ABSTRACT The need for a methodology and an organizational framework on which research in the history of thematic cartography can be based is presented. A methodology geared to the needs of cartographers is suggested. According to the framework outlined, the evolution of thematic cartography is divided into three primary lines of development corresponding to point, line and area symbolization. Within each division, developments are further classified according to whether data illustrated are qualitative or quantitative and whether physical or cultural phenomena are represented. A review of current knowledge, organized according to the framework outlined, is presented as a means of demonstrating the utility of the framework. The use of the framework as a guide to research in the history of thematic cartography is discussed.

The evolution of thematic cartography is an area within the history of cartography that has received all too little attention. Although of more recent origin than general (i.e., reference) mapping, thematic cartography, since its inception in the eighteenth and nineteenth centuries, has exerted a substantial influence on the development and dissemination of knowledge. With the advent of topographic surveys, national censuses, and the growth of the social sciences, the special purpose or thematic map has become a primary mechanism for summarizing and transmitting the increasing volumes of spatially related information which became available.

Research in the history of thematic cartography has been quite haphazard. Concentration has been on individual maps, usually thought to be the first of a kind,1 or on individual cartographers and the maps attributed to them.2 Only in rare cases have these reports included a discussion of the relationship of the maps to other developments in thematic cartography.3 As the amount of knowledge we have has increased, there has become a clear need for some method by which this knowledge can be organized. This organization is needed to classify current knowledge and thereby point out gaps in this knowledge as well as to provide the basis for an understanding of the evolution of basic cartographic concepts. The purpose of the present paper is to suggest an organizational framework to meet these needs, and to illustrate the utility of such a framework.

There seem to be two approaches that can be taken in developing an organizational framework for the history of thematic cartography. One approach is to view the thematic map as a representation of the distribution of various phenomena in space at certain points in time or as the representation of perceptions of these distributions. This approach is compatible with much of the work that has been done in other aspects of the history of cartography. A major emphasis of the history of cartography has been the evolution of knowledge and perception of the world as reflected in the cartographic products of the time. This emphasis is characterized by a concern with the evolution from the Greek-Ptolemaic conception of the world to a more realistic conception as the European sphere of influence expanded and additional knowledge was obtained.

An organization of the history of thematic cartography based on various topics that have been mapped (e.g., population, climate, etc.) would fit with the general point of view outlined above. This kind of framework would be of use to the historical geographer in attempting to reconstruct historic patterns and to

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explain the influence of perception of space, as reflected in maps or produced by maps, on past behaviour. The organization of knowledge about climatic maps, for example, might lead to insights into the influence of perception of climatic patterns on settlement, such as those provided by Dunbar in his analysis of the influence of Blogett’s isotherm maps on perception of central and western Canada.¹

An alternative to the approach presented above is to organize the history of thematic cartography on the basis of the methods of symbolization used. An organizational framework based on methods of symbolization rather than on map content would be of use to the cartographer rather than to the historical geographer. It is this approach that will be presented here.

The cartographer’s interest is in the evolution of current methods of symbolization rather than in the evolution of environmental knowledge and perception. Most cartographers today have little knowledge of the purposes for which methods of symbolization were developed or how the application of these methods has changed through time. It seems that modern thematic cartographers, with their concern for developing theories and the promotion of cartography as a science, would benefit from an understanding of the evolution of their field.

Knowledge of the evolution of various methods of symbolization can provide the cartographer with insights into current and future problems. There is also the possibility that knowledge of methods that, for various reasons, have fallen into disuse may equip the cartographer to develop ‘new and innovative’ uses today. Tobler’s suggestion of choropleth maps without class intervals, for example, is similar to ideas and maps developed by Adolphe Quetelet in 1832 and 1833. Both individuals attempted to eliminate the abrupt unnatural boundaries of choropleth maps by creating a map that gives the impression of a continuous gradation from area to area. A second example, suggested by Robinson, is the revival of an old technique for use in a new context; hachures to represent population gradient.²

Since most current methods of symbolization were developed during the first half of the nineteenth century,³ study of the evolution of methods of symbolization can also serve to familiarize students with basic methods of symbolization currently in use. Study of the original development of a technique is an effective way to obtain an understanding of some of the capabilities and drawbacks of that kind of symbolization. Finding out how a technique was developed to solve a certain problem results in a better understanding of that technique.

