

THE ORIGINAL VEGETATION COVER OF WISCONSIN

A thesis submitted to the Graduate School of
the University of Wisconsin in partial fulfillment
of the requirements for the degree of Doctor of
Philosophy.

by

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Date May 3 , 19 51

To Professors: Trewartha

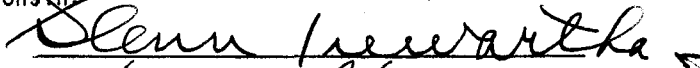
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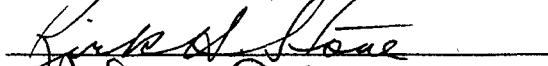
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(Major Professor)

Date May 22, 19 51

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ROBERT WILLIAM FINLEY

A Thesis Submitted in Partial Fulfillment
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CONTENTS

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Section	Page
List of Figures - - - - -	iv
I. Foreword and Introduction - - - - -	1
II. Other Maps of Vegetation Cover in Wisconsin	6
Large-Scale Maps Which Collectively Give State-Wide Coverage - - - - -	8
(a) The Township Sketch Maps of the Government Surveyors, 1832-1866	8
(b) Wisconsin Land Economic Inventory Maps, 1928-1938 - - - - -	9
Generalized Maps of the Entire State -	11
(a) Hoyt's Map of 1861- - - - -	12
(b) The Wisconsin Geological Survey Map of 1882 - - - - -	13
(c) Kellogg's Map of 1930 - - - - -	16
(d) The Forest Service Map of 1940	17
(e) Morris' Map of 1943 - - - - -	18
(f) Curtis' Map of 1948 - - - - -	19
(g) Wilde's Map of 1949 - - - - -	20
Area Maps - - - - -	22
(a) Wisconsin Geological Survey Maps, 1876-1878 - - - - -	22
(1) Chamberlin's Map of Eastern Wisconsin, 1876 - - - - -	23
(2) Wooster's Map of the Lower St. Croix Region, 1876-1877	24
(3) Sweet's Map of the Western Lake Superior Region, 1877	25
(b) Roth's Map of Northern Wisconsin, 1898 - - - - -	26
(c) Trewartha's Maps of the Driftless Hill Lands, 1940 - - - - -	29
(d) Fassett's Map of the Brule River Basin, 1944 - - - - -	31
(e) County Maps - - - - -	32
III. Source of Data - - - - -	35
IV. Techniques Used in Constructing the Map	46
Assembling the Data - - - - -	46

Contents

Analyzing and Interpreting the Data - -	52
(a) Interpretations Concerning Mapping Categories - - - - -	53
(b) Interpretations Concerning the Species Within a Genus - - - -	57
(c) Interpretations Concerning the Placement of Boundaries - - - -	62
Mapping the Data - - - - -	67
V. Classification of Vegetation Types - - - -	72
Forested Areas - - - - -	72
(a) The Boreal Forest - - - - -	78
(b) Deciduous Forest Types - - - - -	80
(c) Mixed Coniferous-Deciduous Forest Types - - - - -	88
(d) The Swamp Forests - - - - -	98
(e) Brushland - - - - -	102
(f) Miscellaneous Vegetation Categories	103
Grassland Areas - - - - -	104
VI. General Patterns of Vegetation Distribution	109
Broad Pattern of the Four Major Vegetation Types - - - - -	110
Pattern of the Smaller Subdivisions of Vegetation - - - - -	123
Summary - - - - -	146
VII. Specific Distributions of Vegetation Types: The Boreal Forest - - - - -	147
VIII. Specific Distributions of Vegetation Types: The Mixed Coniferous-Deciduous Forest -	151
(a) The Beech-Hemlock-Sugar Maple- Yellow Birch-Pine Forest - - - - -	154
(b) Hemlock-Sugar Maple-Yellow Birch- Pine Forest - - - - -	162
(c) Sugar Maple-Yellow Birch-Pine Forest	166
(d) The Pine Forest - - - - -	169
(e) White Birch-Aspen Forest - - - - -	175
(f) Other Mixed Coniferous-Deciduous Forest Types - - - - -	176

Contents

IX.	Specific Distributions of Vegetation Types: The Deciduous Forest - - - - -	179
	(a) The Beech-Sugar Maple-Basswood- Oak Forest - - - - -	181
	(b) The Sugar Maple-Basswood-Oak Forest	184
	(c) Basswood-Oak Forest - - - - -	201
	(d) The Oak Region - - - - -	204
	(e) The Lowland Hardwoods - - - - -	211
X.	Specific Distributions of Vegetation Types: The Grassland - - - - -	214
	(a) Marsh - - - - -	217
	(b) Wet Prairie - - - - -	222
	(c) Upland Prairie - - - - -	224
XI.	Specific Distributions of Vegetation Types: Other Vegetation Categories - - - - -	236
	Swamp Forests - - - - -	236
	(a) Coniferous Swamp Forests - - - - -	242
	(b) Deciduous Swamp Forests - - - - -	246
	Brushland - - - - -	246
	Miscellaneous Categories - - - - -	251
	(a) Windfalls - - - - -	251
	(b) Burned-Over Areas - - - - -	254
XII.	General Summary - - - - -	255
	Appendices - - - - -	260
	A. Instructions to United States Deputy Land Surveyors - - - - -	261
	B. Symbols Used for Recording Vegetation Data	270
	C. Table I. Average Vapor Pressure Difference	272
	Bibliography - - - - -	273
	Figures, Maps, and Diagrams - - - - -	281

LIST OF FIGURES

(To be found at the end of the text in the order listed below.)

- Fig. 1. Date of the Original Government Survey of Townships in Wisconsin
- Fig. 2. Sample of Township Worksheet and Recording Symbols
- Fig. 3. Continental Distribution of the Four Major Vegetation Formations Occurring in Wisconsin
- Fig. 4. The Four Major Vegetation Groups of Wisconsin
- Fig. 5. Generalized Vegetation Map of Wisconsin
- Fig. 6. Postulated Postglacial Changes in Climate and Vegetation in Wisconsin
- (a) First Phase
 - (b) Second Phase
 - (c) Third Phase
 - (d) Fourth Phase
 - (e) Fifth Phase
- Fig. 7. Diagrammatic Arrangement of Principal Vegetation Types of Wisconsin
- Fig. 8. Wisconsin Isotherms for July
- Fig. 9. Average Vapor Pressure Differences for Selected Stations
- Fig. 10. Thornthwaite's Precipitation-Evaporation Indices as Applied to Wisconsin
- Fig. 11. Distribution of Two Mixed Coniferous-Deciduous Forest Types in North America
- Fig. 12. Distribution of Beech in North America
- Fig. 13. Wisconsin Average Warm Season Precipitation
- Fig. 14. Distribution of Beech-Sugar Maple Forest Association in North America
- Fig. 15. Relationship of the Sugar Maple Forest Types to Physical Site Features in Dunn, Pepin, Pierce, and St. Croix Counties, Wisconsin

List of Figures

v

General Soil Map of Wisconsin by A. R. Whitson

Master Map. The Native Vegetation of Wisconsin at the
Time of the Original Land Survey

The master map, "The native vegetation of Wisconsin at the time of the original land survey," is not bound into the dissertation. One copy of it is owned by the University of Wisconsin Map & Air Photo Library and one copy by the Archives & Manuscripts division of the Library of the State Historical Society of Wisconsin. These two copies are non-circulating and cannot be reproduced because they are quite large (around 3'x4') and in color. However, we have been able to obtain for you another form of the map put out by the Wisconsin Geological and Natural History Survey. We hope this map will be of help.

SECTION I

FOREWORD AND INTRODUCTION

Some studies in geography are the presentations of the results of field work or other kinds of primary investigation. Other studies call upon the published results of the work and thinking of others to bring together related facts and ideas from varied sources to be compounded with the author's own thinking in introducing an idea which hitherto has never been presented in the same scope. By both methods new knowledge may be made available. A third method is a combination of these two in which both field investigation and library research are applied toward the solution of a problem. Such was the method used in this study.

The problem involved in this thesis was the compound one of constructing a map of the original native vegetation of Wisconsin and of investigating the causes of the distributions shown on that map. As a result of efforts directed toward these ends, the product consists of two main parts: (1) the map itself, and (2) the accompanying text which discusses the map and the distributions of the original native vegetation within the state.

--Foreword and Introduction

The field work which supplied the data from which the map was constructed was not actually performed by the writer. Since this is a map of the original native vegetation, it was necessary for the data to have been collected before the vegetation was altered by agricultural and lumbering activities. The only systematic field observations which recorded the character of the vegetation as of that time were those made by the surveyors who executed the first government land survey of the state. The vegetation so recorded was original in the sense that it was in its native condition unchanged by civilized man. Actually, in the literal meaning of the word, it would be impossible to determine the nature of the original vegetation, since vegetation is a dynamic feature constantly subject to change with its origins lost in antiquity. But the problem here is to show it in its native condition in the latest attained phase of its development before its destruction and exploitation by white men. The field notes of the surveyors of the original government survey of the state contain the only adequate source of information from which this can be done.

By use of the government survey field notes other vegetation maps have been made. Some are detailed maps of parts of the state, while some are small scale highly generalized maps of the state as a whole. But the survey

--Foreword and Introduction

field notes have never heretofore been fully utilized for the construction of a detailed map of the entire state. The map here presented does not make complete utilization of the source data because of the limitations of scale, although it makes a near approach to complete utilization. The map is constructed at a scale of 1:500,000, or approximately eight miles to the inch. Thirty-three vegetation categories are mapped and differentiated by means of color.

Much has been written about different facets of the vegetation complex of Wisconsin and about the vegetation of other areas that is applicable to the situation in Wisconsin. Thus there is a considerable body of library material pertinent to the subject by means of which the picture of the native vegetation of the state may be greatly clarified. However, up to now there has been no one study which has focused on the vegetation of Wisconsin as a whole. This is considered to be one of the major functions and contributions of the accompanying text. It brings together isolated bits of information about the vegetation categories that exist in the state, or about those that exist beyond its borders but that are pertinent to the state, and applies them to the distributions as they exist in Wisconsin. Most of this is not new information, but it is new in its application to the state. In

--Foreword and Introduction

attempting to make explanations and to point out patterns and relationships, it is necessary to draw upon such fields as plant ecology, botany, forestry, soils, geology, meteorology, and climatology as well as geography.

The text cannot be said to contain a complete and final explanation of the distributions of all the vegetation categories shown on the map. However, it does give as much of an explanation as the writer is able to make at the present time.

As in the case of many undertakings, this study would not have been possible were it not for the cooperation of many people. First, credit should be given to my unwitting colleagues of a century ago, the government surveyors who may be said to have started the study. Although it was not their purpose to help construct a state vegetation map, the map could not have been made without their work.

The idea of putting the survey field notes to this use was suggested by Professor Glenn T. Trewartha, who had had some considerable experience with them in preparing a map of the Driftless Area. In addition to suggesting the possibility of the project in the first place, Professor Trewartha has served as adviser in the preparation of the dissertation. The writer has greatly benefited from his counsel and from the association with him not only in this matter but in all others as well since

--Foreword and Introduction

the first contacts as a beginning graduate student.

The government survey records were made available to the writer by Mr. T. H. Bakken, in charge of the office of the Commissioners of Public Lands in the State Capitol. For help and good humor far beyond the call of courtesy, the writer wishes to express appreciation to him, and also to Miss Lillian Brackenwagen of the same office for help in locating records and interpreting aging handwritten manuscripts.

Professor J. T. Curtis of the University of Wisconsin Botany Department very kindly read the text and made many helpful comments and criticisms. He is in no way responsible for any errors that may have slipped through, although through his help others were eliminated.

Much credit is due my wife for performing the extended laborious and tedious handwork involved in the coloring of copies of the master map and for constant help in other phases of the work. And finally, appreciation is expressed to my parents who may possibly see here a partial fulfillment of a hope.

SECTION II

OTHER MAPS OF VEGETATION COVER IN WISCONSIN

A large number of maps have been made of the native vegetation of Wisconsin. Some cover the entire state, some cover large segments of the state but not all of it, while some cover counties or smaller areas. These maps vary not only in percentage of the state covered but also with respect to the nature of source materials used and in the detail of the mapping. All are based, at least in part, on field observations, made either by the persons constructing the maps or by others, but these observations vary widely as to date, intensiveness of coverage, and system employed.

Only two detailed systematic tabulations from field observations have been made of the character of the vegetation of the state as a whole. The earlier of these was that made by the surveyors who carried out the original government land survey in the years 1832-1866, while the other was that made by the Wisconsin Division of Land Economic Inventory and Land Use in the period 1928-1938. There have also been a number of other less formal studies and personal observations.

--Other Maps of Vegetation Cover in Wisconsin

Of all the surveys of one kind or another that have been made, the best source materials for mapping the original native vegetation of the state are those found in the descriptions given in the records of the original government land survey. These descriptions form the only complete, detailed, and organized record of the character of the vegetation cover as it existed before it had been appreciably altered by the occupance of white men.

Although many maps of the vegetation cover in Wisconsin have been based on the pre-settlement accounts of the government surveyors, those records have not been utilized fully. They have been used to make large scale detailed maps of limited areas and small scale generalized maps of the entire state, but they have never heretofore been fully drawn upon to construct anything approaching a detailed map of all the state.

In order to illustrate how the government survey records have previously been employed in mapping the state's vegetation, and also to show how other source materials have been incorporated into vegetation maps of Wisconsin, it is appropriate to present here a review of the maps existing at the time the present study was begun. This will give a basis for understanding how the map here presented is related to past work of a similar nature.

--Other Maps of Vegetation Cover in Wisconsin

These earlier maps may be grouped into three main classes: large-scale maps of individual townships which taken together cover the state; small-scale generalized maps of the entire state; and area maps. Those within each group will be discussed in the chronological order in which they were produced.

LARGE SCALE MAPS WHICH COLLECTIVELY GIVE STATE-WIDE COVERAGE

Included within this group are the maps made in connection with the two detailed field observations mentioned above, those of the original government surveyors and those of the Wisconsin Division of Land Economic Inventory and Land Use.

(a) The Township Sketch Maps of the Government Surveyors, 1832-1866.

The first methodical mapping of any part of the state's vegetation cover was that begun in 1832 by the government surveyors in connection with their work of surveying the state into townships and sections. In addition to recording the character of the vegetation that occurred along each section line, they normally made a sketch map of each township showing the location of such features as prairies, marshes, swamps, and in some cases, groves, thickets, wind-falls, etc. These sketch maps were made concurrently with the survey work; thus when the survey of the state was complete, there was also a state-wide coverage of township

--Other Maps of Vegetation Cover in Wisconsin

sketches showing distributions of the features mentioned above. Although these sketches were never incorporated into a single map, they were drafted into finished form at a scale of two inches to the mile and bound together into volumes, copies of which are now in the office of the Commissioners of Public Lands in the State Capitol at Madison and in the office of the Bureau of Land Management in Washington, D. C.

It was not intended that these township maps should show the complete character of the vegetation cover or even that they should be primarily maps of vegetation. They were designed to show other features associated with the survey work, and they included some of the vegetation cover types only incidentally. Therefore, they lay no claim to being adequate as maps of the native vegetation, but they were useful in the compilation of vegetation maps that appeared later.

(b) Wisconsin Land Economic Inventory Maps, 1928-1938.

The most intensive cataloguing of the state's vegetation was that made by the Division of Land Economic Inventory during the years 1928-1938 in connection with a detailed assessment of the nature of the total land cover. A group of workers were trained for the project, and as

--Other Maps of Vegetation Cover in Wisconsin

many as 700 mappers were in the field.¹ The investigators ran traverses in cardinal directions at quarter mile intervals. Along with the various other types of land cover, the following kinds of natural vegetation were mapped:²

upland hardwoods	white pine	tagalder, willow,
oak-hickory	Norway pine	dogwood
birch	jack pine	leather leaf
popple with white	red cedar	cattail marsh
birch		sedge marsh
scrub oak	balsam fir	grass marsh
	white cedar	weedy peat
hemlock with hardwoods	black spruce	recent burns
hardwood with conifers	swamp hardwoods	dead timber
		pin cherry

The final published maps are presented by government township units at a scale of one inch to one mile on individual sheets bound together to form booklets by counties. Some indication of diameter of trees, quality of timber, and density of stand is given.

These maps show the vegetation types along with other types of land cover. However, they cannot be considered collectively as a state map of the original native vegetation, because they do not show native vegetation exclusively, and also because the vegetation at this time had been so changed by the interference of man that it

¹Morris, William W., The Land Economic Inventory, (unpublished manuscript, Madison, 1949).

²See any of the county surveys of land cover, Wisconsin Land Inventory, State Department of Agriculture, Land Use Section.

--Other Maps of Vegetation Cover in Wisconsin

had little resemblance to the original cover.³ They do supply data that could be assembled into a single map showing the vegetation as of the period of 1928-1938. A map of this kind would be of interest for comparison with a map of the original native vegetation. Fassett has made such a study of the Brule River Basin (see pp. 31-32).

GENERALIZED MAPS OF THE ENTIRE STATE

Several maps have been prepared that show state-wide distributions of native vegetation. These are mostly small scale maps; all except one have a scale of 1:1,500,000 or less. Due to their limited size, these maps are of necessity very generalized and can show only a limited number of vegetation categories. As a result such categories had to be inclusive to a considerable degree with a wide variety of vegetation types classed under one heading.

All of the maps of this class except two are of the original vegetation. Each emphasizes a different set of vegetation groupings which makes for a considerable variance from map to map.

³The term original is used here to designate the status of the vegetation before it was disturbed by agricultural or lumbering activities.

⁴Fassett, N. C., Vegetation of the Brule Basin, Past and Present, Brule River Survey: Paper No. 4, Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, XXXVI, 1944, pp. 33-56.

--Other Maps of Vegetation Cover in Wisconsin

(a) Hoyt's Map of 1861.⁵

The first map known to the author that attempts to show the distribution of vegetation for the state as a whole is that published in 1861 by J. W. Hoyt, Secretary of the Wisconsin State Agricultural Society. It is entitled, "Map of Wisconsin designed to show General Geology, Climatology, Distribution of Timber, Population, etc. of the state." It is printed in black and white at a scale of approximately 1:1,500,000. In size it measures eleven inches east-west and twelve inches north-south. The part of Hoyt's map dealing with vegetation is very simple and greatly generalized. He has only four vegetation categories, three of which he shows by pictorial symbols. These are pine, heavy hardwoods, and oak openings. Prairies are indicated by "blank areas in the hard timber" districts. Areas of mixed pines and hardwoods are shown by intermingling the symbols for those two types.

Hoyt says that his map is based on observations of a number of persons and mentions a few specifically.⁶

⁵Published as the frontispiece in the Transactions of the Wisconsin State Agricultural Society, Vol. VI, 1861.

⁶I. A. Lapham, P. R. Hoy, and a Professor ^{Jas. L}Hale of the ^AUniversity of Wisconsin.

--Other Maps of Vegetation Cover in Wisconsin

This map is extremely rudimentary, and in showing the vegetation cover, it is more of a pictorial sketch than an actual map. Pine is attributed to all of northern Wisconsin, but little attempt is made to distinguish type, density of stand, or condition of occurrence with respect to presence of other species. From the map all of northern Wisconsin would be taken to consist of a vast pinery with the exception of the Vilas-Oneida County area which is labelled, "Region of lakes and marshes, very scantily timbered." The southern margin of pine is shown quite accurately, and along that margin the pine is correctly shown as being intermingled with hardwoods. Southeastern Wisconsin is indicated largely as having a heavy hardwood cover, while western Wisconsin is shown mainly as oak openings and prairie. The map has a considerable degree of accuracy in what it shows. Its inadequacy lies in its great generalization and in its omissions.

(b) The Wisconsin Geological Survey Map of 1882.⁷

The first real attempt at making a state-wide map showing the distribution of the major vegetation associations was represented by the "General Map of the Native Vegetation of Wisconsin, 1882." This map was based princi-

⁷Atlas of the Geological Survey of Wisconsin, Plate No. IIA.

--Other Maps of Vegetation Cover in Wisconsin

pally on source materials collected by persons connected with the Wisconsin Geological Survey. The chief geologist in charge at the time of publication was Mr. T.C. Chamberlin, who also collected much of the vegetation data.

The law which provided for a complete geological survey of the state was approved by the legislature on March 19, 1873, and stipulated that the survey should have as its objects:

- (1) An examination of the geological structure of the state;
- (2) Accurate chemical analyses and assays of the various minerals discovered;
- (3) A careful topographical survey of the lead region; and
- (4) An examination of soil and subsoil, and observations upon the animal and vegetable production of the state, with reference to its agricultural interests.⁸

Thus, the main focus of the study which resulted in this map was on the geology and the mineral resources of the state, while the investigation of the vegetation cover was more or less incidental. Nevertheless, three of the

⁸Geology of Wisconsin, Survey of 1873-1877, Volume II, pp. 5-6.

--Other Maps of Vegetation Cover in Wisconsin

field men turned in maps and written descriptions of the vegetation of the areas studied by them, while others gave written descriptions only.⁹ These descriptions vary from the systematic township by township summaries of Moses Strong to the more general descriptions of the other observers.

From these sectional maps and from the reports of the individual observers, a general state-wide map of the native vegetation was made. It is printed in color at the scale of 1:950,000. This scale gives a map about nineteen inches wide and twenty inches from top to bottom. The legend shows eight vegetation categories: prairie (grasses); meadow (sedges); oak group; maple group; mixed hardwood and evergreen (the latter mainly pine, hemlock, and balsam); pine group; dwarf oak and pine (including the so-called "barrens"); and swamp conifer group (tamarack, white cedar, spruce). From all appearances little or no use was made of the government survey field notes which had been completed for the state by this time. The boundaries of prairies and meadows, features whose outlines were sketched in detail by the federal surveyors, do not always conform with the same features as given in the survey records,

⁹These appear in Geology of Wisconsin, Survey of 1873-1879, Vols. II, III, & IV. Whether the observers furnished more detailed information for the compilation of the map than that published in these survey reports is not known to the author.

--Other Maps of Vegetation Cover in Wisconsin

although there is a general locational agreement. In some of the other categories there are rather wide disagreements in places. However, there was a time separation between the two studies of from ten to forty years which could account for changes in the vegetation that would be reflected in the maps. The Geological Survey map was made after exploitation had changed the vegetation cover considerably from its original character. Therefore, the map cannot be considered strictly as one of the original native vegetation, although enough fragments of the original vegetation still remained at the time to allow the general pattern of the original cover to emerge. Obviously, much interpolation and generalization had to be made, since at the time of the survey, 1873-1879, a high proportion of the land of eastern, southern, and western Wisconsin had been brought under cultivation, and no cultivated areas are shown as such on the map.

As a product of a reconnaissance survey, this map has a great deal to commend it, but since it is based on reconnaissance it is less concise and less revealing than a map based on a detailed systematic survey would be.

(c) Kellogg's Map of 1930.¹⁰

This is a very small scale (approximately 1:4,800,000)

¹⁰Kellogg, Charles E., Preliminary Study of the Profiles of the Principal Soil Types of Wisconsin, Wisconsin Geological and Natural History Survey Bulletin No. 77A, 1930, p. 22.

--Other Maps of Vegetation Cover in Wisconsin

sketch map printed in black and white of the native vegetation. It measures about four inches by four inches. Because of its small size, it must be greatly generalized and has but four vegetation categories: prairie, oak-hickory, hardwood and conifers, and pine-oak. Kellogg says that this map was "constructed from the reports of the various investigators in the Natural History Survey and from observations of the writer."¹¹ Its purpose is not to show detailed distributions of vegetation types, but to present background information to aid in the understanding of the general character and distribution of soil types.

(d) The Forest Service Map of 1940.¹²

This is not a map of original vegetation, but it is the most recent map of contemporary vegetation of the state. It is dated 1940 and shows in generalized form the conditions as they existed immediately prior to that time. The map is entitled "Distribution of Forests in the Lake States" and includes Michigan and Minnesota as well as Wisconsin. It is in color, has a scale of 1:2,000,000, and measures about nine and one-half inches by nine and one-half inches.

¹¹Ibid., p. 22.

¹²Prepared by the Forest Survey Staff of the Lake States Forest Experiment Station, University Farm, St. Paul, Minnesota.

--Other Maps of Vegetation Cover in Wisconsin

The legend gives the thirteen following classes:

Agricultural and industrial areas

Northern hardwoods

Primarily agricultural land, with 15 to 50% of area supporting northern hardwoods

Aspen, pincherry, highland or swamp brush, open or nonregenerating areas, muskeg

Primarily agricultural land, with 15 to 50% of area as above

Oak

Primarily agricultural land, with 15 to 50% of area supporting oak

Lowland hardwoods, river bottoms

Primarily agricultural land with 15 to 50% of area supporting lowland hardwoods, river bottoms

Pine

Primarily agricultural land with 15 to 50% of area supporting pine

Spruce, balsam, tamarack, cedar

Primarily agricultural land with 15 to 50% of area supporting spruce, balsam, tamarack, cedar.

(e) Morris' Map of 1943.¹³

This map was prepared by Mr. William W. Morris, Forester of the State Department of Agriculture, who was in charge of the timber growth studies made by the Wisconsin Land Economic Survey. The map is at a scale of

¹³Wisconsin Agriculture, Climate and Land Use, Division of Land Economic Inventory and Land Use, Wisconsin Department of Agriculture, Bulletin No. 238, 1943, p. 14.

--Other Maps of Vegetation Cover in Wisconsin

1:3,150,000 and is, therefore, highly generalized. It is in simple form in black and white and shows, by outlining the boundaries, the distribution of five vegetation types: oak and prairie; hard maple-basswood; mixed hardwoods and pine; hemlock, pine and hardwood; and lake shore. There is no legend but the names of the various vegetation classes are printed on the map in the places corresponding to their locations. It has a line marking the southern limit of commercial pine. The map is based on data from various sources, the description contained in the records of the original government land survey, the survey made by the Wisconsin Land Economic Inventory, the study made by Roth in Northern Wisconsin,¹⁴ and the personal knowledge of the author gained from experience in the state.¹⁵

(f) Curtis' Map of 1948.¹⁶

A more recent generalized map of the state as a whole is that prepared by Professor John T. Curtis of the University of Wisconsin Botany Department. This map is in black and white on a small scale, approximately 1:2,900,000,

¹⁴Roth, Filibert, On The Forestry Conditions of Northern Wisconsin, Wisconsin Geological and Natural History Survey, Bulletin 1, 1898, opp. p. 78.

¹⁵Personal Communication, February 1, 1951.

¹⁶Curtis, J. T., Plant Ecology Work Book, Laboratory, Field and Reference Manual, (Minneapolis: Burgess Publishing Company, 1950), p. 31.

--Other Maps of Vegetation Cover in Wisconsin

which gives it a size of about six and one-half inches by six and one-half inches. Because of the small size, it too can show only a limited number of plant groupings. The legend has five subdivisions, spruce, pine, maple, oak, and prairie. Professor Curtis compiled this map from the original government survey records by using the vegetation descriptions given for the township boundaries. Since the data come from the original survey records which antedate the settlement of the state, the map shows the distribution of pre-settlement vegetation types.

(g) Wilde's Map of 1949.¹⁷

The most recent generalized map of the original native vegetation of the state as a whole is that published in 1949 by Wilde, Wilson and White. It is printed in black and white. The scale is 1:4,200,000 approximately, and the dimensions are about four and one-half inches by four and one-half inches. Seven classes of vegetation are distinguished as follows: coniferous type; hemlock-hardwood type; white pine-hardwood type; pine type and scrub oak type; oak-hickory type; swamp forest and marsh types; and prairie type. The distributions shown on this map were inferred from data of soil surveys and from the occurrence of present stands.

¹⁷Wilde, S. A., F. G. Wilson, and D. P. White, Soils of Wisconsin in Relation to Silviculture, Wisconsin Conservation Department, 1949, p. 10.

--Other Maps of Vegetation Cover in Wisconsin

This map departs somewhat from some of the others in its location of the various forest types which may be due to the fact that the authors map combinations of features--soil types and vegetation types--as units, pairing each vegetation type with a soil type and mapping the two together in order to show areal correlations. As it is intended for general orientation only, it does attempt to show precise distributions of the various vegetation types.

Of the seven maps listed in this group, only one, the Forest Service map, shows recent distributions. The other six show vegetation types as they existed either unchanged by man or changed so little that the pre-settlement stamp shows through. These six have much in common, which should be the case, since they depict much the same phenomena, even though they do so from different viewpoints and from different source data. Different classes of vegetation are shown on the various maps. Because of the small scale it was necessary for the authors to make certain restrictions and selections in the mapping categories used. The selections vary with the authors.

The maps of this group serve the various purposes for which they were designed. However, they all have one deficiency in common in that they do not show much

--Other Maps of Vegetation Cover in Wisconsin

detail. Because of the restrictions placed by scale and other circumstances, none of them can give the full picture of the original native vegetation, although no map could do that completely. The ones here described leave an unfulfilled need for a more detailed map with a larger scale based on more detailed source data.

AREA MAPS

A number of maps have been prepared to show the distribution of vegetation within limited areas in the state. Most of these maps are on much larger scales than those described in the previous class and show much more detail. Some of them if expanded to cover the entire state, would serve quite adequately to show the character of the original native vegetation.

(a) Wisconsin Geological Survey Maps, 1876-1878.

Along with the work of gathering the material for the reports of the Wisconsin Geological Survey of 1873-1879 and for the preparation of the "General Map of the Native Vegetation of Wisconsin, 1882" described on pages 13-16, three sectional maps were prepared by members of the field force of the Wisconsin Geological Survey. These include a map of eastern Wisconsin which takes in a strip of land two or three counties wide along Lake Michigan from the Illinois border to the Michigan line on Green Bay; one of the lower St. Croix district; and one of the Western Lake

--Other Maps of Vegetation Cover in Wisconsin

Superior Region.

(1) Chamberlin's Map of Eastern Wisconsin, 1876.¹⁸

The first of these entitled "Map of the Vegetation of Eastern Wisconsin" was prepared by T. C. Chamberlin¹⁹ and was the only sectional vegetation map to be included in the Atlas of the Geological Survey of Wisconsin. It includes all or parts of the twenty-three counties lying in the eastern side of the state that are underlain by Silurian age rocks or younger. This map bears the date 1876 and is at the scale of 1:760,000 with dimensions averaging five inches east-west and fourteen inches north-south. It is printed in color and distinguishes eleven categories of vegetation as follows: (a) Lowland vegetation--grass and sedge group; marsh conifer group (tamarack, arbor vitae, spruce); heath (cranberry) group. (b) Upland vegetation--prairie group; oak and maple group; maple group; maple and beech group; hardwood and conifer group; comprehensive group; pine group.

Although this map and the vegetation map included as a part of the present study were prepared from different source materials, it is interesting to see the close

¹⁸Atlas of the Geological Survey of Wisconsin, Plate No. III.

¹⁹Later to become President of the University of Wisconsin.

--Other Maps of Vegetation Cover in Wisconsin

correspondence between the two in the eastern part of the state as far as vegetation categories depicted are concerned as well as in the detail of the location of the boundaries of the various categories. It is not to be expected that the maps would be identical, since the Chamberlin observations were less close-grained than those of the original surveyors upon which the map accompanying this study was based. Also Chamberlin's observations were made some thirty to forty years later when the original conditions had been altered somewhat by settlement. But the close similarity between the two maps strengthens the credence that can be placed both in the accuracy of the government surveyors' descriptions and in the observations of Chamberlin.

The writer does not know whether Chamberlin's map is based entirely on his own personal observations or whether he had access to other source materials. There is no indication in his report of the latter.²⁰

(2) Wooster's Map of the Lower St. Croix Region, 1876-1877.²¹

In addition to Chamberlin's, the other formal sectional map of the Wisconsin Geological Survey is one entitled "Map of Vegetation of the Lower St. Croix District."

²⁰Geology of Wisconsin, Survey of 1873-1877, Vol. II, pp. 176-187.

²¹Published in Geology of Wisconsin, Survey of 1873-1879, Vol. IV, p. 146.

--Other Maps of Vegetation Cover in Wisconsin

This was prepared in 1876-1877 by L. C. Wooster, one of the field men of the Wisconsin Geological Survey. It covers St. Croix County, most of Dunn County, and the northern edge of Pierce County and is presented at a scale of 1:500,000. On the map the area covered measures about seven inches east-west and three and one-half inches north-south. Six vegetation categories are shown in color as follows: prairie and terrace group; oak and poplar group; hardwood and conifer group; pine group; grass and sedge group; and tamarack group. This map is not as detailed as the Chamberlin map of eastern Wisconsin although the scale is larger. Neither is it as detailed as the map accompanying this study, but when proper allowances are made for the more generalized vegetation groupings, the distributions shown here agree closely with those mapped as a part of the present study. Full descriptions of the vegetation types accompany this map.²² In this report on the vegetation, Wooster does not mention any source of data beyond his own observations.

(2) Sweet's Map of the Western Lake Superior Region, 1877.²³

The third sectional map of the Wisconsin Geological Survey shows only roughly the distribution of vegetation in the western Lake Superior Region. It was prepared by -----

²²Geology of Wisconsin, Survey of 1873-1879, Vol. IV, pp. 146-154.

²³Geology of Wisconsin, Survey of 1873-1879, Vol. III, opposite page 325.

--Other Maps of Vegetation Cover in Wisconsin

E. T. Sweet, a field man of the Wisconsin Geological Survey. He combined the vegetation map with a soil map of the region. No vegetation boundaries are shown, but the names of the general vegetation types for the various parts of the area are simply printed on the map in the appropriate places. The map is in black and white. The scale is 1:630,000 which for the area covered gives measurements of seven inches east-west and an average of three inches north-south. The vegetation combinations listed are white pine; hemlock; poplar and yellow pine; barrens--scrub pines and jack oaks; maple, oak, birch; white cedar, tamarack; tamarack, poplar, birch, cedar and balsam.

(b) Roth's Map of Northern Wisconsin, 1898.²⁴

In 1897 the Wisconsin Geological and Natural History Survey was established, and during this same year it co-operated with the State Forestry Commission and the Forestry Division of the United States Department of Agriculture in a study of the forests of northern Wisconsin. This study was made by Professor Filibert Roth and was published as Bulletin 1 of the newly established Survey. Included with the report was a vegetation map.

²⁴Roth, op. cit., opposite page 78.

--Other Maps of Vegetation Cover in Wisconsin

Roth's study was confined to the part of the state lying north of a line between the city of Green Bay and the mouth of the St. Croix River, plus Portage, Wood, and Jackson Counties. This was an effort to make an inventory of the forest resources of the state as they existed at that time, and it dealt with the northern part of the state only, since that portion was considered to be the area containing the majority of the timber supplies remaining. Restricted as it was to forests, the study did not embrace the total vegetation complex.

The method used in part was to collect and combine information concerning the forests of the area from several hundred lumber men experienced in the region. In addition, access was had to the records of lumber companies. By means of personal observations made on trips to all the counties of the region, Roth was able to integrate and harmonize the data collected from the various sources. As a result of this study he was able to prepare a generalized map of the forests of northern Wisconsin on a scale of approximately 1:1,580,000. In size the map measures about ten inches east-west and eight inches north-south.

In making the map Roth used a system by means of which he could give some indication of the former extent and previous character of the various forest categories in

--Other Maps of Vegetation Cover in Wisconsin

addition to the status at the time of mapping. Thus to a degree his is a map of the original forest as well as of the contemporary one. He accomplished this end by using various background colors to show the original distributions. Upon this background he superimposed symbols to indicate the contemporary condition. For example, pine forest was depicted by the color pink. Where the pine lands still contained considerable merchantable timber, small red plus signs (+) were placed on the pink background; where the pine area was nearly or entirely cut over, minus signs (-) were used; and where the pine consisted largely of jack pine, the letter v was used. Fifteen forest types or conditions were distinguished as follows:

Pinery on sandy land without merchantable hardwoods except in small scattered areas

Pinery with considerable merchantable timber

Pinery nearly or entirely cut over

Pinery largely stocked with jack pine

Mixed forests of hardwoods, pine, and, in the part east and north of red line, hemlock

Mixed forests with 3 to 5 M. feet of hardwood and hemlock per acre of stocked area

Mixed forests with over 5 M. feet of hardwood and hemlock per acre of stocked area

Mixed forests with considerable merchantable pine timber

--Other Maps of Vegetation Cover in Wisconsin

Mixed forests from which pine has largely been cut

Mixed forests from which hardwoods and hemlock have largely been cut or burned

Mixed forests where pine is predominant, the forests resembling pinery

Mixed forests where pine formerly predominated, but is now cut, giving the appearance of a pine slashing

"Openings" with jack pine woods

"Openings" with scrub oak woods

The western and southern limits of hemlock are shown by a red line.

For the part of the state it covers, Roth's map contains a great deal of information. It does not show the distribution of swamps, marshes, and prairies, but it does a good job in showing the general occurrence and distribution of the pines, the mixed forests of various sorts, and scrub oak and jack pine barrens. In addition to the map, the report gives detailed discussions of the various timber types, many of which are not shown on the map.

(c) Trewartha's Maps of the Driftless Hill Lands,
1940.²⁵

In mapping the native vegetation cover of the Driftless Hill Lands, Professor Trewartha included the south-

²⁵Trewartha, Glenn T., The Vegetal Cover of the Driftless Cuestaform Hill Land: Pre-Settlement Record and Post-glacial Evolution, Transactions of the Wisconsin Academy of Sciences, Arts and Letters, XXXII, 1940, pp. 361-382.

--Other Maps of Vegetation Cover in Wisconsin

western part of Wisconsin along with the adjacent areas of Illinois, Iowa, and Minnesota. This study was a part of a continuing research project delving into the total geography of the Driftless Area. The data for mapping the vegetation came from the government surveyors' records, from which the detailed descriptions for both the township lines and the section lines were used. From this source material two maps were made, one entitled "Original Native Vegetation" and the other called "Hardwood Forest Types." Both maps are at a scale of approximately 1:1,700,000 and show distributions by means of gray tints. They measure three inches in east-west dimensions and ten inches northwest-southeast.

The map of original native vegetation shows the distribution of the following broad vegetation classes: prairie, hardwoods, conifers, mixed woodland, brush, and marsh. The second map, that of hardwood forest types, separates the forest into the finer detailed subdivisions of oak, maple, linden, elm; oak (thin stand); oak (denser stand); oak, aspen, linden, elm; oak, hickory; and river bottom woodland (oak, elm, soft maple, willow, ash).

If the type of material contained in these two maps were combined to give a more detailed coverage, the resulting map, for the area of the state covered, would be

--Other Maps of Vegetation Cover in Wisconsin

quite similar to the map that is included as a part of the present study.²⁶

(d) Fassett's Map of the Brule River Basin, 1944.²⁷

Among the maps that have been prepared to show the vegetation cover of a portion of the state are Fassett's maps of the Brule River basin in eastern Douglas and western Bayfield Counties. The study of which these maps are a part makes a comparison between the vegetation of the basin in the period 1852-1856 and that of the period of 1932-1943. There is a map in color for both periods, each with a scale of approximately 1:230,000 and measuring about three inches east-west and seven inches north-south. The first map, showing the original native vegetation, was based on the government surveyors' records. The second was made from the Land Economic Inventory maps and from personal observations by the author. With each map there is a legend which differentiates thirteen vegetation types. These are: maple-yellow birch; maple coppice; pine-hard-

²⁶The idea for the study presented in this thesis grew out of Professor Trewartha's vegetation study of the Driftless Area. It was desired to see what could be done with the whole state using the same kind of source materials that went into the maps of the Driftless Area. Some of the same techniques were used, but the mapping job itself was started anew from the beginning. Although they were arrived at independently, the vegetation types used as mapping categories were similar in some cases, as needs must be, since the same data were used and the same area mapped in part.

²⁷Fassett, op. cit., pp. 33-56.

--Other Maps of Vegetation Cover in Wisconsin

wood; aspen; pine forest; pine barrens; spruce-fir forest; small fir and aspen; lowland hardwoods; willow, alder, etc.; bog conifers; cleared; and marsh.

(e) County Maps.

Maps of the native vegetation of a few of the counties of the state have been made. One is included with a published study of Dane County by R. S. Ellarson.²⁸ Other unpublished ones have been the work of students as a part of study programs.²⁹

Ellarson's Map of Dane County is a carefully prepared interpretation of the surveyors' field records. It uses color to show in detail the distribution of eight vegetation types on a scale of 1:185,000. The map measures fourteen and one-half inches by ten and one-half inches. The subdivisions mapped are open marsh; low prairie; high prairie; oak openings; oak woods; upland hardwoods; lowland hardwoods; and swamp conifers.

Summarizing, the maps described above fall into three classes: (1) those of townships which if put together

²⁸Ellarson, Robert Scott, The Vegetation of Dane County, Wisconsin, in 1835, Transactions of the Wisconsin Academy of Sciences, Arts and Letters, XXXIX, 1949, pp. 21-45.

²⁹Two of these are (1) Dodge County by Herbert Neuenschwander, and (2) Rock County by Phoebe Greene. The latter is a part of a Master's Thesis.

--Other Maps of Vegetation Cover in Wisconsin

would cover the state, (2) generalized maps of the entire state, and (3) area maps of portions of the state. Many are excellent for what they attempt to show, but none attempt to portray the original native vegetation of the whole state in the same manner or in the same detail as does the map presented with this study. Some show all the state but on a scale so large that in order to get statewide coverage hundreds of sectional maps must be used. Some show the entire state in a single unit, but with the vegetation types so condensed and generalized that a minimum of information for particular areas is given. Some show small areas very well and in considerable detail but cover only limited portions of the state. Some show the vegetation as of the date of mapping but do not show the original vegetation. Some show only a few of the vegetation types.

From the standpoint of what is attempted by the map presented here, all the maps described above are limited. They either do not show the original vegetation or they are incomplete in terms of areal coverage or in the detail in which they portray the vegetation. The aim in the making of this map is to show the original native vegetation of the entire state in one unit map so that the continuity and pattern of statewide distributions may be seen, but still to have the scale sufficiently large so that as much

--Other Maps of Vegetation Cover in Wisconsin

detail as possible can be shown within the limits of a map of convenient size. It is hoped in this way that, while giving coverage of the entire state, a balance can be struck which will allow both a reasonable amount of detail and a practicable size of map.

SECTION III

SOURCE OF DATA

The data for the map of the native vegetation cover of Wisconsin accompanying this study were taken from the records of the original government land survey. The notebooks prepared by the surveyors in the field are held in the office of the Commissioners of Public Lands in the State Capitol at Madison.

The area that is now the state of Wisconsin was surveyed, with minor exceptions, during the years 1832-1866 inclusive. The first land to be laid out was that in the southwestern part of the state in present day Grant, Iowa, and Lafayette Counties. The work of surveying proceeded toward the east and northeast, until by 1836 the portion of the state lying south and east of a line formed by the Fox and lower Wisconsin Rivers was surveyed.¹ This southeastern part of the state was the first to be settled, and it was necessary for the survey to keep ahead of the land occupancy. In 1839 the sur-

¹This refers to land exclusive of that withheld in Indian reservations. The Brothertown and Stockbridge Indian Reservations were surveyed in 1840 and 1843 respectively, the Bad River in 1873, the Oneida in 1875, and the Menominee in 1891.

--Source of Data

veyors moved across the rivers and continued to work northward until the last townships were finished in what is now Price County in 1866 (see Figure 1).

There was thus a spread of 34 years from the beginning of the survey work until its close, which means that the date of the source material for the map varies by that number of years from the southern part of the state to the northern. However, this time interval does not impair the usefulness of the data nor the validity of the map in showing the native vegetation in view of the fact that the survey preceded any appreciable agricultural or lumbering operations. Consequently the vegetation cover wherever encountered by the surveyors was, for the most part, in its natural condition unchanged. For that reason its distribution may be reconstructed from the survey records and mapped as a unit even though the source materials are not everywhere of the same date.

Wisconsin was surveyed under the township and range system adopted by the federal government in 1785. The work was carried out under contract by deputy surveyors who were appointed by the Surveyor General of the United States for the area. The deputy surveyors with their crews worked the year round under the difficult conditions of the wilderness. It is to their credit that they performed an arduous task commendably, although by no means

--Source of Data

perfectly.

