A MORPHOGRAPHIC ANALYSIS OF THE EAU CLAIRE WISCONSIN AREA

A Contribution to the Objective Description of Landform Types

Thesis for the Degree of M. A.

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Robert G. Janke

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This is to certify that the

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ABSTRACT

Robert G. Janke

The traditional approach to the analysis of landforms in which individual relief forms are classified according to their origin finds limited usefulness in geographic studies evaluating the relationships between the landform and other phenomena. This study is concerned with the investigation into techniques of objective landform characterization and classification and their application to a small area.

In order to secure a systematic analysis of the individual elements and an objective description of the total complex, the Eau Claire Wisconsin Area was divided into 600 small units, each having dimensions of one and two-tenths miles by one and seven-tenths miles. Each of these unit areas was then considered as an individual in which the internal variations of both the individual elements of the landform and the landform itself were held to a minimum.

An objective description of the surface configuration is made easier by resolving it into a number of component elements. While the number of elements into which the landform may be resolved is large, this study has been restricted to those considered to be most diagnostic of terrain differences and are at the same time readily determined from topographic maps or in the field. The methods of determining and expressing these elements are briefly explored and exemplified.

These elements were divided into two groups, those lying in the horizontal plane such as major crests, slopes, and drainage patterns,

and those lying in the vertical plane such as local relief, slope length, and distribution of elevation. The majority of these factors were converted into forms more useful in characterizing each of the unit areas such as - prevalence of gentle slope, crest density, drainage density, and relative relief. Finally, the range of values for each property was divided into three classes and a single digit assigned to each class. Thus it was possible to briefly characterize each unit area through the use of a single digit.

None of the elements by themselves can adequately differentiate the numerous variations in the landform. To accomplish this task a combining process was utilized in which various combinations of choropleth maps were superimposed. Thus each unit area could be defined by a distinct set of digits which were referred to as a "landform type". In order to keep the number of types to a minimum, the classification was limited to two elements and allowed for only three class distinctions for each element. After extensive experimentation the properties of prevalence of gentle slope and mean slope length were felt to best differentiate the actual terrain differences.

The identification and delimitation of landform regions from the unit areas involves the basic problem of generalization. This consisted of generalizing the individual landform types into landform regions through the use of criteria such as homogeneity of landform types, consistent non-uniformity of types, or predominance of one or two types in relation to a diversified remainder.

The final problem in the characterization of landform regions was the synthetic description. This consisted of both a statistical characterization and a general verbal characterization. The statistical characterization utilized both the diagnostic elements and the other elements not considered to be of primary importance. The general characterization is primarily a description of each region and its subdivisions through the use of data interpreted from the choropleth maps, diagrams, and photographs.

The validity of this objective classification of the landform in the Eau Claire Area is substantiated by the close correlation which exists between the regions delimited in the study and the subjective impressions that are gained in the field. If the exact delineation of regional boundaries still meets with occasional difficulties this may be primarily an expression of the limited number of diagnostic elements used in the landform classification. On the other hand, it may be added that the landform is a continuum and does never easily lend itself to an artificial segmentation in such a small area as that analyzed here.

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A Contribution to the Objective Description of Landform Types

by

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R.G.J.

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CHAPTER I

INTRODUCTION

The Geographic Treatment of the Landform - To those engaged in the study of the landform,[1] one of the central problems in recent years has been the applicability of their studies to the field of geography as a whole. Often the aspects of the landform of significance in relational studies are to be found in the present configuration of the surface rather than its origin. On this basis the investigation and classification of the landform should be centered on those elements which are most closely related to its functional significance and assist in the areal differentiation of assemblages.[2]

This approach to the study of the landform, giving quantitative values and their distributions without reference to developmental processes, is commonly called the objective or descriptive method of landform analysis. This is in contrast with the traditional explanatory descriptive method by which individual relief forms, usually referred to as landforms, are classified on the basis of their structure, process and stage.[3]

The explanatory method has been criticised for its lack of applicability to the field of geography. These criticisms are based primarily

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[1]"Landform" as used in this study refers to the surface configuration and should not be confused with the common usage which refers primarily to landforms as actual objects or relief forms.

[2]"Assemblage" is taken to mean a collection of individual relief forms such as a collection of mountain peaks orientated in a linear fashion is referred to as a range.

[3]For additional discussion of this classification see William M. Davis, Geographical Essays, ed. D.W. Johnson (New York: Dover Publications, Inc., 1954), pp. 249-321.

on the feeling that this method does not adequately describe the landform and in general does not provide quantitative data about the forms discussed.[1] In order to more fully evaluate these criticisms it is necessary to comment briefly upon just how the explanatory method fails to meet the needs of geography.

If the statement that "Geography is concerned to provide accurate, orderly, and rational description and interpretation of the variable character of the earth surface"[2] can be accepted, it may be recognized that the landform is one of the major factors or aspects of this variable character. Traditionally the explanatory approach has been concerned with an explanation of what has happened rather than a description of the actual form which now exists. This leads to the classification of these forms on the basis of their genesis rather than their present form.

The use of this type of classification introduces several problems. The relationship between the genesis of any particular relief form and its present configuration is subject to a great deal of variation which, for the purpose of the geographer, reduces the usefulness of such a classification system. Genetically classified forms often bring to the mind of the reader a picture of a particular form with which the generic term was first associated. Any serious student of physical geography is aware of the fact that these features may manifest themselves in a great variety of shapes and dimensions. An esker or moraine in Wisconsin is not necessarily similar in appearance to one in Michigan or even one in a different part of Wisconsin. These variations in size and shape hold true to a large extent

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[1]"Geomorphology, Geomorphography, Geomorphogeny, and Geography," New Zealand Geographer, Vol. XII No. 1, April 1956, pp. 88-93, and Richard Hartshorne, Prespective on the Nature of Geography, (Chicago: Rand McNally & Co., 1959), pp. 84-96.

[2]Hartshorne, loc. cit., p. 21.

with all other relief forms which have been classified according to their origin. All relief forms are unique. They may have a common origin but this is often subject to dispute. The naive belief that similar size and shape are to be expected in all landforms of a certain type makes regional comparisions of landforms very difficult for all but the most widely travelled.

The genetic classification of landforms may also be criticised when it is used in a study which attempts to relate the landform to some other phenomena such as land use patterns. The usual result of such a study would be an obfuscation rather than a clarification of any interrelations which may exist between the landform and the land use. The genetic classification system cannot adequately deal with the problem of relationships since the logical process used in its formulation is faulty. The logical steps leading to a proper evaluation of the place that the landform has in the total picture should be from observation to description and from there to inferences. On the contrary, the explanatory description often slights the descriptive phase involving the present forms under investigation in favor of the more interesting task of tracing the developmental processes. As a consequence, this disregard of the proper logical steps of observation, description, and then inferences, which are in the last analysis but various levels of abstraction from reality, may lead to erroneous suppositions.[1]

To better serve the needs of modern geography the analysis of the landform should be directed toward the study of the present configuration of the land and should ignore factors not related to that end. As early as 1925, Sauer pointed out that, "There is no necessary relation between

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[1]Alfred Korzybski, Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics (Clinton, Mass.: The Colonial Press Inc., 1958), p. 406.

the mode of origin of a relief form and its functional significance, the matter with which geography is most directly concerned."[1] Therefore, it is desirable to classify relief forms on the basis of the areal distribution of individual forms or groups through the use of a classification system which utilized the various landform elements whose relationships with other geographic phenomena can be examined with some hope of success. This type of classification system would contribute to a clearer comprehension of the totality of areal variation.

It is evident from the above postulate that the selection of elements to be used to classify individual relief forms and groups of forms is a very difficult undertaking.[2] This problem is alleviated to some extent when the analysis is for some specific purpose, but the problem is by no means eliminated since the relationships between the landform and various other phenomena are not clearly understood.

There has been an increasing number of empirical studies of slope, drainage basins, relief, and other elements of the landform appearing in the literature during the past few years. Some of the early studies left much to be desired.[3] These studies usually lacked a good quantitative method of analysis or were limited to a relatively small number of differentiating characteristics. In general, most of them make very little attempt to synthesize the elements into a rational and orderly system which would make it

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[1]C.O. Sauer, "Morphology of Landscape," University of California Publications in Geography II (1925), p. 33.

[2]Hartshorne, op. cit., pp. 87-89.

[3]Guy-Harold Smith, "The Relative Relief of Ohio," Geographical Review, XXV (April, 1935), pp. 272-84; Erwin Raisz and J. Henry, "An Average Slope Map of Southern New England," Geographical Review, XXVII (July 1937), pp. 467-72; and Robert Glendinning, "TheSlope and Slope Direction Map," Michigan Papers in Geography, VII (1937), pp. 359-64.

possible to classify assemblages and to determine their areal distribution.[1] Nevertheless, while these early studies may be deficient in either of these respects they do represent a step toward the morphometric analysis of the landform.

The recent detailed morphometric studies of Strahler represent a high degree of technical achievement in this area of landform analysis.[2] Studies such as these, which make use of a great number of formulas, ratios, and distribution curves, should become increasingly useful for those who are concerned with planning activities that utilize the functional aspects of the landform. In conclusion, morphometric studies represent a step forward though they still fail to deal adequately with the descriptive aspects of the landform and usually leave the reader without a clear impression of exactly what the area looks like.

A slightly different approach to the objective study and description of the landform which attempts to avoid the over-abundance of mathematical expression and to bring out a clearer comprehension and appreciation of the surface configuration is the morphographic study. In the United States Hammond is the chief advocate of the morphographic study as the method which best meets the needs of the geographer.[3] In his Missouri study Hammond utilized objective and systematic procedures but at the same time avoided the use of the morphometric techniques which are highly time-consuming and

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[1]L.A. Wolfanger, "Landform Types," Michigan State College Agricultural Experiment Station Technical Bulletin 175 (February 1941), and W. Bruce Dick and Stanton Ware, "A Land-Type Map of Livingston County, Michigan," Papers of the Michigan Academy of Science Arts and Letters, XXV (1939), pp. 373-84.

[2]Arthur N. Strahler, "Quantitative Analysis of Watershed Geomorphology," Transactions, American Geophysical Union, XXXVII (December 1957), pp. 913-24.

[3]E. Hammond, "On the Place, Nature and Methods of Description in the Geography of Land Form" ONR Contract Number 1202(01), Procedures in the Descriptive Analysis of Terrain, Technical Report No. 1, (1957).

applicable only to a very small area such as a drainage basin or single valley.[1]

What are the relationships between the morphographic, the morphometric, and the morphogenetic techniques of interpretation?[2] The morphographic approach should normally be considered an essential phase of any serious morphogenetic study in that it provides "form" to the traditional structure, process, and stage. If the landform is discussed morphographically prior to beginning the morphogenetic phase, the reader is usually provided with a means of following the thought processes the investigator uses to reach his conclusions. This procedure will also serve as a check on the natural tendency to seek evidence to prove a theory already adopted. Whether or not a morphographic approach should be included in a morphometric study will, of course, depend upon the ultimate use to which the study is destined. The inclusion of more description in these studies certainly would not detract from the usefulness of the data even in the most specialized applications.

Statement of Problem - This study is primarily a morphographic analysis of the landform of a small area. In thus presenting the landform no effort has been made to trace the origin of the individual relief forms nor to determine the developmental processes responsible for the present surface configuration. In keeping with this theme no effort has been made to analyze any relationships which may or may not exist between cultural features and the landform.

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[1] E. Hammond, "Final Report," ibid., (July, 1958).

[2] "Morphogenetic" as used here is analogous to the explanatory descriptive method. The basic aim is to unravel the developmental processes responsible for the relief forms with only secondary emphasis to a description of the actual features under investigation.

A secondary purpose of this study is to initiate the use of morphographic methods in the analysis of small areas. Most of the techniques of landform analysis used in the Eau Claire Area have been developed by others and have appeared many times in various studies. Consequently, no claim can be made for their origination, although through their modification and application to a small area perhaps some contribution has been made toward providing tools by which it may be possible to investigate the landform in an objective manner.

The area of study in this paper referred to as the Eau Claire Area was chosen for several reasons: accessibility, previous knowledge of major terrain differences, and diversity of terrain. The author's permanent residence is also located within the area which has greatly reduced the distances required to properly traverse the area, and materially reduced the costs involved.

Investigation Techniques - Preliminary study of the Eau Claire Area was begun during July and August of 1958. Numerous additional traverses and extensive aerial and ground photography was carried out during the summer of 1959. Over 250 photographs were taken during this period, of which slightly over twenty appear in this paper. United States Geological Survey topographic quadrangles were used to gather quantitative data since direct field measurement of the various elements would prove to be a very time consuming and costly process. Contour maps provide the most convenient source of quantitative data even though they may, especially in early editions, contain minor inaccuracies.

As indicated previously, it was considered necessary to divide the landform into a number of component elements and then select those which contribute significantly to the "character" of the terrain.

Experience has indicated that the number of elements into which the landform complex may be resolved is limited to a large extent only by the imagination of the investigator. The problem of selecting the most diagnostic elements is a difficult intellectual problem.

It has proven necessary to investigate a large number of elements in order to provide a maximum degree of assurance that the elements selected actually give the best classification of the terrain. While most of these elements did not prove to be significant in this respect, they have been included and discussed to provide the reader with an insight into the various methods of analysis and data expression as well as an opportunity to follow more closely the thought processes through which this study has proceeded.

In addition to the division of the landform into component elements it is also necessary to effectively handle the problem of analyzing the variation of these elements from place to place within the study area. This division is most easily done through the breaking up of the complete area into a large number of small areas of equal size. The use of a large number of small comparable units in which internal variations of the individual elements is kept to a minimum is desirable in order to objectively analyze the quantitative variation of these elements from place to place. The unit area also provides a basis upon which the differentiating characteristics may be synthesized into landform combinations which are in this study referred to as landform types.

The use of the unit area as an approach to the analysis of the various elements of the landform is not new nor is it the only approach possible. Recent departures from the use of the unit area have been in the field of drainage basin analysis using dimensionless properties to form comparisions, irrespective of scale.[1]

The use of a rectangular unit area has been the most popular, although the possibility of other geometric forms must not be dismissed. Rectangular units were used in this study primarily on the basis of their general acceptance in morphographic studies and the ease with which they may be constructed. These units which utilize the geographic grid for orientation are easily duplicated by others and are, in that sense, of great assistance in making intra-regional as well as inter-regional comparisions of both individual elements and assemblages.

It is difficult to state generalities concerning the optimum size of the unit area. Examination of the literature indicates a general lack of agreement as to what does constitute the optimum size. Ochocka used unit areas measuring five minutes of latitude by ten minutes of longitude.[2] Smith considered rectangles measuring five minutes of latitude and longitude to be sufficient.[3] But Hammond employed seven and one half minute rectangles,[4] while Young used rectangles of one minute dimensions.[5]

Ideally it is best to secure the maximum number of comparable units and yet maintain dimensions large enough to permit retention of most of the differentiating characteristics. Ward suggested that the area should be large enough so that it "... includes a fair sample of the terrain (including both ridge tops and valley bottoms)," but failed to suggest

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[1]Strahler, loc. cit.

[2]Janina Ochoka, "Krajobraz Polski w' swietle mapy wysokosci wzglendych," Trav. Geogr. Publies sous la Direction de. E. Romber, No. 13, (1939), cited by Smith, loc. cit., p. 270.

[3]Smith, loc. cit., p. 279.

[4]Hammond, "Final Report," p. 15.

[5]Robert Young, "A Geographic Classification of the Landforms of Puerto Rico," Symposium on the Geography of Puerto Rico (University of Puerto Rico Press, 1955), pp. 27-46.

any actual dimensions or how to determine them.[1] Hammond recommended units measuring from one to two miles across, although in one of his studies he used much larger units.[2]

In general, the type of terrain is the most important factor to consider in the selection of the proper size of the working unit. The nature of the differentiating characteristics must also be taken into consideration. Since each element is effected to a different degree by a change in the dimensions of the unit areas the problem becomes more difficult. There is no one best answer. The best compromise that can be made is to select an element whose relationship to the size of the unit area is easy to determine and is at the same time associated with a number of other elements.

This philosophy leads to the selection of the element called local relief. In addition to being easy to measure, the local relief is closely associated with the slope length which is another aspect of the landform which contributes signficantly to the character of the terrain. Furthermore a sharp leveling-off of the relief figure as the dimensions of the unit area is increased is an indication that by and large the average relief form in that particular area has been completely encompassed by the unit area.

Upon this premise an investigation was initiated in an effort to determine what effect rectangles of various dimensions had upon the local relief. Using the corners of the topographic quadrangles involved in this study as points of origin, rectangles of increasing dimension were constructed. The maximum difference between the highest and lowest elevation

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[1]R.G. Ward, New Zealand Geographical Society, Proceedings of the First Geography Conference (Auckland, New Zealand, 1955), pp. A1/4 21-26.

2Hammond, "Final Report".

within rectangles of one, one and one half, two, two and one half, three, four, and five minute rectangles were recorded.

The local relief figures derived from the various rectangles were then plotted graphically with the relief on the ordinate and the size of the rectangle on the abscissa. The resulting curve was then examined in order to determine if there was a breaking point or sharp change in angle, also called a "Knickpunkt", which would indicate at which point the use of larger rectangles would not materially increase the relief figure and only serve to reduce the total number of unit areas into which the study area could then be divided.[1]

The use of this method to determine unit area dimensions would seem to be a desirable practice for each terrain analysis since the magnitude of relief forms, and indirectly, their component elements would not necessarily be the same for those found in the Eau Claire Area.

The curve (Fig. 1) represents a composite of sixteen determinations.

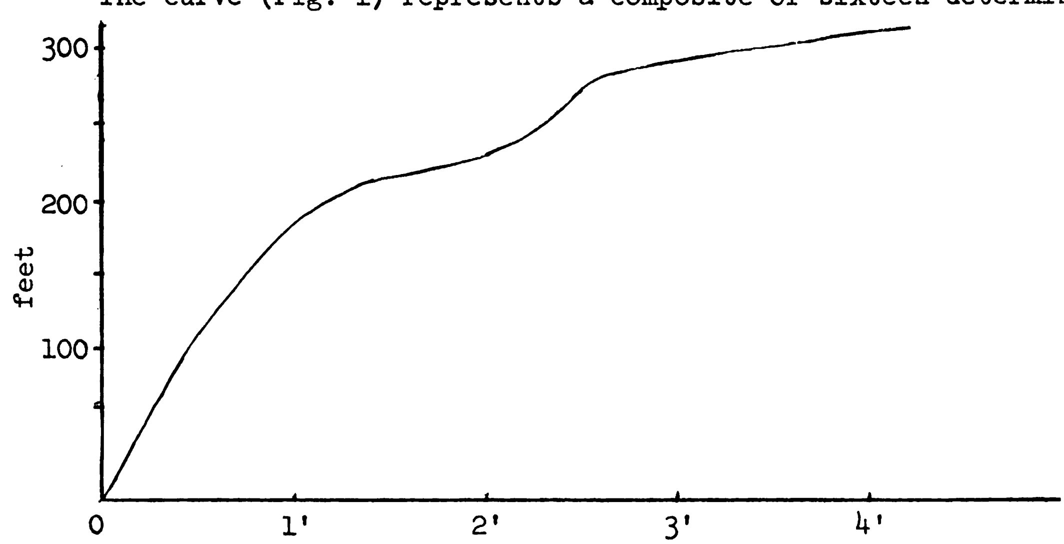

Fig. 1: Relationship between rectangle size and local relief.

As can be seen there are two "Knickpunkte", one at the two and one half

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[1]William D. Thornbury, <u>Principles of Geomorphology</u> (New York: John Wiley and Sons, Inc., 1956), p. 110.

minute rectangle and a secondary inflection at the one and one-half minute dimension.

Since it is desirable to maintain, as far as possible, a maximum number of unit areas, the one and one-half minute rectangle was given preference over the larger dimensions. Rectangles of one and one-half minute dimensions were inscribed on a sheet of acetate which was then placed over the topographic maps used in this study. The resulting units form the basis by which it is possible to characterize a relatively small area in which the variation of individual elements is kept to a minimum (see Fig. 21, Appendix).

The first requirement in the quantitative approach to the analysis of the elements of the landform is the unit area. The second is the sampling method. It is imperative to use a sampling method that is relatively accurate and is at the same time reasonably fast. While there are numerous sampling methods available which may be applied to these elements, they may be considered to fall into three major types: Linear, point, and area samples. The linear sample has been used most extensively in the studies of the landform and especially in the determination of various slope measurements.[1] Most of these methods are very laborious, and on this basis they were not considered to be desirable in this study.

The point sample has been selected for use in the Eau Claire Area due to its simplicity, speed, and relatively high degree of accuracy. The point sample consisted of a random set of points inscribed on an acetate sheet (see Fig. 22, Appendix). The acetate sheet was then placed

[1]Chester K. Wentworth, "A Simplified Method of Determining the Average Slope of the Land Surface," American Journal of Science, XX (1930), pp. 184-94.

over the unit areas and at each point the slope inclination, elevation, and slope length were determined. It should be pointed out that the point sample is by no means limited to the uses mentioned above.[1]

To gain a better understanding of the relative accuracy and reliability of the dot sample, a series of experiments was carried out in which the number of points per unit area was varied. The measurement of discrete phenomena with a polar planimeter indicated that a minimum of ten points per unit area seldom caused inconsistencies of more than five per cent of the value as indicated by the planimeter. Inasmuch as the purpose of the quantitative data concerning slope, elevation, and slope lengths is for regional comparisions and not morphometric analysis, the slight reduction in accuracy from the values secured with the planimeter was considered to be insignificant.

Repeated checking for consistency with the dot sampler indicated that values obtained from the remeasurement of the same unit areas seldom varied more than five per cent.

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[1]Walter F. Wood, "The Dot Planimeter, A New Way to Measure Map Area," Professional Geographer, VI, No. 1 (January, 1954) pp. 12-14.

CHAPTER II

HUMAN AND PHYSICAL SETTING

Human Setting

The Eau Claire Area is located in west-central Wisconsin with the city of Eau Claire at its approximate center (Fig. 2). The area is arbitrarily defined by six contiguous topographic quadrangles arranged in a north-south direction, two wide and three long (Fig. 21).[1] The area thus defined measures approximately twenty-five miles by fifty-two miles.

Within the area are two major cities, seven villages and numerous hamlets. As suggested in Figure 2, the city of Eau Claire, with a population of over 37,000, dominates the area. The only other major city is Chippewa Falls with slightly over 12,000 inhabitants. With the exception of the small villages and hamlets, the remainder of the 81,000 people living in the Eau Claire Area are rural residents, primarily farmers.[2]

The large rural population is reflected in the land use. For the area as a whole, eighty-four per cent of the land is devoted to farms, although the percentage varies from thirty per cent to over ninety-five per cent when considered on a township basis. The average size of farms in this part of Wisconsin is nearly 175 acres. The chief economic base

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[1]United States Geological Survey, Topographic Quadrangles: New Auburn, Wisconsin (1950), Bloomer, Wisconsin (1951), Chippewa Falls, Wisconsin (1936), Elk Mound, Wisconsin (1936), Mondovi, Wisconsin (1932), and Strum, Wisconsin (1930), 1:62,500, Washington 25, D.C.

[2]Wisconsin, State Department of Agriculture, Crop and Livestock Reporting Service, Wisconsin Rural Resources: Buffalo, Eau Claire, New Auburn, Chippewa, Pepin, and Trempealeau Counties, (March, 1957), pp. 9-32.

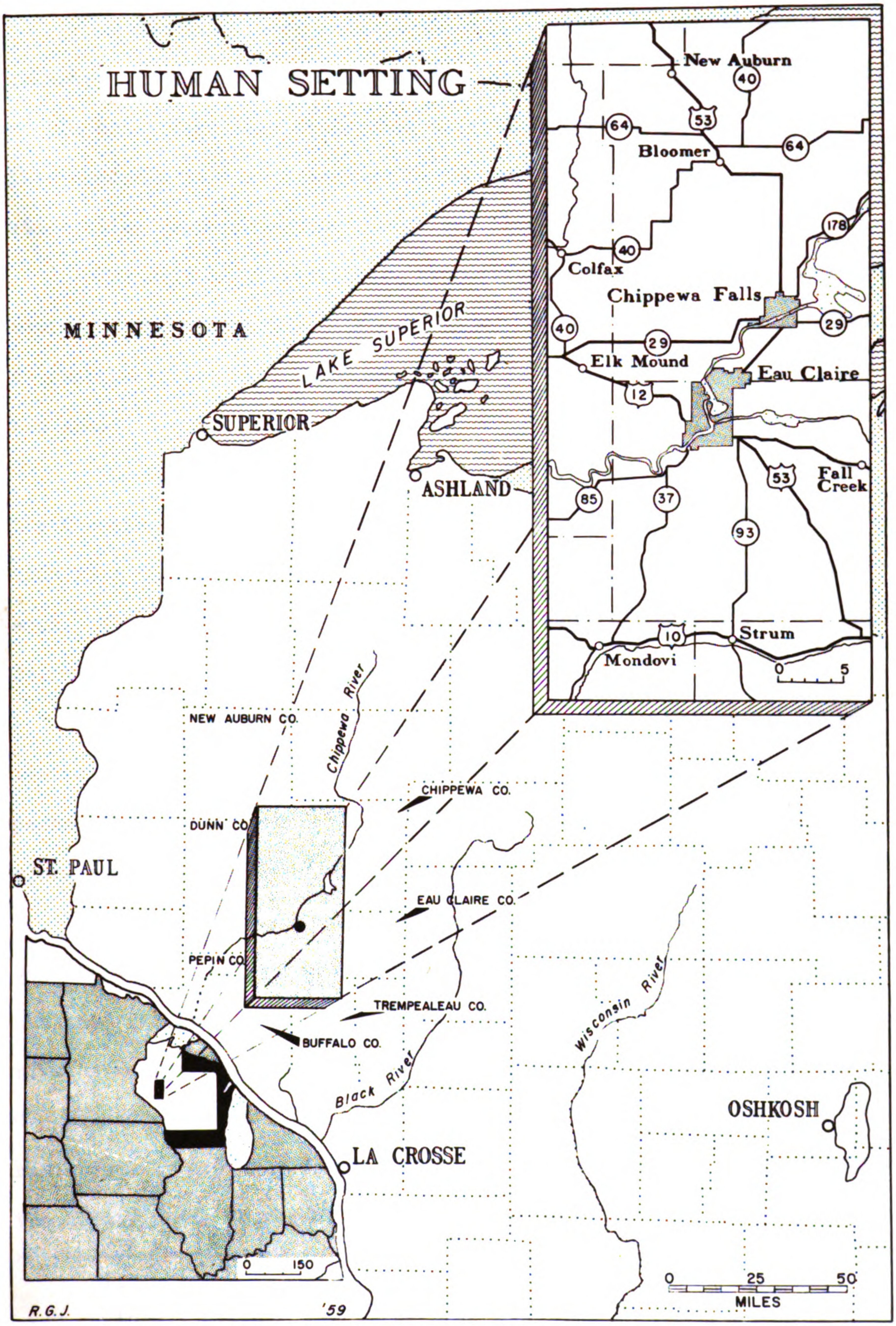
HUMAN SETTING
MINNESOTA
LAKE SUPERIOR
SUPERIOR
ASHLAND
ST. PAUL
LA CROSSE
OSHKOSH
NEW AUBURN CO.
DUNN CO.
PEPIN CO.
CHIPPEWA CO.
EAU CLAIRE CO.
TREMPEALEAU CO.
BUFFALO CO.
Chippewa River
Black River
Wisconsin River
New Auburn
Bloomer
Colfax
Chippewa Falls
Elk Mound
Eau Claire
Fall Creek
Strum
Mondovi
40
53
64
178
29
12
85
37
93
10
0 5
0 150
0 25 50
MILES
R.G.J.
'59

Figure 2

of the Eau Claire Area is the dairy industry. So important is this industry, that cows outnumber people. On an average, nearly forty per cent of the total farm land is devoted to pasture, primarily for milk cows. This emphasis is also expressed in the cash farm incomes. Milk and livestock sales represent about ninety per cent of the total income.[1]

The only major industrial concentrations are those located in the cities of Eau Claire and Chippewa Falls. Manufactured products include automobile tires, pulp and paper products, dairy products, woolen goods, and shoes.