ORGANIZATIONAL FRAMEWORK

As outlined above, an organizational framework for the history of thematic cartography based on methods of symbolization would be of greatest use to the cartographer. A classification based on point, line and area symbols, therefore, is appropriate due to the general acceptance among contemporary cartographers of these basic categories of symbolization.4 Within these divisions, research can be further ordered on the basis of the level of information presented and the character of that information. The level of information can be classified as either
qualitative (i.e., illustrating relative locations of phenomena in space) or quantitative (i.e., illustrating difference in magnitude of phenomena located in space), while the character of information can initially be classified as physical or cultural in nature.

A distinction between physical and cultural maps is justifiable on the basis of the sources of early thematic maps. Early physical maps were constructed primarily by individuals who were associated with various disciplines within the natural sciences (e.g., astronomers, surveyors, engineers, geologists, etc.). Although individuals in these disciplines also contributed maps that could be considered cultural, the majority of early cultural maps were produced by individuals who were more closely aligned with what are now considered social sciences (e.g., statisticians, economists, etc.) or with business interests (e.g., insurance underwriters). This division of professional interests of early thematic map makers acted somewhat as a barrier to the diffusion of innovations in symbolization. As the picture of the evolution of basic methods of symbolization used in thematic cartography becomes clear, a classification of the character of maps beyond the broad physical-cultural distinction should prove useful. Adaptation of these methods of symbolization to the mapping of specific phenomena (e.g., geology, population, transportation, etc.) can then be analyzed.

The fundamental basis of the suggested methodological framework is the division of the evolution of thematic cartography into three somewhat separate lines of development; that of point, line and area symbolization. A discussion of the use of each is therefore in order.

**Point symbols.** Point symbols refer to a particular location in space. A point symbol is used when the phenomenon being mapped is located at a place or is aggregated to a given location. Differentiation among point symbols is achieved by variations in shape, color and size. Point symbols can be used to represent any phenomenon which occupies a location or an area in space. Typical examples of qualitative and quantitative point symbols on both physical and cultural maps are illustrated in Figure 1.

**Line symbols.** Line symbols are used to indicate connectivity or flow, equal values along the line, and boundaries between unlike areas. Line symbols are differentiated on the basis of their form (e.g., continuous versus broken), color and width. Common examples of the use of line symbols are depicted in Figure 2.

**Area symbols.** Area symbols are used to assign a characteristic or value to a whole area on a map. Differentiation of area symbols is achieved through variations in color (i.e., value, hue, and intensity) and pattern. Figure 3 illustrates typical applications of area symbols.

**EVOLUTION OF THE BASIC SYMBOLIZATION OF THEMATIC CARTOGRAPHY**

A review of current knowledge organized according to the proposed framework will be presented as a means of illustrating the utility of the framework. This organization of information should result in an improved understanding of the evolution of various methods of symbolization used on thematic maps. The review will also serve to isolate topics requiring additional attention.
Figure 1. Point symbols.
PHYSICAL

SOUTHERN BOUNDARY OF TUNDRA

PREDOMINANT WIND FLOW

CULTURAL

EXTENT OF MORMON INFLUENCE

DIFFUSION OF CHOLERA - 1866

QUALITATIVE

QUANTITATIVE

AVERAGE JANUARY TEMPERATURE [°F]

GRADUATED HILL SHADING, THE THICKER THE LINE THE STEEPER THE SLOPE

RESIDENTIAL DESIREABILITY FROM CALIFORNIA

SHIPMENTS OF IRON ORE

FIGURE 2. Line symbols
Point Symbols

Point symbols are used to indicate qualitative differences among locations by variations in shape and color, and quantitative differences by variations in size. As may be expected, the use of qualitative point symbols to illustrate variations across space preceded that of quantitative point symbols.

Qualitative Point symbols. Qualitative point symbols convey the most limited range of information of the symbols being considered. This form of symbolization is, therefore, more often applied to general reference maps than to thematic maps. For these reasons, limited attention has been directed to the development of this form of symbolization.

