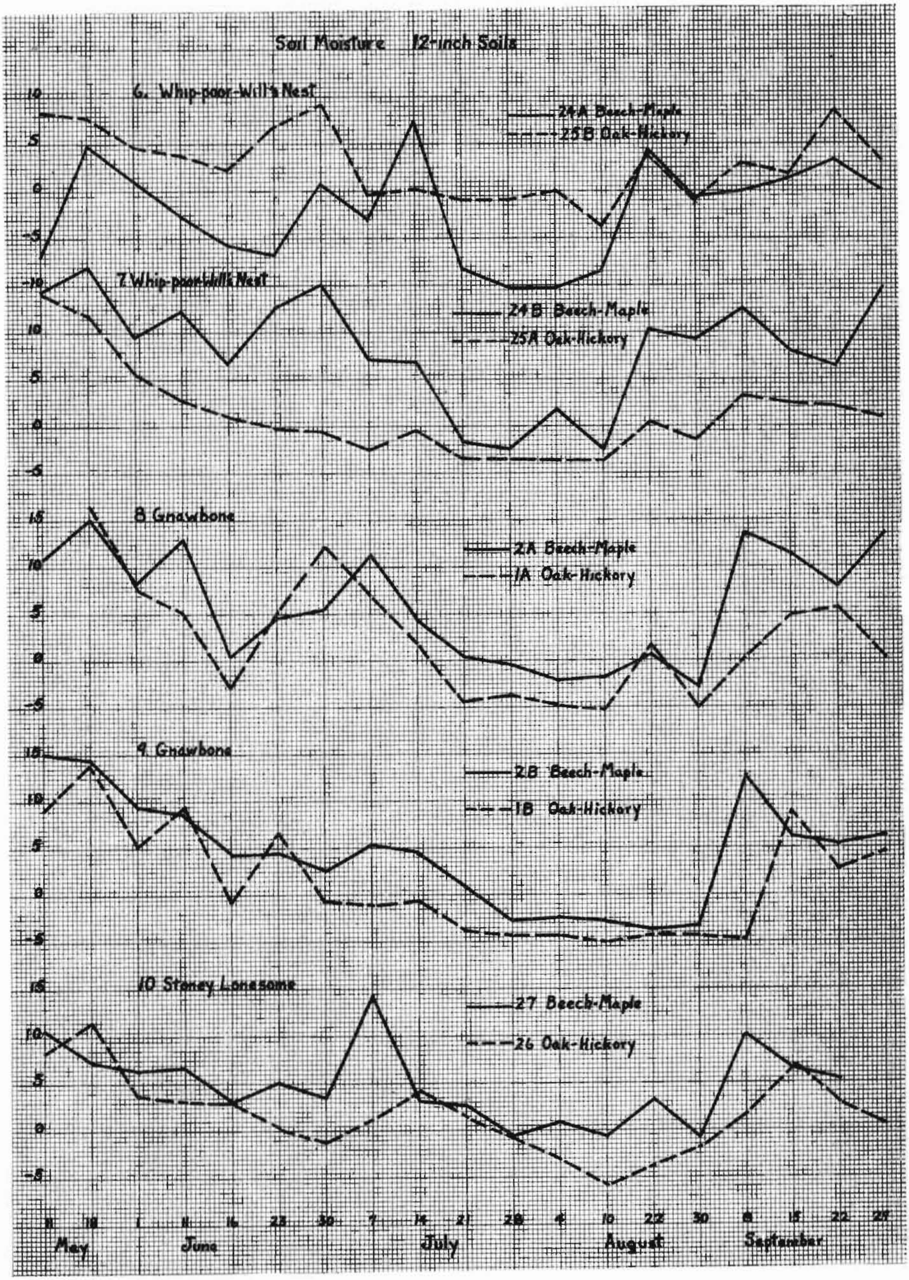
Gnawbone. This area comprised a north-facing slope (Area 1 A, B) and a south-facing slope (Area 2 A, B), on opposite sides of the same narrow valley. It is located about one mile northeast of Gnawbone in Brown county. The north-facing slope was chiefly beech-maple with Liriodendron and *Quercus borealis maxima,* while the south-facing slope comprised *Quercus alba, Q. velutina, Q. coccinea* and *Q. montana* with *Carya glabra* and *C. ovata.* These ridges were neither so high nor their slopes quite so steep as those at Whippoorwill's Nest, but the floristic composition is very similar. Lower portion of the slopes was 1 A and 2 A respectively, while upper portion was 1 B and 2 B.