The first part of the work to be done was the laying out of the township boundaries. This was done by advance crews who superimposed the skeletal township framework on the country-side by running the north-south range lines and the intersecting east-west township lines at six mile intervals. These advance crews were followed by others, who, working side by side as it were in adjacent territories, surveyed the interior of each township and subdivided it into thirty-six square mile sections.

Both the surveyors who established the township boundaries and those who surveyed the interiors of the townships were given a definite set of procedural instructions drawn up by the United States Land Office (see Appendix A). Since the content of the field notes which furnished the data for the compilation of the accompanying vegetation map was determined by such instructions, it is worthwhile here to examine the parts that have to do with description of the vegetation cover. The surveyors were instructed to give "a particular description and the exact location of the following objects", among which, pertaining to the vegetation, were these:

"The name and diameter of all bearing trees, with the course and distance of the same from their respective corners.

- - - - -

--Source of Data

"The name, diameter and exact distance to all those trees which your lines intersect.

- - - - -

"At what distance you enter and at what distance you leave every river, creek or other 'bottom', prairie, swamp, marsh, grove or windfall, with the course of the same at both points of intersection.

- - - - -

"The several kinds of timber and undergrowth, naming the timber in the order of its prevalency."

The surveyors were also told that the "description of the timber, undergrowth, surface, soil and minerals, upon each section line, is to follow the notes thereof, and not to be mixed with them".

As a result of these instructions the field notes of a traverse along a section line contain specific descriptions of individual trees, if any, and a summary of the character of the vegetation along the line. These different types of notations serve to supplement and verify each other. In addition the indication of the exact location on the section line of any prairies, marshes, swamps, groves, windfalls, etc. was found to be extremely helpful in preparing the vegetation map. These features were usually included on sketch maps that the surveyors were instructed to make of each township.

--Source of Data

Two examples of actual field notes for specific section lines are given below:²

T 8 N R 17 E³

North Between Sects 16 & 17

23.38 ⁴	W. Oak 12 ⁵
30.00	Enter marsh
40.00	Set quarter Section post. Aspen 10 S 50 W 46 ⁶
75.00	Leave marsh
80.00	Set post cor. sects 8, 9, 16 & 17 Lynn ⁷ 18 N 60 W 45 B. ⁸ Oak 14 N 68 E 55

Land except marsh rolling second rate--
Sugar Lynn Oak Maple Ironwood Thick
undergrowth
Hazle Briars vines prickly ash etc.

- - - - -

²Spelling, punctuation, and abbreviations are the same as in the handwritten field notes.

³Township 8 north, Range 17 east. This township was surveyed by James H. Mullett in 1836.

⁴The numerals refer to the number of chain lengths along the section line. A chain was 66 feet. A mile traverse was 80 chains in length.

⁵At this point on the traverse the survey line intersected a white oak tree twelve inches in diameter.

⁶The marker tree selected to help locate the quarter section corner was an aspen ten inches in diameter growing at a bearing of south 50° west from the quarter section corner and at a distance of forty-six links. One hundred links were equivalent to one chain.

⁷Linden or basswood.

⁸Black oak.

--Source of Data

T 9 N R 17 E⁹

North between sections 17 & 18

13.08	White oak 24 in. dia
30.65	Sugar 16 in diameter
40.00	Set quarter section post
	Sugar 9 N 12½ E 29
	do 12 N 177 W 25
52.33	Sugar 11 in diameter
68.58	White oak 24 in dia
80.00	Set post corner sections 7.8.17.18.
	Black oak 30 S 23 E 10
	do 12 S 55½ W 35

Land rolling second rate--White and Black
Oak Sugar
Lynn Elm & Ironwood--oak prickly ash and
Hazle

When the surveyor had completed the interior lines of a township, he usually wrote a paragraph or two summarizing the characteristics of the township as a whole and describing the general nature of the vegetation cover along with other features. These summaries were useful in that they further illuminated the vegetation picture. Below are two samples of such summaries; the first written by Nehemiah W. King in 1835 for Township 15 north, Range 18 east, and the second by John M. Gay and John W. Markle in 1852 for Township 34 north, Range 6 east:

⁹Surveyed by John Brink in June, 1836.

--Source of Data

"The most of the prairie in this township is too wet--it will make fine meadow land, however, when drained and cultivated. It is deficient in good timber for fencing etc. There is perhaps a sufficient quantity for firewood--it is mostly low and scrubby.

"It is well watered--some running to the east and some to the west. Here the great Indian trail from Millwakee and the road for Green Bay intersect--and here, in after times, another great road from the mouth of Shebowaegan will intersect. Its vicinity to the Lake will entitle it to consideration

"As a whole it is better calculated for grass than grain."

"This township contains some extensive tamarac swamps mixed with cedar and spruce unfit for cultivation. South and East of Flambeau River, the surface is uniformly level, and in wet seasons most part of it covered with water. On and near the river the surface is more uneven covered with Hemlock, Pine, Birch, Sugar, Elm and Lynn.

"Flambeau River Enters the Township on Section 2 pursues a Southwesterly course and leaves it on Section 19. The current is strong through the township. The banks are dry and firm beginning to rise at the waters edge, ascend gradually to the sumet from 50 to one hundred feet. None of the soil can be considered above 3rd rate and but little 3rd rate."

The description of the trees along the section lines and those used to mark corners, the description of the vegetation as given at the end of the field notes for each section line, and the description of the vegetation as contained in the township summary, all illustrated in the excerpts above, give three sources of information concerning the vegetation in the state. These were supple-

--Source of Data

mented by the township sketch maps. When the work of the surveyors who ran the traverses on the exterior township lines is taken with that of those who surveyed the interior lines, there is data available for each of the four sides of essentially every square mile in the state. This gives an ample body of detail for determining the various plant associations within the state and for mapping the distribution of those associations.

Judging by the degree of mutual corroboration and by the logical patterns that result when they are mapped, the reports of the surveyors were, as a whole, quite accurate in their descriptions of the vegetation cover and uniform from surveyor to surveyor. There were errors from time to time and an occasional surveyor, a large part of whose work was inaccurate. However, cross checks were available which were valuable in exposing errors. The men who ran the exterior township lines were seldom the same persons as those who surveyed the interior lines. Thus the exterior and the interior men, working through the same areas, automatically checked the work of each other. In addition it was often the case that the interiors of adjacent townships, and sometimes even the interior of the same township, would be surveyed by different persons. Where their work adjoined along common boundaries there was an opportunity to check for unanimity of observation

--Source of Data

and recording. By checking and comparing the work of the different people involved, it was possible in most cases to get an adequate picture of the nature of the plant cover and to single out the individuals who were prone to give erroneous statements.

Some parts of the state were not surveyed by the township and range system. These include the French land claims along the lower Fox River and along the Mississippi River at Prairie du Chien as well as part of the former Brothertown and Stockbridge Indian Reservations on the eastern shore of Lake Winnebago in Calumet County. Instead of cutting up the French claims by running section lines across them, the surveyors ran traverses along the claim lines. Here, no summary descriptions of the vegetation along the claim lines were given, and in most instances the only record left was that furnished by markers along the lines and at the corners.

The Brothertown and Stockbridge Indian Reservations were surveyed into 100 acre and 62½ acre tracts respectively for transferral to the individual Indians of those tribes. As yet the field notes have not been located by

--Source of Data

the author, so that area remains unmapped.¹⁰ Another small area that is also unmapped for the same reason is a 4800 acre tract, known as Williams Grant, located on the left bank of the Fox River in western Brown County.

The same type of source materials as that used in the construction of the accompanying map have been used in mapping native vegetation cover in other states. Original government survey field notes have been drawn upon for maps of Ohio¹¹ and of parts of Michigan.¹² Trewartha's

¹⁰ A search has been made for the field notes of these areas in the office of the Commissioners of Public Lands in Madison, the office of the Bureau of Land Management in Washington, D. C., and in the Register of Deeds office in the County Courthouse of both Calumet and Brown Counties. There is some possibility of their being in The National Archives in Washington, although correspondence has produced no results.

¹¹ Sears, Paul B., The Natural Vegetation of Ohio. I. A Map of the Virgin Forest, Ohio Journal of Science, XXV, 1925, p. 142.

_____, The Natural Vegetation of Ohio. II. The Prairies, Ohio Journal of Science, XXVI, 1926, pp. 128-146.

¹² Kenoyer, Leslie A., Ecological Notes on Kalamazoo County, Michigan, Based on the Original Land Survey, Papers of the Michigan Academy of Science, Arts and Letters, XI, 1929, pp. 211-217.

_____, Forest Distribution in Southwestern Michigan as Interpreted from the Original Land Survey (1826-32), *Ibid.*, XIX, 1933, pp. 107-108.

_____, Plant Associations in Barry, Calhoun and Branch Counties, Michigan, as Interpreted from the Original Survey, *Ibid.*, XXV, 1939, pp. 75-77.

--Source of Data

map of the Driftless Area (page 29) covers part of Illinois, Iowa, and Minnesota as well as part of Wisconsin.¹³ Unpublished maps of Minnesota and Michigan are in existence.¹⁴ There may be others of which the writer is not aware.

_____, Plant Associations of Ottawa County, Michigan, at the Time of the Original Survey, Ibid., XXVIII, 1942, pp. 47-50.

¹³Trewartha, op. cit., pp. 361-382.

¹⁴Mentioned by Mr. R. N. Cunningham of the Lake States Forest Experiment Station in a personal communication, September, 1949.

SECTION IV

TECHNIQUES USED IN CONSTRUCTING THE MAP

The problem of mapping the native vegetation of Wisconsin from the field note records of the original surveyors consisted of three parts: (1) assembling the data in a form in which it could be conveniently handled, (2) analyzing and interpreting it, and (3) putting it into map form.

ASSEMBLYING THE DATA

The vegetation descriptions from the survey field notes were recorded by townships on mimeographed sheets prepared for the purpose, one township to a sheet. Each of the worksheets contained a grid composed of a square, six inches on a side, subdivided into thirty-six square inches to represent a township with its thirty-six sections at a scale of one inch to the mile. (See sample in Figure 2.) Space was also provided on the sheet for recording the township and range number, the name of the surveyor, the date of survey, the name of the county of which the township is now a part, and a general summary description of the vegetation of the township.

By use of a code (see Appendix B) as a simplified means of recording, the character of the vegetation

--Techniques Used in Constructing the Map

occurring along the section lines within the townships as noted by the surveyors was entered on the mimeographed worksheets. The data for each section line of the township were placed on the appropriate corresponding line on the worksheet grid. In recording the information on the grid, the sequence of the field notes was followed which meant that the order in which the vegetation data were recorded on the grid was the same as that in which the township was surveyed.¹ As the interior lines of the townships of a particular county were finished, the worksheets were placed in a folder for that county. An index

¹The method used in subdividing the township into sections was for the surveyor to start at the southeast corner and measure off one mile to the west along the south boundary of the township. He then turned north and measured a mile and set a marker. From here he ran a trial line eastward to the range line forming the eastern boundary of the township. He then turned westward and surveyed a corrected line back along the mile he had just covered. This completed a square mile of survey and left the surveyor at the northwest corner of the section so surveyed. From here he ran another line one mile to the north, and then tied it in with the eastern township boundary as before to complete another section. This procedure was followed until the six sections along the eastern side of the township were laid out. The surveyor then came back to the southern boundary of the township and measured off a second mile to the west. From here he turned northward and surveyed out a second tier of six sections in the same manner as before. This system was repeated until the four eastern tiers were surveyed. The fifth and sixth tiers were done concurrently on the same northward sweep with the north boundary of each section of the sixth tier being tied in directly to the range line along the western side of the township as they work proceeded to the north.

--Techniques Used in Constructing the Map

map of the county showing the townships was used to keep a running account of the progress of the work, and each township was crossed off on the index map as it was completed. When the interior lines were finished, the exterior lines of all the townships within the county were recorded.² The work proceeded from county to county until the seventy-one counties of the state were completed. Although the counties as political units were non-existent at the time of the survey, they were used in the work as a convenient means of grouping the townships.

At the end of the field notes for each section line, the surveyor wrote a short description of the vegetation occurring along that mile line. This was the information that was ordinarily recorded on the worksheet grid on the line that corresponded to that particular mile. In addition a close watch was kept on the witness or marker trees used to establish the location of section corners, quarter section corners, and the course of the survey line. The field notes gave an exact description of these trees, and if the notes indicated the presence of significant species not included in the regular description of the cover, then these additional trees were recorded on the grid lines within parentheses.

²The time required to record the data varied of course with the complexity of the vegetation. In general about two to two and one-half days were required to record the data for an average-sized county of twenty-five townships.

--Techniques Used in Constructing the Map

After surveying a township the surveyor wrote a general summary of its physical character, describing the soil, surface, drainage, and vegetation cover. The pertinent facts of this summary were written in a space provided on the worksheet. Such facts included the description of the vegetation and any other items that gave promise of being helpful in interpreting the vegetation distribution.

The shorthand code by means of which the vegetation descriptions were recorded on the worksheets is shown in Appendix B.³ A numeral was used to indicate the kind of formation, such as forest, prairie, brush, etc., while letters were used to indicate plant species. Different species within a genus were distinguished by exponent numerals written with the letter (Figure 2). As an example, a forest of white and black oak would be designated by the symbol $1R^{7-1}$, the numeral 1 indicating that the plant formation was a forest, the letter R meaning that the trees were oaks, and the exponents 7 and 1 identifying the trees as white and black oaks respectively. Such a symbol is short, easy to write, easy to read, and

³This code is not to any appreciable extent original with the author but was developed by graduate students working under the direction of Professor Glenn T. Trewartha. It was experimented with in this study, found to be adequate, and as a result was adopted. Minor changes and additions were made as circumstances required.

--Techniques Used in Constructing the Map

expressive.

For more complicated forms of vegetation cover the symbol also became more complicated but still readily comprehended. When undergrowth was described in the forest, the symbol was written in the form of a fraction with the forest as the numerator and the undergrowth as the denominator. The numeral 3 was used to indicate brush or undergrowth. An example of a forest of beech, sugar maple, basswood, elm, red oak and white oak with an undergrowth of beech, sugar maple and hazel would be written thus $\frac{1eQ^3DJR^{5-7}}{3eQ^3M}$.

Continued use of the code gave enough familiarity with it to make it a rapid means of recording the surveyors' notes on the worksheets. Also the meanings of the symbols could be comprehended at a glance which was of great benefit when it came to visualizing distributions from the worksheets.

For the most part the surveyors did not indicate whether the vegetation cover described for a section line was applicable in sum total to the whole mile or whether some parts applied to one part of the line and some to another. In general in recording on the grid, the described cover was coded as for the mile as a whole and any deviations were matters to be interpreted in constructing the map from the light of other evidence. However, in some

--Techniques Used in Constructing the Map

instances changes in vegetation along the section line were specifically and exactly indicated, and when this was the case, the appropriate symbols were recorded in the specific places along the grid line. This was true for example with features such as swamps, marshes, prairies, groves, thickets, and windfalls, for which the location was given specifically in terms of the exact points at which their margins intersected the line. In addition the surveyors included a sketch map of the township showing the location of such features not only on the section lines alone but also their approximate outlines between section lines. The sketches of these features were transferred to the township grid on the worksheets.

In summary, the pertinent facts concerning the vegetation available from the surveyors' field notes were recorded for each township on worksheets. This information included the general descriptions given for the section lines, the specific descriptions of the witness or marker trees, the sketch maps of special features such as swamps, marshes, prairies, etc., and the general summary for the township as a whole. Other information listed on the worksheet was the name of the surveyor, the township number, the date of survey, and the county of which the township later became a part.

--Techniques Used in Constructing the Map

ANALYZING AND INTERPRETING THE DATA

After the vegetation descriptions were recorded on the worksheets, the next problem was to analyze the material and to formulate mapping categories.⁴ This was done, as described in Section V, with the categories being established primarily on the basis of plant communities. On the whole the descriptions of the vegetation were clear-cut enough to be conclusive, although there were many cases in which there were questions and which called for interpretations of the facts as given. Such interpretations were not mere speculations, but were considered opinions founded upon supporting evidence. They generally fell into one of the three following groups: (a) interpretations concerning the proper mapping category for specific vegetation combinations; (b) interpretations concerning the species within a genus when the species was not definitely identified by the surveyor but when its identification was critical to the mapping; and (c) interpretations concerning the proper placement of boundaries between mapping categories.

⁴ Although these steps were taken in the order indicated, it was not necessary to wait until data for the entire state had been recorded before starting to analyze it, set up mapping categories and place some of the boundaries. Much of this type of work went hand in hand.

--Techniques Used in Constructing the Map

The fact that it was necessary to make interpretations of the materials from time to time leads to the question as to whether different people working with the same materials would reach the same conclusions in every case. Since obviously they would not, it is to the point here to set down some of the general situations in which interpretations were made and some of the principles upon which conclusions were based.

(a) Interpretations Concerning Mapping Categories

In many instances the tree combinations given for individual section lines could logically be classified in more than one category. This comes from the fact that there is no way of telling from the descriptions the percentage frequency of the various tree types listed. It was assumed of course that all the tree types listed did not always occur with the same frequency, and there was uncertainty as to the relative percentages of each. The surveyors were instructed to record the trees in the order of their prevalency, but it is doubtful that they did that with a consistency that was dependable. As an example of the problem, when oak and aspen are listed on the same section line there is a question as to whether the tree stand consists principally of oak with a few scattered aspens, principally of aspen with a few scattering oaks, or whether the relative proportions lie somewhere in

--Techniques Used in Constructing the Map

between. Should such a tree combination be mapped as oak, mapped as aspen, or should a separate category be set up to map the combination as an oak-aspen mixture?

There is a danger in setting up a special category every time a new combination is encountered. Occasional omissions by the surveyors in their recording or minor variations of combinations of species along particular section lines if recognized would tend to fragment the broader communities and obscure their true extent and would result in such an array of combinations as would tend to be unmappable. Also the groupings would in many cases be unreal, since the combinations would not necessarily be natural plant communities in view of the fact that some of the components might grow on one part of the line and some on another without having any ecologic relationship with each other. On the other hand combinations that look different as recorded by the surveyors are often parts of the same plant community and appear to be different only because of irregularity in the recordings from line to line or because of minor variations in the subdominant species.

In order to avoid recognizing a myriad of unrelated possible mapping combinations, while at the same time to recognize combinations that have a true basis in fact in nature, it was necessary to try to determine what the

--Techniques Used in Constructing the Map

dominant species were in an area and to map on the basis of those dominants. In the example of the oak and aspen mentioned above, if the surrounding forest were composed predominantly of oak with aspen listed on a section line only occasionally, it was assumed that just a few aspen were appearing locally in the oak forest, and the cover was consequently mapped as oak forest. If the situation were reversed with the surroundings having aspen predominantly with oaks being listed only now and then, the cover was mapped as aspen forest. In other words the general character of the forest was assessed by observing the surroundings, and from this perspective it was possible to determine better the proper relationships of the local detail.

This same basic idea, that of using the character of the surrounding forest to interpret local detail, was applied in another way. Sometimes the tree species within a genus and the nature of the forest growth would indicate the category in which a local area should be mapped.⁵ In the example of the oak and aspen, if the oaks were large, closely spaced, and of the white and black oak varieties, it would be unlikely that the aspen would be a very

⁵Although it was often true that the field notes gave no inkling as to the general nature of the forest growth.

--Techniques Used in Constructing the Map

important member of the forest community, and the grouping as a result would be mapped as oak forest. If the oaks were of the small scrub oak type, then the aspen would be considered to be an important member of the community. The reasoning behind such interpretations is that aspen is a light-requiring plant that characteristically appears after a catastrophe of some sort has destroyed the forest cover and allowed light to reach the surface. For this reason it is not likely to be an important member of a dense forest of older trees except locally, but if it occurs at all in an area where other trees are small and scattered, it may well occur there in considerable abundance.

Another facet of the problem of determining the proper category in which to classify the vegetation as described by the surveyors is illustrated by the case of oak forest versus oak openings. Often the surveyors did not designate oak openings clearly enough to distinguish them from oak forest. For this reason it is believed that much of the area mapped as oak forest may very well have been in oak openings. There was a considerable lack of agreement among the surveyors. Many times in areas surveyed by different people exterior lines of townships would not agree with the interior lines of the same township, or the interior lines of adjacent townships would not agree. In

--Techniques Used in Constructing the Map

some instances it was possible to compare the notes of all the different surveyors working in the same area and reach a decision based on the general consensus of agreement, but in other instances there was no way from the evidence at hand to resolve the conflict. In such cases the descriptions of the surveyors were mapped as they were recorded, even though contradictory. The areas thus mapped stand out conspicuously and appear to be errors in the mapping, but in following this procedure the problem is exposed instead of being hidden, and the path is left open for further investigation. Detailed study of these areas, particularly with respect to the spacing of marker trees and the kinds of associated understory plants, can go a long way toward separating oak forest from oak openings as shown by Ellarson in his study of Dane County.⁶

(b) Interpretations Concerning the Species Within a Genus.

Closely related to the problem of determining the category to which a particular vegetation combination belongs was the problem of determining what species of a genus was meant when the tree was recorded by genus name only. Often there were two or three species, any one of

⁶Ellarson, Robert Scott, The Vegetation of Dane County, Wisconsin, in 1835, Transactions of the Wisconsin Academy of Sciences, Arts and Letters, XXXIX, 1949, pp. 21-45.

--Techniques Used in Constructing the Map

which could have been the one in question. This situation was encountered with respect to the pines, the maples, the birches, the ashes, and to some extent with the oaks, although the surveyors were rather careful to give the variety names of the oaks.

The problem of determining the species name was closely related to the problem of deciding upon the mapping category, because certain definite species were key dominants which had a bearing on whether a particular vegetation grouping would be classified in one mapping category or another. Therefore, in those cases, it was necessary to distinguish the species.

An illustration of the problem and of some of the means of solving it are seen in the case of the maples. Three varieties of maple are common in Wisconsin, silver maple, red maple, and sugar maple. Silver maple is characteristically associated with the lowland hardwoods, while red maple, although abundant in the state and occurring on both lowland and upland sites, is not considered to be a significant dominant of any community. Sugar maple is a dominant tree in three of the plant communities set apart as mapping categories within the state, and it is considered to be the key tree in setting up one particular forest type, the sugar maple-basswood forest. Therefore, it was essential that that species of maple

--Techniques Used in Constructing the Map

should be distinguished from the other two.

Different surveyors listed sugar maple by different names such as hard maple, sugar maple, sugar, and sugar tree. These varying designations gave no trouble in identifying the type, but difficulty arose where a surveyor would designate it simply as "maple". In such a case there was a possibility of making the identification in one or more of a number of ways.

If the surveyor consistently listed the other maples by the species name but persisted in designating sugar maple simply as "maple", its true identity could be arrived at by a process of elimination. Sugar maple could also be identified when one man, working among others, failed to specify it, if the others were careful to identify it. At contact lines between the adjacent surveys the work of the one who did not specify the species would stand out in contrast to that of the others. When by this means, or any other, a surveyor was singled out who used the term "maple" to signify sugar maple, this practice was watched for in his work thereafter wherever it occurred.

Another means of making sure that "maple" meant sugar maple was by the practice of the surveyors of indicating places where maple sugar was being made by the Indians or the sites where it had been made. If such sites occurred through areas where maples were present on the

--Techniques Used in Constructing the Map

uplands, those maples were assumed to be of the sugar maple variety.

Associated trees also served as indicators to point out the presence of sugar maple in areas where there was no direct evidence. When trees such as red oak, basswood, white walnut, black cherry, ironwood, white ash, etc., were present, the consistent listing of "maple" on upland sites almost certainly could be taken to mean that sugar maple was present. Another indicator was the fact that witness or marker trees for corners were listed by a detailed description which included the species name. If sugar maple were present in any abundance in the forest, it would be represented among the marker trees and there be identified specifically. Often the township summary alone would list it.

Topographic location and drainage characteristics gave some help. It was observed that sugar maple seldom occurred on low poorly drained sites; therefore any maples listed on such sites were likely to be of the other varieties. Also, after the general pattern of distribution of the various forest communities began to take form, experience showed within limits where within the state to expect sugar maple and where not to expect it.

The procedures used in identifying sugar maple are described in some detail because they illustrate the kind

--Techniques Used in Constructing the Map

of techniques resorted to in interpreting the field notes in places where the information given was not sufficiently detailed for use in mapping. Sugar maple was used as an example because there were a number of ways of identifying it, many of them applicable in other cases.

It was especially necessary to apply some of these principles, and others, in distinguishing the various species of pine. The common pines that occur in Wisconsin are white pine, red pine, and jack pine, but the surveyors often failed to indicate which ones of these species were meant when they listed the occurrence of "pine" along a section line. That posed the question as to whether an attempt should be made to separate them for mapping purposes or to map them as a group. It was considered that the map would be improved if some distinction were made between the pines and that the evidence was clear enough in a sufficiently large number of cases to warrant the attempt. Therefore in instances where the species was not specified an interpretation was made. At times the surveyor would give some indication of the general character of the pine growth in the township summaries. The notation, "scrubby growth of pine", would be taken to mean jack pine, while a statement such as "fine growth of large pines" would be interpreted to mean white pine and red pine. The site and associated vegetation would

--Techniques Used in Constructing Map

often give a clue as to the species. If the soil were extremely sandy and there were a minimum of other species in the area, a pine growth would be considered to be jack pine; whereas if the soil were moderately good, and hardwoods and hemlock were in the vicinity, a pine growth would be classed as white pine and red pine. Also if the surveyor specified pine of a particular type throughout most of an area, but in places scattered here and there within the same area he failed to specify a definite type, it was assumed that the general type also carried through the intervening unlabelled spaces.

(c) Interpretations Concerning the Placement of Boundaries

A third situation that called for an interpretation of the information contained in the field notes was the matter of placing the boundaries between adjacent plant communities. Only in rare cases did the surveyors indicate the location on a section line of the boundary between two forest types. This did not apply in dealing with such features as swamps, marshes, prairies, etc. since specific boundaries were given for them. In the forest communities, however, where the mapping categories were determined on the basis of ecological succession to a considerable degree, as discussed in Section V, the boundaries between the different categories could not be as definite. In

--Techniques Used in Constructing the Map

some cases the presence or absence of a single tree type could change the subdivision from one mapping category to another. There is a question then as to where in the transition zone between two adjacent groupings the dividing line should be placed and how the line between the two should be defined. When a new dominant appears, to change the forest type from one category to another, what should be its frequency of occurrence before the boundary line is placed to set off the newly established association? In other words if the forest type changes from sugar maple-basswood-oak to beech-sugar maple-basswood-oak, what should be the percentage occurrence of beech before the type is considered to have changed from the former to the latter? This could not be determined in terms of an exact percentage basis since the survey notes do not deal with the numbers of individual trees of the various types in the forest complex. Also it is not known what the prevalence of a species must have been before it impressed itself sufficiently upon the consciousness of a surveyor as to cause him to record its presence in his notebook. This would vary with the surveyor no doubt. But on the whole it might be considered that when the frequency is great enough for the species to be noticed and recorded, it is also well-established in the forest complex.

--Techniques Used in Constructing the Map

Partly for this reason but largely because there was no other feasible way, the boundaries between categories were placed where key dominants entered or dropped out of the vegetation complex as recorded. This place was taken to be the point where such a dominant was first mentioned or first omitted in the vegetation described for the section line. For example, the line between basswood-oak forest and sugar maple-basswood-oak forest was drawn at the places where sugar maple first entered the complex to separate the parts of the forest that had sugar maple from the adjacent parts of the forest that did not have it.

Another situation that called for a judgment concerning the location of boundaries arose out of the fact that the usual procedure of the surveyors was to summarize the tree species for a whole section line as a unit rather than to indicate which species occurred on which parts of the line. Of course, it was true in a high percentage of cases that all the trees mentioned did occur all along the section line, but this was not always true which meant that at times it was necessary to determine on which part of a line individual parts of the vegetation complex as described should be placed. This was done largely by studying the surroundings and fitting the vegetation to the environment. As an example, on a line running through rough country, a surveyor might list sugar maple, basswood,

--Techniques Used in Constructing the Map

elm, red oak, ironwood, white ash, black ash, willow, and alder. In such a case it would be assumed that the willow, alder, black ash, and possibly the elm would be found along the lower wetter parts of the line, and the boundaries would be drawn accordingly.

The general procedure of plotting the detailed location of boundaries after the data had been placed on the worksheets and assessed was one that called for an interpretation of all the available facts. The boundaries were drawn to conform to the requirements of each local situation as those requirements were interpreted by the writer. It should be remembered that the vegetation descriptions were based on observations made by the surveyors while they were laying out the section lines, which means that the surveyors were observing the vegetation in sample strips. These strips ran in cardinal directions with the section lines and had the same spacing as the section lines; that is, at one mile intervals. The width of such a vegetation strip was restricted to the field of vision of the surveyor, and in a forested area this would be not more than a few hundred feet. Therefore the vegetation data from which the map was constructed are samples only of the total vegetation cover, and being samples they are subject to error in rendering a complete vegetation picture. In plotting the detail on the worksheets,

--Techniques Used in Constructing the Map

interpolations had to be made for areas between the section lines, since no descriptions were given for those areas. These interpolations were not especially difficult to make, because data were available for the four sides of each square mile, but the outlines of the boundaries had to be plotted by means of the basic principles that apply to the drawing of isopleths which meant making the best judgment possible in the light of the available evidence. The result is that between section lines the boundaries follow a reasonable path, which in nature is not always the actual one. However, at the scale of 1:500,000 any deviations of boundaries between section lines from a true representation would tend to be minimized.

In summary, in order to map the native vegetation of the state from the survey records, it was necessary to make numerous interpretations of the source material. Those judgments had to do with decisions concerning the proper mapping category of particular vegetation combinations, the identity of tree species within certain genera, and the proper placement of boundaries on the map. If interpretations of this nature had not been made the map would have to have been highly generalized. By making them it was possible to show much more information, thus making the map more useful. Most of the interpretations

--Techniques Used in Constructing the Map

could be made with a considerable degree of objectivity, so that different people mapping from the same sources should produce closely similar results. There would be a solid core of agreement in the location of the major plant communities and in the overall distribution of the various tree types. Where there is a lack of clear evidence, the interpretations would have to carry further toward the realm of subjectivity, and in making such interpretations, different mappers would be more likely to produce results which might vary somewhat in detail. At a scale of 1:500,000, however, much of this variation in detail would be lost.

MAPPING THE DATA

By use of the principles indicated above, boundaries were drawn in pencil on the township worksheets. (See Figure 2.) All the townships of a given county were processed together, although not simultaneously, in order that a perspective might be gained from working with a larger whole that would be of aid in integrating the individual townships into the developing matrix. By this means the continuity of boundary lines could be easily followed across township margins. For the first few counties processed the worksheets were assembled into county maps and colored in order that the distributions might be better visualized

--Techniques Used in Constructing the Map

and comprehended. This was discontinued as the work progressed and facility was gained.

When each county was finished the detail was transferred to a base map of Wisconsin on a scale of 1:500,000 which contained the county and township boundaries. The transferral was made township by township, and in the process the scale had to be reduced from the 1:63,360 scale of the worksheet grid to the 1:500,000 scale of the base map. This reduction was accomplished by the grid method. The townships on the state map were subdivided into 36 sections by means of rows of dots, each dot representing a section corner, to correspond to the sections on the worksheet plat. The vegetation detail was then transferred from the worksheet to the base map freehand by drawing the boundaries through points on the base map that corresponded to the same points on the worksheet grid. The reduction of scale meant a considerable generalization of much of the detail that was included on the worksheets and the complete omission of some. Features of dimensions of less than one-half mile on a side were rarely entered on the state map. After the vegetation subdivisions were transferred to the base map, color was used to distinguish them and to bring out the

--Techniques Used in Constructing the Map

distributions.⁷

By this method a working copy of a map of the state's vegetation was made, subject to correction and revision. To produce the finished map, an outline base map of the state was prepared on tracing linen at a scale of 1:500,000, the same scale as that of the working copy. Principal streams and lakes were included along with county and township outlines. The township boundaries were shown on the linen by a line heavy enough to be used for orientation purposes while drawing in the detail but thin enough to fade out in the reproduction process. The detail of the vegetation boundaries was then traced, by means of a light table, directly from the working copy to the linen.⁸ Ozalid copies complete with all the vegetation boundaries were reproduced from the finished tracing linen. The distributions of the various plant categories over the state were brought out on the ozalid copies by hand coloring with indelible pencils according to a color legend. The colored maps were sprayed with a fixing agent which dissolved the coloring medium and carried it into the grain

⁷With respect to the time required to determine the boundaries on the worksheets, to transfer the boundaries to the base map, and to color the base map, from one to one and one-half counties could be processed per day. Where the counties were large, the vegetation complex, or the detail minute and complicated, the rate was slower.

⁸Transferring the boundaries to the tracing linen required about three weeks time.

--Techniques Used in Constructing the Map

of the paper, tending to permanize the color. A letter key was placed on the map to support the color legend and to aid in reading the detail.

The selection of colors by means of which to depict the various vegetation categories was a considerable problem because of the large number of categories involved. An attempt was made to choose colors upon both a logical and a psychological basis insofar as possible within the limitations of the range of available colors and of the numerous vegetation categories to be distinguished. For the most part the forest associations that contained evergreen trees were shown by various shades of blue green. The deciduous associations were shown by the warmer colors of the spectrum, the different shades of brown and red. Prairies were shown by a distinctive yellow green which stood out in contrast with the blue greens used for the evergreen forest combinations. Swamps and marshes were shown in shades of blue. All these might be considered as selections made on a psychological basis, since they are colors that in some degree are associated with the vegetation classes they portray.

Where an evergreen species, notably pine, entered an otherwise deciduous association, the mixture was shown by diagonal lines which alternated the colors of the two vegetation groups that were mixed. Where two forest

--Techniques Used in Constructing the Map

associations were adjacent and related, an attempt was made to show them by colors of similar shade, close enough in tone that the eye could follow easily across the break in continuity but still sufficiently contrasted to show the distinction. This kind of use of color may be considered a logical one.

SECTION V

CLASSIFICATION OF VEGETATION TYPES

The principal categories of vegetation mapped from the records of the original land survey of the state include (1) forest and (2) grassland. In addition, there were certain areas which were neither forest nor grassland at the time of the survey but were areas of shrubby growth where catastrophe in the forest had resulted in the temporary removal of the tree cover, giving expanses of burned-over country and strips of blown-down timber or windfalls, both of which in time were covered as the forest replaced itself. Since these burned regions, windfalls and brushlands were associated with the forests they are discussed under that heading in this section.

FORESTED AREAS

The forests of Wisconsin did not exist isolated but were contained within the broad forest regions of eastern North America. In the extreme north along the immediate shore of Lake Superior, outliers of the boreal or subarctic coniferous forest of Canada occurred, somewhat altered, in Wisconsin. In the south and southwest the deciduous forest of east central United States extended across Wisconsin from Lake Michigan to Minnesota. In between these two

--Classification of Vegetation Types

main groups lay a transitional type of mixed coniferous and deciduous trees, which extended across northern Wisconsin, reaching from Minnesota to New England.

In mapping the vegetation of the state these three broad forest groups were easily distinguishable. It was more difficult to distinguish the more minor subdivisions contained within these broad groups. However, in order to bring any degree of detail into the mapping, it was necessary to separate these component sub-types and to map their distributions.

The setting up of sub-types could not be done haphazardly or arbitrarily, but to make sure that they would have pertinence within their surroundings, it was necessary to recognize them upon the basis of some inherent order present within the general vegetation complex. One method would have been to have set up a classification on the basis of physiognomy alone, using a system on the order of that followed by K^uchler.¹ This would have taken into consideration the outward appearance of the vegetation exclusively; whether the plants were woody or herbaceous, whether the trees were deciduous or evergreen, the height

¹"K^uchler, A. W., A Physiognomic Classification of Vegetation, Annals of the Association of American Geographers, XXXIX, 1949, pp. 201-209.

--Classification of Vegetation Types

of the plants, spacing, etc. It would be possible to apply Kùchler's techniques in a limited way in constructing a map from the survey data, but considering the nature of the available source materials, a more meaningful and a more geographically significant map can be made of Wisconsin's native vegetation by combining physiognomic and ecologic aspects as is done in this study.

The system used here takes into consideration the physiognomic character of the vegetation, but it is also based on the ecological relationships of the plant community. From the data available, this system makes provision for showing everything that could be shown by the Kùchler technique with the exception of the presence or absence of undergrowth in the forests. In addition, it goes beyond the Kùchler method to include such things as tree species, burned-over areas, windfalls, and swamp and marsh vegetation. To some degree, it also brings out relationships between the vegetation distributions and the distributions of certain factors of the physical environment such as climate and soil type.

The basic mapping unit in the system used here is the plant community. This is made possible by the fact that under natural conditions in this part of the world plants tend to group themselves in combinations composed of a restricted number of species as a result of the adjustments

--Classification of Vegetation Types

they make to the physical environment. Individual plants have varying ranges of tolerance with respect to environmental factors such as temperature, moisture, light, wind, soil, micro-organisms, etc. Conditions that are ideal for some plants may be only permissive for others or prohibitive for still others. Plants that are adjusted to conditions as they exist in any particular locality live together in plant communities.

With respect to ways in which the various plant communities were distinguished, it may be stated that climax plant associations, stable plant communities that are adjusted to their environment and able to reproduce themselves indefinitely, and the preclimax communities representing stages in the development toward the climax, consist of a few species for which environmental conditions approach the optimum. These species form the dominants of the community, dominant because they are best adapted to the general environment and, therefore, best able to reproduce and to control the status of the community. Alongside the dominants there may be a number of subordinate species for which environmental conditions are permissive. For example, in the sugar maple-basswood-oak forest that occurs in parts of southern Wisconsin, the dominant species are sugar maple and basswood, although associated with these species are red oak, white oak, elm,

--Classification of Vegetation Types

ironwood, white ash, black walnut and cherry in various combinations. It was principally on the basis of the dominants in the climax and preclimax communities that the various forest vegetation categories of the state were recognized and mapped. Clues as to just which trees could be expected to compose the dominant species of the major forest associations were found by referring to botanical references such as those by Weaver and Clements, Oosting, and Whitford,^{2,3,4} indicated below. The dominants indicated were put to the test of repetitious occurrence in the government survey field notes. If the field notes did not corroborate a species as a dominant, then that species was eliminated as such. This happened in the case of the oak-hickory association. Hickory occurred so infrequently that it was not considered to be a dominant in Wisconsin.

However, not all the mapping categories were recognized on the basis of ecological development, using dominants as

²Weaver, John E., and Frederic E. Clements, Plant Ecology, (New York: McGraw-Hill Book Co., Inc., 1938) pp. 478-537.

³Oosting, Henry J., The Study of Plant Communities, (San Francisco: W. H. Freeman & Co., 1948) pp. 247-254.

⁴Whitford, Harry Nichols, The Genetic Development of the Forests of Northern Michigan; A study in Physiographic Ecology, Botanical Gazette, XXXI, 1901, pp. 289-325.

--Classification of Vegetation Types

the indicators of the various plant communities. The physiognomic character of the vegetation complex was also taken into consideration and in cases where this factor gave a greater uniqueness to a plant community, then it became the primary criterion of classification. For example, in the oak forest, oaks of course were the dominant species, but in some areas the trees were so widely spaced that the factor of the scattering distribution was considered to be more significant than the factor of a dominant species. Thus the categories of oak openings and oak barrens are established on a physiognomic rather than on an ecological basis primarily. Again in places where pine entered one of the hardwood communities, the pine itself may not have been one of the dominants, but its presence created a mixed coniferous-deciduous forest and thereby added enough uniqueness to the community as to justify the recognition of a category on that basis, which is a physiognomic one. So where physiognomy was considered to be sufficiently significant, it was used along with the dominant species factor as a basis of classification.

Once the fundamental system of mapping by dominants, augmented by physiognomic aspects, was worked out, order, pattern, and continuity could be revealed in mapping the vegetation. Except in transition zones there was a minimum of fragmentation of categories. As an indication of

--Classification of Vegetation Types

the underlying order and pattern, after some experience in the mapping had been gained, it was possible to anticipate with considerable accuracy the character of a shift in forest types when a boundary was approached.

The characteristics of the several subdivisions of the three principal forest areas of Wisconsin as they existed at the time of the original land survey will be discussed in the following order: (a) those of the boreal or sub-arctic zone, (b) those of the deciduous forest zone, and (c) those of the mixed coniferous-deciduous zone. In addition there are the swamp forests which cut across the boundaries of the three upland forest zones and are discussed separately.⁵

(a) The Boreal Forest

The boreal forest, often referred to as the taiga forest, extends across the continent from western Alaska through Canada to the Atlantic coast (see page 110 and Figure 3). In the southeastern part of its range, it touches the northern part of the Great Lakes region and

⁵Throughout the remainder of this section the present tense is used in referring to the various vegetation categories. Due to the nature of the discussion neither the present nor the past tense could be used exclusively throughout; in order to avoid the continual switching from one to the other, the present tense is arbitrarily used.

-Classification of Vegetation Types

and outliers of it occur in northern Wisconsin in the Lake Superior area.

In general in that part of the boreal forest east of the Rocky Mountains the climax dominants are white spruce and balsam fir. Tamarack is present usually in the bogs, although along the northern border it occurs on the uplands as a climax tree. Black spruce also is typically a swamp species, but it too reaches upland climax status on some sites. Jack pine occurs more or less throughout the area, and arborvitae or white cedar is common. This forest consists principally of coniferous species, although aspen and white birch form an important element and in some areas become climax trees. Other deciduous species include large-toothed aspen and red maple.⁶

The Wisconsin representative of this forest shows the distinctive stamp of the general forest type. The dominant species of white spruce and balsam fir are here in abundance. White spruce is not found in any appreciable quantities anywhere else in the state. Balsam fir occurs in other areas but is usually associated with the fringes of swamps, while in this particular region it occupies upland locations. Tamarack is here to some

⁶Weaver and Clements, op. cit., pp. 488-490.

--Classification of Vegetation Types

extent as an upland tree, whereas characteristically in other areas of Wisconsin, as also in much of the boreal forest, it is a swamp species. White cedar also occurs on the uplands here but not typically so in other parts of the state. These four trees, white spruce, upland balsam, tamarack, and white cedar, mark this forest region as unique in Wisconsin and relate it to the rest of the boreal forest. Aspen and white birch are also present but their presence has no particular significance here, since they are common to other forest types of Wisconsin as well as to the boreal forest.

However, this forest is not entirely unmixed with species more typically found farther south. As it lies at the southern margin of the boreal forest proper and adjoins the mixed coniferous-deciduous forest to the south, some of the species of the latter extend into this representative of the boreal forest. These are hemlock, sugar maple, yellow birch, oak, and white pine.

Since there is such a small area of this forest type within the state, no attempt has been made to subdivide it into component associations other than to separate areas of occurrence of aspen and white birch.

(b) Deciduous Forest Types

The deciduous forest of North America is confined almost entirely to the United States (see page 111 and

--Classification of Vegetation Types

Figure 3). Within this broad deciduous forest region lies a number of distinct forest associations:⁷ (1) the mixed mesophytic forest association of the Alleghany-Cumberland hill lands, (2) the oak-chestnut association which borders the eastern side of the Appalachian upland from New England to Georgia, (3) the beech-sugar maple association of the young drift area from New York through northern Ohio and southern Michigan to Wisconsin, (4) the sugar maple-basswood association which extends intermittently from Wisconsin into Minnesota, and also into Iowa and Illinois, and (5) the oak-hickory association which forms a fringe around the rest of the deciduous forest except on the north.

The last three of these, together with their subdivisions and variations, make up the forest types mapped in the deciduous area of Wisconsin. In all there are seven sub-types in Wisconsin as follows: (1) the lowland hardwoods, (2) the oak forest, (3) oak openings, (4) oak barrens, (5) the basswood-oak forest, (6) the sugar maple-basswood forest, and (7) the beech-sugar maple forest. The relationships between these various forest types are described below and the other of their successional development toward climax associations is indicated.

⁷Oosting, op. cit., pp. 247-254.