An early example of an application of a qualitative point symbol to a physical phenomenon is found in a pair of maps by William Dampier published in 1699. The maps indicate the direction of the trade winds in the Atlantic and the Pacific Oceans. Although it can be argued that these maps are flow maps, the direction of the wind is symbolized by small arrows scattered across the map. Each arrow is, in effect, a point symbol indicating the direction of the wind at the location of the arrow. In a similar application, Haviland, on a geologic map in 1882, showed the direction of slope of mountains by a series of small arrows. Another relatively early example of a qualitative point symbol used to map physical data is found in A.K. Johnston's Physical Atlas of 1850. In this atlas, a map depicting earthquakes with small round dots is presented.

The early application of qualitative point symbols to cultural phenomena appears to have been restricted primarily to the mapping of incidences of disease. The development of this form of symbolization can be credited to doctors in the mid-nineteenth century who were attempting to isolate the cause of cholera outbreaks. In 1848, W.P. Ormerod published a crude map, possibly the first of its kind, using crosses and dots to distinguish between cases of fever and cholera. A map of deaths from cholera in Exeter, England for 1832-34 was published in 1849 by Dr. Thomas Shapter. Dots, crosses, and open circles were used on this map to distinguish among cases of cholera that occurred in each of the three years. The most significant map of this kind, showing the location of deaths from cholera in the Broad Street area of London, was published in London by Dr. John Snow in 1855. The map was used to illustrate Dr. Snow's belief that the incidence of cholera was only among persons who drank from a particular pump. The map and accompanying report resulted in the shutting down of the pump and the almost immediate elimination of new cases of cholera.

Quantitative Point Symbols. It is only on meteorological charts that quantitative point symbols have been frequently applied to the mapping of physical data. A complex symbol, called a station model, is the standard form of symbolization currently used on surface weather maps. This format was introduced at least as early as 1846 on a weather chart of the Eastern United States by Elias Loomis. On this chart Loomis summarized data of wind, clouds, precipitation, pressure and temperature. The first daily weather charts from telegraphic reports were produced at the Great Exhibition from August to October 1851.
The quantitative point symbol has exhibited more widespread use in the mapping of cultural data than in the mapping of physical data. A distinction can be made between those symbols that depict differences by variation in size (i.e., graduated symbols) and those that show differences by variation in the number of symbols placed on the map. Of the first type, the graduated circle was the first to be applied to the representation of data on maps. The graduated circle was developed by William Playfair in 1801. In a publication entitled Statistical Breviary, he presented four graphs containing graduated circles, the area of which was proportional to the area of the country they represented.16

Henry Drury Harness is apparently the first to use graduated circles on maps.17 In 1837, published as part of the Second Report of the Irish Railway Commission, there appeared three maps authored by Harness. On these maps, population of cities is represented by shaded circles whose size is proportional to the population. In this case, the information appears to be secondary to the main theme of each map (i.e., the representation of population distribution across the country, the number of travelers, and the traffic in merchandise). August Petermann, in 1851, extended these early developments of Harness to a population map of the British Isles. On this map, population density is indicated by numbers inserted in the counties, and the population of cities is represented by graduated circles the area of which is proportional to the population.18

Charles Joseph Minard, working independently in France, produced the first maps in which graduated circles were employed to convey information other than population. Funkhouser states that Minard published the first of these maps in 1851, although the topic of the map is not mentioned.19 Robinson presents, as an example, a section of a graduated circle map published by Minard in 1859.20 The map contains circles which represent tonnages handled at the larger ports of the world. In a logical development of the graduated circle technique, Minard published a map, in 1858, that used graduated pie graphs to illustrate amounts and kinds of meat consumed in Paris which were provided by various départements.21 On this map the area of the circle indicates the weight of meat supplied by the département, and the sectors of the circles are colored black, red and green, to represent cows, calves and sheep respectively.

The alternative to varying the size of a point symbol to represent differences in value is to vary the number of symbols. This technique produces the traditional dot map. The predecessors of the dot map are the cholera maps produced by the doctors in England in the mid-nineteenth century. The differences between these and modern dot maps is that each dot represents only location. Modern dot maps generally represent both location and value by assigning a value greater than one to each symbol placed on the map. The earliest example cited in the literature of a dot map in which each symbol equals a number greater than one is an anonymous map of part of New Zealand published in 1863.22 The map represents the distribution of Maoris with each symbol equal to 100 Maoris.

