# L

## *Labeling of Maps.*

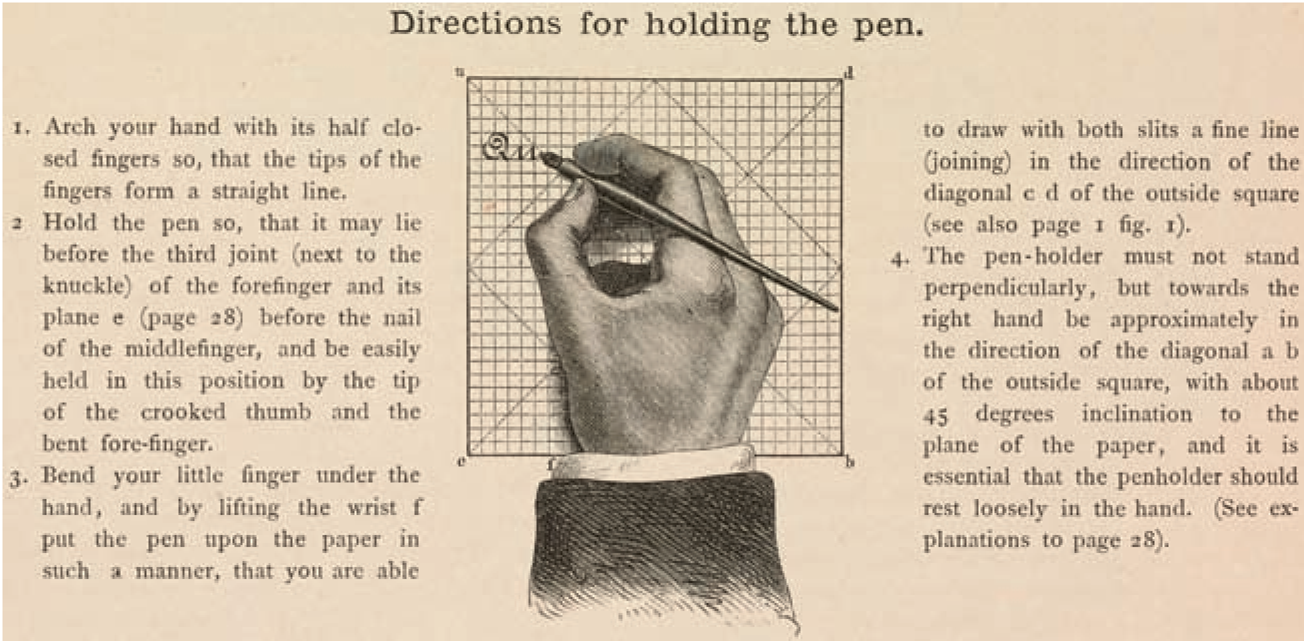
LABELING TECHNIQUES
TYPOGRAPHY AND MAP DESIGN

*Labeling Techniques.* When Erwin Raisz noted in his ground-breaking 1938 textbook that adding place-names to maps was one of the cartographer's most difficult problems, he was voicing an opinion shared by many mapmakers of the precomputer era. Map labels were necessary to identify features on maps, but it was hard to place them without detracting from the map as a picture of the earth (Raisz 1938, 156–57). Raisz also noted the influence of the production technique employed on the appearance of map lettering. For instance, while earlier manuscript maps drawn with pen and ink were often "clogged" with lettering, copper-engraved maps, which dominated from the sixteenth into the nineteenth century, were more sparingly labeled, involving the expensive incision of names in the hard metal plate by a skilled craftsman who could engrave letters in reverse, so they would print right reading. After the early nineteenth century, however, a succession of new techniques facilitated map production and reproduction, including map lettering.

First on the scene was lithography, invented just before 1800 in Germany by Alois Senefelder, who became involved by 1809 in producing lithographic maps for the Bavarian cadastral survey. The chemical basis of the lithographic process, which depends on the antipathy of oil and water, made it versatile, requiring only the creation by some means of a greasy image on a suitable block of limestone. Drawing with pen and greasy ink on the lithographic stone or engraving it (that is, using pointed tools to remove a thin resist coating the stone to expose portions of it for oiling) was easier than copper engraving, even though letters still had to be drawn in reverse. Easier yet was autography, a lithographic technique involving drawing right reading with greasy ink on transfer paper that could be placed face down on the stone and dampened, causing the water-soluble transfer coating to release the image onto the stone when pulled through the press. Used for writing documents and even books, as well as for drawing maps (such as to illustrate geographical journals), transfer paper sparked what has been called an autographic revival (that is, a revival of the manuscript tradition) in the mid-nineteenth century, enabling relatively unskilled persons to write their own text and draw their own graphic images for lithographic printing (Ashwin 1983, 16). With the advent of the photolithographic transfer process in 1860, followed by other photomechanical processes, it became possible to draw maps on paper for photomechanical reproduction.

During the mid-nineteenth century a number of methods were developed for the systematic teaching of writing in schools, an increasing need as education became more accessible. One such method, *Rundschrift* (known as round writing in English and *écriture ronde* in French), was developed in Germany by Friedrich Soennecken for execution with special metal pen points, broad-tipped with an ink feeder, which his company manufactured. Holding the pen at a consistent angle, the writer could make wide and narrow strokes in the same motion, creating rounded letter shapes based on a grid schema (fig. 444). Regarded as easy to write and read, the Soennecken system was taught to European schoolchildren, who also saw it used in school atlases (*Volksschulatlassen*) (Linhoff 1891, 15). *Rundschrift* was adopted for some sheet maps as well as atlases in Austria, Italy, and Germany (Eckert 1921–25, 1:344). The Soennecken system and pens were also marketed in England and, from the late-nineteenth century until as late as 1921, in the United States by Keuffel & Esser, importers of drafting and surveying equipment, whose advertisements recommended its use for map lettering (Keuffel & Esser 1921, 226–27).

The style of printed type also influenced hand lettering for maps. In 1903 the English map publisher G. W. Bacon & Co. advertised its lettering charts, created by


Directions for holding the pen.

1. Arch your hand with its half closed fingers so, that the tips of the fingers form a straight line.
2 Hold the pen so, that it may lie before the third joint (next to the knuckle) of the forefinger and its plane e (page 28) before the nail of the middlefinger, and be easily held in this position by the tip of the crooked thumb and the bent fore-finger.
3. Bend your little finger under the hand, and by lifting the wrist f put the pen upon the paper in such a manner, that you are able to draw with both slits a fine line (joining) in the direction of the diagonal c d of the outside square (see also page 1 fig. 1).
4. The pen-holder must not stand perpendicularly, but towards the right hand be approximately in the direction of the diagonal a b of the outside square, with about 45 degrees inclination to the plane of the paper, and it is essential that the penholder should rest loosely in the hand. (See explanations to page 28).

FIG. 444. "DIRECTIONS FOR HOLDING THE PEN." Although its origins lay in medieval Roman-style scripts written with quill pens, the grid-based system of writing developed by Friedrich Soennecken for use with his line of special metal pen points also reflected industrial-age technology.

Size of the original: 8.9 × 18.1 cm. From Friedrich Soennecken, *Methodical Text Book of Round Writing for Self-Instruction and Use in Schools* (London: A. Eltzbacher, 1879), X. Image courtesy of the Bodleian Library, University of Oxford (2578 d. 10).

Frank Steeley, for systematically teaching type-like printing in addition to cursive writing in schools, and especially recommending it for use in map drawing (Anonymous 1903). Hand lettering with special pens, inks, and drawing materials for photomechanical reproduction was a technology that helped to promote hand lettering and enabled it to survive on printed maps through the mid-twentieth century. However, the difference between hand lettering by skilled draftsmen employed to draw maps for premier geographical publications, such as the journals of the Royal Geographical Society and the American Geographical Society (fig. 445), and more amateur efforts remained evident (Raisz 1938, 159).

Already common in the mid-nineteenth century, treatises on hand lettering for students of engineering and technical drawing continued to appear in the early decades of the twentieth century. Over time such books also began to recommend mechanical aids for achieving greater uniformity of letter shapes and sizes, although not necessarily a faster production speed, and still requiring a deft touch and skill in spacing the letters. As cartography textbooks multiplied in the mid-twentieth century, they mentioned hand lettering less and less and emphasized mechanical lettering aids more. Such devices included lettering stencils (*Schriftschablone* in German) like those produced by the Standardgraph firm founded in Germany in 1911 (fig. 446) and Wrico (Wood-Regan Instrument Company) of New York, which manufactured lettering stencils and pens patented in 1926. The Ames Lettering Guide, patented in 1917, was used to draw precisely spaced guidelines for hand lettering (fig. 447). The Leroy lettering template, patented in 1919, and the Varigraph adjustable lettering machine, manufactured in Madison, Wisconsin, in the mid-twentieth century, employed the pantograph concept to trace grooved letters engraved in a template and guide an attached offset pen that drew them on paper (fig. 448). Around 1960, after direct scribing of negatives had begun to supplant pen-and-ink drafting for photography, the Gebrüder Haff firm of Pfronten-Ried, in Bavaria, developed the Rotograph. That electric-powered adaptation of template lettering could engrave negative lettering on scribecoat by substituting a graver rotating at 3,000 rpm for an ink pen (Raisz 1962, 279). Such devices represented the height of semi-mechanized hand lettering in the mid- to late twentieth century.

However, a parallel strand of typographic lettering technologies had coexisted with hand lettering for centuries. Beginning in the sixteenth century, the difficult task of cutting text labels in relief on woodblocks had been eased by setting metal type into the woodblock letter-by-letter or as entire words or blocks of text copied by stereotyping. During the mid-nineteenth century a new relief process, wax engraving, was developed in

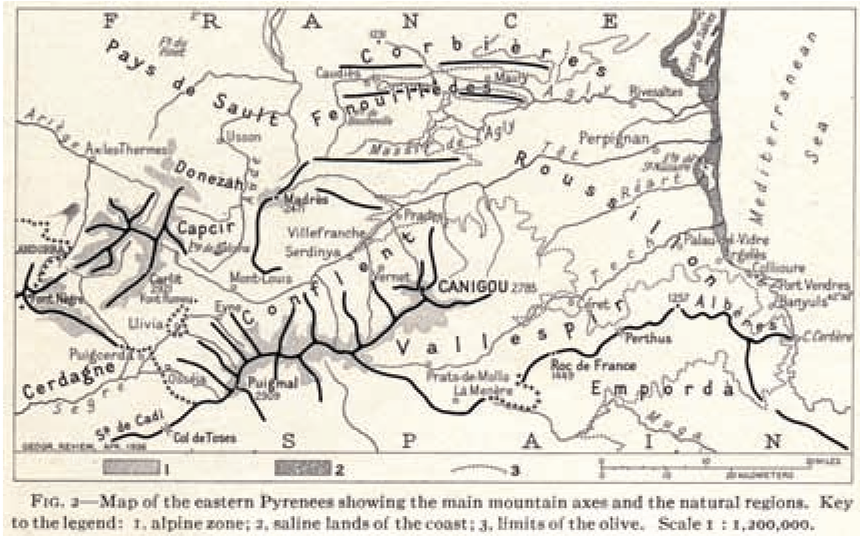



FIG. 445. MAP OF THE EASTERN PYRENEES. The precise and simple hand lettering on American Geographical Society maps betrays the stylistic influence of sans serif type.
Size of the original: 6.2 × 11 cm. From Henri Gaussen, "A View from Canigou: Nature and Man in the Eastern Pyrenees," *Geographical Review* 26 (1936): 190–204, 191 (fig. 2). Permission courtesy of the American Geographical Society, New York.

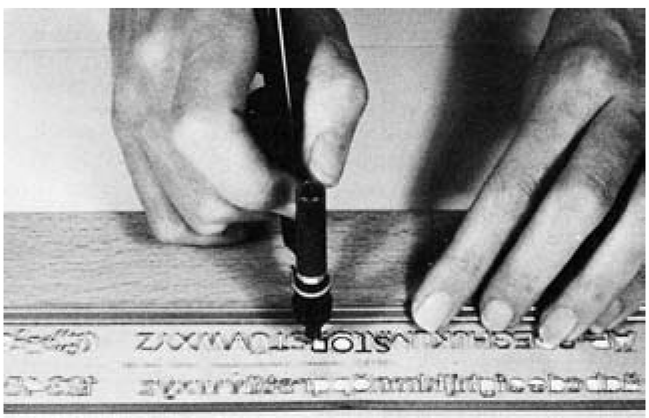


FIG. 446. USING A STENCIL AS AN AID IN LETTERING. Held vertically in a special adaptor, the draftsman holding the Rotring Varioscript stencil pen creates letters by following the guide holes cut in the Standardgraph stencil, which is held in position against a straight edge.
From Lawrence 1971, 125 (fig. 12.7). Reproduced by permission of Taylor & Francis Books U.K.

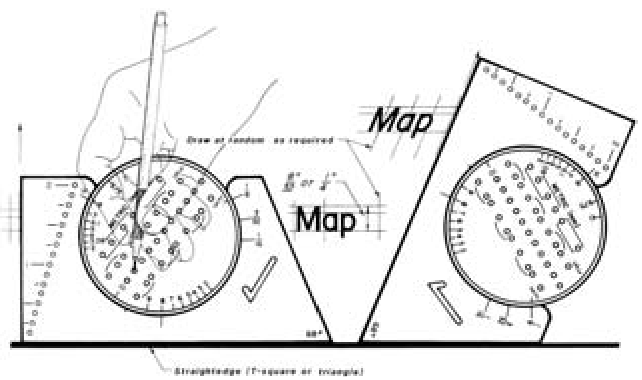



FIG. 447. AMES LETTERING GUIDE. The user could rotate the disk to different angles, thus altering the spacing of the circular holes and of the resulting lettering guidelines when a pencil was inserted into successive holes and the flat base was pulled along a straight edge.
From Claude Z. Westfall, *Basic Graphics and Cartography* (Orono: University of Maine at Orono Press, 1984), 95 (fig. 6.8). Permission courtesy of the University of Maine Press, Orono.

England and the United States. In the latter country it was used by firms such as Jewitt and Chandler of New York and Rand McNally of Chicago so much that it characterized American maps in books and atlases into the twentieth century. The bodies of such maps swarmed with place-names, almost too easily created by stamping type set in straight or curved metal holders into a wax layer, in which the map symbols were also stamped or engraved before the image was copied by electrotyping to form a relief printing plate. In addition to crowding and overlettering, the uniform shapes and sizes of the type lettering added by the wax engraver contributed a look of graphic monotony to wax-engraved maps. Producing such maps was still a craft activity carried out in the print shop.

By the mid-twentieth century, though, a shift of map production from the engraver's or printer's workshop to the cartographic laboratory had taken place. The

The Varigraph Co., Inc., Madison 1, Wis.

**Lettering Machine Adjusts for Size**

You can make your lettering letter-perfect with a machine that uses any one of more than 60 templates, each with a different type face. In addition, you can adjust the width and height of the letters as you wish simply by setting two scales on the face of the machine. As you follow the lines of the template with the stylus, a lettering-pen point forms the letter in the size you want. The housing, made of lightweight Tenite, can be reversed for use by a left-handed person.

FIG. 448. "LETTERING MACHINE ADJUSTS FOR SIZE." More than sixty Varigraph templates, each a different typefont, could be traced by following the grooves in the template and redrawn automatically by a connected pen at different sizes set by adjusting the height and width scales on the machine.
Size of the original: 10.9 × 6.4 cm. From *Popular Mechanics Magazine* 95, no. 5 (1951): 104.

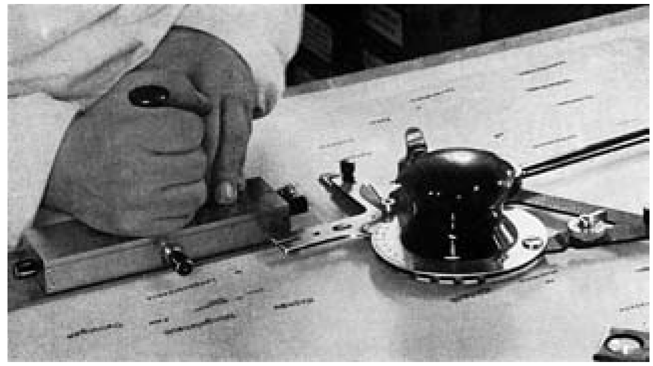
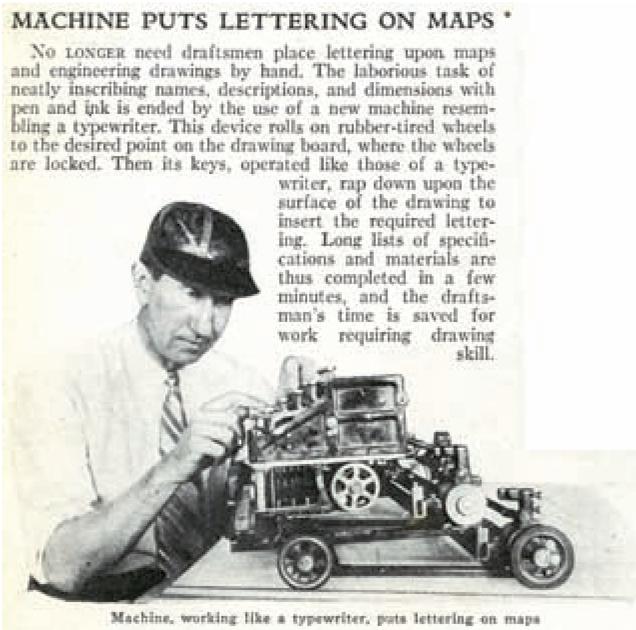


FIG. 449. STAMPING LETTERING WITH THE WULKOW-SCHRIFTSTEMPELGERÄT. Type lettering set in a special holder is being stamped onto a German map using the Wulkow brand of type-stamping equipment.
From Bosse 1954–55, vol. 1, between 96 and 97 (fig. 9). Permission courtesy of Elisabeth Seeger Verlag, Freiburg.

stamping of type lettering, for example, was adapted to the production of maps for photomechanical reproduction (fig. 449). As early as the 1860s the British Ordnance Survey began stamping type lettering on 1:25,000 map sheets intended for photolithographic reproduction (Dickinson 1976, 76). Around 1900 in the United States, J. A. Ockerson, principal assistant engineer of the Mississippi River Commission, found type useful for stamping repetitive numbers indicating water depths on river charts (Jacoby 1909, 81–82). In Germany, it was found that experienced typesetters accustomed to handling type were best suited to stamping type on maps. They worked most efficiently in pairs, alternating two typeholders, with one worker setting type in one holder, while the other worker used the other holder to stamp already-set words on the drafting surface. Simple in principle, it was a craft process requiring nimble knowing fingers for typesetting, a judicious sense of inking and stamping pressure, and scrupulous care when cleaning the quick-drying ink from the type. Stamping 120 names with type onto one sheet of the *Neue Hessische Karte 1:2 000* occupied one workday (Bosse 1954–55, 1:93).

Meanwhile, the typewriter, invented in the United States and first commercially marketed there by the Remington firm in 1873, offered a more accessible method of adding type lettering to maps. In 1907 the new Hammond typewriter no. 12 (the forerunner of the Varityper)—offering features such as instantaneous change of type styles, variable spacing, and the use of paper in any width—was advertised in an American college magazine as very desirable for mathematics and map lettering (Anonymous 1907). In 1932 *Popular Science Monthly*, a U.S. periodical with national circulation, reported on a typewriterlike machine on wheels that could be rolled around atop a map for adding lettering (fig. 450). The introduction of the IBM Selectric in 1961 had a more significant and longer-lasting impact on the more or less informal sector of cartography. Powered by electricity, successively improved models with interchangeable typeballs remained standard U.S. office equipment into the 1980s and were readily accessible to small cartographic operations for adding lettering directly to small maps (such as maps that were often duplicated by mimeograph, ditto, or photocopying for use in university instruction) or for typing and applying lettering to larger


MACHINE PUTS LETTERING ON MAPS *

No LONGER need draftsmen place lettering upon maps and engineering drawings by hand. The laborious task of neatly inscribing names, descriptions, and dimensions with pen and ink is ended by the use of a new machine resembling a typewriter. This device rolls on rubber-tired wheels to the desired point on the drawing board, where the wheels are locked. Then its keys, operated like those of a typewriter, rap down upon the surface of the drawing to insert the required lettering. Long lists of specifications and materials are thus completed in a few minutes, and the draftsman's time is saved for work requiring drawing skill.

Machine, working like a typewriter, puts lettering on maps

FIG. 450. "MACHINE PUTS LETTERING ON MAPS." A machine resembling a typewriter rolls on rubber wheels to the desired point on the drafting board, where the wheels are locked, and the keys rap down on the surface of the drawing to add the required lettering.
Size of the original: 7 × 10.5 cm. From *Popular Science Monthly* 121, no. 3 (1932): 46.

maps as stick-up (also called stick-on) labels, such as by typing on sheets of self-adhesive paper labels (Dillon 1985, 33). In the 1980s more sophisticated, but still precomputer, stand-alone strike-on typing equipment was being employed in-house in mapping organizations, such as the Alaska Division of Geological & Geophysical Surveys, to type lettering orders for maps, as well as formatting text for geological reports. Similar applications of the typewriter were widespread, but still other typographic lettering options had emerged during the early twentieth century and found general use in mapmaking.

As letterpress typesetting transitioned from hand-set metal type to mechanical composition of metal type by Linotype (invented in the mid-1880s) and similar machines, and then to phototypesetting equipment in the 1940s and 1950s, such lettering was being used on maps. Some phototypesetters photographed images of the letters, while others employed negatives; some employed a range of master disks, each bearing a particular disk in a particular size, while others employed a single master for each font, enlarging or reducing the letters photographically as needed.

Various types of adhesives and carrier materials were employed. During the early 1940s one process, which saw limited use due to patent restrictions, employed lettering printed on thin Japanese paper. When in place, it was wetted with a brush of sticky liquid, which filtered through the paper and attached it firmly to the base; by 1948 wax-backed lettering printed on a sheet of cellophane had come into use (Raisz 1948, 140). A shop making its own stick-up lettering could roll a layer of wax onto the back of the paper or film with an electrically heated waxing device, such as the hand-held Electro-Stik waxer.

Lettering for specific maps could either be printed in-house, typically in a large mapping organization, or ordered from a commercial vendor, such as Monsen Typographers, Inc., of Chicago. In 1954 a book on cartographic techniques listed brands of phototypesetting machines manufactured in Hungary (Uhertype), England (Rotofoto, Monophoto), the United States (Intertype Photosetter, Photon, Coxhead-Liner), the Netherlands (Hadego), and Germany (Kart-Lichtsatzgerät) (Bosse 1954–55, 1:94–95). Thousands of names could be set in an hour and printed in negative or positive form for incorporation in film overlays or for stick-up. By 1962 the French Staphograph could photograph already composed names and position them on map-size film (fig. 451). Once exposed and developed, the large

FIG. 451. PHOTOTYPESETTING MACHINE (STAPHOGRAPH). The Staphograph printed all the desired names on seventy-millimeter film and with the help of an electrocoordinatograph positions them according to the position indicator template.
From Raisz 1962, 278 (fig. 27.9).


FIG. 452. A LINE OF FINISHED TYPE EMERGES FROM THE VARITYPER HEADLINER 820, A PHOTOCOMPOSER WITH CHANGEABLE TYPEMASTER DISKS. The type is produced after being photographed, developed, fixed, and washed within the machine.
From A. G. Hodgkiss, *Maps for Books and Theses* (New York: Pica Press, 1970), 84. Permission courtesy of Robert Hodgkiss.

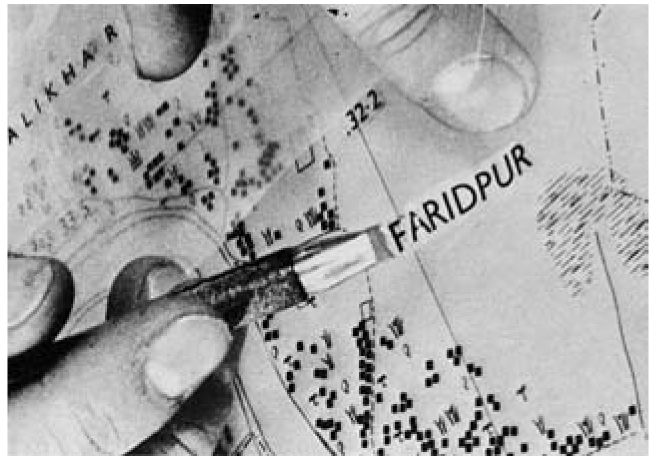



FIG. 453. POSITIONING PREPRINTED-ON-FILM LETTERING. Although this place-name was laid down straight as printed, it was also possible to curve this kind of preprinted lettering by partially cutting between the letters and fanning out the cut side.
From Lawrence 1971, 128 (fig. 12.9). Reproduced by permission of Taylor & Francis Books U.K.

film formed a positive lettering overlay (Raisz 1962, 279). Its greatest potential utility would seem to have been in a large cartographic operation producing large-format map series, such as topographic sheets. Writing in England in 1970, A. G. Hodgkiss (104) recommended the Monotype Photo-lettering machine and the Barr & Stroud Photonymograph as top-of-the-line.