--Classification of Vegetation Types

1. The Lowland Hardwoods.

This community typically occurs on floodplain locations,⁸ usually but not necessarily on land that is intermittently flooded. The individual species that occur on this type of site are willow, elm, black ash, cottonwood, silver maple, river birch,⁹ and in some places basswood and swamp oak. The lowland hardwoods are found both in northern and southern Wisconsin but are located principally in the southwest in the valleys of the unglaciated region.

In order of successional development, this forest is the first woodland community to replace the herbaceous marsh vegetation as lowland sites become built up and better-drained.

This community was readily recognized from the field notes of the surveyors, although all the species characteristic of the group were not listed by the surveyors in every instance.

2. The Oak Forest.

Taking the deciduous forest group of the United States as a whole, the oak-hickory forest covers a larger area

⁸Weaver and Clements, op. cit., pp. 99 and 516.

⁹Oosting, op. cit., p. 255.
Weaver and Clements, op. cit., pp. 65, 99, and 516.

--Classification of Vegetation Types

than any other one type. It also covers more area in Wisconsin than any other deciduous type. However, in this state it does not quite fit the facts to speak of it as an oak-hickory association. Since the area of occurrence of hickory among the oaks is rather limited, it is more properly an oak community, consisting principally of white, black and burr oaks, with each of these occurring in varied numbers from place to place. In places aspen is interspersed among the oaks and in some places elms.

The oak community is one of the more drought-resistant of the deciduous forest types,¹⁰ and in Wisconsin it occurs toward the southern and western portions of the state. On the one hand, it grades into sugar maple-basswood forest through a transition of basswood-oak and on the other hand, it is associated with oak openings and prairie.

Evidence of the successional relationship between the oak forest and the basswood-oak forest is shown by the fact that near the boundary between the two, species usually associated with the basswood-oak forest are found in the oak community. These include such species as red oak, ironwood, cherry, elm, black walnut, and white walnut.

¹⁰Oosting, op. cit., pp. 252-253.

--Classification of Vegetation Types

The occurrence of these species in the boundary zone tends to bind the two types together and emphasizes their transitional relationship.

3. Oak openings.

The lowland hardwoods and the oak forest represent communities recognized and mapped on the basis of their ecological development. The oak openings and oak barrens (discussed below) are variations of the oak forest and are recognized principally on the basis of physiognomic aspects.

Oak openings are transitional, savanna-like areas that bridge the gap between oak forest and prairie.¹¹ The trees, chiefly burr oaks,¹² growing in clumps and as individuals, are loosely spaced at varying distances with prairie grasses growing in the intervening spaces. This pleasant-appearing country stands in sharp contrast to the closed oak forest. Its distinctiveness gives it a place as a separate type. However, it is related to the oak forest successionaly, since improved environmental

¹¹Oosting, op. cit., pp. 253 and 255.

¹²Ibid., p. 255.

--Classification of Vegetation Types

conditions could result in its becoming an oak forest.¹³

4. Oak Barrens.

Oak barrens are also recognized for their physiognomic characteristics. They are similar to oak openings in that both consist of scattered trees with open areas between. However, they differ from oak openings in that they are populated by scrub oak rather than burr oak, and the intervening spaces between the trees do not characteristically have a grass cover but are mostly barren sand. The character of the sparse growth appears to be due more to the sandy quality of the soil rather than to climatic influences. The uniqueness of the oak barrens results from the open spacing of the trees, the small size of the trees, and the barren character of the surface. On the

¹³Since oak openings represent a transition zone there is no definite clear-cut line of distinction to serve as a boundary between them and oak forest on the one hand, and between them and prairie on the other. Thus a problem presented itself to each individual government surveyor as to just where the boundary was between these adjoining vegetation types. When working in this region the surveyors had to be making subjective decisions continually with regard to such boundaries. In mapping the various categories the opinion of the surveyor was usually taken at face value unless surrounding circumstances strongly indicated that he was careless in his statement. One gets the impression that in many cases, surveyors listed oak openings as oak forests. In the case of conflicting opinions between surveyors, the majority opinion was accepted. At best some areas remained unresolved and were placed on the map in a contradictory manner. In doing this it was thought that the actual situation was more truly represented than would be the case if an arbitrary decision were made.

--Classification of Vegetation Types

basis of these qualities, oak barrens are set aside as a separate category, although botanically they might be considered as a phase of the oak forest.

5. The Basswood-Oak Forest.

This community is a transition between the oak forest and the maple-basswood association. Its transitional character is shown by its location which is typically along the margin of the sugar maple-basswood-oak forest, between sugar maple-basswood-oak and one of the oak communities, either oak forest or oak openings (see Figure 5). Again, its transitional successional position is indicated by the fact that its dominant species, basswood and red oak, are also found in the adjoining forest communities. Also some of the associated species of the basswood-oak forest, such as elm, cherry, hickory, ironwood, and walnut, occur in the oak forest near the common boundary as mentioned above and carry through the basswood-oak forest over into the sugar maple-basswood-oak association.

6. The Sugar Maple-Basswood-Oak Forest.

In general where climate is permissive and in places where moisture and soil conditions are favorable, oak forest evolves through basswood-oak forest into sugar maple-basswood forest, which appears to be the climax

--Classification of Vegetation Types

association for most of southern and southwestern Wisconsin.¹⁴ Sugar maple and its seedlings flourish in the dense shaded forest. Thus sugar maple becomes one of the major dominants and along with basswood controls the forest. As the forest stand becomes thicker and the leaf canopy becomes more dense, young burr, black and white oak trees have a tendency to be shaded out, although the more mesophytic red oak is well-adapted to the conditions of this forest. White oak is not entirely lacking and may reach prominence within the general sugar maple-basswood forest on localized sites that are less well-adapted for the other species. Other associated species of the forest are trees such as elm, red maple, cherry, ironwood, hickory, black walnut, white walnut and white ash.¹⁵

7. The Beech-Sugar Maple-Basswood-Oak Forest.

In the cooler, more humid sites of the deciduous forest, which in Wisconsin is along the immediate shore region of Lake Michigan, beech is added to the sugar maple-basswood-oak forest. The resulting forest is considered

¹⁴ However, sugar maple-basswood forest does not occur in all parts of Wisconsin where conditions are permissive for its growth. (See page 133)

¹⁵ Oosting, op. cit., pp. 249-250.

--Classification of Vegetation Types

to be the ultimate climax association of the deciduous forest types. The two major dominants of beech and sugar maple are the most tolerant of shade of the deciduous species.¹⁶ Beech is the ultimate dominant species of this association, although there is little difference in the requirements of beech and sugar maple, so the two together control the forest on more or less equal terms.¹⁷ The addition of beech is the principal criterion that distinguishes beech-sugar maple-basswood-oak from sugar maple-basswood-oak forest, as the associated species are essentially the same in the two associations. However, the occurrence of beech is significant in that it marks out a zone of lake influence.

(c) The Mixed Coniferous-Deciduous Forest Types.

Between the two extremes of the boreal coniferous forest in the north and the deciduous hardwood forest in the south and southwest lies a mixed transition forest containing both coniferous and deciduous species (see page 111 and Figure 3).

There is some variance of opinion concerning the internal and external relationships of this forest. This

¹⁶Weaver and Clements, op. cit., p. 510.

¹⁷Ibid., pp. 510-511.

--Classification of Vegetation Types

is undoubtedly due to its transitional character, encroached upon as it is by the deciduous forest on one side and the boreal forest on the other. Weaver and Clements call it the Lake Forest and assert that it consists of one association, the pine-hemlock, of which the dominants are white pine, red pine, and hemlock. However, they admit to certain variations.¹⁸ Oosting calls it the Hemlock-Hardwoods association of the deciduous forest formation and also indicates variations.¹⁹ Nichols calls it the Hemlock-White Pine-Northern Hardwoods region of eastern North America.²⁰ Although these views may not be entirely in accordance with each other with respect to the general status of the forest, they are closely similar with respect to the actual description. Whitford describes the ecological succession of the forest as it occurs in a part of the northern peninsula of Michigan and in doing so points out definite communities that are also mentioned by Weaver and Clements, Oosting, and Nichols.²¹

¹⁸Weaver and Clements, op. cit., pp. 497-498.

¹⁹Oosting, op. cit., pp. 250-251.

²⁰Nichols, G. E., The Hemlock-White Pine-Northern Hardwood Region of Eastern North America, Ecology, XVI, 1935, pp. 403-422.

²¹Whitford, Harry Nichols, The Genetic Development of the Forests of Northern Michigan; A Study in Physiographic Ecology, Botanical Gazette, XXXI, 1901, pp. 289-325.

--Classification of Vegetation Types

The government survey field notes reveal all these communities and in addition one other, a sugar maple-yellow birch-white pine community, that also stands out as distinct. Together they are: (1) jack pine, (2) jack pine barrens, (3) white birch-aspen, (4) white pine-red pine, (5) hemlock-sugar maple-yellow birch-pine, (6) hemlock-beech-sugar maple-yellow birch-pine, and (7) sugar maple-yellow birch-pine. In addition there is a series of mixed forest types where the pines enter the various deciduous forests. These are discussed below as (8) other mixed coniferous-deciduous forest types.

1. The Jack Pine Forest

The jack pine forest represents a stage in the successional development toward climax forest growth in areas where xeric conditions associated with sandy soils occur. This forest is characteristically located on exposed sand surfaces, particularly where fires have destroyed a pre-existing forest in a sandy region. The greater the destruction of humus by fire, the more likely it is that jack pine will be the secondary succession growth to reforest the area. This species is not only fitted to reforest such regions by reason of its xerophytic nature but also because of the fact that fire may facilitate the

--Classification of Vegetation Types

opening of the cones which are otherwise slow to sprout.²²

As Whitford has described in the northern peninsula of Michigan after jack pine has taken control of an area, red pine and white pine may also enter, but since jack pine is the most xerophytic of the three, the more xeric the local environment the greater the likelihood of the complete dominance of jack pine.²³

In addition to red pine and white pine, other species that sometimes occur in the jack pine forest are aspen and white birch. All these associated species tend to occur in places where the local conditions are less harsh.

2. The Jack Pine Barrens.

This is a variation of the jack pine forest in which the physical aspect is sufficiently different to warrant a separate category. The striking characteristics are the wide spacing of the trees and the open expanses of bare sand between. In these respects, the jack pine barrens resemble the scrub oak barrens. In some places the two occur together as a mixed growth.²⁴ Ecologically jack pine barrens are considered to be a stage in the develop-

²²Weaver and Clements, op. cit., p. 499.

²³Whitford, op. cit., pp. 297-299

²⁴Such a mixture was mapped as a separate category.
See page 98.

--Classification of Vegetation Types

ment of jack pine forests. As mapped in this study they are seen to be in close areal association. As humus accumulates and soil and moisture conditions improve, the trees become more closely spaced until eventually a jack pine forest has developed. With increasingly improved habitat conditions, the red and white pines take control, and they in turn finally give place to the climax forest.²⁵

3. The White Birch-Aspen Forest.

As in the case of the jack pine forest, the white birch-aspen forest often represents a stage of secondary succession that occurs after a more advanced forest has been destroyed.²⁶ The trees of this community require soil of greater humus content than does jack pine, and therefore, they cannot compete with jack pine in the more xeric areas. However, in places where it is able to exist, this forest may be the first to come in after a fire because of the ease with which the seeds of its member species migrate. A characteristic growth sequence that may take place after a fire, that has not drastically destroyed the humus content of the soil, shows first various so-called fireweeds. These may be replaced

²⁵Whitford, op. cit., p. 322.

²⁶Weaver and Clements, op. cit., pp. 499-500.

--Classification of Vegetation Types

by the white birch-aspen forest. Eventually the slower migrating pines reach the area and in time shade out the white birch and aspen. Gradually the pines develop the shade and humus conditions necessary for the establishment of the particular climax forest that may be adapted to the region. If pines do not enter the locality, birch and aspen may give way directly to the climax association.²⁷

Under conditions such as described above white birch and aspen may become established as dominants in a forest type. Pine sometimes occurs in this community as does oak in some places. The white birch-aspen community also exists in the boreal forest.

4. The White Pine-Red Pine Forest.

Pure stands of white pine and red pine are somewhat limited in area in Wisconsin, yet such forests do occur as distinct entities. However, these two species do not always grow in intimate intermixture within their areas of occurrence. The white pine tends to occur on the better soil areas within the range of this forest, while the red pine tends to grow on the less well-favored soils.

Whitford suggests that red pine may occupy a transitional stage between jack pine and white pine.²⁸ At any rate the

²⁷Whitford, op. cit., pp. 317-319.

²⁸Whitford, op. cit., p. 299.

--Classification of Vegetation Types

two follow jack pine and also white birch-aspen in the order of ecological succession as has been indicated.

5. The Hemlock-Sugar Maple-Yellow Birch-Pine Association.

After the pine forest has developed sufficiently suitable conditions of soil and shade, a climax forest consisting of hardwoods and hemlock may enter and take over the control of the area. This forest is one whose dominant species include hemlock, sugar maple, and yellow birch. Yellow birch occurs in lesser numbers than the other two.²⁹

There is some difference of opinion concerning the place of pine within this forest. Weaver and Clements consider both white pine and red pine to be co-dominants along with hemlock.³⁰ Nichols believes that white pine is a normal constituent of the climax forest but not red pine.³¹ Oosting is of the opinion that they are successional species where they occupy, as pure stands, the poorer sites within the climax forest, and that they are relicts of a pre-climax stage where they are scattered individually throughout the forest.³²

²⁹Ibid., p. 301.

³⁰Weaver and Clements, op. cit., p. 498.

³¹Nichols, op. cit., p. 420.

³²Oosting, op. cit., p. 251.

--Classification of Vegetation Types

In addition to the species listed, there are subordinate species such as ash, elm, balsam fir, basswood, red maple, and aspen. This forest type is the most extensive of all those that make up the mixed coniferous-deciduous forest of Wisconsin.

6. The Beech-Hemlock-Sugar Maple-Yellow Birch-Pine Association.

The beech-hemlock forest results from the overlapping of the beech-sugar maple deciduous forest and the hemlock-sugar maple-yellow birch-pine mixed coniferous-deciduous forest in the Green Bay area. It lies immediately to the east of the hemlock-sugar maple-yellow birch-pine forest and bears the same relationship to that forest type as the beech-sugar maple forest bears to the sugar maple-basswood association in the southern part of the state. In each case the entrance of beech results in a different, though related, forest community. The species of the beech-hemlock forest are essentially the same as those of the hemlock-sugar maple forest with the exception of the addition of the beech.

The portion of this forest community in Wisconsin represents the westward limit of extension of the beech-hemlock forest as a whole in North America. Whitford found it in the northern peninsula of Michigan eastward of Marquette, and Kenoyer reported it in the lower

--Classification of Vegetation Types

peninsula of Michigan on the opposite shore of the lake from its area of occurrence in Wisconsin.^{33,34} Nichols shows it occurring eastward from Wisconsin throughout the Great Lakes region and on into New England.³⁵

7. The Sugar Maple-Yellow Birch-Pine Forest.

Westward from the Door Peninsula region the beech-hemlock forest association changes to hemlock-sugar maple as beech is eliminated as a dominant species. Farther to the west in the state, and also in restricted areas within the confines of the hemlock-sugar maple forest, hemlock drops out and the remaining dominants are sugar maple, yellow birch and white pine. Along with these species basswood, oak and aspen may occur. The writer does not know if this forest is a climax association. It probably is not when it occurs within the hemlock-sugar maple forest, but in the western part of the state, the verdict hinges on whether hemlock is able to compete successfully that far west. There is no evidence that it can. If it can, then the sugar maple-yellow birch-pine forest is a pre-climax type awaiting the entry of hemlock

³³Whitford, op. cit., p. 302.

³⁴Kenoyer, op. cit., pp. 107-111.

³⁵Nichols, op. cit., pp. 408 and 417.

--Classification of Vegetation Types

as a dominant. From the mapping data, no evidence is seen that hemlock is migrating westward. Hutchinson thinks that it may be migrating westward in Ontario.³⁶

8. Other Mixed Coniferous-Deciduous Forest Types.

The main body of the mixed coniferous-deciduous forest of northern and northeastern Wisconsin makes contact with the main body of the deciduous forest of southern and southwestern Wisconsin through a gradation zone or belt of varying width that trends generally northwest-southeast from Sheboygan County to Polk County. Along this zone of contact pines from the north and northeast extend into the various deciduous forest communities of the south and southwest, causing them to be mixed coniferous-deciduous types. The pines are often the most conspicuous and the most valuable element in these forest types and as a consequence are geographically significant and therefore are recognized by the setting apart of these combinations in separate mapping categories.

The mixed coniferous-deciduous forest types of this group include: (a) the beech-sugar maple-basswood-oak-white pine forest; (b) the sugar maple-basswood-oak-white pine

³⁶Hutchinson, A. H., Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees, Botanical Gazette, LXVI, 1918, p. 490.

--Classification of Vegetation Types

forest; (c) the basswood-oak-white pine forest (very limited in area); (d) the oak-white pine forest; (e) the jack pine-scrub oak forest; and (f) jack pine-scrub oak barrens.

(d) The Swamp Forests.

The swamp forests stand in contrast to the three main groups of upland forest in the state by virtue of their location on poorly drained sites. In separating the swamp forests from the upland forests, it is not implied that the two types are unrelated. A large proportion of the forest species of the swamp lands are identical with species of the upland boreal forest, so there is a generic relationship. Also the vegetation of the swamps goes through a successional development as the margins are gradually built higher until eventually a climax forest replaces the swamp forest, so there is an ecological relationship.³⁷ This ecological relationship exists between the swamp forests and both the deciduous forest and the mixed coniferous-deciduous forest, but principally the latter since most of the forested swamps are located within its borders. Thus the swamp forests are not to be thought of as being entirely apart. However, because of these varied interrelationships, and because

³⁷Whitford, op. cit., pp. 315-316.

--Classification of Vegetation Types

the swamp forests do not show any particularly systematic distribution with respect to the upland forests but tend to cut across boundaries rather indiscriminately, plus the fact that as swamps they possess a geographic uniqueness of their own, they are mapped and treated separately.

The forests of the swamp lands of the state may be separated into two major classes: (1) the hardwood swamp forests, and (2) the coniferous swamp forests.

1. The Hardwood Swamp Forests.

The hardwood forests of the undrained depressions are usually comprised of such species as black ash, willow, and elm. These species occur both singly and grouped in combinations. The most numerous and wide spread of the species is black ash. It is particularly characteristic of the glacial bogs and is often found in association with coniferous species. Since the hardwood swamp forests cover a relatively small area in the state, the different subdivisions are combined as one unit for mapping purposes.

2. The Coniferous Swamp Forests.

This type of forest is confined almost entirely to glacial swamps. The species include white cedar, black spruce, tamarack, and hemlock. Black ash often occurs as a hardwood element along with the coniferous species, and alder is often present as undergrowth. The tamarack,

--Classification of Vegetation Types

though coniferous and needle-leafed, drops its needles in the winter season and is, therefore, a deciduous tree. It is one of the best represented swamp trees, and it, along with black ash, which is also well-represented, forms a deciduous component in many of these swamp forests, causing them to be mixed evergreen and deciduous.

The most important species in addition to tamarack are white cedar and black spruce. In the northern part of the state these three have a tendency to grow in the same swamps, not as an intermingled growth of individual species, but in an intermixture of clumps of trees of one species in close proximity to clumps of the other species. This comes about due to the successional relationship between the three. Tamarack is usually the first tree to come into a bog after the way has been prepared by the pioneering aquatic plants, sedges, and shrubs. As the margins of the swamps are built higher tamarack gradually migrates nearer the center, and black spruce comes in along the margin. The progression toward the center continues, and in time white cedar follows black spruce in the peripheral zone of the swamp. Black ash

--Classification of Vegetation Types

is often associated with the cedar.^{38,39,40}

The successional relationship between these various species, along with the varied local environmental conditions, results in an intricacy of detail. Because of this detailed arrangement, it was not expedient to map each type individually, but it was more feasible to map them by combinations. They are as follows:

a. White cedar-black spruce-tamarack swamps.

This group is common in the northern part of the state. At times the government surveyors would report cedar alone or with only one of the other two species. Therefore, any combination that contained white cedar was mapped under this category. As mentioned, black ash is a common associate of cedar in the swamp forests, but it also occurs with the other species.

b. Black spruce-tamarack swamps.

In places, cedar drops out, leaving black spruce and tamarack as the swamp dominants. Any areas of spruce alone without tamarack that were sufficiently large to be mapped were also put in this category.

c. Tamarack swamps.

³⁸Oosting, op. cit., p. 242.

³⁹Whitford, op. cit., pp. 314-315.

⁴⁰Weaver and Clements, op. cit., p. 500.

--Classification of Vegetation Types

In some places, especially toward the south, both cedar and spruce are essentially eliminated, while tamarack remains and was mapped as the third main type. Since tamarack was the first species to enter in the order of successional development, it is more or less ubiquitous in each of these three swamp forest types, but it is not necessarily always present.

d. Hemlock swamps.

The fourth type of swamp under this category has no relationship to the other three except in the fact that it contains coniferous trees. There are a few birch and pine intermixed in the swamp, but the principal species is hemlock. In some places hemlock occurs locally in the other three swamps of this category described above.

(e) Brushland

Associated with the forests of the state at the time of the original land survey were certain areas of open brushland. These like the forests may be separated into upland and swamp types.

1. Upland Brush.

Upland brush, in part at least, represents the beginning stages of natural reforestation after a forest has been destroyed by wind or fire. In the mixed conifer-

--Classification of Vegetation Types

ferous-deciduous forest zone, the brush is usually white birch and aspen, or pine.⁴¹ In the deciduous forest zone it is usually oak with or without an admixture of hazel, prickly ash, plum, thorn and hackberry. For mapping purposes no attempt is made to separate the various types of upland brush.

2. Swamp Brush.

The swamp brush consists principally of alder. This bog shrub represents one of the developmental stages in the evolution from marsh to forest.⁴² It occurs singly and in combination with tamarack and with marsh grass.

(f) Miscellaneous Vegetation Categories

There are certain other areas within the state that can not be classified as forest types but which are associated with the forests in having been recently forest covered. These are the burned-over areas and the windfalls.

The term windfall is used by the surveyors to designate areas in which the forest growth was blown down by strong winds.⁴³ There are a surprising number of these areas.

⁴¹This does not refer to underbrush on the forest floor.

⁴²Oosting, op. cit., p. 242.

⁴³These areas were sometimes otherwise designated as windthrows, blowdowns and down timber.

--Classification of Vegetation Types

They tend to be long and narrow and oriented in a general northeast-southwest direction. In some the trees were so tangled and twisted together as to form an almost impenetrable mass. They occur most commonly in the north central and northwestern part of the state (see pages 251-253).

Both the burned areas and the windfalls represent conditions preliminary to the beginning stages of secondary succession in the forests. They are followed by one of the brush types, which in turn is followed by a forest growth. In the windfall the forest environment in terms of humus, soil moisture, etc., is less apt to be radically changed than in a burned-over area, although fires are of different degrees of severity. Therefore, the resulting brush growth in an old windfall is more likely to be made up of some of the same species as those of the destroyed forest than is the case in the burned-over region. When a climax forest is burned, it not only receives a setback in terms of tree growth, but it often reverts to an earlier stage of successional development.

GRASSLAND AREAS

The grasslands of the state, are associated with the extensive grassland of central North America. This expansive grassland area extends from the southern edge of the boreal forest in Alberta, Saskatchewan, and Manitoba, southward in a wide belt to southern Texas (see page 112

--Classification of Vegetation Types

and Fig. 3). The boundary between the grassland and the deciduous forest to the east is not a sharply defined cleavage, but it more resembles a zone of transition through which grassland grades into forest through a savanna parkland zone of scattered trees. This savanna zone occurs in Wisconsin in the form of oak openings as indicated above, but the grassland also occurs in this state as individual isolated patches, some large some small, scattered not only through the oak openings but also in the oak forest as well and to some minor extent even in the basswood-oak and sugar maple-basswood forests.

The grasslands in Wisconsin are here separated into three types: (1) marsh, (2) wet prairie, and (3) upland prairie. Although marsh vegetation cannot be classed as true grass, it resembled grass physiognomically and for that reason is grouped with the grassland. The writer is uncertain as to whether these vegetation types are related through successional development. It is true that in subhumid regions, there is a successional development whereby marsh vegetation is eventually replaced by upland prairie.⁴⁴ Wisconsin does not have a subhumid climate, but the areas of grassland in Wisconsin are relicts that hold over from a time when a subhumid climate

⁴⁴Weaver and Clements, op. cit., pp. 60-65.

--Classification of Vegetation Types

was in effect (see page 122). In some instances there is a locational relationship between these three, with wet prairie occurring on the margins of marshes and upland prairie occurring on the margins of wet prairie. At times the surveyors were not clear in separating these adjacent categories. When marshes adjoined wet prairie or wet prairie adjoined dry prairie, the gradations were apparently quite subtle and the change from one type to another so gradual that it was not easy for the surveyor to fix the boundaries. Also the place of the sedge meadow is indistinct from the field notes. It is rarely mentioned as such, and it is probable that it was classed by the surveyors as marsh at times and at other times as wet prairie.

Whether or not the three categories of marsh, wet prairie, and dry prairie are interrelated on an ecological basis, they stand out as sufficiently distinct entities as to warrant placing them in separate classes. The heavy reed vegetation of the perpetually wet areas contrasted with the finer species of the wet meadow, and both were different in terms of site drainage from the dry upland prairie.

The vegetation types classified in this section are all identified from the field notes of the original government land survey of Wisconsin. The distribution of the

--Classification of Vegetation Types

types thus distinguished are discussed in the remaining sections and shown on the accompanying master map.

Listed in outline form these vegetation types include the following:

I. Forest Areas

A. The Boreal Forest

B. Deciduous Forest Types

1. Lowland hardwoods
2. Oak forest
3. Oak openings
4. Oak barrens
5. Basswood-oak forest
6. Sugar maple-basswood-oak forest
7. Beech-sugar maple-basswood-oak forest

C. Mixed Coniferous-Deciduous Forest Types

1. Jack pine forest
2. Jack pine barrens
3. White birch-aspen forest
4. White pine-red pine forest
5. Hemlock-sugar maple-yellow birch-pine forest
6. Beech-hemlock-sugar maple-yellow birch-pine forest
7. Sugar maple-yellow birch-pine forest
8. Other mixed coniferous-deciduous forest types

--Classification of Vegetation Types

- a. Beech-sugar maple-basswood-oak-white pine forest
- b. Sugar maple-basswood-oak-white pine forest
- c. Basswood-oak-white pine forest
- d. Oak-white pine forest
- e. Jack pine-scrub oak forest
- f. Jack pine-scrub oak barrens

D. Swamp Forest Types

- 1. Hardwood swamp forest
 - a. Black ash-willow-elm forest
- 2. Coniferous swamp forests
 - a. White cedar-black spruce-tamarack forest
 - b. Black spruce-tamarack forest
 - c. Tamarack forest
 - d. Hemlock swamp forest

E. Brushlands

- 1. Upland brushland
- 2. Swamp brushland

F. Miscellaneous Categories

- 1. Burned-over areas
- 2. Windfalls

II. Grassland Areas

- A. Marsh
- B. Wet prairie
- C. Upland prairie

SECTION VI

GENERAL PATTERNS OF VEGETATION DISTRIBUTION

The vegetation cover that existed in Wisconsin at the time of the original government land survey consisted principally of forest and grassland. The forest was composed of three major differentiated types, the boreal forest, the mixed coniferous-deciduous forest, and the deciduous forest. These three classes of forest, taken together with the grassland, make four large vegetation groups that were represented. These larger groups were comprised of a number of different individual plant associations or plant communities. Thus there were two superimposed patterns of vegetation which covered the state, one a broad gauge coarse-grained pattern composed of the four major vegetation formations (Fig. 4), which contained within it a more fine-grained detailed pattern made up of the individual plant communities (Fig. 5).

(In the discussion that follows, in referring to the vegetation that existed at the time of the government land survey, the present tense will be used instead of the past tense. For purposes of explanation it is often necessary to dip back into periods prior to the time of the survey, and in those cases the past tense must be used. If the past tense were used to indicate both the

--General Patterns of Vegetation Distribution

time of the survey and time prior to the survey, the result would be lack of clarity. It will be understood that the vegetation patterns that existed at the time of the government survey, even though the present tense is used in discussing them, were considerably different from those of the present day.)

BROAD PATTERN OF THE FOUR MAJOR VEGETATION TYPES

As Wisconsin is not an isolated vegetation unit, the four major vegetation groups shown in Fig. 4 are not restricted to Wisconsin alone, but the areas in Wisconsin covered by these groups represent small segments only of much more extensive vegetation regions of continental North America that extend beyond the boundaries of the state.

The boreal forest in northern Wisconsin is a very small portion of the extensive subarctic coniferous forest that covers the expansive northern part of the continent from Alaska to Labrador (Fig. 3). The character of this forest and its component parts are discussed on pages 78-80, in Section V. Although the generalized map (Fig. 4) does not show this forest reaching southward into the United States, the government survey field notes show that it occurs in areas of varying size in northern Wisconsin, particularly in the environs of Lake Superior. More

--General Patterns of Vegetation Distribution

detailed maps show that isolated segments also occur in northern Minnesota and in the northern peninsula of Michigan.¹ Thus the boreal forest of northern Wisconsin consists of two relatively large outliers along the shore of Lake Superior and a number of smaller outliers all of which are associated with the southern margin of the broad band of boreal forest of northern North America. Related to this forest ecologically and historically are numerous relict colonies of bog conifers that occur throughout a large proportion of the state.

Toward the opposite or southern end of the state is the deciduous forest, which covers most of southern and southwestern Wisconsin. This forest is also a segment of a more extensive, larger unit that occurs largely in the Central Lowland of the United States (Fig. 3).² Its northern margin reaches across Wisconsin in a sinuous route, trending generally northwest-southeast from Sheboygan County on Lake Michigan to Polk County on the Minnesota border.

¹Shantz, H. L., and Raphael Zon, The Natural Vegetation of the United States, Atlas of American Agriculture, Natural Vegetation, (Washington: Government Printing Office, 1924), pp. 4-5.

²Since Fig. 3 is highly generalized, it shows deciduous forest extending across the Appalachian Upland and the coastal plain to the Atlantic and Gulf coasts, thereby including areas which on a more detailed map would be shown as coniferous and mixed coniferous and deciduous forest.

--General Patterns of Vegetation Distribution

Between these two forest groups, the boreal forest on the extreme north and the deciduous forest on the south and southwest, lies a third forest group, one of a transitional character that partakes of aspects of each of the other two, but at the same time one that is distinct in its own right. This is the mixed coniferous-deciduous forest, sometimes referred to as the Lake Forest. In continental location it extends westward from New England and the upper St. Lawrence Valley through the Great Lakes area to Minnesota, and in doing so it covers the northern half of Wisconsin (Fig. 3).

The fourth major vegetation type, the grassland, occurs within the deciduous forest zone in the southern and southwestern part of the state, where it takes the form of numerous separated fragments of varying sizes and shapes. Most of these bear the relationship of outliers or islands with respect to the main body of grassland of central North America, although some along the southern margin of the state are in the shape of elongated tenuous projections, irregular in outline, that have a direct connection with the main grassland body. As shown by Fig. 3, the main body of the grassland in North America lies in the central part of the continent, east of the Rocky Mountains. The eastern margin projects eastward across Missouri, Iowa, and Illinois to Indiana to form

--General Patterns of Vegetation Distribution

the Prairie Peninsula. Fig. 3 is in diagrammatic form and shows the main body of the grassland extending across southwestern Wisconsin. This is not the actual condition, but rather it reaches into the state in the form of the projections and outliers described above.

In summary, the broad pattern of vegetation of Wisconsin is made up of four major vegetation groups: the boreal forest, the deciduous forest, the mixed coniferous-deciduous forest, and the grassland. Each of these groups within the state represents but a small part of a more extensive formation that covers a large proportion of the North American continent. The deciduous forest and the mixed coniferous-deciduous forest are contiguous parts of their respective larger areas. The boreal forest and the grassland are in the form of outliers, separated from, but lying near, the margin of the main bodies of similar vegetation, or else, as in the case of some portions of the grassland, connected by narrow peninsulas. The boreal forest occurs in a limited area in the extreme northern part of the state. The deciduous forest covers the southern and southwestern portions, while the mixed coniferous-deciduous forest lies in a transitional location between the other two, covering most of the northern half of the state. The grassland occurs as a number of separated patches within the deciduous forest zone.

--General Patterns of Vegetation Distribution

After the vegetation distributions described above have been noted, the question arises, What is the origin of these major vegetation groups that occur in Wisconsin, and why do they assume these particular distributions? Part of the answer at least can be found by tracing the postglacial history of the climatic and vegetative changes of eastern North America, particularly as it applies to the Wisconsin area. The major groups of vegetation in their broad outlines did not spring suddenly into being, but their distribution pattern stems from a series of adjustments that have been in progress since the removal of the ice of the last glacial stage.

Vegetation adjusts to climate and other environmental factors. It evolves, or deteriorates, and it migrates and requires time to do so. Climates fluctuate and other environmental factors change, inducing a continuous response from the vegetation, although there is a time-lag in this adjustment; the response does not necessarily keep pace with the stimuli. The distribution of vegetation over an area at any given time is a representation of the progress attained as of that particular time in the continuing adjustment of the vegetation to the changing physical environment.

The most effective causes of major changes in the character of the vegetation are the pronounced long term

--General Patterns of Vegetation Distribution

variations in the climatic elements. Such profound climatic changes bring about equally pronounced alterations in the vegetation, although as indicated the changes are not simultaneous. A vegetation form may become so firmly established and gain such a secure control of an area during a long period of favorable climate that vestiges of it may persevere for long periods after succeeding vegetation forms brought about by different climatic regimes have entered and occupied the region. The vestiges of the earlier formation will remain as relicts on the sites least favorable to the invaders, and considerable time may elapse before they are displaced from these sites.

Thus because of the time-lag involved in the adjustment of the vegetation to changing climatic conditions, plus the fact that previous formations tend to linger indefinitely on specialized sites, it is impossible to explain existing vegetation forms in terms of the present climate alone, or in terms of any other single environmental factor for that matter. For these reasons, in order to understand present distributions of the major vegetation formations, it is necessary to take into consideration the history of paleo-climates and of the paleo-vegetal formations. Since in Wisconsin the history of the present vegetation dates from the withdrawal of the ice of the

--General Patterns of Vegetation Distribution

Pleistocene glaciation, it is only the climates of post-glacial times that are of significance to the study.³

Although the climates of the postglacial period are imperfectly known and the evidence concerning them is fragmentary both in terms of time sequence and areal coverage, it is well-established that there were marked climatic fluctuations during that period and that the fluctuations followed much the same pattern throughout large portions of the northern hemisphere. Most of the evidence comes from the study of fossil pollens, tree rings, sea and lake levels, varved clays, peat deposits, and archeological remains, plus a direct historical record of the more recent fluctuations.

Sears and others have worked out, by means of fossil pollen studies principally, but also by use of remaining floristic evidence, the climatic sequences for northeastern North America including the Great Lakes area.^{4,5,6,7,8}

³This statement does not take into consideration the possible existence and influence of vegetation in the Driftless Area during glacial times. However, no evidence from the field notes has been found by the writer that would indicate that any such vegetation left an imprint in the major vegetation pattern that persisted down to the time of the government land survey.

⁴Sears, Paul B., Postglacial Climate in Eastern North America, Ecology, XIII, 1932, pp. 1-6.

⁵_____, Forest Sequences in the North Central States, Botanical Gazette, CIII, 1942, pp. 751-761.

--General Patterns of Vegetation Distribution

These studies suggest that in the northern part of the Great Lakes region there was (1) a gradual warming to (2) a period of maximum warmth, and then (3) a gradual cooling. Toward the south the same conditions existed with the exception that there is believed to have been two periods of marked xeric conditions interposed in the sequence which gave it a variation as follows: (1) a cool moist period, followed by (2) a cool period but warmer than at present and dry. This was followed in turn by (3) a warm moist period, (4) a warm dry period, and finally (5) a cool moist period which has extended down to the present.

Also from a study of fossil pollens and floristic relicts, the vegetational history of the area which includes Wisconsin has been worked out. Gleason has put together the general trend of events.⁹ From his account,

6 _____, Forest Sequence and Climatic Change in Northeastern North America Since Early Wisconsin Time, Ecology, XXIX, 1948, pp. 326-333.

7 Krauss, Robert W., and George N. Kent, Analyses and Correlations of Four New Hampshire Bogs, Ohio Journal of Science, XLIV, 1944, pp. 11-17.

8 Truman, Harry V., Fossil Evidence of Two Prairie Invasions of Wisconsin, Transactions of the Wisconsin Academy of Sciences, Arts and Letters, XXX, 1937, pp. 36-42.

9 Gleason, Henry Allan, The Vegetational History of the Middle West, Annals of the Association of American Geographers, XII, 1922, pp. 39-85.

--General Patterns of Vegetation Distribution

measured against studies by others, the following summary may be outlined.

(1) During and after the retreat of the ice, within the period of the first climatic phase mentioned above, tundra vegetation, possibly, and coniferous forest, certainly, spread northward over northeastern North America including the Middle West and Wisconsin. After its northern margin had reached the upper Great Lakes area, this forest extended northwestward to Alaska in addition to continuing its northward spread toward the Hudson Bay region. Thus it covered a large proportion of the northern part of the continent including the Wisconsin area. Balsam fir and white spruce were the dominant trees, although tamarack, black spruce, and white cedar grew on the poorly drained sites, while pines grew on the excessively drained locations (Fig. 6a).

(2) As the climate warmed deciduous trees began a northward march on the heels of the northward-advancing southern margin of the coniferous forest, and it appears that oaks moved into southern Wisconsin at this time.¹⁰ However, the advance of the deciduous forest was halted by the first period of prolonged drought mentioned above. The dry climate that now prevailed allowed the western

¹⁰Truman, op. cit., p. 39.

--General Patterns of Vegetation Distribution

grassland of the High Plains to expand eastward to form the Prairie Peninsula. The northern margin of this grassland wedge probably reached well up into Wisconsin, and grassland probably covered the state south of a line drawn between the present locations of Milwaukee and Minneapolis. From this part of Wisconsin the coniferous forest was generally displaced by the grass, and the conifers remained only in colonies in localized areas where the habitat conditions were less favorable for the invading grasses. Such relict colonies included tamarack, black spruce, and white cedar on the poorly drained sites and pines, and to some extent red cedar, on the more sandy and on the rough rocky locations. The resulting situation then was a vegetation cover of coniferous forest in the northern and northeastern parts of the state and grassland in the south and southwest. Possibly in response to the increased dry conditions, a high percentage of the coniferous forest in the north became preponderantly a pine forest (Fig. 6b).

(3) As the pronounced drought period waned and the climate became humid once more, deciduous species made their entrance into the state in force, coming from the south and from the east. Slowly they encroached upon the grassland, filling in across the interfluves from valley to valley in the southwestern part of the state and moving

--General Patterns of Vegetation Distribution

as a united front from the east. The more mesophytic species such as beech, sugar maple, and red oak presumably came from the east and southeast,¹¹ and there are indications that this mesophytic forest extended across the state at this time and reached into northwest Iowa and into Minnesota. It is likely that hemlock and yellow birch migrated into northern Wisconsin from the east at this time.

The colonies of relict coniferous species that existed on the specialized sites in the grassland in the south were now surrounded by the invading deciduous trees. The main body of the coniferous forest toward the north was infiltrated by the deciduous species, giving as the result a mixed coniferous-deciduous stand in that area. The picture of vegetation distribution within the state now showed a mesophytic deciduous forest in the south and southwest interspersed with relict colonies of conifers, a mixed coniferous-deciduous forest throughout most of the north and northeast, and probably an area of boreal coniferous forest with little or no admixture of deciduous trees in the far north (Fig. 6c).

¹¹Braun thinks they may have also spread outward from the Driftless Area where they took refuge during the Pleistocene glaciation. See page 185.

--General Patterns of Vegetation Distribution

(4) With the coming of the second dry climatic period the grassland again advanced into the zone of the Prairie Peninsula and entered southern and southwestern Wisconsin for the second time, although this time the drought did not last as long as before and the effects were not so widespread. The drought, and the fires associated with the dry conditions, forced the fire-sensitive mesophytic forest to recede, and its place was taken in large part either by grassland or by grassland and scattered fire-resistant, drought-resistant burr oaks. Nevertheless the mesophytic forest was not entirely displaced. Remnants were preserved in localities where water bodies or topographic barriers gave protection from the fires. The mesophytic white spruce and balsam fir of the mixed coniferous-deciduous forest may at this time have moved to a more northerly latitude, leaving behind the drought-resistant pines and the bog conifers as coniferous representatives in the mixed forest along with the moisture-loving hemlocks, which undoubtedly would have receded to the damper soils of the bogs or bog margins.

The situation now became one of an area of grassland in the southwest and south through which was scattered the remaining fragments of the mesophytic forest along with the burr oak openings, plus a few relict colonies of bog conifers in the fire-protected swamps. In the

--General Patterns of Vegetation Distribution

north and northeast was the mixed coniferous-deciduous forest. In the extreme north this forest apparently still contained an admixture of white spruce and balsam fir (Fig. 6d).

(5) A climatic change to a cool, moist regime leading down to the present day reestablished favorable mesophytic conditions for forest growth throughout the state, although the grassland was not quickly displaced. By this time the American Indian had arrived on the scene and his continued burning of the countryside aided the grassland to survive and inhibited the spread of the forest, although the climate was becoming increasingly favorable for forest growth. The area of grassland was very probably diminished by the spread of oak openings, but it is problematical whether the mesophytic forest advanced very far beyond its refuge sites in the southern part of the state until the coming of the white man which removed the Indian with his fires. The pollen profiles show that in the north there was an increase in the amount of white spruce and balsam fir at this time, indicating a possible re-extension of the boreal coniferous forest in the northern margin of the state. It is logical to expect that the hemlock of the mixed coniferous-deciduous forest would have increased its area of occurrence during this period as conditions became more moist (Fig. 6e).

--General Patterns of Vegetation Distribution

This last stage represents the status of the vegetation as it existed at the time of the government land survey and therefore the status shown on the master map accompanying this study. The broad pattern of the four major groups in their distribution over the state is mainly a response to past climates. The variations in climate, as they recurrently spurred and inhibited the development of different vegetation formations, were instrumental in bringing about the present distribution. Time-lag and the ability of certain vegetation types to endure as relicts on specialized sites have also played a part.

PATTERN OF THE SMALLER SUBDIVISIONS OF VEGETATION

The plan of approach in discussing the distribution of vegetation in the state is to narrow the discussion progressively from the general to the detailed; to deal first with the broad distribution pattern of the four major vegetation groups (as was done in the preceding pages of this section); then to go to the distribution pattern of the smaller subdivisions of vegetation, the plant communities, that are contained within the major groups; and finally in the remaining sections to discuss the specific distribution of individual vegetation types.

--General Patterns of Vegetation Distribution

In each case with the exception of the boreal coniferous forest, the major vegetation groups are separated into a number of individual plant communities as indicated in Section V.¹² The detailed distribution of these various communities is governed by one, several, or all of the factors of climate, past and contemporary, drainage, soil, catastrophe, time, surface configuration, etc. Ways in which these factors affect particular distributions will be discussed in the following sections. The remaining portion of Section VI will point out ways in which these individual communities are related to each other in a general pattern, why that general pattern exists, what the exceptions to it are, and why the exceptions occur.

First, in order to point out the pattern and to show that in their relationships with respect to one another the individual communities do not occur haphazardly but have an orderly arrangement, Fig. 7 is used. This figure helps to simplify and to show schematically the distributions that are shown more realistically on the gener-

¹²This is not to say that the boreal forest does not consist of a number of separate associations. However, since the area of occurrence of this category in Wisconsin is so limited, it has been grouped as an individual unit. It is possible to consider some of the widely distributed bog conifer associations as members of the boreal forest family from an ecological standpoint, but the bog nature of their sites renders them sufficiently significant from a geographical point of view as to warrant a separate classification and discussion for them.