A map thus far overlooked with respect to its contribution to the development of the dot map is a map of cholera in the British Isles, published by August Petermann in 1852.23 The map, somewhat crude in construction, is not actually made up of dots, but of shading that conveys the impression of very fine dots in
areas where cholera incidence is low. Upon visual comparison, however, it more closely resembles a modern dot map than does the New Zealand map described above. A stated purpose of a modern dot map is to provide, “an easily understood visual impression of relative density.” Petermann achieves this effect and actually suggests this as the primary purpose of his map in the note in the upper left hand corner of the map stating that the “Shading is darker in proportion to relative amount of mortality.” In addition to being more similar to a modern dot map than is the New Zealand map, a map produced by Petermann, a prominent cartographer of the period, would have had a much greater opportunity to influence the development of the dot map than the anonymous New Zealand map.

**Line Symbols**

Line symbols are used to indicate qualitative differences among locations by variations in direction, color, form, or simply by delineating boundaries between areas that are unlike in whatever characteristic is being mapped. Quantitative variation is depicted by variation in width of line, or by assigning values to the lines as on a contour map. As with the other forms of symbolization, quantitative line symbols tend to have developed from qualitative forms of symbolization. The use of qualitative line symbols on thematic maps has, however, been quite limited.

**Qualitative Line Symbols.** The most common use of the qualitative line symbol has been on physical maps to depict either wind flow or ocean currents. The first such map, a map of the trade winds by Edmond Halley in 1686, is also considered the first meteorological chart. The prevailing winds are shown by tapering lines, the tails of which indicate the direction from which the wind usually comes. Arrows to indicate direction are used only in the Cape Verde area. In *The National Atlas of Historical, Commercial, and Political Geography*, published in 1843, A.K. Johnston presented a map, adapted from Heinrich Berghaus, of the predominant wind flow of the world, with wind flow indicated by lines with arrows to indicate direction. In 1850, Johnston published an edition of his *Physical Atlas* which included a similar map of ocean currents.

A use of a qualitative line symbol which has not survived to the present appears on maps by Heinrich Berghaus in the 1838 edition of his *Physikalischer Atlas*. On these maps, solid lines are used to indicate the location of mountain ridges.

Current literature on the history of thematic cartography provides no examples of qualitative line symbols being applied to cultural data. It seems unlikely, however, that there are no such examples in existence. It is probable that flow maps showing only direction of flow were developed prior to those that show both direction and volume.

**Quantitative Line Symbols.** The principal quantitative line symbol used to represent physical data is the isoline. Isolines that portray physical data (i.e., basic, elemental geographical facts) are termed isometric lines. Among the phenomena that have been illustrated by isometric lines are sea depth (isobath), elevation (isohypse or contour), magnetic declination (isogonic line), magnetic dip (isocline), intensity of
the magnetic field (isodynamic line), temperature (isotherm), and atmospheric pressure (isobar).  

A map by a Dutch surveyor, Pieter Bruinss, in 1584, is the earliest known map to employ any form of isometric line. This map contained isobaths in the River Spaarne. It was not until 1697 that another map with isobaths appeared; this one by Pierre Ancellin illustrating part of Rotterdam and the bottom of the New Maas. The first map to include isobaths in the open sea appears to be a chart of Nova Scotia in 1715 by Nathaniel Blackmore. The map seems not to have been widely known among Blackmore's contemporaries. It was, therefore, not until 1737, after two more off-shore maps of isobaths had been produced (by Marsigli in 1725 and Cruquius in 1730), that a bathymetric map of the English Channel by Philippe Bauche firmly established the isobath as a true navigational aid.

The mapping of elevation above sea level progressed more slowly than had mapping of depth at sea. Several factors account for this, the primary one being motivation. Knowledge of water depth was simply more crucial than that of elevation on land. The safety of ships and their crews depended on knowledge of water depth. In addition, the measurement of elevation on land was more difficult both physically and technically. In 1743, Christopher Packe, on his *Philosophico-Chorographical Chart of Kent*, used barometric readings to calculate spot elevations above sea level. Temporal variation in pressure, however, caused his results to be less than satisfactory.

Real progress was not made until 1777 when Meusnier, a French lieutenant of engineers, proposed "to express very exactly the surface configuration by joining all points with the same number by curves." This proposal was not carried to completion until 1801 when battalion commander Haxo produced a two meter interval contour map of a proposed fortification site.