By 1970 smaller, less expensive desktop photocomposing machines, such the Varityper Headliner 820 (fig. 452) and the Kroy lettering machine were also available. They soon became standard equipment in many smaller cartographic operations. Although costing about U.S. $600 in 1985, the Kroy was still too expensive for some academic users (Dillon 1985, 32). After being cut out and tentatively placed with the aid of a scalpel, such as an X-Acto knife, adhesive-backed stick-up lettering was burnished down once in final position (fig. 453).

Preprinted lettering was also available as sheets of multiple individual letters in different type fonts and sizes. Some brands of preprinted alphabets, such as Artype in the United States, were printed on adhesive-backed film. Although the letters could be repositioned before burnishing them down, aligning and adjusting the spacing between small letters was a touchy and slow task to be avoided if possible. Another type was the dry-transfer variety, such as that made by Letraset in England, consisting of letters affixed to the underside of a transparent carrier sheet, from which they could be burnished down, one-by-one, onto the drafting surface (fig. 454). The letters had to be positioned carefully because they could not be moved once burnished down.

Despite the inventive and varied applications of mechanization to map labeling during the twentieth century, the labeling process, by and large, retained a significant manual component requiring the skill and judgment of the cartographic draftsman, until the advent of computer mapping. Even the Staphograph's position indicator template used to guide the electrocoordinatograph must have involved some initial human decision making about name placement to avoid overlap. Full automation of the labeling process remained a challenge to be taken up by the next new cartographic technology, computer mapping, toward the end of the twentieth century.

KAREN SEVERUD COOK

SEE ALSO: Drafting of Maps: (1) Drawing Instruments, (2) Pen-and-Ink Drafting; Electronic Cartography: Electronic Map Labeling; Raisz, Erwin (Josephus); Reproduction of Maps: Reproduction, Design, and Aesthetics

BIBLIOGRAPHY:

Anonymous. 1903. "Bacon's New Drawing Publications." *School World* 5, no. 50:xiii.

———. 1907. "Have You Seen the New No. 12 Hammond?" *Cornell Era* 39, no. 2 (*Advertiser*):36.

Ashwin, Clive, comp. 1983. *History of Graphic Design and Communication: A Source Book*. London: Pembridge Press.

Bosse, Heinz. 1954–55. *Kartentechnik*. 3d ed. 2 vols. Lahr/Schwarzwald: "Astra" Josef Penyigey-Szabó.

Dickinson, G. C. 1976. *Maps and Air Photographs*. London: Edward Arnold.

Dillon, Brian D., ed. 1985. *The Student's Guide to Archaeological Illustrating*. 2d rev. ed. Los Angeles: Institute of Archaeology, University of California, Los Angeles.

Eckert, Max. 1921–25. *Die Kartenwissenschaft: Forschungen und Grundlagen zu einer Kartographie als Wissenschaft*. 2 vols. Berlin: Walter de Gruyter.

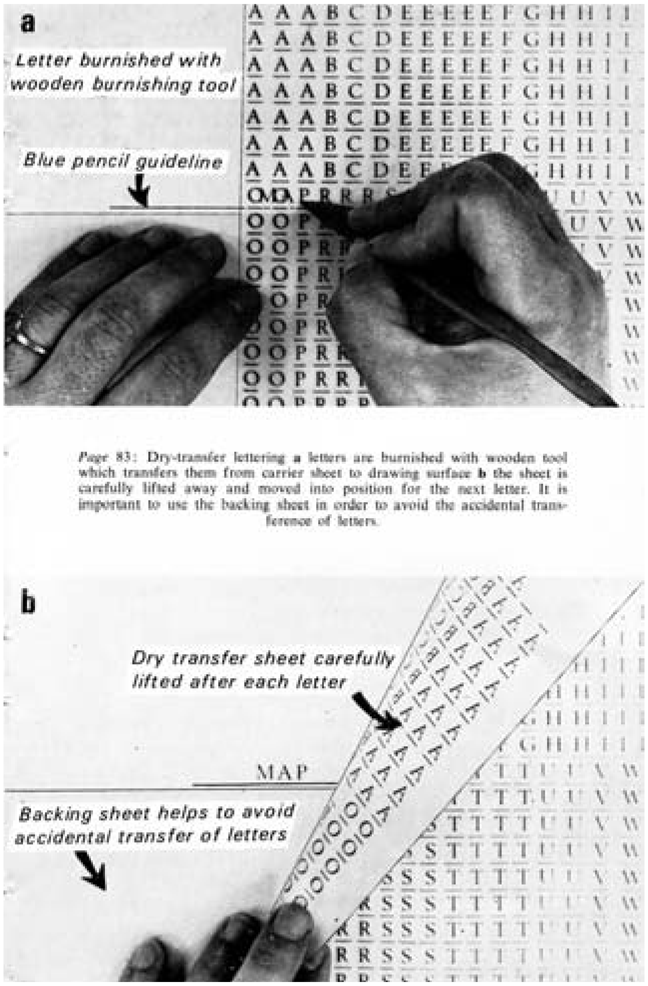



FIG. 454. THE PROCEDURES OF ALIGNING AND APPLYING DRY-TRANSFER LETTERING.
Size of the original: 20.4 × 13.4 cm. From Hodgkiss 1970, 83. Permission courtesy of Robert Hodgkiss.

Hodgkiss, A. G. 1970. *Maps for Books and Theses*. New York: Pica Press.

Jacoby, Henry Sylvester. 1909. *A Text-Book on Plain Lettering*. New York: Engineering News Publishing.

Keuffel & Esser Co. 1921. *Catalogue of Keuffel & Esser Co.: Manufacturers and Importers Drawing Materials, Surveying Instruments, Measuring Tapes*. 36th ed. New York: Keuffel & Esser.

Lawrence, George Richard Peter. 1971. *Cartographic Methods*. London: Methuen.

Linhoff, Mattias. 1891. *Rundschrift oder Eckenschrift?* Münster in Westfalen: Aschendorffschen Buchhandlung.

Lloyd, Malcolm. 1930. *A Practical Treatise on Mapping and Lettering Including the Construction of the Basic Alphabets and the Elements of Map Design*. Philadelphia: P. Blakiston's Son.

Raisz, Erwin. 1938. *General Cartography*. New York: McGraw-Hill Book Company. 2d ed. 1948.

———. 1962. *Principles of Cartography*. New York: McGraw-Hill Book Company.

*Typography and Map Design.* Map lettering has been a challenge for mapmakers throughout the history of cartography. Labels must work closely with the detailed geographic information on a map and accurately indicate referents without obscuring important features. Typography involves the use of standardized movable letters (type) to compose words and pages of words for printing. The initial use of typography for mapmaking closely followed its mid-fifteenth century invention in Germany. Some fifteenth-century woodcut maps had metal type set into mortised slots, and stereotypes of typeset words were glued onto sixteenth-century woodblocks, but neither cumbersome technique became widespread (Woodward 1987, 199–201).

Instead, maps printed from engraved copperplates with hand lettering incised with a burin predominated from the sixteenth century until the invention of lithography at the beginning of the nineteenth century. Drawing maps for printing from lithographic stones revived the manuscript tradition of hand lettering with pen and ink, but not for long. After the mid-nineteenth century, movable type was combined with new printing processes to increase the efficiency of map labeling, marginalizing hand lettering. By the early twentieth century, typographic lettering had become the dominant means of labeling maps.

Twentieth-century map typography experienced three major technological phases. Its first upsurge, in the form of stamped type, accompanied the rise of wax engraving in American commercial cartography. In the United States, Sidney E. Morse pioneered reliable methods using wax engraving to produce printing plates in the early 1840s. American mapmakers adopted the technique widely by about 1870 and continued to use it through the 1930s, with peak years from 1910 to 1920 (Woodward 1977).

Technicians pressed metal type into a wax layer on a metal substrate. Over time, lettering methods progressed from stamping individual letters to whole words set in holders. Stamping type eliminated the need for a trained lettering engraver, so the placement of type lettering often betrayed lack of training. Maps were crowded with many small place-names. Labels were often angled into tight positions and long place-names split to avoid other map features. Only a limited number of foundry typefaces were available, among them Century Schoolbook, News Gothic, Stymie, Clearface Gothic, and Cheltenham.

Some U.S. firms created well-designed wax-engraved maps, among them Matthews-Northrup Co. of Buffalo, New York, which published *The Century Atlas* (1897) (fig. 455) and Elroy McKendree Avery and William Abbatt's *A History of the United States and Its People* (7 vols., 1904–10). Despite such exceptions, mechanical-looking wax-engraved maps characterized American atlases, books, and ephemeral publications like railway timetables well into the twentieth century.

The combination of photocomposed type with photolithographic printing of maps ushered in a second tech-

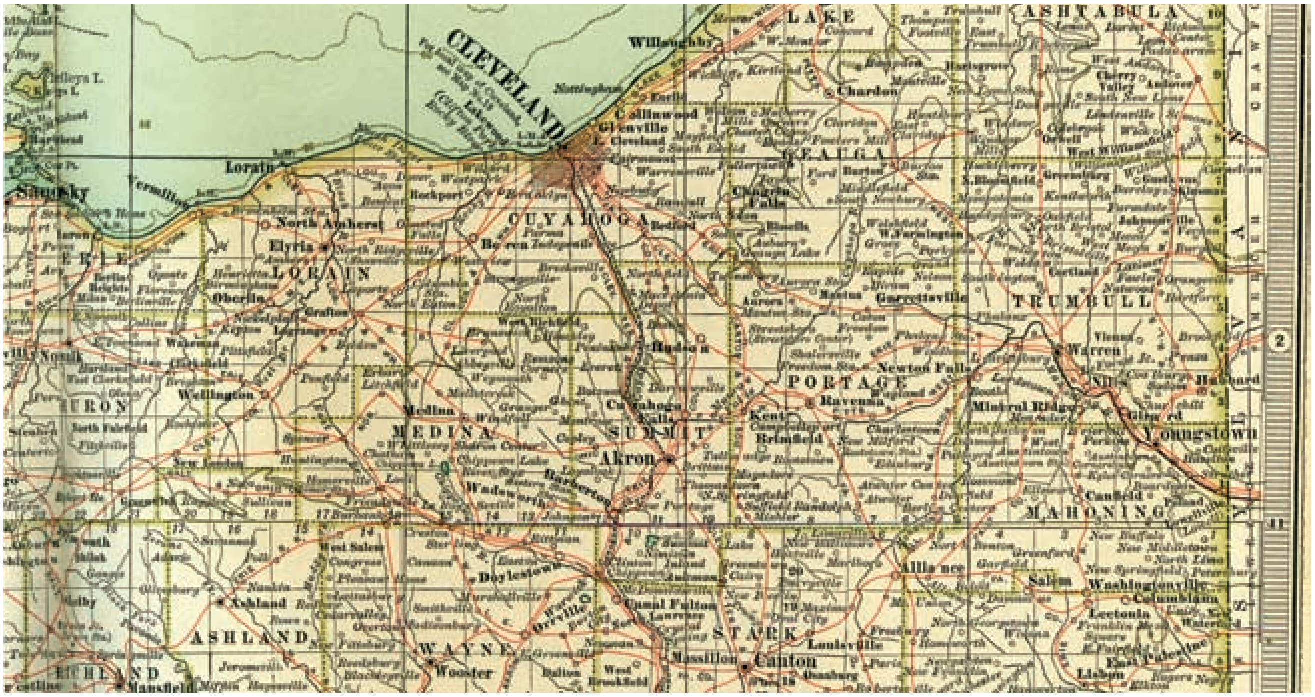



FIG. 455. DETAIL FROM *OHIO, NORTHERN PART*, 1897, 1:1,013,760. Northern Ohio from a wax-engraved map by Matthews-Northrup Co. on which the many nicely positioned place-names in various styles and size hierarchies provide detailed and well-ordered locational information.
Size of the entire original: ca. 26.5 × 37.5 cm; size of detail: 10.4 × 19.4 cm. From Benjamin E. Smith, *The Century Atlas of the World* (New York: Century, 1897), no. 17.

nological phase, lasting from the 1940s until the 1980s. Devices for photocomposition fell into three main categories: manual devices with individual letters placed by hand and then photographed, mechanical devices with letters projected sequentially onto film, and electronic devices with digitally stored letters exposed to photographic film.

After 1850 various inventions prepared the way for phototypography. They included nonphotographic transfer of type onto lithographic stones for map printing, photographic transfer of map images onto different printing surfaces, and type labels stamped on paper for affixing onto maps before photography (Woodward 1987, 204–5). Actual photocomposition of type had been patented as early as 1856 but first reached working model stage in 1915. Commercial adoption began in the 1930s, when map printers were abandoning wax engraving (in the United States) and copperplate engraving (in Europe) and adopting offset lithography (introduced about 1905) using zinc or aluminum plates for printing maps. In the United States, National Geographic Society cartographers built their own photocomposer and designed a typeface suitable for photographic reduction. Their first map with photocomposed type appeared as a supplement to the *National Geographic Magazine* in 1933 (Woodward 1987, 205–6). Innovations in other countries included the Hadego manual photocompositor in Holland in 1948 and the Nomaplot/Bibette used in France for Michelin maps in the 1950s (Woodward 1987, 205). Photocomposed type soon spread from large mapmaking operations to small ones. By the 1970s devices like the Varityper Headliner, which produced strips of photocomposed lettering, were affordable and common in the United States, although large type orders were often placed with suppliers like Monsen Typographers, Inc. A cartographic workshop with a copy camera could also make its own stick-up lettering by photographing text typewritten on an IBM Selectric typewriter and printing it onto photographic paper (later applying hot wax to the reverse to make it adhesive) or onto adhesive-backed film using the PMT (photomechanical transfer) process.

All aspects of map lettering changed with photocomposition of type, not only how typographic designers created letterforms, how typographers and cartographers prepared labels, and how cartographers placed labels, but also the visual character of typefaces. For example, a designer of metal type cut letterforms for each font size separately, ten-point type having different visual characteristics from thirty-six-point type, while photographic type was usually designed with a single master font (Chappell and Bringhurst 1999, 267).

The photographic revolution in typography, along with the widespread shift to offset lithography, led to an explosion of new typefaces. The number and variety of typefaces available increased from the limited set of hot-metal typefaces to over 50,000 commercial typefaces (Chappell and Bringhurst 1999, 285). Writing about map design, Arthur H. Robinson (1952) noted that the problem for the cartographer had become choosing effective typefaces for mapping. He recommended that cartographers should look to graphic designers' use of type because there was little literature on typographic use in cartography.

Twentieth-century European and American cartographers and geographers began to explore new designs of letterforms. At a Royal Geographic Society presentation on the style of lettering for the new Ordnance Survey (OS) maps of Great Britain, J. G. Withycombe (1929) and others examined the conflicting demands of legibility and beauty in lettering. Withycombe argued for reexamination of lettering styles, both manuscript as then practiced and looking toward adoption of typography. He noted that the renaissance in typography and printing afforded an opportunity to improve declining standards in map lettering. Disliking changes made by copperplate engravers to roman and italic lettering, he presented a new set of letters following classic forms. Withycombe emphasized legibility, suitability for photographic reproduction, good style, distinction, and harmony of overall effect. He railed against modern serif faces, such as Bodoni, and sans serif faces. Several discussants focused on the importance of legibility. One of them, C. B. Fawcett (1940), revisited that topic a decade later and declared flourishes on letters to be anathema. He suggested an alphabet of letterforms containing unusual letterforms that one discussant, E. G. R. Taylor, found to be "hideous" (26). Commenting on the sans serif nature of Fawcett's alphabet, A. J. Wilmott noted that serifs were generally better for larger type sizes on maps, while sans serif worked well for small sizes (28). Acceptance of the modern sans serif typeface presaged a general shift to sans serif typefaces for maps.

Cartographers at the National Geographic Society had also created a new set of typefaces in the 1930s, perhaps the first specifically for maps. The typefaces (fig. 456), balancing legibility with visual appeal, were designed for photographic typesetting and offset lithographic printing.

In the 1960s and 1970s, national mapping agencies also reevaluated their choices of typefaces. The U.S. Geological Survey cartographers designed a set of experimental maps with new typefaces to improve simplicity, clarity, and economy of style (Gilman 1983). The primary U.S. Geological Survey typefaces had been Helvetica and Times, and the switch to Univers and Souve-


FIG. 456. LETTERING STYLES, 1947. Six styles of lettering (top to bottom: roman, block, script, antique, decorative script, and shaded) designed by Charles E. Riddiford, staff cartographer, for photocomposition and photographic reduction for use on National Geographic Society maps.
Size of the original: 19.8 × 8 cm. From Wellman Chamberlin, *The Round Earth on Flat Paper: Map Projections Used by Cartographers* (Washington, D.C.: National Geographic Society, 1947), 15. Permission courtesy of the National Geographic Society, Washington, D.C.

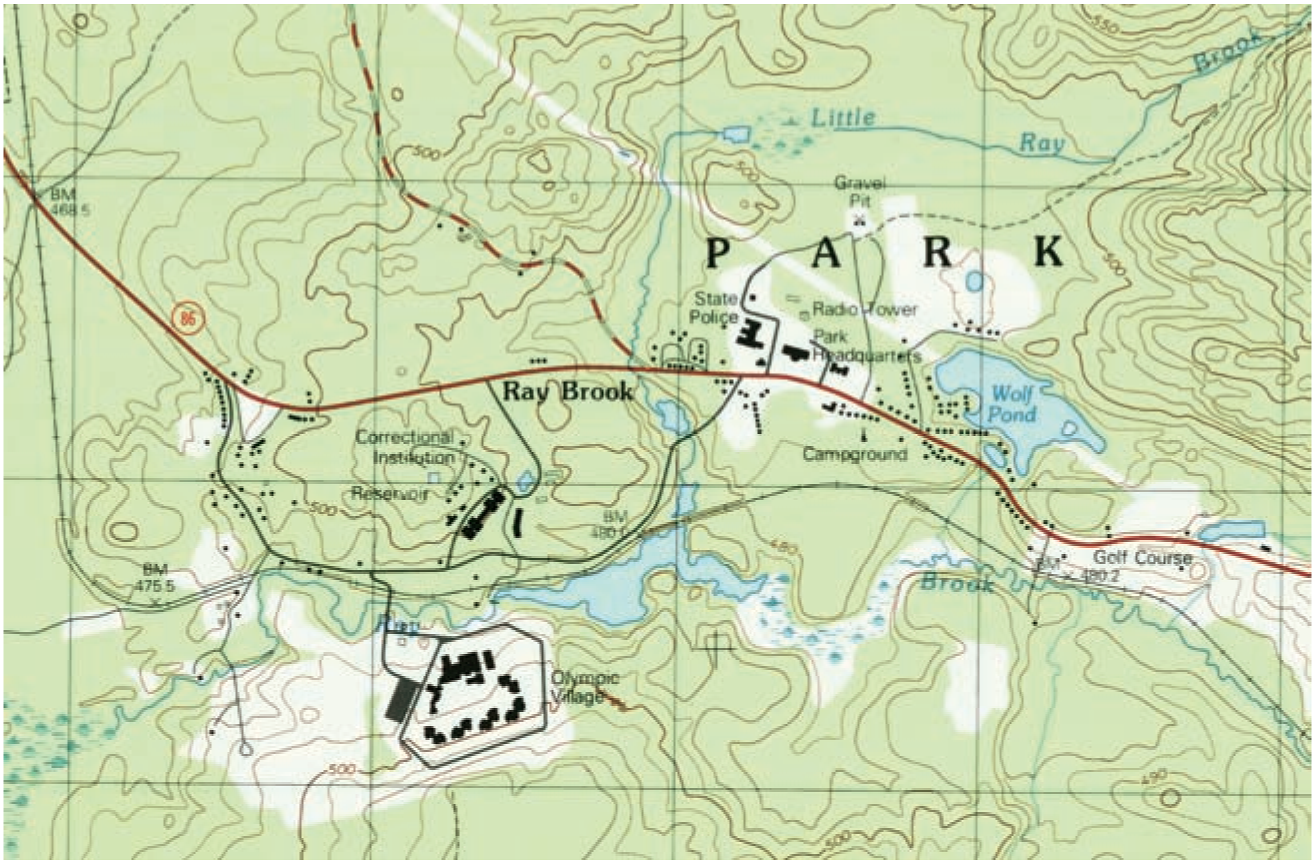



FIG. 457. DETAIL FROM *SARANAC LAKE, NEW YORK*, 1:25,000, 1979. Detail of topographic quadrangle with photocomposed place-names in two typefaces of which the sans serif Univers has held up stylistically better than Souvenir, whose rubbery serifs, evocative of the early twentieth-century art nouveau period when it was designed, were already dated when the U.S. Geological Survey adopted the typeface in the 1970s.
Size of the entire original: 61.1 × 95.7 cm; size of detail: 11.3 × 17.3 cm.

nir gave the maps a different visual character (fig. 457). Critics accepted Univers as a clean and efficient sans serif face but were concerned about Souvenir (Woodward 1987, 208). Designed for advertising signage in the 1920s, Souvenir gave the maps a period look. Usability and legibility suffered, too. The bowed legs of some letterforms (such as capitals A, U, W, and Y) exhibited softness, and the four weights were insufficiently differentiated for effective map use.

The Ordnance Survey also introduced a new series of maps, which drew the attention of English cartographers. Oliver M. Dixon (1975, 8) noted the complete adoption of Univers (which subsequently became a modern sans serif typeface of choice for cartographers) for all map lettering except sites of antiquity. He objected that lack of variation in the letterforms hindered readability, and that a more varied typographic palette would have improved the design.

The phase of photographic type ended with the advent of computer composition of letters into labels for maps, although output was still to film for mechanical stick up. Soon computers also were used for type design, name composition, and label placement.

The digital revolution changed the look of typography and of maps again. The addition of a second and radically different major form of map display, the computer screen, had an important effect. The development of digital typefaces began in the 1980s with the creation of replicas of photographic type families. The 1990s ushered in an era of more original digital faces (Chappell and Bringhurst 1999).

The computer made cartographers into their own typesetters and, in some cases, type designers. Those changes had important effects on map lettering. Traditional typographic style slipped due to the use of improper glyphs (such as inch marks instead of quotation marks) and computer-generated type varieties instead of individually designed letterforms (such as small caps and bold and italic versions of typefaces). However, the digital shift brought more effective map lettering through typographic manipulation software. Cartographers altered the look of commercial typefaces and added characters, symbols, and diacritical marks.

The democratization of the type design process spurred production of new typefaces, often by small type foundries or individuals. Participating in that typographic design surge, Felix Arnold (2000), in conjunction with the Bundesamt für Landestopografie, created a new font specifically for cartography, perhaps the first since the National Geographic Society in the 1930s. Cisalpin, originally called Cassini, was a clean sans serif font designed to work within the confines of a map. It represented the culmination of the cartographic shift from serif to sans serif typefaces (fig. 458).

Digital technology affected typography and map design by adding the computer screen as a reproduction medium. To account for the vagaries of computer screens, especially resolution, cartographers pushed type sizes larger, embraced anti-aliasing (smoothed edges), and adjusted label density (Brewer 2005; Jenny, Jenny, and Räber 2008). In addition, sans serif typefaces emerged as a dominant choice. Their clean design and lack of adornments rendered well on screen. The six typefaces recommended in an essay on Internet map design were all sans serif: Verdana, Lucida Grande, Frutiger, Stone Sans, Cisalpin, and Myriad (Jenny, Jenny, and Räber 2008, 42–43).

A succession of three technical revolutions in twentieth-century typography and map reproduction led to changes in map lettering and design: metal type combined with wax engraving, photographic type combined with offset lithography, and digital type combined with reproduction to computer screen. The fact that Robinson devoted three (of ten) chapters in his seminal *The Look of Maps* (1952) to lettering bears witness to its importance in map design. Each new technology stimulated cartographers to adapt map lettering to the new methods of typography and reproduction, changes


FIG. 458. DETAIL FROM *KANTON SCHAFFHAUSEN*, 1:75,000, 2005. The sans serif typeface used in this map was developed in the late 1990s specifically for cartography by the Swiss type designer Felix Arnold who first called it Cassini but later renamed it Cisalpin. Several test maps were made, but only two maps were published with Cisalpin font.

Size of the entire original: 51 × 61 cm; size of detail: 11.4 × 17.3 cm. Image courtesy of the Zentralbibliothek, Zurich. Permission courtesy of the Education Department, Schaffhausen Canton, Schaffhausen.

that also gave maps a distinctive typographic look. In the twentieth century, first with the revolution of photographic type but even more with the revolution of digital type, cartographers gained freedom to choose from among thousands of typefaces and exert more control over the design of typographic lettering on maps.

ALEX TAIT

SEE ALSO: Art and Cartography; Imhof, Eduard; Reproduction of Maps: Reproduction, Design, and Aesthetics

BIBLIOGRAPHY:

Arnold, Felix. 2000. "Cassini: Ein Schriftprogramm für die Kartographie = A Typeface Program for Cartography." *Typografische Monatsblätter* 68, no. 2:17–32.

Brewer, Cynthia A. 2005. *Designing Better Maps: A Guide for GIS Users*. Redlands: ESRI Press.

Chappell, Warren, and Robert Bringhurst. 1999. *A Short History of the Printed Word*. 2d ed., rev. Point Roberts, Wash.: Hartley & Marks.

Dixon, Oliver M. 1975. "The Ordnance Survey 1:50,000 Series." *Bulletin of the Society of University Cartographers* 9, no. 1:4–9.