--General Patterns of Vegetation Distribution

alized map, Fig. 5. On Fig. 7 the diagram represents the state, with north at the top of the page. Individual plant communities are represented by segments of the diagram. By comparing Fig. 5 and Fig. 7, it may be seen that adjacent communities are interlocked and inter-related by the carry-over of certain dominant tree species from one association to the other. For example, eastward from south central Wisconsin there is a tendency for oak forest to change to basswood-oak forest, but oak is a dominant species in both associations and so forms a connecting link between the two. Further eastward basswood-oak forest changes to sugar maple-basswood-oak forest, but basswood is a dominant species in the latter association as well as in the former. In turn sugar maple-basswood-oak forest gives way to a beech-sugar maple-basswood-oak association toward Lake Michigan, but sugar maple still holds a position as a dominant species.

Turning northward along the Lake Michigan coastal zone toward and beyond the Green Bay area, the beech-sugar maple-basswood-oak association is merged with the hemlock-sugar maple-yellow birch-pine association from the west, and the two together form the beech-hemlock-sugar maple-yellow birch-pine forest as a unit in the mixed coniferous-deciduous forest group. However, this mixed forest unit retains beech and sugar maple as domi-

--General Patterns of Vegetation Distribution

nants, and thereby it is related to the beech-sugar maple-basswood-oak forest of the southeast.

This pattern of adjacent interrelated associations continues to the westward as shown on both Figs. 5 and 7. Beech drops out, but the hemlock, sugar maple, yellow birch and white pine of the previous association remain. Toward the western side of the state hemlock is eliminated, leaving sugar maple, yellow birch and white pine. Southward from here yellow birch and white pine are left behind, as the deciduous forest is re-entered, but sugar maple remains to supply the thread of continuity, and basswood once again is seen as a dominant.

Farther toward the south the continuity is broken and the pattern of gradual change is lost. Most of the remaining area is covered with oak forest and oak openings, although there is a considerable quantity of sugar maple-basswood-oak forest scattered about in seemingly haphazard distribution.¹³ In addition a high percentage of the area is covered with grass vegetation. This is true of the deciduous forest zone in general except for the portion in eastern Wisconsin northward of Racine County that is covered by beech-sugar maple and sugar maple-basswood

¹³Further examination shows that the distribution is not due entirely to chance. See pages 186-189.

--General Patterns of Vegetation Distribution

forest.

Fig. 7 has been used as a schematic device to point out the fact that there is a unifying pattern underlying the vegetation distribution in Wisconsin. That all the plant communities do not blend into that pattern is evident when Fig. 7 is compared with the generalized vegetation map, Fig. 5, and with the master map. It has just been pointed out that the pattern is lost in southwestern Wisconsin. It will be noted also that the pine forests of central, northeastern, northern, and northwestern Wisconsin do not fall into the pattern completely. They conform only in the sense that they, like other coniferous upland species, are essentially restricted to the northern half of the state. Other exceptions to the general pattern are seen in the instances of brushlands and swamp forests.

As a general statement as to why the pattern exists and why the exceptions occur, it may be said that pattern occurs in nature as a demonstration of the continuity of a cause and effect relationship. Such a repetitious demonstration of the cause and effect relationship comes about as a result of some controlling factor or a group of factors acting in unison. When the control loses its dominance, the pattern is interrupted, and other controls make their influence felt to break down the continuity of the repetition. Such is the case with the vegetation

--General Patterns of Vegetation Distribution

distribution in Wisconsin. It is believed that contemporary climate, taking into consideration the time-lag necessary for plant adjustment, has been largely instrumental in setting the broad pattern of distribution of plant communities within the state. It is the most important control, and since in their broad aspects the individual elements of climate are extensive in their distributions and change gradually from place to place, so the plant forms they induce have broad scale, expansive and patternful distributions. Where local or site factors become more important as controls than climate, there the general distribution pattern breaks down, changes become immediate and abrupt, and distributions become intermittent.

Some of the relationships between the distribution pattern and climatic features will now be pointed out, and it will be shown how the areas that deviate from the general pattern are related to local or site factors.

Some of the broad scale effects of climate on vegetation distribution may be seen in species changes from north to south and from east to west. The north-south changes such as the elimination of hemlock, yellow birch and pine as important forest trees with distance toward the south may be due to differences in temperature. A comparison of Figs. 5 and 8 shows how closely the southern

--General Patterns of Vegetation Distribution

limit of pine follows the July isotherm of 70°. This may be mere coincidence as far as temperature is concerned in the central and western parts of the state, since a change in soil type also follows rather closely along that isotherm and may have an effect on the vegetation change, but it appears to be something more than coincidence in the eastern part of the state where both the isotherm and the southern limit of pine dip southward across soil boundaries to follow along the cool lake shore. Fig. 5 shows that hemlock also extends southward along the lake shore.

Hutchinson thinks that the changes in species from east to west are due to differences in available moisture supply.¹⁴ The east-west change is one in which mesophytic types drop out with increasing distance westward. This is illustrated both in the north and in the south. In the northern half of the state, beech is the first to drop out toward the west. The elimination of beech is followed in turn by that of hemlock and then yellow birch, although sugar maple continues almost to the western boundary of the state. In the south the same sort of elimination system occurs, although less perfectly and with a some-

¹⁴Hutchinson, A. H., Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees, Botanical Gazette, LXVI, 1918, p. 469.

--General Patterns of Vegetation Distribution

what different set of species. Here again beech is the first to drop out, followed by sugar maple and then basswood. Oak remains as a dominant in the western side of the state. Sugar maple and basswood, however, are not eliminated altogether. As mentioned before they occur in patchy distribution throughout much of the south and southwest.

That there is a decreasing scale of moisture availability from east to west is suggested by the graphs in Fig. 9. These show average vapor pressure differences for a limited number of stations.¹⁵ The graphs were constructed from data listed in Table I, (p. 272). Vapor pressure difference means the difference between the actual vapor pressure of the air at a given time and the potential vapor pressure if the air were saturated with moisture at the existing temperature. The greater the vapor pressure difference, the greater is the capacity of the air to hold moisture, the greater the evaporation, and the less the moisture available for plant growth. It is assumed that the average figures for the time interval for

¹⁵Vapor pressure difference is determined by subtracting the saturation vapor pressure of the temperature of the dew point, which is the equivalent of the actual vapor pressure at the existing temperature, from the saturation vapor pressure of the actual temperature. The saturation vapor pressures at different temperatures and elevations are available from tables.

--General Patterns of Vegetation Distribution

which weather data have been kept are also representative of conditions as they existed at the time of, and for a considerable interval preceding, the original land survey.

It should be mentioned that average vapor pressure difference is not a perfect index to the amount of moisture available for plant growth. It does not take into direct account such factors as wind velocity, ground water level, temperature of foliage surfaces, amount and distribution of precipitation, cloud cover, etc. It is conceivable that a desert coast paralleled by a cool current might have enough moisture in the air and a sufficiently low temperature to result in a small average vapor pressure difference but still be without adequate water for plant growth. In Wisconsin, however, where the moisture supply is generally adequate for forest growth, it may be considered that variations in average vapor pressure difference would indicate enough contrast in evapotranspiration rates from place to place as to be indicative of variations in the type of forest cover. In other words the pattern of vapor pressure difference, if complete, might serve as an index to the pattern of distribution of plant associations having varying moisture requirements.

Fig. 9, even though an insufficient number of stations are represented to give the desired coverage,

--General Patterns of Vegetation Distribution

suggests an increase in potential evaporation from east to west in both southern Wisconsin and in north central Wisconsin. Milwaukee, in the south, as a result of its lake shore location, has relatively cool summer temperatures, more cloud cover and a higher relative humidity than stations to the interior. Consequently it has a relatively low average vapor pressure difference.

Madison, halfway across the state, shows a higher average vapor pressure difference, while Dubuque just across the Mississippi River from the southwest corner of the state shows a still greater deficit than that of Madison. Thus it appears that the potential evaporation rate increases from Milwaukee westward to the Mississippi.

The change in vegetation type from east to west bears out this trend to some extent. At Milwaukee the forest type is beech-sugar maple-basswood-oak. Beech is considered the most extreme mesophyte of the hardwood species of eastern North America.¹⁷ Immediately to the west, beech is eliminated, and the forest association becomes sugar maple-basswood-oak. Further westward the sugar maple-basswood-oak forest tends to grade through basswood-oak forest, or to go directly into oak forest and oak openings. Throughout most of the southern and south-

¹⁷Weaver and Clements, op. cit., p. 510.

--General Patterns of Vegetation Distribution

western part of the state, the vegetation distribution becomes a mosaic of patches of oak forest, prairie, basswood-oak forest, oak openings and sugar maple-basswood-oak forest. There appears to be a higher proportion of oak openings and prairie with increasing distance westward which supports the idea of less available moisture for plant growth westward from Lake Michigan. However, the sugar maple-basswood-oak forest can exist in the west as evidenced by its presence, although it is possible that conditions are barely permissible and less favorable than in the east. That prairie can exist on ostensibly the same kind of sites as sugar maple-basswood-oak forest is also shown by its presence on those sites. That the two can exist together would indicate that some explaining factor other than contemporary climate is involved. That factor can be found, it is believed, in the history of climatic change and the fires associated with the dry periods of grassland dominance.

In the north lack of stations with the necessary climatic data limit the full picture of the trend of average vapor pressure deficit across that part of the state, although there is a marked increase at Minneapolis over that of Green Bay. This is in agreement with the nature of the vegetation distribution from east to west in that section. In the Green Bay area the mesophytic

--General Patterns of Vegetation Distribution

beech-hemlock-sugar maple-yellow birch-pine forest association occurs, while in the extreme west of Wisconsin in the neighborhood of Minneapolis the vegetation consists of the more xerophytic types, prairie and oak openings. In between there is a gradation on a decreasing scale of mesophytism as shown by Fig. 5. Beech drops out first, then hemlock, followed in order by yellow birch, and sugar maple, leaving in the extreme west prairies, oak openings and brushland.

The fact that prairies and oak openings are found here does not necessarily mean, however, that they are the only forms that can exist or that their presence is entirely due to decreased moisture availability. As in southern Wisconsin, sugar maple-basswood-oak forest is found in the same vicinity with prairie, and the same forest type recurs to the westward through much of central Minnesota.¹⁸ This near juxtaposition of prairies, oak openings, oak forest, and sugar maple-basswood-oak forest, here as well as in southern Wisconsin, can not be explained entirely in terms of present conditions but must be explained in terms of the history of past climatic and vegetational changes (see pages 139-141).

¹⁸ Daubenmire, Rexford, F., The "Big Woods" of Minnesota: Its Structure and Relation to Climate, Fire and Soils. Ecological Monographs, VI, 1936, pp. 233-268.

--General Patterns of Vegetation Distribution

The graph for Duluth in Fig. 9 shows a small vapor pressure difference for the southern Lake Superior shore area. This is as might be expected because of the influence of Lake Superior which results in cool moist air being present along the southern shore especially in summer. It is in this area alone in Wisconsin, with the exception of minor spots elsewhere, that the boreal forest, requiring cool and moist conditions, occurs. However, this does not necessarily mean a cause and effect relationship (see page 148).

Average vapor pressure difference represents one way of estimating the relative capacity of the air for evaporation from place to place. In an area such as Wisconsin where the amount of annual precipitation is much the same throughout, the vapor pressure differences should give a fairly good indication of the variability of evaporation and an indication of the amount of moisture remaining for plant growth, in other words the effectiveness of precipitation.

Another way of attempting to get at the effectiveness of precipitation for plant growth is by means of Thornthwaite's precipitation-evaporation indices.¹⁹

¹⁹Thornthwaite, C. Warren, The Climates of North America According to a New Classification, The Geographical Review, XXI, 1921, pp. 633-655.

--General Patterns of Vegetation Distribution

Fig. 10 shows the distribution of the indices as plotted for Wisconsin.²⁰ As in the case of the vapor pressure difference graphs, this figure shows a higher precipitation effectiveness in eastern Wisconsin than in western. However, it also appears to show that the decrease from east to west is an irregular one rather than a gradual steady change as might be inferred from the meager number of vapor pressure difference graphs. Fig. 10 also shows an increase in precipitation effectiveness along the margin of Lake Superior, a condition shown by the vapor pressure difference graph for Duluth.

A comparison of the generalized vegetation map, Fig. 5, and the precipitation-evaporation indices map, Fig. 10, shows that there is a broad correlation between vegetation distribution and the distribution of Thornthwaite's indices. On the Lake Michigan shore in southeastern Wisconsin the distribution of the forest associations containing beech follow rather closely the area having a precipitation-evaporation index above 74. As the P-E index decreases toward the interior, mesophytic beech

²⁰The calculation of these indices upon which the map (Fig. 10) is based involved the solving of some 1400 computations from the formula $P/E = 115 \left(\frac{P}{T} \right)^{10/9}$. This work was very kindly done by T-10 the Computing Service of the Department of Mathematics of the University of Wisconsin under the direction of Professor Kenneth J. Arnold.

--General Patterns of Vegetation Distribution

drops out. For the most part hemlock is also confined to areas with a P-E index of 74 or greater. The region of boreal forest near Lake Superior coincides fairly well with the area having a P-E index of more than 66. The sugar maple-basswood-oak forest of Richland and Vernon Counties occurs in part where the index of 74 and above reaches south into that section. Prairie and oak openings occur in St. Croix and Pierce Counties where the P-E index falls below 66.

On the other hand there is a marked lack of correlation in much of the state. North-south changes in vegetation zones could not be anticipated by examining the P-E indices map. Prairie occurs both in areas having an index of less than 74 and in those with an index above 74. An area having an index of less than 70 in Shawano, Langlade and Marathon Counties has little to mark its existence on the vegetation map. There is a large area in the north central part of the state, extending through Price County to the east and to the south, in which the P-E index is above 78 with no apparent corresponding change in the vegetation. Also the area in Crawford and Vernon Counties in which the index goes as low as 58 has little to indicate it on the vegetation map in the form of extreme xerophytic type vegetation.

--General Patterns of Vegetation Distribution

In view of these facts it may be said that although the P-E index correlates broadly with the distribution of some vegetation types, it is not a dependable indicator of vegetation changes on a fine scale. Quick found a similar condition to be true in the southern peninsula of Michigan.²¹ He found some correlation between forest distribution and the ratio of evaporation to rainfall but stated that these ratios did not mark out the actual areas of distribution. This is no less than is to be expected when it is remembered that a number of varied factors have an effect on the detailed distribution of vegetation and not just one phase of the one factor, climate.

The discussion thus far has been dealing with the general pattern of distribution of vegetation over the state and has pointed out some possible cause and effect relationships. It has considered distribution patterns that appear to result from climatic causes and the relationships between certain phases of climate and the vegetation pattern. Next to be discussed will be the major exceptions to the general pattern and the non-climatic causes responsible for those exceptions.

²¹Quick, B. E., A Comparative Study of the Distribution of the Climax Association in Southern Michigan, Papers of the Michigan Academy of Science, Arts and Letters, III, 1923, p. 234.

--General Patterns of Vegetation Distribution

It was pointed out that in southern and southwestern Wisconsin the pattern of orderly distribution disappears and that mesophytic and xerophytic vegetation--basswood-oak forest, oak openings, sugar maple-basswood-oak forest, prairies, and oak forest--are scattered about without much order. In attempting to answer why this condition exists, it is necessary to look into the history of the vegetation of the area. There appears to be no explanation in terms of modern environmental factors. Examples of the vegetation classes involved occur alike in both glaciated and unglaciated areas, on varying soil types, in valleys and on uplands. Although the climate becomes increasingly xerophytic toward the west, the principal result appears to be the ruling out of beech with distance from Lake Michigan.

The fact that sugar maple-basswood-oak forest occurs in patches throughout the area would argue that the climate supplies at least sufficient moisture to support that forest type. The capacity of a region to support vegetation is measured in terms of the highest, most advanced type that is capable of growing there. In this area the distribution of the existing vegetation shows that at least the sugar maple-basswood-oak forest is capable of existing in the region. The question then is, Why does not this forest type cover the entire area? Why do oak forest, oak open-

--General Patterns of Vegetation Distribution

ings, and prairie exist over much of the area? A probable answer may be read from the historical development of the vegetation.

A brief review of the large scale climatic changes in postglacial times and the accompanying vegetation changes shows (1) a cool moist period immediately following the ice retreat in which coniferous forest advanced across the state; (2) a period of rising temperature and decreased moisture in which oak partially displaced coniferous forest in southern Wisconsin and in turn was largely displaced by grass, as the grassland of the west expanded and extended eastward to form the Prairie Peninsula; (3) a period of increased temperature and increased moisture supply with forests invading grasslands in the Middle West to a much greater extent than at the present time; (4) a second period of eastward advance of the grassland, although this time the effects were less extensive and of shorter duration than before, and (5) a change to the wetter conditions that have existed to the present day.

During the third period mentioned above it is likely that sugar maple-basswood-oak forest covered most or all of southern and southwestern Wisconsin. There is evidence that the beech-sugar maple forest extended further to the interior than at the present time (see page 182). With

--General Patterns of Vegetation Distribution

the deterioration of climatic conditions as the fourth phase was entered, trees, particularly the mesophytic species, found it more difficult to exist. In the increasingly drought-stricken environment, fire became a more and more potent factor in the destruction of the existing forest. Since sugar maple because of its thin bark, is the most susceptible to fire damage, it was the first species to be destroyed.²² As drought and fire removed the forest, grassland gradually came to the dominance. The area that did not become grassland was occupied by oak openings and possibly to some extent by xerophytic oak forest. However, in sites protected from fires by water bodies and topographic barriers, it may be postulated that sugar maple-basswood-oak forest was able to endure and weather out the dry period. It is on such fire-protected sites almost without exception that sugar maple-basswood-oak forest is found today. If the dry period had lasted longer, it is possible that the last vestige of this forest type would have been removed.

As moisture conditions improved, coming into the last or recent period, there was a general advance of the forest into the prairie after a time-lag of shorter or longer

²²Daubenmire, Rexford F., op. cit., pp. 259-260.

--General Patterns of Vegetation Distribution

duration. Oak openings encroached on prairie, oak forest on oak openings, and possibly sugar maple-basswood-oak forest on oak forest. To observe the situation as it existed at the time of the original land survey is to freeze the action as of that moment and show the various associations intermixed throughout the area. If one could watch the development through time as it would have gone without the exploitative intervention of white men, he would see the prairies gradually diminish away and a successional development proceed through oak openings, oak forest, basswood-oak forest until eventually sugar maple-basswood-oak forest spread from its refuge sites to cover the area as the climax forest, bringing the vegetation of the region finally into accord with the climate.

If dry climatic conditions and fires caused such a striking disorganization of the general vegetation pattern in southern and southwestern Wisconsin, why did they not work a similar result in northern Wisconsin? The prolonged dry periods undoubtedly did have an effect on the vegetation of northern Wisconsin, but since that area lay outside the Prairie Peninsula zone, it did not experience drought conditions sufficiently severe as to change the vegetation from forest to grassland. Borchert has ex-

--General Patterns of Vegetation Distribution

plained why the Prairie Peninsula zone suffered the most acutely from drought.²² However, the vegetation of the northern areas must have responded to the prolonged, though less intense dry periods. That response was probably in the form of an increase in the proportion of xerophytic pine forest. Fires undoubtedly took their toll to some degree here too and in doing so left their mark in the character of the present day vegetation. But the combined and intensified forces of grassland climate and fires were not at work.

Ordinary fires have a very important effect on the forest character and may be considered as part of the normal environment. Maissurow thinks that the very existence of hemlock, yellow birch and white pine as components of the northern forest is due to the fact that fire has created openings in the canopy and thus provided light for the growth of the seedlings of these trees.²³ Fires of this nature have not disrupted the broader pattern of vegetation distribution.

There are some exceptions in northern Wisconsin to the orderly pattern of distribution, although the exceptions

²²Borchert, John R., The Climate of the Central North American Grassland, *Annals of the Association of American Geographers*, XL, 1950, pp. 1-39.

²³Maissurow, D. K., The Role of Fire in the Perpetuation of Virgin Forests of Northern Wisconsin, *Journal of Forestry*, XXXIX, 1941, pp. 206-207.

--General Patterns of Vegetation Distribution

are minor compared to that just described in southern Wisconsin. These disruptions may be entirely, or in part, due to severe burnings as a result of which the timber has been set back to a subclimax condition.

One such instance is that of the brushland and scrub oak which extends northwest-southeast through Dunn, Chippewa, Eau Claire, Trempealeau and Jackson Counties. Oak brush is a characteristic vegetation type for some localities that have suffered severe and repeated burnings. The earth materials may also have something to do with the presence of this vegetation type, since its location is confined largely to the older drift portion of the Central Plain. The soil type is Boone fine sandy loam. The northern boundary of the brush vegetation coincides almost exactly with the northern boundary of the soil type.

Other exceptions or disruptions to the general vegetation pattern are the pine areas of central, northeast, north, and northwest Wisconsin (Fig. 5). These pine areas may also result from repeated burnings which have set the forest back to subclimax, but the study of Potzger and Richards in Vilas County shows that their occurrence

--General Patterns of Vegetation Distribution

is more likely due to the marked sandy character of the soil.²⁴ It may be noted by comparing the generalized vegetation map, (Fig. 5), with Whitson's General Soil Map of Wisconsin (last map at end of text), that each area is located on a sandy soil region, which is conducive to pine growth, or at least discouraging to the growth of other species. The jack pine barrens of the northwest almost completely coincide with the soil type region.

Similar to these but of a smaller individual extent are the spots of aspen-white birch forest that are scattered throughout most of northern Wisconsin. They come about locally as a result of fires and wind-falls which set the timber back to a subclimax stage and are of a nonclimatic origin.

Another type of vegetation that owes its distribution more to site factors than to climatic causes, and therefore does not fit into the general pattern, is that of the swamps. This type occurs wherever the swamps are found both in southern and northern Wisconsin, for the most part in the glaciated region of young drift.

²⁴Potzger, J. E., and Ruth R. Richards, Forest Succession in the Trout Lake, Vilas County, Wisconsin Area: A Pollen Study, Butler University Botanical Studies, V, 1942, pp. 179-189.

--General Patterns of Vegetation Distribution

Summary

The existence and general location of the four major vegetation groups of Wisconsin, the boreal forest, the mixed coniferous-deciduous forest, the deciduous forest, and the grassland, can be largely explained in terms of the history of fluctuating postglacial climates and their associated vegetation regimes. The distribution of the smaller subdivisions of vegetation within the major groups are explained in terms of other factors including contemporary climate, soils, catastrophe, surface configuration, drainage, and time.

SECTION VII

SPECIFIC DISTRIBUTIONS OF VEGETATION TYPES:

THE BOREAL FOREST

The general patterns of distribution and the interrelationships of the various vegetation groups within the state have been examined. The discussion is now ready to proceed with a more detailed treatment of the specific distributions of the major vegetation formations and their component subdivisions.

The boreal or taiga forest extends across the northern part of North America from Alaska to Newfoundland and touches, in the form of outliers, the northern part of Wisconsin. The composition of this forest in terms of species is described on pages 78-80. Its location within the state coincides very closely with that of the Lake Superior Lowland, although minor patches occur farther east in Iron, Vilas, Forest and Florence Counties. The portion in the Superior Lowland occurs in two main areas, separated to correspond in location to the two subdivisions of the Lowland itself in Wisconsin. The larger of the two areas of this forest type occupies the northern one-third of Douglas County and the northwest corner of Bayfield County. Toward the east it breaks

--The Boreal Forest

into smaller fragments and continues across the northern margin of Bayfield County. The other large segment lies in the environs of Chequamegon Bay, covering most of the northern one-fourth of Ashland County and extending westward into east central Bayfield County.

It does not appear that Lake Superior, through its influence on the climate of the region, has very much effect on the distribution of this forest type. If the presence of this forest were due to lake influence alone, then the species which comprise it should occur in greatest abundance on the Bayfield Peninsula and the Apostle Islands which reach out into the lake and come more clearly under lake influence than the remainder of the region. However, these particular sites have only a meager representation of the forest type. But the fact that the location of the boreal forest almost exactly coincides with the location of the Superior red clay soils suggests the possibility that the soil factor is significant. A comparison of the master vegetation map with Whitson's General Soil Map of Wisconsin reveals the near-identical location of these two features. Here is one of the closest correlations between vegetation cover and soil type to be found in Wisconsin. The boreal forest occurs almost exclusively on the red clay soils, and the red clay soils are con-

--The Boreal Forest

fined for the most part to the two subdivisions of the Lake Superior Lowland.

The principal dominants of this forest are white spruce and balsam fir. The clay soils upon which they occur here are heavy and water-retentive.¹ Hutchinson mentioned that in the Algonquin Park region of Ontario fir and spruce grow on the lowlands.² He further states that balsam fir seldom thrives in anything but moist soil, because in drier soils a fungus attacks the roots, and that spruce is related with the fir. White spruce also prefers a moist soil.³ The suitability of the soil plus the close correlation between forest type and soil type in location suggests that the soil type is a very important factor in explaining the distribution of the forest.

Temperature probably enters the picture too, but more as a permissive factor than an explanatory one. Balsam fir prefers a summer temperature of not more than

¹Whitson, A. R., Soils of Wisconsin, Wisconsin Geological and Natural History Survey Bulletin No. 68, 1927, p. 168.

²Hutchinson, A. H., Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees, Botanical Gazette, LXVI, 1918, p. 472.

³Waterman, Alma M., R. U. Swingle, and Clayton S. Moses, Shade Trees for the Northeast, Trees, United States Department of Agriculture, Yearbook of Agriculture, 1949, p. 60.

--The Boreal Forest

70° F. and an annual temperature of not more than 40° F.⁴ This area has some of the coolest summer temperatures of Wisconsin with a July average in the neighborhood of 66° F. (Fig. 8). Its annual average temperature is around 40° F.

Thus it would appear that as the boreal forest migrated northward as a result of the changing climates of postglacial times, it was able to retain a foothold in, or has re-invaded, Wisconsin in the Lake Superior Lowland where favorable soil conditions encouraged its tenure and climatic factors remain permissive.

⁴Hutchinson, op. cit., p. 485.

SECTION VIII

SPECIFIC DISTRIBUTIONS OF VEGETATION TYPES:

THE MIXED CONIFEROUS-DECIDUOUS FOREST

The mixed coniferous-deciduous forest extends eastward from Wisconsin through the Great Lakes region to New England (Fig. 3). In Wisconsin it occupies the northern and northeastern part of the state with the exception of the area covered by the boreal forest. Its position in the state is in general complementary to that of the deciduous forest.

The boundary between this mixed forest and the deciduous forest to the south coincides with the zone where the forest ceases to be mixed or beyond which coniferous trees are no longer a significant part of the composition of the forest. This zone, as shown on Fig. 5, does not trend straight east-west but starts well to the north along the Minnesota boundary, dips far southward in Juneau and Adams Counties, bends sharply north again to northern Portage County, from whence it runs sinuously eastward to northeastern Outagamie County and then bends abruptly southeastward to meet Lake Michigan at the middle of the shoreline of Sheboygan County.

It has been noted that this line follows remarkably closely the July isotherm of 70° F. (Fig. 8). It is

--The Mixed Coniferous-Deciduous Forest

doubtful that this isotherm in itself has any particular significance in terms of vegetation distribution other than that it happens to follow rather closely the zone of separation between the area having hot summers and moderate to cold winters and the area having cool summers and cold winters. This is in general the same line that separates Koeppen's D_{af} climate from the D_{bf} climate and Trewartha's Humid Continental Climate With Warm Summer from the Humid Continental Climate With Cool Summer. Coniferous trees such as white pine and hemlock are largely confined to the northern side of this line. Just what the upper limits of temperature are under which these species can compete in the forest complex, the writer does not know; but Wisconsin does not exist as an isolated case with respect to this division between northern and southern forest zones. Quick points out a similar situation in the southern peninsula of Michigan.¹ There the southward extension of northern plants coincides quite well with a line separating the southern part of the state having hot summers from the northern part having moderate summers and a cold winter.

¹ Quick, B. E., A Comparative Study of the Distribution of the Climax Association in Southern Michigan, Michigan Academy of Science, Arts, and Letters, III, 1923, p. 234.

--The Mixed Coniferous-Deciduous Forest

Soil type appears to be an influencing factor in fixing the detail of the southern boundary of the mixed coniferous-deciduous forest. Where the soils are sandy within the boundary zone, coniferous trees, pines principally, grow on the sandy surfaces and stop at the outward margins where the sands make contact with the heavier soils. This is the case along the outer margin of the unglaciated portion of the Central Sand Plain. The margin of the unglaciated sand country and the edge of the mixed forest follow along the Franconian escarpment, which marks the contact with the heavier soils of the Western Upland, from Jackson County south and southeast to the junction with the end moraine of the Green Bay glacial lobe in southern Adams County. This moraine trends north-south and separates the extremely sandy soils of the unglaciated area to the west from the heavier soils to the east where the sands have been intermixed with finer materials by glacial action. The forest boundary turns northward here and follows almost precisely the moraine to northern Portage County, with the mixed forest occurring on the sands to the west of the moraine. That the mixed forest coincides with the sandier soils is due largely to the fact that the pines, which supply the main coniferous element, are well-adapted to compete with deciduous species in the dry, humus-poor

--The Mixed Coniferous-Deciduous Forest

sands, but on the adjacent heavier soils, under the existing temperature and moisture conditions, the pines are crowded out by the deciduous species.

The above considerations indicate that temperature sets the general southern limit of the mixed coniferous-deciduous forest, but that the soil type is instrumental in fixing the detail of parts of the boundary. The distributions of the various subtypes that compose this forest group will be discussed in the following order:

- (a) beech-hemlock-sugar maple-yellow birch-pine forest;
- (b) hemlock-sugar maple-yellow birch-pine forest;
- (c) sugar maple-yellow birch-pine forest; (d) the pine forest; (e) white birch-aspen forest; and (f) other mixed coniferous-deciduous forest types.

(a) The Beech-Hemlock-Sugar Maple-Yellow Birch-Pine Forest (heQES)²

This forest is situated in northeastern Wisconsin in the environs of Green Bay (see Fig. 5 and the master map). It occupies all of Door and Kewaunee Counties, the northeast corner of Manitowoc County, the northern two-thirds of Brown County, parts of northern Outagamie and northeastern Waupaca Counties, the eastern part of Shawano County, all of Oconto County except the northwest corner,

²For convenience in referring to this forest, instead of using the long unwieldy name each time, it will be designated by the shorthand symbol by means of which it was recorded from the surveyors' field notes on to the township worksheets as explained in Section IV. This symbol is heQES.

--The Mixed Coniferous-Deciduous Forest

and parts of southern and eastern Marinette County. In addition it extends slightly into southeast Langlade and southeast Forest Counties. Wisconsin has only a small portion of the total area of the heQES forest. As seen from Fig. 11, it extends eastward into the adjacent portion of the Upper Peninsula of Michigan, is found across the lake in the Lower Peninsula of Michigan, and from there continues eastward through the Great Lakes region into New England.

Although the dominants of this forest type include beech, hemlock, sugar maple, yellow birch and white pine, the boundaries of the forest are defined by the limit of beech on the north and on the west and by the limit of hemlock on the south. That the boundaries are set by the limits of these two species is due to the fact that this type is defined as the forest where a portion of the beech forest stands in juxtaposition with a portion of the hemlock forest. Beech and its associates intermingle with hemlock and its associates, and wherever either beech or hemlock is eliminated, this forest type as such ends.

Since the occurrence of the heQES forest is limited to the area of coexistence of beech and hemlock, to understand its boundaries it is necessary to know what causes beech to become eliminated toward the west and toward the north and what causes hemlock to drop out toward the

--The Mixed Coniferous-Deciduous Forest

south. Although there is a general dearth of knowledge concerning the exact environmental requirements necessary for the stabilized growth of different forest species, evidence can be assembled to give at least a partial explanation of the factors that limit the extent of this forest.

Beech occurs in most of eastern United States with the exception of peninsular Florida (see Fig. 12). It reaches westward into the eastern edge of Wisconsin and from there extends its western margin southward into Illinois, southeast Missouri, Arkansas, and east Texas. A study was made toward this western margin of growth in northern Indiana by Diller to try to determine what the critical factors are that have a bearing on beech growth.³ It was found that the variations in width of tree rings correlated inversely with the temperature of the month of June but correlated directly with the precipitation for that month. Drought years showed their effect the following year, probably due to an accumulated deficiency of soil moisture. The study indicated that an extended drought period would result in a retrogression of the beech forest in favor of types that require less moisture.

³Diller, Oliver D., The Relation of Temperature and Precipitation to the Growth of Beech in Northern Indiana, Ecology, XVI, 1935, pp. 72-81.

--The Mixed Coniferous-Deciduous Forest

The reason that June holds the position as key month was thought by Diller to be due to the fact that the greatest formation of woody tissue in the tree takes place at that time. The fact that he found growth varying directly with precipitation and inversely with temperature points to precipitation-effectiveness as the critical factor. However, when the average precipitation effectiveness figures for June were plotted for Wisconsin on the basis of Thornthwaite's formula, no significant positive correlation was seen. This does not necessarily mean that there is no correlation between June precipitation effectiveness and the occurrence of beech. It may mean that Thornthwaite's method is not designed to show the relationship.

On the other hand when figures for the year as a whole were plotted, a positive correlation was revealed between precipitation effectiveness in eastern Wisconsin and the distribution of beech. This is evident from a comparison of Figs. 5 and 10. Whether there is a cause and effect relationship involved in this correlation cannot be shown. However, it may be pointed out that the western boundary of beech, in gradually coming nearer to Lake Michigan with distance toward the south, behaves as it might be expected to do under the existing temperature and precipitation conditions. As seen from Figs. 8 and

--The Mixed Coniferous-Deciduous Forest

13, warm season temperatures increase toward the south, but there is no corresponding increase in warm season precipitation. This should result in increased evaporation toward the south. Thus on the basis of temperature and precipitation alone, there should be less moisture available for tree growth with distance toward the south. Hutchinson thinks the water factor limits the western extension of beech.⁴ Other factors may have a bearing such as the effect of drier climates of the past and the fires that accompanied them. Also, it is not known to what extent the time factor is involved; whether beech has reached its western limit climatically, or whether it could spread still farther to the west if given time, is not known.

It has been pointed out that the western and northern boundaries of the heQES forest are determined by the western and northern limits of beech. As has been shown there is reason to think that climate has something to do with the location of the western boundary. There is evidence indicating that the character of the soil is the critical factor in limiting the northern extent. Beech shows a preference for heavy soils. That it can

⁴Hutchinson, A. H., Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees, Botanical Gazette, LXVI, 1918, p. 469.

--The Mixed Coniferous-Deciduous Forest

grow on sands is shown by its presence on sands along the eastern side of Door Peninsula, but this seems to take place only after a humus layer has developed. Quick⁵, in describing its distribution in southern Michigan, says that it is found most frequently on clay soils, but whenever sand has had a sufficiently long development of humus and where soil water is not too inadequate, beech will develop along with the other trees of the climax forest. Hutchinson⁶ says that beech has a range of tolerance toward soil more restricted than that of sugar maple, which is limited to mature soils that are well-drained, well-aerated and that contain large amounts of intermixed humus. Both Quick and Hutchinson think beech is dependent on soils of good humus content for the reason that it is in such soils that the micro-organisms thrive which are necessary for the growth of beech.^{7,8} According to Hutchinson there is evidence that beech is migrating northward, the progress being contingent on the rate at which the soils develop the qualities

⁵Quick, op. cit., pp. 222-223.

⁶Hutchinson, op. cit., p. 491.

⁷Quick, op. cit., p. 223.

⁸Hutchinson, op. cit., p. 472.

--The Mixed Coniferous-Deciduous Forest

necessary to the growth of the species.⁹

A comparison of the detailed vegetation map with the soil map shows that beech extends northward to the margin of the sandy soil region centered in Marinette County. This soil region, composed of the Vilas, Plainfield, and Coloma sandy soils, marks in general the northern limit of beech in Wisconsin and in doing so sets the northern boundary of the heQES forest type in the state. It may be that this margin is moving northward but that the sands have acted as a temporary barrier.

The southern boundary of this forest type is along the line where hemlock is eliminated to the south. It has been pointed out that hemlock is confined to that part of the state which has Humid Continental Cool Summer climate. Suggestive of a possible reason for this is the fact that hemlock trees are shallow-rooted and suffer injury from heat, drought and exposure. Secrest found that the severe and prolonged droughts of the early and middle nineteen thirties resulted in a high mortality of hemlocks on the Menominee Indian

⁹Hutchinson, op. cit., p. 491.

--The Mixed Coniferous-Deciduous Forest

Reservation in Wisconsin.¹⁰ The fact that the boundary extends farthest south along the Lake Michigan shore supports the idea that hemlocks require cool summer temperatures. A further evidence of this is the fact that across the lake on the Michigan shore, where summer temperatures are still cooler, hemlock extends even farther to the south. Quick says that it is found as far south as the Indiana line.¹¹ Also toward the interior of Wisconsin, where hemlock occurs south of its normal range, it is found in cool shaded sites such as the gorges tributary to the Dells of the Wisconsin River. All of these evidences point to summer temperature as being the limiting factor for hemlock on the south, and where hemlock is delimited, the southern boundary of the heQES forest type is marked out.

In summary the beech-hemlock-sugar maple-yellow birch-pine forest occurs where the beech-sugar maple forest from the southeast reaches into and intermingles with the hemlock forest of the north. The northern and western limits are marked by the extremity of range of beech--

¹⁰ Secrest, H. C., H. J. MacAloney, and R. C. Lorenz, Causes of Decadence of Hemlock at the Menominee Indian Reservation, Wisconsin, Journal of Forestry, XXXIX, 1941, pp. 5-6, 12.

¹¹ Quick, op. cit., p. 225.

--The Mixed Coniferous-Deciduous Forest

along the north the limiting factor is soil, while along the west the limiting factor is not clear cut but appears to be a climatic factor. The southern limit of the heQES forest is marked by the extremity of range of hemlock. The controlling factor here is a climatic one, apparently involving summer temperatures.

(b) Hemlock-Sugar Maple-Yellow Birch-Pine Forest
(hQES)¹²

This forest type is similar to the type described immediately above but differs from it in that beech is no longer present. Westward from Lake Michigan beech is eliminated, and the beech-hemlock-sugar maple-yellow birch-pine forest becomes a hemlock-sugar maple-yellow birch-pine forest. This latter type not only extends farther west than the former but also reaches farther to the north. Going beyond the borders of Wisconsin, it touches the southern shores of Lake Superior in Michigan. From there it trends eastward through southern Canada, parallel to but extending beyond the northward limit of the heQES forest (Fig. 11). This greater northward range of the hQES forest results from the fact that the domi-

¹²This is the symbol used in recording the hemlock-sugar maple-yellow birch-pine forest on the township worksheets. Note that it is slightly different from the symbol used for the beech-hemlock-sugar maple-yellow birch-pine forest (heQES).

--The Mixed Coniferous-Deciduous Forest

nants, hemlock, sugar maple, yellow birch, and white pine, are all able to grow farther to the north than is beech.¹³ As pointed out above, this is due to the soil requirements of beech as compared to those of the other species.

In Wisconsin the hemlock-sugar maple-yellow birch-pine forest type lies in the northern part of the state with its center shifted just slightly east of the state's mid-section (see master map). It is largely excluded from the Lake Superior Lowland but occupies most of the Bayfield Peninsula and the Apostle Islands. Its western margin extends southward from the Bayfield Peninsula through the middle of Sawyer and Rusk Counties into northern Chippewa County. From there the margin trends southeastward through northeastern Chippewa County, northern and northeastern Clark County, southeastern Marathon and northeastern Wood Counties to northern Portage County. Changing direction slightly here, it winds generally eastward until it reaches the western edge of the beech-hemlock-sugar maple-yellow birch-pine forest in Outagamie County. Thus is outlined the largest single contiguous area of one forest type in the state.

¹³Munns, E. N., The Distribution of Important Forest Trees of the United States, United States Department of Agriculture Miscellaneous Publication No. 287, 1938, Maps 1, 35, 81, 87, and 148.

--The Mixed Coniferous-Deciduous Forest

Only one outlier of any considerable size occurs and this lies in the southwest corner of Bayfield County with its edges extending over into Douglas, Washburn and Sawyer Counties.

Although the boundaries described above enclose essentially all of the hQES forest in Wisconsin, it does not follow that all the area so enclosed is covered by that forest type. A high proportion of the area thus enclosed is in scattered coniferous swamps. Two large areas of pine are included within the limits of the hQES forest, one in the northeast corner of the state and one in the north central section. A body of sugar maple-yellow birch-pine forest, separate and distinct and of some considerable size, is located within this region in southern Langlade County. In addition there are scattered fragments of white birch-aspen forest, a few small outliers of sugar maple-basswood-oak forest, numerous areas of windfall, and some patches of brushland.

As indicated above the eastern boundary of the hQES forest type is located where beech enters the forest complex. The causes that determine that boundary have been discussed. The western and southern boundaries are defined as the line along which hemlock is eliminated from the forest complex. As in the case of the beech-hemlock-sugar maple-yellow birch-pine forest to the east,

--The Mixed Coniferous-Deciduous Forest

hemlock is eliminated along the southern boundary as a result of the higher summer temperatures that are encountered in that direction. Also along a part of the southern boundary soil-type seems to be an effective deterrent to hemlock. The hemlock margin comes up against a very sandy soil in the Central Plain in Portage and Waupaca Counties. According to Nichols hemlock has a very shallow root system, seldom penetrating more than twenty inches.¹⁴ Therefore, an excessively sandy soil with marked under drainage would not permit the growth of the mesophytic hemlock.

In the extreme northwest in Bayfield and Sawyer Counties, the hemlock also reaches a sandy soil barrier, but for most of the western and southwestern margin there is no readily apparent explanation in the physical environment as to why hemlock is eliminated. It is true that the lines of precipitation effectiveness trend in the same general direction here as does the boundary of the forest type (Figs. 5 and 10), but there is no evidence that this is not mere coincidence. On the basis of the numerical value of these index lines, hemlock might be expected to extend farther to the west before

¹⁴Nichols, George E., The Vegetation of Connecticut: II. Virgin Forests, Torrey, XIII, 1913, p. 211.

--The Mixed Coniferous-Deciduous Forest

being eliminated. Hutchinson believes that it is still migrating westward; that the water factor limits the western extension but that it has not yet reached the line where it is in full adjustment with the climatic limit.¹⁵ However, no evidence is seen from the government survey notes that would show this to be the case in Wisconsin. His evidence for this is the fact that hemlock maintains a good size to the verge of its range and always appears to terminate abruptly, while stands of mature trees are found as outliers beyond the general area of its distribution. There is an abrupt termination on the west and southwest with a minimum of outliers.

(c) Sugar Maple-Yellow Birch-Pine Forest.

Where hemlock is eliminated along the west and the southwest, the forest type changes from hemlock-sugar maple-yellow birch-pine to sugar maple-yellow birch-pine. This latter type is the third forest type in sequence from east to west within the mixed coniferous-deciduous forest group. It results from the elimination of forest species from east to west, first beech and then hemlock. The remaining dominant species, sugar maple, yellow birch and white pine are also constituents of the two more easterly forest types, the heQES and the hQES forests, but here

¹⁵Hutchinson, op. cit., pp. 469 and 490.

--The Mixed Coniferous-Deciduous Forest

these species stand together with their more minor associates to make up the bulk of the forest.

The sugar maple-yellow birch-pine forest occurs in two principal segments. One is in the form of a linear strip lying along the southwest margin of the hemlock-sugar maple-yellow birch-pine forest. It extends in a northwest-southeast direction, occupying most of the northern half of Wood and Clark Counties and a large part of eastern Chippewa County. Its inner or northeastern boundary is marked as the line where hemlock becomes an element of the forest. Its outer or southwestern boundary appears to result from a change in soil type. Along this outer line where Colby silt loam is replaced by Boone fine sandy loam, the sugar maple-yellow birch-pine forest is replaced by a mixed pine forest or by brushland (see master vegetation map and soil map).