A few years after Meusnier's proposal, in 1782, J.I. Dupain-Triël pushed forward a similar proposal by du Carla. This proposal outlined procedures necessary to produce what is now known as a contour map. An hypothetical contour map was provided as an illustration. In 1791, Dupain-Triël published the first small scale contour map; a map of France. By 1810, French geographic engineers, under the direction of Captain Clerc, had begun detailed contour maps of the whole country. The adaptation of contour mapping from large scale topographic maps to the small scale thematic map can be considered complete by 1833 with the publication by Olsen of a contour map of Europe.

A somewhat separate line of development exists for isometric lines that represent phenomena other than elevation. This development can be traced to an Italian, Christoforo Borri, who in 1630 is thought to have constructed a chart employing isogones. This chart, though not extant, is referred to in several editions of Kircher's book on magnetic declination. Probably due to Kircher's account, Edmond Halley published, in 1701, a chart of the Atlantic Ocean that is the first published map using isogones. This map, which is also the first published isoline map of any kind, included a clear explanation of the construction of isarithms. Halley's map was followed by many maps showing various aspects of the variation of magnetic force across space. Examples include a map of isoclines by Whiston in 1721, Hansteen's map of isodynamic lines in 1725–26, Whicke's 1768...
isoclinic map of the world, the first to show the location of the observations, and Lambert's 1770 map which was the first to depict isogones over land.36

The first real innovation in the chain of development initiated by Halley was the creation of the isotherm in 1817 by Alexander von Humboldt.37 Humboldt called attention to the similarity between his isotherms and Halley's isogones.38 Humboldt's map, as did Halley's initiated numerous similar developments. Starting where Humboldt left off, Berghaus, in editions of his Physikalischer Atlas, presented not only a map of isotherms, but of isohyets, isobars, and even a map of lines of equal frequency of thunderstorms.

Quantitative line symbols other than isometric lines have also been used to map physical data. An alternative to the contour line that underwent relatively parallel development is graded hill shading. In this technique, lines are drawn parallel to the direction of slope (i.e., perpendicular to the direction of contour lines). The thickness of the line is used to indicate the steepness of the slope. Early examples of this technique are Christopher Packe's 1743 Philisophico-Chorographical Chart of Kent and Philippe Bauche's 1757 maps of river systems and watersheds. In 1799, Lehmann developed the first scientific system of representing relief by parallel lines with the thickness of lines proportional to the slope and the intervals between lines inversely proportional to slope.39

The application of quantitative line symbols to cultural data occurred considerably later than had the similar application to physical data. The first isopleth maps were two population maps of Denmark, for the years 1845 and 1855, published in 1857 by Nils F. Ravn, a first lieutenant of the Danish Hydrographic Department. The idea behind the development of this application of an isoline had been formulated in Germany in 1845 by M. Lalanne. It is unlikely that Ravn, with the background he had, could have developed this idea independently. It appears more probable that Lalanne's idea was communicated to Ravn by Privy Councillor C. Anrae, who had contacts with Ravn, access to Lalanne's work, and quite possibly was acquainted with Lalanne himself.40

Another form of quantitative line symbol that became popular in the mid-nineteenth century is the graduated flow line. This symbolization was first employed by Henry Drury Harness on two of the previously mentioned maps in the Second Report of the Irish Railway Commission in 1837. Two of the maps included in this report are flow maps that Harness termed a Conveyance map and a Traffic map. The Conveyance map shows movement of travelers, and the traffic map shows traffic in merchandise. On both maps, the width of line is in direct proportion to the volume of flow.41

As with graduated circles, Charles Joseph Minard, working independently in France, duplicated Harness' development of the graduated flow line. Minard's first flow map, published in 1845, although fairly crude in construction, used lines the width of which were strictly proportional to the number of travelers moving in the region from Dijon to Mulhouse.42 Minard constructed many flow maps on various topics; for example a map in 1854 showing exports of coal from England, and a map published in 1865 depicting the export of wine from France by ocean. The last maps made by Minard may have been his best known.43 These are a pair of flow maps, published in 1869, which illustrate the reduction in size of the armies
of Hannibal in his campaign into Italy and of Napoleon into Russia. The map of Napoleon's campaign is especially striking in showing, by a steadily diminishing line, the reduction in an army of 422,000 to one of only 10,000.