Fawcett, C. B. 1940. "Formal Writing on Maps." *Geographical Journal* 95:19–29.

Gilman, Clarence R. 1983. "Map Design at USGS: A Memoir." *American Cartographer* 10:31–49.

Jenny, Bernhard, Helen Jenny, and Stefan Räber. 2008. "Map Design for the Internet." In *International Perspectives on Maps and the Internet*, ed. Michael P. Peterson, 31–48. Berlin: Springer.

Robinson, Arthur H. 1952. *The Look of Maps: An Examination of Cartographic Design*. Madison: University of Wisconsin Press.

Withycombe, J. G. 1929. "Lettering on Maps." *Geographical Journal* 73:429–46.

Woodward, David. 1977. *The All-American Map: Wax Engraving and Its Influence on Cartography*. Chicago: University of Chicago Press.

———. 1987. "The Manuscript, Engraved, and Typographic Traditions of Map Lettering." In *Art and Cartography: Six Historical Essays*, ed. David Woodward, 174–212. Chicago: University of Chicago Press.

***Land Surveying.*** See Property Mapping; Property Mapping Practices

***Land Systems Analysis.*** Land systems analysis is a regionalization of land into distinct assemblages of land units to enable rapid reconnaissance surveys in poorly mapped areas primarily for the assessment of their natural resources. It is based on physiography, that is, the in-depth study of the earth's surface, geology, climate, soils, water, vegetation, and their interaction. Intended to characterize the earth's surface very broadly, the land systems approach is also referred to as the "landscape approach" (Mitchell 1973), in recognition of its origin, early in the twentieth century, in the regional concept.

Land systems analysis was refined after World War II in Australia by the Commonwealth Scientific and Industrial Research Organization (CSIRO), which adopted a holistic approach to the exploration of remote areas of Australia (Christian and Stewart 1953). Similar projects in southern and eastern Africa as well as in the United Kingdom triggered an international collaboration that standardized nomenclature in the mid-1960s (Brink et al. 1966). The Canada Land Inventory, established in 1962, applied similar methods, and they were also widely applied in the Soviet Union in the 1960s and 1970s.

Land systems surveys have varied their selection of physiographic attributes to reflect project objectives as well as the area studied. Erosion control and agricultural irrigation are inherently different, for example, and traits important to the analysis of a semiarid plain are generally less relevant to a mountain environment in the humid tropics. The choice of variables also depends on assumed relationships among landscape elements. Some studies have favored geomorphological traits, while others have focused on landscape ecology and the interactions of animal or plant communities. Man-made features in the landscape have also been incorporated into terrain profiles and classifications.

Land systems analysis is based on the assumption that areas consist of homogeneous elements or sites. The smallest, most homogeneous mapping unit is the *facet*, which consists of one or more uniform elements or sites, sufficiently homogeneous to serve the objectives of the study (Mitchell 1973, 29–30). In many studies, facets are not mapped separately; instead distinctive assemblages of facets are mapped, termed *land systems* by the CSIRO Division of Land Research and Regional Survey (fig. 459), and also known as natural regions or terrain systems. In general, a land system is an area with a persistent pattern of geology, hydrology, topography, soils, and vegetation (Christian and Stewart 1968, 242).

Mapping assemblages of land units rather than lower-order, more finely categorized features has been found to yield useful results as well as save time and expense. But when a map is focused on land systems or more complex areal units, the user who needs to locate homogeneous areas within the land systems typically must find them by using supplementary maps or remote sensing sources. Because the degree of generalization can be varied to reflect the size of the area, the scale of the map, or the purpose of the survey, agencies using the land systems approach have often constructed elaborate hierarchies of regions.

Block diagrams describing both vertical and horizontal relationships are valuable supplements to land systems maps and physiographic descriptions. These three-dimensional graphics have been particularly useful in showing the location of facets within land systems and thereby pointing out unmapped units. Even so, inexperienced users often have difficulty using land systems maps, block diagrams, and tables to locate facets in the field.

Although planners and researchers agree that a hierarchical structure of land units is useful, there is no

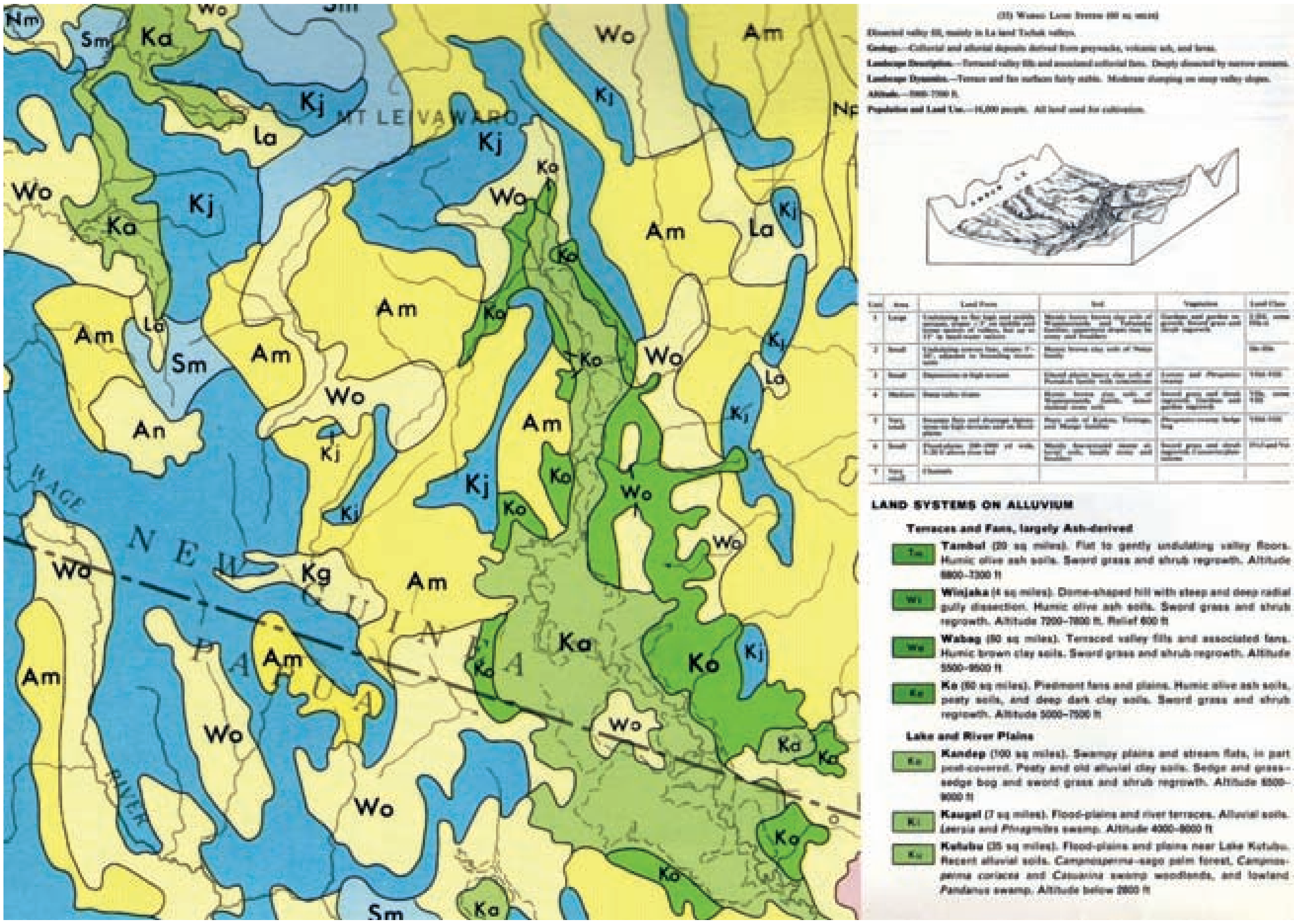



FIG. 459. MONTAGE OF DETAILS OF A LAND SYSTEMS MAP, 1965. Map (left) and portion of legend (lower right) are from *Land Systems of the Wabag-Tari Area: Territory of Papua and New Guinea*; the block diagram and description of the land system (upper right) are from the accompanying *General Report on Lands of the Wabag-Tari Area, Territory of Papua and New Guinea, 1960–61*, Land Research Series No. 15 (Melbourne: Commonwealth Scientific and Industrial Research Organization, Australia, 1965), 51.
Image courtesy of Alastair W. Pearson.

consensus on the level within the hierarchy at which an investigation might most efficiently commence. Some investigators have preferred the land system or province as their starting point (e.g., Christian and Stewart 1968), while others stressed the need to focus first on lower-level features (e.g., Wright 1972).

Until the 1970s almost all land systems mapping relied heavily on the photointerpretation of stereoscopically viewed aerial photographs accompanied by fieldwork. In the latter part of the twentieth century other forms of remote sensing, such as satellite imagery and radar, have also been used. The analyst typically uses available information to interpret relationships among the various components of the terrain and at a final stage provides inferences about the suitability of the terrain units for particular uses. Efficiency depends, of course, on the type of terrain insofar as some types of region are more easily identified than others. In general, regionalization is relatively straightforward, where vegetation cover is low and where human transformation of the vegetation cover is limited.

Delineation of land systems inevitably involves substantial subjectivity. To overcome this issue, considerable effort has been put into the objective definition of terrain units, a process often requiring systematically arranged data. The U.S. Army Corps of Engineers (USACE) Waterways Experiment Station in Vicksburg, Mississippi, which was concerned with trafficability and other military applications, pioneered the application of grid squares for terrain description. The USACE strategy began by recording multiple distinctive characteristics for each cell, which produced a grid with multiple layers. Class boundaries were established for each layer, and the resulting "factor maps" superimposed to produce a "factor complex" map showing regions typified by values for each factor. The layers could then be integrated mathematically to provide a combined estimate of terrain suitability or performance (Townsend 1981, 123).

In the final decades of the twentieth century, geographic information systems (GIS) were often used to improve the objectivity of the resultant regions. Although physiographic regionalization had become a far less important tool in collecting and analyzing terrain data and in estimating the likely potential or consequences of terrain, the ability of an operational GIS to retrieve data for any particular geographical location did not diminish the importance of regionalization. After all, a significant proportion of the data planes in a GIS, such as soils or geology, are themselves composed of regions, derived in part by physiographic principles. Moreover, terrain unit data can form a unique and valuable data plane within a GIS.

Similar approaches to land evaluation rely on a land systems approach, even though the term may not be explicitly used. These include the use of agro-ecological zones to assess crop production potential (e.g., Sivakumar and Valentin 1997) and the global SOTER (soils and terrain) digital database (FAO 1993). Diverse applications of a land systems approach include estimation of biodiversity, effectiveness of protected areas, land hazard mapping, poverty alleviation, and resource management and archeological prediction for hominid land use.

JOHN R. G. TOWNSHEND

SEE ALSO: Planning, Urban and Regional; Property Mapping; Property Mapping Practices

BIBLIOGRAPHY:

Brink, A. B., et al. 1966. *Report of the Working Group on Land Classification and Data Storage*. Christchurch, England[: Military Engineering Experimental Establishment].

Christian, C. S., and G. A. Stewart. 1953. *General Report on Survey of Katherine-Darwin Region, 1946*. Melbourne: Commonwealth Scientific and Industrial Research Organization.

———. 1968. "Methodology of Integrated Surveys." In *Aerial Surveys and Integrated Studies: Proceedings of the Toulouse Conference*, 233–80. Paris: UNESCO.

Davis, Charles M. 1969. *A Study of the Land Type*. Ann Arbor: University of Michigan, Department of Geography.

Food and Agriculture Organization of the United Nations (FAO). 1993. *Global and National Soils and Terrain Digital Databases (SOTER): Procedures Manual*. Rome: Food and Agricultural Organization of the United Nations. Rev. ed. 1995.

Mitchell, Colin W. 1973. *Terrain Evaluation: An Introductory Handbook to the History, Principles, and Methods of Practical Terrain Assessment*. London: Longman.

Sivakumar, M. V. K., and Christian Valentin. 1997. "Agroecological Zones and the Assessment of Crop Production Potential." *Philosophical Transactions: Biological Sciences* 352:907–16.

Townshend, John R. G. 1981. "Regionalization of Terrain and Remotely Sensed Data." In *Terrain Analysis and Remote Sensing*, ed. John R. G. Townshend, 109–32. London: George Allen & Unwin.

Wright, R. L. 1972. "Principles in a Geomorphological Approach to Land Classification." *Zeitschrift für Geomorphologie* 16:351–73.

***Land Use Map.*** The common land use map is a twentieth-century artifact. Its roots, however, date back to the earliest cadastral surveys and land ownership plats, second–third millennia B.C. More pertinent antecedents were special-purpose maps developed through the eighteenth and nineteenth centuries in England, France, Germany, and Holland; they portrayed variation in geographical qualities such as topography, ethnicity, forest cover, soils, fire outbreaks, insurance values, disease, and rail networks (Wallis 1981).

The land use map proper distinguished itself from these earlier representations through its form and function. *Formally* a land use map was designed to classify and delineate bounded units of land that people put to work—residential, commercial, agricultural, recreational, productive, nonproductive, urban, suburban, waste, and the like. *Functionally* the land use map developed as a tool to administer and coordinate land uses themselves.

Land cover maps and land utilization maps were two varietals also invented during the twentieth century; both were used almost interchangeably with land use map. Land cover maps tended to depict the physical features that visibly predominated in a given area, such as forest, crop, and vegetation types, while land utilization maps often took on more prescriptive, planning-oriented aims.

There was no single moment or individual solely responsible for pioneering the first land use map. Instead, the map evolved over time as a practical tool in the hands of several different groups of land users. Each group defined distinctive categories of land use in order to serve its own specific social goals, whether natural resource appraisal, population engineering, disciplinary development, ecological conservation, or government administration.

Great Britain probably has the strongest claim to be the birthplace of large-scale land use surveys. In the nineteenth century the Scottish biologist and planner Patrick Geddes had proposed the idea of the "regional survey" in order to promote harmonious economic developments (James 1972, 276), while the Ordnance Survey had earlier mapped land cover of the entire nation at 1:10,560. These efforts paved the way for the seminal Land Utilisation Survey, a national effort to gain "a snap-shot picture of Britain," with no "political colour" or "ulterior motives," undertaken by L. Dudley Stamp and a team of some 250,000 young fieldworkers (schoolchildren) between 1931 and 1933 (Fuller, Sheail, and Barr 1994, 173–75). Its classificatory categories ("waterside meadows," "lowland heaths & moors," "commons," "orchards," "gardens," and so on) reflected powerful social currents of the day. Stamp and his collaborators not only satisfied a desire to inventory rural resources comprehensively for efficient commerce and administration, they also resonated with a cultural ethos that linked one's experiences traversing the countryside to a healthy body politic and robust national character (Matless 1992). A second national survey, launched in

1960, took full advantage of aerial photography, while a third, the Land Cover Map of Britain (1988–91), deployed Landsat's Thematic Mapper (TM) (Fuller, Sheail, and Barr 1994).

During the interwar years American city planners developed their own administrative technology—the zoning plan—that has become arguably the quintessential style of modern land use map. The zoning plan combined aspects of the *Regional Survey of New York and Its Environs* (8 vols., 1927–31), which sparked the production of similarly sweeping maps for purposes of multiphase metropolitan management, intensive studies of neighborhood composition by sociologists at the University of Chicago, and Ebenezer Howard's ambitious turn-of-the-century plans for "garden cities" in Britain. Planners' maps tended to codify a rational, synoptic view of controllable urban spaces because such a perspective dovetailed nicely with their professionalizing aims. Key texts in this line included Harland Bartholomew's *Urban Land Uses* (1932), Thomas Adams's *Design of Residential Areas* (1934), Ladislas Segoe's *Local Planning Administration* (1941), and Robert B. Mitchell and Chester Rapkin's *Urban Traffic: A Function of Land Use* (1954) (Birch 2001, 409–10). In the 1960s and 1970s, the authority and role of planners began to shift in response to larger socioeconomic currents. Widespread suburbanization, urban deterioration, the rise of environmental activism, and civic unrest caused planners to reevaluate their apolitical, positivist approach to mapping (in which slums, for instance, had been considered "obsolete land uses"). By the 1980s and 1990s, many planners held that land use maps were as important for the inclusive, participatory, community-sustaining *processes* involved in their production as for what they actually portrayed on sheets (Birch 2001).

Perhaps the century's most influential species of land use maps came from American geographers. Carl Ortwin Sauer introduced the German ideal of integrated *Landschaft* field surveying methods to a generation of American geographers eager to repudiate their young discipline's taint of environmental determinism. Large-scale land use maps of small towns, counties, and regions offered a pathway to legitimacy. Through rigorous fieldwork practices like areal differentiation, geographers sought empirically to correlate on maps the physical fundament (soil, slope, surface patterns, vegetation) with types of economic use (agricultural, residential, recreational, industrial) (James 1972, 229–32). The capstone of this mode was V. C. Finch's extraordinary map of Montfort, Wisconsin (1:15,000; 1928–33). It employed a "fractional code method," in which each classified unit was assigned a fractional symbol (fig. 460). The Montfort map dealt with some 20,000 geographical facts (Finch 1933, 8), took five years to compile, and was deemed by Finch an interesting failure for its labor intensiveness (Checkovich 2004). Only aerial photographs or Hollerith punch card data processing machines, it seemed, would make similarly detailed land use maps practicable.

The adoption of aerial photographs in the Great Depression and electronic computers following World War II revolutionized the capacity of cartographers to tailor their "pictures" of land uses to timely practical ends. Suddenly Montfort-like documents, rich with data on land cover, quality, use, and possibilities, could be produced across large areas and with substantially reduced labor in the field. In the hands of conservationists, regional planners, natural resource scientists, and government officials all over the world, land use maps exploded in number and kind (James 1972, 490–502). The American New Deal especially spurred the creation of new types of land use maps, as newly formed "action agencies" strove cartographically to master lands such as the Dust Bowl, the Great Lakes Cutover, and the eroded cotton South that ordinary citizens had used "inefficiently." The Michigan Land Economic Survey and the Tennessee Valley Authority (TVA), for instance, were two programs whose daily functions and remedial scope depended utterly on land utilization data embodied in maps (Checkovich 2004).

Land use maps have continued to evolve beyond their interwar heyday. Advocates for economic development exported the TVA model of comprehensive basin-wide land use planning to nations in Latin America, Asia, and Africa. That model had mixed success in soil conservation and dam building programs, even as the programs themselves ensured the land use map's global preeminence as the technological means through which states conceptualize human-environmental interactions. Such cases demonstrate that land use maps have become technologies whose use affects different people in profoundly material ways (Robbins and Maddock 2000). Geographical information systems, meanwhile, enabled cartographers to take knowledge formerly locked into paper documents, and manipulate those data in ways that suited cartographer's peculiar purposes as participants in ecologies both natural and, at the same time, institutional. Remote sensing technologies, finally, permitted a (by no means uniform) community of scientists and planners to track precise land use changes over time for quite specific areas, underscoring everyone's role, however small, in modifying entire nations' "original vegetation cover" and in shaping and responding to forces such as soil erosion, sprawl, and climate change (UNEP/FAO 1994).

The common strand uniting all these developments, from Geddes to the geographic information system, has been the land use map's role as a culturally situated facilitator of humans' understanding and shaping of the natural world. Over the twentieth century, car-

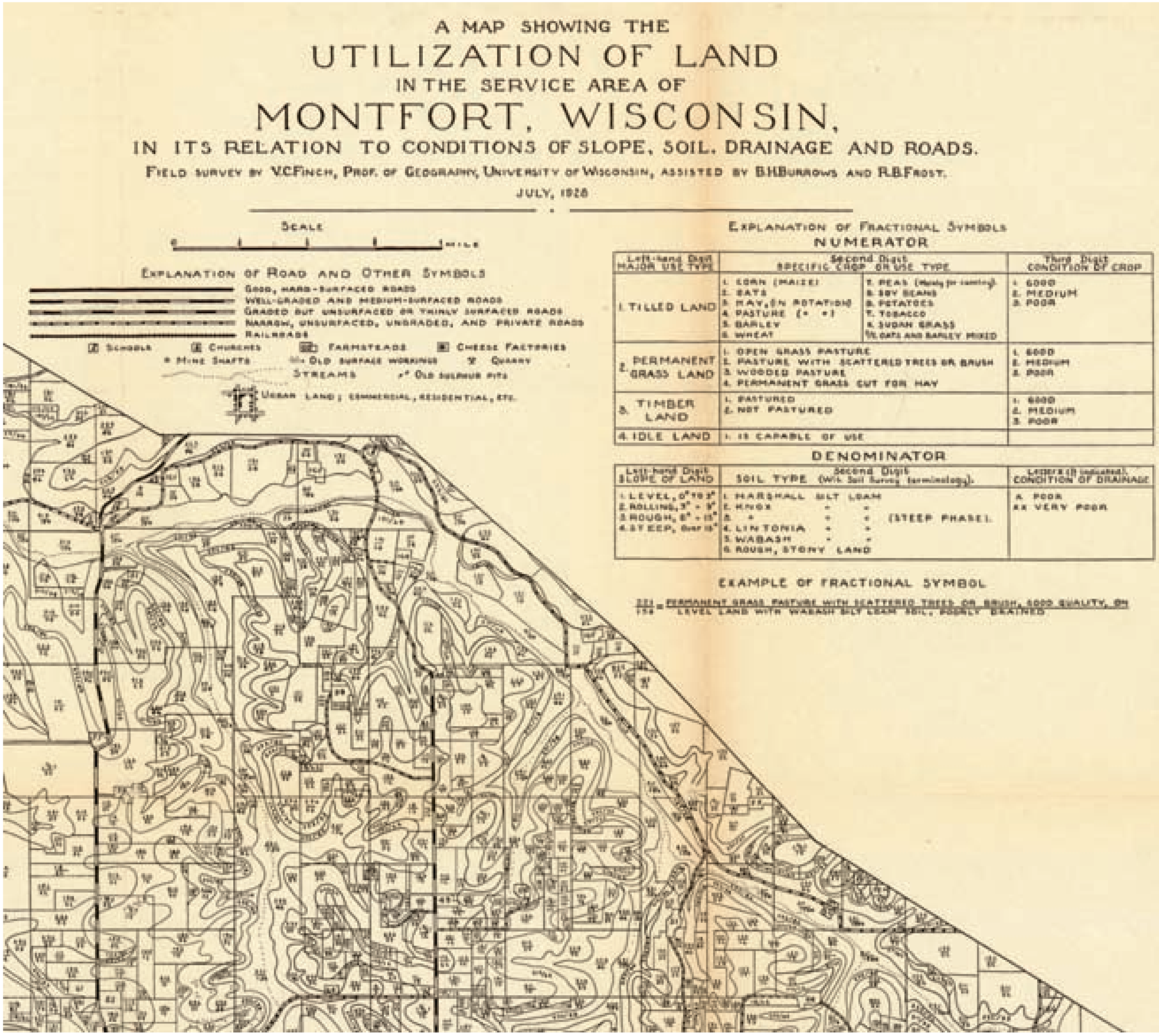



FIG. 460. DETAIL FROM *A MAP SHOWING THE UTILIZATION OF LAND IN THE SERVICE AREA OF MONTFORT, WISCONSIN, IN ITS RELATION TO CONDITIONS OF SLOPE, SOIL, DRAINAGE AND ROADS*, 1928. The Montfort map embodies both the conceptual achievements and the practicable limits of the intensive, ground-based land use mapping tradition. Only with innovations in aerial survey and data processing would land use maps of similar empirical richness be made at regional scales. In the fractional code method, "221 / 15x" denoted "permanent grass pasture with scattered trees or brush, good quality, on level land with Wabash silt loam soil, poorly drained."
Size of the entire original: 55.4 × 56.4 cm; size of detail: 26.3 × 29.6 cm. From Finch 1933, pl. 1. Image courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries. Permission courtesy of the Geographic Society of Chicago.

tographers constantly refined the goals, methods, and physical forms of their land use maps in ways that both reflected and shaped the highly particular social and environmental contexts of their times.

ALEX CHECKOVICH

SEE ALSO: Administrative Cartography; Cadastral Map; Photogrammetric Mapping: Air Photos and Geographic Analysis; Planning, Urban and Regional; Urban Mapping

BIBLIOGRAPHY:

Birch, Eugenie Ladner. 2001. "Practitioners and the Art of Planning." *Journal of Planning Education and Research* 20:407–22.

Checkovich, Alex. 2004. "Mapping the American Way: Geographical Knowledge and the Development of the United States, 1890–1950." PhD diss., University of Pennsylvania.

Finch, V. C. 1933. "Geographic Surveying," and "Montfort: A Study in Landscape Types in Southwestern Wisconsin." In *Geographic Surveys*, ed. Charles C. Colby, 3–11 and 15–44. Chicago: For the Geographic Society of Chicago by the University of Chicago Press.