Stoney Lonesome. This area comprises a north-facing slope (Area 27) and a south-facing slope (Area 26) on opposite sides of a narrow valley. It is located at Stoney Lonesome about one-half mile east of the Brown-Bartholomew county line. The slopes are on opposite sides of Indiana Road 46. On the north-facing slope is a mature stand of almost pure beech-maple, while on the south-facing slope is a very much less mature stand of *Quercus velutina*, *Q. montana* and *Q. alba*. The ridges are still lower and the slopes less steep than either of the other stations.

Soil samples were taken at surface, 6-inch and 12-inch depths from each of these areas at weekly intervals from May 11, to September 29, 1934. Percentage of moisture in terms of dry weight of soil was determined for each sample and from these percentages was subtracted the percentage of unavailable water, thus giving the percentage of available moisture. Curves show the percentage of available water, or, when this falls to zero, minus percentages are given, showing the difference between the wilting coefficient of the soil and the percentage of water present. The details of technique used were the same as used in our earlier studies dealing with soil moisture, (4). A comparison of the curves (beech-maple vs. oak-hickory: Curve 1 for Areas 24 A vs. 25 B, lower part of slope; Curve 2 for Areas 24 B vs. 25 A, upper portion of slope; Curve 3 for Areas 2 A vs. 1 A, lower portion of slope; Curve 4 for Areas 2 B vs. 1 B, upper portion of slope; Curve 5 for Areas 27 vs. 26) shows very definitely that surface soils in beech-maple areas are, with few exceptions, higher in available moisture than similar soils in oak-hickory areas. A comparison of the same curves shows also that surface soils rarely show lack of available water in these beech-maple areas but very frequently do in our oak-hickory areas. Beech-maple areas showed lack of available water in surface soils for only two weeks of the season, viz., July 28 at Stoney Lonesome and August 30 at both Gnawbone and Stoney Lonesome. Beech-maple areas at Whippoorwill's Nest showed absence of available water at no time during the season. In striking contrast to this, oak-hickory areas show absence of available water for eleven different weeks, as follows: at Whippoorwill's Nest, June 16, July 14, 21, and August 4, 10, 30; at Gnawbone, June 16, July 14, 21, 28, August 4, 10, 22, 30, and September 8, 15; at Stoney Lonesome, June 1, 16, July 21, and August 4, 10, 22, 30. The similarity in dates when there was lack of available soil moisture in oak-hickory areas at the different stations is all the more striking when we note that the Whippoorwill's Nest station is five miles from Gnawbone, which is in turn five miles from Stoney Lonesome.

When we turn to 12-inch soils, Curves 6-10, we find again that, with few exceptions, beech-maple soils are higher in available moisture than oak-hickory soils. The only exception of any consequence is found when the lower parts of the ridge at Whippoorwill's Nest are compared. Here (Curve 6) the beech-maple soil on the north side of the ridge was lower in available moisture (except for three different weeks) than the oak-hickory soil on the south side of the ridge.


Soil Moisture Surface Soils
1. Whip-poor-Will's Nest
24A, Beech-Maple
25B, Oak-Hickory
2. Whip-poor-Will's Nest
24B, Beech-Maple
25A, Oak-Hickory
3. Gnawbone
2A, Beech-Maple
1A, Oak-Hickory
4. Gnawbone
2B, Beech-Maple
1B, Oak-Hickory
5. Stoney Lonesome
27, Beech-Maple
26, Oak-Hickory
May
June
July
August
September


Soil Moisture 12-inch Soils
6. Whip-poor-Will's Nest
24A Beech-Maple
25B Oak-Hickory
7 Whip-poor-Will's Nest
24B Beech-Maple
25A Oak-Hickory
8 Gnawbone
2A Beech-Maple
1A Oak-Hickory
9 Gnawbone
2B Beech-Maple
1B Oak-Hickory
10 Stoney Lonesome
27 Beech-Maple
26 Oak-Hickory
May
June
July
August
September