The villages in the area serve primarily as service centers for the farmers, although many contain some type of milk processing facility, usually a creamery. Very little whole milk or cream is shipped out of the area. Butter, powdered skim milk, cheese, and ice cream are the leading dairy products.[2]

Eau Claire is located on a major route of the Chicago and Northwestern Railroad. Another important route, joining Eau Claire with Superior, passes through the city of Chippewa Falls. Villages are either located along these major routes, or are served by spur lines.

A well developed system of federal, state, county, and town roads and highways permit rapid and regular hauling of farm products to the markets and facilitates the supplying of services to those who live in the rural areas. The major roads usually follow direct and straight routes. County and town roads, especially the older roads, follow paths of least resistance by avoiding swamps, steep hills, and narrow valleys. Many of the county roads in the hill lands follow the ridge tops. In those areas

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[1] *Ibid.*, pp. 35-48.
[2] *Ibid.*, p. 49.

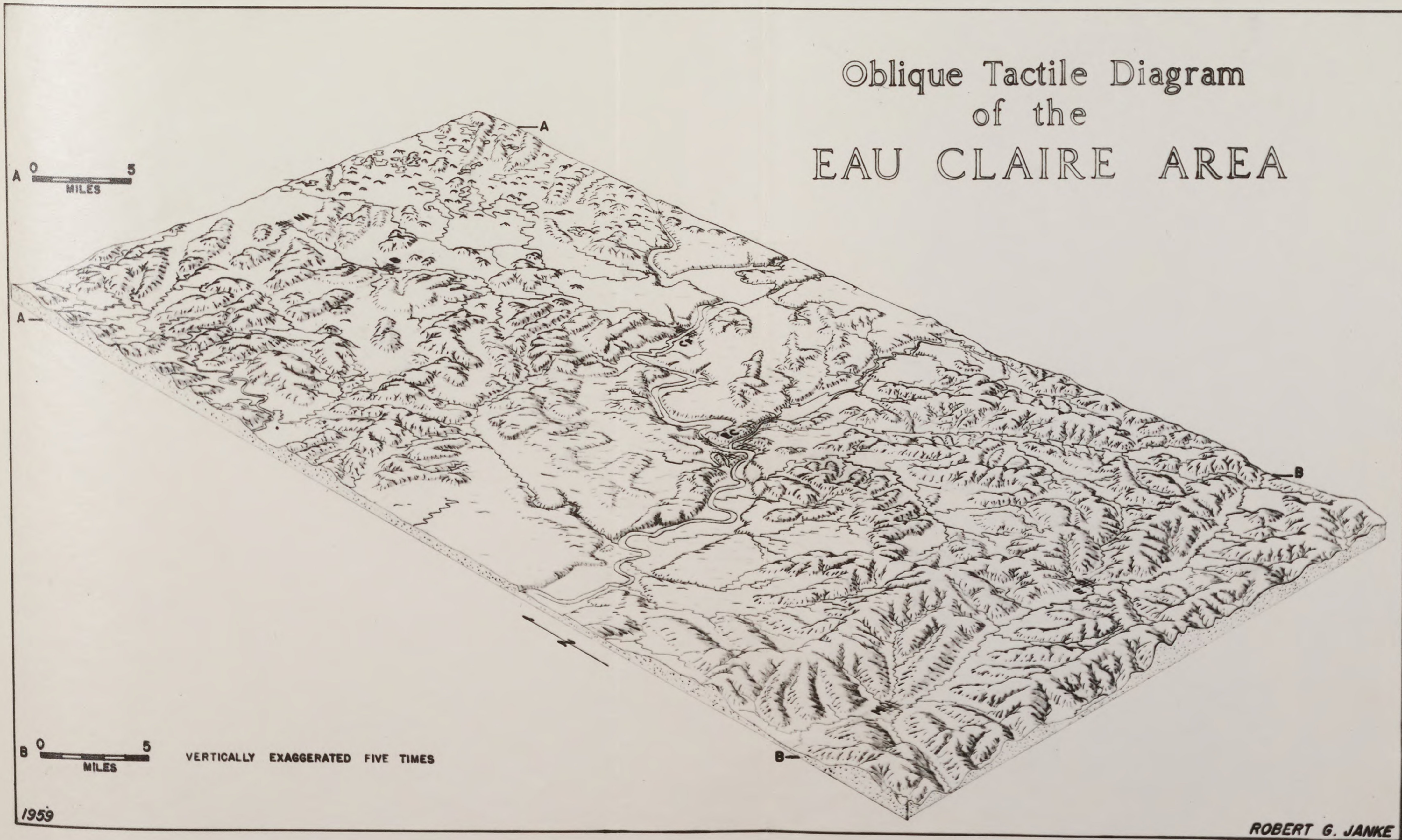

Oblique Tactile Diagram
of the
EAU CLAIRE AREA
A 0 5
MILES
B 0 5
MILES
VERTICALLY EXAGGERATED FIVE TIMES
1959
ROBERT G. JANKE

Figure 3

where the terrain is essentially level and devoid of swamps or other obstacles the roads are laid out along the section lines and take on the characteristic checkerboard pattern.

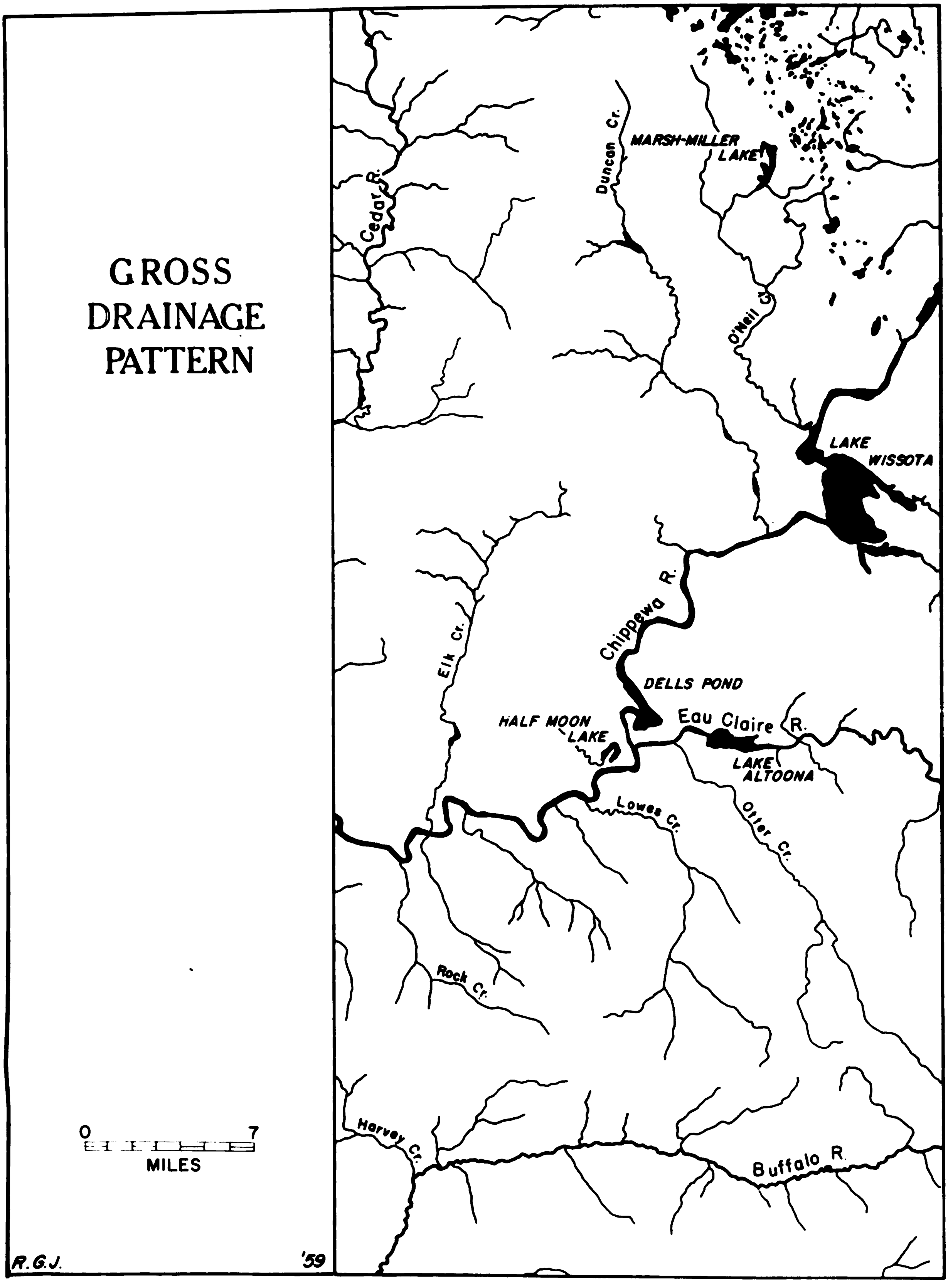
Physical Setting

Knowledge of the types of relief features which can be expected, their approximate size, distribution, and composition provides assistance in evaluating the relevancy of the criteria selected for the landform analysis. In addition, a working knowledge of the genetic classification of the landforms within the area provides a means of comparing the differences and similarities of the regional boundaries as determined through two systems of landform analysis.

Although highly generalized, Figure 3 does provide an overall view of the major terrain differences within the area. Even a cursory examination of the diagram will reveal the existence of several areas which "hang together", and, in this sense, form natural, although highly subjective. regions. These regions will, for the purposes of this chapter, be assigned the arbitrary names of hill, morainic, and plains regions.

The most distinctive region differentiated on this basis is the hill region of the southern third of the Eau Claire Area. This region, as illustrated in Figure 3, is characterized by a relatively large per cent of the total surface in slope. In the northwest corner is another hill region which differs from the first in that there is a relatively greater percentage of level land which is typically found in the valley bottoms.

Unfortunately the terrain drawing cannot indicate the complexity and diversity of the terrain found in the northeast corner referred to as the morainic region. Here are found a great number of small, usually isolated, relief features with swamps and marshes interspersed between


GROSS
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R.G.J.
'59
Cedar R.
Duncan Cr.
MARSH-MILLER
LAKE
O'Neill Cr.
LAKE
WISSOTA
Chippewa R.
DELLS POND
Elk Cr.
HALF MOON
LAKE
Eau Claire R.
LAKE
ALTOONA
Lowes Cr.
Otter Cr.
Rock Cr.
Harvey Cr.
Buffalo R.

Figure 4

them. When the relief features are joined together it is often in a linear manner giving rise to belts of low hummocky hills.

The plains region is more diverse than the previous regions with respect to both the characteristic features and areal distribution. In general, the plains are characterized by a great predominance of very gentle terrain with occasional relief features rising above the general level of the plain as isolated hills or ridges. The Chippewa River serves to unite the plains region.

Drainage - Running water has been one of the major agents of gradation responsible for the development of the landform as it exists in the Eau Claire Area today. The drainage features may be resolved into three moderately distinct patterns (Fig. 4) which correspond closely with the regions as differentiated in the previous section.

The hill region is characterized by a well developed drainage network. Although there is a great diversity within the hill region, one may generalize the pattern and subjectively refer to it as a well developed dendritic pattern. The density of streams is usually related to the number and pattern of the relief features. On this basis one may further differentiate between the hill region in the southern third of the area from that found in the northwest.

The pattern found in the morainic region is best described as one of imperfect development. Few of the streams in this region show any discernable orientation as they often flow from one marsh or small lake into another. The exterior drainage is confined to a few small streams which radiate in all directions. Plates I and II are typical of the hydrologic features found in this region.

The plains region is by and large one of limited surface drainage,

PLATE I

TYPICAL SWAMP AND MARSH IN THE MORAINIC AREA

PLATE II
SMALL POND AND ASSOCIATED MARSH IN MORAINIC AREA

especially when considered from the point of view of smaller tributaries. The map of Gross Drainage (Fig. 4), does not fully bring out this distinctive aspect of the pattern which can only be appreciated when viewed at the detailed level.

In general the drainage features do not in themselves appear as prominent elements in the landform. The Chippewa River, the largest hydrologic feature, is seldom more than 300 feet wide and is often much less. Other rivers, the Cedar, Buffalo, and Eau Claire, are seldom more than twenty-five to fifty feet wide. Lakes, the majority of which are to be found in the morainic region, are seldom of any great size.

While the hydrologic features are not in themselves important, the valleys through which they flow are often of sufficient magnitude to constitute important parts of the total terrain complex. The Chippewa and Buffalo Rivers are especially important in this respect.

Bedrock - Although the Eau Claire Area is underlain by rocks representative of all three major classes, the sedimentary rocks are the most prevalent (Fig. 5).[1] The sedimentary rock is the Potsdam sandstones which include several different formations of varying composition and cementation.[2] It is not within the scope of this paper to delve into the various ramifications of the tendency of these formations to erode differentially, but the importance of the sandstone to the landform should be acknowledged. In a sense, the relief features of the Eau Claire Area are the stratal remanents of the sandstone formations, as produced by the variations in the intensity and types of denudational processes and deposition, coupled with

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[1]After Geologic Map of the United States, United States Geological Survey (1932), 1:2,500,000.

[2]Lawrence Martin, The Physical Geography of Wisconsin, Wisconsin Geological and Natural History Survey Bulletin No. XXXVI (2d ed.; Madision, 1932), p. 4.

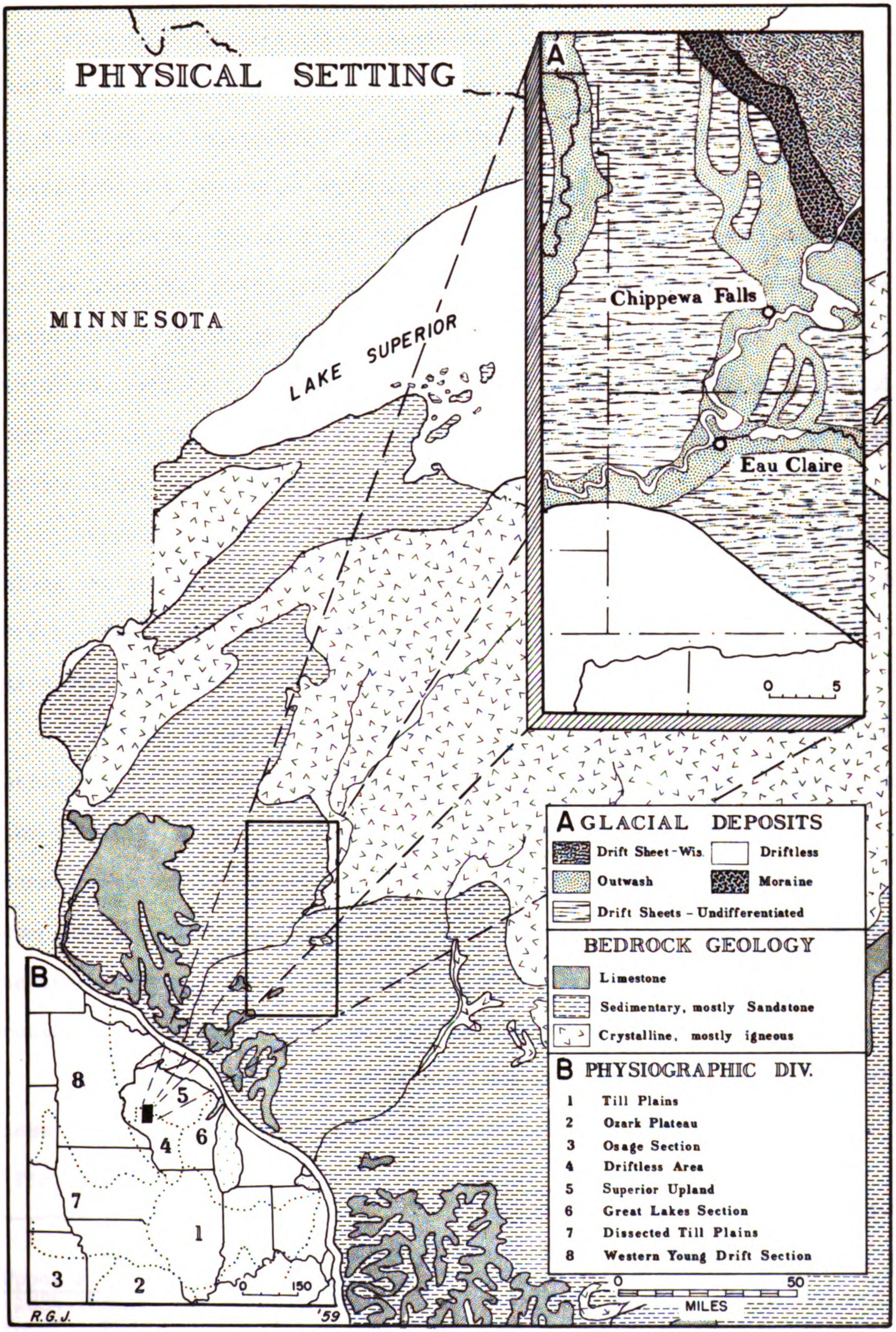
PHYSICAL SETTING
MINNESOTA
LAKE SUPERIOR
A
Chippewa Falls
Eau Claire
0 5
A GLACIAL DEPOSITS
Drift Sheet-Wis.
Driftless
Outwash
Moraine
Drift Sheets - Undifferentiated
BEDROCK GEOLOGY
Limestone
Sedimentary, mostly Sandstone
Crystalline, mostly igneous
B PHYSIOGRAPHIC DIV.
1 Till Plains
2 Ozark Plateau
3 Osage Section
4 Driftless Area
5 Superior Upland
6 Great Lakes Section
7 Dissected Till Plains
8 Western Young Drift Section
0 50
MILES
B
0 150
R.G.J.
'59

Figure 5

the inherent resistance of the sandstone itself. These sandstones are not normally highly resistant to the processes of erosion and therefore do not form outcrops except along the banks of rivers and streams where conditions are favorable for their formation.

Limestone deposits are very limited. There are several small inliers of the Lower Magnesian limestone on the tops of the higher bluffs in the southwestern corner of the area near the city of Mondovi. The ridges in this area exhibit a slightly greater upland development than those found north of the Buffalo River and which may be due to the superior resistance of the limestone formations.

Crystalline rocks as shown in Figure 5 are limited to a narrow zone along the northeast border and a small outlier north of the village of Fall Creek. The crystalline rock is primarily granite which in the Eau Claire Area does not form relief features of any great significance.

Glacial Deposits - The diversity of glacial deposits within a relatively short latitudinal distance was one of the instrumental factors in the selection of the Eau Claire Area for study. The variety of surface forms which have resulted from till and glaciofluvial deposits and the completely unglaciated areas have added an additional element of challenge to the problem of selecting the best differentiating characteristics which could be applied with equal success to a wide variety of terrain types.

Basically four types of glacial deposits and a portion of the Driftless Area are to be found within the boundaries of the Eau Claire Area (Fig. 4A).[1]

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[1]After T.C. Chamberlin and R.D. Salisbury, The Driftless Area of the Upper Mississippi, 6th Annual Report of the United States Geological Survey (1884-1885). Plate XXVII "Quaternary Map of the Driftless Area and Environs". The boundary of the Driftless Area was modified as suggested by Robert F. Black, Department of Geology, University of Wisconsin.

The undifferentiated drift sheets, the older drift, compose the most extensive surface deposits. These sheets are, as illustrated in Plate III, modifiers of the pre-existing terrain. The till is usually found in the flat areas between the hills and ridges and exists as a thin veneer over the sandstone near the summits and is often missing entirely on the steeper slopes. Mass wasting may be the most important factor in this distributional pattern.

Dissecting the older drift and coinciding to a large extent with the present courses of the Chippewa, Eau Claire, and Cedar Rivers are the outwash deposits. These deposits, consisting of silt, sand, and gravels of various sizes, are characteristically extremely flat and lacking in any appreciable relief (see Plate IV).

Although a distinction between the terminal moraine and the till plains associated with it has been made in Figure 4a, the extreme similarity of these two regions does not warrant such a distinction in this discussion. The scenes in Plate I and II, an abundance of forest cover, short steep slopes, swamps, marshes, and glacial erratics, are repeated over and over throughout both the terminal moraine and the drift sheet.[1]

The Driftless Area (see Plate V) is the antithesis of the terminal moraine both in respect to the developmental processes involved in their formation and the present surface configuration. These contrasts were poetically and powerfully described some seventy-five years ago by T.C. Chamberlin and R.D. Salisbury:

> Standing on the border line, along the face of the moraine, no observer can fail to be impressed with the verity of the contrast

[1]The illustrations of the regions of the various types of glacial deposits have been selected as to give the most representative views and avoid the marginal areas where the surface configuration is often difficult to classify without extensive field investigation. See Figure 23 for the location of each photograph.

PLATE III - The Older Drift. In the distant background may be seen a number of erosional remnants which are usually covered with a thin layer of drift. The level areas between these hills are composed of deeper deposits of drift and glacio-fluvial materials.

PLATE IV - An Outwash Plain. The outwash deposits are distinctive in their extreme flatness in many parts of the Eau Claire Area. This photograph, taken north of Chippewa Falls, illustrates this aspect of the outwash deposits. In the distance may be seen the beginning of the terminal moraine.

PLATE III

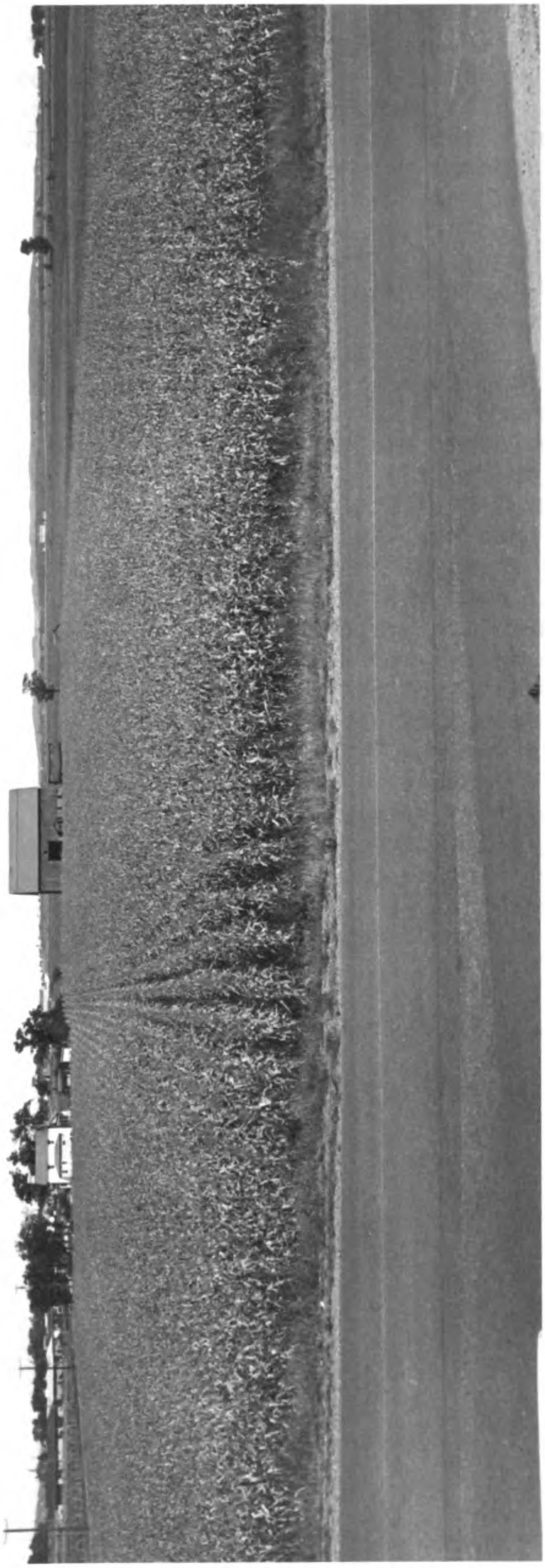

PLATE IV

in the phenomena presented, nor with its extreme significance. On the one side there is a perfect drainage system; on the other, drainage is incomplete and considerable areas have no external drainage at all. On the one hand is a region everywhere betraying the impress of drainage sculpture; on the other, a region which drainage sculpture is absolutely incompetent to produce. On the one hand the drainage lines are symmetrical; every least ravine fitly joins its neighbor ravine, and their confluent valley joins another of like origin, leading on and on to other unions until the whole system has gathered into the great drainage arteries of the region. Not an acre is without its appropriate portion of the drainage system, save an occasional solution pit, or an abandoned channel on the bottoms, or an inter-dune depression. On the other hand, the drainage lines are distorted into irregular and anomalous forms; the valleys are gnarled and twisted, blocked by ridges, or anon expanded into flats and marshes or lakes, or otherwise deformed in the most irregular and unsymmetrical fashion. On the one hand are intelligibly arranged ridges, betraying the hand of nature's symmetrical sculpture; on the other, ridges bunched in the most irregular forms, setting at defiance all laws of symmetry set over against the even more unique beauty of asymmetry. On the one hand are rolling hills, with smooth erosion contours or with mural faces outjutting along their steep sides; on the other, a sea of confused drift hills. On the one side is a thin mantle of residuary material; on the other, a thick, corrugated sheet of heterogeneous drift. On the one side is only local material, the simple result of universal terrestrial agencies; on the other, an inextricable mixture of local, semi-local, and foreign material, the extraordinary results of phenomenal causes. The one region is bowlderless, while over the other are strewn in great abundance erratics from distant regions.[1]

Although these differences are distinct and easily perceived while in the field there is some question as to the validity of the Driftless Area concept.[2]

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[1]T.C. Chamberlin and R.D. Salisbury, loc. cit., pp. 260-261.

[2]Interview with Robert S. Black, Department of Geology, University of Wisconsin, Madison, July 14, 1958.