Also published in the *Bulletin of the Geographic Society of Chicago* 9.
Fuller, R. M., J. Sheail, and Colin Barr. 1994. "The Land of Britain, 1930–1990: A Comparative Study of Field Mapping and Remote Sensing Techniques." *Geographical Journal* 160:173–84.
James, Preston Everett. 1972. *All Possible Worlds: A History of Geographical Ideas*. Indianapolis: Odyssey.
Matless, David. 1992. "Regional Surveys and Local Knowledges: The Geographical Imagination in Britain, 1918–39." *Transactions of the Institute of British Geographers*, n.s. 17:464–80.
Robbins, Paul, and Tara Maddock. 2000. "Interrogating Land Cover Categories: Metaphor and Method in Remote Sensing." *Cartography and Geographic Information Science* 27:295–309.
United Nations Environment Program/Food and Agriculture Organization of the United Nations (UNEP/FAO). 1994. *Report of the UNEP/FAO Expert Meeting on Harmonizing Land Cover and Land Use Classifications: Geneva, 23–25 November 1993*. Nairobi: United Nations Environment Programme; Food and Agriculture Organization of the United Nations.
Wallis, Helen. 1981. "The History of Land Use Mapping." *Cartographic Journal* 18:45–48.

***Landsat.*** Prior to the twentieth century, ground surveys provided the bulk of data for mapmaking. In the first decades of the twentieth century, controlled flight and camera systems suitable for use on airborne platforms revealed the promising capabilities of overhead surveys. Advanced film emulsions and filters, electronic sensors, and more robust airborne platforms extended these capabilities and provided a theoretical foundation for observations of the earth from space.

Landsat was the first nonmilitary satellite program to acquire, archive, and distribute earth observations from space for the global community. The history of the Landsat program illustrates both the benefits and the limitations of earth observations for cartography, especially thematic cartography. That history also illustrates the political, economic, and bureaucratic constraints on satellite remote sensing.

The Landsat program emerged partly from government programs in the United States that used aerial photography to collect data for mapping and public administration. The systematic acquisition of large-format (e.g., 9 × 9 inch), low-to-medium altitude, panchromatic aerial photography began in the 1930s. Typically collected for use as stereo pairs, these photographs were used primarily for topographic mapping, but were also employed by the Tennessee Valley Authority; the U.S. Department of Agriculture (USDA), including the U.S. Forest Service (USFS) and the Soil Conservation Service (SCS); and the U.S. Department of the Interior, including the U.S. Geological Survey (USGS), among others, for thematic maps based on the interpretation or photogrammetric measurement of land cover. In the two decades following World War II, the introduction of infrared film—black-and-white infrared as well as color infrared—broadened the use of aerial photography for research and thematic mapping significantly. Of particular utility was the sensitivity of the spectrum's near-infrared wavelengths (0.7 to 0.9 microns) to the vigor of vegetation and the boundary between land and water.

Observations obtained from the first weather satellites in the late 1950s and 1960s and photographs taken by Apollo astronauts in the mid- to late 1960s demonstrated the potential benefit of extending observations from airborne platforms to earth orbiting satellites. The USGS, under the leadership of William T. Pecora, developed specifications for the first Landsat mission in the late 1960s. The National Aeronautics and Space Administration (NASA), established in 1958 and responsible for the civilian space program, built and launched Landsat 1, initially called the Earth Resources Technology Satellite, or ERTS, in 1972. Landsat 1 was the first nonmilitary satellite to acquire imagery of the earth and make the images available to the public. By century's end, NASA had launched six successful Landsat satellites (Landsat 6 failed to obtain orbit) with Landsat 7 placed in orbit on 15 April 1999.

Table 32 lists the primary characteristics of the first seven Landsat satellites. Landsat 1 carried two instruments: the Return Beam Vidicon (RBV) and the Multispectral Scanner System (MSS). The RBV was the primary instrument and acquired video snapshots, similar to images on television. The MSS was an experimental four-channel imaging spectrometer that acquired digital images with a ground resolution (pixel size) of approximately 80 meters for a continuous swath 185 kilometers wide. Landsats 2 and 3 carried the same instruments, but Landsat 4's instrument package replaced the RBV with the Thematic Mapper (TM), an imaging spectrometer with broader spectral coverage and finer ground resolution than the MSS. In addition the TM colleced thermal (ground temperature) data, which proved valuable in monitoring water availability, particularly irrigation requirements in the American West. Landsat 5 duplicated the Landsat 4 payload, but Landsats 6 and 7 eliminated the MSS in favor of enhanced versions of the TM known respectively as the Enhanced Thematic Mapper (ETM) and the Enhanced Thematic Mapper Plus (ETM+) (figs. 461 and 462). The primary enhancement was the addition of a higher ground resolution (15 m) panchromatic band. Table 33 summarizes the characteristics of the instruments on six Landsat systems.

The value of Landsat observations is based on several characteristics, not all in place with Landsat 1. These include a synoptic view; large areal coverage; regular, repeat coverage; broad spectral coverage and a ground resolution useful for thematic mapping and related analysis; and global imaging. Synoptic view refers to an ability to detect relationships between objects on the

TABLE 32. Characteristics of the Landsat systems

| System | Launch (end of service) | Instrument(s) | Resolution (in meters) | Communications | Altitude (in kilometers) | Image repeat period (in days) | Downlink rate (in mbps) |
|---|---|---|---|---|---|---|---|
| Landsat 1 | 7/23/72 (1/6/78) | RBV MSS | 80 80 | Direct downlink with recorders | 917 | 18 | 15 |
| Landsat 2 | 1/22/75 (2/25/82) | RBV MSS | 80 80 | Direct downlink with recorders | 917 | 18 | 15 |
| Landsat 3 | 3/5/78 (3/31/83) | RBV MSS | 30 80 | Direct downlink with recorders | 917 | 18 | 15 |
| Landsat 4 | 7/16/82 ceased transmissions 1993 (6/15/01) | MSS TM | 80 30 | Direct downlink TDRSS | 705 | 16 | 85 |
| Landsat 5 | 3/1/84 (6/5/13) | MSS TM | 80 30 | Direct downlink TDRSS | 705 | 16 | 85 |
| Landsat 6 | 10/5/93 failed to obtain orbit (10/5/93) | ETM | 15 (pan) 30 (ms) | Direct downlink with recorders | 705 | 16 | 85 |
| Landsat 7 | 4/15/99 | ETM+ | 15 (pan) 30 (ms) | Direct downlink with recorders (solid state) | 705 | 16 | 150 |

ground by viewing a single image or a combination of overlapping images. An intrinsic characteristic of earth imaging from airborne and space-based platforms, the synoptic view was enhanced in Landsat by the large area encompassed by each Landsat scene—a standard TM image, covering approximately 18,500 square kilometers, provided insights at the local to regional level in a single image. Landsat's near-polar, sun-synchronous orbit allowed for repeat acquisitions over any spot on the earth at the same time of day every sixteen days. Regular data acquisition enhanced utility of the data by fostering applications in which temporal change is crucial, most notably the monitoring of crop condition, forest growth, and water availability. The sixteen-day return interval partly compensated for cloud cover.

Global imaging, that is, the ability to acquire images anywhere and everywhere on the earth, was not a mission requirement until Landsat 7. Although the recording capability of Landsat 1 allowed for acquisition of images, the system was not intended to collect global data sets systematically and periodically. The Landsat 2000 global data set, the first global data set acquired by a single Landsat system, demonstrated the utility of this information for studying change on broad geographic and temporal scales. In 2000 the USGS inaugurated the systematic publication of special Landsat global data sets at five-year intervals as a service to the research community.

The Landsat program had the longest history of continuous earth observations in the twentieth century, and its data were the most used of any earth observations system. Even so, the program suffered from technical and institutional instability. Historian Pamela Etter Mack (1990), who chronicled the program's development from the mid-1960s through the early 1980s, examined NASA's difficulties in establishing a new community of users for its advanced technology as well as assignment of operational responsibility among federal agencies with an interest in the program, notably the USDA, the Departments of Defense and Interior, and the Office of Management and Budget (OMB). The Landsat program, Mack argued, exemplified a "social construction" whereby "a community of interested individuals and organizations negotiates a definition of the character and goals of the new technology" (Mack 1990, 4). USGS and NASA worked diligently to spur applications worldwide, in both developed and developing countries,

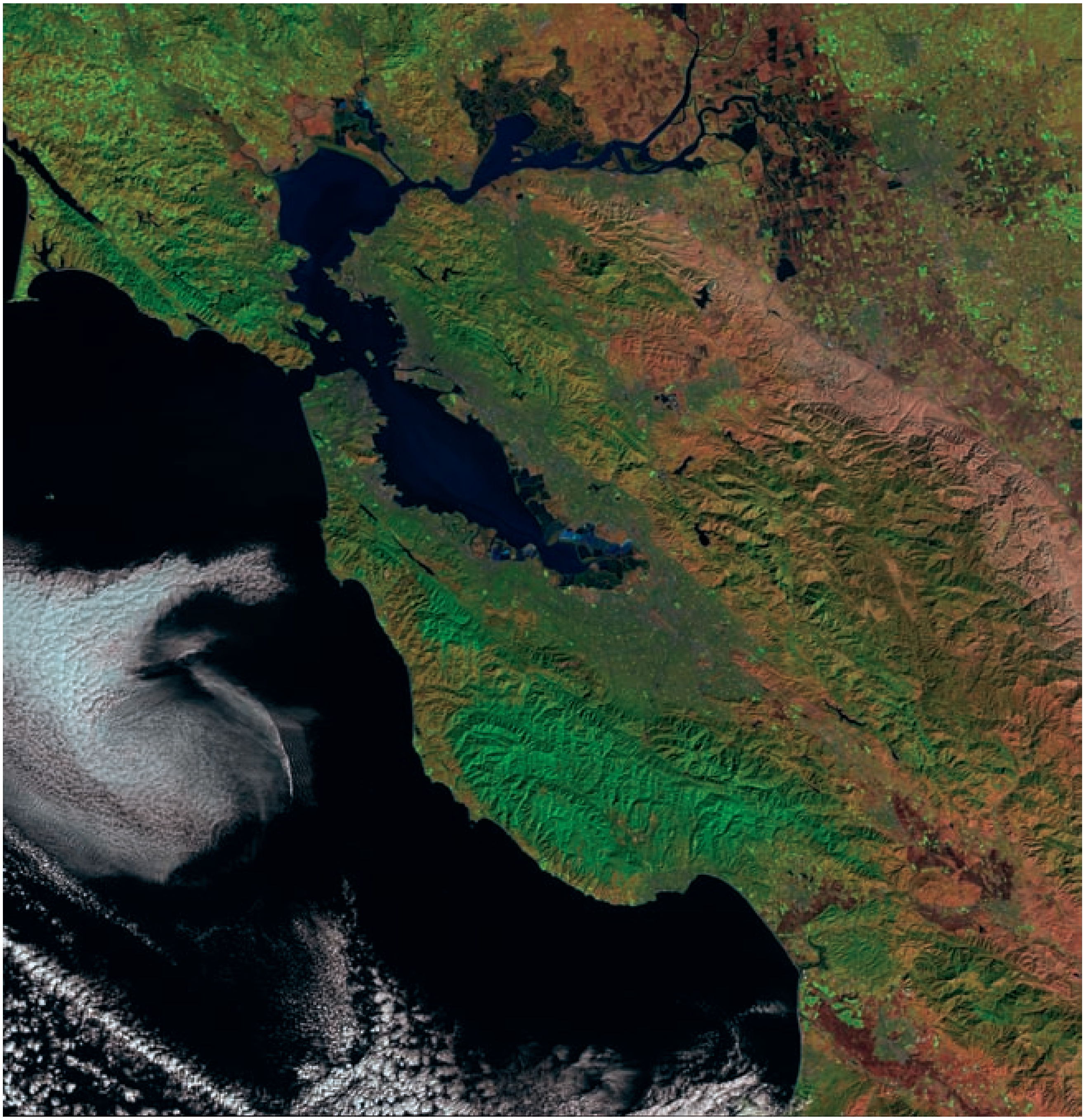


FIG. 461. LANDSAT 7 ETM+ (ENHANCED THEMATIC MAPPER PLUS), SAN FRANCISCO BAY AND PACIFIC OCEAN. False color composite image using data acquired on 30 December 1999. Image display in RGB using Landsat data bands 5, 4, and 3 respectively.

Image courtesy of the USGS Earth Resources Observation and Science Center (EROS).

particularly at universities but also by civilian government agencies and nongovernmental organizations.

NASA and the USGS were responsible for Landsat until the early 1980s, when the U.S. Congress, enthusiastic about privatization, turned operational control over to the Earth Observation Satellite Company (EOSAT), a consortium of Hughes Aircraft and RCA, under a contract administered by the National Oceanic and Atmospheric Administration (NOAA). The assumption that Landsat was a commercially viable system was

FIG. 462. LANDSAT 5 IMAGE OF SAN FRANCISCO BAY–OAKLAND. Created by combining three bands (1 + 2 + 3 = true color) to make a color image in combination with a digital elevation model with a vertical exaggeration factor of three to emphasize details. Landsat 5 data acquired on 27 September 1997.
Image courtesy of the NASA/Goddard Space Flight Center Scientific Visualization Studio.

TABLE 33. Characteristics of the instruments on Landsats 1, 2, 3, 4, 5, and 7

| *Bands* | Multispectral scanner Landsat 1–5 (in micrometers)* | Resolution (in meters) | Thematic Mapper Landsat 4–5 (in micrometers) | Resolution (in meters) | Enhanced Thematic Mapper Plus Landsat 7 (in micrometers) | Resolution (in meters) |
|---|---|---|---|---|---|---|
| Band 1 (4*) | 0.5–0.6 | 80 | 0.45–0.52 | 30 | 0.45–0.52 | 30 |
| Band 2 (5*) | 0.6–0.7 | 80 | 0.52–0.60 | 30 | 0.52–0.60 | 30 |
| Band 3 (6*) | 0.7–0.8 | 80 | 0.63–0.69 | 30 | 0.63–0.69 | 30 |
| Band 4 (7*) | 0.8–1.1 | 80 | 0.76–0.90 | 30 | 0.76–0.90 | 30 |
| Band 5 | – | – | 1.55–.175 | 30 | 1.55–1.75 | 30 |
| Band 6 | – | – | 10.40–12.50 | 120** | 10.40–12.50 | 60 |
| Band 7 | – | – | 2.08–2.35 | 30 | 2.08–2.35 | 30 |
| Band 8 | – | – | – | – | 0.52–0.90 | 15 |

*Bands 1–4 in this table encompass the same wavelengths as bands 4–7 on Landsats 1–3.
** Delivered product is resampled to 60 meters.

disproved when the EOSAT raised prices sixfold and data sales, especially among the research community, fell dramatically. With the Land Remote Sensing Policy Act of 1992, Congress transferred responsibility for Landsat back to the federal government and promised to maintain continuity of Landsat-type observations at a reasonable price.

Despite this instability, Landsat data were greatly appreciated and widely used. Perhaps the prime legacy of the Landsat program was the vast worldwide community of technically savvy data users, most of whom learned about remote sensing through Landsat.

EDWIN J. SHEFFNER

SEE ALSO: Biogeography and Cartography; Land Use Map; National Aeronautics and Space Administration (U.S.); Remote Sensing: (1) Earth Observation and the Emergence of Remote Sensing, (2) Data Handling and Information Extraction from Remotely Sensed Data; U.S. Geological Survey

BIBLIOGRAPHY:

Jensen, John R. 1981. "Urban Change Detection Mapping Using Landsat Digital Data." *American Cartographer* 8:127–47.

Joyner, Christopher C., and Douglas R. Miller. 1985. "Selling Satellites: The Commercialization of LANDSAT." *Harvard International Law Journal* 26:63–102.

Leimgruber, Peter, Catherine A. Christen, and Alison Laborderie. 2005. "The Impact of Landsat Satellite Monitoring on Conservation Biology." *Environmental Monitoring and Assessment* 106:81–101.

Lo, C. P. 2007. "The Application of Geospatial Technology to Urban Morphological Research." *Urban Morphology* 11:81–90.

Mack, Pamela Etter. 1990. *Viewing the Earth: The Social Construction of the Landsat Satellite System*. Cambridge: MIT Press.

National Research Council (U.S.). 2002. *Down to Earth: Geographic Information for Sustainable Development in Africa*. Washington, D.C.: National Academies Press.

Sheffner, Edwin J. 1994. "The Landsat Program: Recent History and Prospects." *Photogrammetric Engineering & Remote Sensing* 60:735–44.

Treitz, Paul, Philip J. Howarth, and Peng Gong. 1992. "Application of Satellite and GIS Technologies for Land-Cover and Land-Use Mapping at the Rural-Urban Fringe: A Case Study." *Photogrammetric Engineering & Remote Sensing* 58:439–48.

***Landscape Architecture and Cartography.*** In contrast to architects, who design buildings, and civil engineers, who design bridges and dams, landscape architects typically plan on a much wider scale, for parks and large gardens, the land surrounding a structure, and the layout and landscaping of office campuses, housing developments, and similar projects for which aesthetics are important. Professional landscape architects have been active throughout the twentieth century, using maps at various stages of a project, including initial and intermediate discussions with the client; presentations to governing bodies or potential investors; research and site analysis; and the comparative evaluation of alternative designs. Detailed topographic maps are indispensable in identifying possibilities and potential obstacles, including terrain features that might require reshaping. Because the contour interval on existing maps was typically too coarse, a special survey was often necessary to assess drainage and visual impact as well as to calculate the amount of surface material that had to be added, removed, or relocated to achieve the desired effect. The final design always included one or more maps, demonstrating persuasively how the finished project would look.

Historical geographer D. W. Meinig (1976), who examined the diverse graphic representations of landscapes, noted that maps and photographs can depict the visual environment in ten different ways: as nature, habitat, artifact, system, problem, wealth, ideology, history, place, or aesthetic. At different levels, landscape architects are concerned with all of them.

Like other design professionals, landscape architects have always valued skill in freehand sketching and the crafting of three-dimensional models. Lettered by hand, their plan-view and oblique three-dimensional maps have a distinctive look. Indeed, the examples in figures 463 and 464, taken from the 1904 catalog of the architecture department at the Massachusetts Institute of Technology (MIT), are little different, except for their lettering, from drawings produced a hundred years later. Required courses in MIT's four-year landscape architecture program, an option within the architecture department, included six semesters of Freehand Drawing, two semesters each of Water Color and Pen and Ink, a semester each of Modelling, Topographical Drawing, and Field Work and Drawing, in addition to four semesters of Surveying (including a semester of plane tabling) (MIT 1904, 75).

By century's end much of the work, and collegiate instruction as well, had shifted to computer workstations, on which comparatively sophisticated software tools afforded interactive analysis and design using digital elevation models, overhead imagery, land-survey data, and environmental databases. Improved software available since the late 1980s not only made three-dimensional modeling and viewshed analysis far easier but also supported realistic shadow effects, rapid but aesthetically acceptable lettering, and visual simulations showing how a landscape might be expected to look years ahead, once planted vegetation reached maturity. What's more, as environmental design educator D. Dayton Reuter (2002, 91) noted, the zoom capability of interactive graphic workstations eliminated the "fat fingers syndrome" whereby "graphics have traditionally been drawn at a size determined primarily by the metrics of the human hand." Computer-aided design (CAD) also removed the stress involved in working with very large drawings, allowed several people to work simultaneously on the same design, and enabled the ready generation of corrected or revised versions.

Landscape architecture's most significant cartographic contribution is overlay analysis, one of the earliest, if not the most fundamental, analytical functions in the GIS (geographic information system) toolkit. The earliest apparent use of hand-drawn overlays occurred in 1912, when multiple maps drawn at the same scale helped planners in Billerica, Massachusetts, analyze local patterns of traffic and land use (Steinitz, Parker, and Jordan 1976). That same year planners in Düsseldorf, Germany, used various maps at a common scale to assess the city's expansion between 1874 and 1912. In the early 1960s, Ian L. McHarg and his associates developed

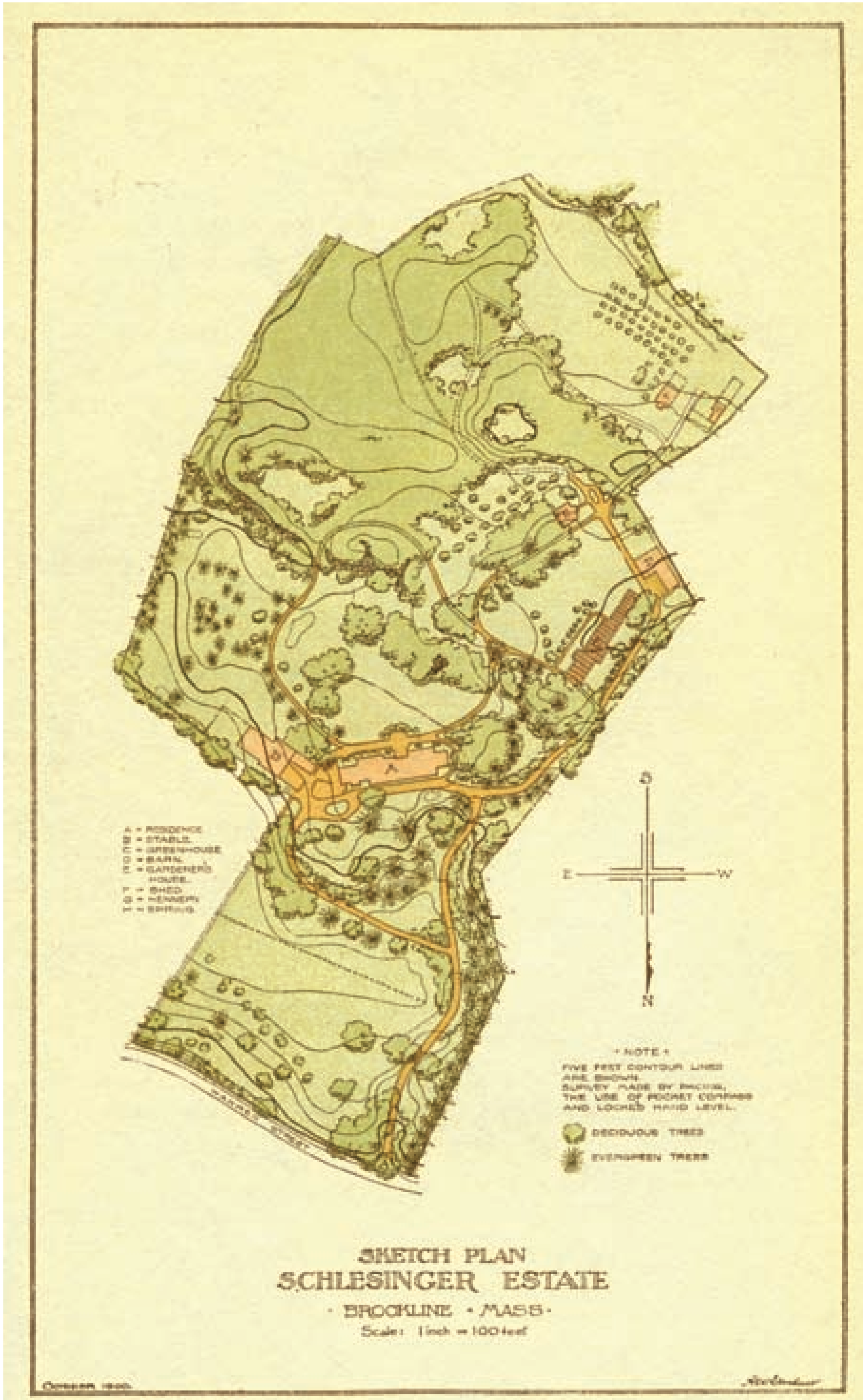



FIG. 463. *SKETCH PLAN SCHLESINGER ESTATE, BROOKLINE, MASS*, 1900. Example of a landscape architect's plan-view sketch map, enhanced with watercolor. Size of the original: 19 × 11.2 cm. From MIT 1904, 61.

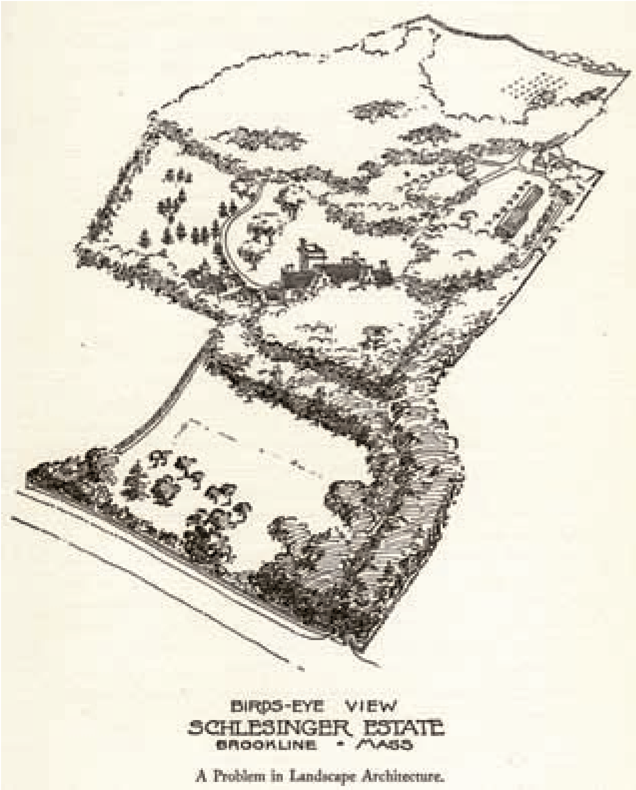



FIG. 464. *BIRDS-EYE VIEW SCHLESINGER ESTATE, BROOKLINE, MASS.* Oblique pen-and-ink sketch map. Size of the original: 15.7 × 12.3 cm. From MIT 1904, 63.

a more advanced form of overlay analysis, illustrated with numerous examples in his classic *Design with Nature* (1969), which was widely acclaimed by both environmentalists and other landscape architects. McHarg's principles were an important influence on students and staff at Harvard University's Graduate School of Design, home to the Laboratory for Computer Graphics and Spatial Analysis, which from the mid-1960s through the early 1980s fostered the development of computer-based mapping technology and what evolved into commercial GIS software. Jack Dangermond, who founded Environmental Systems Research Institute (ESRI) and guided the development of ARC/INFO and ArcGIS, received a master's degree in landscape architecture from Harvard University in 1969, and numerous other influential GIS professionals had a connection with the laboratory.