Twelve-inch soils more often showed moisture content falling below wilting coefficient than surface soils. With the exception of Curve 6, beech-maple soils showed much smaller number of weeks without available moisture than oak-hickory soils. Beech-maple soils showed lack of available moisture as follows: Whippoorwill's Nest (Curve 7), 2 weeks; Gnawbone (Curve 8), 4 weeks; Gnawbone (Curve 9), 5 weeks; Stoney Lonesome (Curve 10), 3 weeks. In contrast, oak-hickory soils showed lack of available moisture varying from 6 to 12 weeks, as follows: Whippoorwill's Nest (Curve 7), 12 weeks; Gnawbone (Curve 8), 6 weeks; Gnawbone (Curve 9), 10 weeks; Stoney Lonesome (Curve 10), 7 weeks.

Beech-maple and oak-hickory relations are reversed when lower portions of the ridge at Whippoorwill's Nest are compared. Here (Curve 6) beech-maple soil showed lack of available moisture for 10 weeks, while oak-hickory soil showed similar lack for only 3 weeks.

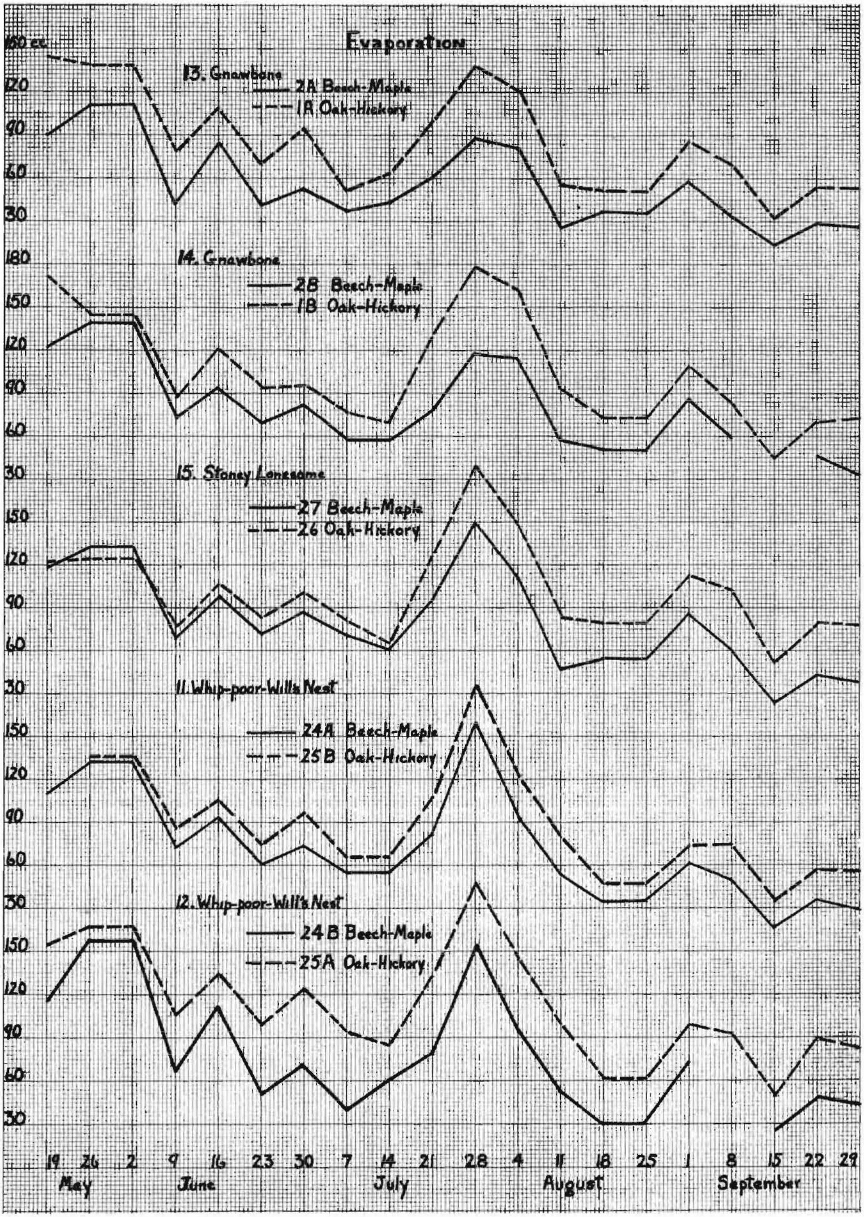
EVAPORATION

Livingston porous-cup white atmometers were set up in each station and refilled weekly from May 12 to September 29. Evaporation loss (standardized) for each station is shown in Curves 11-15. These curves show remarkable similarity in respect to periods of high and low evaporation, even though the stations varied up to ten miles apart. Comparison of curves for beech-maple and oak-hickory areas in the same locality and under comparable topographic conditions shows that for almost every week and in every locality evaporation was greater in oak-hickory areas than in beech-maple areas.