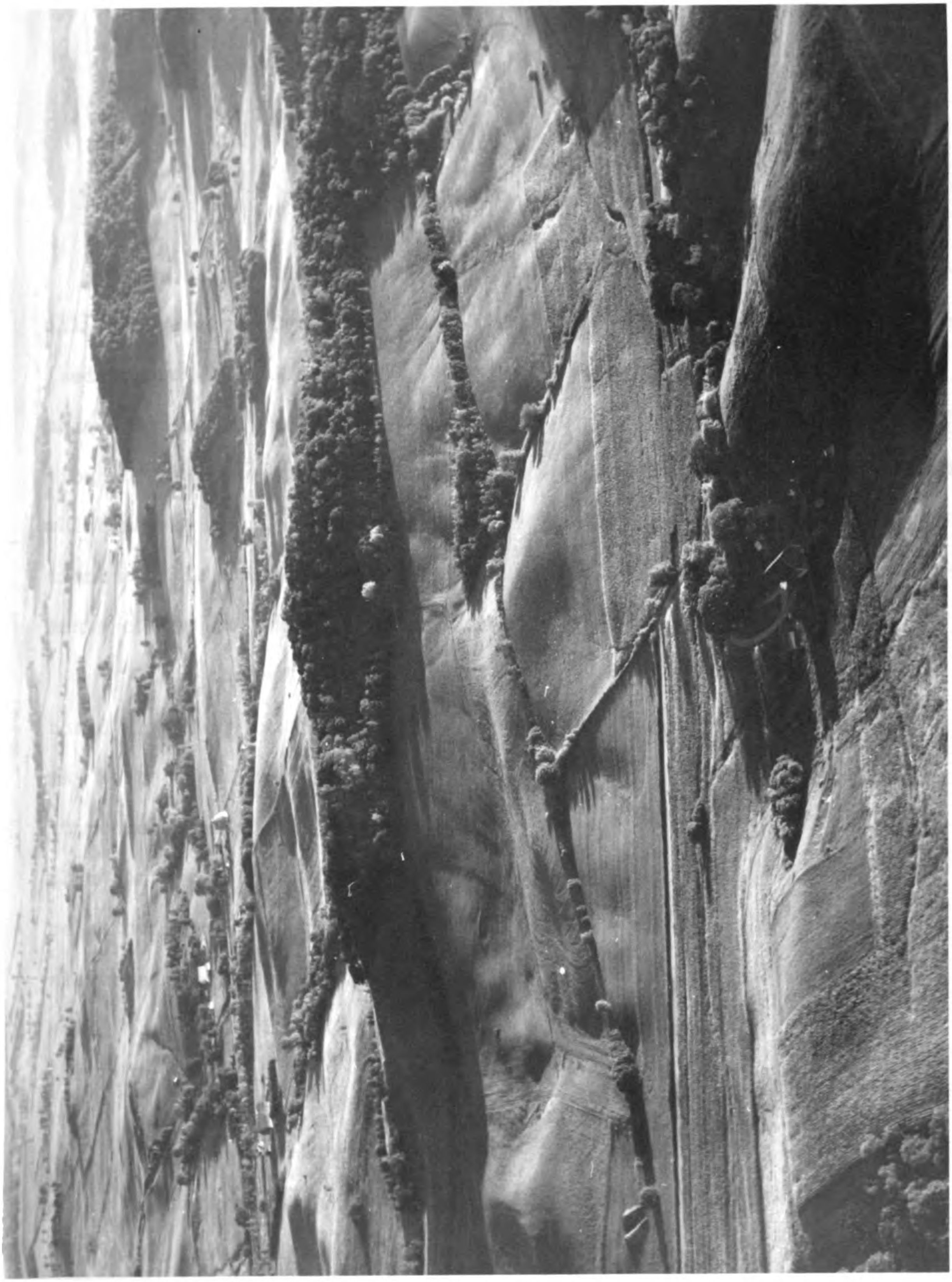

PLATE V
THE DRIFTLESS AREA

CHAPTER III

INDIVIDUAL ELEMENTS OF THE LANDFORM

The analysis of any complex phenomena such as the landform is usually made easier if the component elements can be resolved and characterized separately. A synthesis, which is usually organized and weighted according to the purpose of the study, is then possible through the utilization of these component elements. Although the number of pertinent items which may be resolved and characterized is large, the space and time limitations of this study have made it necessary to include only the major elements of the landform.

These elements have been arranged into a scheme of organization based primarily upon which of two planes, vertical or horizontal, they may be best analyzed. This simple classification serves two purposes: it reduces the suggestion that any one element is of greater importance than another and produces a compartmentalization of elements based upon relationships. The relationships referred to here are simply that the elements in one plane usually show a closer interrelationship with each other than with elements found in the other plane.

Elements in the Horizontal Plane

Of numerous elements considered only three were thought to be of major importance in the determination of landform types. These are:

1) The areal distribution of slope classes
2) The distribution of major crests
3) The density of drainage features

Slope - Perhaps the most obvious feature of the visible natural landscape is that of the surface configuration. Of the various elements comprising this feature, slope is probably the single most important.[1] While various aspects of the slope of the land are important, the number of studies appearing in the literature of landform analysis is also a reflection of the nature of slope data itself. All things considered, most of the slope indices lend themselves to numerical and mathematical expression with greater ease than any other element with the possible exception of local relief.

Many of the classical studies in the field of slope analysis have been centered around the determination of average slope.[2] The validity of the average slope value for any particular area is questionable. For example, an area of essentially level terrain with a number of sharp erosional remnants or deeply incised streams may give the same approximate average slope as an area of undulating terrain. In addition, as can be seen in the first example, the average slope may not exist at all or in such a minor percentage of the total area as to be insignificant.

Still another method of characterizing the slopes of an area is to summarize them through the use of the modal slope value or class. While this index does exist in reality, and its very definition indicates it is the most prevalent slope class, there is an inherent fault in this type

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[1]The slope, or inclination of a surface, is in theory a dimensionless point. But for all practical purposes the slope must be measured not as a point but as a short segment of reasonably constant inclination. In this study the slope is expressed in per cent of inclination.

[2]C. Wentworth, "A Simplified Method of Determining the Average Slope of Land Surfaces," American Journal of Science, II, Ser. 5, 1930, pp. 184-194, and J.L. Rich, "A Graphical Method of Determining the Average Inclination of a Land Surface from a Contour Map," Trans. of Illinois Academy of Science, IX, 1916, pp. 195-99 represent two such studies.

of characterization. Seldom does one find an area in which the slope distribution rises to a well defined maximum. On the contrary, many such distribution curves show two or more maxima and may in some cases fail to indicate a clear maximum. Therefore to classify an unit area on the basis of the most prevalent slope class is to simplify the actual conditions within the area unnecessarily.

The problem then is to summarize the slope data in such a way that it is readily comprehensible and at the same time realistic. The first step in this process is some type of generalization. The most obvious of several generalization procedures is to group the entire range of slope values into a small number of classes. The presentation of slope data in this manner represents a relatively simple and unrefined summation of the actual slope conditions. However, even this is a step far more meaningful than the more often used mean slope index.

With mean slope index and modal slope class having been ruled out as useful expressions of slope conditions, one is forced to consider other avenues of expression. There are two major alternatives: the slope classes may be expressed for individual unit areas through the use of pie, bar, or line graphs or one may classify individual areas on the basis of the prevalence of one or two of the most significant slope classes. The most significant slope class is determined either by the ultimate use of the data or by the best understanding of the moment.

The importance of slope as an element of primary importance suggests that it may be advisable to abandon temporarily the pursuance of slope data from the viewpoint of the unit area approach. Therefore in addition to the dot sampling on an unit area basis, a second method utilizing a continuous determination of slope classes has been included in this study. The continuous determination method simply outlines those

areas of similar slope on the basis of a constant contour spacing.[1] The proper spacing is determined through the use of a slope scale.[2] The path that the scale takes in the determination of each of the slope categories is simultaneously recorded on a transparent acetate overlay. Each of the six contour maps was examined three times, once for each of the three slope categories. These categories; gentle, moderate, and steep; are based on arbitrary values of five per cent or less for gentle slopes, six to eleven per cent for moderate, and all those over eleven per cent were classified as steep (see Fig. 6).[3]

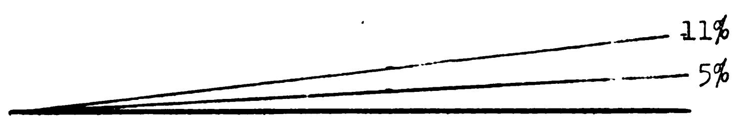

Fig. 6: Diagram of Slope Categories

Considering the complete Eau Claire Area, the percentage of the total area under each of the three slope categories is approximately equal. Gentle slopes account for thirty-three and four-tenths per cent of the area, moderate slopes for another thirty-two and six-tenths per cent, and

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[1]See: Dieter Brunnschweiler, "Problems of Land Use in the Municipios of Ciales, Morovis, and Orocovis," Symposium on the Geography of Puerto Rico, ed. Clarence F. Jones (Puerto Rico: University of Puerto Rico Press 1955), pp. 403-39.

[2]The slope category values are similar to the limiting values for various slope classes as used by the United States Department of Agriculture Soil Conservation Service for soil conservation purposes in this part of Wisconsin.

[3]The slope scale is a simple device based on the spacing of contour lines which makes possible a very rapid determination of slope of the land. See Figure 22.

steep slopes for the remaining thirty-four per cent.[1]

Examination of Figure 8 reveals that, while the distribution of the three categories is approximately equal, they are by no means equally divided among the six topographic quadrangles. The Strum and Mondovi Quadrangles account for a large portion of the steep slopes, the Elk Mound and New Auburn Quadrangles are primarily moderate slopes while the Chippewa Falls and Bloomer Quadrangles are to a large extent composed of gentle slopes.

The steep slope category is usually found in one of three distinct situations. The most extensive area of steep slope occurs in the southern third of the region, primarily in the Strum and Mondovi Quadrangles. The steep slopes here form a continuous and extensive expanse of sloping terrain without interruption except by the relatively narrow and short valleys which extend from the Buffalo River Valley into the hills on either side. Plate VI illustrates a typical steep slope complex as found in this area. This slope category is also found in association with the erosional remnants which are completely surrounded by terrain which is essentially level. This association is most prevalent in the Elk Mound and New Auburn Quadrangles and through the center of the Chippewa Falls sheet. Examples of this type of slope association can be found in Plate III. Figure 3 also illustrates the general configuration of these erosional features. The third steep slope association consists of the steep river banks of the Chippewa River and its tributaries. These slopes usually have gentle terrain on either side of the band of steep slope. Significantly enough the

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[1]The various percentages have been determined on the basis of a 6,000 point sample. For example, 2,007 samples were considered to be in the gentle slope category which is equivalent to thirty-three and four-tenths per cent of the total sample. Hence it is also equivalent to thirty-three and four-tenths of the total area sampled.

PLATE VI
A STEEP SLOPE COMPLEX

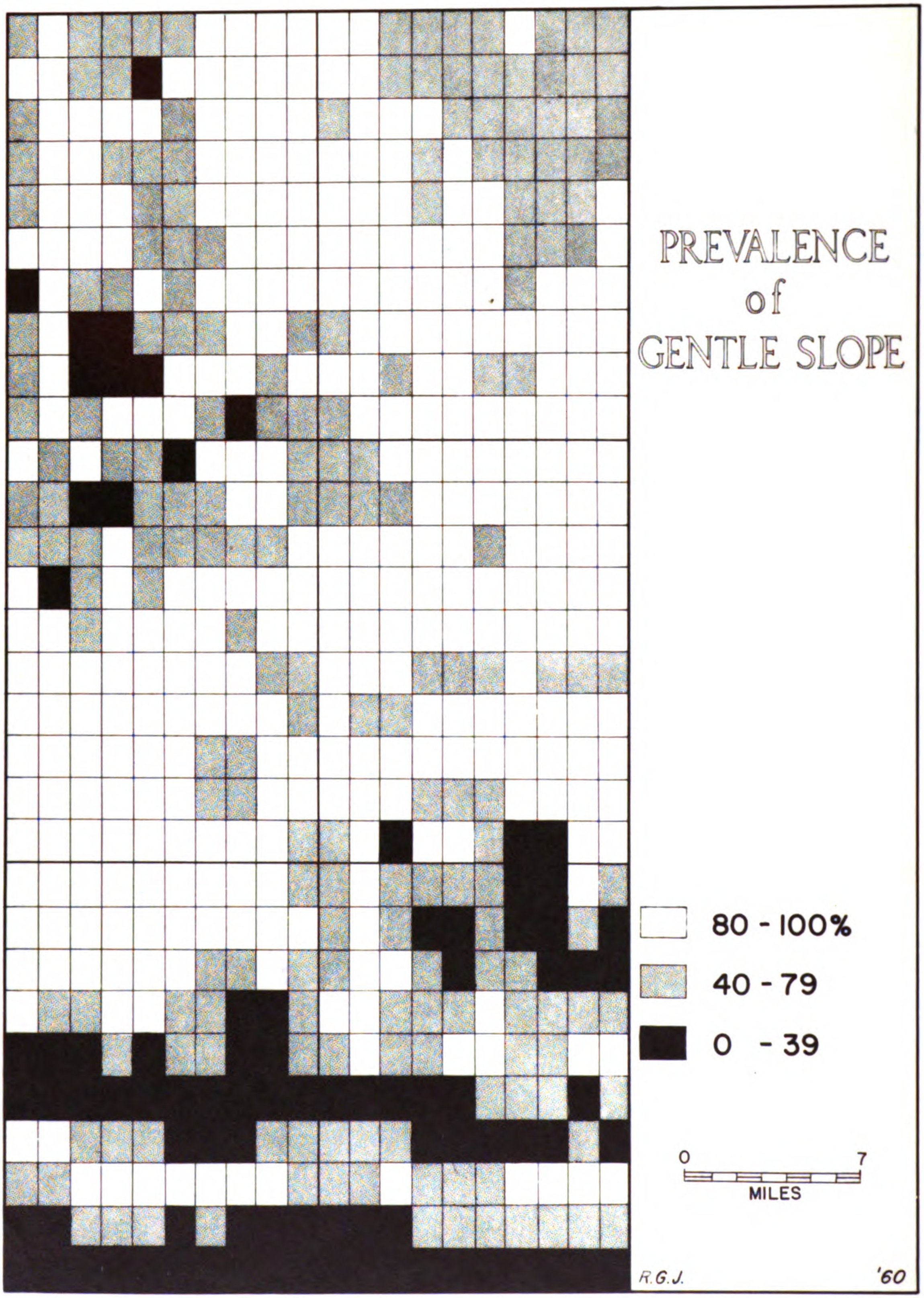


Figure 7

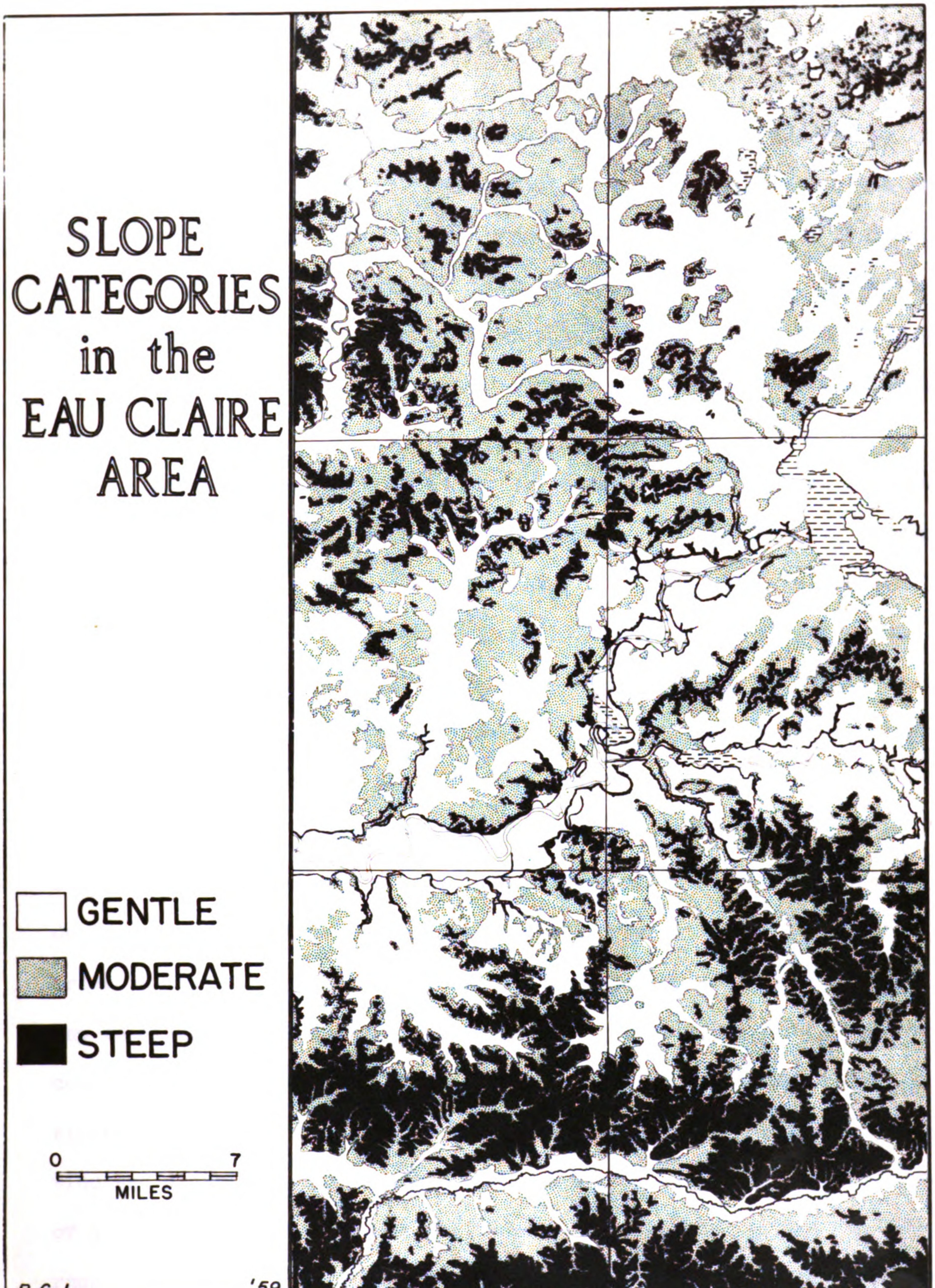

SLOPE CATEGORIES in the EAU CLAIRE AREA
GENTLE
MODERATE
STEEP
0
7
MILES
R.G.J.
'59

Figure 8

other major rivers, the Buffalo and Cedar Rivers, do not show this type of river bank configuration.

Equally significant from the point of view of area covered by them and certainly more important with respect to land utilization is the moderate slope category. Most of the moderate slopes represent a transition from the steep to gentle slopes. This is especially true in the Strum and Mondovi Quadrangles. The remainder of this slope category is to be found in the extensive areas of undulating terrain of the Elk Mound Quadrangle (see Plate VII).

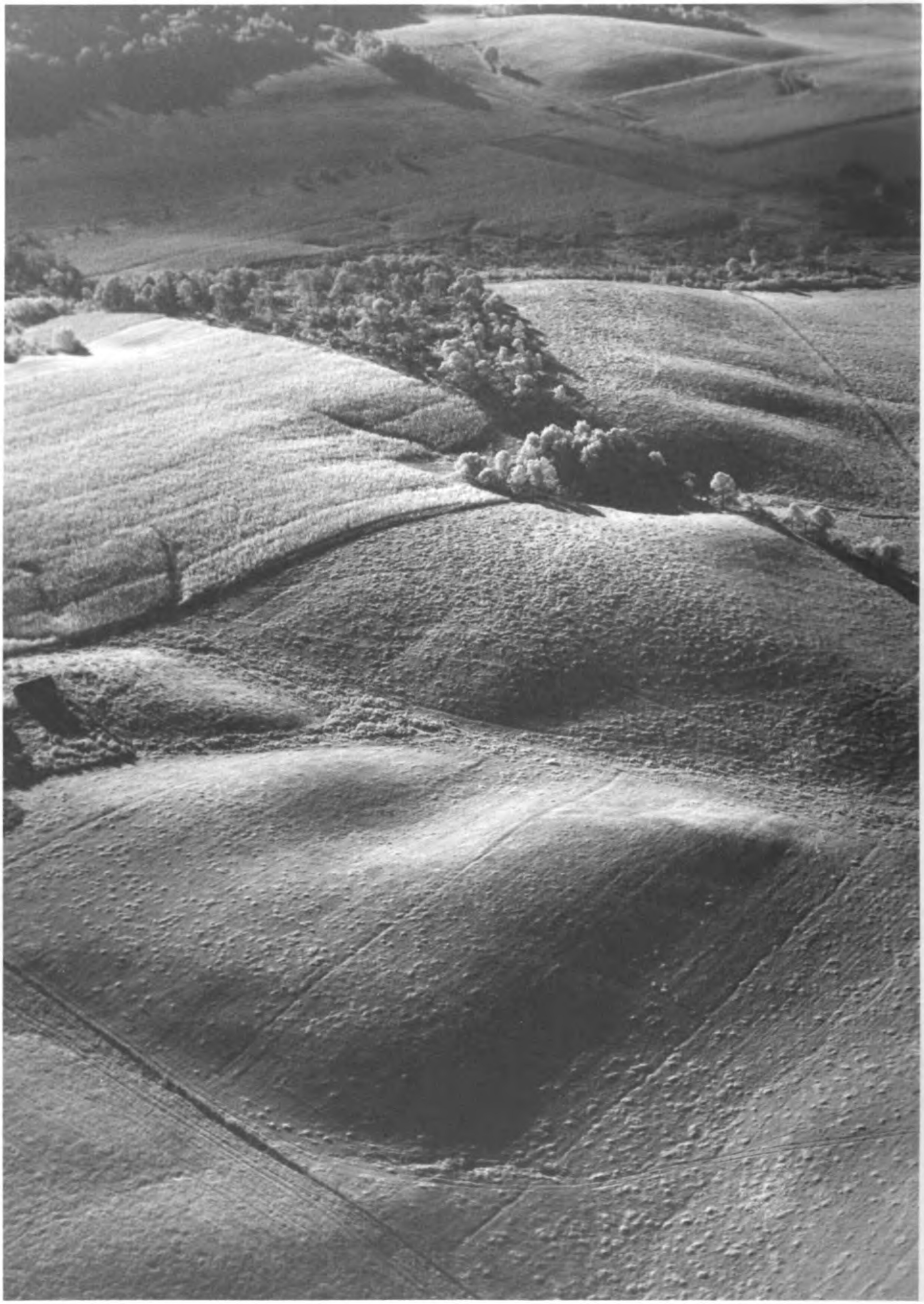
The gentle slopes account for the remaining third of the total area. The majority of the slopes in this category is to be found along the major bodies of water although as one moves away from that body the terrain trends toward greater inclination (see Plate VIII). One aspect of the gentle slopes in the Eau Claire Area is brought out well in Figure 8. This is with reference to the virtual absence of these slopes along the crests of the various ridges and hills.

What are the problems and merits connected with this method of slope analysis? One of the most impressive attributes of a slope map derived through the use of the continuous determination of slope categories is the vivid portrayal of the distribution of slopes. From such a map as Figure 8 a skillful morpholgist can extract valuable information concerning the percentages of the study area under each slope category, slope directions, relationships between slopes and drainage, and the location and distribution of various areas of uniform slope. The last type of information would prove useful to both the morphologist and the geographer wishing to relate land use to slope. In addition to the more obvious types of information which can be extracted from the slope category map as indicated above, there are often additional benefits to be derived

PLATE VII - Moderate Slopes. Extensive areas of moderate slope are to be found in the Elk Mound Quadrangle. As can be seen in this photograph the local relief is moderate although the majority of the surface is in slope.

PLATE VIII - Gentle Slopes near Chippewa Falls. Along a significant portion of the Chippewa River the gentle slopes increase in inclination as the distance from the river increases. This aspect of the gentle slopes is illustrated in this photograph. The terrain in the immediate background is classified as gentle slope while the terrain in the foreground is considered to be steep slope.

PLATE VII



UNDULATING TERRAIN - MODERATE SLOPES

PLATE VIII

GENTLE SLOPES NEAR CHIPPEWA FALLS

from these maps.

Chamberlin and Salisbury ascribed symmetrical profiles to the valleys and ridges of the Driftless Area.[1] This view cannot be supported upon a close examination of Figure 8. On the contrary, there appears to be a noticeable tendency for the valleys and ridges in the Driftless Area to assume asymmetrical profiles. The Buffalo River Valley is the best example of this. On the north side of the valley the steep slope category comes close to bordering directly upon the river while in the southern portion of the valley there is an extensive zone of moderate slopes which separate the river from the steeper slopes. In addition one can observe that the gentle slopes, which probably represent the flood plain of the river, are much more extensive along the south side. Several of the tributary valleys of the Buffalo River also display the same tendency toward asymmetry.

This phenomenon is not restricted to the Buffalo River Valley alone. For example, one may notice that a large number of the isolated hills and ridges in the northern part of the Elk Mound Quadrangle and extending through the New Auburn Quadrangle also deviate from the idealized symmetrical profile. It is interesting to note that the hills of the Elk Mound Quadrangle and part of the southern edge of the New Auburn Quadrangle were once thought to be a part of the Driftless Area.[2]

The problem of asymmetry is difficult to explain since the sediments from which the ridges and valleys have been carved dip to the south. All things considered, the valleys should have developed asymmetry in the opposite direction. This problem is beyond the scope of this paper, but

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[1]T.C. Chamberlin and R.D. Salisbury, loc. cit., p. 262.
[2]Ibid., Plate XXVII.

it does point out in a succinct manner the type of information which is not readily apparent from examination of topographic maps or in the field.

The general absence of any large expanse of level or even moderate slope on the ridge tops is also evident. This indicates either a "mature" stage of dissection or modification by other forces. For the geomorphologist the slope category map can provide additional objects for study. Beyond the problems suggested above there seems to be a relationship between the amount of steep slope and the various glacial boundaries. Also, narrow strips of gentle slope which connect the morainic area of the Bloomer Quadrangle with the Cedar and Eau Claire Rivers stands out. These could conceivably be ancient glacial spillways, although this hypothesis would necessarily require extensive field work in order to prove its validity.

The continuous determination method is not without limitations. For example, one factor which cannot be fully appreciated from the discussion of the technique nor from the accompanying map is the time involved in compilation. The method is slow. Where the texture of the terrain is fine the process of determining the proper place for the category isopleth is an arduous task. The rapid change in slope and general lack of extensive areas of uniform slope forces one to make numerous arbitrary decisions which reduces the accuracy of the final slope map. One also experiences difficulty in those areas in which the terrain takes on the character which has often been termed "gently rolling" or "undulating" (see Plate VII). Here the very gradual shift from one slope category into another demands intense concentration and constant judgement in order that the isopleth may be drawn in the proper place.

The second method of slope analysis used in this study is based upon a summary of the slope conditions in the individual unit areas. As indicated previously the Eau Claire Area was divided into 600 unit areas which measure approximately one and two tenths by one and seven tenths miles. A sheet of transparent acetate which had previously been inscribed with a set of dots in a random orientation was placed over the topographic quadrangles. The density of these dots was such that ten of them would fall within each of the unit areas. At each dot the slope inclination was determined through the use of the slope scale. The total slope sample therefore consisted of 6,000 determinations. With experience it soon became feasible to estimate the inclination at each dot without the use of the slope scale. This practice materially reduced the time required to secure the slope data.

With the slope data in a discrete form for each of the unit areas, it then becomes possible to discuss each unit as an individual or to compare one unit to another. The best method of presenting the data is to characterize each unit on the basis of the prevalence of gentle slope. All things considered, one may also assume that the per cent of the total area of each unit area under a particular slope category is identical to the percentage of that category with respect to the total number of samples taken.[1]

While it may be possible to devise a classification based upon the modal slope class it would be of limited usefulness. A system using secondary and tertiary maxima would be better but the scheme would become too complex and lose most of its meaning.

The prevalence of gentle slope in the Eau Claire Area is illustrated in Figure 7. When interpreting this map one must remain aware of the method used in its compliation. A choropleth map of course suffers aesthetically when compared to the isopleth map. One is immediately faced

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[1]Wood, loc. cit.

with the fact that individual relief forms have been generalized out of existence, and only the general trend of terrain within the unit areas is discernable. This is due to the fact that the units are too large to give the whole of "reality" and is actually a summary of slope conditions with the unit area. The larger the area with a uniform slope, and in a sense a larger relief form, the greater will be the accuracy of that area when mapped by this means. Minor features such as narrow ridges, isolated hills, and steep river banks are commonly reduced to a great extent or eliminated entirely. Dismemberment of river valleys often proves to be distressing unless there is a full appreciation of the technique used in compiling the map.

A brief examination of the two slope maps (Figures 7 and 8) indicates a surprising degree of correlation between the patterns produced by the slope data. The two maps do not concern the same phenomenon in the sense that they depict different aspects of the slope. The major difference between them is primarily one of detail.

The hills along both sides of the Buffalo River and to the south and west of the village of Fall Creek are found on the Prevalence of Gentle Slope map in essentially the same form as on the Slope Category map. Unfortunately, with the exception of those to the northeast of Colfax, most of the hills in the Eau Claire Area are generalized out of existence. The major correlations mentioned above are a reflection of the principle that large areas of uniform slope or of one predominate slope will fare better in a choropleth map than will fine textured areas. The fact that the unit area grid may bisect some of the smaller hills also enters into the elimination of some hill areas while a fortuitous placement may magnify others out of proportion. Examples of magnified hill areas may be found in unit areas 3b and 71d while unit areas 48c and 49a are examples of the elimination of others.

The morainic area of the Bloomer Quadrangle shows a high degree of correlation on the two maps. This is a reflection of the nature of the terrain in this particular moraine. The presence of a large number of swamps and marshes which are normally classified as gentle in slope is matched by thenumerous hills and ridges. One should also keep in mind that the map of gentle slope does not differentiate between the various slope categories. An area which is classified as having thirty-nine per cent gentle slope does not indicate the relative prcportions of the various slope categories in the remaining sixty-one per cent. One could overcome this by including another map concerning the prevalence of steep slopes although for most purposes the slope category map would serve the same purpose, and, at the same time, allow for a better understanding of the areal distribution of slope categories.