**Area Symbols**

Variation in color, pattern, or both is used in area symbols to differentiate between areas which differ in either qualitative or quantitative characteristics. As with point and line symbols, applications of area symbols to qualitative data were the first to be developed. Unlike point and line symbols, however, area symbols have been, and still are, used as frequently to map qualitative data as they are to map quantitative data.

*Qualitative Area Symbols.* It is difficult to separate general reference and thematic applications of qualitative area symbols to physical data. The first true thematic maps using area symbols are probably the maps of France and North-west Europe drawn by Philippe Bauche in 1746. On these maps, Bauche attempted to depict the results of geological observation over large areas. The pattern of rocks and sedimentary deposits is defined, and the location of fossils and minerals is indicated by distinctive symbols.45 Bauche followed these maps, in 1752, with maps of the mineralogy of North America and Switzerland.46 On the map of North America, thirty-eight symbols represent a wide range of mineral resources, while fifty symbols are used on the map of Switzerland.

Although Bauche's maps are a significant contribution, William Smith is credited with the development of geologic mapping.47 Smith was the first to adequately correlate fossils with the associated strata. His first geologic map, appearing in 1799, is a map of the Bath district in which geologic formations are distinguished by a color key; possibly the first graphic legend of any kind. Smith produced many other geologic maps, the most important of which is his 1815 map covering all of England and Wales. This map was shortly followed, in 1819, by John MacCulloch's map of Scotland and by Sir Richard Griffith's map of Ireland.48 Griffith's map was completed in 1821, although it was not exhibited publicly until 1835.

The mapping of economic resources was a logical outgrowth of the mapping of mineral resources. A.F.W. Crome published, in 1782, the first map to apply qualitative area symbolization to cultural data. A variety of symbols were used to show the distribution of fifty-six commodities in Europe. The map seems to have not been well known and not imitated.49

Thomas Milne, in 1800, produced what appears to be the first land use map; a map of London. Letters and colors, applied by hand, were used to indicate seventeen categories of land use. In a similar application, Joseph Fletcher constructed a land use map of England and Wales in 1847. Colors, applied by hand, were again used to differentiate among eight land use types. On several maps in 1849, Fletcher used seven degrees of monochrome shading in place of color to represent his classes of land use.50

On a less complex scale, the first map of disease, Dr. Robert Baker's "Cholera Plan" of Leeds in 1833, used hatching to indicate districts in which cholera
prevailed. This idea was again applied, in 1848, by W.P. Ormerod on his map of Oxford in which districts “Chiefly visited by disease generally” were depicted by light shading. Along the same lines, Dr. H.W. Acland published, in 1856, a map of Oxford in which the undrained parts of the city were illustrated by colors and symbols.51

Quantitative Area Symbols. The principal application of quantitative area symbols to the mapping of physical data has been the shading of isometric maps. The first attempt to shade an isometric map was by J.I. Dupain-Triel in 1798. To his contour map of 1791, he applied three hypsometric tints in an attempt to emphasize the representation of relief.52 It is not known whether this map influenced later attempts at hypsometric shading.

In 1804, A. Zeune published a hypsometric map of the world in which grey tints of higher and higher intensity were used to show increasing elevation. Carl Ritter, in 1806, published a similar map of Europe in which he developed the convention of the higher the altitude the lighter the tone.53 This convention was adopted by Adolf Stieler in his Hand Atlas published from 1817 to 1834. The application of shading to isometric maps of other phenomena was introduced by Heinrich Berghaus in various editions of his Physikalischer Atlas which began publication in 1838.

Developments in the representation of cultural data had a similar beginning but progressed along somewhat different lines. In a manner similar to that employed by Ritter and Zeune for elevation, Baron Charles Dupin, in 1819, used gradual shading from black to white to illustrate the distribution of illiteracy in France. This effort was followed by the development of a new form of thematic map; the choropleth map.54

Dupin, in 1827, published what was apparently the first true choropleth map.55 In 1829, Adrian Balbi and A.M. Guerry published a map of the various crimes committed by district in France. This map was followed in 1832 and 1835 with maps, published by Adolphe Quetelet, that were similar to Dupin's map of 1819.56 Guerry, in 1833, published six quite sophisticated choropleth maps. Ratio or percentage values are used in all cases. On all maps, each district is numbered according to its rank order. Shading from a solid color (brown, green, or black) to white is applied to each district to indicate the value calculated for the district. Districts are also listed in rank order beneath the map with the specific value indicated.57

The next major development occurred in 1837 with the publication of Harness' population map of Ireland.58 This map has been identified as the first example of the dasymetric technique.59 Position of the class boundaries is inconsistent and class limits can not be determined. It is apparent, however, by Harness' explanation of the map, that he did attempt to employ the dasymetric technique.