When water loss in beech-maple communities is compared with that in oak-hickory communities when the two are on opposite sides of the same ridge or on opposite sides of the same valley, the more xerophytic character of oak-hickory sites is strikingly revealed. Average weekly water loss in such comparable stations is shown below:

AVERAGE WEEKLY EVAPORATION

	Beech-Maple	Oak-Hickory
Whippoorwill's Nest—Lower part of ridge	71.92 cc.	87.25 cc.
Whippoorwill's Nest—Upper part of ridge	77.03	112.42
Gnawbone—Lower part of ridge	55.19	85.45
Gnawbone—Upper part of ridge	80.15	104.84
Stoney Lonesome	80.45	100.73
Average of all stations	72.90	98.25


Evaporation
160 cc
120
90
60
30
13. Gnawbone
2A Beech-Maple
1A Oak-Hickory
180
150
120
90
60
30
14. Gnawbone
2B Beech-Maple
1B Oak-Hickory
150
120
90
60
30
15. Stoney Lonesome
27 Beech-Maple
26 Oak-Hickory
150
120
90
60
30
11. Whip-poor-Will's Nest
24A Beech-Maple
25B Oak-Hickory
150
120
90
60
30
12. Whip-poor-Will's Nest
24B Beech-Maple
25A Oak-Hickory
19 26 2 9 16 23 30 7 14 21 28 4 11 18 25 1 8 15 22 29
May
June
July
August
September

If these data are compared with results obtained in other seasons and in other localities, it will be seen that the season of 1934 in Brown and Bartholomew counties was considerably more severe than any other season for which we have records available except the year 1930 in Brown county.