In those areas of moderate slope the pattern of generalization is similar to that found in areas of steep slope. The major deviation between the slope category map and the map of gentle slopes with respect to extensive areas of moderate slope is to be found along the eastern edge of the New Auburn Quadrangle and in the unit areas 54a, 54c, 54d, 55a, and 55b. Here the probable explanation lies in the generalized nature of the slope category map. In its construction it was pointed out that large areas of moderate slope were difficult to map accurately. One result of this is to generalize out of existence small areas of gentle slope while equally small areas of steep slope are more likely to be retained since they are easier to recognize. In securing slope data for the unit areas this tendency is eliminated since each slope sample is discrete, and there is seldom any doubt as to which slope category the sample belongs.

The dismemberment or elimination of river valleys is another feature of the Prevalence of Gentle Slope map which may cause concern. The Chippewa River is a prime example of the disregard for a "major" feature of the landform. The river itself is only a major feature when considered with respect to differences in surface materials or with reference to hydrologic features. On the basis of slopes the river is a minor part of the total complex. Since the immediate river valleys as well as the upland terraces are essentially level, there is really no difference between them with respect to slopes. The Cedar River is an example of the dismemberment of a river valley. A vertical row of unit areas containing a high percentage of gentle slopes traces the location of this valley. Near the village of Colfax the valley ceases to exist on the map. Inspection of the slope category map suggests that this is the result of the narrowness of the valley at this point. The location of unit area boundaries must also enter into the reasons for this. The elimination of the Buffalo River Valley south of the city of Mondovi also demonstrates this.

In conclusion, it is difficult to form any generalizations concerning the relative merits of one slope analysis method over the other. Since each system and the resulting maps are designed to show different aspects of the slopes of an area, there is little basis for a direct comparision. The purpose of the landform study should be the major factor in the selection of the precise method to be used. Studies directed toward morphometric and morphogenetic ends would probably benefit more through the continuous determination method while relational studies would best be served by the unit area approach. In addition, the size of the study area should be considered. Experience seems to indicate that the continuous determination method has more or less reached an upper limit with the size of the Eau Claire Area. Less complex terrain and a limiting of the investigation to a fewer number of slope categories or an increase in the number of investigators

would allow larger areas to be analyzed without undue effort. With larger areas a limiting factor of generalization would also negate one of the best attributes of this technique, namely the vivid portrayal of the distribution of the slopes. On the other hand, the unit area approach is close to the lower limit with the size area used in this study. With areas of greater dimensions it would become increasingly more applicable.

Major Crests - The major crests represent an important element of the landform which have to a large extent been ignored in the study of landform elements. The crests contribute much to the general character of the landscape and are often one of the salient features which serve to differentiate one area from another.[1]

The process of locating and mapping the major crests is most conveniently done through the use of topographic maps. A transparent acetate sheet is placed upon the topographic map and the extent, and the location of each major crest is recorded directly upon the acetate. The delineation of major crests produces an interesting and graphical representation of the pattern of these features on a regional basis (Fig. 10). Upon close examination of Figure 10 four basic patterns of crests may be recognized in the Eau Claire Area.

A major portion of the entire area is without a major crest as defined in this study. Plate IX is a typical area which falls into this pattern. From the photograph one may see the distinctive aspect of terrain without

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[1]A major crest in this study was arbitrarily defined as one which is at least 1,000 feet long, not over 500 feet wide at the summit, and whose sides are steeper than eleven per cent. To compensate for the fact that a major crest in one area is not necessarily of the same importance in another, a crest should have a vertical rise equal to at least one-third the maximum relief of the unit area in which it lay. The crest criteria used here are experimental and should not be considered binding.

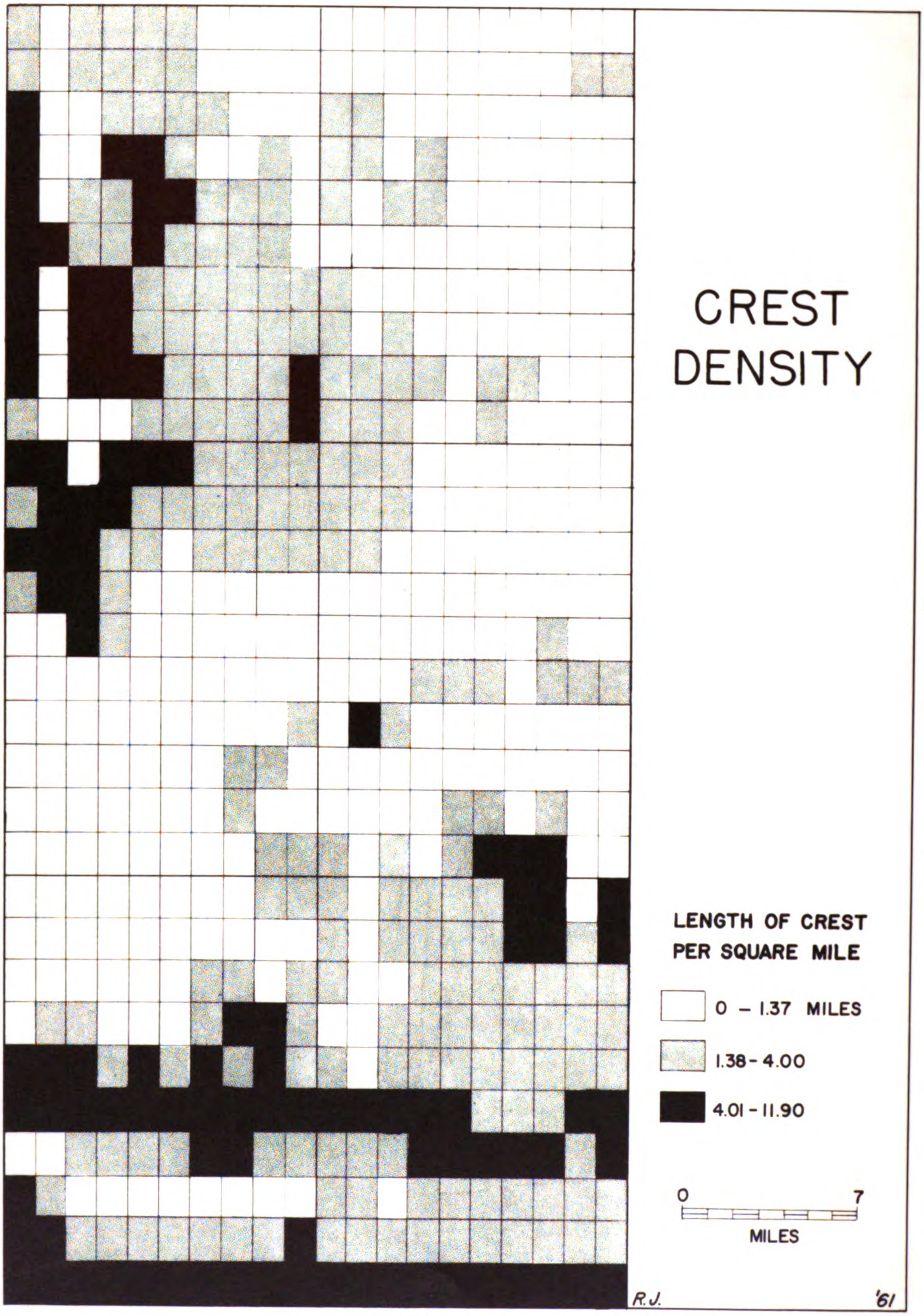
CREST
DENSITY
LENGTH OF CREST
PER SQUARE MILE
0 – 1.37 MILES
1.38 - 4.00
4.01 - 11.90
0
7
MILES
R.J.
'61

Figure 9

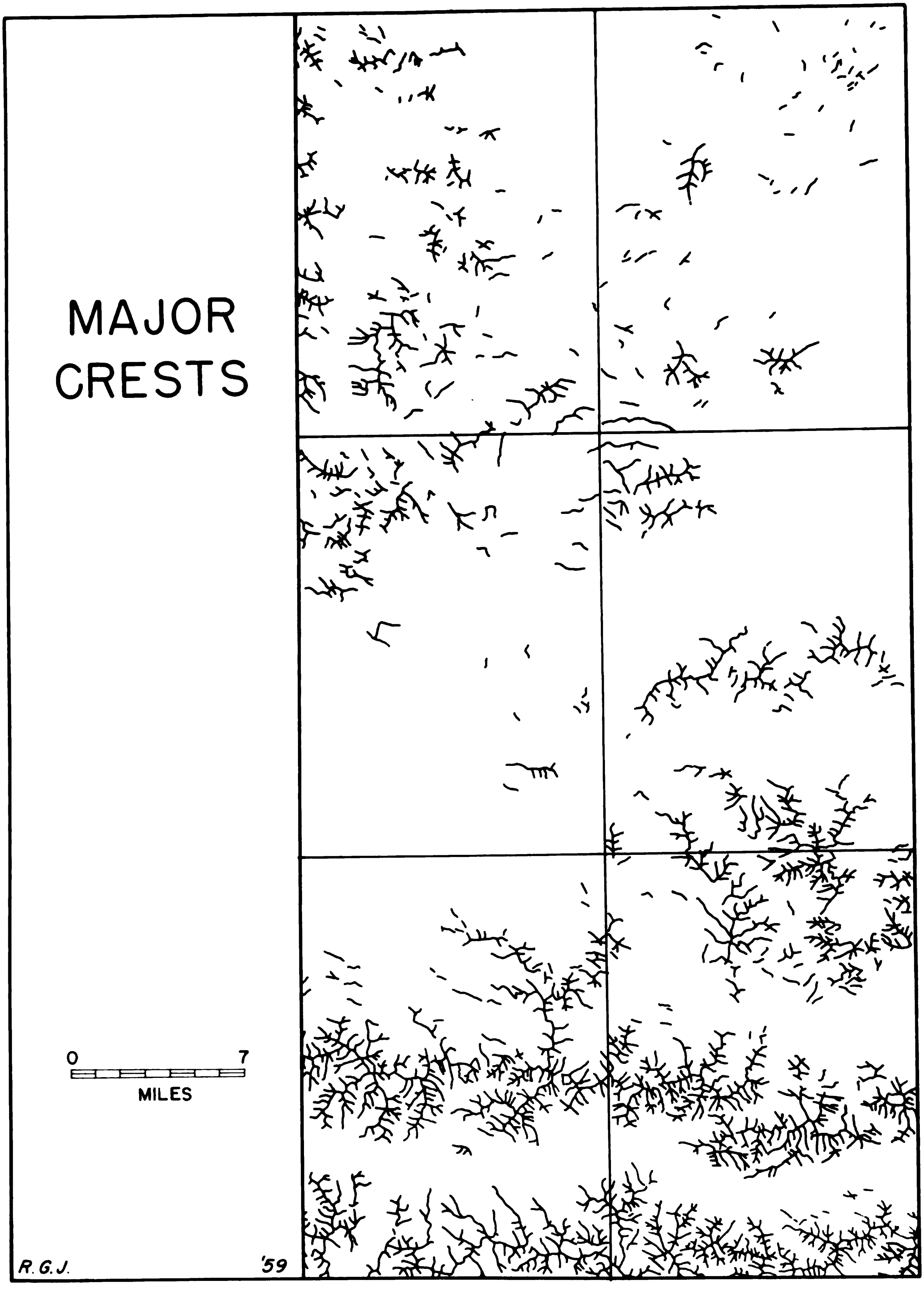

Figure 10

a major crest is the relatively long distance which may be encompassed at one time unless interrupted by vegetation.

Another pattern which is restricted to the northeast corner of the Bloomer Quadrangle could be subjectively described as a fragmental pattern. A typical association of crests found in this area is represented in Plate X. The third pattern, which has arbitrarily been called a dismembered dendritic pattern, is found in a number of different areas although the best example is to be found in the New Auburn Quadrangle. The crests here are large in an absolute sense, but, at the same time, the level areas between major crests are also larger. Thus, proportionately they are no more important in the total landform complex than the crests discussed in the previous pattern(see Plate XI).

The last pattern is best developed in the Mondovi and Strum Quadrangles. The dendritic pattern produces both a distinctive pattern in Figure 10 and a distinctive regional difference in terrain which is easily observed in the field. For this reason one can quite definitely say that the major crest here is not only a significant element in the character of the terrain but is perhaps the single most important element in the total complex (see Plate XII).

Crest Density - While Figure 10 does contribute to an understanding of the landform, especially when used in conjunction with photographs and other landform data, it is relatively useless for objective regional comparisions on the unit area basis. This is due to the difficulty in characterizing the arrangements of the crest and to delimit regions based upon a similarity of patterns. A mathematical expression of various pattern types is theoretically possible, but this is best reserved for morphometric analyses. On the other extreme, a verbal classification and description such as that offered in the preceeding pages is likely to involve a

PLATE IX - <u>Terrain without a Major Crest</u>. This view, looking north from the center of the Elk Mound Quadrangle, illustrates the unrestricted views offered in regions without major crests. In the background are a series of hills which constitute another type of crest pattern.

PLATE X - <u>Fragmental Crests</u>. The major crests in this photograph may be seen at the edges of the photograph with the stream flowing between them. This scene also illustrates an important aspect of the crests as defined in this study, namely that the crest does not have to assume major dimensions in order to be a prominent feature in the landscape. Relative dimensions are more important than absolute dimensions.

PLATE IX

PLATE X

considerable degree of subjectivity.

The problem of putting the crest data into a useful form is similar to that found in utilizing the slope data. The map of major crests keeps distortion of "reality" to a minimum yet does not provide a means of making objective comparisions. To circumvent this problem the crest data may be converted into a relatively simple and useful index called the crest density. The total length of major crests within each of the unit areas is measured, and then each unit area is classified according to the linear extent of crests within the unit expressed in crest length per unit of area.

The major problem connected with the conversion process was the determination of the proper class values. It is desirable to keep the number of classes to a minimum, but, at the same time, there should be a sufficient number of distinctions to adequately reflect regional differences. Class values should ideally be based upon criteria which would take into consideration the relationships between the major crests and the total landform. Since these relationships, if they do exist, are not understood, the values were determined through extensive experimentation in which various possible class values were evaluated. The final selection was based upon finding a set of values which most nearly approximated the subjective patterns discussed above. This course was taken in the absence of any other valid means of determining the optimum class values.

The nature of the crests in relation to the unit areas does not permit a regionalization identical to that arrived at subjectively. A close examination of the fragmental pattern in the Bloomer Quadrangle will supply the reason behind this statement. Many of the unit areas in this portion of the quadrangle are completely devoid of a major crest while others may have one or more short crests within their borders. Thus any

PLATE XI - A Major Crest in the Dismembered Dendritic Pattern. In this pattern the major crests exhibit greater absolute dimensions than in the previous pattern and usually have a greater extent of level terrain between crests. Notice the larger dimensions of both the crest and the level terrain surrounding the crest.

PLATE XII - The Dendritic Crest Pattern. In this area the most significant feature of the terrain are the crests. The numerous crests also inhibit complete utilization of the land since many of the crests are in forest and the valleys between are often too moist for cropland.

PLATE XI

PLATE XII

class value of sufficient magnitude to include the majority of the unit areas in this region would necessarily include most of the remainder of the Eau Claire Area whose unit areas display little or no crest development. On the other hand, the use of a set of values to include those units which have crests and at the same time exclude those without would unduly fragment the regional pattern. At the same time a large number of unit areas in the New Auburn Quadrangle would be included in the same classification even though the crests in these two regions bear little resemblance to each other. The best compromise is to include the fragmented pattern into the least dense class which includes those units with little or no crest within them.

The class values were then applied to the data for each of the 600 unit areas and recorded on a base map (Fig. 9). As with the Prevalence of Gentle Slope map (Fig. 7), the major difference between the choropleth map and the map indicating exact crest locations is primarily one of greater abstraction from reality. From an overall point of view the greater abstraction depicted in the crest density map is not objectional since broad regional differences are indicated.

All things considered, the major crests represent a significant part of the landform complex although it is difficult to devise a means of using the data effectively. In other areas of greater uniformity the crest density could conceivably contribute significantly to a valid regionalization.

<u>Drainage Patterns</u> - In a temperate, humid region the rivers and streams represent the single most important agent of degradation. For this reason it seems logical that the nature of the terrain should be to a large extent a reflection of the relative density of these features.

The complete drainage pattern (Fig. 12) is essentially the same as that depicted in Figure 4, the major difference has been accomplished through the addition of intermittent streams, swamps, and marshes.

For the Eau Claire Area as a whole the drainage pattern assumes a form often referred to as dendritic. The major exception is found in the northeast corner of the Bloomer Quadrangle. Here the drainage is disrupted and flows in all directions without a preferred orientation. This area is also characterized by numerous swamps, marshes, and lakes. Another area of swampland occurs along the south side of the Chippewa River in the Mondovi Quadrangle. Here the cause of excessive water accumulation is more difficult to explain.

A third pattern is that, which occupies a zone of terrain on both sides of the Chippewa River and especially on the north side, is characterized to a large extent by a lack of surface drainage features. Again this may be related to previous deposits of the Chippewa River which have a high infiltration capacity. The surface material in this area is composed mostly of sand.

<u>Drainage Density</u> - In an attempt to place the drainage patterns on the same basis as other elements, the same classification techniques as those used in the study of major crests were applied to the data concerning total stream length in each unit area. Unfortunately the surface expression of drainage is subject to a number of variables beyond simple differences in precipitation. These variables concern different types of soil, bedrock, and relief. Other forces such as previous glacial activity and associated deposits have also served to modify the drainage network. As Playfair succintly expressed it, in an idealized drainage network:

> Every river appears to consist of a main trunk, fed from a variety

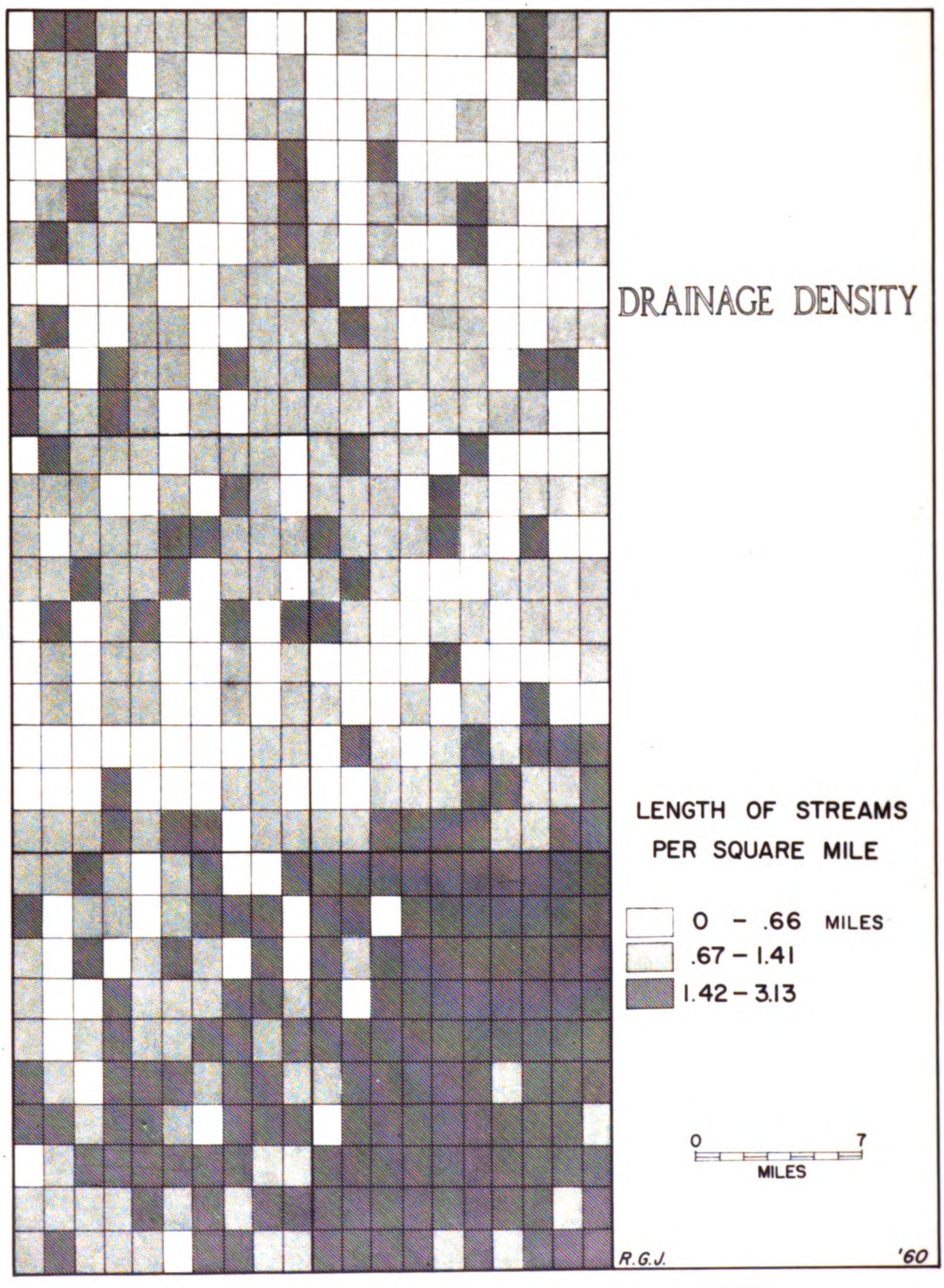
DRAINAGE DENSITY
LENGTH OF STREAMS
PER SQUARE MILE
0 - .66 MILES
.67 - 1.41
1.42 - 3.13
0
7
MILES
R.G.J.
'60

Figure 11

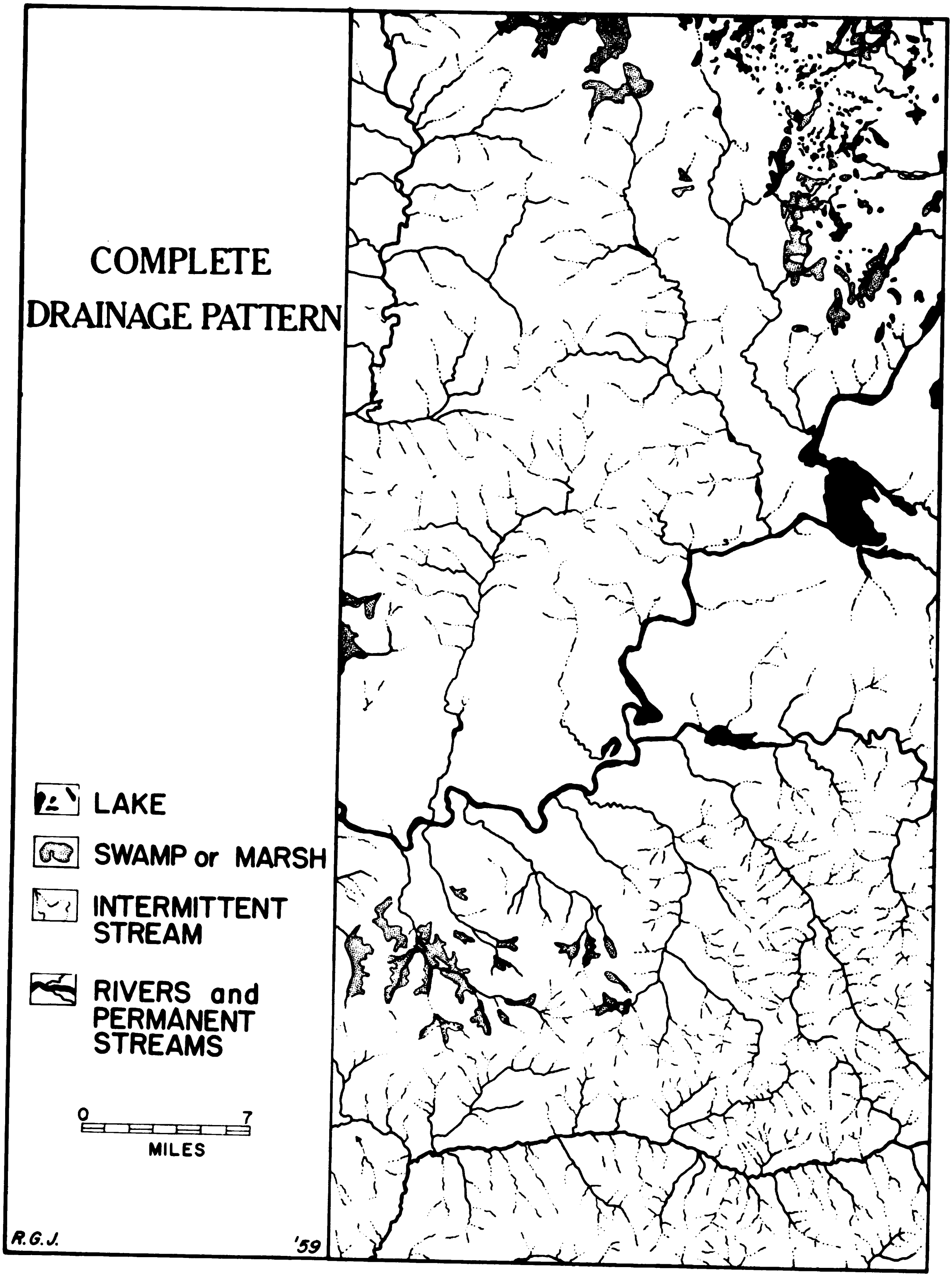
COMPLETE
DRAINAGE PATTERN
LAKE
SWAMP or MARSH
INTERMITTENT STREAM
RIVERS and PERMANENT STREAMS
0
7
MILES
R.G.J.
'59

Figure 12

> of branches, each running in a valley proportioned to its size, and all of them together forming a system of vallies, communicating with one another, and having such a nice adjustment of their declivities, that none of them join the principal valley, either on too high or too low a level; a circumstance which would be infinitely improbable, if each of these vallies were not the work of the stream that flows in it.[1]

Assuredly this does not fit the entire Eau Claire Area. For this reason the value of the drainage density as a differentiating characteristic in landform analysis is greatly reduced. Nevertheless, both the drainage patterns and drainage density do contribute another valuable set of factors which aid in a better understanding of the nature of the terrain and the internal differences which exist.

A study of other uses which might be made of the drainage density suggested that it might be possible to determine mean slope length without the necessity of individual slope length determinations. Since the length of overland flow should be equal to approximately half the reciprocal of the drainage density, or:[2]

$$OF = \frac{1}{2} Dd$$

this formula could provide a short-cut to the more valuable index, namely the mean slope length.[3] However, after determining the length of overland flow within a selected sample of unit areas and comparing the data to that derived by actual measurement of a series of slopes, there did not appear to be sufficient agreement between the two sets of figures to justify use of the formula.

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[1]John Playfair, Illustrations of the Huttonian Theory of the Earth (Edinburg: Printed for Cadell and Davies, London, and William Creech, Edinburg, 1802), p. 102.

[2]Robert E. Horton, "Erosional Development of streams and their Drainage Basins: Hydrophysical Approach to Quantitative Morphology," Bulletin of the Geological Society of America, LVI (March, 19545), p. 284.

[3]Length of overland flow refers to the length of flow of water over the surface before it enters a stream channel.

Although time did not allow further investigation of this problem the most likely answer is connected with the definition of what constitutes a slope. The mean slope lengths were consistently greater than the data derived through the use of the formula. This indicates that there is a basic difference between a mean slope length index based upon consideration of all slopes in an area and another based upon major slopes only.

Elements in the Vertical Plane

Elements in the vertical plane may be divided into two groups. One group consists of those elements which are readily apparent in the field and can be said to contribute visibly to the character of the terrain. Valley and ridge profiles, the height of hills, ridges, cliffs, terraces, and the depth of valleys, rivers, and canyons are typical examples of elements which find expression in the vertical plane. Basically all of these dimensions are expressions of individual slopes which, when taken together as a group, give areal extent to these features. In addition to these easily perceived aspects of the vertical plane, there are a number of distributions which occur in the vertical plane and often contribute to the total impression of an area and at the same time are useful in comparative study. In this group are relations between relief and slopes, between elevations and slopes, distributional pattern of slopes, and the distribution of elevation.