MARK MONMONIER

SEE ALSO: Historic Preservation and Cartography; Planning, Urban and Regional; Viewshed Mapping

BIBLIOGRAPHY:

Massachusetts Institute of Technology (MIT), Department of Architecture. 1904. *Massachusetts Institute of Technology, Boston: Department of Architecture*. Boston: Geo. H. Ellis.

Meinig, D. W. 1976. "The Beholding Eye: Ten Versions of the Same Scene." *Landscape Architecture* 66:47–54.

Reuter, D. Dayton. 2002. *Computer Graphics for Architects, Engineers, and Environmental Designers: An Introduction to Computer Graphics for Architects, Engineers, Landscape Architects, Land Use Planners, and Environmental Consultants*. New York: Allworth Press.

Steinitz, Carl, Paul Parker, and Lawrie Jordan. 1976. "Hand-Drawn Overlays: Their History and Prospective Uses." *Landscape Architecture* 66:444–55.

***Law of the Sea.*** On 2 August 2007, two Russian submersibles planted a Russian flag on the ocean floor beneath the North Pole. Forty years earlier, at the height of the Cold War and the space race, this act would have been viewed as an expression of scientific achievement. But by the time the two submersibles descended beneath the Arctic ice pack, the Cold War had ended, and the space race had become a collaboration. Despite this apparent progress, the act of planting the flag triggered fears among many of Russia's Arctic neighbors that the days of the colonial land grab had returned. These fears reflected the evolution of the Law of the Sea in the latter part of the twentieth century.

Control of nearby ocean waters has long been important for coastal states, both as a matter of national defense and as a means for controlling access to resources, primarily fisheries. Because of comparatively primitive technologies for sailing, making war, and exploiting the marine resources, territorial claims had been confined to narrow strips of water adjacent to the mainland and offshore islands. In the twentieth century, however, improved ship design and propulsion systems, longer-range weapons, depletion of nearshore fisheries, and an increased ability to exploit resources on or beneath the bottom of the sea spurred demand for ever-wider zones for the control of resources if not for outright sovereignty. That demand eventually led to the 1982 United Nations (UN) Convention on the Law of the Sea, which in turn triggered what is arguably one of the largest territorial grabs in history.

For any coastal state, the basic challenge of determining the exact boundary between land and sea is more difficult than it might seem. The periodic rise and fall of the tide means that the position of the shoreline changes constantly, with most places experiencing two high tides and two low tides each day. Tidal levels also change over the course of the month and year as the positions of the sun and moon (relative to earth) continually shift. (Other factors affect water level, but tidal action is more relevant to the discussion at hand.) Changes in water level generally have little effect on shoreline location where slopes are steep, but where the gradient is gentle, as it is on much of the Atlantic and Gulf coasts of the United States, the distance between the positions of the shoreline at high and low tide can be substantial.

Most mapped shorelines are based on the mean high-water line, that is, the average position of the shoreline at high tide, which is important to navigators because it represents the land as seen from offshore. Even so, from the standpoint of national sovereignty, maps based on high-water lines needlessly forfeit potential territory—akin to building a backyard fence a couple of feet inside your property line rather than on the property line itself. The ideal boundary is the low-water line—the position of the shoreline at low tide—because it allows a nation to claim not only more land but also a greater swath of adjacent waters. Although painstaking and time-consuming, shore-based surveys and offshore triangulation could be used to map the low-water shoreline. The development of the airplane as a platform for aerial photography and remote sensing revolutionized the mapping of the intertidal zone. A photographic mission timed for low tide could capture the land-water boundary at its most expansive position. At the end of the century airplanes were usually more efficient for coastal mapping than satellites, which cannot adjust their orbits to local tide tables.

Once the shoreline is mapped, the next challenge is to delineate offshore boundaries. The easiest method is to draw a series of circles with a radius representing the width of the nation's territorial claim and centered along the shoreline. While an infinite number of these circles might be drawn, it is usually sufficient to center them on locally prominent headlands. The maritime boundary is then delineated by the outward arcs of intersecting circles, perhaps generalized by straight-line segments joined at turning points where the coast changes shape or where adjustment is needed to encompass offshore islands.

In 1951 the World Court in The Hague ruled that the low-water line should be used as the basis for delimiting the territorial sea—the belt of water considered part of a nation's sovereign territory. In keeping with the 1951 decision, the 1958 UN Convention on the Territorial Sea and the Contiguous Zone endorsed the low-water shoreline "as marked on large-scale charts officially recognized by the coastal State" (sec. 2, art. 3) as the baseline for delineating the territorial sea. This begs the question, which low-water shoreline? Mean low water—the long-term average of all low tides? Or mean lower-low water—the long-term average of the lowest of each pair of daily low tides, and thus the more advantageous definition? The convention left it up to coastal nations to determine which datum to use. (The United States designated the mean lower-low water as the appropriate datum for its territorial claims.)

The UN convention recognized that most coastlines have complex shapes and issued guidance on how cartographers could adjust their baselines to cope with that complexity. Where the coastline is deeply indented by a bay or some other feature, or where islands are located near the coast, coastal states could draw straight baselines joining appropriate points along the coast, for example, across the mouth of the Chesapeake Bay from Cape Henry to Cape Charles. The 1958 convention mandated that baselines follow the general trend of the coastline, and that any water included within the baseline should be near enough to the coast to be "subject to the regime of internal waters" (sec. 2, art. 4). Although baselines could take into account economically important areas for which a coastal state could demonstrate a long history of use, the 1958 convention prohibited straight baselines that might deny other coastal states access to the high seas. It also allowed a state to enforce its laws on immigration, environmental protection, customs, and taxation with a contiguous zone adjacent to its territorial waters but extending no more than twelve nautical miles beyond the baseline of the territorial sea.

The 1958 convention failed to explicitly specify the maximum width of a state's territorial sea, which was traditionally limited to three nautical miles, the range of a shore-based cannon and thus the distance a coastal state could reasonably expect to project its power and exercise sovereignty. By the end of World War I the development of modern artillery, the invention of the airplane, and the realization of the latter's potential as a long-range weapon—dramatically demonstrated by U.S. Brigadier General William "Billy" Mitchell, whose aircraft sank the captured German dreadnought *Ostfriesland* off the coast of Virginia on 21 July 1921—rendered the cannon-shot principle obsolete.

The international community met again in 1960 to discuss the law of the sea, but reached no agreement on the legal width of the territorial sea. As some nations had begun to claim twelve-mile and even wider limits, the issue could not be ignored much longer. The third UN Conference on the Law of the Sea, with more than 160 nations participating, began meeting in 1973. After a protracted, painstaking effort to reach an international consensus on the matter, in 1982 they adopted the UN Convention on the Law of the Sea (UNCLOS), which went into effect on 16 November 1994. UNCLOS set the width of the territorial sea at twelve nautical miles from the baseline and also expanded the contiguous zone to no more than twenty-four nautical miles from the baseline.

Two parts of UNCLOS triggered a scramble for seabed rights. Part five allows coastal states to claim an Exclusive Economic Zone (EEZ) extending no more than 200 nautical miles beyond the baseline for the territorial sea. Within its EEZ a coastal state has the sole right to manage—and exploit—living and nonliving resources. Where the claims of two nations overlap, as in the Gulf of Maine or the Straits of Malacca, the boundaries may be set at the midpoint between the two adjacent nations. Otherwise, EEZ boundaries are set by treaty or settled by litigation in the World Court.

Part six addresses the continental shelf as the "natural prolongation" of a coastal state's territory to "the outer edge of the continental margin," or out to 200 nautical miles from the territorial baseline if the shelf doesn't extend that far (art. 76.1). UNCLOS gives the coastal state rights to the resources of the seabed, including living resources attached to the seabed, but not resources in the waters above. The maximum area a coastal state can claim as continental shelf is either 350 nautical miles from its territorial baseline or 100 nautical miles outward from the 2,500-meter isobath, whichever is greater. In the case of submarine ridges that extend beyond the edge of the continental shelf, the coastal state may claim seabed rights that extend no more than 350 nautical miles from the territorial baseline. The Russian flag planting beneath the North Pole was part of an expedition gathering data to prove that the Lomonosov Ridge, which runs under the North Pole, was part of the continental shelf and thus a legitimate extension of Russian territory.

Seabed claims on the continental shelf promise access to potentially massive reserves of mineral and energy (petroleum and natural gas) resources. The Arctic Ocean, for example, has proven reserves of both, and additional amounts could become accessible if climate change causes a breakup of the Arctic ice cap. Russia's planting of its flag on the seabed beneath the North Pole—despite its denials of any territorial significance of the act—put increased pressure on the other nations bordering the Arctic Ocean, including the United States and Canada, to conduct their own oceanographic surveys and prepare their own claims and counterclaims.

DAVID M. LAWRENCE

SEE ALSO: Boundary Disputes; Geopolitics and Cartography; Marine Chart; Marine Charting: Overview of Marine Charting

BIBLIOGRAPHY:

International Hydrographic Organization. 2006. *A Manual on Technical Aspects of the United Nations Convention on the Law of the Sea—1982*. 4th ed. Publication S-51. Monaco: International Hydrographic Bureau.

Monmonier, Mark. 2008. *Coast Lines: How Mapmakers Frame the World and Chart Environmental Change*. Chicago: University of Chicago Press.

Prescott, J. R. V., and Clive H. Schofield. 2005. *The Maritime Political Boundaries of the World*. 2d ed. Leiden: Martinus Nijhoff.

Reed, Michael W. 2000. *The Development of International Maritime Boundary Principles through United States Practice*. Vol. 3 of *Shore and Sea Boundaries*. Washington, D.C.: U.S. Department of Commerce and National Oceanic and Atmospheric Administration.

Shalowitz, A. L. 1945. "Safeguarding Our Seaways—the Modern Nautical Chart." *Scientific Monthly* 61:249–64.

———. 1964. *Interpretation and Use of Coast and Geodetic Survey Data*. Vol. 2 of *Shore and Sea Boundaries*. Washington, D.C.: U.S. Department of Commerce and Coast and Geodetic Survey.

Shelley, Anthony F. 1985. "Law of the Sea: Delimitation of the Gulf of Maine." *Harvard International Law Journal* 26:646–54.

Steinberg, Philip E. 2001. *The Social Construction of the Ocean*. Cambridge: Cambridge University Press.

Yenikeyeff, Shamil Midkhatovich, and Timothy Fenton Krysiek. 2007. "The Battle for the Next Energy Frontier: The Russian Polar Expedition and the Future of Arctic Hydrocarbons." *Oxford Energy Comment* (August). Oxford Institute for Energy Studies. Online publication.

***League of Nations.*** The League of Nations was established under the terms of the Treaty of Versailles in June 1919 (Northedge 1986). The idea of a "general association of nations" that might ensure collective security had been extensively debated for decades but was formally proposed in January 1918 in the last of the Fourteen Points issued by American President Woodrow Wilson to ensure a just and lasting settlement to World War I, then entering its fifth year. The League's Covenant, which committed member states to the peaceful resolution of disputes, was adopted in April 1919, and the first Assembly took place in Geneva in November 1920 (Kennedy 2005). The League was dissolved in April 1946, when its assets and responsibilities were transferred to the new United Nations.

The League's influence was limited from the outset. Only forty-two nations signed the 1919 Covenant, the most important absentee being the United States, which had refused to ratify the Treaty of Versailles. A further twenty-one states subsequently joined the League, including Germany (1926) and the USSR (1934), but seventeen states withdrew, including Germany (1933), Japan (1933), Italy (1937), Spain (1939), and several Latin American countries; six had their memberships dissolved. The USSR was expelled in 1939. With no peace-keeping capacity of its own, the League was entirely dependent on its fluctuating membership to enforce its conventions. It was also chronically short of cash. The annual budget was significantly below $5 million (£1 million) through the 1920s and fell in real terms during the economic depression of the early 1930s.

The League's principal executive agency was the Secretariat, based in Geneva. This was supported by several auxiliary organizations concerned with economic and financial trends, transport and communications, health, disarmament, labor organization, refugees, slavery, the mandated territories, the drug trade, and intellectual cooperation. Research was facilitated by a small reference library, bankrolled by the American billionaire John D. Rockefeller (Aufricht 1951, 120), which expanded from a modest 2,000 volumes in 1920 to 95,000 volumes by 1928.

The League had no specialist cartographic unit and was therefore unable to challenge the dominance of national mapmaking agencies, most of which were controlled by the military. Even so, it developed a map library, which eventually comprised over 100,000 sheets covering most of the globe. The League's *Statistical Year-Book* began to appear on a consistent format after the 1928 International Convention Relating to Economic Statistics and included simple geographical maps showing political boundaries, the mandated territories, and the changing distribution of League membership. Thematic maps featured in publicity materials were issued to convince a skeptical public within and beyond the member states that the League was a worthwhile and effective organization (fig. 465). Cartographic imagery reinforcing the principles of international cooperation also appeared in architectural form in League buildings (fig. 466).

The possibility of constructing a new twentieth-century cartography consistent with the League's guiding principles was exemplified by the International Map of the World (IMW), an idea originally proposed in 1891 by the German geographer Albrecht Penck under the auspices of the International Geographical Congress (Pearson et al. 2006). The proposal was subsequently developed by the major national cartographic agencies at IMW conferences in London in 1909 and Paris in 1913. The United States withdrew on the eve of the latter event though the remaining thirty-four national delegations agreed that IMW map sheets would adopt a standard 1:1,000,000 scale, a simple polyconic projection, and a consistent set of conventions and symbols. Carried out entirely by national cartographic agencies, the project was facilitated by a Central IMW Bureau based at the British Ordnance Survey in Southampton.

Progress was slow before 1914 and stalled altogether during World War I, though the British Geographical Section, General Staff (GSGS) prepared its own 1:1,000,000 map series for Western Europe and the Middle East in the Royal Geographical Society, based loosely on the IMW (Heffernan 1996). After the war, the IMW was embraced by the League's Commit-


FIG. 465. MAP OF TRAFFIC IN WOMEN AND CHILDREN AND ASSOCIATED LEAGUE OF NATIONS DATA ON SOCIAL QUESTIONS. From League of Nations, *The League of Nations: A Pictorial Survey* (Geneva, [1929]).

Size of the original: 11.2 × 17.3 cm. Permission courtesy of the League of Nations Archives, UNOG Library, Geneva.

FIG. 466. MEETING OF THE LEAGUE OF NATIONS COMMISSION ON OPIUM AND OTHER NARCOTIC DRUGS, 1939. Note the large sculpted wall map with lines radiating from the League's headquarters in Geneva.

Image courtesy of the League of Nations Archive, UNOG Library, Geneva.

tee on Intellectual Cooperation (CIC), a forerunner of UNESCO (Renoliet 1999). This was established in 1922 under the chairmanship of the French philosopher Henri Bergson to encourage international scientific collaboration between previously hostile nations (Canales 2005). The CIC had no financial resources to support the IMW, but it ensured that the vast majority the League's member states signed the 1913 conventions. By 1926, forty-four national cartographic agencies were involved in preparing IMW sheets, over 200 of which had been published, though only twenty-one conformed exactly to the 1913 specifications (fig. 467). National agencies operating outside the IMW agreement developed their own 1:1,000,000 mapping projects, notably the Brazilian Clube de Engenharia, which produced a fifty-sheet *Carta do Brasil* through the 1920s and 1930s. The most important non-IMW million-scale mapping project was undoubtedly the *Map of Hispanic America*, compiled at great expense over twenty-five years by the American Geographical Society.

The ability of the League to influence the process of global million-scale mapping was undermined by the outbreak of World War II. During the war, military authorities in the United States, the United Kingdom, the Soviet Union, Germany, Italy, and Japan commissioned new map series at this scale for different theaters of war. The United Nations assumed responsibility for the IMW in September 1951, but the early twentieth-century idealism that had inspired both the International Map of the World and the League of Nations no longer had much relevance in the very different circumstances of the Cold War.

MICHAEL HEFFERNAN

SEE ALSO: Geopolitics and Cartography; International Map of the World; Paris Peace Conference (1919); United Nations; World War I; World War II

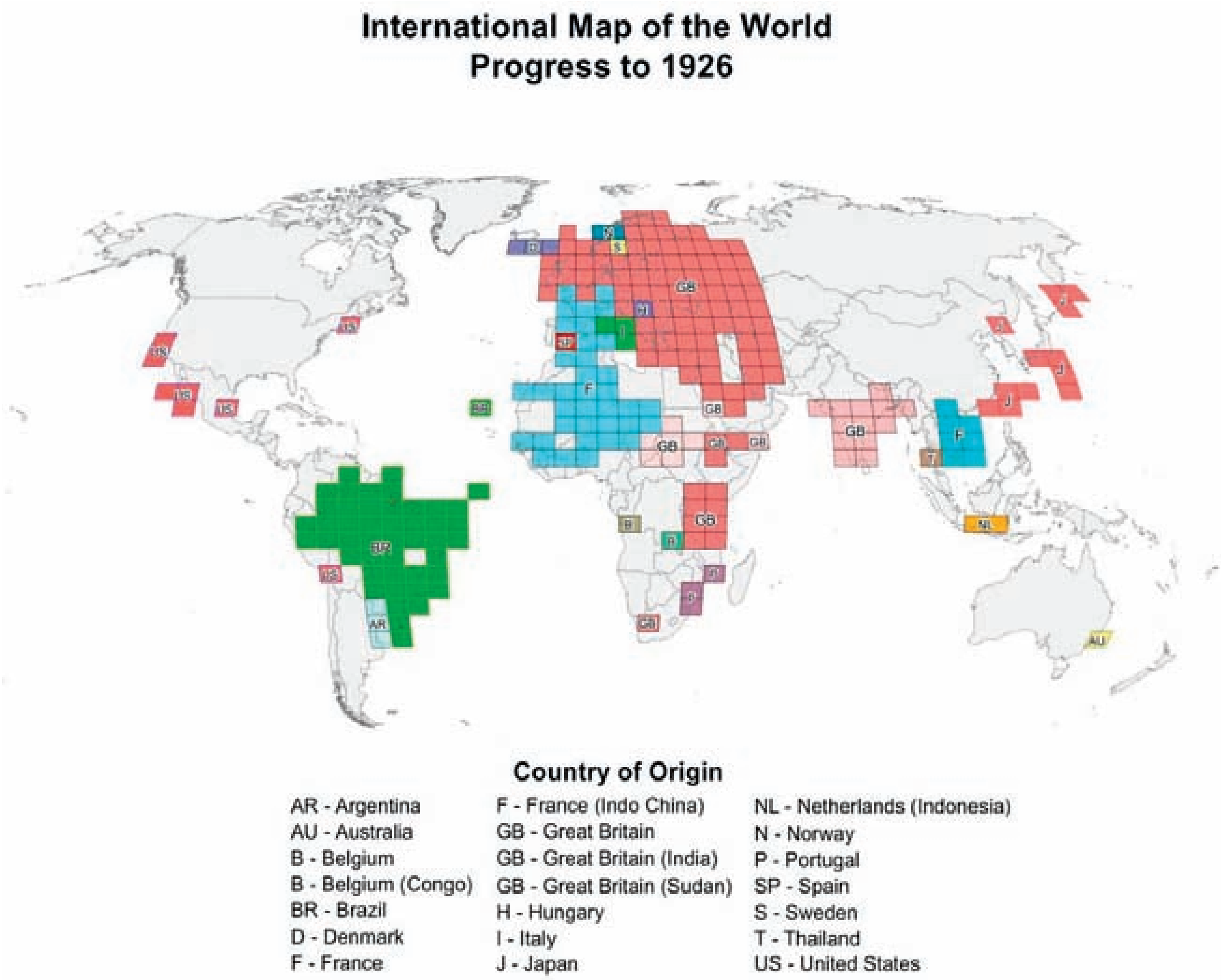



FIG. 467. INTERNATIONAL MAP OF THE WORLD, 1:1,000,000, PROGRESS TO 1926.

Based on Pearson et al. 2006, 156. 

BIBLIOGRAPHY:

Aufricht, Hans. 1951. *Guide to League of Nations Publications: A Bibliographical Survey of the Work of the League, 1920–1947*. New York: Columbia University Press.

Canales, Jimena. 2005. "Einstein, Bergson, and the Experiment that Failed: Intellectual Cooperation at the League of Nations." *Modern Language Notes* 120:1168–91.

Heffernan, Michael. 1996. "Geography, Cartography and Military Intelligence: The Royal Geographical Society and the First World War." *Transactions of the Institute of British Geographers*, n.s. 21:504–33.

Kennedy, David. 2005. "The Move to Institutions." In *International Organizations*, ed. Jan Klabbers, 3–148. Aldershot: Ashgate.

Northedge, F. S. 1986. *The League of Nations: Its Life and Times, 1920–1946*. Leicester: Leicester University Press.

Pearson, Alastair W., et al. 2006. "Cartographic Ideals and Geopolitical Realities: International Maps of the World from the 1890s to the Present." *Canadian Geographer* 50:149–76.

Renoliet, Jean-Jacques. 1999. *L'UNESCO oubliée: La Société des Nations et la coopération intellectuelle (1919–1946)*. Paris: Publications de la Sorbonne.

***Librarianship.*** See Societies, Map Librarianship

***Libraries, Map.*** Map libraries are collections of geospatial information sources in various formats, not only hard copy and digital maps but also remote sensing images, aerial photographs, atlases, globes, cross-sections, and relief models. Most map libraries are units within organizations and agencies, such as university and public libraries and governmental and nonprofit agencies. The major purpose of map collections is to gather cartographic materials together in one place, either at a physical location in a building or as a virtual library over the World Wide Web. The concentration of cartographic materials makes their consultation quicker and more efficient. It also fosters the comparison of cartographic materials and geospatial data of various kinds and from different times.

It was in fourteenth- and fifteenth-century Europe, during the Renaissance period, that maps first began to be regarded as collectible in the same way as book-format materials, with the first map library established in 1459 (Wolter 1973, 240–41). As early as the first half of the sixteenth century, maps were being collected in Europe on however limited a basis by libraries and by private collectors. But it was not until nearly the middle of the twentieth century that map libraries became numerous in the Western world. When members of the Geography and Map Group, Special Libraries Association prepared a special feature on “Maps in the Library” for the *Library Journal* in 1950, they were consciously writing about coping with that new phenomenon (Yonge 1950). The impetus had been World War II, when the map holdings of libraries in America and Europe, material previously considered unimportant or largely of scholarly interest, became vital to carrying on warfare (Hooker 1950).

Map collections flourished in the United States, Canada, Western Europe, Australia, and New Zealand during the second half of the twentieth century, when map libraries experienced their greatest growth, both in number and in size of collections (Wolter 1973, 238–46). That growth began shortly after World War II in the United States with the distribution of surplus maps to map libraries by the U.S. Army Map Service, a practice effectively continued into the early 2000s. Another growth incentive from the 1960s onward was the expansion of the depository program administered by the U.S. Government Printing Office (Cobb 1990, ix). In the early 1950s there were 527 map collections listed in a directory of U.S. and Canadian collections, with 497 of them in the United States (Special Libraries Association 1954, 1). By 1975 there were 743, with 684 in the United States (Carrington and Stephenson 1978, vii). By 1983 there were 919 map collections in the United States, ranging from 19 collections with 250,000 or more maps to 78 percent with less than 50,000 maps. The largest collection was that of the Geography and Map Division of the Library of Congress (LCG&M) with 3.8 million maps, while the largest academic library was the University of California, Los Angeles (UCLA) with over 506,000 maps, and the largest public library was the New York Public Library with almost 356,000 maps (Cobb 1986, x–xi). By 1989 there were 975 map collections in the United States, including twenty map libraries with more than 250,000 maps. The largest library (LCG&M) had almost 4 million maps, and the largest air photo collection, in the U.S. National Archives, contained 10 million images (figs. 468 and 469) (Cobb 1990, x–xi, xiii).

By 2004, though, only 564 collections were listed in a directory of U.S. map collections despite the fact that a threshold of 1,000 maps, considerably lower than for earlier editions of the directory, had been established as the minimum number of maps for including a collection. The lesser number of map collections listed was partly due to the combination of statistics for some collections (held by the same agency) listed separately in the previous edition. However, the number of persons working exclusively with maps had declined. After specialists retired, responsibility for map collections merged with other positions, most often in general reference or government documents. Instead, there was a substantial increase in the number of positions opening for geographic information systems (GIS) specialists in university libraries, positions sometimes affiliated with the map library but often with the government publications department or the digital services department of the main library. In 2006 LCG&M had over 4.8 million maps, the largest academic collection was still that of UCLA (614,000), the largest public library was Boston Public Library (1,400,000), the National Archives still held the largest number of air photos and satellite images with 18 million, and the largest academic library collection of remote sensing images was that of the University of California, Santa Barbara (UCSB) with 4.4 million images (Thiry 2006, 1, 307, 309, 311, 312).