AVERAGE WEEKLY EVAPORATION

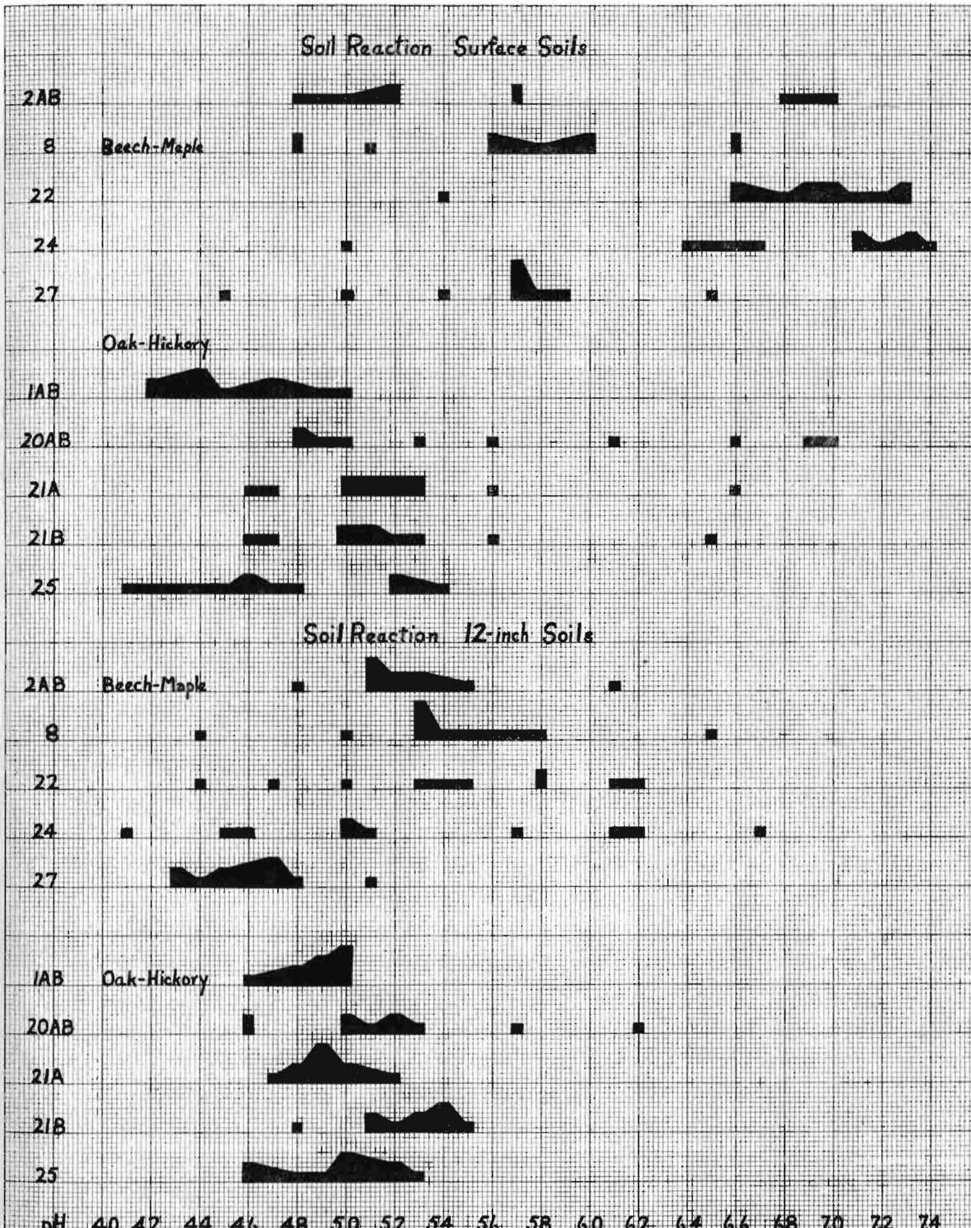
	Beech-Maple	Oak-Hickory
Chicago (5), 1910-1912	49.1 cc.	61.8 cc.
Washington-Idaho (7), 1914	58.8	
Sycamore Creek (Indiana) (1), 1928	46.2	56.8
Sycamore Creek (4), 1929	56.7	
Turkey Run (3), 1929	50.4	
Trevlac, Brown County (4), 1930	80.9	
Average stations in present study, 1934	72.9	98.25

If we use evaporation in the beech-maple association as a standard, we find that the oak-hickory associes in our studies shows up considerably more xeric than in any of the other studies that we have available for comparison. This is shown in the following comparison:

Beech-Maple	100 cc. per week
Oak-Hickory—Chicago Area (5)	126 cc. per week
Oak-Hickory—Sycamore Creek (1)	123 cc. per week
Oak-Hickory—Average of present stations	135 cc. per week

SOIL REACTION

Soil reaction in each forest area studied was determined from ten samples at each of three depths, viz., surface, 3-inch and 12-inch soils. Readings were made on the Youden apparatus. The range of reaction in surface soils for beech-maple does not show much difference from that of oak-hickory, except that the reaction spread is a little nearer alkalinity in beech-maple, extending from pH 4.5 to 7.53, and a little more acid in oak-hickory, extending from pH 4.1 to 7.24. Reference to the graphs where an attempt is made to indicate the number of samples giving a particular pH reading shows a better picture of the soil reaction results than mere pH range. Here it will readily be seen that the majority of the soil samples gave a decidedly more acid reaction for oak-hickory than was found in any of the beech-maple areas except one. It will also be seen that while the oak-hickory range exhibits as wide a spread as the beech-maple, the majority of the samples fall within a much narrower range


Soil Reaction Surface Soils
2AB
8
Beech-Maple
22
24
27
Oak-Hickory
1AB
20AB
21A
21B
25
Soil Reaction 12-inch Soils
2AB
Beech-Maple
8
22
24
27
1AB
Oak-Hickory
20AB
21A
21B
25
pH 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74

which is mucb more acid than the majority of the readings for beech-maple soils.