Local Relief - One of the vertical dimensions of the landform which is often the subject of study is that called the local relief.[1] Usually the local relief is determined for an area which is larger than that which

[1]"Local relief" as used in this study refers to the maximum difference in elevation between the highest and lowest points within an unit area.

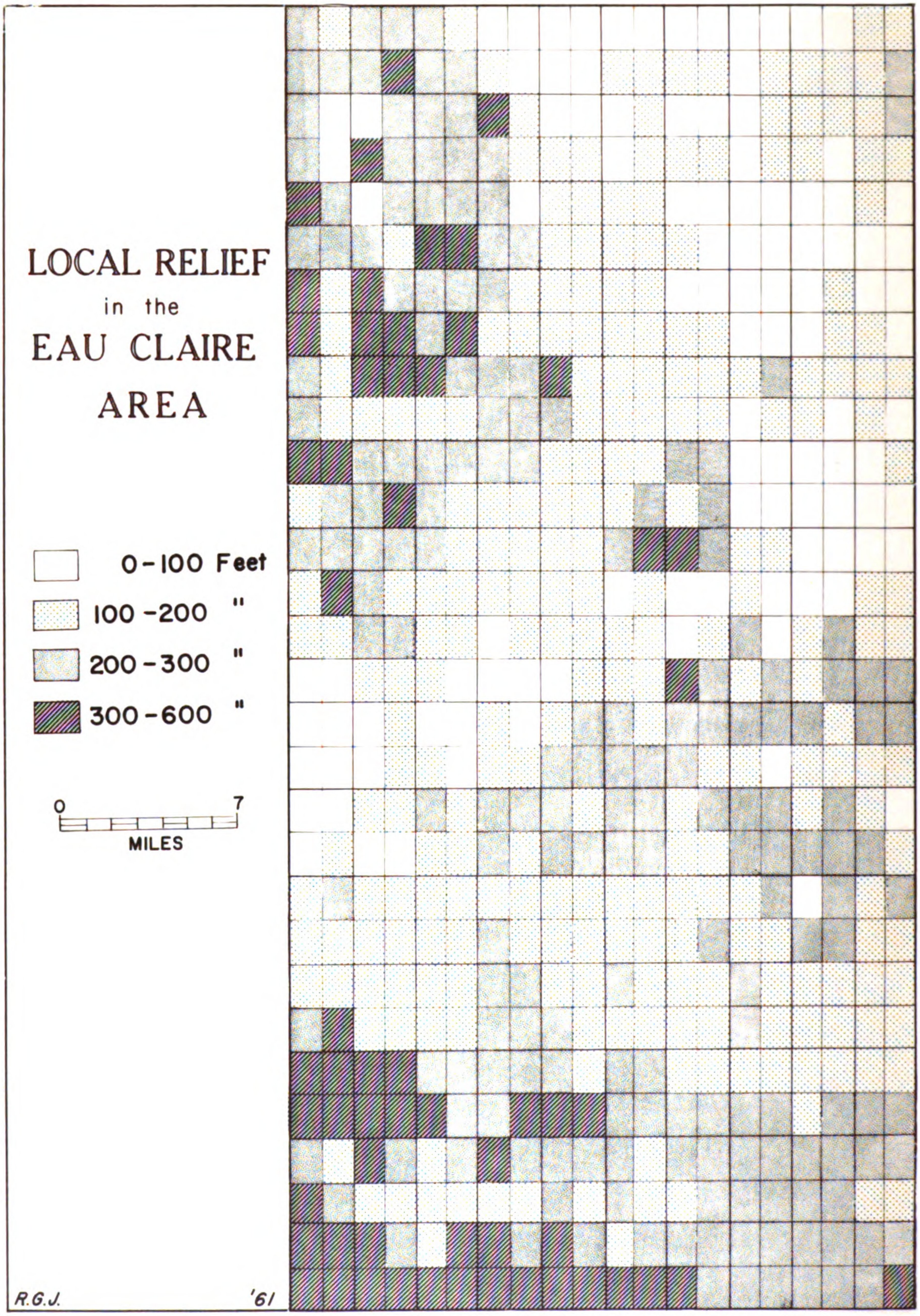
LOCAL RELIEF
in the
EAU CLAIRE
AREA
0-100 Feet
100-200 "
200-300 "
300-600 "
0
7
MILES
R.G.J.
'61

Figure 13

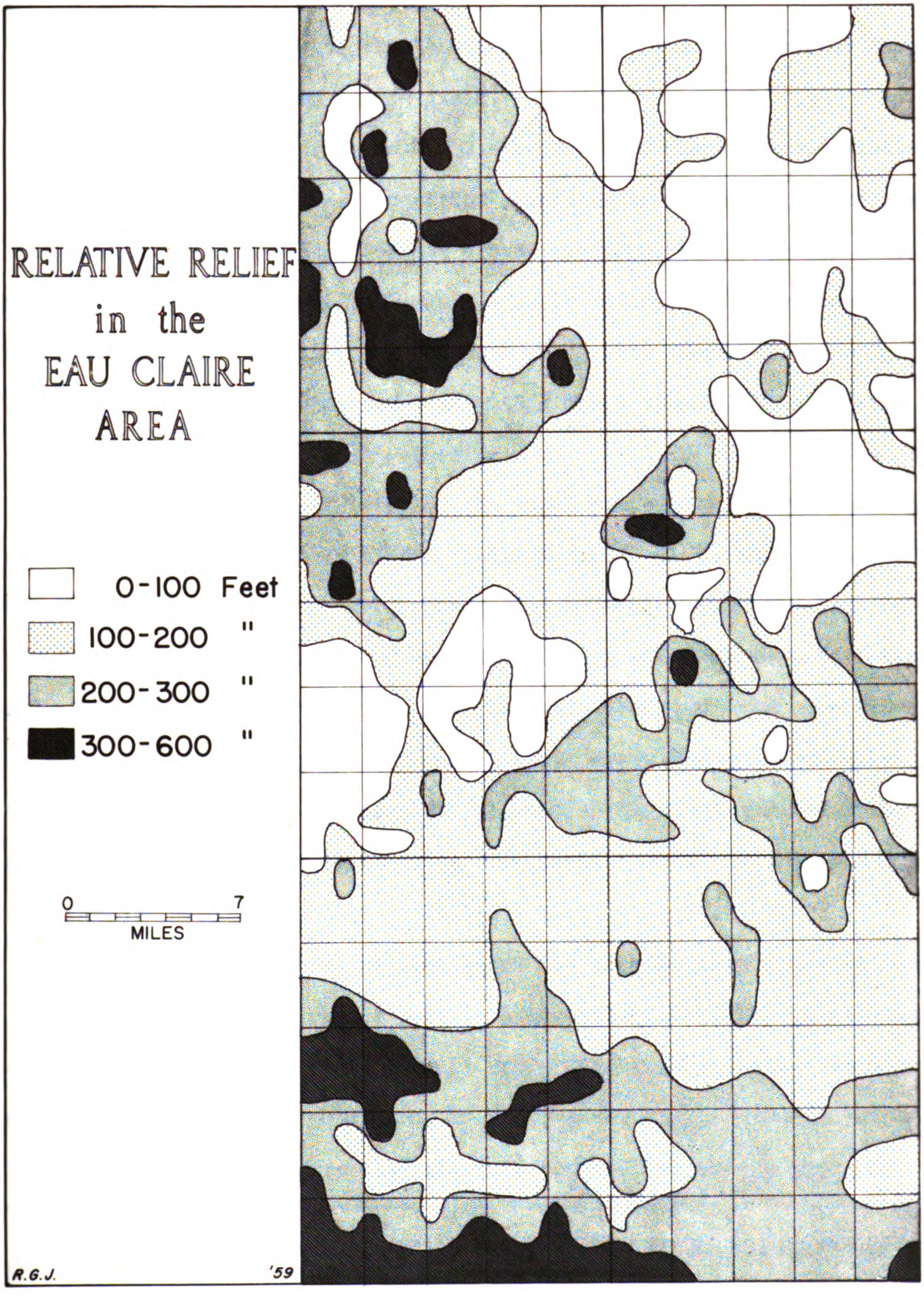
RELATIVE RELIEF
in the
EAU CLAIRE
AREA
0-100 Feet
100-200 "
200-300 "
300-600 "
0
7
MILES
R.G.J.
'59

Figure 14

can be encompassed in one view. In this sense the local relief is a somewhat artificial property of the landform since its value is greater than the actual relief as seen in the field.

The local relief for the Eau Claire Area was computed as indicated above. Each unit area was classified according to the total relief available within the unit and plotted on a base map (Fig. 13). The map contains few surprises. As a whole the relief closely follows the prevlance of steep slopes. A comparision of Figure 8 shows this close relationship. In general, the greater the areal extent of steep slopes within an area the greater will be the local relief.

Relative Relief - Related to the local relief and derived from the same data is another aspect of the landform called the relative relief.[1] Briefly, the local relief is converted into relative relief by plotting the location of the highest and lowest points in each unit area on a base map. Next isopleths for each of the class intervals selected were drawn on the map.[2] These isopleths delineate those areas having essentially the same local relief. The completed map which shows the relationship of each area to adjacent areas of less or greater relief is called a "relative relief" map.

Which of the two relief maps bears the closest resemblance to reality? Either of the two relief maps if used without the other relief map and additional landform elements will often suggest conclusions which are not entirely justified. For example, there are numerous areas in which identical relief values are the result of diverse factors and types of

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[1]G.H. Smith, "The Relative Relief of Ohio," Geographical Review, XXV, pp. 272-84.

[2]The class limits were determined by the natural breaks in a distribution curve of relief figures for the 600 unit areas.

terrain. The Chippewa River appears on both of the maps as a discontinuous band of moderate relief between areas of less relief. Plate XIII is a view of the river at this point. Here the river has a steep sided valley within an area of essentially level terrain. Thus, while the great majority of the unit area may be nearly level it is necessarily classified in a higher relief category. On the other hand one may view the Cedar and Buffalo Rivers and see that the relief values are derived from a situation diametrically opposite. Basically the major difference between the rivers is a matter of valley profiles. The Chippewa River flows in a relatively narrow and steep sided valley while the Cedar and Buffalo Rivers flow through broad open valleys. As a result the Cedar and Buffalo Rivers have a flood plain which is bordered by hills and ridges (see Plate XIV). The best solution to the problems created by river valleys as illustrated above is to reduce the size of the unit area as much as possible. This in a sense is a means of increasing the agreement between the map and "reality".

In conclusion, while the local and relative relief aspects of the landform may not contribute to the ultimate delineation of regions on an objective basis, they do provide another important and highly necessary landform characteristic to a morphographic analysis.

Mean Slope Length - Closely related to local relief is the landform element which in this study shall be called the mean slope length. The mean slope length is perhaps a more meaningful characteristic of the landform than is the local or relative relief. This is due to the fact that the individual slopes are the actual elements of the landform which are perceived and from which the subjective impression of the actual local relief is based.

The mean slope length for each unit area was determined through

PLATE XIII

CHIPPEWA RIVER BETWEEN EAU CLAIRE AND CHIPPEWA FALLS

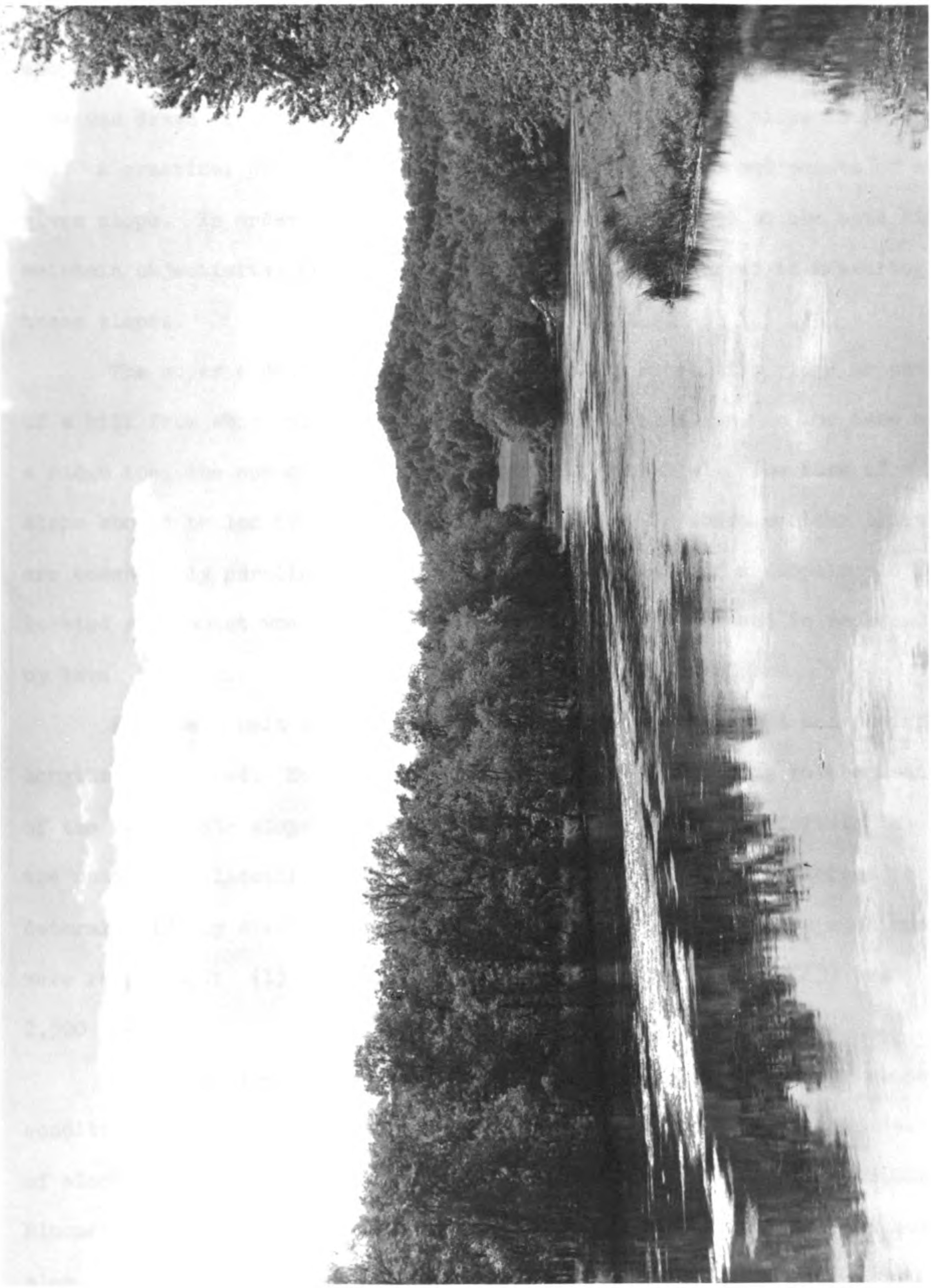

PLATE XIV
CEDAR RIVER NORTH OF COLFAX

averaging a selected sampling of slopes from the unit area. The individual slopes were chosen through the use of a random dot sample. At each dot a line was drawn on the topographic map from the top of the slope to its bottom. A practical problem is encountered in defining the end points of any given slope. In order to avoid the very minor slopes and at the same time maintain objectivity, certain principles should be observed in measuring these slopes.

The uuper end of a slope should be at the crest of a ridge or peak of a hill from which slopes radiate in all directions, or, in the case of a ridge top, the contour lines are essentially parallel. The base of a slope should be located at the bottom of a valley in which contour lines are essentially parallel. In some instances the base of a slope would be located at a point where the slope loses its inclination and is replaced by level terrain.

From each unit area ten individual slopes were plotted and their lengths determined. Each unit area was classified according to the mean of the ten sample slopes. To determine the optimum class intervals in the unit area classification, the 600 mean slope values were plotted to determine if any distinct groupings occurred. In general three such groups were recognized: (1) 0 - 500 feet, (2) 500 - 2,500 feet, and (3) over 2,500 feet.

The mean slope map (Fig. 15) is a graphical presentation of slope conditions throughout the entire area. A number of interesting aspects of slope are bought out in this map. First, the northeast corner of the Bloomer Quadrangle contains a solid block of unit areas in which the mean slope length is less than 500 feet. Second, the major hill regions do not as a rule contain the longest slopes, and, third, the extensive areas of gentle slope and low relief usually have the longest mean slopes.

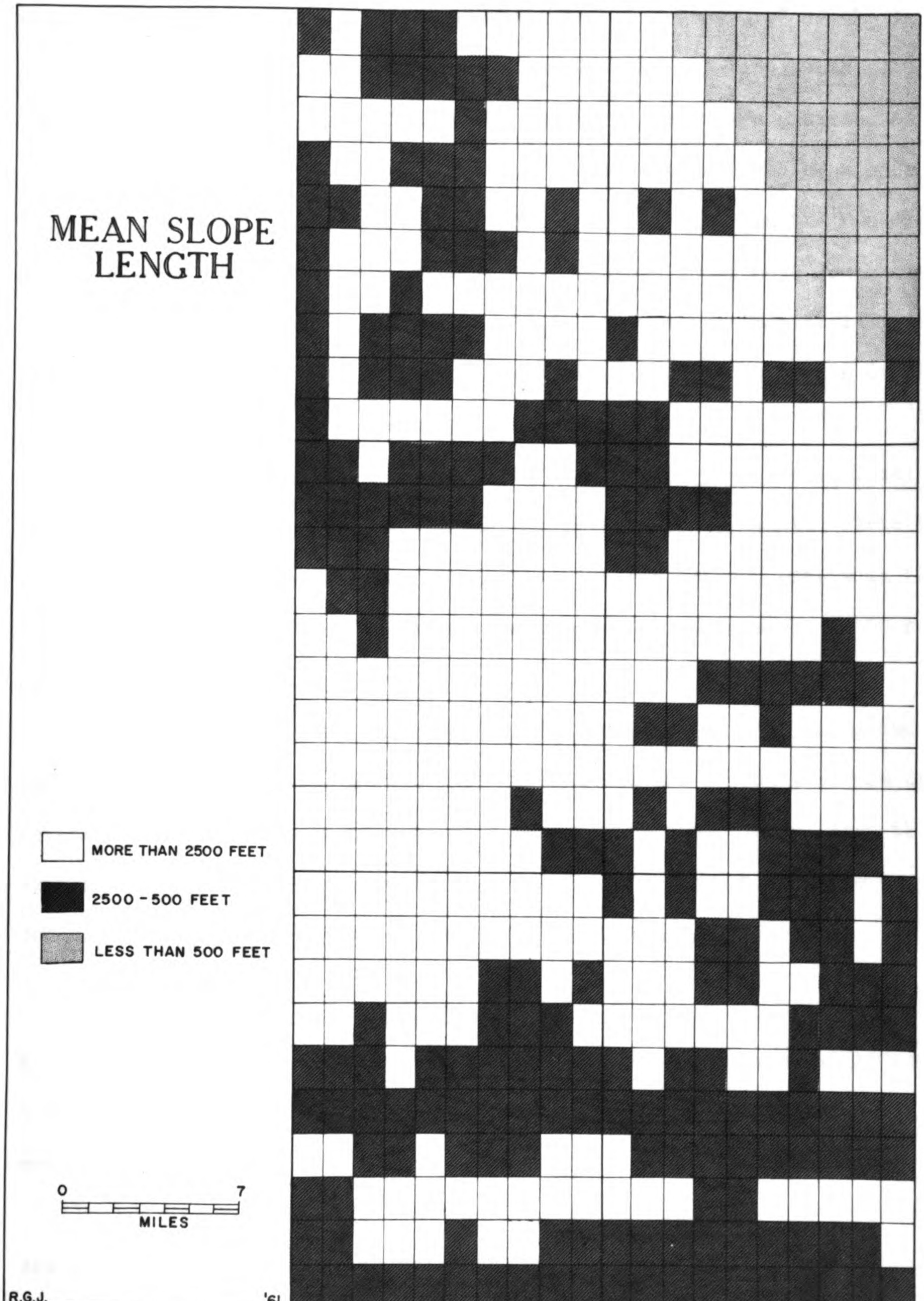
MEAN SLOPE LENGTH
MORE THAN 2500 FEET
2500 - 500 FEET
LESS THAN 500 FEET
0
7
MILES
R.G.J.
'61

Figure 15

The explanation of this distribution is relatively simple. In the northeast corner of the Bloomer Quadrangle the fine "texture" of the landform (see Plates II and X) results in a large number of very short slopes. These short slopes represent one of the major factors which contributes to the distinctive terrain in this area. The moderate length of slopes in hill regions is an expression of the limited local relief in the Eau Claire Area. With greater local relief these hill regions would have longer individual slopes. Another factor which acts to limit slope lengths is illustrated in Plate XV. Here the moderating factor is the high degree of dissection which usually acts to reduce slope lengths.

Long slopes are generally confined to areas of very little local relief, absence of crests, and predominant gentleness of slope. Plate IX is an example of one such area. Since the distance between crests in these areas is usually more than one mile, the slopes are as a result 2,500 feet or more.

Notwithstanding the deficiencies of this index in describing the landform, it does provide a realistic regionalization of the landform differences. The differentiation is of a sufficient degree as to allow this element along with the prevalence of gentle slope to constitute the two primary diagnostic elements in the formation of landform types.

Slope - Relief Relationships - Since each of the 6,000 slope determinations was tabulated on the basis of individual unit areas, it becomes a simple matter to relate the slope inclination to any other phenomena measured on the same basis.

One such relationship concerns the way in which various slope classes will vary with respect to the local relief (Figure 16).[1] From a purely

[1]Early investigations differentiated five slope classes. Class IV slopes were between nineteen and twenty-nine per cent, Class V slopes were those above twenty-nine per cent. Class III, IV, and V were combined into one group and referred to as "steep".

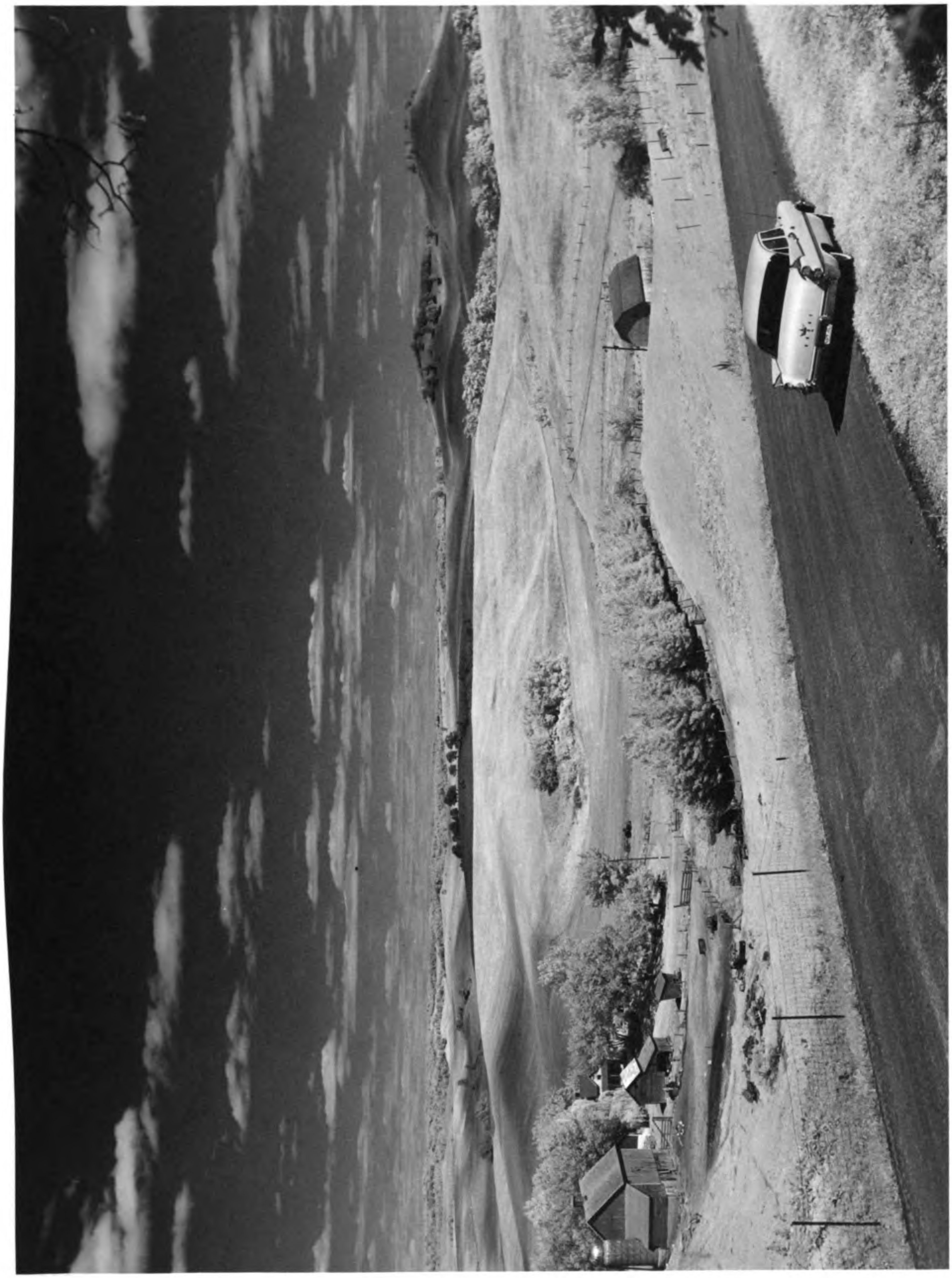

PLATE XV
SHORT SLOPES IN HILL REGION

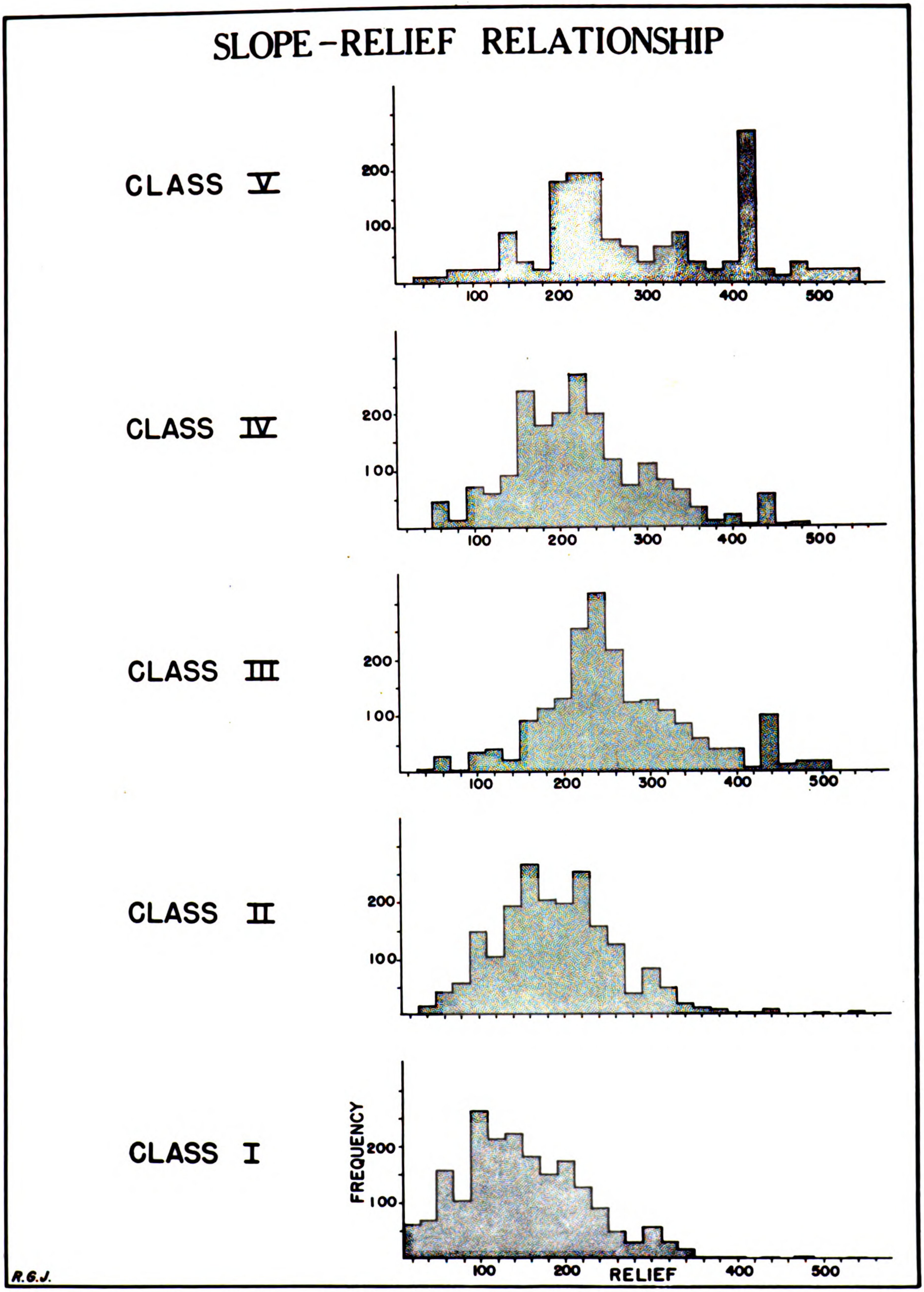
SLOPE-RELIEF RELATIONSHIP
CLASS V
CLASS IV
CLASS III
CLASS II
CLASS I
FREQUENCY
100
200
100
200
300
400
500
RELIEF
R.G.J.