The other major area of the sugar maple-yellow birch-pine forest type extends westward from the edge of the hQES forest in Rusk and Sawyer Counties and reaches halfway across Polk County. From here it bends southward into eastern St. Croix County. The northern boundary of this segment follows in general the edge of the Kennan silt loam as it makes contact with the Plainfield sandy soil to the north. Along this line the sugar maple-yellow birch-pine forest gives way to jack pine and jack pine

--The Mixed Coniferous-Deciduous Forest

barrens. For a part of its extent the southern boundary is defined where the Colby silt loam is replaced by Boone fine sandy loam and the forest gives way to brushland. Along the rest of the southern boundary, where there is no drastic change in soil type, there is a gradual transition to a sugar maple-basswood-oak forest as yellow birch and pine are lost with distance toward the south.

The western boundary is the line along which yellow birch is eliminated from the forest complex. This line extends southward from the middle of the northern boundary of Polk County to the southeast corner of St. Croix County. The reason the yellow birch stops along this line can not be given with complete assurance by the writer. An examination of its distribution within the continent shows that yellow birch is here reaching its western limit. Although it does occur a little farther to the west in Minnesota as shown by Munn¹⁶ and Nichols¹⁷, that occurrence in this latitude is probably in scattered patches only. There is an abrupt halt in its even distribution as a major forest tree along this line in

¹⁶Munn, op. cit., Map 81.

¹⁷Nichols, G. E., The Hemlock-White Pine-Northern Hardwood Region of Eastern North America, Ecology, XVI, 1935, p. 408.

--The Mixed Coniferous-Deciduous Forest

Wisconsin. Yellow birch, along with hemlock and white pine, is one of the trees which extends outward from a center of distribution located within the Great Lakes region.¹⁸

In addition to these two major areas of occurrence of the sugar maple-yellow birch-pine forest there are at least three smaller ones of some significance. Two of these are along the western margin of the hemlock-sugar maple-yellow birch-pine forest, one in southwest Bayfield County, and the other extending from Bayfield County southward into Sawyer County. The third area is the inlier mentioned previously in southern Langlade County. It should be pointed out that all portions of these latter areas do not occur exclusively on the heavier soils, but in part are located on sandy soils.

(d) The Pine Forest.

Pines occur throughout the area of mixed coniferous-deciduous forest as individual trees mixed in with other species. As such it is their southern limit that marks the southern boundary of the mixed forest group (Fig. 4). Scattering patches are found in localized areas to the south of this line in the deciduous forest zone, but the

¹⁸Nichols, op. cit., p. 420.

--The Mixed Coniferous-Deciduous Forest

occurrences are minor.

In this state pines grow in pure, or at least in highly concentrated, stands only in areas where the soil is of a very sandy character. A comparison of the master map and the soil map shows the clear correlation between the location of the four major pine areas and the location of the four extensive sandy soil areas of the state. Of all the forest communities in Wisconsin there is none more clearly related to soil type than the pines, as demonstrated in those areas. Apparently it is not the sand itself that attracts the pine or repels the more mesophytic tree types--it is the excessive underdrainage and the lack of humus that prevents the more mesophytic species from occupying these sites. The pines since they are tolerant of such conditions but are intolerant of the deep shade of the dense forest, find little competition in these open areas that are avoided by the other trees.¹⁹ Both Cowles and Quick mention the fact that a mesophytic climax forest will grow on a sandy soil if there is an intermixture of humus and both give examples of such within the Great Lakes region.^{20,21} But why do sandy

¹⁹Hutchinson, op. cit., p. 489.

²⁰Cowles, Henry C., The Physiographic Ecology of Chicago and Vicinity; A Study of the Origin, Development and Classification of Plant Societies, Botanical Gazette, XXXI, 1901, p. 177.

--The Mixed Coniferous-Deciduous Forest

soil regions tend to lack humus more characteristically than regions of heavier soils? It may be that on these sites, where conditions of life are so difficult and the quantity of plant life so limited, that humus develops more slowly; also in a region subject to forest fires the meager accumulations may be periodically burned and destroyed. Under such conditions the advanced forest would have little chance to develop.

Of all the forest trees of this region the pines are best suited to come in and occupy sites most lacking in humus whether caused by fire or other factors. This is particularly true of jack pine, which survives where it can avoid competition by enduring severe conditions.²² It is tolerant of dry conditions and low temperatures as well as of soils poor in humus. Fire is often an aid in the spread of jack pine because it not only obstructs the growth of competitors but also helps in opening the seeds.²³

White pine and red pine are also pioneers among the conifers and require high light intensity and a well-drained soil. However, they do not tolerate such extremes

²¹Quick, op. cit., pp. 234-238.

²²Hutchinson, op. cit., p. 489.

²³Weaver, John E., and Frederick E. Clements, Plant Ecology, (New York: McGraw-Hill Book Company, Inc., 1938), p. 499.

--The Mixed Coniferous-Deciduous Forest

in these conditions as does the jack pine.²⁴ Where white pine exists as a dominant in the various mixed associations of northern Wisconsin, it is thought to owe its beginnings to small openings due to wind or fire, and its continuance to its longevity and its height, which permits it to stand above or at least on a level with later competitors.^{25,26}

As a forest stand jack pine occupies the locations where the conditions are more harsh, while white pine and red pine tend to occur in locations somewhat more ameliorated.²⁷ The most extreme conditions may permit even jack pine to occur only in thinly scattered distribution over the surface, to give the vegetation type known as jack pine barrens. This condition may persevere for some time after a severe fire, which destroys the humus content of the soil so completely that a considerable period is required even for jack pine to become established as a dense growth.

The principal area of jack pine barrens in Wisconsin is located in the northwest in Polk, Burnett, Washburn,

²⁴Hutchinson, op. cit., p. 489.

²⁵Nichols, op. cit., pp. 410-411.

²⁶Hutchinson, op. cit., p. 489.

²⁷Whitford, Harry Nichols, The Genetic Development of the Forests of Northern Michigan; A Study in Physiographic Ecology, Botanical Gazette, XXXI, 1901, pp. 299-300.

--The Mixed Coniferous-Deciduous Forest

Douglas, Sawyer, and Bayfield Counties (see master map). It trends northeast-southwest in a strip some five to fifteen miles wide and eighty miles long. Other smaller areas are located in each of the other major pine regions, especially in central Marinette County and in southeast Wood and southwest Portage Counties.

In places where jack pine attains a denser growth, a jack pine forest results. An area of this forest type extends east-west through central Burnett and Washburn Counties immediately southeast of the extensive barrens mentioned above (see master map). Also a high proportion of the pine forest of Marinette County is of this type. In the Central Sand Plain jack pine is joined by scrub oak to form a jack pine-scrub oak forest. This is especially well demonstrated in northwest Adams and northeast Juneau Counties (see page 177). Also, in small patches throughout this general section of the state, there are barrens of scattered jack pine and scrub oak.

The major stand of white pine and red pine in Wisconsin is centered in Vilas and Oneida Counties. Potzger and Richards have found evidence to indicate that pines replaced a spruce-fir forest in this area in the early part of the postglacial period and that pine has been the dominant species here continuously since that

--The Mixed Coniferous-Deciduous Forest

time.²⁸ Why this particular area should have a higher proportion of the more mesophytic white and red pine species than the other pine regions of the state can be partially explained at least. This location has higher warm-season precipitation than any of the other pine regions, except that of the Central Sand Plain, and lower summer temperatures than any of the others (Figs. 8 and 13). In comparison with the other regions the combination of lower temperature and more or about the same precipitation should result in a lesser rate of evaporation for the Vilas County-Oneida County region and more available moisture for plant growth.

Also the time factor may enter in. The more moist conditions may have given better natural fire protection than in the other areas. Jack pine growth may have been the predecessor, but in the absence of devastating fire, jack pine may have had time to ameliorate the harsh soil conditions sufficiently to permit white and red pine to become established.

In addition to the large white pine region in Vilas and Oneida Counties, other areas of white pine of some

²⁸Potzger, J. E. and Ruth Rebecca Richards, Forest Succession in the Trout Lake, Vilas County, Wisconsin Area: A Pollen Study, Butler University Botanical Studies, V, 1942, pp. 179-189.

--The Mixed Coniferous-Deciduous Forest

considerable size occur in northwestern Wisconsin through central Douglas County, central and northern Bayfield County and northwestern Sawyer County; in northeastern Wisconsin in northern Marinette County; and in Central Wisconsin in southern Clark and eastern Jackson Counties. Other small patches are found throughout much of northern Wisconsin, especially throughout the northwestern and northeastern areas.

(e) White Birch-Aspen Forest.

Like the pines, jack pine particularly, aspen and white birch represent pioneer subclimax forms. They appear in the mixed coniferous-deciduous forest when an area is returned to pioneer conditions as by fire or wind-fall. They require a high degree of light intensity and are shaded out as other species invade their sites.²⁹ Usually they occur on soil of some humus content, leaving the extremely sandy locations to jack pine. In experiments Stoeckler found that very sandy soils or very heavy soils are both inimical to the best development of aspen; it shows its best growth on sites of good sandy loam.³⁰ Such sites of sandy loam soils are more subject

²⁹Whitford, op. cit., pp. 316-318.

³⁰Stoeckler, Joseph H., The Growth of Quaking Aspen as Affected by Soil Properties and Fire, Journal of Forestry, XLVI, 1948, pp. 736-737.

--The Mixed Coniferous-Deciduous Forest

to invasion by the more mesophytic forest trees than are the locations typically held by jack pine which may be the reason why there are fewer extensive unbroken areas of unmixed white birch-aspen forest type.

The two largest occurrences of this forest type are in the extreme southwest corner of Polk County on the Miami fine sandy loam and in southwestern Douglas County on Kennan loam. The white birch-aspen forest of this latter area is much fragmented, being intermixed with patches of swamp conifers, pine forest and sugar maple-yellow birch-pine forest. The proximity of this area to the boreal forest immediately to the north is shown by a sprinkling of balsam fir, white spruce, and upland tamarack species in the white birch-aspen forest.

In addition to these two large areas, patches of aspen and white birch are scattered throughout most of the mixed coniferous-deciduous forest, cropping out almost everywhere where the forest has been returned to sub-climax conditions except in the very sandy locations. Individual trees are widely scattered throughout the mixed coniferous-deciduous forest region and even extend far to the south into the deciduous forest region.

(f) Other Mixed Coniferous-Deciduous Forest Types.

Other mixed coniferous-deciduous types are those that occur in a belt, varying in width up to fifty miles, that

--The Mixed Coniferous-Deciduous Forest

fringes the southern margin of this major vegetation grouping. These mixed forest types result from the fact that pines reach southward into what otherwise are the various deciduous forest communities. For this reason most of the deciduous forest types have a mixed coniferous-deciduous counterpart where the deciduous forest is invaded by pines along this transition zone or belt (see master map). Thus there is a white pine-beech-sugar maple-basswood-oak forest, a white pine-sugar maple-basswood-oak forest, a white pine-basswood-oak forest, a white pine-oak forest, and a jack pine-scrub oak forest. All except the last are simply the projection of pine, white pine principally, into hardwood forest types. The last, or the jack pine-scrub oak forest, however, deserves some special mention because here the largest area of scrub oak in the state and one of the largest areas of jack pine occur in juxtaposition to give a rather unique forest type. In some places the trees are scattered so widely as to result in barrens, but there is one large area of some 400 to 500 square miles of this forest type which spreads across northeastern Juneau County and northwestern Adams County on the glaciolacustrine plain of former glacial Lake Wisconsin. It is in the locality that lies immediately west of the end moraine of the Green Bay lobe where coarse

--The Mixed Coniferous-Deciduous Forest

outwash was deposited from the ice front. The soil as a result is of a very sandy nature, largely lacking in humus, and ill-adapted to any trees other than the rugged hardy jack pine and stunted oak.

SECTION IX

SPECIFIC DISTRIBUTIONS OF VEGETATION TYPES:

THE DECIDUOUS FOREST

The deciduous forest of Wisconsin is a part of the widespread deciduous forest of the eastern United States (Fig. 3), and is most closely related to the portion of that forest that lies within the Central Lowland. The deciduous communities that occur in southern Wisconsin extend beyond the state boundaries into neighboring states; the associations of eastern Wisconsin also occur across the lake in southern Michigan, those along the southern boundary of the state carry on southward into Illinois, while the associations of the western part of the state continue on into Iowa and Minnesota. In other words, as in the case of the boreal forest and the mixed coniferous-deciduous forest, the deciduous forest group is a part and continuation of a more extensive vegetation unit that in its distribution has no regard for arbitrary political boundaries.

Within Wisconsin the deciduous forest lies in the southern and southwestern part of the state, south of the southern limit of pine as an important forest tree, and in a complementary position to that of the mixed coniferous-deciduous forest (Fig. 4). The individual

--The Deciduous Forest

forest types of the deciduous group do not have the same orderliness in their distribution with respect to one another as was noted above in the mixed coniferous-deciduous forest. In that forest group there is an orderly change of forest communities from east to west as first beech is eliminated, then hemlock, and finally yellow birch. In the deciduous forest group there is the start of a similar progression westward from Lake Michigan in the change from beech-sugar maple-basswood-oak forest to sugar maple-basswood-oak forest to basswood-oak forest, but this series is restricted to the eastern side of the state. In the central portion and toward the west there is a general mixture of all the deciduous types with the exception of the beech-sugar maple-basswood-oak forest. This apparent disorderly arrangement is not a haphazard one in the sense that it comes about due merely to chance. There is a cause and effect relationship behind much of it at least and possibly behind all of it, if it could be correctly interpreted.

The distribution of the various associations of the deciduous forest will be discussed in the following order: (a) the beech-sugar maple-basswood-oak forest, (b) the sugar maple-basswood-oak forest, (c) the basswood-oak forest, (d) the oak forest, (e) the oak openings, (f) the oak barrens, and (g) the lowland hardwood forest.

--The Deciduous Forest

(a) The Beech-Sugar Maple-Basswood-Oak Forest.

This forest association occurs in the lake shore region of southeastern Wisconsin in Manitowoc, Calumet, Sheboygan, Washington, Ozaukee, Milwaukee, Waukesha, and Racine Counties, with small amounts in Fond du Lac and Dodge Counties. The width of the zone depends on the varying distance to which beech reaches to the interior from the lake, since the forest changes on the west to sugar maple-basswood-oak forest along the line where beech is eliminated. The width of the beech zone is less here than farther north in the beech-hemlock-sugar maple-yellow birch-pine forest. This may be due to the fact that as temperature increases toward the south with no appreciable corresponding increase in precipitation, increased evaporation results in less moisture available for plant growth. Or it may be that the Prairie Peninsula crowded beech to the Lake Michigan shore in the southern part of the state during the fourth postglacial climatic phase, and that since that time in the face of the existing conditions, beech has not been able to reestablish itself westward. That beech-sugar maple-basswood-oak forest may have extended farther west before the last resurgence of grassland climate is indicated by the fact

--The Deciduous Forest

that beech pollen has been found in Lake Wingra at Madison, Wisconsin,¹ and in a bog in North Central Iowa.² The latter was in very small amounts only.

This western boundary of beech in the southeastern part of the state, and therefore, the margin of the beech-sugar maple-basswood-oak forest, extends southward from southeastern Calumet County through the western edge of Sheboygan County into Washington County, where it reaches westward well into the interior of that county, then turns abruptly eastward and southeastward, cutting through the northeast corner of Waukesha County and northern Milwaukee County to the Lake Michigan shore. Between this line just described and the lake shore lies most of the beech-sugar maple-basswood-oak forest of Wisconsin. To the south in Milwaukee County there is a narrow coastal strip which continues southward into Racine County. Another outlier of some proportions is in northwestern Washington County. The western-most representative of the beech-sugar maple-basswood-oak forest is a small outlier in eastern Dodge County between Iron Ridge and

¹As shown by an unpublished study mentioned by Professor J. T. Curtis of the University of Wisconsin Botany Department.

²Lane, George H., A Preliminary Pollen Study of the East McCulloch Peat Bed, Ohio Journal of Science, XXXI, 1931, pp. 165-171.

--The Deciduous Forest

Rubicon.

The northern boundary of the beech-sugar maple-basswood-oak forest is located where pine enters to change the forest complex to a mixed coniferous-deciduous type. This boundary is not an exact, even line but exists in the form of an irregular transition zone in which the two types of forest intermesh with numerous outliers and inliers. This meeting zone is in Manitowoc County and northern Sheboygan County.

The relatively narrow area of beech-sugar maple-oak forest in southeastern Wisconsin as delimited above is only a small part of the total beech-sugar maple-basswood-oak forest of northern United States. It extends eastward and southeastward into southern Michigan, central and northeastern Indiana, western and northern Ohio, southern peninsular Ontario and continues eastward into northwestern New York (Fig. 14).

Although moisture availability may be a limiting factor as far as the western boundary is concerned, on the other hand, too much moisture is not desirable. Within its area of occurrence beech-sugar maple-basswood-oak forest avoids the undrained depressions. These appear to be the only sites that are not adapted to its growth within this area of Wisconsin. It occurs on

--The Deciduous Forest

varied soil types here, indiscriminately growing on the red Superior clay loams on the Miami silt loam and on the Miami fine sandy loam as well as on the rough interlobate morainal soils.

(b) The Sugar Maple-Basswood-Oak Forest.

The sugar maple-basswood-oak forest is broken into a number of isolated areas and is distributed widely over southern and southwestern Wisconsin. The largest of these areas lies adjacent to and on the west side of the beech-sugar maple-basswood-oak forest. It reaches southward from the border of the mixed coniferous-deciduous forest north of Lake Winnebago in Outagamie County to the Lake Michigan shore in Milwaukee County. It is the second forest zone in order westward from the Lake Michigan shore in most of southeastern Wisconsin, and it is the forest type that results when beech is eliminated from the forest complex toward the interior. It touches the Lake Michigan shore toward the southeast corner of the state where beech is eliminated in that direction. From its distribution this forest shows that, although it is a mesophytic type, it ranks second to the beech-sugar maple-basswood-oak forest in degree of mesophytism. In contrast to that of the beech-sugar maple-basswood-oak forest, the western boundary of this particular section of sugar maple-basswood-oak forest is

--The Deciduous Forest

quite clearly marked by the Rock River.

It was pointed out in Section VIII that in northern Wisconsin sugar maple extends across the state from east to west. In southern Wisconsin it also occurs across the state but does so in interrupted patches rather than in an unbroken continuous body. The probable role of fire in causing this scattered distribution in the southern and western part of the state was suggested in Section VI, page 121. To elaborate on that explanation, it may be said that one type of hard maple, the type most common in Wisconsin, probably migrated into Wisconsin from the east and spread as far as Grant County in the extreme southwest.^{3,4} (Another type, the black maple, less common in the state and occurring mainly in the southwest, has an unknown origin. Desmarais found it to be associated in location with the Prairie Peninsula in some unexplained way.⁵ Braun says that a maple-basswood forest appears to have taken refuge in the Driftless Area during the time of Pleistocene glaciation and spread outward from there in post-Pleistocene times.⁶)

³Gleason, Henry Allen, The Vegetational History of the Middle West, Annals of the Association of American Geographers, XII, 1922, pp. 74-75.

⁴Desmarais, Yves, Dynamics of Leaf Variation in the Sugar Maples, Ph.D. Thesis, University of Wisconsin, 1948, pp. 56-58.

⁵Ibid., p. 59.

--The Deciduous Forest

However, the migrating front of a forest association usually has continuity with the rest of the forest mass to the rear,⁷ and regardless of whether the maple-basswood forest entered the state solely from the east or whether part of it originated in some other region, in its advance it would have covered the area, over which it spread, as a contiguous body and would not have occurred as a number of isolated units. Now sugar maple-basswood-oak forest occurs throughout southern and southwestern Wisconsin in the form of isolated patches, and in the same form it extends beyond the borders of the state into Minnesota, Iowa and Illinois. The fact that it is there indicates that it must have got there by migration as a contiguous body and that at one time those isolated areas were connected without interruption. The fact that they are no longer connected means that in the meantime conditions changed to such an extent that the sugar maple-basswood-oak forest was able to endure only in certain localized areas. There must have been something in the environment of those areas to make them more suitable for the preservation of the sugar maple-basswood-oak forest

⁶Braun, E. Lucy, *Deciduous Forests of Eastern North America*, (Philadelphia: The Blakiston Company, 1950), p. 524.

⁷Weaver and Clements, *op. cit.*, p. 131.

--The Deciduous Forest

than were the surrounding areas.

The most likely time for the migration of sugar maple-basswood forest across southern Wisconsin was during the third postglacial climatic period described in Section VI, page 119-120. The first period was a time of spread and decline of coniferous forest in southern Wisconsin. The second period was a time of grassland dominance. The third period with its favorable conditions of temperature and moisture saw the rise to dominance of a deciduous forest. The fourth period was a time of readvance of the grassland. The fifth period brought a partial reestablishment of the deciduous forest, coming down to modern times.

The assumption is made that sugar maple-basswood's migration across the state occurred during the third period of postglacial climatic fluctuation. This appears to be the only period when such a migration can be logically postulated. Climatic conditions were favorable only in the third and fifth periods. That it did not take place in the fifth period, which comes down to the present day, can be seen from an examination of present distributions; the sugar maple-basswood-oak forest occurs in scattered, isolated areas, with the spaces between covered with grassland and oak openings. The presence of those latter vegetation types in the intervening areas

--The Deciduous Forest

shows that there has not been universal coverage of sugar maple-basswood-oak forest in the southern part of the state since the time the grassland and oak openings gained a foothold, which, in the case of the grassland at least, dates from the fourth climatic period. Therefore, the time of the migration across the state of sugar maple-basswood-oak forest must have antedated the fourth climatic period which leaves the third climatic period as the only other probable time of the migration. If this forest association covered the region during the third period but not during the fifth, then it must have been separated into isolated areas during the fourth period, the second stage of grassland dominance, which was a time of prolonged drought and dessication.

The question arises as to why sugar maple-basswood-oak forest was preserved in some areas but not in others. Extended drought might possibly have destroyed the trees, but if so, it should have destroyed them more or less impartially over the whole region unless some special site characteristic were able to nullify the effects of the drought in certain localized areas. In examining the locations of the fragmented forest patches, the sites do not appear to have anything in common in this respect. They show sugar maple-basswood on upland and lowland, on exposed slopes and in sheltered valleys, in glaciated

--The Deciduous Forest

areas and unglaciated, on young drift and on older drift, on one soil type here and on another there. No one site characteristic that might have any bearing on resistance to drought is common throughout. So drought may be ruled out as the immediate destroying factor.

However, fire is an accompanying phenomenon of prolonged drought conditions, and it is known that sugar maple is very susceptible to fire damage.⁸ It might be expected that as successive severe fires burned through the area, the sugar maple forest would be destroyed. Where for any reason an area was protected from fires, the forest might have survived. Examination of the various sites where the sugar maple-basswood-oak forest was preserved shows one thing common to many of them. In a majority of cases, of the larger areas particularly, there is a water barrier of some sort, either lake, stream, or marsh, or in some instances a topographic barrier, along the western side or on both the western and the southern sides. This is in the direction from which the greater percentage of brisk winds blow and the direction from which fire would be expected to advance most readily. There are a number of exceptions, particularly with ref-

⁸Daubenmire, Rexford F., The 'Big Woods' of Minnesota: Its Structure and Relation to Climate, Fire and Soils, Ecological Monographs, VI, 1936, pp. 259-260.

--The Deciduous Forest

erence to the smaller sites. Most of the areas in Green County, large and small alike, can not be explained on the basis of water protection from fires, since the prairie touches the edge of the sugar maple-basswood forest with no protecting water features between.

However, the largest area of sugar maple-basswood-oak forest in Wisconsin, that described above in the southeastern part of the state, reaches water boundaries along a large part of its western and southern margin. It is a significant fact that this forest projects farthest westward where it has a protective water barrier, and it reaches its farthest western extremity in following the detail of that water barrier, the Rock River, in a westward bend. (Compare the vegetation detail on the master map with the drainage detail on the soils map.) There can be little mistake concerning a cause and effect relationship here. Between Lake Winnebago and Horicon Marsh where the Rock River is an insignificant stream and hence no barrier, oak forest reaches far to the east and touches the beech-sugar maple-basswood-oak forest, an unusual situation; but immediately to the south sugar maple-basswood-oak forest extends westward to the eastern edge of Horicon Marsh and follows southward along the east side of the Rock River to the northeast corner of Jefferson County. Here it turns westward still following

--The Deciduous Forest

the left bank of the river until it reaches the vicinity of Watertown in southern Dodge County, where it turns southward as the river bends to the south and follows downstream to the point where the tributary Bark River enters the Rock.

The margin of the forest here turns eastward through southern Jefferson County, with the Bark River serving as a flanking bulwark on the south and east. Following the right bank of the Bark River, the forest then trends northeastward upstream through eastern Jefferson County and across the northwest corner of Waukesha County to the south boundary of Washington County. From there it continues south and southeast behind marshes and tributaries of the Fox River of the southeast until it reaches the Root River, which it follows to Lake Michigan near the present city of Racine. This south and southeast trend in the last leg of the route is general enough that it is difficult to say whether it results from coincidence or from a cause and effect relationship with the location of the water bodies. However, in one stretch at least it follows the water barrier in so much detail that there is little question. This instance is in southwestern Milwaukee County where a bulge to the north in the forest margin follows exactly the outline of Ditch Creek, one of the tributaries of the Fox River.

--The Deciduous Forest

The second largest region of sugar maple-basswood-oak forest also has definite water boundaries along its western and southern margins. This is the area centered in Richland, Crawford and Vernon Counties. Its southern edge reaches to the valley bluffs along the north side of the Wisconsin River. Its western edge is along the east side of the Kickapoo Valley northward from where the Kickapoo joins the Wisconsin, through Crawford County to about six miles into Vernon County. There it leaves the Kickapoo and continues northwesterly and northerly following closely but not exactly the trend of the West Branch of the Kickapoo River to northern Vernon County, where it turns eastward. The northern and eastern boundaries bear no particular relationship to the drainage features or any other physical features.

Two outliers immediately to the east of this latter area are without hydrographic relationships on the south and on the west sides. One of these lies across the Juneau-Sauk County line. The other is in Sauk County on the north slope of the South Baraboo Range and in the synclinal valley to the north. The northern margin of the sugar maple-basswood-oak forest here follows the detail of the Baraboo River. Although all other sides seem to have no particular relationship to water features, it is of significance that the western and southern

--The Deciduous Forest

margins follow closely the top of the Baraboo Range, a formidable topographic barrier with its rocky slopes.

The third largest area of sugar maple-basswood forest lies principally in Pierce County and southwestern Dunn County with small portions extending into Pepin and St. Croix Counties. Outliers extend to the north and northeast as a transition is made to the sugar maple-yellow birch-pine forest.

The eastern edge of this small forest region shows an interesting relationship with certain physical features of the site. In the first place, the eastern margin of the forest association follows the general trend although not the exact delineation of the Lower Magnesian Escarpment from north to south through southwestern Dunn County into Pepin County. The forest margin stands a short distance to the east of the east-facing escarpment. However, it follows almost exactly the soil boundary that separates the Knox silt loam on the west from the Boone fine sandy loam on the east (Fig. 15). Also it follows southward along the west side of the Red Cedar River for a distance of between five and ten miles and then moves westward to the west side of the Eau Galle River and continues southward with that river approximately to its junction with the Chippewa River. It so happens that the soil boundary coincides with the river boundaries

--The Deciduous Forest

in the same way that the vegetation coincides with them.⁹
To the east of these river boundaries on the sandy loams
the vegetation is of a mixed nondescript nature--oak
barrens, oak forest, oak brush and prairie intermixed.
To the west on the heavier soil, it is the sugar maple-
basswood forest. What causes the abrupt change?

The brush vegetation to the east is of the type
that might be expected to result when a hardwood forest
is subjected to successive severe burnings. The sugar
maple-basswood cover to the west indicates a lack of
severe burning. It might appear that the streams have
acted as fire barriers, but other clues are seen that
suggest otherwise. The sugar maple-basswood forest lies
to the west or windward side of the streams rather than
on the leeward side as is the case of most other examples
of forest preserved by fire barriers. This does not mean,
of course, that winds always blow from one or two direc-
tions or that fires cannot spread from the leeward side
toward what is normally the windward side. A still
more significant factor is the exactness with which the
forest boundary coincides with the soil boundary. The

⁹The soil boundary also changes near the escarpment front.
The Boone fine sandy loam to the east is underlain by
soft Cambrian sandstone. The Knox silt loam to the
west of the escarpment is underlain by Lower Magnesian
limestone.

--The Deciduous Forest

two move from the Red Cedar River to the Eau Galle River at the same place in addition to bordering each of the rivers along the same path (Fig. 15). If fire were the limiting factor at this point it would be a rare coincidence for fire destruction of the forest to follow the detail of soil boundary. So it looks as though soil is here the major limiting factor, although the stream barriers may also have played a part. This view is bolstered when it is remembered that a few miles to the east, on the opposite side of this area of Boone fine sandy loam, the sugar maple-yellow birch-pine forest also stops along the margin of the sandy soil (see page 167). It should be kept in mind that a sandy soil is not a permanent barrier to the advance of the climax forest, although it may act as a temporary one and delay the establishment of the climax forest.

Northward along the eastward margin of this sugar maple-basswood-oak area, there is further evidence that soil is the critical factor in controlling the vegetation type. Where the sugar maple-basswood forest leaves the Red Cedar River the soil type boundary also leaves it, and the two trend away in the same direction (Fig. 15). For the most part this forest type is not found on the Boone fine sandy loam soil, although there are minor exceptions. Quick found that in southern

--The Deciduous Forest

Michigan sugar maple will grow on sandy soil, but the climax association of which it is one of the most influential members is more quickly developed on heavier soil.¹⁰

The bulk of the evidence points toward soil differences rather than water barriers as the limiting factor controlling the eastern boundary of this sugar maple-basswood-oak forest sub-region centered in Pierce County. As in other cases noted previously, the northern boundary here has no particular physical relationships with site characteristics. A part of this boundary makes contact with the sugar maple-yellow birch-white pine forest and a part of it with the prairie region of St. Croix County. The western boundary also appears to lack any correlation with site characteristics, although the St. Croix and Mississippi Rivers are only a short distance away to the west.

Along the southern margin there is some evidence of water marked boundaries. From the vicinity of the Chippewa River on the east the southern margin trends westward along the north side of the Plum River and follows closely the detail of the stream meanders.

¹⁰Quick, op. cit., p. 222.

--The Deciduous Forest

Farther to the west this forest type reaches southward to the Mississippi, but in one place only. This on the narrow strip of land between Rush River and Isabelle Creek.

As far as the specific boundaries of the area are concerned, only a small proportion shows any evidence of coinciding exactly with what may be construed as fire barriers. However, it will be noted that this whole region lies within a pocket between the Red Cedar-Chippewa Rivers on the east, the Mississippi River on the south and the St. Croix River on the west. Although the edges of the forest reach the streams in only a limited number of places, the forest remains enclosed on three sides by water barriers. The fact that some of the area so enclosed has a vegetation cover less advanced than the sugar maple-basswood-oak type could mean that the fire protection was no perfect; that some fires were able to come in and set the sugar maple-basswood-oak forest back to sub-climax vegetation types in places. But lack of perfect protection would not necessarily mean that the barriers were wholly ineffective. Even though an occasional fire were able to get in and reduce the status of the vegetation cover, there may have been enough fire protection to save the sizable area of sugar maple-basswood-oak forest that did

--The Deciduous Forest

remain.

A fourth area of sugar maple-basswood forest lies farther to the north in northwestern Polk County and southern Burnett County. It has two boundaries which coincide distinctly with changes in soil type. The sugar maple-basswood-oak forest occurs on Kennan silt loam. Along its western side it extends to the edge of the Plainfield sand soil that supports scattered jack pine and little else. Its northern margin makes contact with a small area of white pine, also on the Plainfield sand. Its eastern boundary does not coincide with a change in soil type, but touches the sugar maple-yellow birch-white pine association of the mixed coniferous-deciduous forest group along the line at which yellow birch is eliminated in that forest (see page 168). The southern border is an indistinct transition zone which grades into aspen-white birch forest in the neighborhood of the line along which Kennan silt loam changes to Miami fine sandy loam.

The remaining areas in the state of sugar maple-basswood-oak forest are small in size, but most of them follow the pattern of a location on the leeward side of water barriers. Two examples of such are in southern Grant County. The more westerly one lies to the east of the Grant River and within a bend of that stream. It is

--The Deciduous Forest

limited on the north by Pigeon Creek and on the southeast by Bois Creek. The more easterly area is located in the fork formed by the Platte River and its tributary, the East Branch of the Platte.

Other small occurrences of this forest type are scattered over Grant County. Of especial interest are those confined to the steep-walled ravines near the confluence of the Wisconsin and Mississippi Rivers. These are the only instances noted in the state where sugar maple-basswood-oak forest is restricted to such sites.

Farther east in Walworth County the isthmus between Lake Geneva and Lake Como is covered with sugar maple-basswood-oak forest. It is shielded on the south by Lake Geneva, on the north by Lake Como, and on the west by a marsh that joins the two lakes. It should be mentioned also that on the unprotected side of both this marsh and Lake Geneva there is a small spot of sugar maple-basswood forest.

The pattern of location on the leeward side of water bodies is repeated with some emphasis in Dane County. Each of the lakes in the Madison chain of lakes has a small segment of this forest on its east or north side. Lake Mendota has the area known as Maple Bluff on its east side. This section of sugar maple-basswood-oak forest extends southeastward until it touches the north

--The Deciduous Forest

shore of Lake Monona. Where the forest crosses the neck of land between the two lakes, the Yahara River marsh forms a protective barrier to the southwest. Lake Waubesa has a small area on the east side, and Lake Kegonsa has one on the northeast shore. With the exception of a small fragment on East Blue Mound, these are the only representatives of this forest type in Dane County. The repetition of the pattern on each of the four lakes is striking.

As was pointed out not every occurrence of sugar maple-basswood-oak forest is located on the leeward sides of drainage features, but this pattern repeats itself in so many cases that it appears to result from a common cause. The typical location and the spacing of the fragments of this forest type suggest that it at one time covered most if not all of southern and southwestern Wisconsin. The most likely time for this situation to have existed was during the third major post-glacial climatic phase. The remnants that are left probably owe their preservation to the protection against fires during the fourth climatic phase or second period of grassland dominance. There may have been some readvance of sugar maple-basswood-oak forest during recent times with the swing back to forest climate, but if so it is not possible to say to what extent, since there is no way of knowing

--The Deciduous Forest

the status of the forest with respect to the area occupied at the close of the period of grassland dominance.

In addition to the areas of sugar maple-basswood-oak forest described above, there are numerous small patches in the transition zone between the deciduous forest formation on the south and mixed coniferous-deciduous forest formation on the north. Sugar maple itself as a forest tree has one of the widest distributions within the state of any of the forest species. It occurs from the extreme north in the Apostle Islands to the Illinois border, and across the width of the state from east to west.

(c) Basswood-Oak Forest.

Basswood-oak forest in southern and southwestern Wisconsin is sub-climax to the sugar maple-basswood-oak forest. By its distribution over the area, the sugar maple-basswood-oak forest shows that once it becomes established it is capable of living and perpetuating itself throughout southern and southwestern Wisconsin. No more-advanced forest type shows any inclination to establish itself anywhere except in the extreme east where beech-sugar maple-basswood-oak forest stands as

--The Deciduous Forest

post-climax to sugar maple-basswood-oak,¹¹ but since beech shows no predilection for spreading westward it may be excluded from consideration at the moment. The successional development of plant associations in this part of the state is from prairie to oak openings to oak forest to basswood-oak forest to sugar maple-basswood-oak forest, which is the climax association. Thus basswood-oak forest is but one step removed from the climax stage. It forms the transition in the development between oak forest and sugar maple-basswood-oak forest. There is only a small amount of this forest type in the state, and in its distribution within the deciduous forest group there is a tendency for it to occupy a buffer position between sugar maple-basswood-oak forest and oak forest. Rarely is it seen growing independently dissociated from the sugar maple-basswood-oak forest. One exception is that in stream valleys where it sometimes occurs along with lowland hardwood forest. Daubenmire found a similar relationship existing between basswood-

¹¹The term post-climax refers to the relationship a more mesophytic plant association bears to a less mesophytic one. A climatic change toward more moist conditions would see beech encroaching on sugar maple-basswood-oak forest. A change to drier conditions would see beech retreating before the sugar maple-basswood-oak forest.

--The Deciduous Forest

oak forest and sugar maple-basswood-oak forest in Minnesota.¹² He attributed it to the fact that sugar maple, being more sensitive to fire damage, was eliminated around the margin of the sugar maple-basswood-oak forest, leaving a basswood-oak association. It also could mean an advance of the more mesophytic forest types in which basswood-oak forms the fore-runner, setting the stage for the coming of the sugar maple-basswood-oak forest.

The most important areas of occurrence of basswood-oak forest are, first, in the southeastern part of the state where it stands on the western and southern margins of the sugar maple-basswood-oak forest, as is observed immediately southwest of Lake Winnebago, through southern Dodge County, central Jefferson County and in northern and eastern Waukesha County (see master map). A second area of significant size is located toward the western side of the state in eastern Richland County where it reaches from the margin toward the interior of a sugar maple-basswood-oak forest. Numerous smaller areas occur, but these too, like the larger ones, are for the most part associated with sugar maple-basswood-oak forest.

¹²Daubenmire, op. cit., pp. 259-260.

--The Deciduous Forest

(d) The Oak Region.

Although oaks of one species or another extend northward to the northern extremities of the state, they occur only in limited numbers in the mixed coniferous-deciduous forest north of Portage County. They occur in considerable quantity throughout the transition belt between the deciduous forest and the mixed coniferous-deciduous forest, but they reach their greatest numbers and fullest development of species throughout the deciduous forest of the state where they are found as components of all the various hardwood communities. They occur with increasing dominance as the communities go through a decreasing scale of mesophytism from beech-sugar maple-basswood-oak forest through sugar maple-basswood-oak forest and basswood-oak forest, where they hold a dominant position, to oak forest, oak openings, and oak barrens where they occur essentially in pure stands.

The oaks vary greatly in degree of mesophytism. Judging on the basis of the trees with which they are associated, the gradation of the commonly occurring oaks in Wisconsin, on the scale from more moisture-requiring to less moisture-requiring species, is from red oak to white oak to black oak to burr oak. Red oak and white oak commonly occur in the beech-sugar maple forest and

--The Deciduous Forest

in the sugar maple-basswood forest. The basswood-oak forest contains red oak along with white and black oak. The dominant species in the oak forest and oak openings are white oak, black oak and burr oak, with burr oak occurring more characteristically in the oak openings than in the oak forest. There is a considerable quantity of red oak sprinkled through the oak forest in areas that are adjacent to, or not far removed from, the sugar maple-basswood forest. The trees of the oak barrens consist of a scrubby dwarf oak growth.

Oak forest and oak openings together occupy more area than any other deciduous forest type in Wisconsin. They lie to the interior, or westward, of the north-south trending tiers of beech-sugar maple-basswood-oak forest and sugar maple-basswood-oak forest in eastern Wisconsin. As these two latter forest types dwindle in width toward the southeast, the oaks reach the Lake Michigan shore in the extreme southeastern part of the state. Southward they touch the Illinois boundary and extend across it into Illinois and Indiana.¹³ To the west they reach the Mississippi and extend beyond it into Iowa and Minnesota.¹⁴ They are seen eastward across

¹³Braun, E. Lucy, *Deciduous Forests of Eastern North America*, (Philadelphia: The Blakiston Company, 1950), pp. 185-186.

¹⁴*Ibid.*, pp. 182,184.

--The Deciduous Forest

Lake Michigan in the lower peninsula of Michigan.¹⁵

Within Wisconsin they extend northward in two projections, one going as far north as northeastern Portage County in central Wisconsin and the other reaching into Dunn and Pierce Counties in western Wisconsin, with outliers spreading beyond into Polk and Barron Counties.

From the surveyors' field notes, it is difficult to separate oak forest from oak openings for mapping purposes with a great degree of assurance, since the surveyors often were ambiguous in describing oak openings. If they merely mentioned the tree species without indicating the spacing, it was difficult to decide whether the density of growth was consistent with that of oak openings or that of oak forest. In oak openings the individual trees are loosely spaced, now occurring in open clumps and now scattered singly over the countryside. Hoyt describes them in southern Wisconsin as follows:¹⁶

"They are, moreover, the most beautiful portions of the varied and picturesque surface of the country. Grouped here and there, like so many old orchards, on the summit of a gentle swell of land, or on the border of a marsh, prairie or lake, there is nothing in the whole catalogue of American sylvia that equals these burr oaks for the charming, homestead-like expression they give to the landscape."

¹⁵Ibid., pp. 185,187.

¹⁶Hoyt, J. W., Report of the Executive Committee, Transactions of the Wisconsin State Agricultural Society, VI, 1860, p. 48.

--The Deciduous Forest

If the surveyors simply noted the species as "white, black, and burr oak", such a statement could be interpreted, in the absence of other clues, as oak forest. In mapping the two categories, oak forest and oak openings, the policy adopted was to follow the literal statements of the surveyors insofar as possible. As a rule the only areas mapped as oak openings were those that were clearly designated as having a scattered stand. All that were not indicated as openings were mapped as oak forest unless the weight of evidence clearly indicated otherwise; as, for example, in instances where a number of different surveyors would agree on the vegetation of a particular area as against one dissenting opinion, the majority opinion would be the one accepted.

Because of this policy of mapping openings only when they were plainly designated as such and calling everything else oak forest, the openings that are mapped can be considered authentic and accurate. On the other hand, much of the area mapped as oak forest may in reality be oak openings, and there is some reason to believe that such may be the case. There are clues that might make it possible upon closer study to distinguish between the two, but this would necessitate going into the matter in much greater detail than is in accordance

--The Deciduous Forest

with the scope of this study. For local areas such intensive work can be made to yield results, as Ellarson has shown in his study of Dane County.¹⁷

However, when it is stated that possibly much of the area mapped as oak forest may actually be in oak openings, that is not to be interpreted to mean that there is no genuine oak forest at all in Wisconsin. In a region where on the one hand patches of the climax sugar maple-basswood-oak forest exist and on the other hand xerophytic prairies, it is not reasonable to suppose that all the intervening gradations were eliminated in favor of the one vegetation type, oak openings. The existence and location of basswood-oak forest, which is one of the intervening associations, have been noted, and it is certain that there are also areas of oak forest. It is not certain at present just to what extent they exist and what proportion of the area they share with oak openings.

The origins of oak forest and oak openings may be postulated as follows. With the coming of a grassland climate in the fourth post-glacial climatic phase,

¹⁷Ellarson, Robert Scott, The Vegetation of Dane County, Wisconsin, in 1835, Transactions of the Wisconsin Academy of Sciences, Arts and Letters, XXXIX, 1949, pp. 21-45.

--The Deciduous Forest

drought and fires accompanying the drought were able to destroy the climax sugar maple-basswood-oak forest except in protected locations. Much of what had been forested area was then taken over by grassland; just how much is now known. Some of the sugar maple area may have been merely reduced to oak forest and oak openings. Or it may be that the areas of oak openings and oak forest resulted from a re-invasion of the grassland by oak trees after the drought conditions began to moderate with the arrival of the fifth and most recent climatic phase. The burr oak, especially, is fitted by its highly developed, deep-reaching root system and its thick, fire resistant bark to invade grassland areas.^{18,19} It is likely that in some areas, after oak openings had become established in the grassland, and as climatic and other environmental conditions became more favorable, oak forest then gradually supplanted oak openings. Curtis has shown that this has happened in Green County since the land has been occupied agriculturally.²⁰

¹⁸Weaver, J. E., and Joseph Kramer, The Root System of Quercus Macracarpa in Relation to the Invasion of Prairie, Botanical Gazette, XCIV, 1932, pp. 82-83.

¹⁹Daubenmire, op. cit., p. 260.

²⁰Curtis, John T., Hardwood Woodlot Cover and Its Conservation, Wisconsin Conservation Bulletin, XVI, Feb. 1951, pp. 11-15.