Density, in addition to being depicted by the intensity of shading, has also been illustrated by systems of horizontal ruling. The first attempt of this nature occurred in 1839 on a map of world population by George Poulett Scrope. The map used lines of varying thickness to illustrate the “Extent of the Fully-peopled, the Under-Peopled, and the Yet Un-Peopled Parts of the Earth.”68 Using a more
scientific approach, Minard, in 1866, constructed a population map of Spain. On this map parallel rulings were spaced in strict proportion to the “specific” population; the more dense the population the closer the lines. Minard felt that his system eliminated the ambiguity which results when data are classed and a shading pattern is assigned to the whole class.

APPLICATIONS TO FUTURE RESEARCH

Organization of existing knowledge according to the framework outlined has served to point out several gaps in this knowledge. A lack of information concerning the development of qualitative line symbols in general and of applications of point symbols to physical maps has become apparent. By organizing maps according to the method of symbolization rather than the topic of the map, the possible role of August Petermann’s 1852 map of cholera in the evolution of the dot map has been indicated. In an area cutting across all forms of symbolization, it can be pointed out that the literature contains no research into the evolution of graphic legends for any of the three forms of symbolization. In addition to gaps in knowledge, there has been a general lack of integration of knowledge once it has been obtained.

The organizational framework presented here is designed as a method for the systematic integration of existing knowledge. The framework is also intended as a basis for research focusing on the initial development, spread, and evolution to the present of symbolization techniques rather than simply on the initial development as in the past.

Based on the classification system outlined, research within each major category (i.e., point, line and area) can be divided into four stages according to the qualitative-quantitative and physical-cultural distinctions. Research can be directed to developments within a category as well as to developments between categories.

Within each category, a significant question involves the degree to which symbolization was adapted from general reference maps versus the development of new symbolization to meet specific needs. The advent of maps that show more than one qualitative distribution (e.g., geology, vegetation, or land use) is likely to have been a significant event in the development of techniques of symbolization created specifically for thematic maps. These multi-category maps forced the cartographer to experiment with variations in pattern, texture, value and color to achieve adequate variation among the categories. The evolution of the fire insurance map in the U.S., as outlined by Ristow, is a good example of this kind of development in response to a specific need.

It is assumed that direction of evolution between categories in most, if not all, situations has been from qualitative applications of a technique to quantitative applications (e.g., dots to represent location leading to dots to represent a specific quantity at a location). The direction of evolution between physical and cultural applications of techniques is less certain. It appears, however, that for point symbols development may have been from cultural to physical while for line and area symbols it has been the reverse. Choropleth maps may be an exception to this
generalization since they are and have been primarily used with cultural data. It is likely, however, that the choropleth technique can be traced to shaded isarithmic maps of elevation through Dupin's 1819 map of illiteracy in France. At any rate, the question of transfer of ideas between physical and cultural applications deserves some attention.

Many questions concerning the interrelation of developments in various categories remain unanswered. It is known, for example, that flow lines to show wind direction developed before passenger or commodity flow maps. The influence, if any, of the former on development of the latter, however, is not known. Although the development of the isopleth from the isarithm has been thoroughly examined, the connections between these techniques and the choropleth and dasymetric techniques has yet to be examined.

The organizational framework presented has provided the basis for a review of the history of thematic cartography that can be used as a source of information and a guide to further study. It should facilitate research by providing a scheme for relating independent discoveries to the field as a whole, and stimulate research by isolating topics that require attention.

NOTES


6 Thrower, op. cit., footnote 5, 98.

7 More detailed classification systems exist, such as that developed by Robinson (Robinson and Sale, op. cit., footnote 5, 95-101) in which point, line, and area symbols are each divided into six sub-classifications. This level of detail, however, would prove to be more of a hindrance than an aid in historical research.