Figure 16

theoretical point of view it is natural to expect steeper slopes to be found in greater numbers as the local relief of an area increases. This conclusion is valid only if the terrain has reached the erosional stage often referred to as "maturity". Erosional development in which extensive areas of gentle slope were to be found on the interfluves would cause deviations from the normal distribution curves. The absence of Class I (gentle) slopes in the unit areas with local relief values above 360 feet and, to a large extent, not above 260 feet coincides well with the critical relief values as determined by Glock.[1]

The remaining slope classes (Classes II, III, IV, and V) follow the trend of reaching the modal value at increasingly higher local relief values. In general, any deviation from the normal curve can be explained on the basis of minor features in the total complex. Thus the concentration of steep slopes in the 420 - 440 foot relief values is probably an expression of the limestone cap rock at the crest of ridges in the southwestern portion of the Mondovi Quadrangle (Fig. 5). The presence of steep slopes in unit areas with little local relief is generally the result of steep river banks such as those found along the Chippewa and Eau Claire Rivers. Some of the erosional remanents in the Chippewa Falls, Elk Mound, and New Auburn Quadrangles may also produce steep slopes in low relief areas.

Slope - Elevation Relationships - Along with each slope sample an elevation determination was also made. Thus each of the 6,000 slope determinations was identified as to the elevation at which it lay. Figure 17 depicts the relationship between the various slope classes and elevations

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[1]Waldo S. Glock, "Available Relief as a Factor of Control in the Profile of a Land Form", Journal of Geology XL (1932), pp. 221-22. The critical relief is that at which the flat uplands disappear and the valley flats begin to appear.

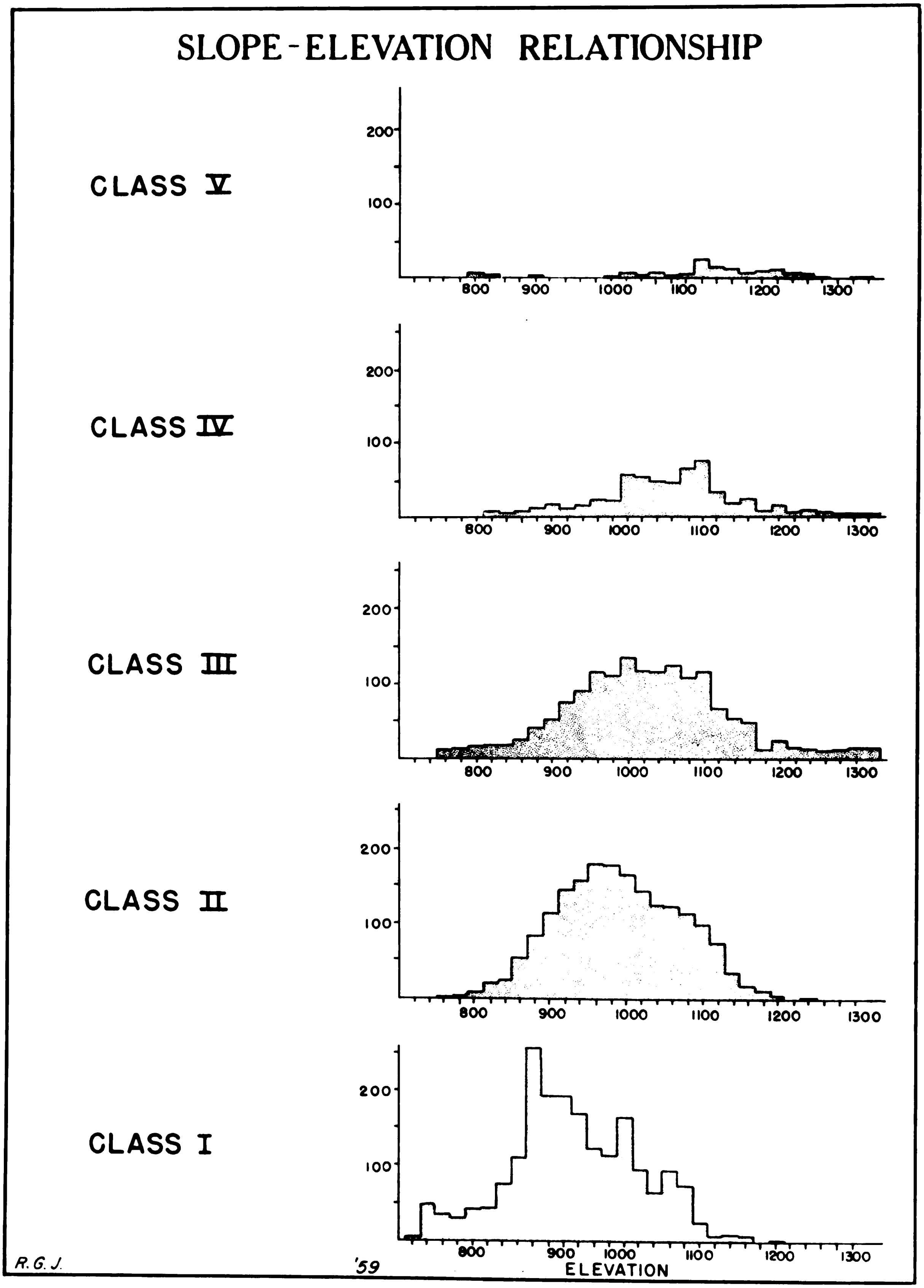
SLOPE-ELEVATION RELATIONSHIP
CLASS V
CLASS IV
CLASS III
CLASS II
CLASS I
200
100
800
900
1000
1100
1200
1300
ELEVATION
R.G.J.
'59

Figure 17

at which they are found. The distribution curves for the extremes of slope, Class I and Class V, present the greatest departures from a "normal" curve.

The deviation in the Class V slopes is found at the 800, 820, and 900 foot elevations. This is a reflection of the steep river banks of the Chippewa and Eau Claire Rivers which occur at these low elevations. The major aberration in the Class I distribution curve is to be found betwe- between the 860 and 880 foot elevations. Again the Chippewa River provides the explanation. Elevations below 880 feet are primarily the flood plain while those at higher elevations are the reflection of the terrace system. Other than these minor departures from ideal conditions, the remainder of the distribution curves follow a normal trend, namely that as the elevation increases there is an increase in the frequencey of steeper slopes.

Distribution of Elevation - Within limits, the distribution of elevation in the Eau Claire Area may be considered normal (Fig. 18A). Elevation ranges from 720 feet at the exit of the Chippewa River from the area to a maximum of 1,380 feet in the central portion of the New Auburn Quadrangle. The great majority of the area lies between 880 and 1,100 feet. Approximately eighty-four per cent of the total area involved in this study lies between these two elevations. The median elevation is approximately 970 feet with the modal elevation at 940 feet. If there were some practical means of neutralizing the regional slope, which amounts to approximately 200 feet, the distribution of elevation would be concentrated to a much greater extent in the middle portion of the total elevation range close to the 900 foot contour. This regional slope effects the gentle slopes to a significant degree since they are found to a large extent along either side of the Chippewa River.

The hypsographoid of the Eau Claire Area (Fig. 18B) represents

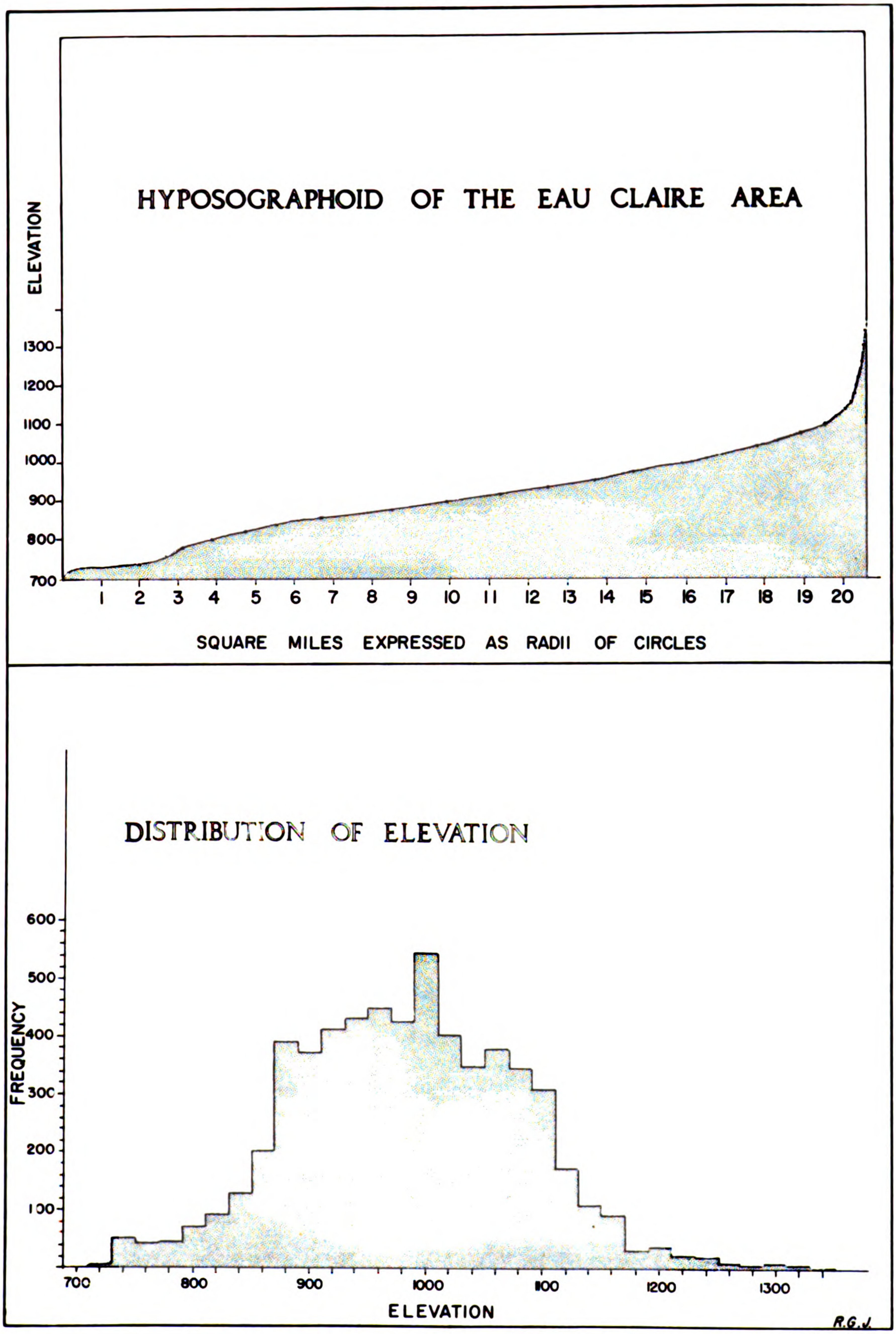
HYPOSOGRAPHOID OF THE EAU CLAIRE AREA
ELEVATION
1300
1200
1100
1000
900
800
700
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SQUARE MILES EXPRESSED AS RADII OF CIRCLES
DISTRIBUTION OF ELEVATION
FREQUENCY
600
500
400
300
200
100
700 800 900 1000 1100 1200 1300
ELEVATION
R.G.J.

Figure 18

another less often used means of depicting the distribution of elevation within an area. In theory, the hyposographoid is a generalized profile of an area which is constructed on the basis of the percentage of the total area under any given elevation. To construct the curve the area which is enclosed by the lowest contour is measured, then the area inside the next higher elevation, (always adding) until the highest elevation in the area has been reached. Upon reaching this point 100 per cent of the area will be below this elevation. Next it is necessary to determine the size a circle must have in order to equal the area under each of the above contours. The radius of each circle is then computed, and a continuous curve is drawn in which the contour interval is represented on the ordinate and the radii of the proportional circles along the abscissa.[1]

While the usual means of determining the area under each contour is through the use of a planimeter, this method proves to be both tedious and time consuming. Here the dot sampling method is of great assistance. It is based on the theory that any percentage of the total sample was equivalent to a corresponding percentage of the total area which lay below each contour.[2]

The resulting profile shows a slight break in an otherwise smooth curve at the 760 -780 foot elevations. This break in the curve is a reflection of the flood plain of the Buffalo River. The regional slope is of sufficient magnitude to cause a rise of some twenty to forty feet between the flood plain of the Buffalo River and those of the Chippewa and Eau

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[1]Eugene Romer, "Une Nouvelle Representation Graphique de l' Hypsometrie," Comptes-Rend. International Cong. Geog., I, (Paris, 1931) pp. 328-40, cited by Erwin Raisz, General Cartography (New York: McGraw Hill Book Company, Inc., 1948), p. 281.

[2]Wood, loc. cit., p. 12.

Claire Rivers. This break is also an expression of the terrain along the Chippewa River south from the city of Eau Claire. Here there is a low-lying flood plain approximately one mile wide which is bordered by terraces lying some forty feet higher than the flood plain. The curve also indicates that the amount of land above the 1,100 foot contour is limited. This confirms the observation made from Figure 5, namely that the areal extent of uplands in the Eau Claire Area is limited.

Another common method of expressing elevational distributions is through the use of the hypsometric curve. The hypsometric curve is developed by plotting the total area within the drainage basin which lies below any given elevation. Therefore it becomes a simple matter to determine the percentage of the total area lying below any given elevation. They hypsometric curve was not included in this study since the distribution of elevation is not considered to be a primary element in the description of the landform and was mainly a dividend resulting from the sampling method used to determine other data.

CHAPTER IV

THE DETERMINATION OF LANDFORM TYPES AND REGIONS

Landform Types - As shown in the previous chapter the landform is a complex of many elements and not a collection of discrete relief forms. It has also been shown that through the subdivision of the larger area into many small unit areas it is possible to systematically characterize each of these elements as they vary from place to place. However valuable this element-by-element characterization of unit areas may be it still leaves something to be desired.

Since the landform is a complex, none of the elements by themselves can adequately differentiate the numerous variations in the landform. Through a combining process involving all or a portion of these individual elements each unit area may be defined in terms of these combinations and can then form an integral part of the study area. If several of these elements are to be used in the combining process, the characterization procedure becomes exceedingly complex and difficult. In this study the ultimate goal is to provide a broad regionalization based upon the morphographic differences in the terrain. This goal is best served if the unit area characterization is limited in scope but at the same time systematic and comparable. Such a limited characterization requires a careful selection of the elements to be used. After selecting these elements, each unit may then be described on the basis of the classification elements and other aspects of the complex, if desired.

Each unit area thus becomes characterized by a series of numbers or indices, one for each element that was selected for the characterization. This set of numbers represents a highly concise description of that unit and provides a basis by which they may be compared and contrasted with other unit areas. This is a systematic classification of the landform. It is not the individual relief form being classified but areas in which certain landform elements are essentially uniform.

The major steps in the fabrication of the classification system involves, first, a decision concerning the number of elements needed to adequately differentiate the landform into types and, second, the specific elements which are most competent to accomplish this task.

As suggested above, a large number of landform types can be derived from even a simple systematic classification. A classification based upon two different properties which make allowance for only three degrees of distinction with respect to each property could conceivably result in nine different landform types. If a third property were added to the classification and still only three degrees of distinction allowed, the total number of types would be increased to twenty-seven. If all twenty-seven types were to appear on a map such as the one used in this study, it is obvious that the resulting patterns would be exceedingly fragmented and difficult to interpret.

One solution to such a problem would be to simplify the pattern through an elimination of individual and small groups of unit areas which failed to meet certain size requirements. One could also eliminate all enclaves and peninsulas if they failed to meet other specified size requirements. In order to avoid such a solution, the classification system used in the Eau Claire Area made use of only two properties, with three degrees of distinction recognized for each property. The use of these criteria could in theory have produced nine landform types. In practice only seven occurred.

The second and more difficult step in construction of the classification system involves the selection of specific elements to be used. In the absence of any previous studies which could have pointed out specific relationships between the various elements and the resulting surface configuration as it is manifested in this area, the only recourse was to trial combinations of the various elements. These trials were directed toward a combination which would produce the most realistic differentiation of the actual terrain differences. To reduce the subjective aspects involved in the selection as much as possible these terrain differences were determined on the basis of actual regions as brought out in the analysis of the various elements. Not all of these regions were evidenced by any one element, but a number of general areas were set apart when consideration was given to the complete series of analyses.

Of all possible combinations, only the prevalence of gentle slope and the mean slope length differentiated all of the major regions as determined above.

Data from the maps of the prevalence of gentle slope and mean slope length were transferred to base maps. Each unit area on each base map was characterized by a designator digit. For the slope map, an unit area composed of from eighty to 100 per cent gentle slope was designated by the number one, areas with forty to seventy-nine per cent gentle slope were designated by the number two, and those areas with less than forty-nine percent gentle slope by the number three. In the case of mean slope length those unit areas in which the slopes exceeded 2,500 feet were designated by the number one, slopes from 500 to 2,500 feet by the number two, and those in which slopes averaged less than 500 feet by the number three.

The two base maps with the appropriate designators recorded in each unit area were then superimposed on a single work sheet. By entering the numbers for each element in the proper unit area the 600 unit areas were then characterized according to the two elements selected for the classification.

Another problem in the classification scheme involves the selection of the proper hierarchy of the elements. This was not a serious problem in the Eau Claire Area since the general objectives of the study allowed considerable freedom in formulating this order of importance. In the present investigation the most important characteristic was felt to be connected with the relative amounts of gentle slope. On this basis the slope designators were considered to be of a higher order in the system than the mean slope length. The resulting map (Fig. 19) depicts the distribution of the various landform types as they appear in the Eau Claire Area.

Landform Regions - A characterization of small unit areas provides a means of formulating larger areas built up from a number of these unit areas. The larger areas are then referred to as landform regions.

To accomplish this involves some problems of generalization. Experience has shown that, even though the classification system used in defining landform types was simple, the pattern which results is in most cases so fragmented that only one or two large contiguous areas of any one landform type will be found. Therefore the techniques of generalization are all important for without them the establishment of regions and the presentation of a formal description of their differences and similarities are impossible.

There are a number of generalization procedures which may be followed. One may simplify the pattern of types by reducing the amount of information offered about the individual unit areas. In effect, this would

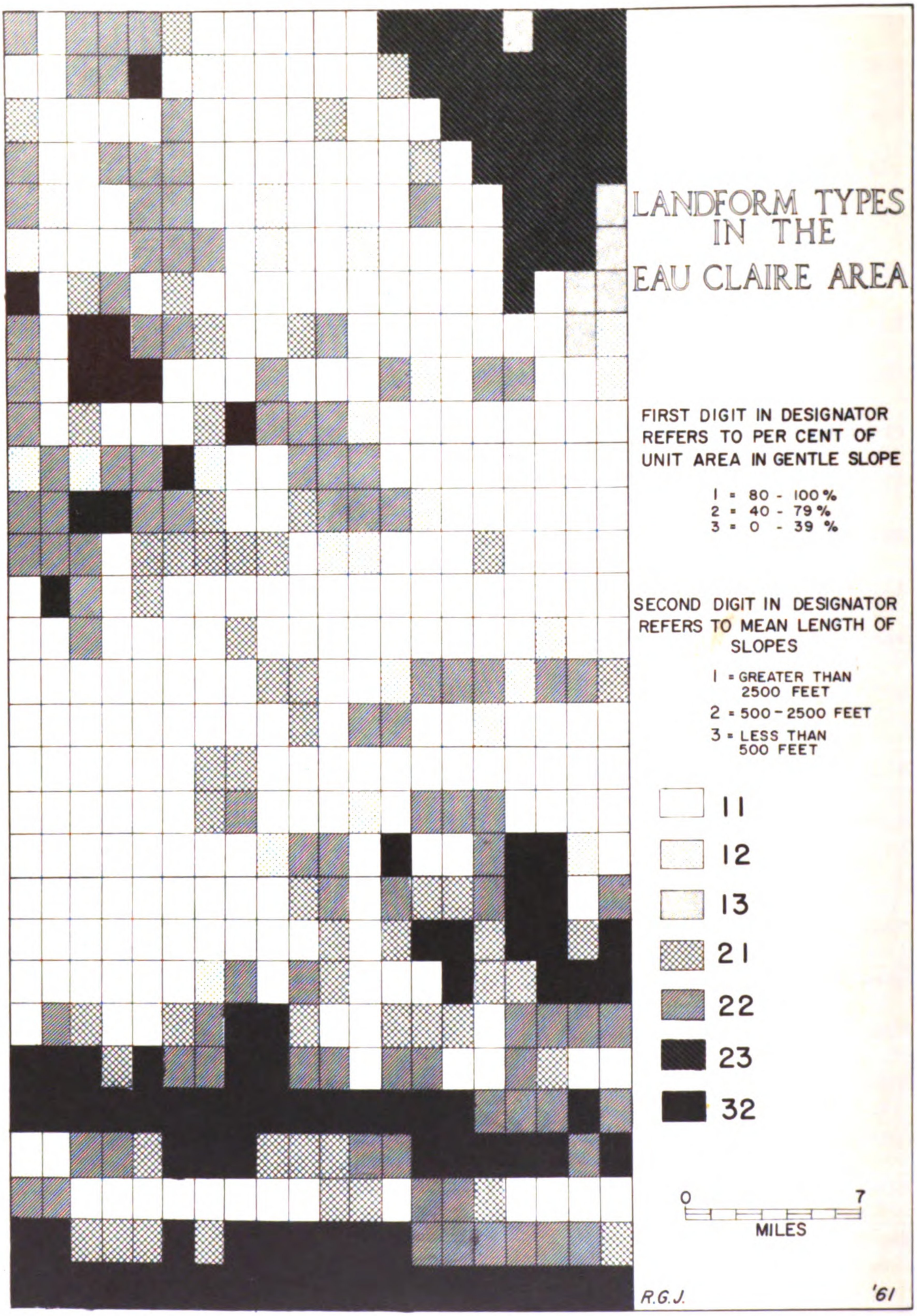
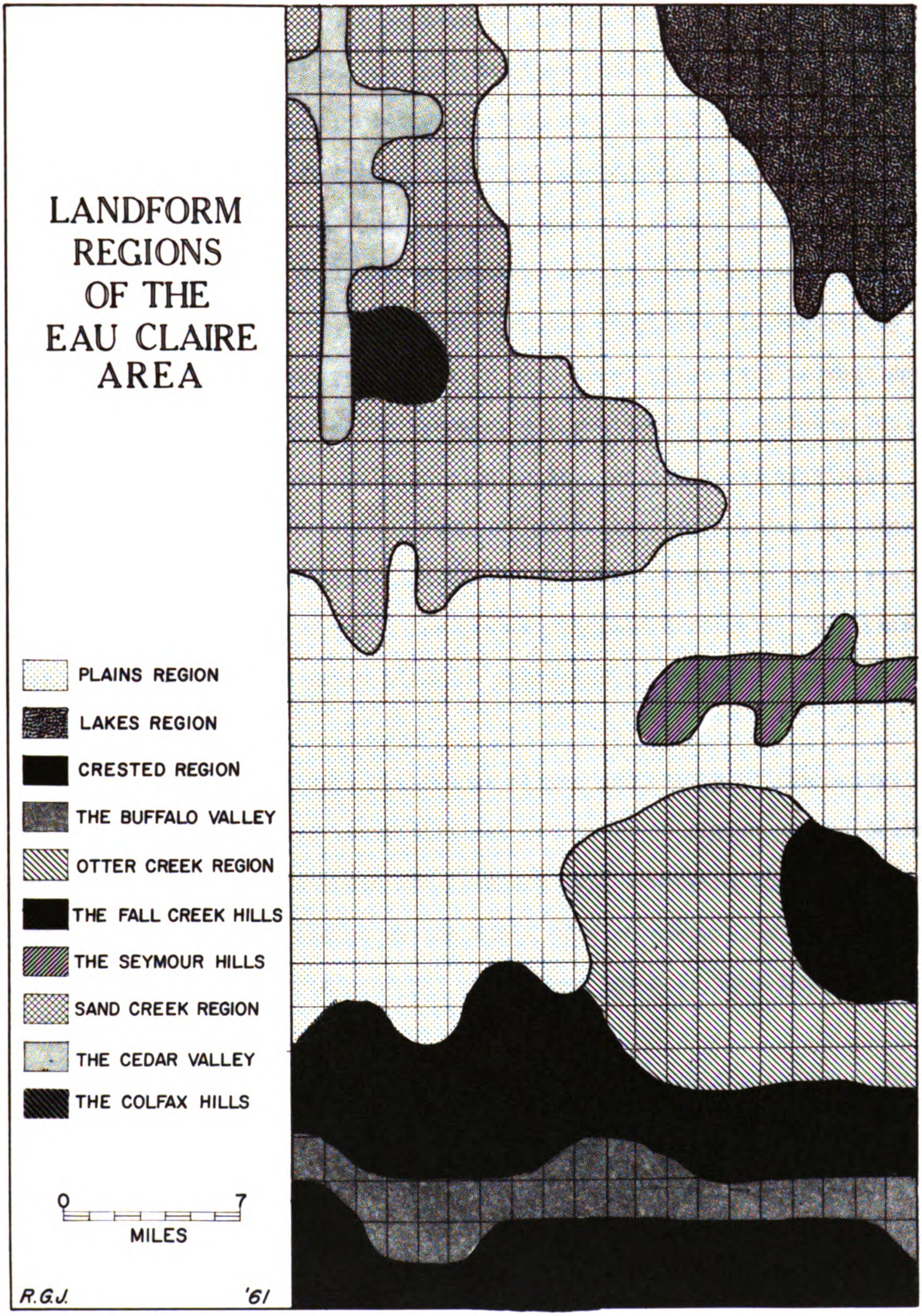

LANDFORM TYPES
IN THE
EAU CLAIRE AREA
FIRST DIGIT IN DESIGNATOR
REFERS TO PER CENT OF
UNIT AREA IN GENTLE SLOPE
1 = 80 - 100 %
2 = 40 - 79 %
3 = 0 - 39 %
SECOND DIGIT IN DESIGNATOR
REFERS TO MEAN LENGTH OF
SLOPES
1 = GREATER THAN
2500 FEET
2 = 500 - 2500 FEET
3 = LESS THAN
500 FEET
11
12
13
21
22
23
32
0
7
MILES
R.G.J.
'61

Figure 19



LANDFORM REGIONS OF THE EAU CLAIRE AREA
PLAINS REGION
LAKES REGION
CRESTED REGION
THE BUFFALO VALLEY
OTTER CREEK REGION
THE FALL CREEK HILLS
THE SEYMOUR HILLS
SAND CREEK REGION
THE CEDAR VALLEY
THE COLFAX HILLS
0
7
MILES
R.G.J.
'61

Figure 20

reduce the complexity of the pattern to a point where a limited number of large areas composed of one landform type would dominate the entire study area. A reduction of information on the part of each individual unit area will at the same time reduce the precision of the information at the regional level. If possible this approach should be avoided.