--The Deciduous Forest

Although they are known to be spotted throughout the oak region, the highest proportion of positively identified areas of oak openings are in the southwestern part of the state, particularly in Grant, Iowa and Lafayette Counties. Other large localities are definitely identified as having oak openings. One extends southward through western Jefferson County into northern Rock County. Another is in central, western and northern Waukesha County. A third covers much of central and eastern Winnebago County and extends southward to cover most of western Fond du Lac County, plus a sizeable area immediately southeast of Lake Winnebago. A fourth region includes much of eastern Buffalo County and reaches eastward through southern Trempealeau County into southwestern Jackson County. There also is reason to believe that oak openings can be assigned to much of Dane, Dodge, Columbia, Marquette, and Green Lake Counties.

Some portions of the oak region are neither oak forest nor oak openings. These are the oak barrens where thin stands of scrubby dwarf oak grow on sands or sandy loams. This type of vegetation cover occurs in small fragmented areas distributed through a zone extending northwest-southeast through Eau Claire County, eastern Dunn County, and western Chippewa County.

--The Deciduous Forest

(e) The Lowland Hardwoods.

The lowland hardwoods, comprising such species as soft maple, willow, elm, cottonwood, ash, river birch, and swamp oak, occur along stream valleys in the moist soils that may be either periodically inundated or near enough to the ground water table to receive ample supplies of moisture. This is a deciduous forest, and it occurs principally in the deciduous forest region, although in certain instances it may follow the streams northward into the mixed coniferous-deciduous forest area.

Specifically, in Wisconsin this type is found for the most part along the Mississippi River lowland and in the valleys tributary to the Mississippi. The main exception to this is the example that occurs along the lower Wolf River from Shawano County southward to the confluence of the Wolf and the Fox Rivers in Winnebago County.

Along the Mississippi River and its tributaries the largest examples are in the unglaciated areas. The Wisconsin River from Dane County to the Mississippi is well-bordered with lowland hardwoods. Upstream from Dane County this type is seen intermittently as far north as southern Marathon County.

In the Mississippi valley, north of the confluence with the Wisconsin, the size of the areas of lowland

--The Deciduous Forest

hardwoods on the Wisconsin side varies with the width of the lowland between the river and the valley bluffs. The alluvial terraces, which are usually covered with grass, stand as exceptions. Where the tributary valleys enter the main valley, the lowland broadens and the area supporting this type of forest broadens correspondingly.

Of the valleys tributary to the Mississippi above the junction of the Wisconsin, that of the Black River is the first to show lowland hardwoods. Here they occur in considerable quantity upstream as far as southern Jackson County, and after that only at rare intervals farther up the valley to northern Clark County. The next tributary valley in order up the Mississippi to have this forest type is the Trempealeau, which contains lowland hardwoods in its lower reaches between Buffalo and Trempealeau Counties. The next is the Buffalo River valley, which has a small occurrence where the valley widens as it enters the Mississippi gorge.

The Chippewa valley has a wide expanse of lowland hardwoods where it opens into the Mississippi gorge. The forest narrows upstream to the northern boundary of Buffalo County and then occurs upstream intermittently only to southern Chippewa County.

Due to its lack of valley lowland, the St. Croix River has no bordering lowland hardwood forest until the

--The Deciduous Forest

valley widens above the St. Croix Dalles. From here this forest type borders the stream almost continuously as far upstream as southern Douglas County. At this latter point the lowland hardwoods reach the most northerly location at which they are mapped anywhere in the state.

SECTION X

SPECIFIC DISTRIBUTIONS OF VEGETATION TYPES:

THE GRASSLAND

The fourth major vegetation category that occurs in Wisconsin in addition to the boreal forest, the mixed coniferous-deciduous forest, and the deciduous forest, is the grassland. As in the case of each of the other three, the grassland owes its origin to climatic conditions of the past. It is a relict form that dates from a time when grassland climate dominated the Middle West. This is assumed to have been the fourth climatic phase of post-glacial time, the second period of prolonged subhumid conditions with grassland dominance (see page 121). Since the close of that period, the climate has been such as to favor forest rather than grassland, but forest has been able to displace the grassland only slowly and with difficulty. It may be that because there has not been sufficient time for the forest to reclaim all the grassland areas, grassland remains in numerous localities throughout southern and southwestern Wisconsin.¹

¹The present tense is still being used to indicate time as of the period of the government land survey.

--The Grassland

The species best adapted to invade the prairies are the xerophytic light-requiring white oak, black oak, and burr oak. Of these three the burr oak is especially well-suited.² Just how much of the state was actually occupied by grassland during the fourth climatic phase, and how much, if any, of this area had been recaptured by oak openings and oak forest at the time of the original land survey can not be determined at this time. It is probable that much more of Wisconsin was occupied by grassland during that climatic phase than at the present time. This is suggested by the distribution of the grassland remnants. They occur throughout the deciduous forest zone within the areas of oak dominance. To get this wide distribution the climate must have been favorable for grassland dominance throughout the entire area where grassland fragments now remain, and if the grass migrated over the area as an uninterrupted contiguous body, much of what is now intervening forest land must have previously been covered with grass. It is believed that some forest persisted into the period of grassland dominance as evidenced by the remnants of sugar maple-

²Weaver, J. E., and Joseph Kramer, The Root System of Quercus Macracarpa in Relation to the Invasion of Prairie, Botanical Gazette, XCIV, 1932, pp. 82-83.

--The Grassland

basswood-oak forest behind the water barriers. Outside of those protected remnants it is not known how much if any forest remained. It is possible that at one time grassland covered all the unprotected portions but that since the dry conditions have ameliorated, oak openings and oak forest have readvanced to the present coverage.

However, if grassland covered most of southern and southwestern Wisconsin, the period of duration of such coverage was limited, judging by the amount of prairie soil in the state as compared with the amount of forest soil. The master vegetation map and Whitson's soil map show that most, not all, regions of prairie soil have approximately the same size and distribution as the present regions of prairie grassland. This indicates that prairies, if not confined in the past essentially to their present locations, have at least existed only in those locations long enough to leave a characteristic soil type. If they did have a more expanded coverage in the past, it was only for a period too short in duration to result in the development of a prairie soil profile, or else any such profiles that may have developed have since been obliterated.

As indicated above, a significant fact with respect to the distribution of the grasslands is that they are almost entirely confined to the deciduous forest zone,

--The Grassland

and within that zone they are almost entirely confined to the oak regions. There are only a few minor instances in which they are intermingled with the basswood-oak or sugar maple-basswood-oak forests, and almost no cases where they exist in the beech-sugar maple-basswood-oak forest. This latter fact supports the idea, although it is not conclusive evidence, that sugar maple-basswood forest was preserved behind the water barriers during the time of grassland dominance and that grassland was excluded from these locations.

The three subdivisions of the grassland shown on the master map are marsh, wet prairie, and upland prairie.

(a) Marsh.

Although marsh vegetation is not composed of true grasses, it is here classed with the grassland types, because it closely resembles grass in its physiognomic appearance. The areas of marsh vegetation in Wisconsin, like those of the true grass communities, are located with few exceptions in the oak region of the deciduous forest zone. Further, it may be said that for the most part they are located in the glaciated portion of the oak region. This results from the fact that they occupy poorly drained sites, and most of such sites occur within the glaciated region. Thus, being largely in the glaciated section of southern Wisconsin and outside of

--The Grassland

the beech-sugar maple-basswood-oak and the sugar maple-basswood-oak areas, the majority of the marshes of the state are confined to a north-south zone, lying to the east of the Driftless Area and to the west of the mesophytic forest of the Lake Michigan region, reaching from the latitude of the northern end of Lake Winnebago to the Illinois border.

The significant thing concerning the concentration of marshes within this zone is not that the marshes occur, but that they occur to the essential exclusion of swamp forest communities. This point is emphasized when it is observed that immediately to the east in the sugar maple-basswood-oak forest and to the north in the mixed coniferous-deciduous forest zone, marsh vegetation communities are almost completely absent, and the wet lands have a forest growth of bog conifers and swamp hardwoods. A reason for this that suggests itself is that in the marsh zone, which is located in the region of former grassland dominance, the low basins became sufficiently dry at intervals for recurring fires to burn through, removing any forest vegetation that may have been there and preventing its return; while on the other hand, the depressions in the sugar maple-basswood region to the east lay behind fire barriers and were protected in the same way as the sugar maple-basswood-

--The Grassland

oak forest itself was protected (see page 190). The mixed coniferous-deciduous forest zone to the north was beyond the region of grassland dominance and must have escaped to some extent the fires associated with the grassland.

Within the glaciated region the wet sites in which the marshes occur are of different types. They may be located along a stream where the stream widens to form a broad shallow expanse of water. Instances of this type are seen along the Crawfish River and along the Rock River in Jefferson and Dodge Counties. The Horicon Marsh in northern Dodge County is a prime example. They may occur on the till plain in the depressions between drumlins where they are oriented in the direction of ice movement. Numerous examples are seen in eastern Dane and Columbia Counties and in western Dodge County. They occur in the kettles in marginal moraines as in Waukesha County. They occur in the sluggishly drained inner lowland in front of the Lower Magnesian escarpment extending in a belt northeastward from near Portage in Columbia County to northern Winnebago County. A fifth type of site in which they occur is along the low-lying margins of lakes as seen along the north side of Lake Mendota in Dane County and Lake Koshkonong in Jefferson County.

--The Grassland

In the unglaciated portion of southern Wisconsin the marshes are characteristically limited in number and extent. Although not resulting from direct glacial action, the poorly drained sites which the marsh vegetation occupies in this area originated indirectly from glaciation for the most part. They are usually either in valleys filled with glacial outwash, where local inequalities in the fill leave swampy sites, or in tributary valleys whose mouths have been blocked by detritus-filling in the parent valley with the resultant lowering of the gradient and flooding of much of the floodplain in the tributary valleys.

However, the largest marsh of the unglaciated region and of the state is not in a river valley site but rather occupies the lower undrained portion of the bed of former glacial Lake Wisconsin. This Great Swamp reaches from the edge of the deciduous forest northward into the transition zone between the deciduous forest and the mixed coniferous-deciduous forest. A large proportion of it is vegetated with bog conifers, although more than 150 square miles in Juneau, Wood, Jackson, and Monroe Counties are in marsh. Scattered through much of this marsh itself are many islands and clumps of bog conifers whose varying proportions caused some difficulty to the surveyors in classifying the vegetation of the region and to the writer in mapping the results of the surveyors' findings.

--The Grassland

This was particularly true along the western margin of the marsh where lack of agreement on the part of the surveyors has led to an artificial-looking trend to the boundary of the marsh. The actual boundary undoubtedly trends north-south in that general vicinity, but it is unlikely that it would follow as straight a line, and one that so closely corresponds to the township lines, as that mapped.

In northern Wisconsin the area covered by marsh vegetation is extremely limited as compared with that of the southern part of the state. Four places of occurrence stand out. One is located in the shallow coastal waters along the west side of Green Bay. A second occurs along the coast of Lake Superior in the lowland behind Chequamegon Point Bar in northern Ashland County. A third includes Manitowish Marsh and Flambeau Marsh in southwestern Vilas County in the Northern Lake District. The fourth location is that associated with the Northwestern Lake District in western Burnett County and Central Polk County.

Marsh vegetation represents an early phase in the successional development on poorly-drained sites. The general scarcity of marshes in northern Wisconsin shows that there the vegetation of the depressions has in general remained undisturbed for a period sufficiently

--The Grassland

long to allow swamp forest to replace the marsh. Where marsh does occur its presence indicates that the site either has not had time to develop forest vegetation or that forest vegetation once developed has been destroyed, as by fire. Of the marshes listed in the paragraph above, the first two, those along the margin of Green Bay and Chequamegon Bay, apparently are on newly invaded sites that have not had time to develop swamp forest growth. The Manitowish and Flambeau Marshes may also be of this type. However, the marsh areas of the Northwest Lake District appear to result from the same cause as those of south central Wisconsin, namely fire. In this section the marshes of central Polk County are in areas of recent burns, while those in western Burnett County are in a region of jack pine barrens which is subject to recurrent fires.

(b) Wet Prairie.

Wet prairies occur typically in areas of poor drainage. They often grade into upland prairie on the drier margins and into sedge meadow and marsh along the wetter margins. Although they occupy, with respect to drainage, a location intermediate between that of upland prairie on the one hand and that of sedge meadow and marsh on the other, they may occur independently as well as occurring in conjunction with either one or both of

--The Grassland

the other two communities.

The surveyors reported this vegetation type in a rather haphazard manner, some designating it by one term and some another. Since it is usually limited in extent, many areas were probably omitted entirely or reported either as prairie or as marsh. This is suggested by the many instances where marsh and upland prairie are shown adjacent to each other without any mention of any intervening wet prairie as a transition. Therefore, it is fairly certain that not all areas of wet prairie that existed at the time of the original survey are mapped as such. The total area of wet prairie that is mapped is rather limited in extent; although since it is a transitional type, it might be expected to occupy less space than either marsh or upland prairie.

One of the greatest regions of concentration of wet prairie is in the southeastern counties of the state from Kenosha and Racine Counties westward into Rock and northward into Waukesha and southwestern Jefferson Counties. It is also seen in the valleys throughout much of the Western Upland with an unusual concentration in Buffalo County. Northward in the mixed coniferous-deciduous forest zone, it is found along the Lower Fox River near Green Bay and in the Northwest Lake District in Burnett County.

--The Grassland

(c) Upland Prairie.

Upland prairie is normally a subhumid climate community. It is present in Wisconsin as a relict form from the past which is persevering on whatever sites it may retain a foothold. In its struggle for existence it is undoubtedly aided by recurring minor cycles of drought years and hindered by wet year cycles. The average moisture conditions of the deciduous forest zone in which it occurs are favorable to forest growth rather than upland prairie. Therefore as a xeric form holding its ground outside of its natural climatic environment, it might be expected to linger longest on the more xeric sites where excessive drainage or some other cause gives the greatest difficulty to the invading forest. Curtis and Greene have shown that upland prairies in Wisconsin tend to exist on such sites.³ They have differentiated three types, (1) high prairies, (2) dry lime prairies, and (3) sand prairies. High prairies occur on deep soil which has good drainage and which may become very dry during a part of the summer. They are also found over level beds of glacial outwash gravel and sands or on gently rolling upland.

³Curtis, John T., and H. C. Greene, A Study of Relict Wisconsin Prairies by the Species-Presence Method, Ecology, XXX, 1949, pp. 83-92.

--The Grassland

The dry lime prairie is a very distinct type that occurs on thin soil areas where in some cases there may be only two or three inches of soil above the parent rock. The sites are flat to steeply rolling limestone-capped hills and ridges, especially in the Driftless Area.

The sand prairie encompasses a broad group unified by occurrence on sandy soil. It is found on residual sands in the Driftless Area, in glacial lake beds, and on river terraces of glacial outwash.

Moisture conditions vary from place to place in the different types but all are subject to occasional severe drought.

The master map shows the distribution of upland prairie within Wisconsin. In general it extends across the southern extremity of the state in irregular fragmented streamers and patches. From this southern concentration, an archipelago of broken disjoined pieces extends northeastward to the vicinity of Lake Winnebago; while a second one consisting of smaller, more separated segments, extends north and northwest through the Western Upland to St. Croix County, where it culminates in one of the largest prairie masses in the state.

In the southwest, south of the Wisconsin River the prairies follow the pattern of the ridge tops. They

--The Grassland

occupy the crest of the Galena-Black River cuesta from the vicinity of Mt. Horeb in Dane County to the neighborhood of Mt. Ida in Grant County, a distance of more than fifty miles. From this axis streamers reach toward the south following the divides that separate the streams flowing down the dip slope of the cuesta. The first of these prairie areas on the west, slightly separated from the main axis, occupies the broad upland between the Mississippi and the Grant Rivers. The next toward the east, also disjoined from the main east-west axis, is oriented north-south on the divide between the Grant and the Platte Rivers. The third in order to the east extends between the East Platte and the Pecatonica Rivers until it meets the headwaters of the Galena River, where it splits to form an inverted Y. One arm of the Y extends southwest between the Galena River and the East Platte and the other southeast between the Galena and the Pecatonica. The fourth southward extension of upland prairie follows the crest of the divide between the Pecatonica River and the East Branch of the Pecatonica.

Eastward from this last arm and beyond the East Branch of the Pecatonica the upland country becomes interrupted and broken by numerous tributary valleys between this stream and the Sugar River. Here the upland prairie also becomes discontinuous and occurs in

--The Grassland

separated fragments that correspond in location to the separated ridge tops. Southward the ridge tops broaden in the upland country of central and southern Green County, and the upland prairie also broadens correspondingly to form one of the larger contiguous prairie regions of the state.

Some of the prairie land of the Southwestern Upland, although not all, fits Curtis' and Greene's description of dry lime prairies. Situated on ridge crests in thin soil areas having rapid surface drainage, the moisture supply is apt to be limited. An additional factor that is common to all prairies throughout this area is that of exposure. The open ridge tops are exposed to the warm, drying winds of summer and the cold, drying winds of winter, which are even more damaging to forest growth. The prairies in occupying these sites thereby retain the locations least desirable for forest growth and those from which the forest has the greatest difficulty in dislodging the grassland. They are also in the most favorable location for the movement of fires, being situated on the high, windy ridge tops and slopes.

The time factor is also undoubtedly involved. The first forest invasion into the grassland would be by way of the moist and protected stream valleys. The high divides between the valleys would be the last

--The Grassland

areas reached by the invading forests and therefore, the last areas from which prairie vegetation would be displaced. It may be stated that the time factor underlies all these other considerations. Anything which delayed the advance of the forest could be considered as an adjunct of the time factor.

The prairies just described lie along the crest and back slope of the Galena cuesta in the Driftless Area. Only one part mentioned, that in Green County, has been glaciated.

The archipelago of separated prairie areas that extend northeastward from Dane County to the vicinity of Lake Winnebago occurs on an upland surface formed by the blending together of the Galena cuesta and the Lower Magnesian cuesta. These two cuestas form a broad, gently rolling upland which is covered by young glacial drift deposits. The prairies scattered over this upland appear to be in the class designated as high prairies by Curtis and Greene. The surface is higher than the general surroundings, is broad-shouldered and gently rolling, and has a minimum number of deep, protected valleys along which invading forests might find sheltered access to the area. The open, uninterrupted character of the surface also is favorable to the unimpeded sweep of fires through the grassland which

--The Grassland

would act as a further repellent against an encroaching forest. These prairie areas coincide with the Parr-Clyde prairie loam soils,⁴ which are deep and bedded upon glacial boulder clay.

In the extreme southeastern part of the state in Kenosha and Racine Counties is a large prairie area, located on the Elliot-Ashcum silt and clay bams.⁵ This is a gently rolling surface located on low areas of marginal moraines that trend north-south. Much of it is poorly drained and contains a considerable admixture of wet prairie.

Westward from there in Walworth, Waukesha, and Rock Counties are a number of prairies that coincide closely with areas of glacial outwash materials. The largest of these is the Rock Prairie to the east and southeast of Janesville. These prairies are for the most part on the Parr-Clyde soils⁶ with stratified beds of sand and gravel at depths varying from two and one-half to six feet beneath the surface. That there is a relationship between these prairies and the outwash

⁴Muckenhirn, R. J., and N. P. Dahlstrand, Soils of Wisconsin, (A leaflet published by the Soil Survey Division, Wisconsin Geological and Natural History Survey and the Agricultural Experiment Station, University of Wisconsin, Madison, 1947.)

⁵Ibid.

⁶Ibid.

--The Grassland

materials is suggested by the repeated instances in which they coincide on the same locations. It may be that the underlying coarse materials with their poor water-holding qualities are not encouraging to tree growth. Other prairies on outwash materials near the margin of the end moraine of the Green Bay ice lobe are the Sauk Prairie in southeastern Sauk County and the prairies of Waushara County.

In the stream valleys of the Western Upland are a number of prairies that occur on valley train terraces of glacial outwash. These are among the ones referred to by Curtis and Greene as sand prairies. Examples are seen in the Wisconsin River valley below Dane County as at Arena, Spring Green, etc. That forests have difficulty in gaining a foothold on such sites, even without the competition of grass, is shown by the fact that the principal trees that have arrived on the scene are the xerophytic jack pine and some scrub oak.

Other cases of this type of prairie on alluvial terraces are found along the Mississippi Valley, as for example at Prairie du Chien and at the mouths of the La Crosse, Black, and Trempealeau Rivers. Other sand prairies occur along the Chippewa River, principally below the site of the city of Eau Claire, and along the tributaries of the Chippewa.

--The Grassland

In the Western Upland north of the Wisconsin River are a few instances of prairies on ridge top sites somewhat similar to those on the Galena cuesta south of the river. These can not be considered lime prairies, since they occur on the St. Peter sandstone rather than the Galena dolomite or Lower Magnesian limestone. The principal example of prairie on a ridge top site north of the river is that which occurs on the divide between the Mississippi River and the Kickapoo River. In Vernon County most of this divide and its principal western spur have a vegetation cover of upland prairie which probably results from causes similar to those that explain most of the occurrences on the ridges south of the Wisconsin River. In both areas the sites have rather thin soils and rapid surface drainage, both areas are openly exposed to the dehydrating effects of sweeping winds and the unimpeded movement of fires. The ridge top sites in both cases have a veneer of loessial material whose general thickness is from one to three feet,⁷ although whether this fact is related to the occurrence of prairie vegetation the writer does not know.

⁷Whitson, A. R., Soils of Wisconsin, Wisconsin Geological and Natural History Survey, Bulletin No. 68, 1927, p. 60.

--The Grassland

At the northern extremity of the Western Upland in St. Croix County where the Lower Magnesian cuesta is covered by older drift, the country assumes a broad gently rolling upland aspect similar to that of the Lower Magnesian cuesta in Dane and Columbia Counties. On this surface lies one of the largest contiguous areas of upland prairie in the state. Although this is one of the few prairie regions that appears to be anywhere near an accord with the precipitation-evaporation indices (Fig. 10), it is probable that little credence should be given to the indices in view of the fact that the other prairie areas so entirely disregard them. If factors other than precipitation and evaporation are decisive in the other areas, then there is some reason for doubting that precipitation and evaporation are the sole factors here responsible for the prairie's occurrence. Site conditions here as well as elsewhere are probably more significant as causative factors.

The site characteristics of this St. Croix County prairie fit very well the characteristics mentioned by Curtis and Greene as accompanying high prairies. One feature that stands out here is that most of this prairie

--The Grassland

is located on soil mapped as Hines-Hersey silt loam,⁸ which is a forest soil, rather than a prairie soil. Although there is a lack of exact correlation in most areas between prairie soil as mapped and prairie vegetation as mapped, this is the greatest single discrepancy.

As a relict form prairies would be expected to endure longest on those sites most poorly adapted to forest growth. Most of the sites occupied by upland prairie in the state meet in general those expectations; that is, they are on sites located on high windy ridge crests, or on sites having sandy surfaces, sandy subsoils, or thin soils on steep slopes, in other words sites that have a deficiency in available moisture either through excessive surface drainage, excessive underdrainage, or excessive evapotranspiration rates. However, this does not seem to tell the whole story. Some of the sites occupied by the high prairie type of Curtis and Greene have no apparent serious disadvantages for tree growth. It would seem that on these sites, and probably on all others, something else enters in that would not be superficially evident in the physical location. This might be termed the inertia of the ex-

⁸Muckenhirn and Dahlstrand, op. cit.

--The Grassland

isting situation or the time factor. It may be that there is no particular reason why forests have not invaded some of these specific sites other than the matter of having had farther to advance to cover the areas than was the case in other areas of similar site characteristics.

Also prairie fires may have been more effective as a deterrent to forest growth in some areas than in others due to the topographic detail of the sites. Rough land would impede the free sweep of fires to a greater extent than flat or gently rolling land, and therefore, would be more conducive to tree growth, than to prairie growth. Where fires could gain free access, forest migration would be impeded and prairies would survive longer in a forest climate. Forests have spread with the reduction in the number of fires since the agricultural occupancy of the land has been established.

It has been suggested that the lack of mycorrhizal fungi necessary for healthy tree growth has acted as a deterrent to the spread of tree growth in prairie soils.⁹ Where planted artificially, however, many trees grow quite well in prairie soils as can be noted in numerous instances.

⁹Wilde, S. A., F. G. Wilson, D. P. White, Soils of Wisconsin in Relation to Silviculture, Wisconsin Conservation Department, 1949, p. 107.

--The Grassland

In summary there is reason to believe that the time factor, as related to the delaying effects of fire, topography, excessive drainage, winds, etc. is the most important feature in an explanation of the prolonged existence of the upland prairie relicts into the modern era of forest climate.

SECTION XI

SPECIFIC DISTRIBUTION OF VEGETATION TYPES:

OTHER VEGETATION CATEGORIES

Boreal forest, mixed coniferous-deciduous forest, deciduous forest, and grassland are four major vegetation categories of North America that are represented in Wisconsin. Two other groups, swamp forests especially, and brushlands, are important in the state. In addition to these, two miscellaneous categories, windfalls and burned-over areas, deserve mention.

SWAMP FORESTS

The swamp forests are grouped together because of one factor they have in common, the factor of their location in undrained or poorly drained depressions. Also they cannot readily be classified with any other vegetation grouping. The fact of their location on undrained sites causes them to stand distinct from the other forests of the state. Some of the swamp forests are related to one major forest type generically and to another ecologically, which offers difficulty in an attempt to classify them with the major forest groups, but they have one feature in common with each other, that of a swampy site, and on that basis they may be

--Other Vegetation Categories

grouped together.

In general swamp forests are located in those parts of the state affected by glaciation, since the undrained depressions have resulted largely, either directly and indirectly, from glacial action. Most of the depressions are derived directly from glacial action and are in the areas which were covered by the ice and where unequal deposition or scouring left an uneven surface. There are a few poorly drained depressions which result indirectly from glaciation in the so-called Driftless Area. These occur where there has been unequal deposition of glacially-derived material in stream valleys or glacial lake beds by water which originated from the melting ice, or where wind has shifted such water deposited materials. The two typical site locations of this sort in the Driftless Area are in the valleys tributary to the Wisconsin and Mississippi Rivers and in the basin of glacial Lake Wisconsin. The majority of the undrained depressions and consequently the swamp forests are in the glaciated sections. A few are in areas of older drift but most are in the young drift regions.

A second fact that stands out is that an overwhelming proportion of the swamp forests are not only in the glaciated portion of the state but in the part of the glaciated area occupied by the mixed coniferous-deciduous

--Other Vegetation Categories

forest. Relatively few are located in the areas occupied by the boreal forest and by the deciduous forest. The boreal forest has few swamps because it is largely restricted to the Lake Superior Lowland, which is a glacio-lacustrine plain sloping downward toward Lake Superior. The numerous short streams flowing across it have sufficient gradients to incise deep valleys in the soft lacustrine clay deposits and to develop tributaries which reach into essentially all the area. Thus whatever swamps there may have been originally, have been largely drained away. The principal swamp area in the Lowland is in the coastal zone behind Chequamegon Point Bar where wave deposition has retarded drainage.

With respect to the scarcity of swamp forests in the deciduous forest zone, reasons have been noted for their general absence in the portion that is included within the Driftless Area. It has also been pointed out that marsh vegetation instead of swamp forests occupies the larger proportion of the poorly drained depressions in the glaciated portion of the deciduous forest zone (see page 218). The only part of the deciduous forest region that has swamp forests in any quantity is the area in the eastern part of the state between the Rock River and Lake Michigan. This area

--Other Vegetation Categories

coincides almost exactly with the area containing the beech-sugar maple-basswood-oak and the sugar maple-basswood-oak forest associations. The boundaries of this mesophytic forest and of the area to which swamp forests are restricted in the southern part of the state are essentially identical. These boundaries, on the western and southern margins, are essentially the water barriers formed by the Rock River and the Bark River respectively. It has been pointed out that to the windward side of these water boundaries the upland vegetation cover is mostly xerophytic oak and prairie, and the vegetation cover of the poorly drained depressions is marsh. On the leeward side the upland vegetation is the mesophytic beech-sugar maple-basswood-oak and sugar maple-basswood-oak forests, while the vegetation of the wet depressions is swamp forest. It would appear that swamp forest is restricted largely to this area in the deciduous forest zone for the same reason that the mesophytic beech and sugar maple forests occur here. They were preserved in this location by the fire protection afforded by the river barriers on the west and south. However, the swamp forests are not completely restricted to the leeward side of these rivers. Tamarack swamps do occur to some extent west of the Rock River in western Jefferson and eastern Dane Counties. Also areas of tamarack swamp are

--Other Vegetation Categories

sprinkled through the Central Sand Plain in a strip extending from northwestern Columbia County to northeastern Waushara County. But the fact remains that most of the swamp forests of the deciduous forest zone of glaciated southern Wisconsin are east of the above-mentioned water boundaries.

Another factor which might have encouraged the growth of coniferous swamp forests in the Lake Michigan shore area is the cooler summer temperature and the resultant lower evaporation rate. Of all the deciduous forest zones, this part has a summer climate most similar to that of northern Wisconsin where the bulk of the swamp forests occur.

Although the great majority of the swamp forest sites of Wisconsin are in the mixed coniferous-deciduous forest zone in the northern half of the state, they are not distributed evenly throughout that zone, but tend to be concentrated in certain localities. One of these areas of concentration extends northeast-southwest through central Douglas County in the extreme northwestern part of the state. This area lies in a belt of terminal moraines, which give numerous undrained depressions, and at the same time, it is on the divide between streams flowing to the St. Croix River and those flowing to Lake Superior. (See the drainage

--Other Vegetation Categories

detail on Whitson's soil map.) Stream headwaters have not had time to finger back into the area sufficiently to drain the swamps.

Another area of swamp concentration occurs in the central part of northern Wisconsin. Starting in southwestern Ashland County, it continues eastward into Iron County, following the drainage divide between the headwaters of the Chippewa and Flambeau Rivers to the south and the headwaters of the streams flowing to Lake Superior on the north. In Iron County the main concentration turns southward on the divide between the Flambeau River and the Wisconsin River. Toward the east there is a break where the Wisconsin River goes through, but east of the river the concentration of swamps begins again and trends northeastward through Langlade, Oneida and Forest Counties on the divide between the Wisconsin River and the streams flowing southeastward into Green Bay.

Another zone of swamp forest concentration lies to the interior of the Lower Magnesian cuesta in the inner lowland, trending northeast-southwest through eastern Waupaca and northwestern Outagamie Counties, southeastern Shawano County, central Oconto County and part of southern Marinette County. This lowland area stands between the higher land of the crystalline upland on the northwest

--Other Vegetation Categories

and the slightly higher land of the Lower Magnesian and Galena-Black River cuestas on the southeast. It is a continuation of the poorly drained inner lowland zone that holds a concentration of marsh land in central Wisconsin (see page 219).

Smaller concentrations of swamp forest sites occur along the western shore of Green Bay and the western shore of Lake Michigan along the eastern side of the Door Peninsula. In these areas where the dip slope of the Galena-Black River cuesta and the dip slope of the Niagara cuesta carry the land surface under Green Bay and under Lake Michigan respectively, the coastal zones are low and poorly drained.

(a) Coniferous Swamp Forests.

The coniferous swamp forests include white cedar, black spruce, tamarack, and hemlock swamps. The first three of these occur singly or intermixed in various combinations and comprise most of the swamp forests of the state. The coniferous species of these swamps are referred to as the bog conifers. The last, the hemlock swamp, has only a limited representation in Wisconsin.

The bog conifers are related to both the boreal forest and the mixed coniferous-deciduous forest, perhaps also to the deciduous forest. With the exception of hemlock, and possibly white cedar, the species of the

--Other Vegetation Categories

coniferous swamp forests may be looked upon as relicts of the boreal forest and hold-overs from the time when the boreal forest covered the state. They survive and endure in the sites most poorly adapted to the invaders which displaced the main body of the boreal forest. The bog conifers themselves, too, were largely displaced from the area in southern Wisconsin dominated by the grassland.

White cedar, black spruce and tamarack are important elements of the boreal forest of Canada as well as of the small portion of boreal forest represented in Wisconsin. In the boreal forest they also typically occupy the swampy locations, except that in the more rigorous areas where other species disappear, black spruce and tamarack especially take over the upland locations.¹ Even in the boreal forest in northern Wisconsin tamarack sometimes occurs on the uplands. These trees, then, especially the black spruce and tamarack, are boreal species, and their widespread occurrence over the state as relicts results from a past history of coniferous forest dominance.

¹Weaver, John E., and Frederick E. Clements, Plant Ecology, (New York: McGraw-Hill Book Company, Inc., 1938) pp. 489-490.

--Other Vegetation Categories

The bog conifers are also related to the mixed coniferous-deciduous forest. This, however, is largely an ecologic relationship rather than a generic one. Tamarack and black spruce give way to white cedar around the drier margins of the swamps, while white cedar is replaced on the drier sides by the upland mixed forest.

The bogs of the north and central portions of the state have cedar, spruce and tamarack in varied combinations, some swamps have only one of the three species, some two, and some all three. Cedar is more abundant than either tamarack or spruce in the northern part of the state. There are only a few swamps in which it is not present. Weaver and Clements say that it belongs to the forest of the Great Lakes region.²

With distance to the south, tamarack becomes more important than either cedar or spruce. Spruce is of little importance south of the lower end of Lake Winnebago, although it does occur to some extent. One of its principal concentrations lies rather far to the south in eastern Jackson County toward the western margin of the lacustrine plain of glacial Lake Wisconsin.

The largest concentration of tamarack swamp in the state is located in a circular zone along the outer

²Ibid., p. 490.

--Other Vegetation Categories

reaches of this same lacustrine plain. It is found especially in eastern Jackson County, southeastern Clark, southern Wood, southwestern Portage and northeastern Adams Counties. There is almost no cedar in this area. However, cedar and tamarack extend together into southeastern Wisconsin, although cedar is not quite as abundant as tamarack and does not extend quite as far south. Neither does it extend as far west in southern Wisconsin. Tamarack is the only one of the bog conifers that occurs in the valleys of the Western Upland. Here it occupies only those sites whose poor drainage results from the blocking of tributary valleys by glacial materials, transported mainly by water but also to some degree by wind.

Hemlock throughout most of its range in Wisconsin is not a swamp species, although it shows a tolerance and possibly some preference for low sites in many places where other dominant species of the climax drop out. However, there is at least one area where it definitely occurs as a swamp tree. This is in a concentration that covers a large proportion of four townships located west of the Wisconsin River in northwestern Portage County, northeastern Wood County and southern Marathon County.

--Other Vegetation Categories

(b) Deciduous Swamp Forests.

Deciduous swamp forests consist mainly of black ash, elm, willow and silver maple. These species occur individually and in combination. Often some of them, particularly black ash, are seen in swamps also occupied by conifers. The hardwood swamp forest type occurs to some extent in poorly drained sites along streams, but more often it is seen in glacially formed depressions. The total area it covers is by no means comparable to that occupied by the bog conifers. The greatest area of concentration is in eastern Wisconsin, to the north, east and southeast of Lake Winnebago.

An interesting fact is that, like the bog conifers, these species tend to avoid the marsh depressions west of the Rock River and south of the Bark River in glaciated southern and southeastern Wisconsin. About the only swamp tree to be seen in this area, in addition to a few willows here and there, is the tamarack.

BRUSHLAND

The two types of brushland in the state are upland brush and swamp brush. Of the two, upland brush is by far the more important with respect to area covered.

--Other Vegetation Categories

Upland brush or shrub growth is not considered a stable vegetation form in Wisconsin on the same basis as forest or grassland. It consists of a vegetation cover of small growth much of which is in the process of becoming a forest and therefore only temporarily in the brush stage. Most of the forested areas of the state have a lower story of underbrush which consists of true shrubs and young trees of shrub size. However, this type of growth is considered to be an integral part of the forest community and is not mapped as a vegetation type in itself. But if the forest is destroyed a young growth of even age springs up, and because of its small size and brushy nature, forms a vegetation cover that is distinctly different from either forest or grassland, even if it is of a temporary character only. It may consist of seedlings or sprouts of forest trees, although not containing representatives of all the trees of the original forest, since only the light tolerant species can now grow on the unshaded surface. It may also contain some of the true shrubs such as hazel and sumac. As the young trees grow and attain maturity, the true shrubs are shaded out if they are light demanding. If not, they may take their places along with others that come in as a part of the under-story on the forest floor.

--Other Vegetation Categories

Two natural means by which a forest growth may be sufficiently destroyed as to result in the development of brushland are fire and wind. Of these two, fire causes more widespread destruction and results in a more extensive area of brushland. Destruction of a forest by wind is usually of a more restricted nature and leaves a narrow linear strip so that the resulting brush growth assumes a ribbon-like shape.

The most common species in the composition of upland brush is oak, with aspen, white birch, hazel, sumac, elm, crab apple, plum, and thorn also occurring from place to place. There are only small amounts of pine brushland. This would suggest that most of the brushland is in the deciduous forest zone, which is in general true. Most of this vegetation type is either in the deciduous forest zone or in the transition belt between the deciduous forest and the mixed coniferous-deciduous forest. In the deciduous forest area, oak is the usual pioneer and therefore, composes a high percentage of the brush growth. In the more restricted brush areas of the mixed forest, aspen, white birch, and pine form the common species, since these are the normal pioneer species of that area.

Much of the upland brush growth is associated with prairies which could mean that repeated fires from the

--Other Vegetation Categories

prairies, spreading into the adjacent forested area, have reduced the forest to a brush and scrub vegetation. The presence of brushland near prairies might also mean that the brushland represents former prairies that are in the process of being reclaimed by forest. However, this is doubtful, since oak openings rather than brush appears to be the transitional vegetation form between prairies and forest.

In general the greatest proportion of upland brushland occurs in the western part of the state, with the largest concentration extending from northern Jackson and Trempealeau Counties northwestward through Eau Claire, Chippewa and Dunn Counties to southern Barron County.

A second area, much smaller, lies to the west of the one mentioned above. It is located in northwestern St. Croix County and lies adjacent to the large prairie region of that county.

Throughout much of the Western Upland there are scattered spots of upland brush. One concentration of note is that that occurs on the divide between the Mississippi River and the Kickapoo River. Along this divide fragments of brushland and fragments of prairie are intermingled. Other concentrations are restricted to stream valleys.

--Other Vegetation Categories

There is a minimum of brushland in the extreme southern part of the state, and the same is true of the eastern part. Most of the mixed coniferous-deciduous forest zone of northern Wisconsin has little in the way of brushland. There is only one area that is in any way comparable to the one in the western part of the state. This is a zone of concentration that extends northwest-southeast through parts of Shawano and Oconto Counties. Most of the brushland that occupies windfalls or areas of blown down timber are in the mixed coniferous-deciduous forest zone, since most of the windfalls occur in this part of the state.

Swamp brush consists largely of willow and alder growth with the latter being dominant by far. Alder is widely distributed in swamps and marshes throughout the state, where it occurs in conjunction with swamp forests. However, in many swampy places it occurs alone and forms one of the common swamp vegetation forms. Unlike much of the upland brush types it is a stable shrub form and does not develop into a forest growth. Also being restricted to swamp locations its individual areas of occurrence are apt to be much more restricted in size than those of upland brush.

--Other Vegetation Categories

MISCELLANEOUS CATEGORIES

In addition to the various vegetation groups whose distributions within the state have been mapped, there are two other categories, windfalls and burned-over areas, which although not classed as vegetation, have a significance with respect to vegetation, and are mapped accordingly. Both of these features are temporary and fleeting with respect to their actual place locations. The existing vegetation is destroyed in each, the scar remains for a time, and a new growth of vegetation replaces the old. But even though the scars are temporary for any one location, under natural conditions the features themselves are permanent in the sense that they are constantly being renewed at other locations. Thus windfalls and burns are ever present features somewhere within the state at all times and therefore merit some consideration.

(a) Windfalls.

Windfalls are open areas in the forest, usually in the form of linear strips, where violent, localized winds have uprooted and toppled the mature trees, leaving a tangled mass of branches, trunks and roots. Pits and mounds resulting from the uprooting give an uneven surface. With the destruction of the forest trees the local

--Other Vegetation Categories

environment with respect to light, temperature and evaporation conditions is changed, which may favor the growth of different plant species. Thus within such areas the vegetation may be set back to a subclimax form and must start again its development toward the climax. However, since the accumulated humus is not destroyed, as is the case after severe burns, the vegetation may not be reduced to as low a level in the successional scale as after fires and consequently may recover more rapidly.

The occurrence of windfalls is restricted almost entirely to the northern half of the state in the area of mixed coniferous-deciduous forest and boreal forest. The occurrences are very rare within the deciduous forest zone; one in central Crawford County is the only one of any consequence to be noted in that region at the time of the original land survey.

In the northern half of the state instance after instance of windfall was recorded. The more numerous occurrences there may be due to a combination of several causes. In many places the regolith layer is shallow which makes for shallow root systems. Trees of moist areas, such as this is, do not ordinarily have roots as deep-reaching as trees of drier regions. Examples by way of contrast are seen in the cases of the hemlock of

--Other Vegetation Categories

the north with its shallow roots, reaching to depths of about 20 inches only,³ and the burr oak of the south with its deep roots that may go as deep as fourteen feet.⁴ The bog trees also are often very shallow-rooted, many of them developing on the surfaces of quaking or muskeg bogs. The soil over much of the area is light, giving less anchoring effect, and it is also apt to be well-lubricated with moisture. Evergreen tree crowns are heavy and offer much resistance to the wind at all seasons. These reasons may very well account for the contrast in frequency of occurrence of windfalls between the northern and southern parts of the state.

A zone of special concentration of windfalls extends from Rusk County and northern Chippewa County eastward through Taylor and Price Counties to Marathon and Lincoln Counties. This concentration may possibly be explained in part by the fact that this is also the zone of greatest frequency of tornadoes within the state.⁵

³Nichols, George E., The Vegetation of Connecticut, II. Virgin Forests, *Torreya*, XIII, 1913, p. 211.

⁴Weaver, J. E., and Joseph Kramer, The Root System of Quercus Macracarpa in Relation to the Invasion of Prairie, *Botanical Gazette*, XCIV, 1932, pp. 82-83.

⁵U.S.D.A., Yearbook of Agriculture, 1941, Climate and Man, p. 1200.

--Other Vegetation Categories

(b) Burned-Over Areas.

At the time of the land survey, areas of recent burns were also more frequent in northern Wisconsin than in southern. The one noted farthest to the south is in northern Buffalo County. Although burns are distributed throughout much of the northern part of the state, three separate areas stand out in particular. One is in the northwest in Polk and St. Croix Counties in a section whose vegetation indicates that fires may be of common occurrence. Areas of prairie, brushland, aspen forest and oak forest are rather intimately mixed, and among these are large patches of burned-over countryside.

The other areas having a higher percentage of burned-over land than is common are in Vilas County in the north central pine region and in Marinette County in the northeastern pine region.

SECTION XII

GENERAL SUMMARY

The field notes of the original government survey contain the only systematic description of Wisconsin's vegetation cover as it existed prior to white settlement. These field notes were utilized in this thesis as the basic source material for the preparation of a map showing the original vegetation cover of the state. The map is at a scale of 1:500,000 and shows in color the distribution of thirty-three vegetation categories which are distinguished on the basis of their ecological relationships and physiognomic characteristics.

The original vegetation cover of Wisconsin formed a broad pattern, consisting of four major formations, boreal forest, deciduous forest, mixed coniferous-deciduous forest, and grassland. Each of these was but a small segment of a more extensive unit within continental North America. The boreal forest occurred in scattered locations in the northern part of the state, principally on the wet clays of the Lake Superior Lowland. The deciduous forest was located in the southern and southwestern area, south of a line trending sinusously from Sheboygan County to Polk County. The

--Summary

mixed coniferous-deciduous forest occupied most of northern Wisconsin in a position within the state complementary to that of the deciduous forest. The grassland occurred within the deciduous forest zone in the form of separated areas of irregular size.

The areal pattern of these four major formations is largely explained in terms of response to fluctuating climates of the postglacial period. A series of climatic changes recurrently encouraged and inhibited the growth of coniferous forest, deciduous forest, and grassland at different times and to varying degrees in diverse parts of the state. Local environmental conditions also were effective to some extent in prolonging or deterring the existence of representatives of the various formations on specialized sites. As a result of the interaction of the different factors involved, the final broad distribution pattern of the four major formations was composed of a deciduous forest with intermingled areas of grassland in the south, and a mixed coniferous-deciduous forest plus small areas of boreal forest in the north.