Similar trends in map libraries in Australia, Canada, the United Kingdom, and a few other countries may be tracked through the multiple editions of each country’s individual map library directories. See, for example, the directory of map collections in Australia (published in paper format from the first edition, *Directory of Map Collections in Australia*, 1974, through the last paper edition, *Map Collections in Australia: A Directory*, 1991, and subsequently in digital format on the web), the *Directory of Canadian Map Collections = Répertoire des collections de cartes canadiennes* (paper editions 1969–99) and *A Directory of UK Map Collections* (paper editions 1983–2000 and subsequently on the web).

The directories of map collections worldwide compiled by a map-interest group of the International Federation of Library Associations (IFLA) could not be used in the same way here to track the growth of map library collections around the world. The compilers of the worldwide directories included only the largest collections from those countries having their own directories of map collections (e.g., Australia, Canada, France, Germany, the Netherlands, the United Kingdom, and the United

FIG. 468. USER AREA FOR PRINT MATERIALS. Map and Imagery Laboratory, Davidson Library, University of California, Santa Barbara, 2007.

Image courtesy of Larry Carver.

FIG. 469. MAP CASES. Map and Imagery Laboratory, Davidson Library, University of California, Santa Barbara, 2007.

Image courtesy of Larry Carver.

States) (IFLA 1986, xiv; 1993, ix). Nonetheless, there was an obvious increase in number of collections over the years, with 285 collections reported worldwide as of 1972 (IFLA 1976, 8), 522 collections from 67 countries in 1990 (IFLA 1993, ix) and, as of the late 1990s, 714 collections in 121 countries (IFLA 2000, vii). The general pattern in most countries was that of governmental map collections—often as part of national libraries, national archives, and the national topographic and geologic surveys—and of maps collected by university libraries and by libraries in scholarly societies. One map group in Europe—Groupe des Cartothécaires de LIBER (Ligue des Bibliothèques Européennes de Recherche)—was active during the last quarter of the twentieth century, as was the Geography and Map Libraries Section of IFLA.

The growth of map libraries was strongly influenced by several factors. Primary among these were scientific and technological developments in cartography after 1700, developments that speeded up the issuance of mapping products and greatly increased the quantity produced. Not only did cartographic products become important, even essential, tools in times of war during the twentieth century, but they also proved themselves to be valuable for governance at every level, as evidenced by the proliferation of GIS data sets from the world level down to the level of city governments at the end of the century.

Technological advances in cartography contributed directly in many ways to the growth of collections. The most obvious were the use of remote sensors in airplanes and in satellites to gather information about the earth and other planets, the use of digital methods to develop mapping products, and the development of the Internet as a method of making maps and images available. The latter led to far more use of digital maps than had ever occurred with paper maps.

Changing technology also influenced the operation of map libraries during the twentieth century (Larsgaard 1998). As in other types of libraries, map-library work began with the selection and acquisition—budget permitting—of materials of greatest interest to a collection's primary user groups. Finding the maps to acquire was challenging, several articles pointed out in 1950, because map publishers were so numerous, maps were so ephemeral, and there was no centralized documentation of new maps published (although several journals did publish notices of new maps) (Espenshade 1950, 431, 434; Felland 1950). For those reasons, map acquisition remained more difficult than the development of library book collections through the end of the century. However, identifying desiderata became less of a problem when, as early as 1972, map librarians began to employ computers to analyze map-use statistics and adjust collection development policies accordingly (Fairclough 1972, 291).

Throughout the twentieth century the most used and versatile materials in almost all map collections were the many sheets of detailed topographic map series. Topographic map sheets could be employed in many ways by different types of users and served as base maps for every other thematic map series. The available coverage of topographic maps increased due to the application of aerial photography during World War I and even more during and after World War II, thus speeding up data collection and map compilation. Thematic map collecting in most libraries consisted mainly of land use (cadastral and planning), transportation, geology, and vegetation maps. General world atlases formed part of almost every map collection; national atlases and thematic atlases were obtained when appropriate for a given map library's users. Collections often included monographic and serial text materials on cartography. Collection of digital geospatial data first occurred in a very few map libraries in the mid-1980s and became common only in the early to mid-1990s as U.S. government agencies, such as the U.S. Bureau of the Census, the National Aeronautics and Space Administration, and the U.S. Geological Survey, began to distribute data on CD-ROMs.

Following selection and acquisition, materials were classified, generally but not always, by geographic area. The object of classification, for digital as for hard copy cartographic items, was to place like items together so they could easily be found. Each item was given an identifying call number, sometimes assigned arbitrarily and sometimes encoding the map's geographical and other characteristics. There was no consensus in 1950 about the best method of classifying maps and the level of cataloging they should receive (Anderson 1950), a debate that continued for decades without total resolution. The next step was to catalog cartographic items using technology that progressed during the latter part of the twentieth century from manual typing of catalog cards to computer-printed catalog cards, which in turn gave way to computer catalogs accessible for direct searching on local networks and later on the web (fig. 470).

A major problem was that relatively few map collections had been fully cataloged. In the late 1980s only about 60 percent of all libraries in the United States with map collections had cataloged them (Cobb 1990, xiii). Many map libraries relied for access on direct searching of uncataloged maps stored in rough geographical arrangement. Another major problem was that 95 percent of most map collections was composed of large series (mainly topographic series or air-photo flights). Cataloging was most often done at the series or flight level rather than at the sheet or aerial photograph level, largely due to the substantial amount of work required to create a catalog record for each sheet or image. In-

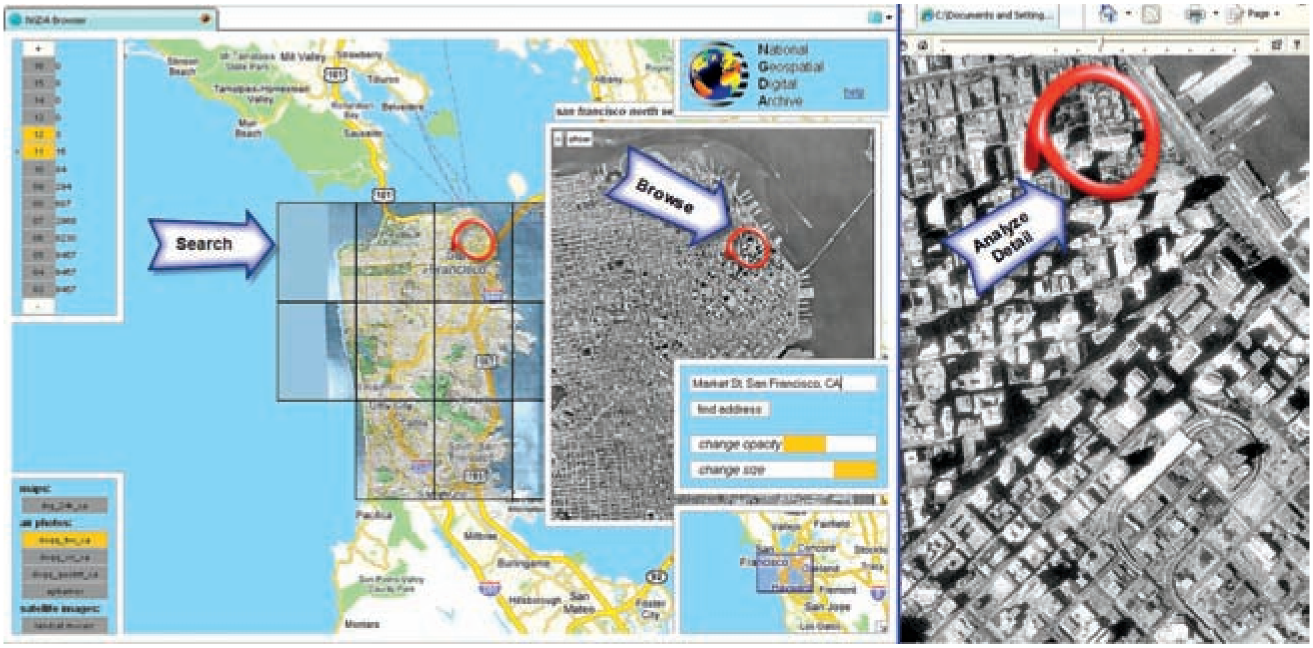



FIG. 470. ONLINE CATALOG INTERFACE FOR SEARCHING DIGITAL GEOSPATIAL DATA. National Geospatial Digital Archive at the Map and Imagery Laboratory, Davidson Library, University of California, Santa Barbara, 2007.

Image courtesy of Larry Carver.

stead, access to map series was often by means of paper index maps marked up to show local holdings.

With the addition of digital geospatial data to map collections from the 1980s onward (data that were rapidly increasing in both number of files and amount in bytes), the need for item-level cataloging became increasingly acute. Many map libraries continued to catalog at series or flight level but began to place scans of graphic indexes online; examples included the map indexes of the Earth Sciences & Map Library at the University of California, Berkeley, and the air photo flight indexes of the Map & Imagery Laboratory, UCSB. Map libraries without fully cataloged paper maps were suddenly confronted with the need to catalog large amounts of digital geospatial data. The challenge was considerable, because cataloging digital geospatial data was significantly more time consuming than cataloging hard-copy geospatial items.

While map library users and staff were in complete agreement about the utility and importance of making cartographic items available in digital form and preferably online, map libraries experienced some problems associated with the collection of digital files. One was that files of digital geospatial data were much larger than text files, meaning that a map library's requirements for computer disk space were much larger than other library departments. It was common for files of digital geospatial data to range from ten megabytes to several hundred megabytes. Large file size became even more critical in the world of the web as map libraries, horrified by the short life span of internet addresses (URLs) and the disappearance of files with them, began to change from merely pointing at a web location of a file to downloading files of greatest interest and saving them to local disks.

All libraries experienced a constant tension between ensuring preservation of materials and providing information to users. Circulation of single-sheet paper and film materials inevitably accelerated the physical aging of the materials loaned out, so relatively few map libraries circulated maps and aerial photographs. Even though sleeving or encapsulating maps in polyester film could considerably lessen handling damage, only 36 percent of map libraries circulated their maps in the late 1980s (Cobb 1990, xiii–xiv). Interlibrary loan of paper maps and images on film was the exception rather than the rule. Short print runs meant that maps typically went out of print quickly, while original film aerial photographic negatives were one of a kind. Hard copies could be made and mailed, but cost was a factor even though the photographic and photostat copy services standard during the early twentieth century had given way by the 1960s to cheaper photocopying processes (black-and-white, later joined by large-format and/or color). Concerns about mailing or copying irreplaceable maps were rapidly lowered in the 1980s as technology made it possible to send digital files instead, but digital files presented other preservation problems.

On the positive side, digital files could be reused frequently without damage, and files were relatively easy to replace if bit rot occurred. The ability to safely send a digital copy of a cartographic item through the mail on a CD-ROM or DVD or over the web changed map-library practices. It became common to scan and send public domain or otherwise out-of-copyright paper maps to requestors instead of placing the hard copies in the mail.

On the other hand, the preservation of digital geospatial data became a serious problem for map libraries. The necessity of regular and frequent backups of digital data and of migrating digital data from one digital medium to another before the first medium became obsolete presented difficulties. All too often a map librarian became aware too late that a digital file had become unusable. Digital image files usable only with certain application software, in turn usable only with a certain operating system, doomed many CD-ROMs to the recycle bin after one or both became unavailable. Although paper products deteriorate over time, such deterioration tends to be slow and apparent to the naked eye. The same cannot be said of digital files, which have to be opened up in order to determine the health of the file.

It would have been highly unusual for any map library to copy every one of its paper maps once a month, keep three or four versions of each in case the most current version should prove faulty (and the fault faithfully copied for the last several versions), and then throw out any copies more than four versions back. It was an onerous task to periodically check digital files for file deterioration (using, for example, the comparisons of checksums at different times for each file), and, when file deterioration had occurred to hunt through backup tapes to find a copy of the file in its original condition. Yet these procedures became standard practice in backing up digital geospatial files on hard drives.

Aerial photographs, usually 9 × 9 inch (23 × 23 cm) in hard copy in the United States, were small enough to be well suited to viewing in digital form on a computer. They required only the simplest image processing software to enlarge, reduce, pan, and change properties (e.g., change contrast or convert scan of negative to a positive image). However, preferences for using other cartographic objects in hard copy remained valid, based as they were on the limits of the human senses. It was much more informative to view, touch, and turn a three-dimensional globe than to watch a video of a whirling globe on a computer monitor. With large maps and atlases, the benefits of hard copy over digital format were less obvious and came as a surprise not only to users but also to map librarians. Small printed maps, such as the 8.5 × 11 inch (22 × 28 cm) maps of individual countries issued by the U.S. Central Intelligence Agency, were well suited to online viewing of the entire map. Being in the public domain, they became the mainstay of websites, such as that of the Perry-Castañeda Library's Map Collection at the University of Texas at Austin. However, viewing a scan of a map substantially larger than the size of a standard computer monitor, as the majority of paper maps were, proved to be unexpectedly difficult for the user. At the start of a viewing session, the entire map appeared as a very small image that the user usually enlarged immediately with the aim of viewing the area of interest in greater detail. Soon the enlargement reached a point where either the scan showed insufficient detail because of the small file size (to ensure quick accessibility over the web) or the user no longer had sufficient context for the small geographical area shown on the screen. Paper maps were designed to be viewed as a whole; even a viewer interested in only one small area of a given map would normally use the entire map as context. By the early 2000s map libraries began to consider obtaining large (4 × 3 ft) screens that could be rotated to match the orientation (landscape or portrait) of a given map to assist users in viewing scans of large maps.

The same problem did not arise with born-digital materials designed to be viewed on a computer. The layers or "coverages" of GIS data sets were constructed in digital form to enable users to view a small area at a time. Other important aids for viewing digital cartographic images were the floating scale and the north arrow, the latter especially useful for viewing items not oriented with north at the top, such as some aerial photographs.

It was also a surprise that digital atlases, popular for home use online or on disc, were not, after the initial novelty, of much interest to users in libraries. There, paper atlases continued in frequent use and even large atlases were often checked out (despite their considerable size and weight), as evidenced by the frequent necessity to rebind worn copies.

Map libraries around the world entered the twenty-first century in a major period of transition as they sought to maintain both their hard-copy collections and quickly expanding digital collections, often with staffing levels the same as, or lower than, the days when maps were solely hard copy. When the online catalog listings of a map library's holdings were incomplete, as was often the case, it was impossible to search for map holdings without consulting staff members working in the map collection. Also, the majority of map library users still needed reference assistance to identify the best maps for different purposes and to interpret map features (Millea 2005, 65, 72–73). Map libraries routinely had web pages and were providing users with digital geospatial data, but their collections of hard-copy cartographic items remained popular with users, especially when copyright restrictions prevented scanning the hard-copy item or when the digital equivalent was difficult to use. As the twenty-first century dawned such hybrid map libraries seemed likely to persist, unless the attention of researchers, hitherto focused on developing digital technology, were to shift toward solving the human-factor problems of viewing geospatial data in digital format.

MARY LYNETTE LARSGAARD

SEE ALSO: Antiquarian Maps and Grand Larceny; Digital Library; Libraries and Map Collections, National; Public Access to Cartographic Information; Societies, Map Librarianship

BIBLIOGRAPHY:

Anderson, Ottilia C. 1950. "No Best Method to Catalog Maps." *Library Journal* 75:450–52.

Carrington, David K., and Richard W. Stephenson, comps. 1978. *Map Collections in the United States and Canada: A Directory*. 3d ed. New York: Special Libraries Association.

Cobb, David A., comp. 1986. *Guide to U.S. Map Resources*. Chicago: American Library Association. 2d ed., 1990.

Espenshade, Edward Bowman. 1950. "No One Source for Acquiring Maps." *Library Journal* 75:431–36.

Fairclough, R. H. 1972. "Original or Facsimile." *New Library World* 73:291–94.

Felland, Nordis Adelheid. 1950. "Periodical Aids to Map Acquisition." *Library Journal* 75:438, 488.

Hooker, Ruth H. 1950. "Maps in the Library (Foreword)." *Library Journal* 75:429.

International Federation of Library Associations (IFLA). Geography and Map Libraries Sub-Section., comp. 1976. *World Directory of Map Collections*. Ed. Walter W. Ristow. Munich: Verlag Dokumentation.

———. 1986. *World Directory of Map Collections*. 2d ed. Ed. John A. Wolter, Ronald E. Grim, and David K. Carrington. Munich: K. G. Saur.

———. 1993. *World Directory of Map Collections*. 3d ed. Ed. Lorraine Dubreuil. Munich: K. G. Saur.

———. 2000. *World Directory of Map Collections*. 4th ed. Ed. Olivier Loiseaux. Munich: K. G. Saur.

Larsgaard, Mary Lynette. 1998. *Map Librarianship: An Introduction*. 3d ed. Englewood: Libraries Unlimited.

Millea, Nick. 2005. "Map Library Usage in Europe: A Vision for the Future? An Assessment of a Questionnaire Conducted during the Summer of 2003." *Journal of Map & Geography Libraries* 1, no. 2:51–83.

Special Libraries Association. Geography and Map Division. Map Resources Committee. 1954. *Map Collections in the United States and Canada, a Directory*. New York: Special Libraries Association.

Thiry, Christopher J. J., ed. 2006. *Guide to U.S. Map Resources*. 3d ed. Lanham: Scarecrow Press.

Wolter, John A. 1973. "Geographical Libraries and Map Collections." In *Encyclopedia of Library and Information Science*, ed. Allen Kent et al., vol. 9, 236–66. New York: Marcel Dekker.

Yonge, Ena L. 1950. "How This Maps Feature Came into Being." *Library Journal* 75:430.

***Libraries and Map Collections, National.*** During the twentieth century, national map collections, usually located in national libraries, took shape and developed specific characteristics. The nineteenth century had witnessed the first such foundations: in 1828 of the Département de géographie de la Bibliothèque royale (Paris); in 1844 of the collection at the British Museum (London) that would become the Department of Maps and Charts; in 1859 of the Kartenabteilung in the Königliche Bibliothek (Berlin); and in 1897 of the Hall of Maps and Charts in the main building of the Library of Congress (Washington). In some countries, the national collection of maps developed within the national archives, as was the case, notably, in Canada. In other countries the map collections in the national archives, although important, did not have the priority of acquiring new cartographic publications. The maps in national archives often came from archived document series, from which they were extracted for separate storage suited to cartographic formats. In some countries the national libraries were also university libraries. In any case, it was not possible for national map collections to be exhaustive. They were usefully complemented by map collections in other institutions for which national directories of map libraries, which were compiled and published during the twentieth century, served as useful finding aids.

The continuing development of mapmaking and publishing throughout the twentieth century enabled national map libraries to collect increasing quantities and varieties of maps, ranging from topographic series to thematic maps, and place them at the disposal of researchers. Maps became incorporated into national publication distribution networks because entries for cartographic publications were included in the bibliographies (or bibliographical supplements) often published by national libraries (Bell 1998) and, more recently, in the databases of those libraries. National libraries also valorized their older map holdings by continuing acquisition of older maps, by mounting exhibitions, and by publishing studies and catalogs. Such activities by national map libraries facilitated the growth of the history of cartography as a field of study during the twentieth century.

The difficulties of storing the various cartographic formats led national libraries to form special map departments with the capacity to store material ranging from large sheet maps and atlases to fragile and cumbersome three-dimensional objects, such as globes and topographic models. In several national libraries, however, manuscripts departments still retained manuscript maps. For example, the Map Library of the British Library (the name changed from Map Room to Map Library when the British Library (BL) separated from the British Museum in 1973) included the Geographical Collection of King George III (Topographical Collection and Maritime Collection) of printed and manuscript maps and views, as well as the national collection of printed maps, but most of the BL's manuscript map holdings remained in the Department of Manuscripts.

During the twentieth century the names of other national map libraries also reflected administrative changes. In France the Département de géographie of the Bibliothèque nationale (BN) became the Département des cartes et plans, while at the Library of Congress (LC), the Hall of Maps and Charts became the Geography and Map Division in 1965. Maps and prints were sometimes brought together, as was the case in Brazil and Bulgaria, while institutions in Latin America (Chili, Cuba, Mexico, and Peru) tended to adopt the name Mapoteca Nacional.

The cartographic departments of national libraries became leaders and coordinators of activities connected with their work: adaptation of sites for preservation and consultation of documents in different formats; establishment of policies regarding the acquisition and cataloging of cartographic documents; publication of catalogs and map bibliographies; active participation in specialized associations (ranging from the International Federation of Library Associations and Institutions [IFLA] to national and regional associations of librarians, geographers, and cartographers); and support of research in the history of cartography.

National map collections are inventoried in the four editions of the *World Directory of Map Collections*, drawn up by the Section of Geography and Map Libraries of the IFLA and published in 1976, 1986, 1993, and 2000 (Loiseaux 2000). It is difficult to summarize their evolution, but a few selected examples will show how conservation has often been combined with innovation.

Progress in the conservation and copying of cartographic documents reflected the concern of curators to prevent their degradation. At the LC, Clara Egli Le Gear conducted one of the first studies on the subject (1949, 1956). Meanwhile Myriem Foncin at the BN in Paris saw through to completion a project delayed by World War II, the installation of the Département des cartes et plans in a new, and what was hoped to be exemplary, site (Foncin 1954). It is interesting to compare the storage solutions adopted by the two institutions: drawers (LC) versus portfolios (BN) and special treatment at the BN for large-format maps and portolans, both valuable and numerous in that collection. However, both libraries adhered to the basic principle of flat storage for the majority of maps and for large-format atlases. Special storage facilities for large formats remained a major objective of map librarians.

The greatest change during the twentieth century was the way cartographic materials were consulted. Prior to World War II photostats and printed facsimiles on paper served as surrogates and broadened access to cartographic material. The postwar shift to photographic reproduction on microfiche and microfilm was followed by end-of-the-century projects to create digital images of map holdings, either from existing microformat copies or from the paper originals, and to provide access to them on the Internet. Along with deciding whether to acquire paper or digital formats when building current map collections, map librarians faced the question of whether digital reproductions of older cartographic materials would replace costly paper facsimiles.

Technical issues were debated in professional meetings organized by the IFLA and its national counterparts during the twentieth century. Map librarians from national libraries who were instrumental in founding national organizations included Le Gear (LC) and the Geography and Map Division of the Special Libraries Association, founded in 1941; Helen Wallis (BL) and the Map Curators' Group of the British Cartographic Society, founded in 1966; and Monique Pelletier (BN) and the Commission documentation du Comité français de cartographie, founded in 1981. The Groupe des cartothécaires (Map Curators Group) of the European Ligue des Bibliothèques Européennes de Recherche (LIBER) was founded in 1980 by map curators, many of them from European national libraries, and membership was progressively expanded to Eastern and Central Europe. Meetings and seminars, combining visits to map collections with reports on advances in administering map collections, flourished in Europe and America during the second half of the twentieth century.

National collections typically acquire cartographic materials by gift, purchase, or legal deposit. Acquisition by gift or purchase of older public or private collections brought spectacular growth to many map libraries during the twentieth century. For example, in 1924 the BN received from the Ministry of Foreign Affairs 8,700 maps collected by eighteenth-century geographer Jean-Baptiste Bourguignon d'Anville and in 1942 and 1947 25,000 maps from the Service hydrographique de la Marine. The British Museum Library's acquisition in the 1960s of drawings compiled by Ordnance surveyors in the first half of the nineteenth century complemented its collection of published Ordnance Survey topographic map series. After World War II, the transfer of superseded maps from military agencies became another major mode of acquisition at both the BL and LC. However, legal deposit remained one of the main sources of growth for national map collections. The twentieth century witnessed the creation and modification of numerous laws relating to copyright of published material, which often specified the deposit of maps, plans, globes, atlases, and nautical charts (Jasion 1991). Maintaining relations with establishments that produce cartographic documents and are concerned with their preservation became one of the accepted missions of national collections.

Philip Lee Phillips, who had been appointed the first superintendent of maps at the LC in 1897, maintained that the cataloging of maps differed little from that of books. However, his nine-volume atlas catalog, *A List of Geographical Atlases in the Library of Congress, with Bibliographical Notes* (Phillips 1909, 1914, 1920), continued by Le Gear (1958, 1963, 1973–74, 1992), revealed the limitations of his approach in its requirement for constant updates. Taking a different approach, late twentieth-century compilers of collective catalogs and map bibliographies tended to limit the geographical and chronological coverage, such as to atlases published in a certain country during a particular period. However, such researchers were reliant upon the assistance of curators and the availability of good-quality reproductions in order to identify maps from different map collections and construct their cartographic genealogies. That need provided impetus for the progressive digitization of collections, an ongoing process in which national map collections became active in the late twentieth century.

At the same time directors of map collections were also collaborating to develop national and international standards for map cataloging in order to meet the requirements for automation of catalogs and bibliographies. The IFLA created a working group for the standardization of bibliographic descriptions of cartographic documents in 1973, which resulted in the *ISBD (CM) International Standard Bibliographic Description for Cartographic Materials* in 1977 and a revised edition in 1987. Hugo L. P. Stibbe and colleagues at the National Archives of Canada coedited the first edition of *Cartographic Materials: A Manual of Interpretation for AACR2* in 1982, while Elizabeth Unger Mangan of the LC edited the second edition (2003).