8 Physical phenomena are considered to be those of the natural environment (e.g., landform, geology, vegetation, meteorology, etc.). Cultural phenomena are those produced by or as a result of man (e.g., population, transportation, agriculture, disease, etc.).

9 For a reproduction of these maps see Thrower, op. cit., footnote 2, 661.


11 For a reproduction of this map see Gilbert, op. cit., footnote 9, 176.
12 Ibid., 174-175.
13 The station model is a standard format used to summarize current and past weather conditions by arranging symbols and numbers around the location of the weather station on the map.
17 For a reproduction of this map see Gilbert, op. cit., footnote 3, 448f.
20 Ibid., 103-105.
21 Hargreaves, op. cit., footnote 1.
22 For a reproduction of this map see H.J. Jusatz, "Die geographisch-medizinische Erforschung von Epidemien," Petermann's Geographische Mitteilungen, 86 (1940), 201-204.
23 Robinson and Sale, op. cit., footnote 5, 119.
26 For a more complete listing of isograms, see Thrower, Maps and Man, Appendix B (op. cit., footnote 3, 164-165).
27 Robinson, op. cit., footnote 21, 50.
29 Robinson, op. cit., footnote 21, 50.
32 For a reproduction of this map see Dainville, op. cit., footnote 32, 396.
33 Robinson, op. cit., footnote 21, 51.
34 Ibid.
35 Ibid.
36 For a reproduction of this map see Robinson and Wallis, op. cit., footnote 3, 120.
37 Robinson and Wallis, op. cit., footnote 3, 121.
39 Robinson (op. cit., footnote 21, 50), defines isopleth as a line that portrays relative value. It is a higher order line than the isometric line, and as applied to more complex geographical concepts that are a function of one element and space (e.g., persons per square mile).
40 Robinson, op. cit., footnote 21, 52-53.
41 Robinson, op. cit., footnote 3, 442.
43 Ibid., 99.
44 Skelton, op. cit., footnote 12, 621-622.
46 Thrower, op. cit., footnote 3, 85.
48 Funkhouser, op. cit., footnote 1, 299-300.
49 Ibid., 300.
50 Gilbert, op. cit., footnote 9, 172-183.
51 Foncin, op. cit., footnote 1.
52 Thrower, op. cit., footnote 3, 88.
53 In simple choropleth mapping the objective is to present the magnitude of statistical data as it occurs within a unit area (e.g., county, state, etc.) (Robinson and Sale, op. cit., footnote 5, 148-151).
55 See Adolphe Quetelet, Sur l'homme et le développement de ses facultés, ou Essai de physique sociale, (Paris: Bachelier, 1835).
THE EVOLUTION OF THEMATIC CARTOGRAPHY

58 For a reproduction of this map see Robinson, op. cit., footnote 3, 447f.
61 Robinson, op. cit., footnote 2, 104.

RÉSUMÉ L'auteur explique le besoin d'une méthode de travail et d'un plan structurel sur lesquels pourrait s'appuyer la recherche sur l'histoire de la cartographie thématique. Une méthode de travail axée sur les besoins des cartographes est suggérée. Selon le plan décrit, la cartographie thématique évolue dans trois directions primaires: la symbolisation par point, par ligne et par région. Ces directions se subdivisent selon que les données illustrées sont qualitatives ou quantitatives ou que la représentation de phénomènes est physique ou culturelle. La révision des connaissances actuelles, faite selon le plan de travail proposé, est présentée comme un moyen de prouver l'utilité de ce plan. L'auteur traite de l'utilisation de ce plan comme guide à la recherche sur l'histoire de la cartographie thématique.


RESUMEN Se presenta la necesidad para una metodología y guía organizacional en la cual se puede basar la investigación de la historia de la cartografía temática. Se ofrece una metodología dirigida a las necesidades de los cartógrafos. Según la guía presentada, la evolución de la cartografía temática se divide en tres líneas primarias de desarrollo correspondientes a la simbolización con punto, línea y área. Dentro de cada división, se clasifican los desarrollos aún más, según si demuestran datos cualitativos o cuantitativos o fenómenos físicos o culturales. Se presenta una reseña de los conocimientos actuales, organizada según la guía, para demostrar la utilidad de ésta. Se trata del uso de la guía en la investigación de la historia de la cartografía temática.