Contained within the matrix of this broad pattern was a more detailed pattern made up of adjacently interrelated plant communities. However, not all of the vegetation types were integrated into this finer pattern.

--Summary

Since the vegetation communities were subdivisions of the major vegetal formations, they too had their origins seated in the fluctuating climatic regimes of post-glacial times, although the orderly distributions within this detailed pattern appear to have resulted in response to contemporary climate. The distributions that stood as exceptions to this pattern occurred where non-climatic factors, such as soil type, drainage, topography, catastrophe, and time-lag, were able temporarily to overrule the factor of contemporary climate.

The detailed pattern of interrelated forest communities included in southeastern Wisconsin a sugar maple-basswood-oak forest, which, in the direction of Lake Michigan, became a beech-sugar maple-basswood-oak forest, as the tempering influence of the lake permitted the entrance of beech. Northward along the lake shore, where cooler summer temperatures were met, this latter forest merged with hemlock, yellow birch, and pine to form a beech-hemlock-sugar maple-yellow birch-pine forest in the environs of Green Bay. Westward from here, with a decrease in moisture availability, beech, hemlock, and yellow birch were eliminated in that order. Where beech dropped out the vegetation type became hemlock-sugar maple-yellow birch-pine forest, which covered

--Summary

most of north central and northeastern Wisconsin. Toward the western part of the state hemlock was eliminated, leaving a sugar maple-yellow birch-pine forest. Farther west yellow birch dropped out, and southward where summer temperatures are higher, both yellow birch and pine were eliminated, leaving a sugar maple-basswood-oak forest.

Here the pattern of orderly distribution based on contemporary climate ended. Southeastward in southern and southwestern Wisconsin, the pattern was completely interrupted, and areas of climax sugar maple-basswood-oak forest were intermingled with basswood-oak forest, prairies, oak forest, and oak openings. This irregular distribution had its origin in the fluctuating post-glacial climates. Alternating periods of dry and humid climate resulted in alternating vegetation covers of grassland and forest. Remnants of one persisted on into the periods of dominance of the other. Fires associated with the dry climatic phases were an aid in establishing the grassland and prolonging its existence, while at the same time they discouraged forest growth. Drainage features and some topographic features often impeded the movement of fires and thus tended to protect remnants of the climax forest in favored locations. Pioneer forest types encroached upon grassland during the most

--Summary

recent climatic phase, but grassland remnants remained on sites least favorable for forest invasion. As a result there was an irregular distribution of vegetation in this part of the state rather than a distribution having an orderly pattern.

In central and northern Wisconsin other important exceptions to the orderly pattern of vegetation distribution occurred on areas of extremely sandy soil, whose inhospitable character held the vegetation cover to a subclimax growth of pines or scrub oaks.

Another exception to the general pattern was swamp forests. These were more numerous in northern Wisconsin than in southern, since in southern Wisconsin fires associated with the dry climatic phases had decimated them, except in protected sites, and had permitted the continuance of marsh vegetation rather than forest growth on the poorly drained sites.

APPENDICES

Appendix A: Instructions to United States Deputy Land Surveyors¹

STANDARD CHAIN

Your chain, adjusted to the standard in this office, must be carefully guarded against all injury, and by it you will compare and adjust your measuring chain every morning after the latter has been in service, and note the difference between them in your field book, and if none, then state that fact also.

CORRECTIONS AND RESURVEYS

Full notes of every line and part of a line which you retrace, of every one which you re-establish, of every random line which it is necessary for you to run, which measured or not, of every corner which you re-establish, alter or perfect, of every offset, of the elements of every distance obtained by triangulation, are to be carefully entered at the time in the proper place in your field books.

FIELD NOTES AND BOOKS

The second page in each field book must contain the names and duties of assistants then engaged upon your lines. Whenever you employ a new assistant or change the duty of one, the fact, with the cause thereof, must be given in an entry immediately preceding the notes taken under the new arrangement.

The notes which you take in the field are to be returned to this office. With this view you will enter your notes, taken as above directed, in books containing a number of pages, that will admit of their being entered in every particular in conformity to these instructions. The books must be of regular form, size and material. If after the notes of any one or more townships are thus taken, the book or books are too much worn, soiled or defaced to be returned in conformity to said instructions, you will make out and submit, with the original, a fair handed and neat copy of the same. You are to use no other than black ink of the best quality. No erasures are to be made. If mistakes occur, the pen may be drawn

¹Original Manuscript (date about 1851) in State Land Office, Madison, Wisconsin.

--Appendix A

across the erroneous entry, but always in such a manner that the words can be read afterwards. No leaves are to be cut, torn or otherwise taken out of your field books, as reason is given for suspicion that there was something upon the missing leaves which it was not to the interest of the deputy to have known.

With these instructions you are furnished diagrams of each of the townships of your district upon a scale of two inches per mile, upon which are accurately laid down the respective boundaries of each township, the length of each of the closing lines, the magnetic variation of each mile, and at least two of the bearing trees, at all the section corners thereon, where bearings were taken. P. in M. signifies post in mound, the pits to which (unless it is otherwise stated) are in the direction and at the distance hereinbefore prescribed.

DIAGRAMS

With your field notes you are to return a map of each township of your district, upon the scale above named, upon which is to be expressed the length and variation of each of your lines with all the topography neatly laid down. With a view to the completeness of these maps, you should make sketches of the topography as you progress with your lines, that you may be able to present not only the points upon your lines at which the same occurs, but also its direction and position between the lines or within each section as every object to topography is to be properly closed or connected. These maps form the basis of all the official plots, and are carefully preserved in this office.

SWAMP LANDS

By an act of Congress, approved September 28th, 1850, all the swamp and overflowed lands that are unfit for cultivation, which were unsold at the date of the passage of the said act, were granted to the State or Territory in which said lands are located. In order that the field notes of surveys may hereafter clearly present the quantity and locality of the lands thus granted, you will, in addition to the objects of topography required by the foregoing instructions, note the point upon which you enter and leave all lands which are clearly the subject of the above grant, stating the character of the land thus noted, and of the above grant, stating the character of the land thus noted, and whether it is a

--Appendix A

swamp or marsh, or subject from other cause to inundation, to an extent that would in the absence of artificial means render it uncultivable. The depth of inundation, if in timber, may be easily determined from the marks upon the trees, and its frequency may be ascertained, either from your knowledge of the general character of the stream which overflows, or from the testimony of those residing upon or near the locality under examination. The usual phraseology for entering or leaving a swamp or marsh may be employed with the addition of "unfit for cultivation;" but if the margin of bottom, swamp, or marsh in which uncultivated land exists is not identical with the margin of such uncultivated land, then a separate entry must be made for each opposite the marginal distance at which they respectively occur.

LANDS OVERFLOWED BY ARTIFICIAL MEANS

When lands are overflowed by artificial means (say by dams for milling, logging, or other purposes) you will in no instance set meander posts, but continue your lines across said overflowed tract, in the manner directed in the foregoing instructions, stating particularly in your notes the depth of water and how the overflow is caused.

ERRORS IN TOWN LINES

Should you find a manifest error in the measurement of any of the township lines of your district, you are to correct the same by resurveying and re-establishing such line or lines, from the point where the error was detected, to the north or west end thereof, noting your intersection with each one of the erroneous corners as you progress, which you are to demolish and deface with all evidences thereof. Of such re-measurement and corrections you are to take full and complete field notes, in a separate book, to be returned to the Surveyor General's office, with the field notes of your subdivision.

HOW AND WHAT TO MEANDER

1. In subdividing any one township, you are to meander as hereinafter directed, any lake or lakes, pond or ponds, lying entirely within the boundaries thereof, or the area of forty acres and upwards, and which cannot be drained and are not likely to fill up, or from any cause to become dry.

--Appendix A

2. Whenever required by special instructions, to meander any stream or body of water, passing through or lying within your district, you are also to meander all islands situated therein.

3. Standing with your face toward the mouth of a stream, the bank on your left hand, is termed the left bank, and that upon your right hand, the right bank. These terms are to be universally used to distinguish the two banks of a river, both in running lines and meandering.

4. In meandering rivers, you are to commence at a meander corner in the township boundary, and take the course and distance of the bank upon which you commence, to a meander corner upon the same or another boundary of the same township, carefully noting your intersection with all intermediate meander corners. By the same method you are to meander the opposite bank of the same river.

5. In meandering lakes, ponds or bayous, you are to commence at a meander corner upon the township line and proceed as above directed for the banks of a navigable stream, except where a lake, pond or bayou lies entirely within the township boundaries, when you will commence at a meander corner established in subdividing, and from thence take the course and distance of the entire margin thereof.

6. To meander a pond, lying entirely within the boundaries of a section, you will run a random line thereto from the nearest section or quarter section corner. At the point where this random line intersects the margin of such pond, you will establish a witness point, by fixing a post in the ground and raising a mound or taking bearings, as at a meander corner, except that the post and the larger face upon the bearing trees will be marked with the letter W only.

7. In meandering islands, you are to proceed as directed in sections 5 and 6 of this Chapter, except that where there are no meander corners established upon an island, you are to take the course and distance of your starting point from the nearest meander corner, instead of section or quarter section corner.

8. The meander of each fractional section, or between any two meander posts, or of a pond or island interior of a section, must close within one chain and fifty links.

--Appendix A

9. Your field notes of meanders in any one township, are to follow immediately after the notes of the subdivision thereof. They are to state and describe, particularly, the meander corner from which they commenced, each one with which they close, and are to exhibit the meanders of each fractional section separately, following and composing a part of which will be given a description of the land, timber, depth or inundation to which the bottom is subject, and the banks, current and bottom of the stream or body of water you are meandering.

10. To furnish data that will enable this office to fix their exact location, you will note in the proper place in the meanders of each fractional section the exact position and extent of all falls and rapids, fords, portages and mill sites existing in, or connected with the river or other body of water which you are meandering.

11. No blazes or marks of any description are to be made upon your meander lines, though the utmost care must be taken to pass no object of topography, or change therein, without giving a particular description thereof in its proper place in your meander notes.

FIELD NOTES

1. Your field notes are to form a full and perfect history of your operations in the field.

2. The field notes of the subdivision of every township whether fractional or not, are to be written in a separate book.

3. Description of the timber, undergrowth, surface soil and minerals, upon each section line, is to follow the notes thereof, and not to be mixed with them.

4. The language of your field notes must be so concise and clear, the hand in which they are written so plain and legible, that no doubt can exist as to your figures, letters, words or meaning.

5. No abbreviations are to be made in your field notes, except such as relate to course, to express which, the proper combinations for the capital letters, N. S. E. and W. are to be used; except when a course is exactly to a cardinal point, in which case it is to be written in full.

--Appendix A

6. The description of each mile must be independent, and not refer to a preceding description.

7. The date of each day's work must follow immediately after the notes thereof.

8. All rivers, creeks and other streams, lakes, ponds, prairies, swamps, marshes, groves, hills, bluffs, windfalls, roads and trails, are to be distinguished in your field notes by their original and received names only, and where such names cannot be ascertained or do not exist your imagination is not to supply them.

9. Your field notes must be kept in the exact form of the specimen herewith furnished you.

Objects and data to be embraced in your field notes.

You are to enter in their proper places in the field notes of your survey, a particular description and the exact location of the following objects:

1. The length and variation or variations of every line you run.

2. The name, and diameter of all bearing trees, with the course and distance of the same from their respective corners.

3. The name of the material of which you construct mounds, with the course and distance to the pits.

4. The name, diameter and exact distance to all those trees which your lines intersect.

5. At what distance you enter, and at what distance you leave every river, creek or other "bottom", prairie, swamp, marsh, grove or windfall, with the course of the same at both points of intersection.

6. The surface, whether level, rolling, broken or hilly.

7. The soil, whether first, second or third rate.

8. The several kinds of timber and undergrowth, naming the timber in the order of its prevalency.

--Appendix A

9. All rivers, creeks and smaller streams of water, with their actual or right angled widths, course, banks, current and bed, at the point where your lines cross.

10. A description of all bottom lands, whether wet or dry, and subject to inundation, state to what depth.

11. All springs of water, and whether fresh, saline or mineral, with the course and width of the stream flowing from them.

12. All lakes and ponds, describing their banks and the depth and quality of their water.

13. All coal banks, precipices, caves, sink-holes, quarries and ledges with the character and quality of the same.

14. All water-falls and mill sites.

15. All towns and villages, houses, cabins, fields and sugar camps, factories, furnaces and other improvements.

16. All metalliferous minerals or ores, and all diggings therefor, with particular descriptions of both, that may come to your knowledge whether intersected by your lines or not.

17. All roads and trails, with the course they bear.

18. All offsets or calculations by which you obtain the lengths of such part of your lines as cannot be measured with the chain.

19. The precise course and distance of all witness corners from the true corners which they represent.

AFFIDAVIT

Following the field notes and general descriptions, in each of your field books, an affidavit of the following form is to be written, and to be signed by yourself and each of your assistants in the field:

--Appendix A

I, A. B. Deputy Surveyor, do solemnly swear (or affirm) that, in pursuance of a contract with C. D. Surveyor General of the United States for Wisconsin and Iowa, bearing date the day of , 18 , and in strict conformity to the laws of the United States, and the instructions of the said Surveyor General, I have regularly surveyed principal meridian (State or Territory) of and I do further solemnly swear (or affirm) that the foregoing are true and original field notes of the said survey, executed as aforesaid.

G. H.)		
I. H.)	Chainmen	A. B. Deputy Surveyor
L. M.	Marker	
N. O.	Flagman	

Subscribed by said A. B. Deputy Surveyor, and sworn before me at this day of 18 . P.Q. Justice of the Peace (or other officer authorized to administer oaths) of in the county of State (or Territory) of

2. Your attention is directed to the following section of an Act of Congress, approved August 8th, 1846, entitled "An Act to equalize the compensation of Surveyors General of the public lands of the United States, and for other purposes:"

3. "That the Surveyors General of the public lands of the United States, in addition to the oath now authorized by law to be administered to deputies on their appointment to office, shall require each of their deputies, on the return of his surveys, to take and subscribe an oath or affirmation that those surveys have been faithfully and correctly executed, according to law and the instructions of the Surveyor General; and, on satisfactory evidence being presented to any court of competent jurisdiction that such surveys, or any part thereof, had not been thus executed, the deputy making such false oath or affirmation shall be deemed guilty of perjury, and shall suffer all the pains and penalties attached to that offense; and the district attorney of the United States for the time being, in whose district any such false, erroneous, or fraudulent surveys shall have been executed, shall, upon the application of the proper Surveyor General, immediately

--Appendix A

institute suit upon the bond of such deputy; and the institution of suit shall act as a lien upon any property owned or held by such deputy, or his sureties, at the time such suit was instituted."

The above section of the said law applies to the foregoing affidavit, and will be in all particulars and in every instance rigidly enforced.

GENERAL REMARKS

Your attention is particularly directed to the following specimen of field notes, which will illustrate the order and method of performing the work, and the manner in which your field notes are to be returned, and is to be regarded, therefore, as a part of these general instructions, any departure from which, without special authority, will be considered a violation of your contract and oath, and a forfeiture to all claim of payment. As your work will be rigidly examined in the field, by a Deputy appointed by this office for the special purpose, any neglect on your part cannot fail to be reported, and the penalty, however disagreeable, will certainly be enforced.

Appendix B: Symbols Used for Recording Vegetation Data

TYPE OF PLANT GROWTH

- 1. Forest
- 2. Grassland
- 3. Brush
- 4. Marsh or swamp
- △ Scattered stand
- $\frac{3}{3}$ Undergrowth

GENERIC TYPES

- A. Crab Apple
- B. Ash
 - B¹ Black ash
 - B² Red ash
 - B³ White ash
- C. Aspen
- D. Basswood or linden
- E. Birch
 - E¹ Paper or White birch
 - E² River or Black birch
 - E³ Yellow birch
- F. Box elder
- G. White walnut or butternut
- H. Cherry
- I. Cottonwood
- J. Elm
 - J¹ Red elm
 - J² White elm
 - J³ Black elm
- K. Hackberry
- L. Hawthorn
- M. Hazel
- N. Hickory
- O. Ironwood
 - O¹ Water beech
- P. Locust
- Q. Maple
 - Q¹ Red maple
 - Q² Silver maple
 - Q³ Sugar maple

--Appendix B

- R. Oak
 - R¹ Black oak
 - R² Burr oak
 - R³ Yellow oak
 - R⁴ Jack oak (or scrubby growth)
 - R⁵ Red oak
 - R⁶ Swamp oak
 - R⁷ White oak
- S. Pine
 - S¹ Jack pine
 - S² Red or Norway pine
 - S³ White pine
- T. Plum
- U. Red bud
- V. Black Walnut
- W. Willow
- X. Prickly ash
- Y. Cedar
 - Y¹ Red cedar
 - Y² White cedar
- Z. Spice tree
- a. Sumac
- b. Tamarack
- c. Balsam poplar
- d. Alder
- e. Beech
- f. Cranberry
- g. Spruce
- h. Hemlock
- i. Balsam fir
- j. Witch hazel
- k. Sycamore
- m. White haw
- n. Red root
- p. Gooseberry
- r. Grape vine
- l. Dogwood
- t. Whortleberry
- w. Huckleberry
- y. Leatherwood

TABLE I

AVERAGE VAPOR PRESSURE DIFFERENCES¹⁶
 (Expressed in inches of mercury)

	J	F	M	A	M	J	J	A	S	O	N	D
Dubuque, Ia.	.0269	.0345	.0651	.1283	.1853	.2224	.2873	.2416	.1712	.1188	.0619	.0337
Duluth, Minn.	.0097	.0131	.0313	.0678	.0989	.1200	.1420	.1363	.0959	.0698	.0344	.0142
Green Bay, Wis.	.0217	.0255	.0486	.0925	.1473	.1967	.2472	.1903	.1448	.0875	.0556	.0305
LaCrosse, Wis.	.0290	.0236	.0503	.1153	.1559	.1885	.2282	.2029	.1395	.1032	.0442	.0273
Madison, Wis.	.0181	.0229	.0498	.0966	.1571	.1957	.2629	.2175	.1528	.1013	.0489	.0246
Milwaukee, Wis.	.0267	.0324	.0534	.0836	.1243	.1693	.2240	.2019	.1502	.1148	.0563	.0310
Minneapolis, Minn.	.0242	.0283	.0551	.1168	.1842	.2255	.2989	.2499	.1729	.1196	.0531	.0291

¹⁶Based on relative humidity and humidity data for the stations concerned from the Local Climatological Summary, 1949, U. S. Department of Commerce, Weather Bureau.

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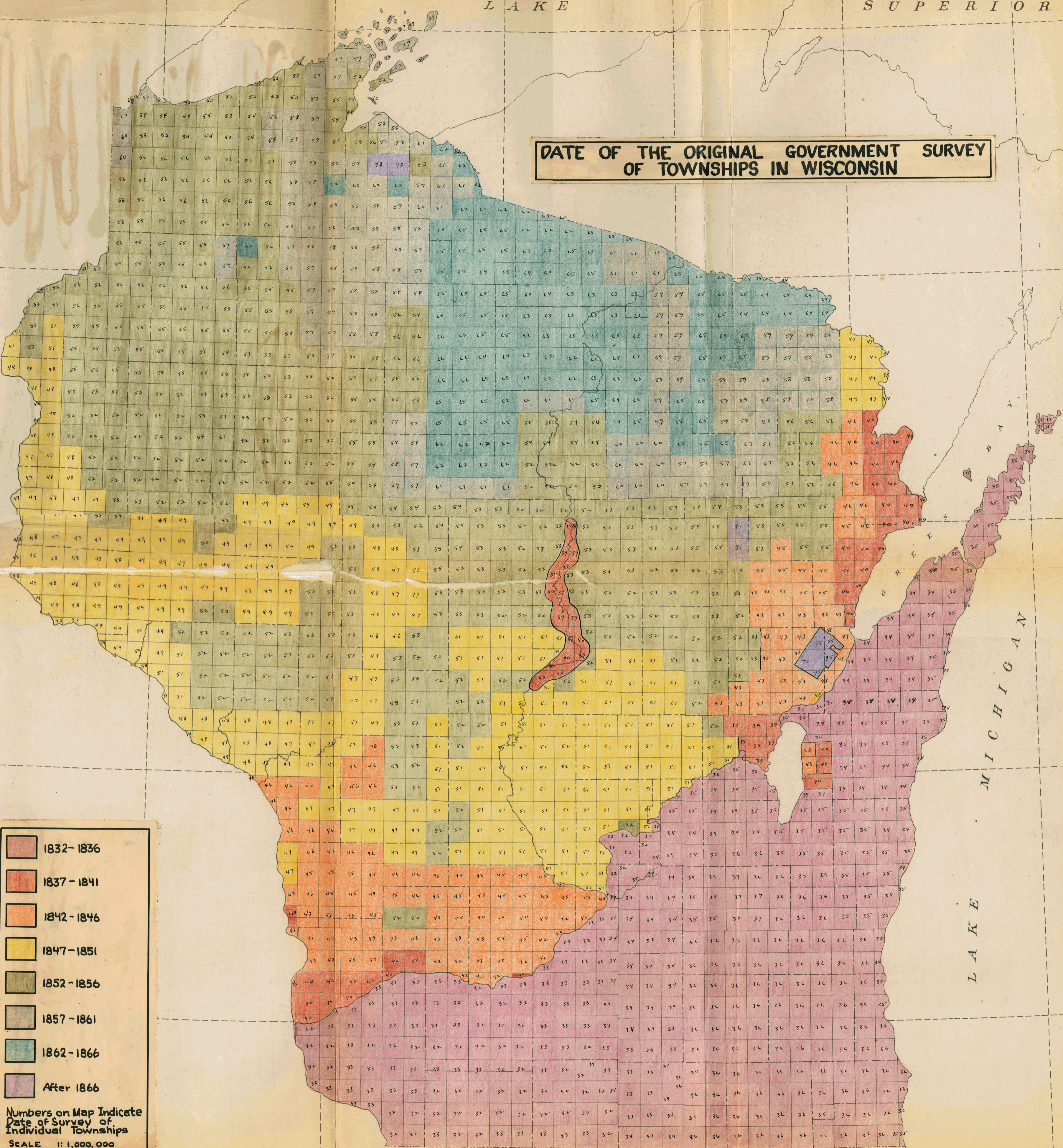
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DATE OF THE ORIGINAL GOVERNMENT SURVEY OF TOWNSHIPS IN WISCONSIN



1832-1836
 1837-1841
 1842-1846
 1847-1851
 1852-1856
 1857-1861
 1862-1866
 After 1866

Numbers on Map Indicate
 Date of Survey of
 Individual Townships
 SCALE 1: 1,000,000

County Langlade

Town 31 N Range 11 E or W of 4th. P.M

Surveyor H. C. Fellows Date Sept, 1860

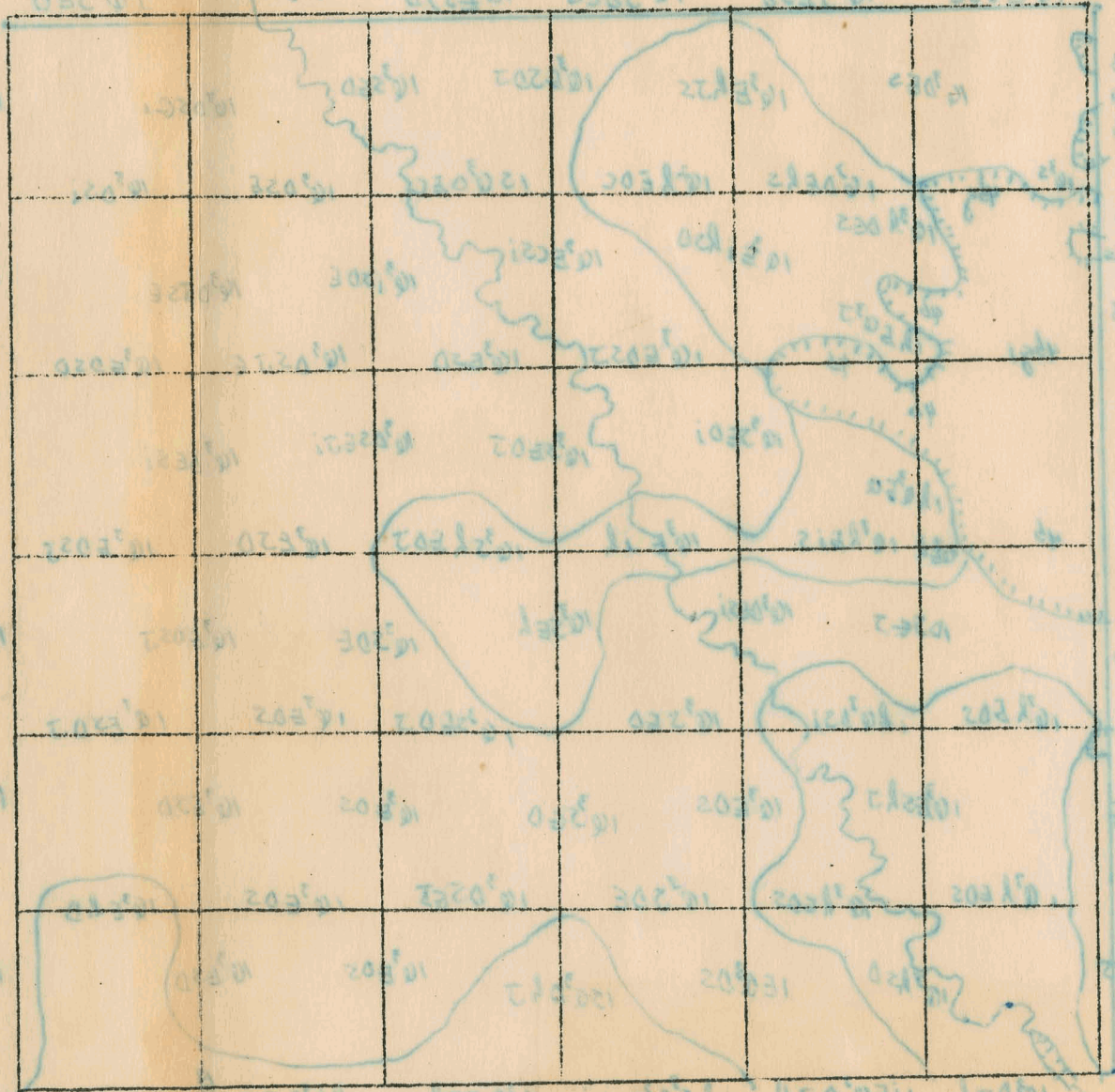


Fig. 2. Sample of Township Worksheets and Recording Symbols.

CONTINENTAL DISTRIBUTION OF THE FOUR MAJOR VEGETATION FORMATIONS OCCURRING IN WISCONSIN

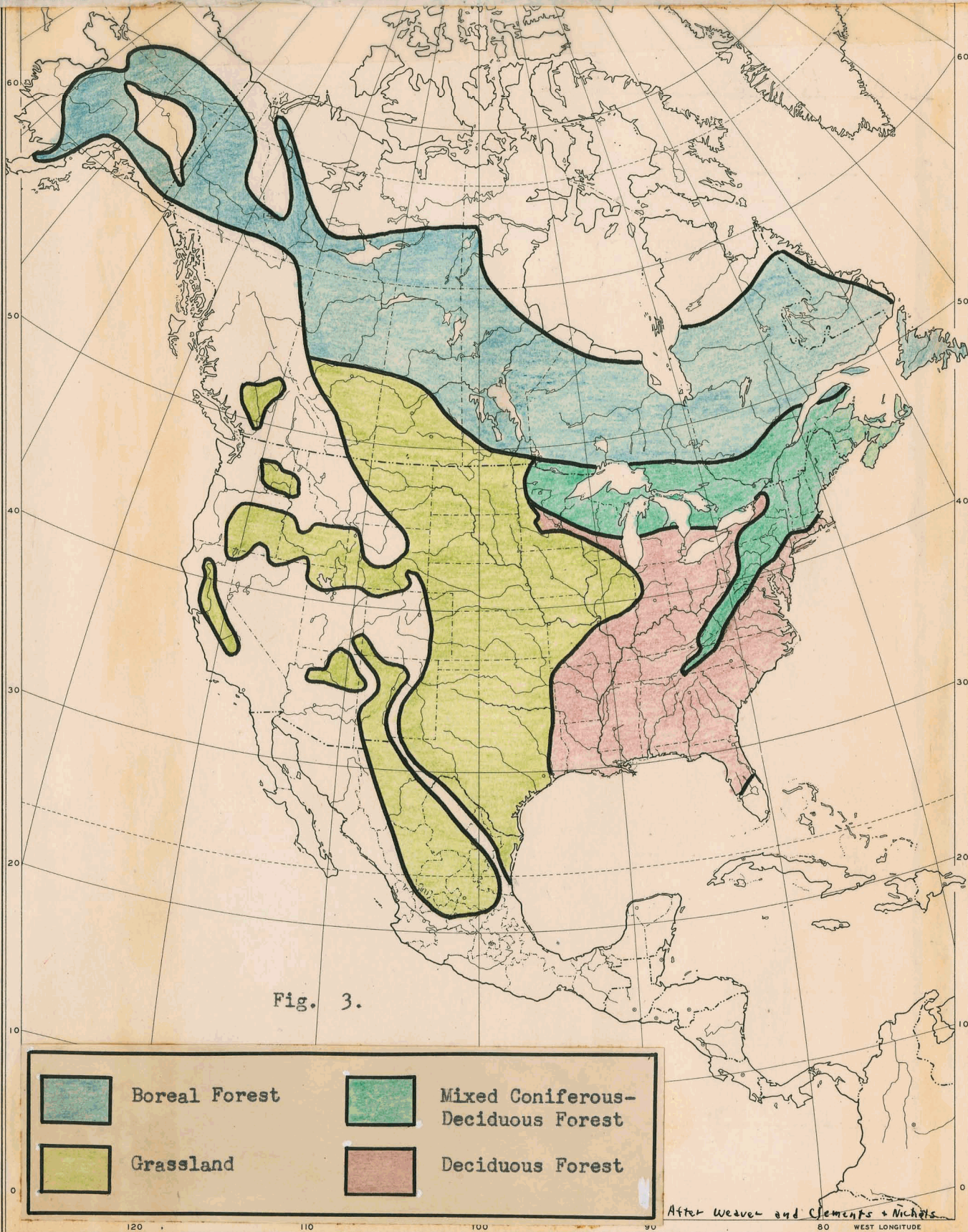






Fig. 3.

	Boreal Forest		Mixed Coniferous- Deciduous Forest
	Grassland		Deciduous Forest

After Weaver and Clements + Nichols

THE FOUR MAJOR VEGETATION GROUPS OF WISCONSIN

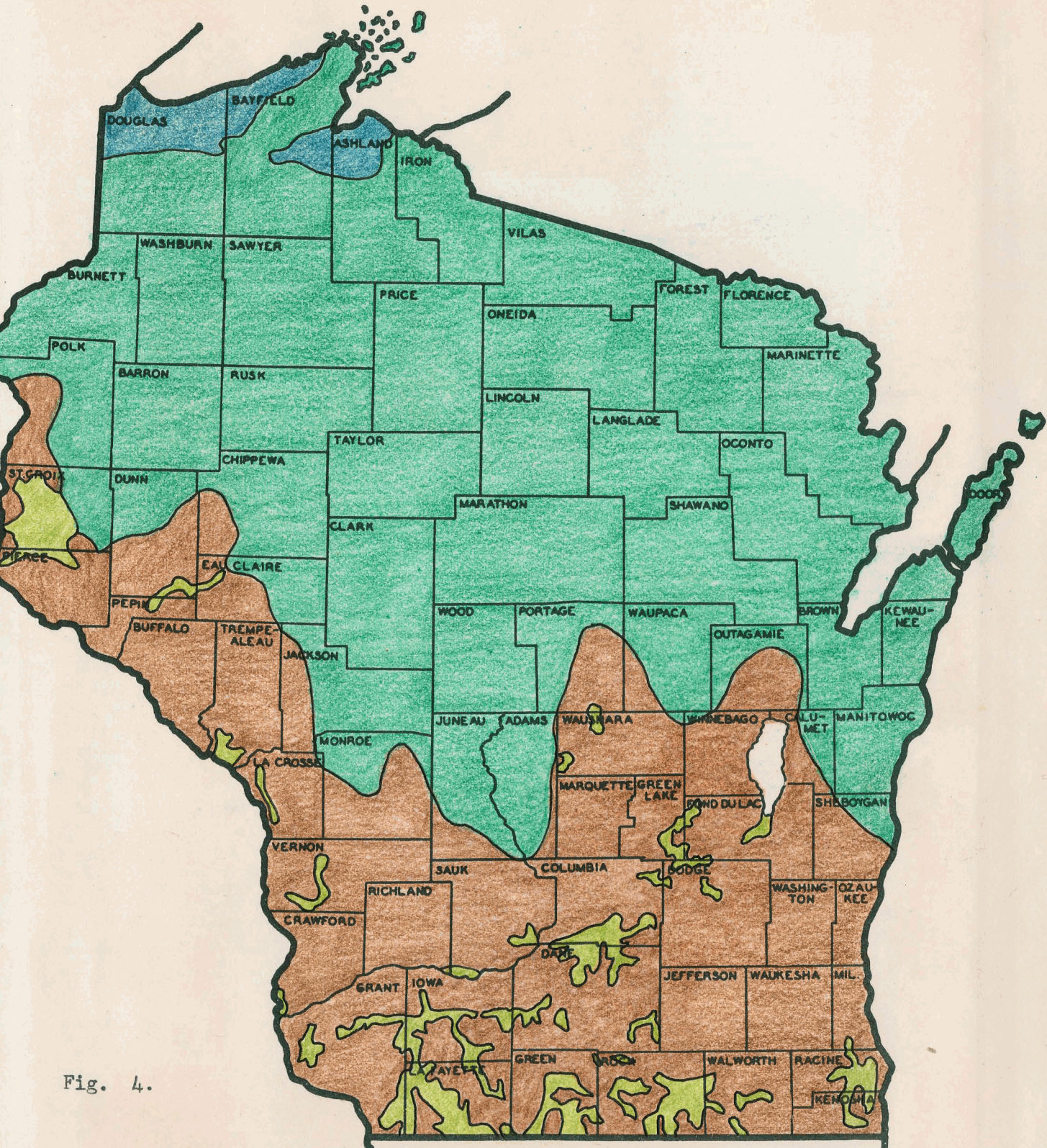


Fig. 4.

- | | | | |
|---|------------------|---|-----------------------------------|
|  | Boreal Forest |  | Mixed Coniferous-Deciduous Forest |
|  | Deciduous Forest |  | Grassland |

GENERALIZED VEGETATION MAP OF WISCONSIN

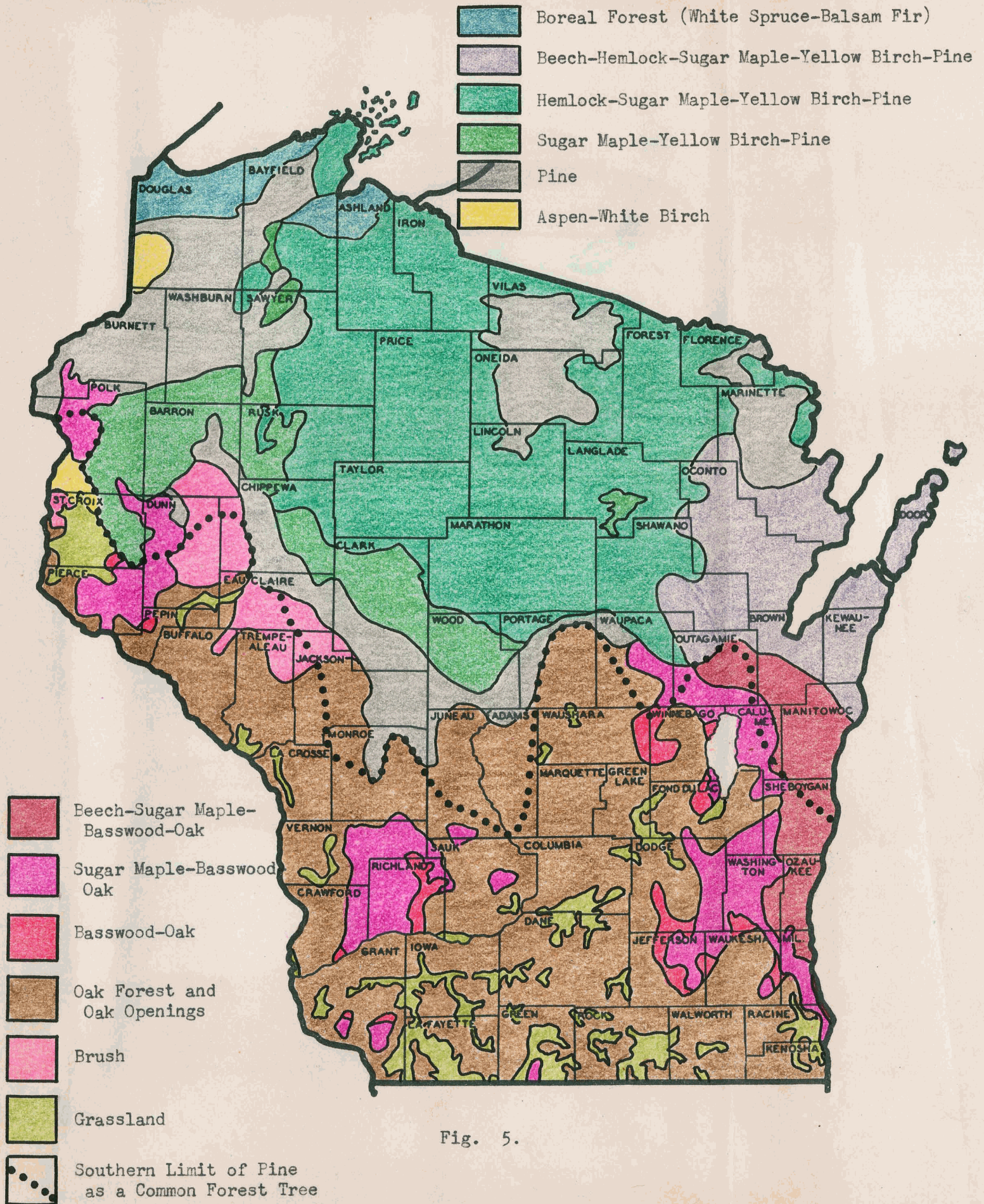


Fig. 5.

Figs. 6a, b, c, d, e. Postulated Postglacial Changes in
Climate and Vegetation in Wisconsin.

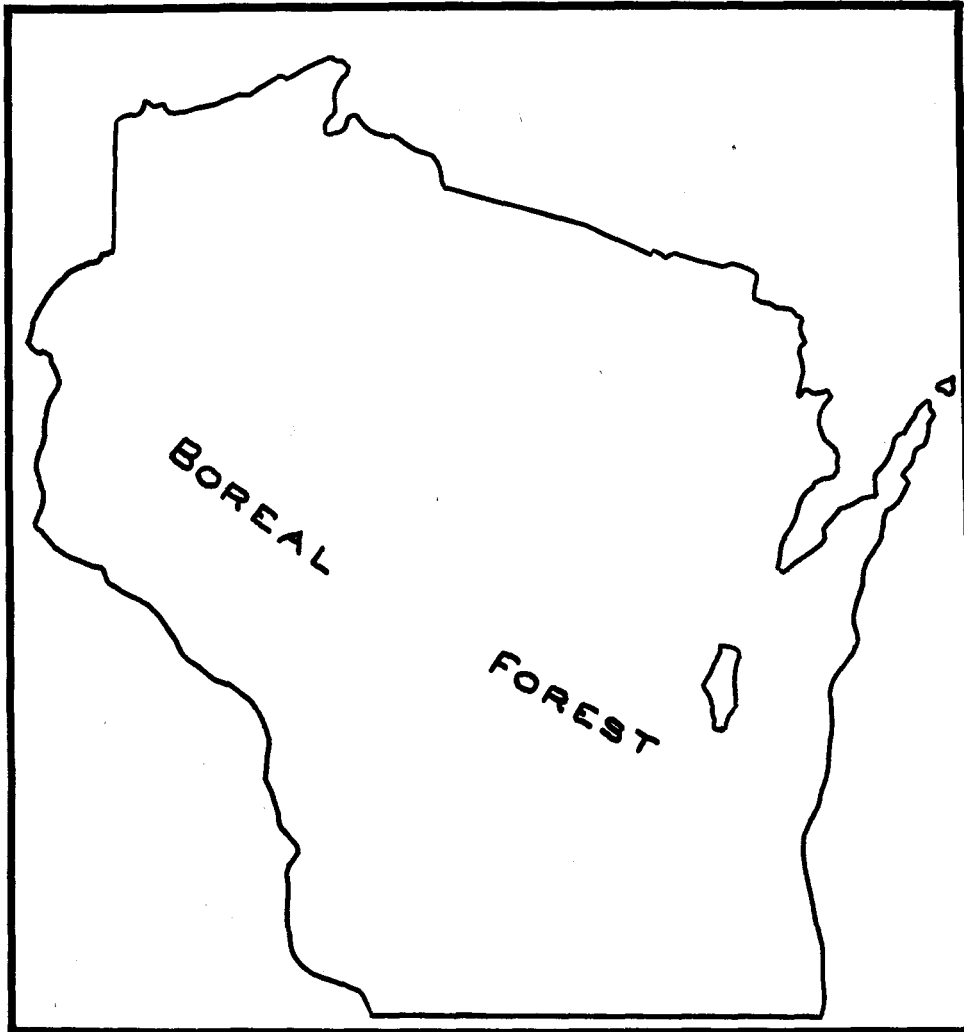


Fig. 6a. First Phase.

Climate--Cool and moist.

Vegetation-- Boreal forest dominance over entire state. Spruce and fir on uplands. Bog conifers in swamps. Pines on xeric sites. Possibly some hardwoods in south near the end of the period.

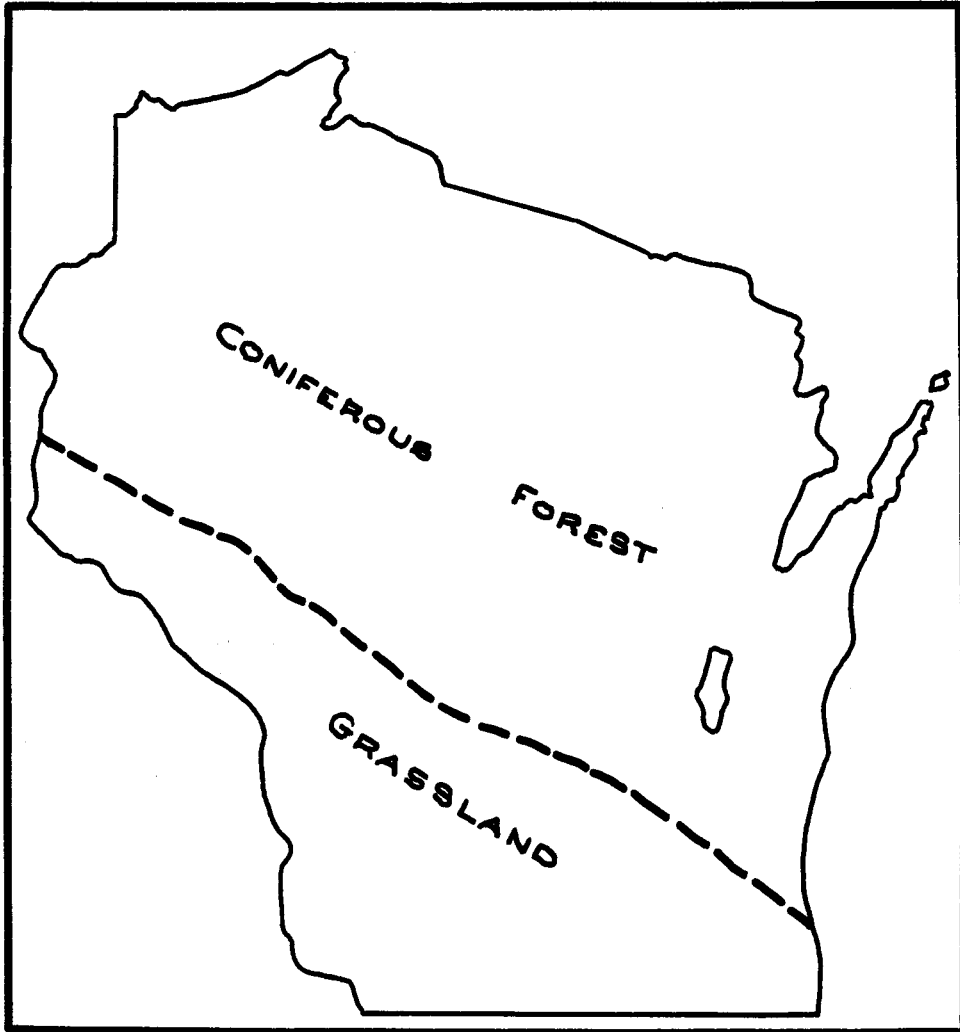


Fig. 6b. Second Phase.