When 12-inch soils are considered, we find that while beech-maple exhibits a considerably wider range in pH readings than oak-hickory soils, the majority of beech-maple samples are massed in a part of the range with higher pH value than the majority of the oak-hickory samples. There is a general tendency, therefore, for beech-maple soils to give a higher pH reading and oak-hickory soils to give a lower pH reading.

To what extent these two forest types are cause and to what extent they are effect of these pH differences it is difficult to say. Judging from the reaction ranges and comparing these with the position within the ranges where majority of readings occur for each type, it seems a fair conclusion that either forest type can tolerate a fairly wide range of soil reaction, but, once established, there may be a tendency for the decomposition products of the two forest types to be such that the net result is a higher acidity in oak-hickory soils than in beech-maple soils. This is to say, that it is likely that the difference in reaction of soil in these forest types is due more to the differences in vegetation than the reverse.

DISCUSSION

If we follow the concept of Clements (2) and consider the climax vegetation to be the most mesophytic type capable of being permanently supported by the climate of a region, it becomes quite clear that since beech-maple is generally distributed over this south central portion of Indiana and not limited to isolated areas where edaphic and physiographic conditions give it sites more mesophytic than is general in terms of climatc for the area, it is to be considered the climax forest type of the region. Oak-hickory, occurring under the same general climatic conditions, but on sites where edaphic and physiographic conditions combine to make available soil moisture generally less and evaporation demands almost invariably greater, and hence on more xerophytic sites, must be considered as a subclimax associes.

It is likely that this oak-hickory associes will be of indefinite duration before the edaphic and physiographic changes necessary to transform the sites into those sufficiently mesophytic to permit succession to beech-maple. For this reason we use Clements' term "subclimax" here and reserve his term "preclimax" for those oak-hickory communities which are on sites edaphically and physiographically capable of supporting beech-maple but where ecological succession has not yet reached the climax or final stage.

As noted by Potzger (6), the most characteristic single feature of the hilly part of south central Indiana is this dual nature of the forest climax wherein beech-maple is the climax and oak-hickory forms a subclimax of indefinite duration.

SUMMARY

1. Oak-hickory occurs in Indiana under three sets of ecological conditions, i. e., climax, subclimax and preclimax.

2. In areas where oak-hickory is subclimax or preclimax, beech-maple forms the climax.

3. Subclimax oak-hickory is the end of forest succession and will persist for periods of indefinite duration on those sites where edaphic and physiographic factors render the conditions more xeric than are general for the larger region, but climax oak-hickory occurs in the northern fifth of the state, where average annual rainfall drops rather suddenly from 38 to 35 inches, followed by a second drop to 33 inches.

4. Preclimax oak-hickory occurs on sites where conditions are capable of supporting beech-maple but where ecological succession has not yet reached the final or climax beech-maple stage.

5. When subclimax oak-hickory is compared with climax beech-maple, available soil moisture is lower and evaporation demands higher for almost all of the late spring and summer season in oak-hickory than in beech-maple communities.

6. Soil acidity shows no striking difference in beech-maple and oak-hickory sites, except that surface soils under oak-hickory are more acid than those under beech-maple.

LITERATURE CITED

1. CAIN, STANLEY A., and R. C. FRIESNER. Some ecological factors in secondary succession: Upland hardwood. I. Evaporation studies in the Sycamore creek region. Butler Univ. Bot. Stud. 1:1-15. 1929.
2. CLEMENTS, F. E. Nature and structure of the climax. Jour. Ecol. 24:252-284. 1936.
3. DAUBENMIRE, REXFORD F. The relation of certain ecological factors to the inhibition of forest floor herbs under hemlock. Butler Univ. Bot. Stud. 1:61-76. 1930.
4. FRIESNER, RAY C., and J. E. POTZGER. Studies in forest ecology. I. Factors concerned in hemlock reproduction in Indiana. Butler Univ. Bot. Stud. 2:133-144. 1932.
5. FULLER, GEORGE D. Evaporation and soil moisture in relation to the succession of plant association. Bot. Gaz. 48:193-233. 1914.
6. POTZGER, J. E. Topography and forest types in a central Indiana region. Amer. Midland Nat. 16 (2):212-229. 1935.
7. WEAVER, J. E. Evaporation and plant associations in southeastern Washington. Plant World 17:273-294. 1914.