The complexity of landform patterns may also be reduced through a simplification procedure. The cartographic complexity is reduced by eliminating enclaves and peninsulas of unit areas which fail to meet specified size requirements. For example, all peninsulas or enclaves less than two unit areas wide would be eliminated. Or one could eliminate individual unit areas or small groups of unit areas surrounded by large areas of one contiguous type. In situations where extensive areas are composed of a complex of types the problem becomes difficult. For this reason a third form of generalization must also be utilized - that of the homogeneous region.

Homogeneous regions, regions of strong uniformity of character, may be defined in any of three distinct concepts. A region may be delimited by an extensive area in which one landform type dominates the entire area. One may also define a region on the basis of a consistent non-uniformity of types or by the predominance of one or two types in relation to a diversified remainder.

In practice, all three procedures of generalization are followed to some extent in the regionalization of the Eau Claire Area (Fig. 20), although the use of the homogeneous region represents the primary generalization procedure. Subdivision of the larger regions are the product of taking into consideration small groups of one landform type or an area in which a limited number of types are arranged in a systematic manner. A small area of hills surrounded by a different type of terrain is an example of the first type of subregion while a major river valley such as the Buffalo River Valley is an example of the second type of subregion.

The final problem in the characterization of the landform is that of describing the areas analyzed from a regional point of view as well as at the subregional level. Descriptions of the regions may be brief and concise when extensive use is made of statistical tabulations and little verbal characterization. A description may be enriched through the use of various other techniques of presentation. These would normally include maps, sketches, photographs, diagrams, and verbal description. The full regional description brings out features and aspects of the landform complex which are not included in the differentiation of landform types as well as those features which are not readily amenable to unit-by-unit discussion. Included here would be such features as major drainage divides and drainage systems.

In developing the "Landform Region" map (Fig. 21) several areas proved to be exceedingly difficult to delimit into regions. These areas were those characterized by a large amount of pattern fragmentation. The regionalization in these areas is necessarily more subjective than others, and the boundaries offered here are only one of several which could be defined. In all cases the boundaries were drawn only after careful consideration of the amount of distortion done by each of the several alternative choices. The more difficult areas to delimit were those found in the New Auburn Quadrangle and the northern portion of the Strum Quadrangle.

The resultant map depicts the regions of the Eau Claire Area as defined on the basis of landform types (Fig. 20). Each region has been assigned a descriptive name. The descriptive names as offered here are devices of convenience only.

The Plains Region - The Plains Region is in general located along either side of the Chippewa River with extensions along the Eau Claire River and Duncan Creek. The largest of the five major regions, it comprises approximately forty-four and five-tenths per cent of the total study area.

Statistical Characterization

Slopes: Class I - 51 per cent of area (prevalent slope)
Class II - 32 per cent of area
Class III - 12 per cent of area
Class IV - 4 per cent of area
Class V - 1 per cent of area

Local Relief:
Maximum - 300 feet
Mean - 140 feet
Modal - 120 feet

Mean Crest Density - .37 mile/square mile
Mean Drainage Density - .63 mile/square mile
Predominant landform type - 11

General Characterization. The Plains Region, as the name implies, consists of a plain of low relief and, in general, very gentle slopes. Were it not for the Chippewa and Eau Claire Rivers and the isolated erosional remanents to the northwest of the city of Eau Claire the plains would in general have less than 120 feet of local relief and be almost completely devoid of slopes steeper than five per cent. Even with these valleys and isolated hills, slopes gentler than eleven per cent account for more than four-fifths of the area. Steep slopes are, in general, rare.

The hydrology of the Plains Region is simple. Approximately fifteen per cent of the unit areas within this region are without any significant stream channel while another fifteen per cent contain less than one mile of channel. The drainage pattern is essentially dendritic although drawn out in the direction of the master stream, the Chippewa River. This river meanders across the region and is joined by a number of important tributaries such as the Eau Claire River, Duncan, Elk, O'Niel, Lowes, and Rock Creeks. The Chippewa River has a gradient of about four feet per mile. These creeks which empty into the Chippewa River are unusual in that the major portion of their tributaries are to be found in the upper reaches of the stream (Fig. 12). In general the lower three or four miles are without any permanent or intermittent tributaries. Except for a few small artificial lakes and ponds the only body of standing water is Half Moon Lake.

The pattern of the valleys is simple. The major valley, that of the Chippewa River, corsses the region in a northeast-southwest direction. Except for the portion between Eau Claire and Chippewa Falls the valley of the Chippewa River is broad and gentle. Between Eau Claire and Chippewa Falls the valley is relatively narrow and steep sided (see Plate XIII). The tributary valleys enter the major valley at right angles.

There are no major regional crests in this region. Sixty-seven per cent of the unit areas are without any major crest. Those crests which do exist are to be found in the isolated hills scattered throughout the region.

The surface materials throughout the region are generally gravel or sand. Outcrops of bedrock are restricted to stream beds and along the summits of the hills.

Plate XVI is a representative view of the Plains Region. The reader is also referred to Plates IV, VIII, IX, and XIII for additional views of this region.

<u>The Lakes Region</u> - The Lakes Region lies in the northeast corner of the Bloomer Quadrangle, to the north of the Chippewa River and east of the Plains Region. The descriptive name applied to this region has been derived from one of the distinctive aspects of the area - the numerous

PLATE XVI

PLAINS REGION NEAR EAU CLAIRE

lakes and ponds. Although the Lakes Region is small, six and two-tenths per cent of the total area, it presents one of the more distinct terrain types.

Statistical Characterization

Slopes: Class I - 31 per cent of area
Class II - 34 per cent of area (prevalent slope)
Class III - 26 per cent of area
Class IV - 7 per cent of area
Class V - 2 per cent of area

Local Relief:
Maximum - 220 feet
Mean - 130 feet
Modal - 100 feet

Mean Crest Density - .33 mile/square mile
Mean Drainage Density - .45 mile/square mile
Predominant Landform Type - 23

General Characterization. The Lakes Region may be described as a region of hummocky terrain with moderate local relief. The hummocky nature of the terrain is one of the more important factors which differentiates the terrain of this region from all other regions. The local relief varies from forty feet to more than 220 feet. Relief is greatest in the northwestern corner of the region and becomes lower as the eastern edge of the Plains Region is approached.

While the steep slopes represent the modal class, both the moderate and gentle slopes occupy essentially equal proportions of the total regional area. Gentle slopes are usually found in the form of swamps, marshes, and standing bodies of water. Steep slopes are found on the sides of the numerous and closely spaced hills. Moderate slopes are either the transition zone between steep sides of hills and ajoining flat surfaces or constitute the entire sloping area of less pronounced hills.

The hydrology of this region is complex. There is no major channelized stream flowing within this region. The streams are in general disconnected, flowing from one small lake or marsh into another. The majority of the streams are small and flow without any recognizable orientation (Fig. 12). Marshes and swamps abound, the lakes are abundant, especially in the northwestern corner of the region. These lakes are seldom large, usually not over 500 feet when measured along their greatest dimension (Plate XVII).

The valleys within this region are indistinct and extremely fragmented. Profiles of these valleys are characteristically steep sided and flat bottomed. The flat bottoms represent the bodies of water which are usually found in this situation.

As with the valleys, the major crests show little uniformity in length or orientation (Fig. 10). Fifty-three per cent of the unit areas are without a major crest while the remaining forty-seven per cent usually have less than two miles of crest per unit area.

Standing bodies of water, lakes and streams, account for nine per cent of the regional area, and the swamps and marshes account for another eleven per cent. The remainder of the region is covered with rocky soils.

See Plates XVII and XVIII for typical views of this region. Attention is also directed to Plates I, II, and X which also illustrate this region.

<u>The Crested Region</u> - The Crested Region is found in the southern two-thirds of the Strum and Mondovi Quadrangles. The regional name was derived from the outstanding aspect of the region, namely the high crest densities. The boundaries of the Crested Region are similar but not identical to the Driftless Area (see Fig. 5). There is one major subdivision of the Crested Region, the Buffalo Valley.

Statistical Characterization

Slopes: Class I - 7 per cent of area
Class II - 20 per cent of area
Class III - 38 per cent of area (prevalent slope)
Class IV - 27 per cent of area
Class V - 8 per cent of area

PLATE XVII - <u>The Lakes Region</u>. Looking west over the Lakes Region. The extreme eastern margin of the Plains Region may be seen in the distant background. The large lake in the background is Marsh-Miller Lake. Many of the smaller lakes are being filled in with vegetation.

PLATE XVIII - <u>Typical Lake in the Lakes Region.</u> The lake in this photograph is typical of the majority of water bodies in this region. The lakes are small and shallow with vegetation growing to the edge of the water.

PLATE XVII

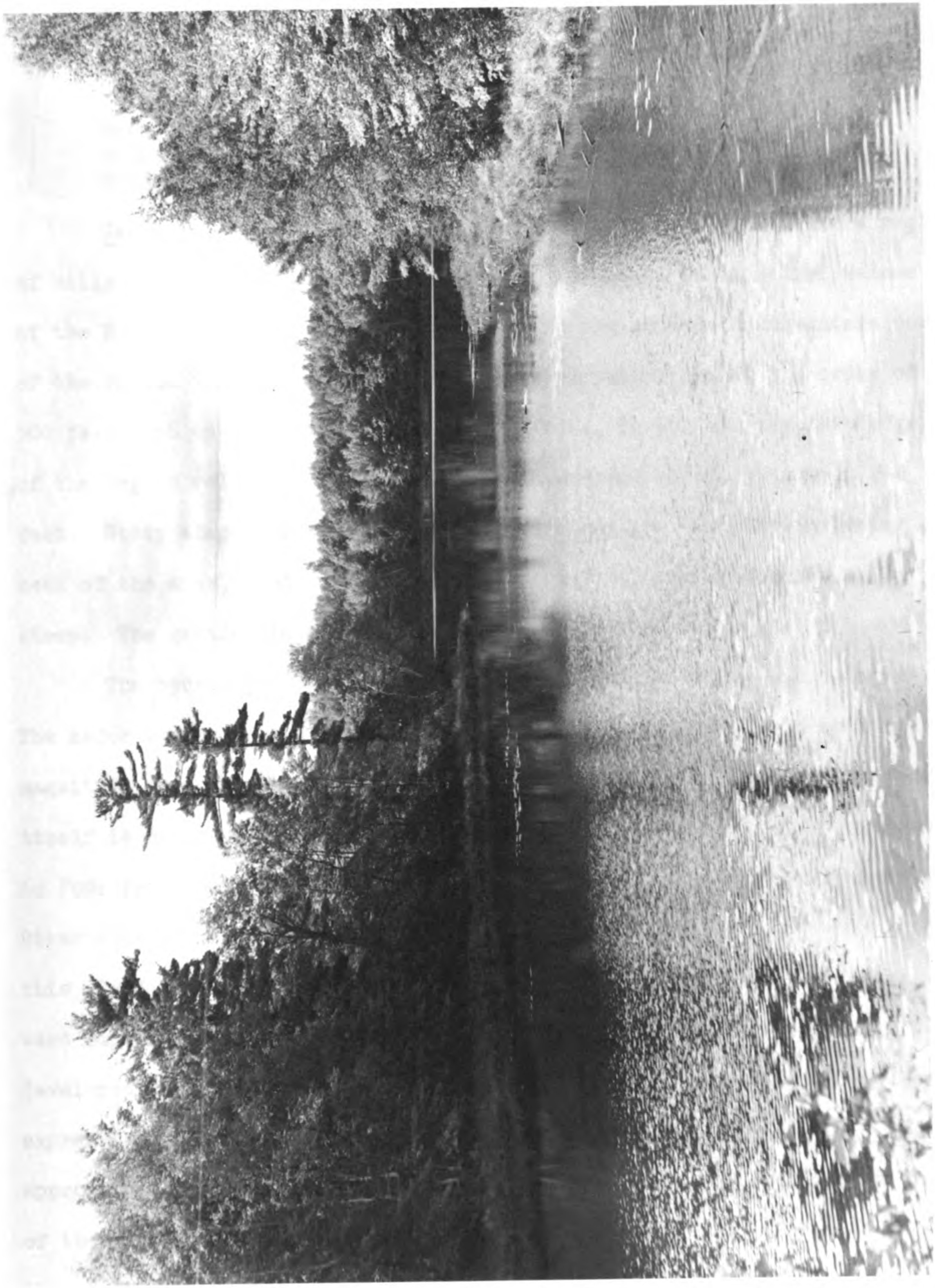


PLATE XVIII

Local Relief:
Maximum - 540 feet
Mean - 295 feet
Modal - 240 feet

Mean Crest Density - 6.6 miles/square mile
Mean Drainage Density - 1.5 miles/square mile
Predominant Landform Type - 32

General Characterization. The Crested Region is in a sense a region of hills. Within these hills are found the greatest local relief values of the Eau Claire Area. They are highest in the extreme southwestern corner of the region where maximum differences in elevation are in the order of 500 feet with an absolute maximum of 520 feet. Toward the northern edge of the region relief values decrease to an average of approximately 240 feet. Steep slopes are the dominant slope category. Seventy-three per cent of the area, exclusive of the Buffalo Valley, are considered to be steep. The gentle slopes are confined to the valley bottoms.

The hydrologic patterns in the Crested Region are well developed. The major stream is the Buffalo River which lies in a valley of sufficient magnitude as to be considered as a separate subregion. The Buffalo River itself is not large, seldom measuring more than twenty feet wide and three to four feet deep. The complex of crests on the north side of the Buffalo River constitute a major drainage divide. Streams flowing northward from this divide empty into the Chippewa River, and the streams flowing southward empty into the Buffalo River. The tributary streams display a well developed dendritic pattern. The completeness of this pattern also finds expression in the high drainage density index for the region which averages approximately three miles of stream channel per unit area. The majority of the tributary streams enter the master stream at an acute angle. Other than a few artificial ponds and lakes there are no natural bodies of standing water in the Crested Region.

The pattern of valleys is essentially identical to that of the drainage pattern. The major exception is the continuation of the Otter Creek Valley which extends into the Buffalo River Valley (Fig. 8). Another exception to the general agreement of streams and valleys is the continuation of the Buffalo River Valley westward from the city of Mondovi. At this point the river flows southward through a relatively narrow valley while the major valley continues westward. Along the northern margin of the Crested Region many valley give the appearance of having been filled in (see Plate XIX).

In general this region contains the highest crest densities of any portion of the Eau Claire Area (Fig. 9). Mean crest value for unit areas in this region is fourteen and six-tenths miles of crest per unit area. Individual unit areas may contain as much as twenty-six miles of crest. There is no distinct regional crest although the pattern of crests (Fig. 10) suggests that the continuous series of crests along the north side of the Buffalo River could be considered as such.

The predominant surface material in this region is soil. The soils are usually sand in nature, a consequence of the sandstone parent material. Bedrock exposures are limited to the summits of the higher hills and to road cuts.

Plates XX and XXI are examples of the surface configuration within the Crested Region. Plates V, VI, XII, and XV are additional examples of the terrain.

The Buffalo Valley - The Buffalo Valley is the only significant subdivision of the Crested Region. The valley is located in the southern portion of the Strum and Mondovi Quadrangles and is orientated in an east-west direction. At the city of Mondovi the Buffalo River flows southward although the valley itself continues in a westward direction.

PLATE XIX
FILLED-IN VALLEY OF NORTHERN PORTION OF CRESTED REGION

PLATE XX

AERIAL VIEW OF CRESTED REGION

PLATE XXI

CRESTED REGION - NORTH OF BUFFALO RIVER

Statistical Characterization

Slopes: Class I - 34 per cent of area
Class II - 35 per cent of area (prevalent slope)
Class III - 22 per cent of area
Class IV - 7 per cent of area
Class V - 2 per cent of area

Local Relief:
Maximum - 300 feet
Mean - 220 feet
Modal - 200 feet

Mean Crest Density - 1.9 miles/square mile
Mean Drainage Density - 1.8 miles/square mile
Predominant Landform Types - 11, 21, and 22

General Characterization. The Buffalo Valley is a broad and shallow valley averaging four miles wide as measured from crest to crest and is approximately 450 feet deep in the western portion and less than 200 feet deep in the east. The Buffalo River, a small meandering river, flows through the valley. The river has a gradient of six feet per mile and flows in a westerly direction. At Mondovi it turns sharply to the south and flows out of the Eau Claire Area through a deep and relatively narrow valley. Here the valley is over 500 feet deep and less than two miles wide.

The distribution of slopes is an expression of the unit area method of securing data and delimiting boundaries. Since data is collected for an entire unit area and the unit is then classified according to the predominant class value an actual "edge" of the valley may cross the middle of many unit areas, and yet the area is necessarily considered to lie wholly within the valley region. There is also the semantic problem of just where the valley ends and the ajoining ridge begins.

There are no major crests in the valley itself although spurs of the crest complexes to the north and south of the valley do extend for considerable distances into the valley proper. See Plate XXII.

The Otter Creek Region - The Otter Creek Region is located in the

PLATE XXII - The Buffalo Valley. This is a view of the Buffalo Valley from a point south and west of the city of Mondovi. The hills in the far background are approximately five miles distant and represent the crest complex on the north side of the valley. The Buffalo River flows southward from Mondovi although the valley proper continues to the west. The perspective is slightly altered due to the use of a telephoto lens.

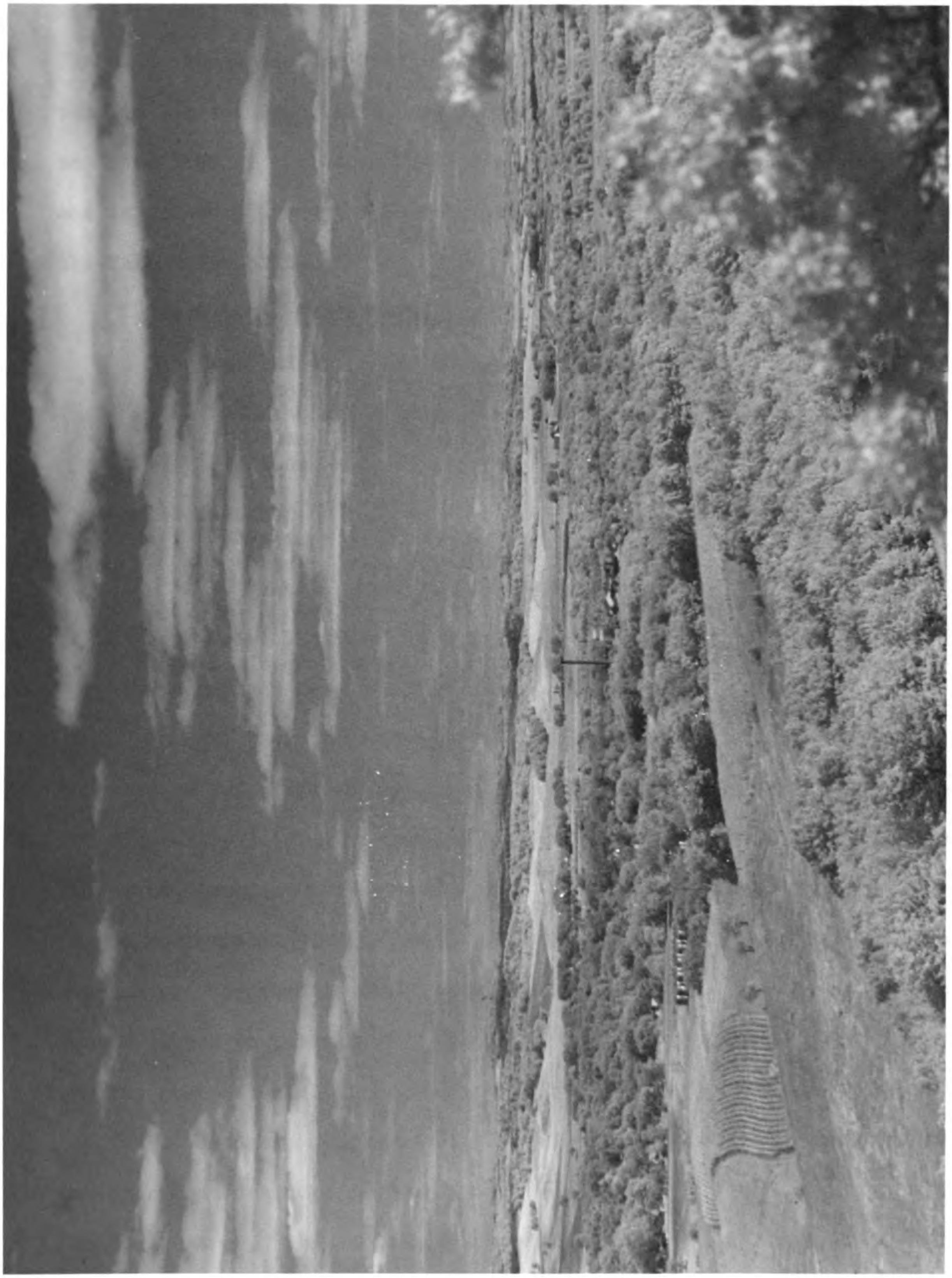


PLATE XXII

northern half of the Strum Quadrangle. To the north and west lies the Plains Region while the Crested Region lies to the south. The regional name is derived from the master stream in this region, Otter Creek. A small outlier of the Otter Creek Region lies across the Eau Claire River and is referred to as the Seymour Hills Subregion. Another subregion is the Fall Creek Hills.

Statistical Characterization

Slopes:
- Class I - 19 per cent of area
- Class II - 48 per cent of area (prevalent slope)
- Class III - 26 per cent of area
- Class IV - 5 per cent of area
- Class V - 2 per cent of area

Local Relief:
- Maximum - 300 feet
- Mean - 195 feet
- Modal - 160 and 180 feet

Mean Crest Density - 2.1 miles/square mile
Mean Drainage Density - 1.7 miles/square mile
Predominant Landform Types - 11, 21, and 22

General Characterization. The Otter Creek Region is an area of moderate relief, broad open expanses of moderate slope, and numerous gentle but distinct ridges lying between the areas of moderate slope. The majority of the nineteen per cent of the area in gentle slope is to be found in the bottomlands of the creeks in this region. Slope lengths are on a average greater than in the Crested Region due to the greater expanses of gentle slopes in the valleys. This is one of the major distinctions between the two regions which gives the Otter Creek Region a more "open" appearance.

The drainage system is well developed in this region and results in a higher mean drainage density than is found in any other region in the Eau Claire Area. The largest drainage channel is Otter Creek although the creek is less than fifteen feet wide at its mouth and seldom over one foot deep. The valley through which the creek flows is large in relation to the size of the stream, averaging two miles in width. The head of Otter Creek is located within 1,000 feet of Pine Creek, which is a tributary of the Buffalo River. Other streams in this region are small and seldom obtain a width of more than ten feet or depths of more than one foot (see Plate XXIII). With the exception of artificial bodies of water there are no natural lakes within the Otter Creek Region.

The valleys follow the same pattern as the streams of the region although they are significantly larger than the streams which flow through them would seem to warrant. The continuation of the Otter Creek Valley into the Pine Creek Valley is a major deviation from the pattern of having a stream within each of the major valleys.

Crest densities vary to a large degree. Fifteen per cent of the unit areas contain no major crest while another fifteen per cent contain over ten miles of crest per unit area. In general, the crest density increases toward the Crested Region and again as the Fall Creek Hills are approached. A broad zone of unit areas through the center of the region contain relatively few crests. These same unit areas are identified by landform types 11 and 21 which is in contrast to the higher numbered landform types for the remainder of the region.

Surface materials in the Otter Creek Region consist of various types of soil. As with the Crested Region the soils are generally sandy, an expression of the parent material. Outcrops of bedrock are rare. See Plate XXIV for a typical view of this region.

<u>The Fall Creek Hills</u> - Approximately one mile west of the village of Fall Creek rise a series of hills, which, although small in areal extent, differ significantly from the remainder of the Otter Creek Region.

<u>Statistical Characterization</u>

Slopes: Class I - 6 per cent of area
Class II - 22 per cent of area
Class III - 41 per cent of area (prevalent slope)

PLATE XXIII

TYPICAL SMALL STREAM IN OTTER CREEK REGION

PLATE XXIV

THE UPPER LOWES CREEK VALLEY

Class IV - 28 per cent of area
Class V - 3 per cent of area

Local Relief:
Maximum - 260 feet
Mean - 190 feet
Modal - 220 feet

Mean Crest Density - 5.7 miles/square mile
Mean Drainage Density - 1.0 miles/square mile
Predominant Landform Type - 32

General Characterization. There is a close resemblance between the Fall Creek Hills and the Crested Region the major difference being with respect ot local relief. Slope distribution, crest, density, and predominant landform type are all similar. The majority of gentle slopes are to be found in the valleys of the region while moderate slopes appear with greater frequency on the ridge summits.

There is no major stream flowing through the region although it contains numerous tributaries of Otter and Fall Creeks. The drainage pattern is dendritic as is the pattern of valleys and crests. The surface materials are by and large sandy soils although the summits of some hills may have rocky soils.

The Seymour Hills - Along the north side of the Eau Claire River is another subregion of the Otter Creek Region. The Seymour Hills Subregion is surrounded on all sides by the Plains Region.

Statistical Characterization

Slopes: Class I - 22 per cent of area
Class II - 38 per cent of area (prevalent slope)
Class III - 27 per cent of area
Class IV - 10 per cent of area
Class V - 3 per cent of area

Local Relief:
Maximum - 320 feet
Mean - 215 feet
Modal - 220 feet

Mean Crest Density - 3.2 miles/square mile
Mean Drainage Density - .54 mile/square mile
Predominant Landform Type - 22

General Characterization. The Seymour hills consist essentially of a series of three parallel ridges surrounded by the Plains Region. No major tributaries of either the Eau Claire or Chippewa Rivers originate in this region. This lack of surface drainage is also reflected in the low drainage density which is lower than that of the Plains Region. All three ridges reach approximately equal elevations.

The higher percentage of gentle slopes in this region is partially a result of including valleys between the three ridges and the greater expanse of gentle slope in the summits of the ridges. Surface material is composed mostly of sandy soils although local areas may contain large numbers of small gravel.

The Sand Creek Region - The Sand Creek Region is located in the western two-thirds of the New Auburn Quadrangle and the northern third of the Elk Mound Quadrangle. To the east and south lies the Plains Region. The Sand Creek Region has two subdivisions, the Cedar Valley and the Colfax Hills.

Statistical Characterization

Slopes: Class I - 13 per cent of area
Class II - 42 per cent of area (prevalent slope)
Class III - 28 per cent of area
Class IV - 11 per cent of area
Class V - 6 per cent of area

Local Relief:
Maximum - 340 feet
Mean - 235 feet
Modal - 200 and 300 feet

Mean Crest Density - 2.5 miles/square mile
Mean Drainage Density - .9 mile/square mile
Predominant Landform Types - 22 and 21

General Characterization. The region is characterized by a large proportion of the total area in moderate slopes with isolated hills or ridges rising two to three hundred feet above the level of the remainder of the terrain. Thus, the gentle slopes which are confined to the bottoms of the valleys between these ridges are limited while the moderate and steep slopes constitute a larger proportion of the area. Relief values are evenly distributed throughout the total range of local relief available in this region. This even distribution is a reflection of the isolated hills which are of the same maximum elevation while the intervening lowlands are also essentially at the same elevation.