Although staff of national map collections routinely instructed readers how to access their modern cartographic holdings as well as their older ones, the historical depth and significance of national map collections also afforded curators with special opportunities to teach a broader range of audiences about the history of cartography. While displays for visiting groups might be small and informal, there were numerous large map exhibitions open to the public during the second half of the century. For example, the British Museum celebrated its bicentenary in 1953 with an exhibition (organized by R. A. Skelton of the Map Room and colleagues) of 235 items illustrating the history of mapmaking to the eighteenth century, and the BN celebrated the 1828 creation of its Département de géographie with an exhibition of 225 items, organized in 1979, concerning ten centuries of cartography. Curators also taught courses in the history of cartography, sometimes in collaboration with universities, such as the series inaugurated in 1989 by the Institut cartogràfic de Catalunya and the Département de géographie de l'Universitat autònoma de Barcelona. Curators also gave presentations at conferences, including meetings of the International Cartographic Association (1961–) and the International Conference on the History of Cartography (1964–), the latter often hosted by national map libraries. Curators also published articles in relevant journals, such as *Imago Mundi*, and contributed essays to festschrifts honoring former colleagues. In addition to national directories of map libraries, they contributed to more focused guides (e.g., Wallis and McConnell 1994). Curators from national libraries were also actively involved in the *History of Cartography* series, published by the University of Chicago Press (1987–).

During the twentieth century national map collections developed into much more than map repositories. As the century progressed, their curators promoted national and international collaboration to improve and standardize the methodology of map library administration, especially in regard to computerization of cataloging. They led the way in disseminating information about map collections through directories, catalogs, and cartobibliographies. While establishing connections with professional colleagues around the world, the staff of national map libraries also provided instruction, exhibitions, publications, and websites to attract and instruct the public and make cartographic information accessible to them. In addition to staying abreast of developments in modern mapping, national map collections became centers for the growth of the history of cartography as a field of study.

MONIQUE PELLETIER
(IN CONSULTATION WITH SARAH TYACKE)

SEE ALSO: Antiquarian Maps and Grand Larceny; Collecting, Map; Digital Library; Libraries, Map; Public Access to Cartographic Information; Societies, Map Librarianship

BIBLIOGRAPHY:

Bäärnhielm, Göran, Folke Sandgren, and Anders Burius, eds. 2003. *Accurata descriptio: Studier i kartografi, numismatik, orientalistik och biblioteksväsen tillägnade Ulla Ehrensvärd = Papers in Cartography, Numismatics, Oriental Studies and Librarianship Presented to Ulla Ehrensvärd*. Stockholm: Kungl. Biblioteket.

Bell, Barbara L. 1998. *An Annotated Guide to Current National Bibliographies*. 2d rev. ed. Munich: K. G. Saur.

Bracke, Wouter, ed. 2006. *Margaritae cartographicae: Studia Lisette Danckaert 75um diem natalem agenti oblata*. Brussels: Archives et Bibliothèques de Belgique.

Foncin, Myriem. 1954. "Les nouvelles installations du Département des cartes et plans de la Bibliothèque nationale." *Bulletin de l'Association des bibliothécaires français* 15:137–46.

Gestel–van het Schip, Paula van, and Peter van der Krogt, eds. 2007. *Mappæ Antiquæ: Liber Amicorum Günter Schilder*. 't Goy-Houten: HES & De Graaf.

Jasion, Jan T. 1991. *The International Guide to Legal Deposit*. Aldershot: Ashgate.

Le Gear, Clara Egli. 1949. *Maps: Their Care, Repair and Preservation in Libraries*. Washington, D.C.: Library of Congress. Rev. ed. 1956.

Loiseaux, Olivier, comp. and ed. 2000. *World Directory of Map Collections*. 4th ed. Munich: K. G. Saur.

Wallis, Helen, and Anita McConnell, eds. 1994. *Historians' Guide to Early British Maps: A Guide to the Location of Pre-1900 Maps*

*of the British Isles Preserved in the United Kingdom and Ireland*. London: Royal Historical Society.
Wallis, Helen, and Arthur H. Robinson, eds. 1987. *Cartographical Innovations: An International Handbook of Mapping Terms to 1900*. Tring: Map Collector Publications in association with the International Cartographic Association.

***Lidar.*** Light detection and ranging (lidar) is an active remote sensing system that records the distance, or range, of a laser fired from a platform to the earth's surface. By converting the ranging data in different ways, accurate high-resolution elevation models can be created that represent bare ground, vegetation, or buildings in three dimensions. Lidar-derived products also include measurements of vegetation features such as canopy height, canopy closure, and biomass; structural features of urban areas such as building footprints; and three-dimensional city models.

A lidar system uses a laser to calculate the range from a sensor to a target. In simplest terms, a laser pulse is fired, hits a target, and is reflected back to the detector. Travel time of the laser pulse is recorded by a very accurate instrument. Total travel time is multiplied by the speed of light and divided by two to give the one-way distance from the reflected target to the sensor (Lefsky et al. 2002, 19). There are three general types of lidar systems: those that work over water (bathymetric lidar), those that work over land (terrestrial lidar), and those that sense the atmosphere (atmospheric lidar) (fig. 471). Because terrestrial lidar systems are the most common systems used for cartographic purposes, we focus on them here.

Lidar technology encompasses several disparate scientific discoveries and has several components that were developed independently. The main components of a lidar system are the laser, the inertial measurement unit (IMU), the Global Positioning System (GPS), the scanning mirror (for airborne laser scanners), and the onboard computer.

The invention of lasers is generally credited to Arthur L. Schawlow and Charles H. Townes. In 1954, they invented the maser (microwave amplification by stimulated emission of radiation). In 1958, they theorized about a visible laser (light amplification by stimulated emission of radiation) that used infrared or visible light instead of microwave radiation. Schawlow and Townes demonstrated that a specific wavelength of light could be concentrated into a very coherent narrow beam and aimed at a target.

The history of laser ranging began in 1964 when the National Aeronautics and Space Administration (NASA) launched the Beacon-B satellite. This was followed by a mission to determine the distance from the earth to the moon by firing a laser beam from the earth to a reflector placed on the moon during the Apollo 11 mission and then calculating the range, or distance. Laser altimeter systems, the predecessors of lidar, were flown on the Apollo 15, 16, and 17 missions to record the moon's surface topography. Since the 1960s, a global network of ground stations has measured ranges to satellite-borne reflectors, and satellite laser ranging is still an integral part of NASA's space geodesy program.

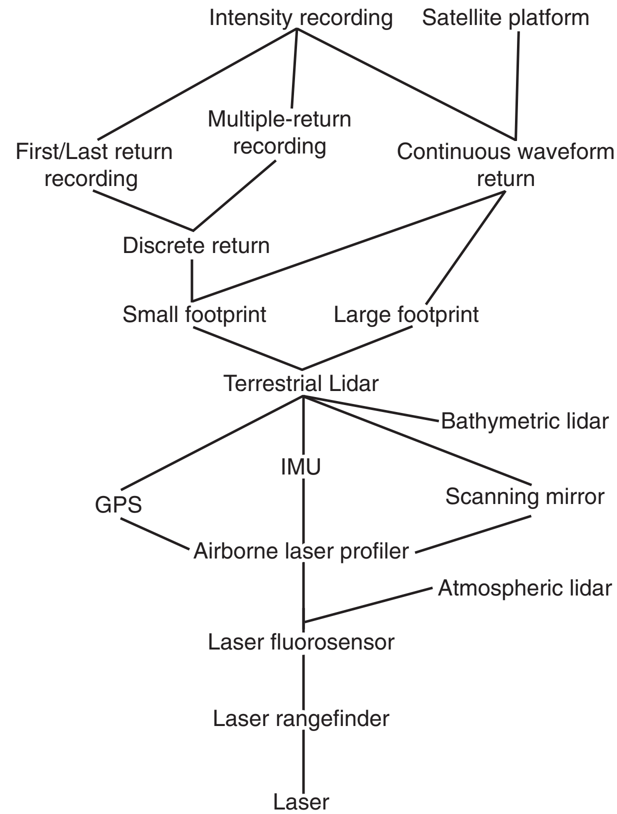



FIG. 471. HISTORY OF LIDAR DEVELOPMENT TREE.

In the 1980s, lasers were flown to create a single profile of the ground directly below aircraft. By the 1990s, laser scanners could collect a swath of laser data using a scanning mirror (Fowler 2001). Detectors could record the first, last, or multiple returns per laser pulse or could digitize the entire reflected laser pulse waveform. In the early 1990s, NASA's Goddard Space Flight Center began using large-footprint scanning continuous waveform systems to measure vertical vegetation structure and subcanopy topography in forests (Dubayah and Drake 2000).

In the 1990s, the development of position and attitude technologies enabled precise and accurate mapping with aerial lidar. The distance from the aircraft to the target could be accurately measured with the laser, but this distance was meaningless without a way to determine the position and attitude of the aircraft. Two additional components were necessary: the IMU and the GPS.

Inertial technology is based on two well-known laws of physics: an object spinning very rapidly will maintain its relative orientation, and on the earth, a rapidly spinning object typically aligns itself with gravity. IMUs contain rapidly spinning gyroscopes inside a gimbal or cage. If the cage is attached and aligned to the laser head, the angle of the laser can be measured. IMUs also contain accelerometers to measure the velocity of the aircraft. Incorporating a high-precision clock and a way to measure angles, the accelerometer measures the speed and direction of aircraft movement. The IMU is usually composed of three accelerometers and three gyros, with electronics to record the data. The accelerometers are arranged in an orthogonal triangle that measures the force applied to the IMU. The gyros are similarly arranged and measure the angular movement of the IMU.

However, no accelerometer in use as of the beginning of the twenty-first century could remain accurate after long periods of movement; directional accuracies start to drift with travel time. The GPS was incorporated into the lidar system as a way to periodically reset and update the accelerometer's true position.

During the late 1950s and early 1960s, the U.S. Navy sponsored two satellite-based navigation systems, Transit and Timation. At the same time, the U.S. Air Force was conducting studies on a system called System 621B. In April 1973, the Air Force was asked to combine Timation and 621B into a single Defense Navigation Satellite System. From this emerged the Navstar (Navigation System with Timing and Ranging) GPS. In February 1978, the first operational Navstar satellites were launched. Civilian access to the GPS signal was formally guaranteed in 1984. The GPS constellation of twenty-four satellites was declared to be in initial operation in December 1993 and in full operation in July 1995 (French 1996, 15–17).

GPS operates on the principle of trilateration, in which the position of an unknown point is determined by measuring the lengths of the sides of a triangle between the unknown point and two or more known points (the satellites). Each satellite transmits a unique radio signal code. A GPS unit on the ground receives a signal from every satellite in range and measures the time it takes for each signal to travel to the receiver. The distance to each satellite is then computed and the receiver's position can be determined.

Over the past forty years, the use of lidar sensors and data has transitioned from research and development into a cost-effective means of generating dense, accurate digital models of topography and associated features (fig. 472). Lasers can pulse up to 150,000 times per second and record multiple returns per pulse. As of the beginning of the twenty-first century, waveform systems were primarily restricted to the NASA research sector, but their public use is increasing. Improvements in GPS and IMU technology enable more accurate calculations of position and attitude.

FIG. 472. LIDAR IMAGE FOR AN AREA IN SOUTH DAKOTA. A combination of elevation and laser intensity information from lidar data collected in 2005 over the U.S. Geological Survey EROS Center, Sioux Falls, South Dakota.
Image courtesy of Jason M. Stoker.

Lidar allows rapid, cost-effective, accurate mapping of linear corridors such as power utility rights-of-way, gas pipelines, railroads, highways, and telecommunications. A survey that would take months with ground instruments can be completed in hours using lidar. Results vary, but generally lidar provides very accurate elevations: within or better than fifteen to twenty centimeters in the vertical and around fifty centimeters (depending on operating conditions) in the horizontal (Stoker et al. 2006, 613). For many cartographic applications, lidar systems are deployed in conjunction with other sensors, such as aerial film or digital cameras, multi- or hyperspectral scanners, or hybrid imagery.

Lidar is a more flexible way to obtain bare earth elevation models in forests than photogrammetry or extensive ground surveys. Because it can record multiple returns of the laser pulse, airborne lidar, unlike radar or satellite imaging, can simultaneously map the ground beneath the tree canopy as well as tree tops. Lidar has been used for estimating forest biomass and timber volume. Lidar surveys are cost-effective in areas of limited contrast and width, such as beaches and coastal zones, where traditional photogrammetry is difficult to employ. Lidar has improved flood models by more accurately delineating watersheds and yielding the friction coefficients over the floodplain. As part of its Map Modernization plan, the Federal Emergency Management Agency (FEMA) began using lidar to create digital flood insurance rate maps (DFIRMs) for the National Flood Insurance Program (NFIP). These are just a few examples. New applications are appearing every day.

Lidar has become the technology of choice for rapid, accurate three-dimensional mapping. Contour lines and spot elevations that were once derived from stereo photogrammetry can now be measured directly with lidar. Information about the structure of vegetation canopies and models of urban buildings are also important products of lidar. In the past, cartographers portrayed a three-dimensional world solely on flat paper. Lidar enabled them to create immersive, interactive, three-dimensional representations that vividly depict the real world.

JASON M. STOKER AND SUSAN K. GREENLEE

SEE ALSO: Hazard and Risk, Mapping of; Hydrographic Techniques: Sounding; Photogrammetric Mapping: (1) Feature Extraction and Photointerpretation; (2) Orthophotography and Orthophoto Mapping; Remote Sensing: Data Handling and Information Extraction from Remotely Sensed Imagery; Terrain Analysis and Cartography

BIBLIOGRAPHY:

Dubayah, Ralph O., and Jason B. Drake. 2000. "Lidar Remote Sensing for Forestry." *Journal of Forestry* 98, no. 6:44–46.

Fowler, Robert. 2001. "Topographic Lidar." In *Digital Elevation Model Technologies and Applications: The DEM Users Manual*, ed. David F. Maune, 207–36. Bethesda: American Society for Photogrammetry and Remote Sensing.

French, Gregory T. 1996. *Understanding the GPS: An Introduction to the Global Positioning System, What It Is and How It Works.* Bethesda: GeoResearch.

Froome, K. D., and L. Essen. 1969. *The Velocity of Light and Radio Waves*. London: Academic Press.

Lefsky, Michael A., et al. 2002. "Lidar Remote Sensing for Ecosystem Studies." *BioScience* 52:19–30.

Schawlow, Arthur L., and Charles H. Townes. 1958. "Infrared and Optical Masers." *Physical Review*, 2d ser., 112:1940–49.

Stoker, Jason M., et al. 2006. "CLICK: The New USGS Center for Lidar Information Coordination and Knowledge." *Photogrammetric Engineering & Remote Sensing* 72:613–16.

***Linguistic Map.*** The term *linguistic map* encompasses two broad categories: maps that show the distribution of the different language communities in a region and those that help the reader visualize linguistic variety within a language area. The former offer a more comprehensive approach to the geography of language and can be called *ethno-linguistic maps*, whereas the latter document the spatial patterns of specific linguistic phenomena and can be called *dialect maps*.

## Ethno-linguistic Maps

Because it is more difficult to discern variation within a language than between languages, the dialect map is more recent than the ethno-linguistic map. The first maps delineating areas inhabited by speakers of different languages emerged in the sixteenth century, and the first scientifically systematic linguistic maps appeared in the eighteenth century. Ethno-linguistic mapping flourished in nineteenth-century Europe in response to multiethnic empires like Austria-Hungary as well as the rise of nationalism in the early nineteenth century and the appearance of censuses in which inhabitants were asked to state their mother tongue. An example of language mapping as a form of nationalism is the map of the Slavonic peoples of Europe, published in 1842 in Prague by Pavel Jozef Šafárik, *Slovanský zeměvid*. An example of state-inspired language-mapping based on censuses is the 1855 ethno-linguistic map of the Habsburg Empire, *Ethnographische Karte der Österreichischen Monarchie*, 1:864,000, by Karl von Czoernig.

When the era of multiethnic empires drew to a close early in the twentieth century, and language maps were used to determine the boundaries—or indeed the fate—of nation-states, it became common to show one's own language group as covering as large an area as plausible. What might be termed map wars ensued when parties to the post–World War I peace conferences at Versailles exchanged maps that favored their own claims with vivid colors backed by biased methodologies.

This type of linguistic map evolved from simple qualitative maps showing the extent of language areas, which often overlapped neighboring linguistic regions, to quantitative maps based on census results and using color tints in various intensities to show in increasing detail—for countries, provinces, judicial districts, and individual municipalities—the percentages of the population speaking a specific language. Color symbols also allowed the joint portrayal of two or more languages on a single map. Mixed areas, urban agglomerations, and uninhabited areas posed problems of graphic complexity and cartographic reliability, as did the presence of language minorities, often dealt with by representing them on a separate map or with colored outlines.

Aside from the challenge of representing different percentages of different nationalities living in the same area there was the added factor of different religions. This problem was particularly acute in the Balkans, home to Catholic and Orthodox Serbo-Croatian-speaking communities, Muslim and Christian (Gagauz) Turkish peoples, and Orthodox and Muslim (Pomaks) Bulgarians, among others. Because the various religions could be classified together with major language groups in diverse ways—for example, the Pomaks could be included with either the Bulgarians or the Turks—a variety of different ethno-linguistic maps were possible. This potential complexity and conflicting political motives account for the many language maps of this area produced since the 1850s showing different distribution patterns (Wilkinson 1951).

Cartographic refinements introduced between 1900 and 1920 also took account of uninhabited areas, a category that included very sparsely inhabited territory as well as areas occupied only seasonally, such as parts of the otherwise uninhabited Carpathian mountains visited in summer by Romanian shepherds. In the latter case, sparse seasonal occupancy by shepherds and their sheep had been sufficient to show the entire Carpathian mountain range as Romanian-speaking. In 1920 the geographer Count Pál Teleki, twice prime minister of Hungary (1920–21 and 1939–41), addressed this issue on his ethnographical map of Hungary by making colored areas proportional to the number of speakers of a specific language group (figs. 473 and 474). Similar in principle to the value-by-area cartogram, every colored square millimeter on his 1:1,000,000 map denoted 100 inhabitants. Gradually the notion took hold that population density should be taken into account in order to present a meaningful image of the distribution of speakers of different languages. Recognition that population cartograms could play a decisive role in visualization led to the search for other methods, but this came too late for Hungary, which lost many areas predominantly inhabited by urban Hungarians in spring 1920 at the peace negotiations in Trianon, on the palace grounds at Versailles, where Allied cartographers reconfigured the country's boundaries using qualitative choropleth maps showing presence or absence rather than intensity.

Soviet ethno-linguistic cartography from the 1930s onward recognized the significance of population density. Areas densely and more or less continuously occupied by a specific language group were shown by color that filled the area, while linguistic minorities inhabiting intervening territory were indicated by open colored point symbols. In sparsely settled areas, only colored point symbols were used. Soviet ethno-linguistic maps (as, for instance, the *Karta narodov SSSR* 1:5,000,000, 1951) distinguished three levels of habitation: uninhabited areas (left white), sparsely settled areas (shown in gray), and more densely settled areas (shown with colored bands for four classes—under 40, 40–60, 60–80, and over 80 percent).

A later refinement, possibly inspired by the work of Teleki, occurred in the 1940s, when Wilfried Krallert produced 1:1,000,000 language maps of Eastern and Southeastern Europe for the German army using the International Map of the World, 1:1,000,000, as a base map. Language communities were represented using the dot map technique instead of quantitative or qualitative choropleth methods with their boundaries based on administrative subdivisions. Here the resulting images of the patterns were no longer defined by administrative boundaries, and density variation was taken into account as well. Krallert also gave special attention to the base map, which in his view should also act as an explanation of the distribution of the different language communities. He included the hydrography in blue and the contour lines and names printed in gray. He included religious affiliation, shown using differently shaped symbols such as crescents for Muslims and squares for Orthodox Christians (fig. 475). The prime issue remained the use of color, which usually favored the language community that produced the map.

Geographer Henry Robert Wilkinson, in his 1951 study of ethnic mapping in Macedonia, and Krallert, in a 1961 article, stressed the importance of data collection. Differences in the relative prominence of specific language groups, as shown by consecutive censuses, could depend heavily on the phrasing of questions about nationality and language. Nationality could be loosely self-identified or tied to parentage, place of birth, or the dominant nationality of the neighborhood or village, whereas the language enumerated in the census could reflect the respondent's colloquial language used at home or the more formal language used outside the home in business, education, and dealings with public authorities. In a bi- or trilingual area, how the question was asked was no less important than the fear of possible political repercussions.

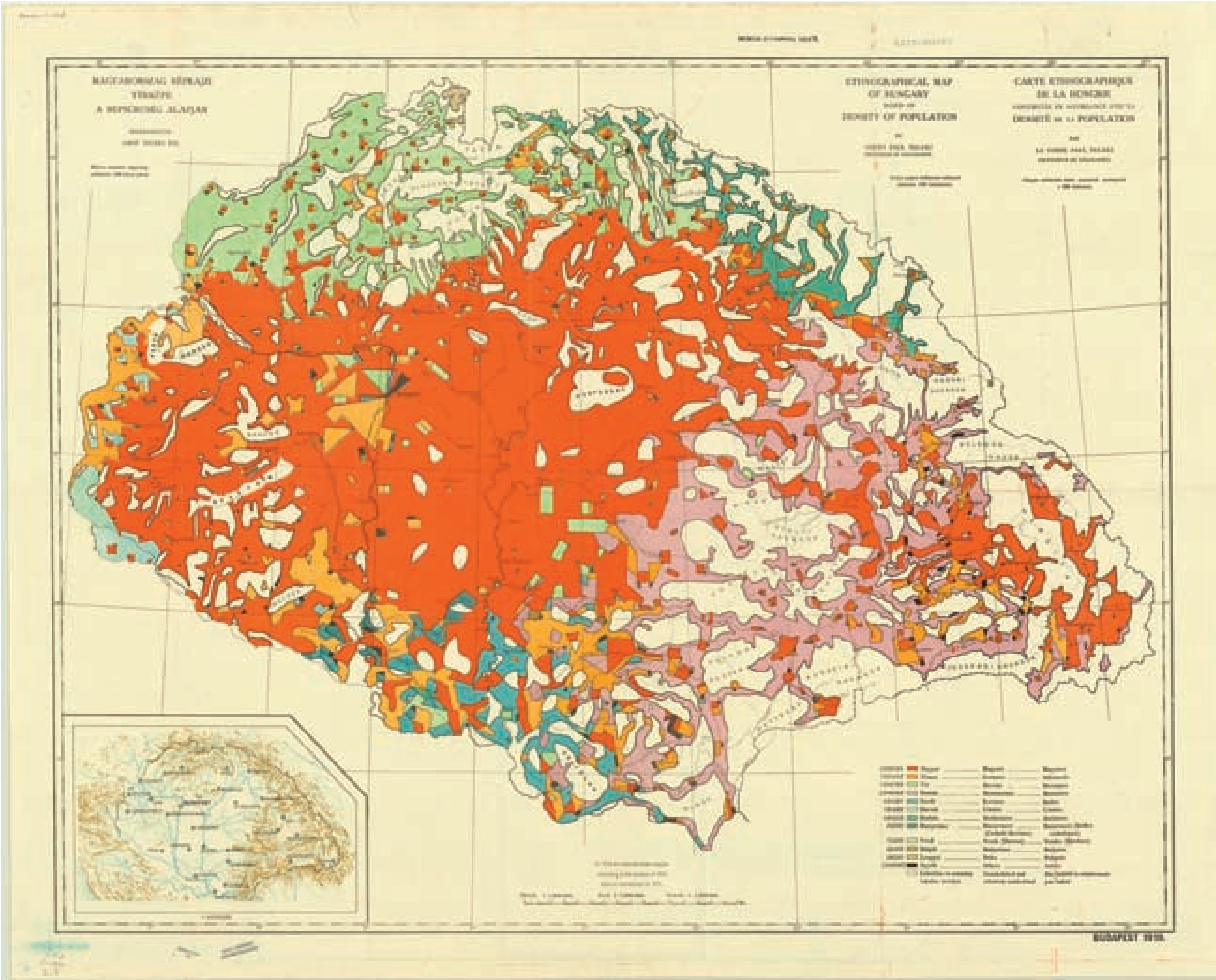


FIG. 473. PÁL TELEKI'S ETHNOGRAPHICAL MAP OF HUNGARY ACCORDING TO THE 1910 CENSUS. On Teleki's *Magyarország néprajzi térképe a népsűrűség alapján* (Budapest, 1919), one square millimeter represents 100 speakers of a specific language.

Size of the original: 65.7 × 83.7 cm. Image courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.