Climate--Warmer (but still cool) and dry.

Vegetation--Grassland dominance in the south with some hardwoods.
Coniferous forest in north, probably pine dominance.

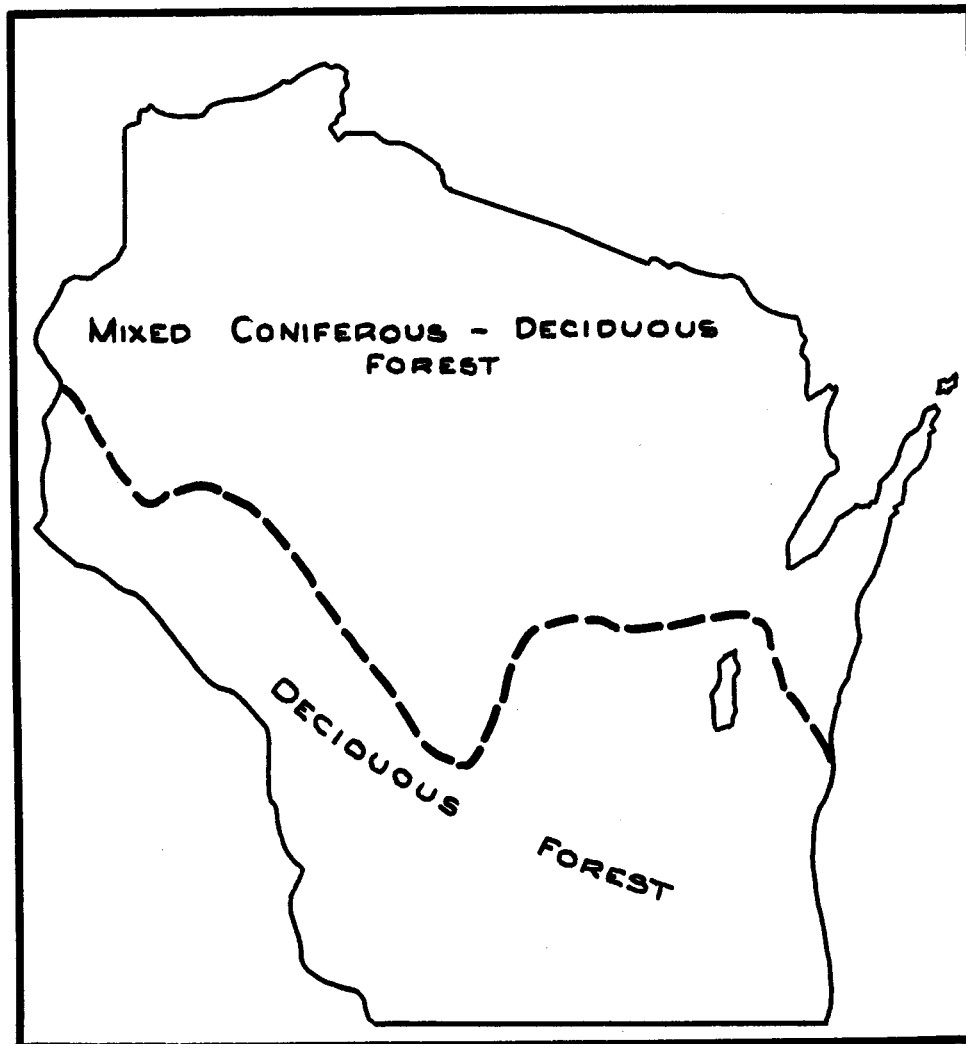


Fig. 6c. Third Phase.

Climate--Warm and moist.

Vegetation--Mesophytic deciduous forest in south, sugar maple-basswood climax, some beech. Mixed coniferous-deciduous forest in north.

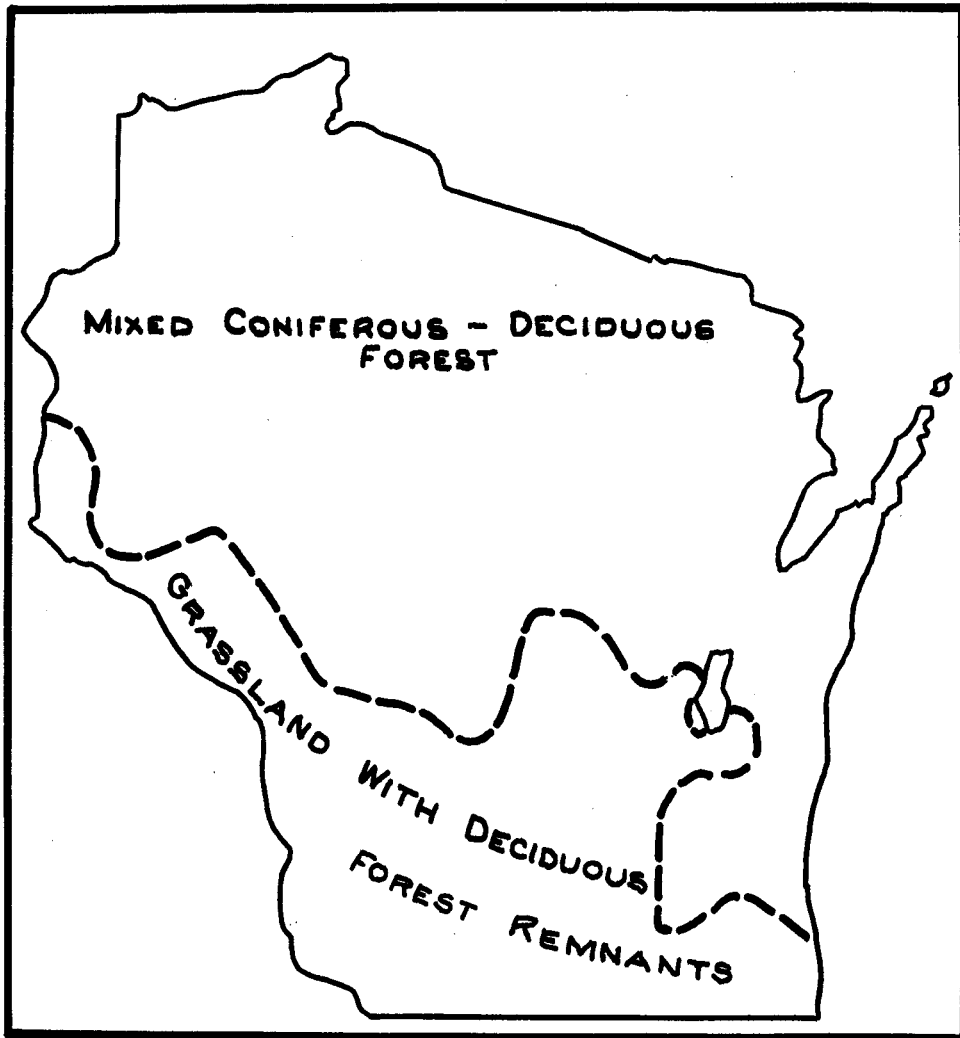


Fig. 6d. Fourth Phase.

Climate--Warm and dry.

Vegetation--Grassland dominance in south with isolated remnants of sugar maple-basswood forest. Mixed coniferous-deciduous forest in north, probably pine-oak dominance.

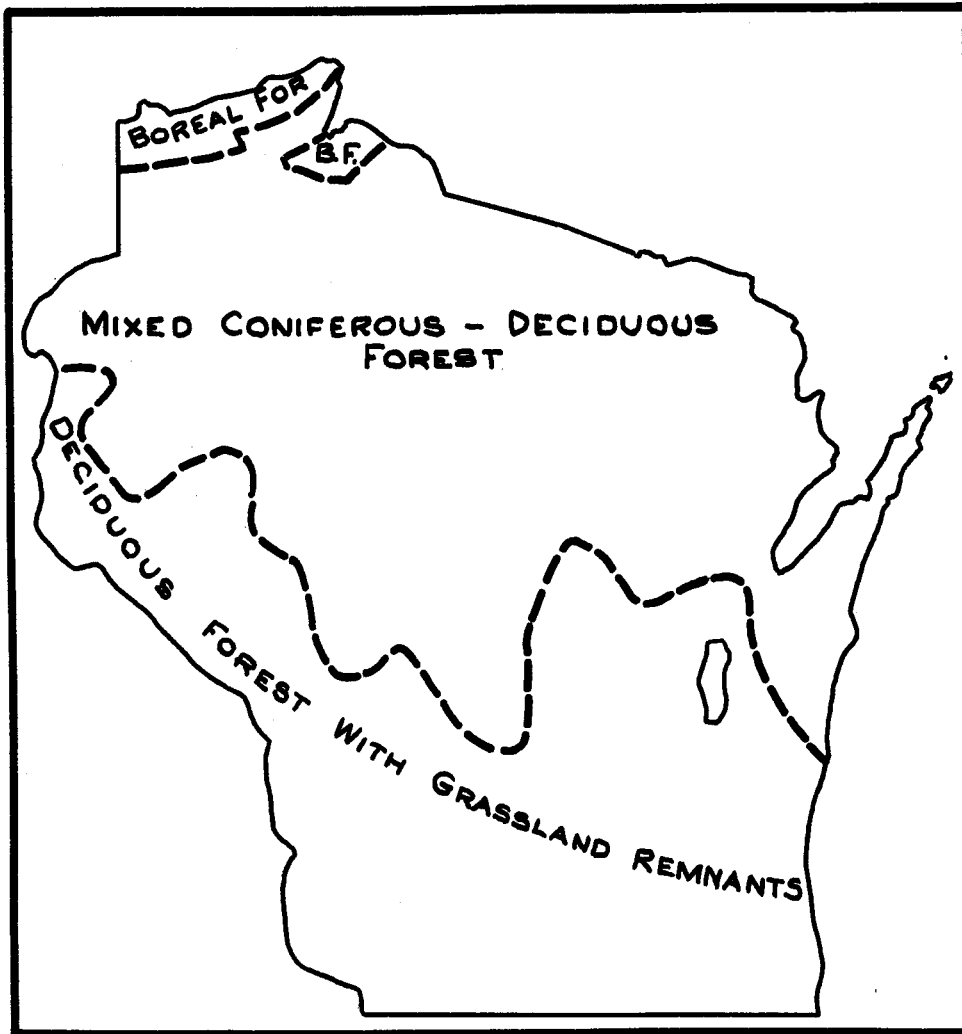


Fig. 6e. Fifth Phase.

Climate--Cool and moist.

Vegetation--In south deciduous forest, oak with progression toward sugar maple-basswood climax, remnants of grassland. In north mixed coniferous-deciduous forest, isolated areas of boreal forest.

DIAGRAMMATIC ARRANGEMENT OF PRINCIPAL VEGETATION TYPES OF WISCONSIN

**BOREAL FOREST
WHITE SPRUCE-
BALSAM FIR**

**SUGAR MAPLE-
YELLOW BIRCH-
PINE**

**SUGAR
MAPLE-
BASSWOOD-
OAK**

BASSWOOD-OAK

**BEECH-HEMLOCK-SUGAR
MAPLE-YELLOW BIRCH
PINE**

**SUGAR MAPLE-
BASSWOOD-OAK**

**OAK
OAK OPENINGS
SUGAR MAPLE-BASSWOOD-OAK
BASSWOOD-OAK
GRASSLAND**

BASSWOOD-OAK

**BEECH-
SUGAR MAPLE-
BASSWOOD-
OAK**

Fig. 7. In central part of Wisc. there are extremely sandy soils. They have an inhospitable character. Vegetation in that part is mostly restricted to pines or scrub oaks whose can hold sandy soils. It was caused by influence of the people becoming.

In northern Wisc. there are rarely swamps. They develop in general because it prevents trees from state to southern part of a to diminish. Dry and associated with fires let marsh vegetation to develop better than forest veget. While needs much more water than marsh veget.

There are rarely swamps where are exceptions. They develop in general because it prevents trees from state to southern part of a to diminish. Dry and associated with fires let marsh vegetation to develop better than forest veget. While needs much more water than marsh veget.

other parts of Wisconsin land and vegetation were influenced less by climate changes and more by postglacial climates. Climate became humid then dry then humid and dry etc. Those changes left mixed vegetation covers of grassland & forest. When it was very dry there was a lot of fire. Fire encouraged growth of grasses and discouraged growth of forest. Drainage incidents caused most likely forest cover. Some of a forest types take over grasslands in recent climate stage. Not every grassland is favorable for forest cover, so there's an irregular distribution of vegetation cover in south and northwestern Wisconsin.

Moving westward hemlock was eliminated and vegetation that left consisted

More to wards west there was less moisture and trees like beech, hemlock and yellow birch were eliminated. When beech was eliminated vegetation became

Moving north from swamps were older and from hemlock, yellow birch and pine vegetation transformed to

WISCONSIN ISOTHERMS FOR JULY FAHRENHEIT

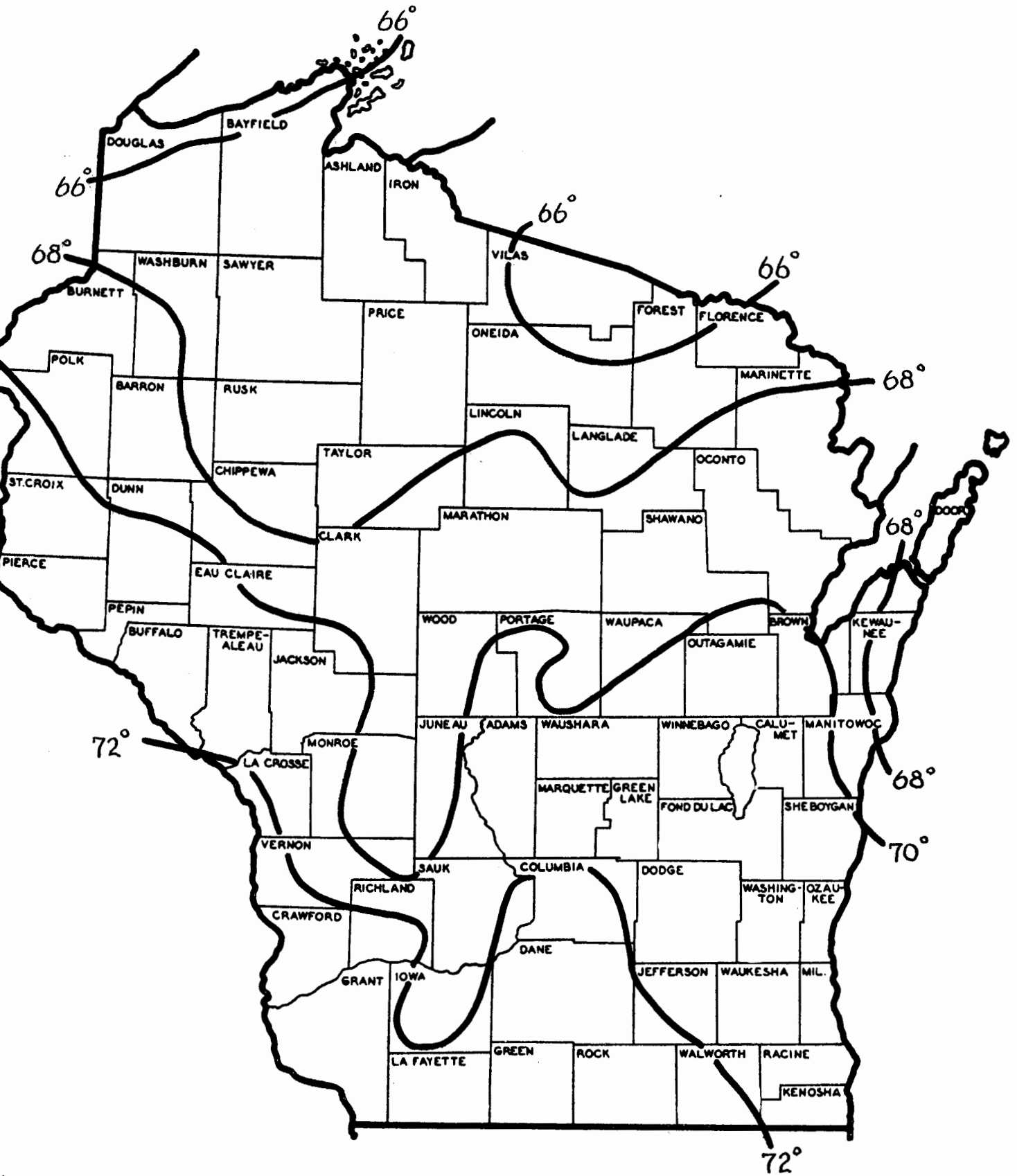


Fig. 8.

AVERAGE VAPOR PRESSURE DIFFERENCES
FOR
SELECTED STATIONS

(Expressed in hundredths inches of mercury)



Fig. 9.

THORNTHWAITE'S PRECIPITATION-EVAPORATION INDICES AS APPLIED TO WISCONSIN

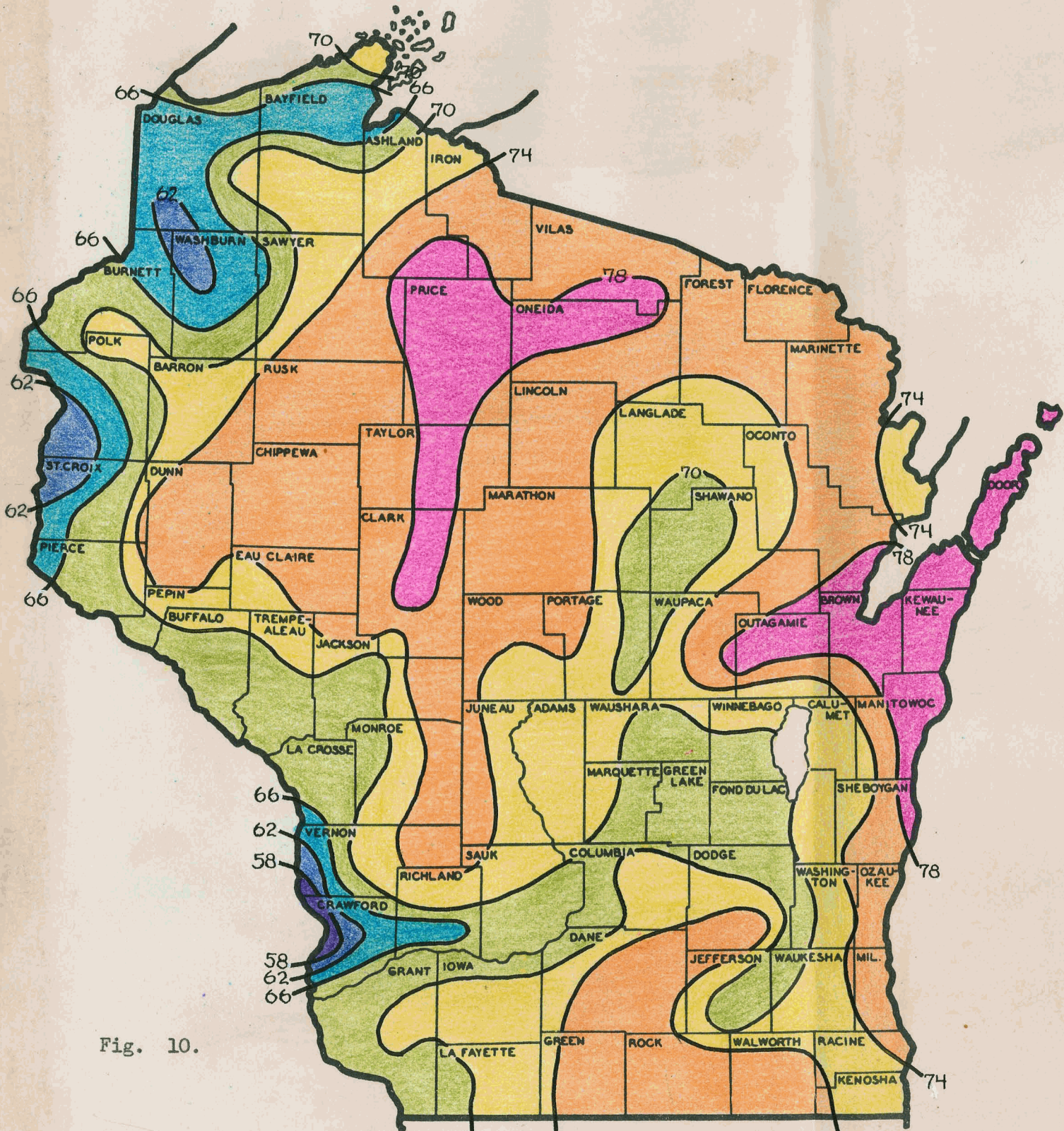


Fig. 10.

HUMIDITY PROVINCE	CHARACTERISTIC VEGETATION	P-E INDEX
Wet	Rain Forest	128 and above
Humid	Forest	64 to 127
Sub-humid	Grassland	32 to 63
Semi-arid	Steppe	16 to 31
Arid	Desert	less than 16

DISTRIBUTION OF TWO MIXED CONIFEROUS-DECIDUOUS FOREST TYPES IN NORTH AMERICA

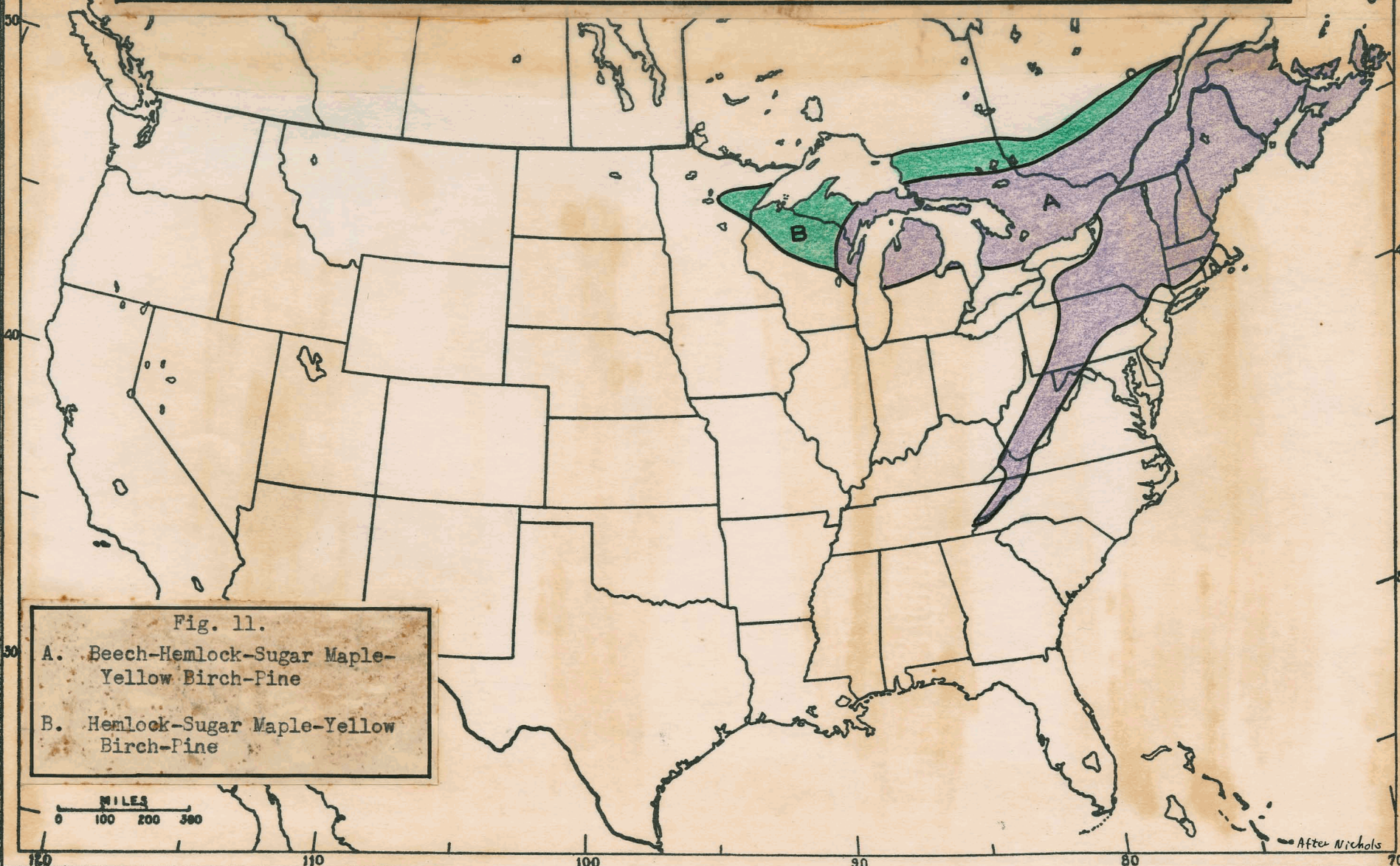


Fig. 11.

A. Beech-Hemlock-Sugar Maple-
Yellow Birch-Pine

B. Hemlock-Sugar Maple-
Yellow Birch-Pine

MILES
0 100 200 300

After Nichols

After Nichols

DISTRIBUTION OF BEECH IN NORTH AMERICA

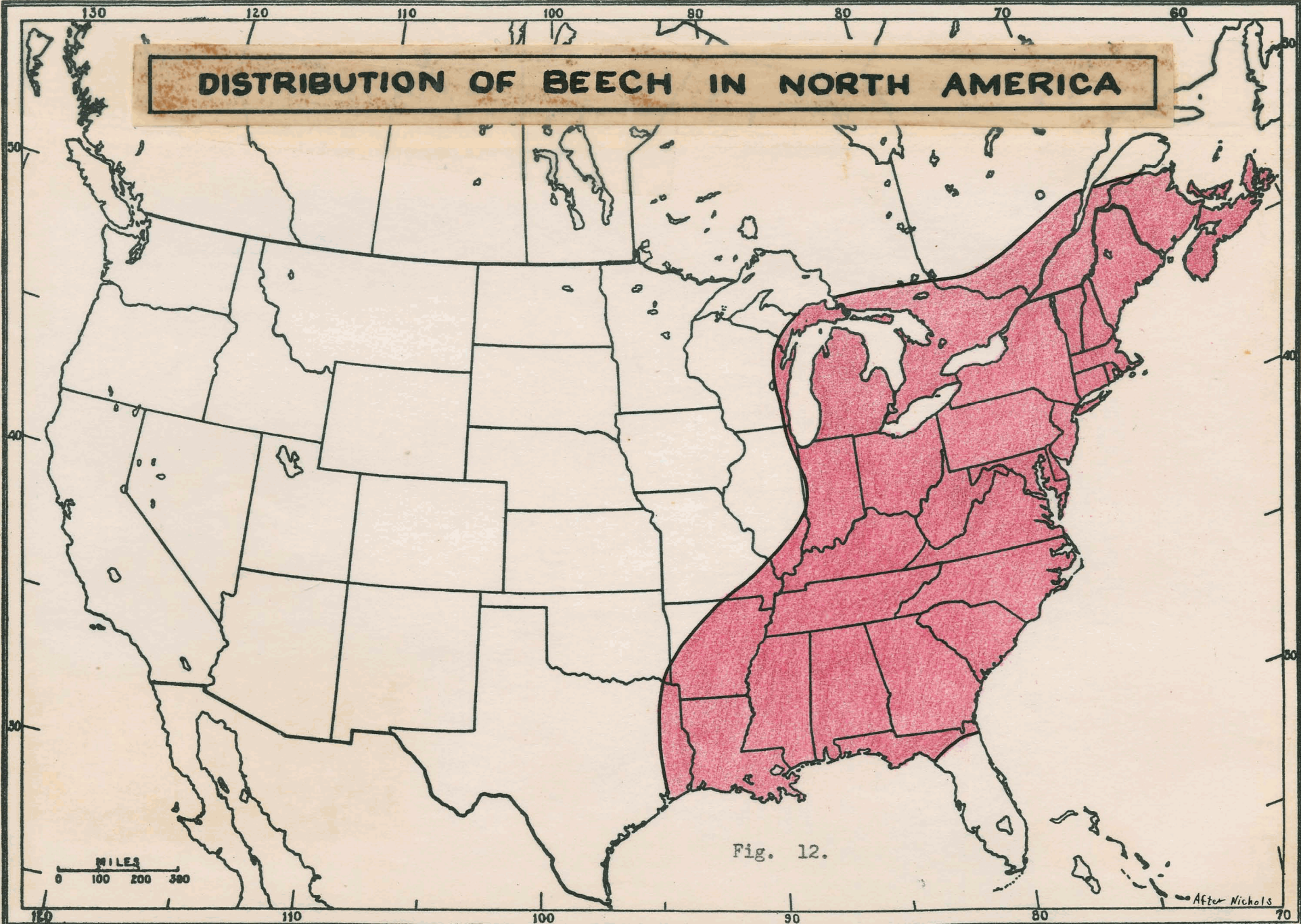


Fig. 12.

After Nichols

After Nichols

DISTRIBUTION OF BEECH - SUGAR MAPLE FOREST ASSOCIATION IN NORTH AMERICA

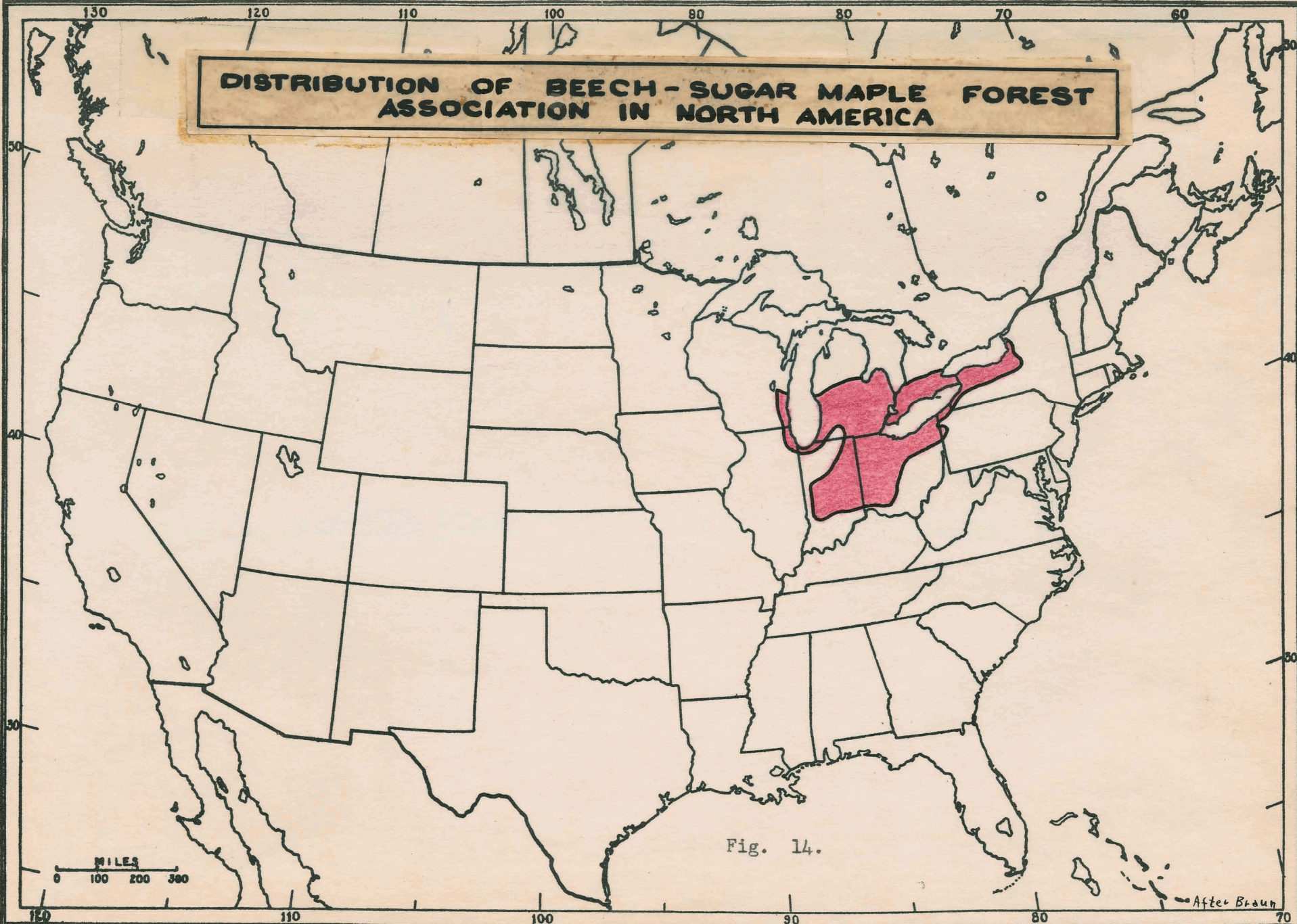
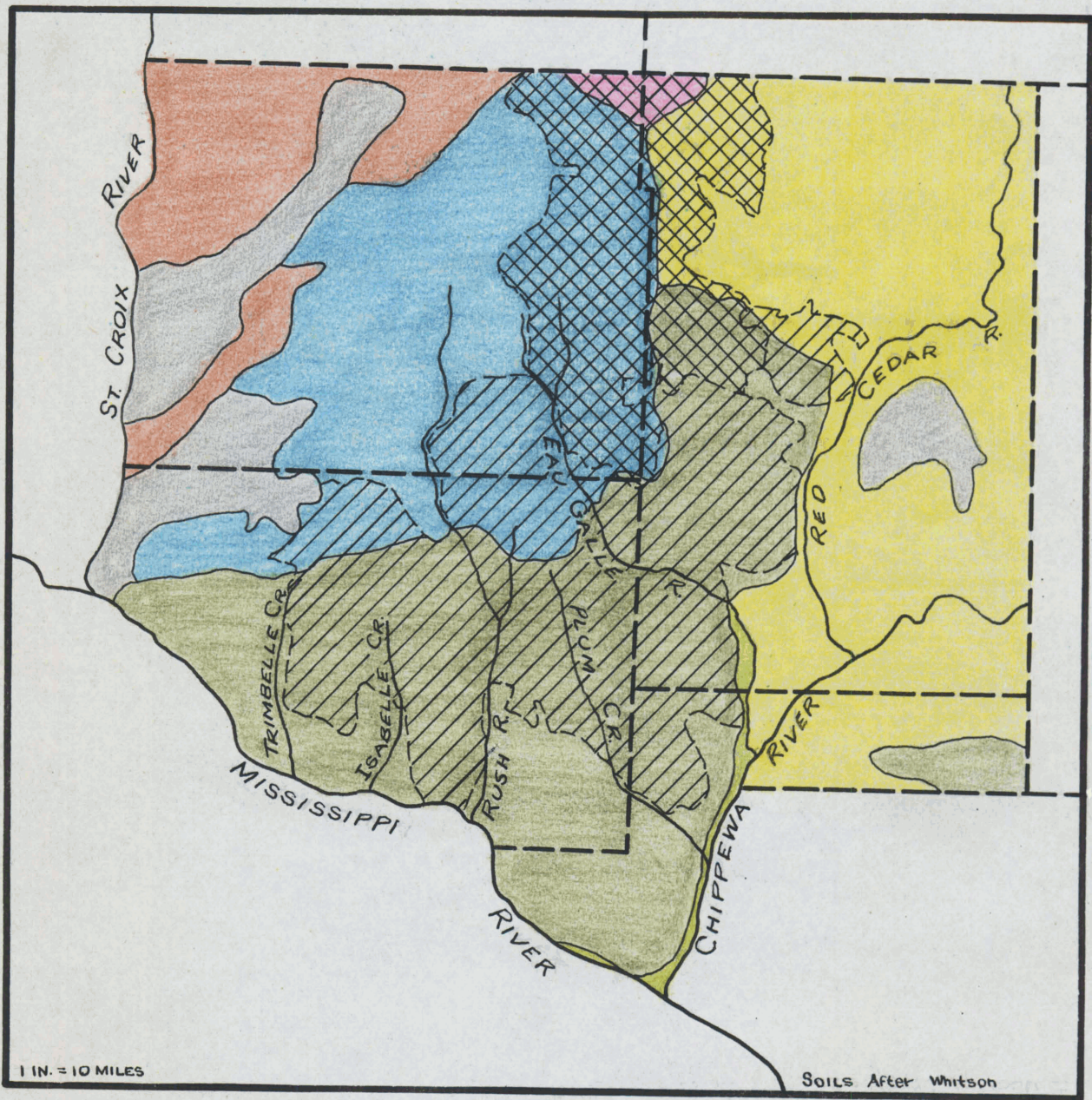


Fig. 14.

After Braun

Fig. 15. Relationship of Sugar Maple Forest Types to Physical Site Features in Dunn, Pepin, Pierce, and St. Croix Counties, Wisconsin



FOREST TYPES



Sugar Maple-
Yellow Birch-
Pine



Sugar Maple-
Basswood-
Oak



Knox Silt Loam



Miami Silt Loam



Boone Fine Sandy
Loam



Wet Land

SOIL TYPES



Prairie Soils



Miami Fine Sandy
Loam



Colby Silt Loam

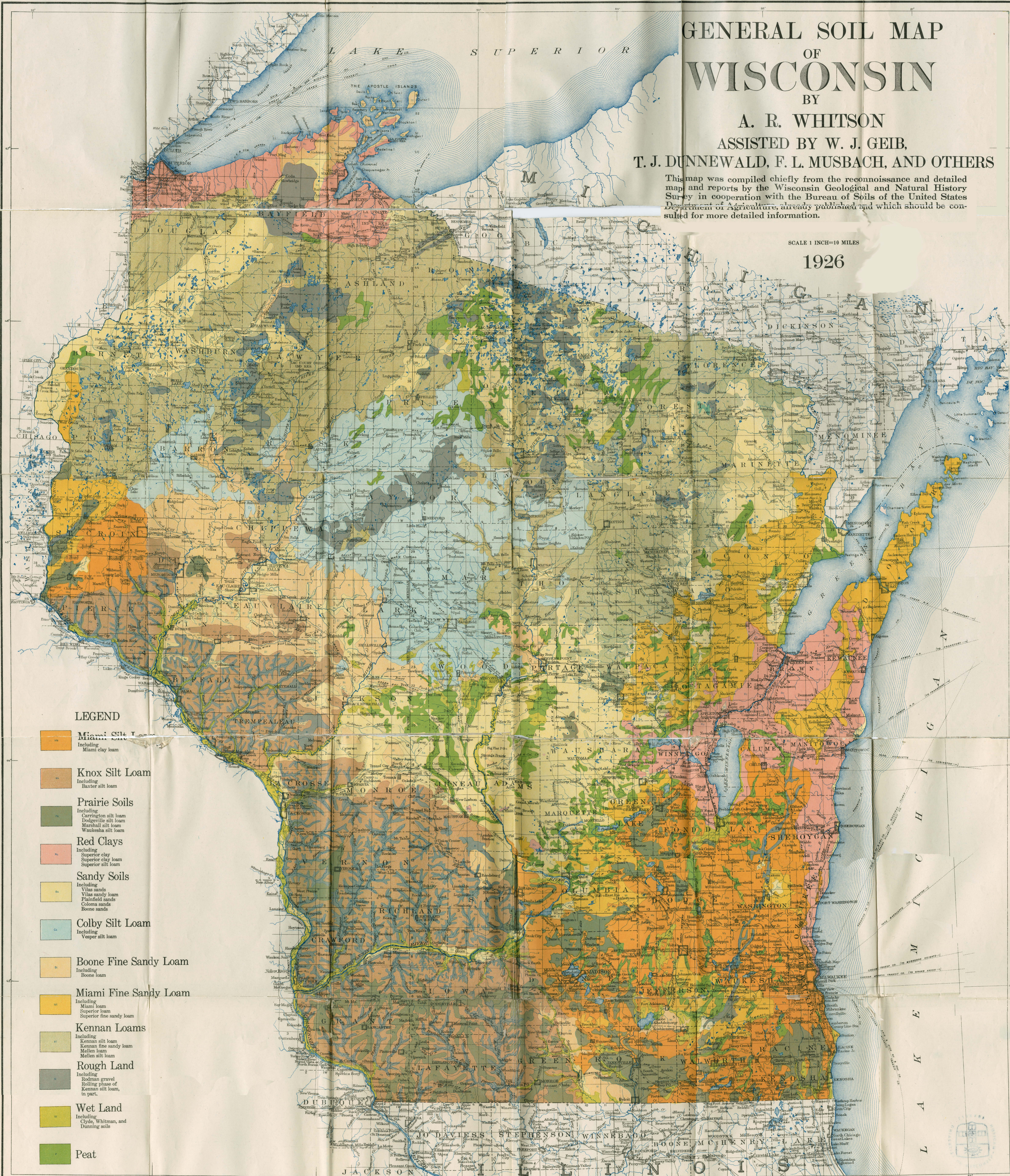
GENERAL SOIL MAP OF WISCONSIN

BY
A. R. WHITSON
ASSISTED BY **W. J. GEIB,**
T. J. DUNNEWALD, F. L. MUSBACH, AND OTHERS

This map was compiled chiefly from the reconnaissance and detailed map and reports by the Wisconsin Geological and Natural History Survey in cooperation with the Bureau of Soils of the United States Department of Agriculture, already published and which should be consulted for more detailed information.

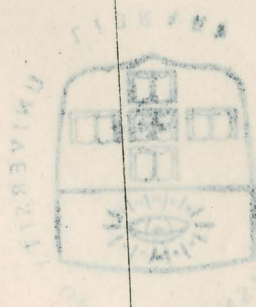
SCALE 1 INCH=10 MILES

1926



LEGEND

- Miami Silt Loam**
Including:
Miami clay loam
- Knox Silt Loam**
Including:
Knox silt loam
- Prairie Soils**
Including:
Carrington silt loam
Dodgeville silt loam
Marshall silt loam
Waukesha silt loam
- Red Clays**
Including:
Superior clay
Superior clay loam
Superior silt loam
- Sandy Soils**
Including:
Vilas sands
Vilas sandy loam
Plainfield sands
Coloma sands
Boone sands
- Colby Silt Loam**
Including:
Vesper silt loam
- Boone Fine Sandy Loam**
Including:
Boone loam
- Miami Fine Sandy Loam**
Including:
Miami loam
Superior loam
Superior fine sandy loam
- Kennan Loams**
Including:
Kennan silt loam
Kennan fine sandy loam
Mellen loam
Mellen silt loam
- Rough Land**
Including:
Rothman gravel
Rolling phase of
Kennan silt loam,
in part.
- Wet Land**
Including:
Clyde, Whitman, and
Dunning soils
- Peat**



TITLE OF THESIS The Original Vegetation Cover of Wisconsin

Full Name Robert William Finley

Place and Date of Birth Jackson, Missouri, February 24, 1911

Elementary and Secondary Education Public Schools, Carterville, Illinois

Colleges and Universities: Years attended and degrees

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University of Wisconsin, intermittently from 1936 to 1948.

Master of Philosophy

Doctor of Philosophy

Membership in Learned or Honorary Societies

Publications A Great Lakes-to-Ozark Profile of Dispersed Swelling Types, Geographical Review,

Major Department Geography

Minors Distributed - Economics, Art History, Sociology

Date May 22, 1951

Signed Clara Trevertha
Professor in charge of thesis