The hydrology of the region is simple, the drainage density is low. The major stream in this region is the Cedar River which forms a separate subregion. With the exception of the portion of the region lying in the Elk Mound Quadrangle and a minor portion in the eastern edge of the New Auburn Quadrangle all of the drainage in the region is associated with the Cedar River watershed. This river flows through a broad valley and is discussed as a separate region. The streams in this region are small and slow flowing and may have some localized areas of swamp along the downward portion of the channel. There is no distinct drainage divide, the Chippewa River whose tributaries are in several places less than one half mile from Cedar River flow in large shallow valleys which makes a distinct divide impossible. With the exception of artificial ponds and lakes there are no natural standing bodies of water.

The pattern of valleys is essentially the same as the drainage pattern. As with the Otter Creek Region, the streams in this area often flow through broad open valleys which do not seem to be the result of the erosional activities of the present streams. These valleys are also connected with the Plains Region to the east (Fig. 8).

Major crests are significant features in the landscape although they are in most instances disconnected (see Plate XI). Surface materials are primarily soils of varying types. Bedrock exposures are limited to the summits of some ridges.

Plate XXV is a typical view of the Sand Creek Region as found near the city of Colfax.

The Cedar Valley - The Cedar Valley lies along the extreme western edge of the New Auburn Quadrangle. The Cedar River is the master stream of this region and flows through the valley.

Statistical Characterization.

Slopes: Class I - 53 per cent of area (prevalent slope)
Class II - 30 per cent of area
Class III - 12 per cent of area
Class IV - 3 per cent of area
Class V - 2 per cent of area

Local Relief:
Maximum - 300 feet
Mean - 170 feet
Modal - 240 feet

Mean Crest Density - .4 mile/square mile
Mean Drainage Density - 1.1 miles/square mile
Predominant Landform Type - 11

General Characterization. The Cedar Valley differs from the other valley subregion, the Buffalo Valley, in that it is more open with reference to tributary valleys which tend to give this valley a less definite edge. The valley is approximately three miles wide at the point of entery into the Eau Claire Area and narrows to less than one mile near the city of Colfax. The high percentage of gentle slopes as compared to the Buffalo Valley is due partially to the open edges of the valley which reduces the amount of steep slopes which may occur in those portions of unit areas not actually completely in the valley itself. Thus the possibility of steep valley sides entering into the slope statistics is greatly reduced.

A lower mean crest density is also associated with the more gentle valley sides. The surface materials of the Cedar Valley are mostly alluvial and consequently tend toward a high sand content. Bedrock exposures are rare. See Plate XXVI for a representative view of this subregion.

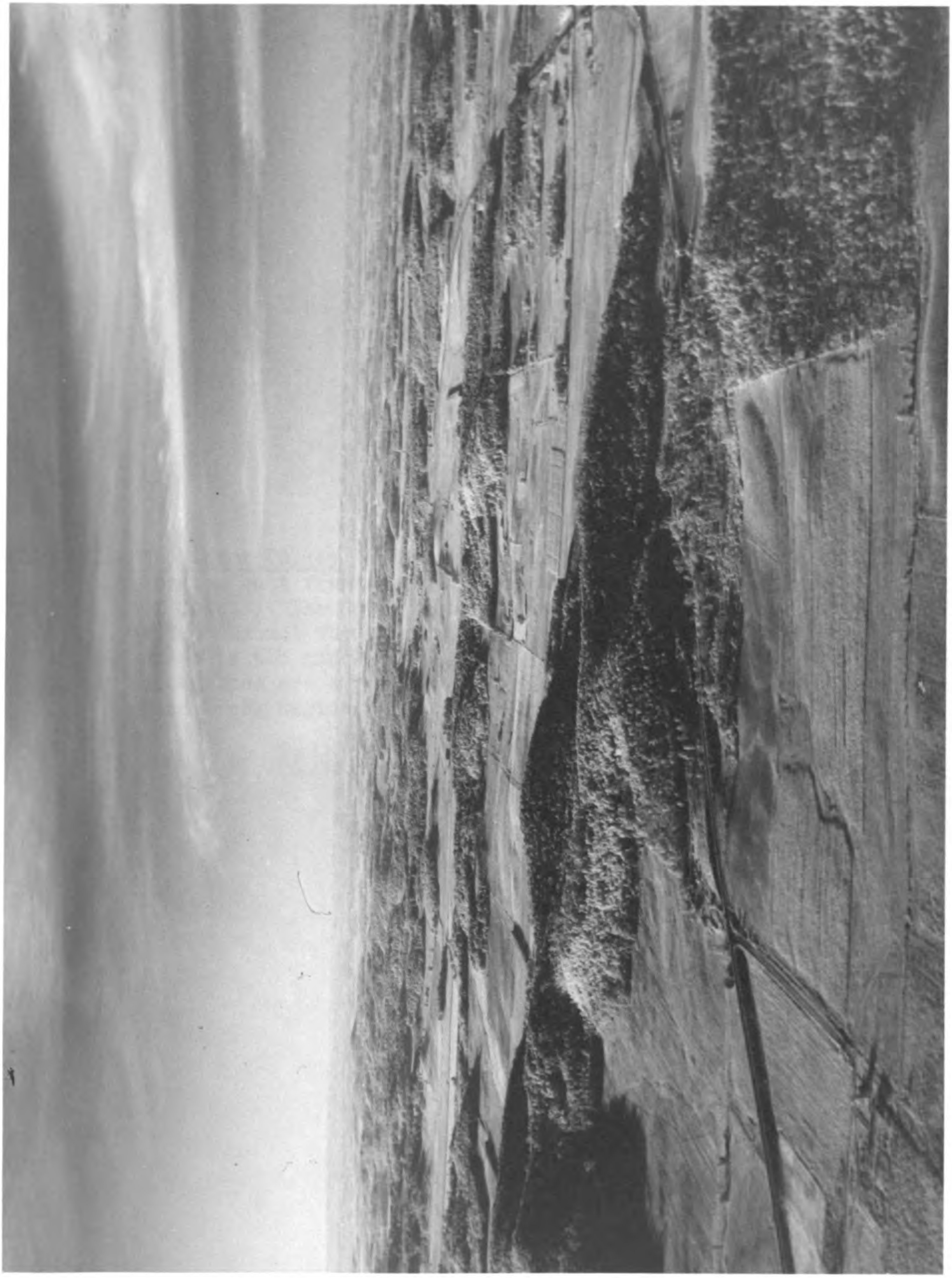


PLATE XXV

AERIAL VIEW OF SAND CREEK REGION NEAR COLFAX

PLATE XXVI - The Cedar Valley - This is a view of the Cedar Valley looking east from a point approximately four miles north of Colfax. The Cedar River flows through the narrow steep sided channel whose location is indicated by the belt of trees in the middle background. The hills in the distant background are a portion of the other subregion of the Sand Creek Region, the Colfax Hills.

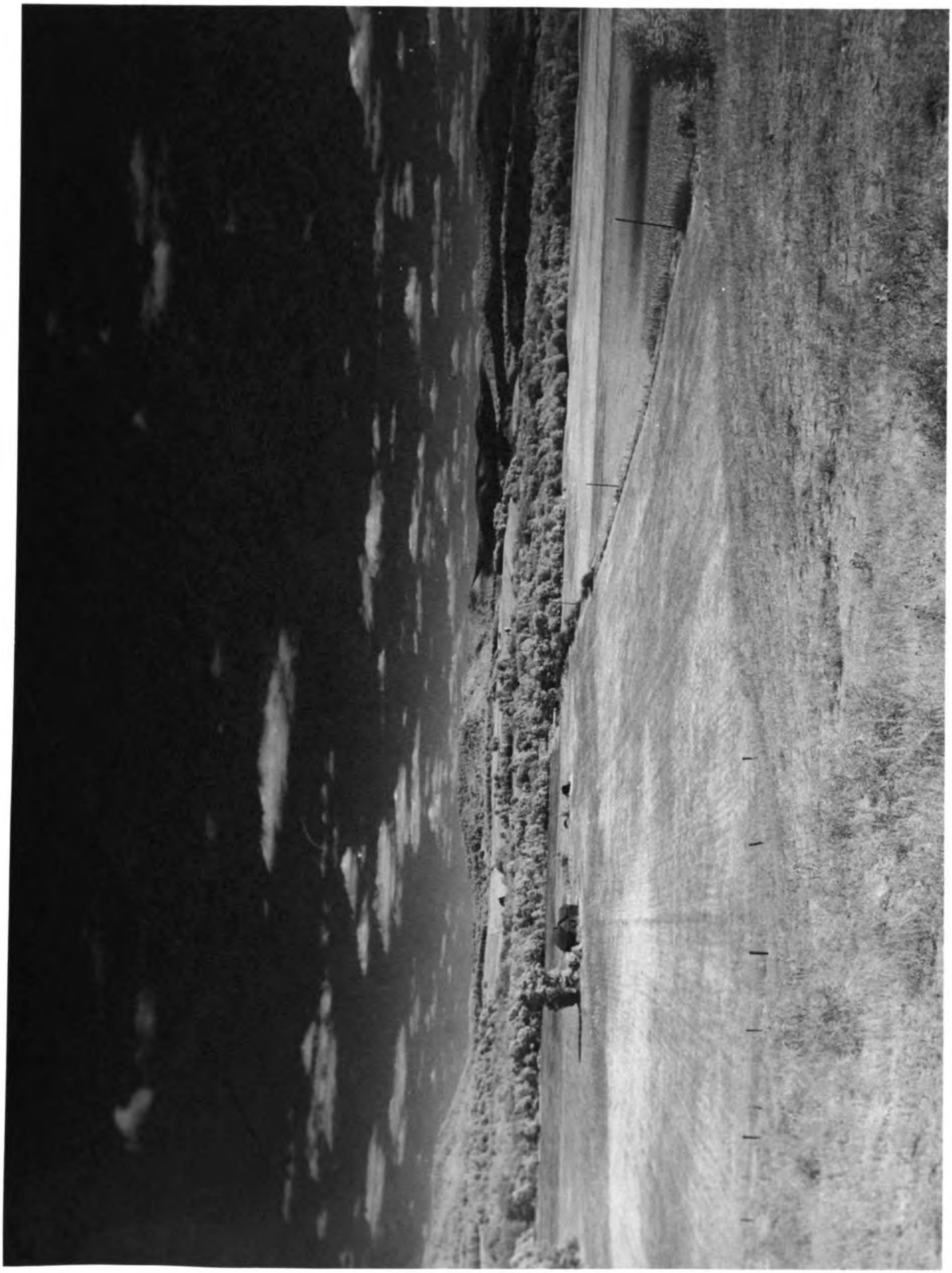


PLATE XXVI

The Colfax Hills - This subregion is located northeast of the city of Colfax and is in many ways similar to the typical hill complexes of the Crested Region.

Statistical Characterization

Slopes: Class I - 2 per cent of area
Clas- II - 14 per cent of area
Class III - 50 per cent of area (prevalent slope)
Class IV - 20 per cent of area
Class V - 14 per cent of area

Local Relief:
Maximum - 400 feet
Mean - 345 feet
Modal - 320 feet

Mean Crest Density - 4.6 miles/square mile
Mean Drainage Density - .8 mile/square mile
Predominant Landform Type - 32

General Characterization. Although the Colfax Hills display a high percentage of their total area in the steep slope classes, these percentages would be materially reduced and more closely approach the slope distribution of the Crested Region if valley bottoms and lesser hills were included as was done in the Crested Region statistics.

Although there are no major streams in this region, several tributaries of the Cedar River originate within the regional boundaries. These tributaries have eroded valleys which are in the order of 200 feet deep and one half mile wide. The interfluves account for the high crest densities. Maximum elevations are over 1,300 feet which are as much as 400 feet above the adjoining Cedar Valley. The predominant surface material is soil. Bedrock outcrops are common near the summits of the hills in this region.

CHAPTER V

CONCLUSION

An appraisal of the value of a regionalization of the Eau Claire Area based upon a morphographic approach to the study of the landform can only be made after it has been put to some use. The purpose of this study was a general one concerning mainly methods of analysis and a simple regionalization based upon landform types. Therefore this study cannot adequately serve as an example of an investigation into specific relationships. It has brought out in a systematic fashion the areal differences of the terrain which had not been done on any previous map of the area. These differences actually exist and are readily evident in the field. The terrain differences are also perceived by those who must make use of the land, and the varying land use patterns are to some degree an expression of these differences. There have also been a number of interesting genetic studies suggested through the analysis of the various landform elements.

The dissection of the landform complex into its component elements has been accomplished in such a manner as to give the reader a clearer comprehension of the actual terrain differences than could be derived from a simple examination of a topographic quadrangle or from a simple field reconnaissance. Not all of the elements investigated proved to be useful in the regionalization process, but they have added flesh to the simple framework of the landform types.

Several difficulties were encountered in this study. The use of unit areas proved to be a highly useful device in giving an objective basis

to the regions. At the same time the use of a more nearly square unit area would have improved considerably the relationship between various landform elements and "reality". In order to reduce the complexity of the patterns of the landform types, a highly simplified classification system was utilized. However, even a classification system based upon two landform elements was highly successful in differentiating the actual terrain differences. Using the simplified landform types as a framework upon which additional information may be added seems to be a means of avoiding complex designator indices or unduly fragmented patterns and at the same time achieve a well rounded characterization.

Many geographical investigations have need for an objective characterization of the terrain. Each may have slightly different needs in this respect but basically all need to know what surface forms exist, in what locations, and in what magnitude. To meet all of these needs some form of objective characterization of the landform is necessary. The differentiation of the landform according to its constituent elements is one means of achieving these ends.

APPENDIX

UNIT AREAS, SAMPLING TOOLS, LOCATION OF PHOTOGRAPHS

and

TECHNICAL DATA ON PHOTOGRAPHS

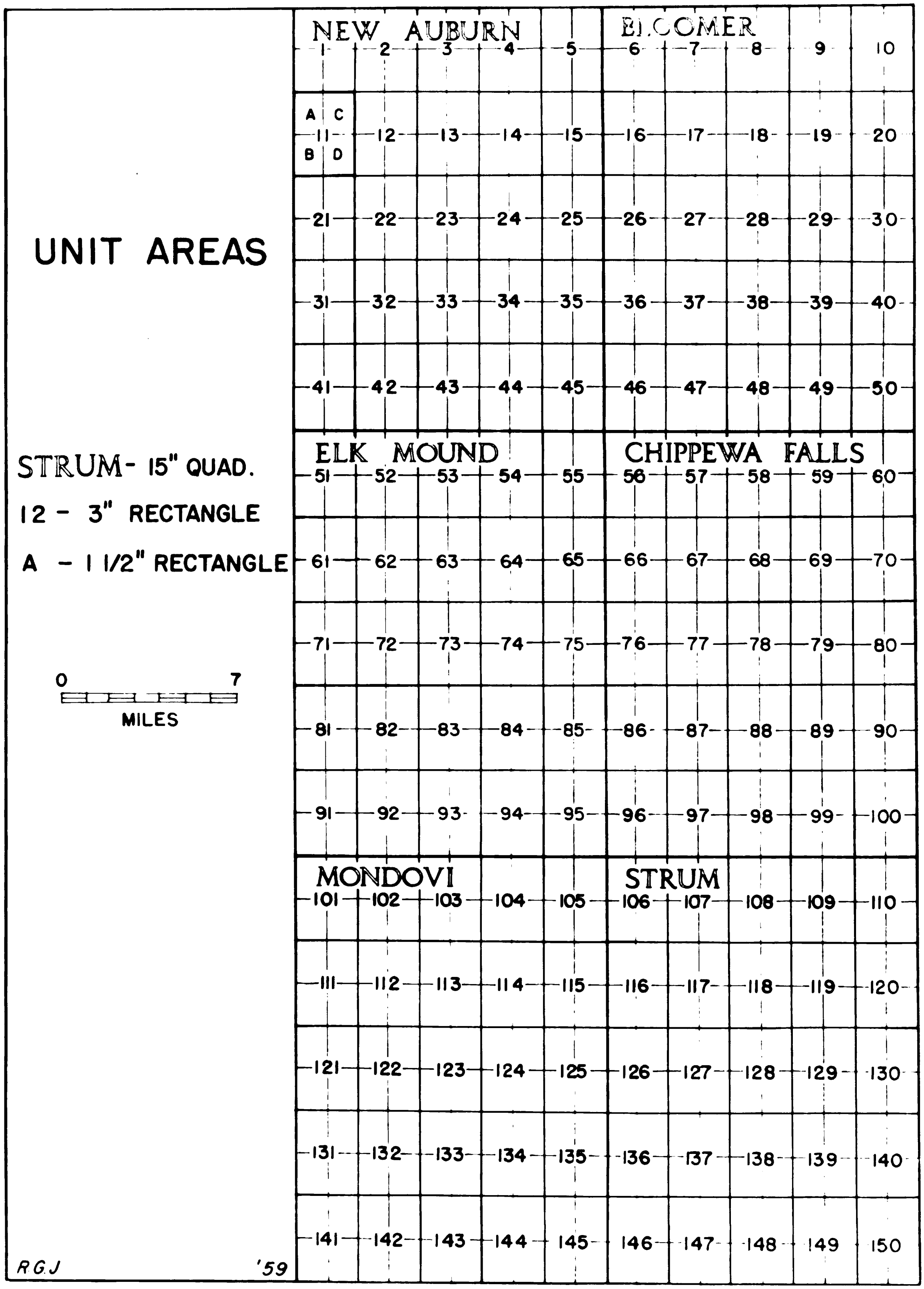

UNIT AREAS
STRUM- 15" QUAD.
12 - 3" RECTANGLE
A - 1 1/2" RECTANGLE
0
7
MILES
RGJ
'59
NEW AUBURN
BLOOMER
ELK MOUND
CHIPPEWA FALLS
MONDOVI
STRUM
A
C
B
D
1 2 3 4 5 6 7 8 9 10
11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40
41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60
61 62 63 64 65 66 67 68 69 70
71 72 73 74 75 76 77 78 79 80
81 82 83 84 85 86 87 88 89 90
91 92 93 94 95 96 97 98 99 100
101 102 103 104 105 106 107 108 109 110
111 112 113 114 115 116 117 118 119 120
121 122 123 124 125 126 127 128 129 130
131 132 133 134 135 136 137 138 139 140
141 142 143 144 145 146 147 148 149 150

Figure 21

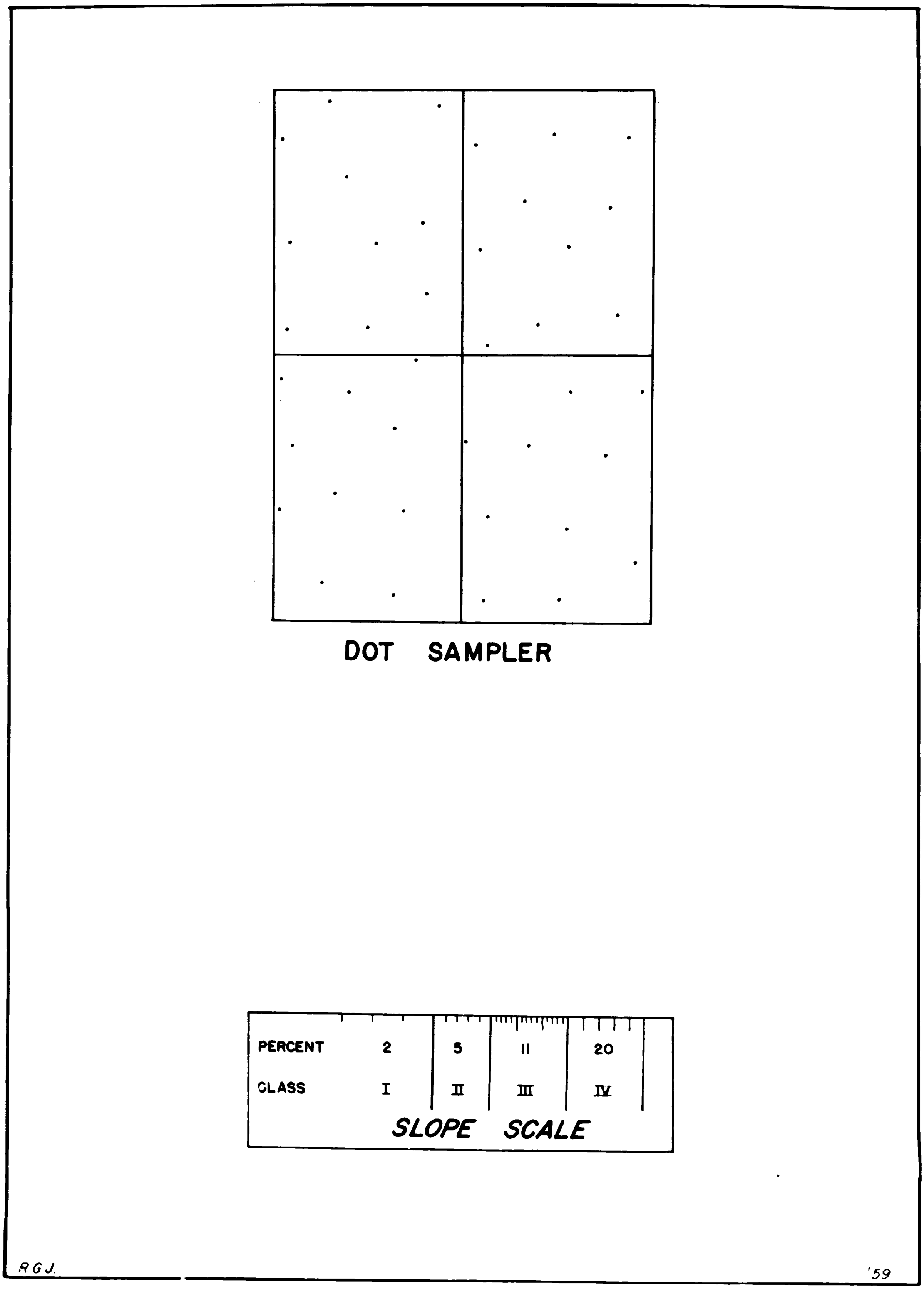

DOT SAMPLER
PERCENT 2 5 11 20
CLASS I II III IV
SLOPE SCALE
R.G.J.
'59

Figure 22

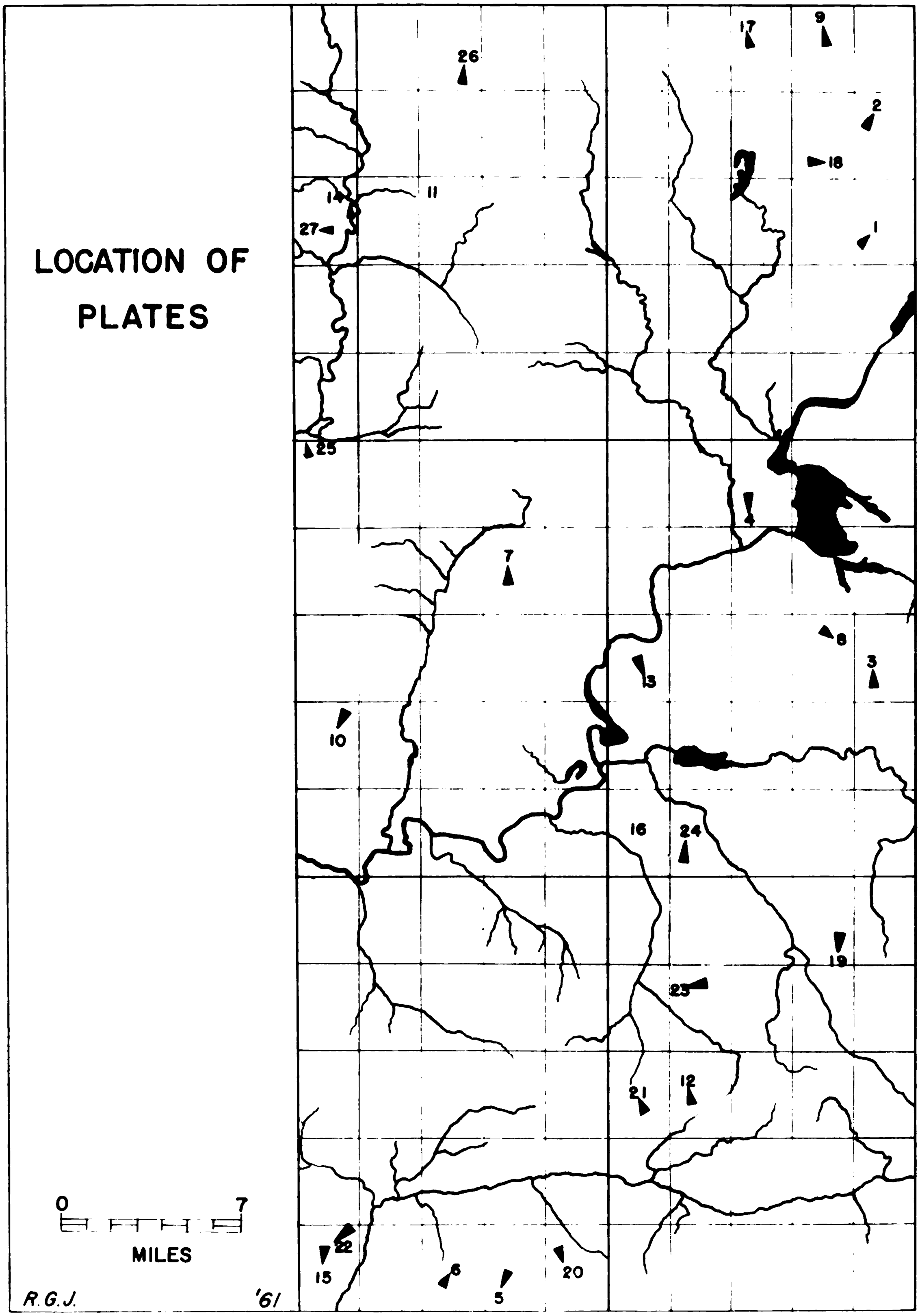

LOCATION OF
PLATES
0
7
MILES
R.G.J.
'61
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

Figure 23

TECHNICAL DATA ON PHOTOGRAPHS

Plate

I. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with Wratten A filter.

II. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with Wratten A filter.

III. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter.

IV. Linhof Super Technika 4 x 5 150 mm lens, Kodak Super-Panchro Press film.

V. Ansco Speedex $2\frac{1}{4}$ x $2\frac{1}{4}$ 90 mm lens, Kodak Panatomic film, Altitude 1,000 feet.

VI. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter.

VII. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter. Altitude 800 feet.

VIII. Linhof Super Technika 4 x 5 150 mm lens, Kodak Super-Panchro Press film, K2 filter.

IX. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with K2 filter.

X. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with Wratten A filter.

XI. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter.

XII. Speed Graphic 4 x 5 150 mm lens, Kodak Royal Pan film with K2 filter.

XIII. Ansco Speedex $2\frac{1}{4}$ x $2\frac{1}{4}$ 90 mm lens, Kodak Panatomic film, Altitude 800 feet.

XIV. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with K2 filter.

XV. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter.

XVI. Ansco Speedex $2\frac{1}{4}$ x $2\frac{1}{4}$ 90 mm lens, Kodak Panatomic film, K2 filter, altitude 1,000 feet.

XVII. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film with Wratten A filter, altitude 1,000 feet.

XVIII. Speed Graphic 4 x 5 150 mm lens, Kodak Super-Panchro Press film with K2 filter.

XIX. Speed Graphic 4 x 5 150 mm lens, Kodak Super-Panchro Press film with Wratten A filter.

XX. Ansco Speedex $2\frac{1}{4}$ x $2\frac{1}{4}$ 90 mm lens, Kodak Panatomic film, K2 filter, altitude 1,000 feet.

XXI. Linhof Super Technika 4 x 5 150 mm lens, Kodak Royal Pan film with Wratten A filter.

XXII. Linhof Super Technika 4 x 5 360 mm lens, Kodak Infrared film with Wratten A filter.

XXIII. Ansco Speedex $2\frac{1}{4}$ x $2\frac{1}{4}$ 90 mm lens, Kodak Panatomic film with K2 filter, altitude 800 feet

XXIV. Speed Graphic 4 x 5 150 mm lens, Kodak Royal Pan film

XXV. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film, Wratten A filter, altitude 1,200 feet.

XXVI. Linhof Super Technika 4 x 5 150 mm lens, Kodak Infrared film, Wratten A filter.

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