FIG. 474. LEGEND FROM FIGURE 473.
Size of detail: 9.5 × 17.8 cm. Image courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

## Dialect Maps

Linguistic maps showing variation within a language did not emerge until the second half of the nineteenth century, when scholars in Europe began to systematically collect information on dialects. For their planned "Sprachatlas des Deutschen Reichs," Georg Wenker and Ferdinand Wrede collected data on sounds and forms of words between 1876 and 1887 from over 45,000 locations and produced manuscript maps for the atlas between 1888 and 1923. Eventually Walther Mitzka and Bernhard Martin published generalized versions of Wenker's maps in their *Deutscher Sprachatlas* (1927–56). Jules Gilliéron initiated research in France on spatial differences in dialects, and his colleague Edmond Edmont

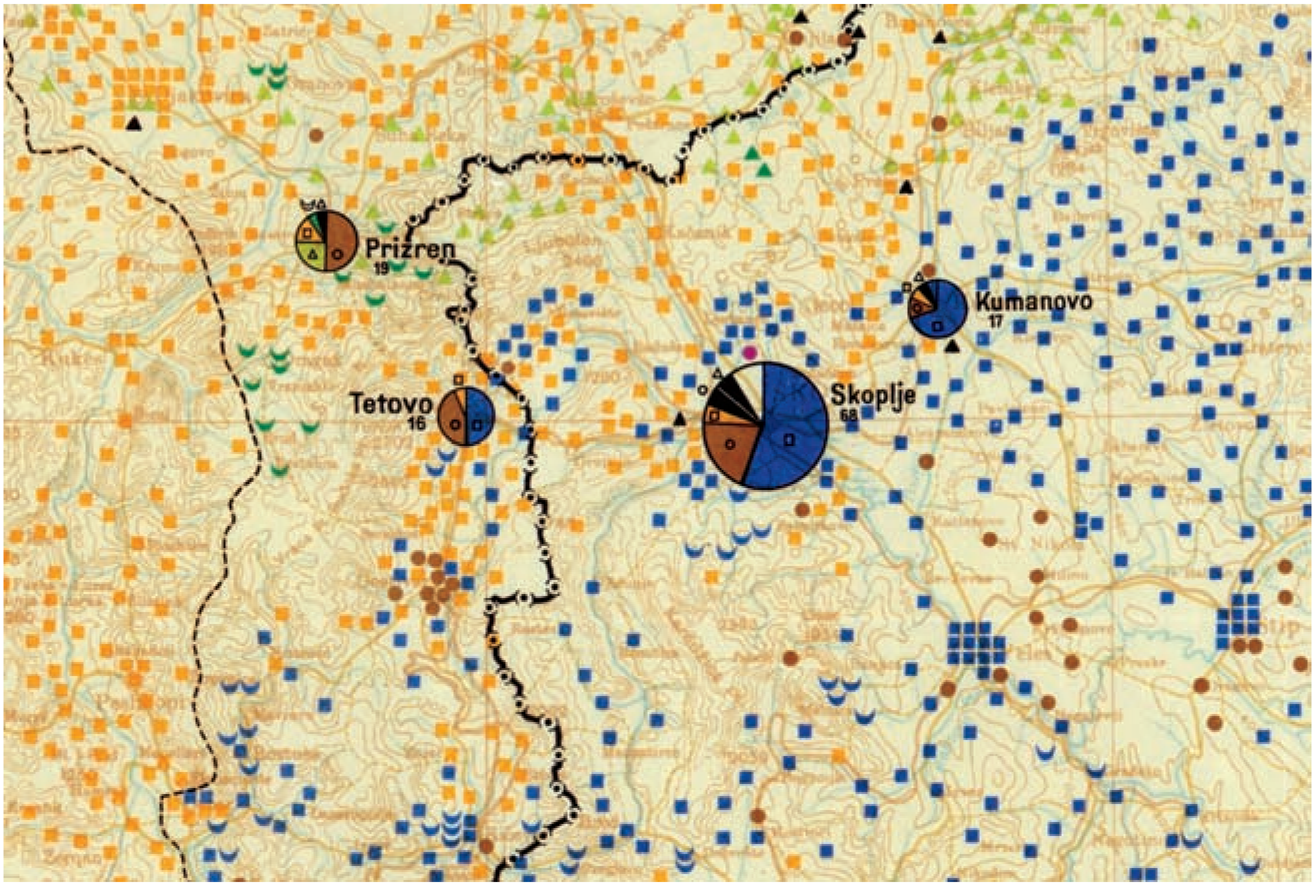



FIG. 475. DETAIL FROM THE *WELTKARTE 1:1,000,000 SONDERAUSGABE VOLKSTUM*. Vienna, 1943, by Wilfried Krallert, sheet K 34, *Sofia*.

Size of the entire original: 57.6 × 53.8 cm; size of detail: 11.6 × 17.3 cm. Image courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

collected and checked the dialect data for the 600 locations he had selected. Together they published the *Atlas linguistique de la France* (1902–10). Jakob Jud and Karl Jaberg used the methods pioneered by Gilliéron for their *Sprach- und Sachatlas Italiens und der Südschweiz* (1928–40).

Dialect mapping projects were massive endeavors requiring many years of data collection and many years of cartographic analysis and map production. Wenker initiated data collection by sending a questionnaire to the schoolmasters of all primary schools in Germany. The instrument contained sentences that had to be converted to the local dialect by someone the schoolmaster deemed representative of the dialect. The data thus collected were rendered on over 1,500 maps. The next step consisted of interpreting these maps, and plotting boundary lines known as isoglosses, which look like isolines but do not link points of equal value (Lameli 2010, 574–75). These maps are based on the assumption that language varies spatially in a continuum of sorts so that individual changes in dialect—morphological, phonetic, syntactic, or semantic—can be represented cartographically. On a dialect map isoglosses thus serve as word boundaries, separating communities that use different words for the same concept, pronounce the same word differently, or reflect notable syntactical variations. Several isoglosses, each referring to a single linguistic variable, can coincide to form an isogloss bundle, which Wenker treated as a dialect boundary, useful in delineating distinctive speech areas. In this way linguistic maps describe the geographic extent of particular dialects, and the width of these isogloss bundles can be used to devise a hierarchy of dialect groups, useful in showing the geographic structuring of language across space (Kurath 1949). In the next step, Wenker combined related items or different words for the same concept on the same map. He also experimented with plotting word endings on transparent overlays so that the ensuing maps could easily be compared.

Gilliéron, who also used questionnaires to collect data, introduced the practice of using a single expert to collect and process the data, thereby guaranteeing greater uniformity than if schoolmasters or other laic data collectors were used, as Wenker had done. Gilliéron color-coded the results on the map and scrupulously documented the age, sex, profession, and other key traits of informants. And unlike Wenker, he used a phonetic transcription system.

Apart from selecting a phonetic notation system (usually the International Phonetic Alphabet), the project director needed an overall methodology that included a strategy for selecting informants who were representative of speech within the regional speech as well as a particular social level of interest to the researcher. Both Wenker and Gilliéron developed standard sentences that informants would render in accord with the local dialect as well as lists of concepts for which each informant was to supply a local word. When data were collected for the first German dialect atlas, the social standing of the informants had not been recorded.

In the United States, Hans Kurath, who initiated the systematic study of geographic variation in American English, was largely responsible for starting a series of atlases collectively known as the "Linguistic Atlas of the United States." He perpetuated the tradition of Gilliéron insofar as the latter's pupil Jud contributed to the theory and methodology of the first planned atlas, a pilot study of New England that evolved into the *Linguistic Atlas of New England* (1939–43), which in turn provided a model for later atlases covering the Middle and South Atlantic States, the North Central States, the Gulf States, the Upper Midwest, the Pacific Northwest, the Pacific Coast, and the American West. Kurath, who was well informed on the various European approaches to linguistic mapping, initiated fieldwork in 1931 to uncover geographical differences in grammar, vocabulary, and pronunciation. Fieldwork consisted of interviews—two per county—using informants who met strict requirements regarding their education and social status. The respondents were chosen to represent one of three categories—folk, common, and cultured—and also two age groups: aged/old-fashioned and middle-aged/modern. Because respondents had to have lived locally their entire life, researchers often sought out members of the oldest local families. In areas where data collection depended heavily on agricultural terms, the maps mostly reflected the speech of older respondents. In general, respondents were selected to provide an even geographic distribution representative of both older and more recent settlements within the region.

Each map in these American dialect atlases is either a lexical map showing the use of different words for the same thing (e.g., pants and trousers), a phonetic map showing the varying pronunciation of a particular word (e.g., "tom-ah-toe" rather than "tom-ay-toe") (fig. 476), or a morphological map contrasting differences in the grammatical forms or constructions employed in a given situation (e.g., "has" in contrast to "has got," as in "he has/has got warts"). All responses were recorded in phonetic notation on preprinted worksheets, and for each item mapped, the key word was stated, often with a description of context.

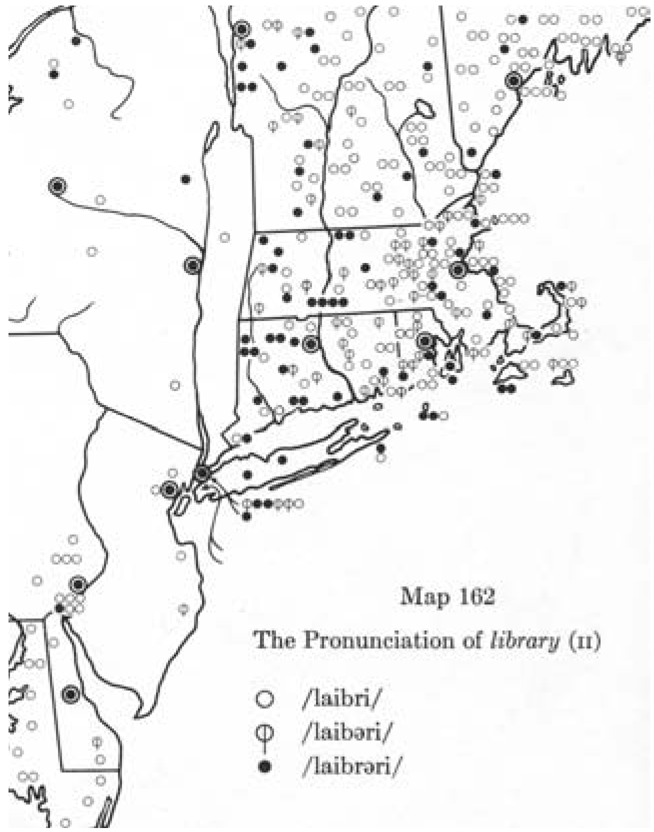



FIG. 476. DETAIL AND LEGEND FROM A 1961 LINGUISTIC ATLAS MAP. Three of five common pronunciations of "library." These three are especially common in New England and, except for "laibri," are relatively rare in the rest of the Atlantic states.
Size of the entire original: 22 × 19 cm; size of the detail: 10.9 × 8.5 cm. From Hans Kurath and Raven I. McDavid, *The Pronunciation of English in the Atlantic States* (Ann Arbor: University of Michigan Press, 1961), map 162.

Since the 1970s colors rather than isoglosses were used increasingly to visualize the occurrence of individual variables. At the century's end the investigation of other linguistic levels (syntax and morphology) had become more prominent (Lameli 2010, 582), and surveys no longer focused largely on nonmobile older rural males. Later American dialect atlas projects addressed linguistic differences related to ethnicity, race, and gender.

The influence of the computer became increasingly apparent in the collection, processing, and storage of the data as well as in their visualization. The *Atlas Linguarum Europae* (*ALE*), the first installment of which was published in 1975, was the largest and most ambitious linguistic atlas. Although its maps were computer plotted, rather than drawn by hand, from the 1980s onward, the main contributions of digital techniques were the interactive linguistic database, or language corpus, often available online, and the integration of data from diverse sources (as with the *ALE*). In addition, electronic scanning was providing fuller access to older material such as the Wenker atlas, notably through the Digital Wenker Atlas Project, in Marburg. And digital data were, of course, more readily amenable to statistical analysis. Electronic technology also offered increased efficiency in both data collection and the dissemination of examples of differences in pronunciation. For example, some data for the *Atlas of North American English* (Labov, Ash, and Boberg 2006) were collected by telephone, the maps for publication were generated electronically (e.g., fig. 477), and print, CD-ROM, and online versions were released in 2006. Moreover, as records of the first dialect surveys were being digitized, a second generation of studies, based on follow-up surveys and comparisons with previous data, was under way to examine dialect change.

FERJAN ORMELING

SEE ALSO: Ethnographic Map; Geopolitics and Cartography

BIBLIOGRAPHY:
Krallert, Wilfried. 1961. “Methodische Probleme der Völker- und Sprachenkarten dargestellt an Beispielen von Karten über Ost- und Südosteuropa.” *International Yearbook of Cartography* 1:99–120.
Kretzschmar, William A. 2003. “Linguistic Atlases of the United States and Canada.” In *Needed Research in American Dialects*, ed. Dennis Richard Preston, 25–48. Durham: Duke University Press for the American Dialect Society.
Kurath, Hans. 1934. “The Linguistic Atlas of New England.” *Proceedings of the American Philosophical Society* 74:227–43.

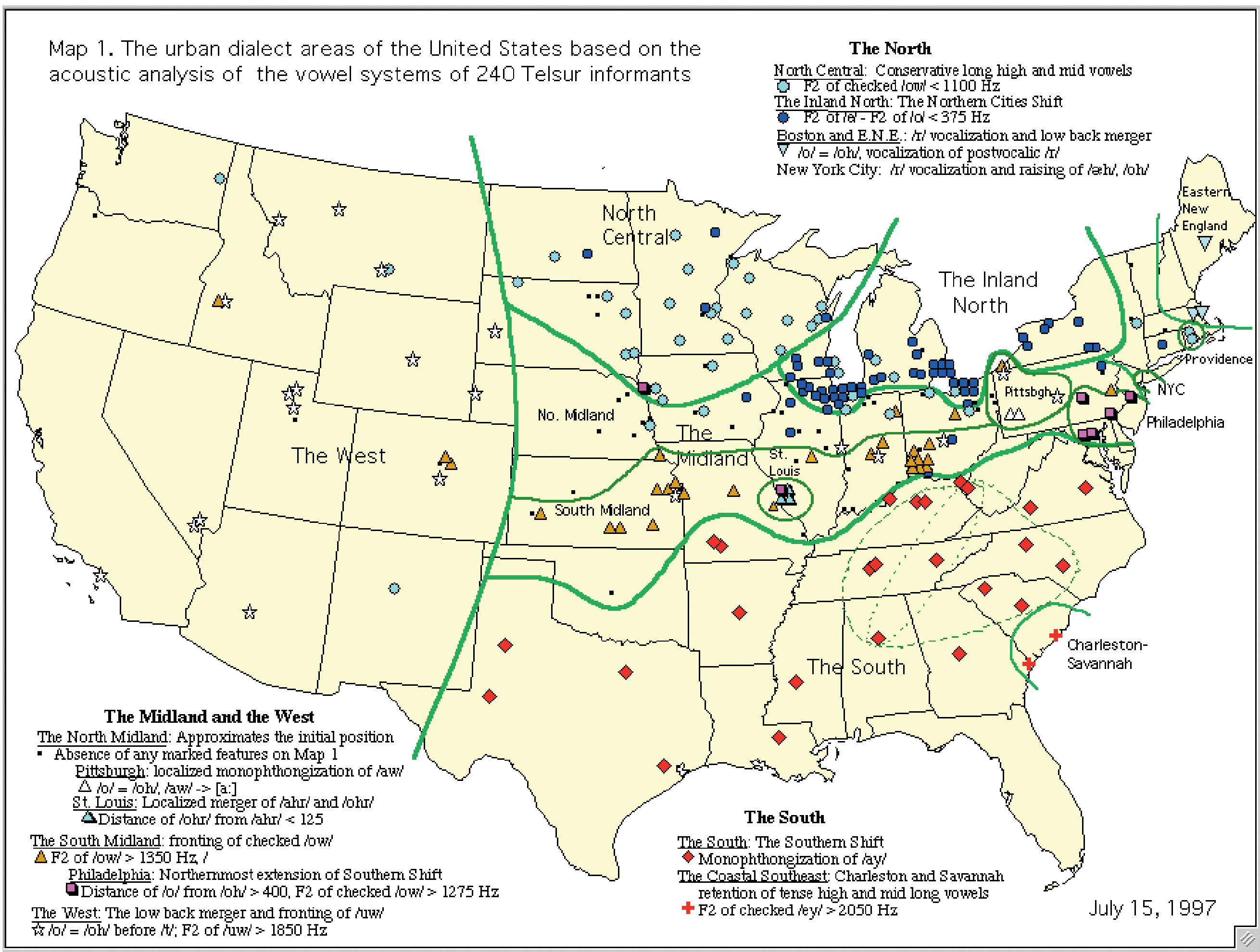



FIG. 477. THE URBAN DIALECT AREAS OF THE UNITED STATES. The map is based on the acoustic analysis of the vowel systems of 240 informants in the Telsur Project.

From William Labov, Sharon Ash, and Charles Boberg, *A National Map of the Regional Dialects of American English*, map 1 (online publication).

———. 1939. *Handbook of the Linguistic Geography of New England*. Providence: Brown University.

———. 1949. *A Word Geography of the Eastern United States*. Ann Arbor: University of Michigan Press.

Labov, William, Sharon Ash, and Charles Boberg. 2006. *The Atlas of North American English: Phonetics, Phonology and Sound Change: A Multimedia Reference Tool*. Berlin: Mouton de Gruyter.

Lameli, Alfred. 2010. "Linguistic Atlases—Traditional and Modern." In *Language and Space: An International Handbook of Linguistic Variation*, *Volume 1: Theories and Methods*, ed. Peter Auer and Jürgen Erich Schmidt, 567–92. Berlin: De Gruyter Mouton.

Meynen, Emil, ed. 1938. "Volks- und Sprachenkarten Mitteleuropas." *Deutsches Archiv für Landes- u. Volksforschung* 2:240–62, 963–1011.

Mitzka, Walther. 1952. *Handbuch zum Deutschen Sprachatlas*. Marburg: Elwertsche Universitätsbuchhandlung.

Teleki, Pál. 1935. "Un système de cartes ethnographiques et son emploi pour des régions de densités différentes." In *Comptes rendus du Congrès international de géographie, Varsovie, 1934*, 1:279–83. Warsaw: Kasa im. Mianowskiego.

Wilkinson, Henry Robert. 1951. *Maps and Politics: A Review of the Ethnographic Cartography of Macedonia*. Liverpool: University Press.

***Literature and Cartography.*** The twentieth century eclipsed all previous periods in the number, range, and dissemination of literary works involving maps. From the proliferation of public libraries to the advent of electronic databases on the web, the past century expanded exponentially the readership of earlier map-inspired literature (John Donne, Madeleine de Scudéry, Jonathan Swift, Robert Louis Stevenson) and produced its own exemplars. Entering keywords like "map(s)," "mapping(s)," "mapmak*," "cartograph*," and "atlas" into online collections like the Chadwyck-Healey Literature Collections, Columbia Granger's World of Poetry, LitFinder, NoveList, and MLA International Bibliography reveals thousands of poems and fictional works in which these terms appear and hundreds of scholarly publications that, since the 1970s, have used such terms to critique poetry and fiction.

As was the case for earlier map-inspired works, twentieth-century literary maps appear as illustrations and objects of discussion. Their metaphorical connotations, use as plot elements or thematic motifs, and relationship to those who create or view them are what make them memorable. Two influential novels frame the century. In *Heart of Darkness* (1902), the blank spaces and colors on imperialist maps seduce Joseph Conrad's alter ego, Marlow, into exploring the Belgian-controlled Congo. In Michael Ondaatje's *The English Patient* (1992), an apolitical Hungarian cartographer whose maps of the Sahara fall into Nazi hands becomes the patient whose burned body loses its mappable features.

Because the field is vast and analyzing maps in literature is as interdisciplinary as cartography itself, no comprehensive history of maps in twentieth-century fiction and poetry yet exists. A unified history would need to accommodate not only the various literary genres but also the cultural, historical, and (auto)biographical contexts of each significant text and its map(s) in the many literatures of the world. Essential critical tools would include sensitivity to literature and iconography, familiarity with literary and critical theories, and knowledge of geography and cartographic science and history. The cost of permissions, the explosion of literary maps that accompanied resistance to the established "canons," and the blurring of genres in the latter part of the century all help explain why few critics have focused on more than a single map-inspired work. What follows, then, is one provisional map of sources and salient examples.

## Maps as Illustrations

Though rarely mentioned within the texts themselves, illustrative maps are prominent in several genres. J. B. Post's *Atlas of Fantasy* (1973, 1979) reproduces over 100 maps from fantasy and science fiction. Jules Zanger (1982) critiques significant maps in classic novels like Ross Lockridge's *Raintree County* (1948). Jeffrey C. Patton and Nancy B. Ryckman (1990) focus on large-scale maps in children's literature. And Leslie Edwards (2000) presents mystery maps that help the detective or orient the reader. Just as the worlds illustrated range from "realistic" to overtly fictitious, so the maps themselves vary in detail, scale, level of abstraction, and their success in communicating with the reader. Perhaps the most influential example to date has been the small-scale map of Middle-earth that appeared as the frontispiece in J. R. R. Tolkien's *The Lord of the Rings* (1954–55). The complexity and appeal of Tolkien's Secondary World encouraged other writers and their publishers to include cartographic images.

Conventionally, the map occupies the frontispiece or endpaper of a work, so that readers view the author's world before savoring its verbal description. We admire the mapped layout of Umberto Eco's fictitious abbey, for example, even before Adso, the youthful narrator in *Il nome della rosa* (1980; trans. *The Name of the Rose*, 1983), compares the abbey's harmonious proportions to the universe's. Ursula K. Le Guin's science fiction classic *The Dispossessed* (1974) opens with illustrations of the twin planets Anarres and Urras. But Le Guin, who included maps in works as varied as the Earthsea series (1968–90) and *Always Coming Home* (1985), also placed simplified copies of the maps within the text's original edition to help readers locate her physicist/protagonist in time and space: alternating chapters offer maps of Urras (the story site) or Anarres (the flashback site).

Mysteries and historical novels commonly feature maps "hidden" within the text. Because the library in Eco's *Name of the Rose* remained out-of-bounds, Brother

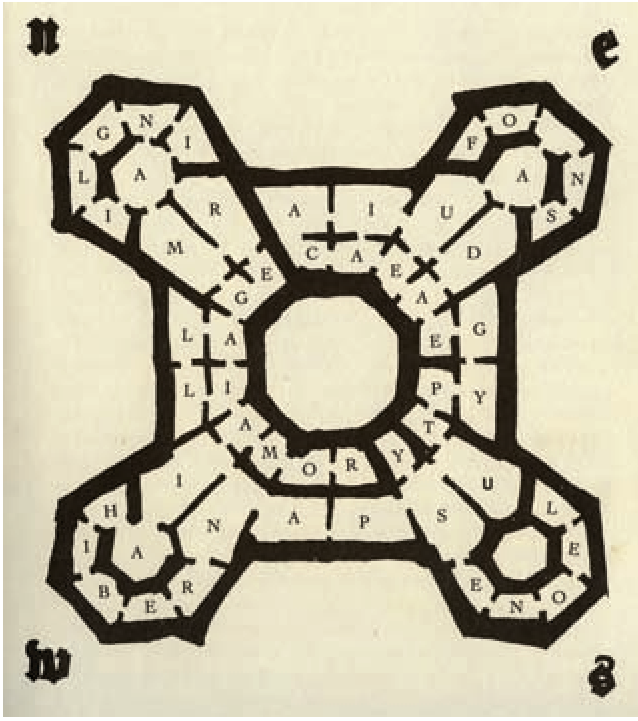


FIG. 478. THE LIBRARY MAP IN *THE NAME OF THE ROSE* BY UMBERTO ECO. Perhaps the most important and least ambiguous of Brother William of Baskerville's victories in *The Name of the Rose* is his realization that the library is ordered like a world map, with corridors of rooms bearing the Latin names of countries and Biblical sites: e.g., FONS ADAE ("Adam's Birthplace"), IUDAEA, AEGYPTUS, YSPANIA, and HIBERNIA.
Size of the original: 13.2 × 11.8 cm. From Umberto Eco, *The Name of the Rose*, trans. William Weaver (San Diego: Harcourt Brace Jovanovich, 1983), 321. Copyright © 1980 by Gruppo Editoriale Fabbri-Bompiani, Sonzogno, Etas S.p.A., English translation copyright © 1983 by Houghton Mifflin Harcourt Publishing Company. Reprinted by permission of Houghton Mifflin Harcourt Publishing Company. All rights reserved.

William of Baskerville and Adso began mapping it after their first incursion, halfway through the story (Haft 1995). Yet readers do not encounter Eco's illustration until their second entry, after William has recognized that each corridor is named for a country and that the library is designed like a medieval world map (fig. 478). Paul Auster's "maps," on the other hand, parody maps that appeared in classic mysteries written between 1920 and 1950. In *City of Glass* (1985), part of *The New York Trilogy*, Auster's writer-turned-detective plots on a street grid the walks taken by a man just released from prison. Buried within the novella are the mapped shapes that the protagonist decides must represent "O" "W" "E" and combines with the shapes of other walks he's mapped to deduce that the sequence spells "The Tower of Babel."

Maps often grace book jackets and covers. From 1942 to 1951, the multigenre Dell paperbacks known as "mapbacks" featured on their back covers a map of either a crime scene or the story's principal location (Lyles 1983, 83–118) (see fig. 1115). Furthermore, since the 1980s, maps have often appeared on covers of poetry collections like Robert Bringhurst's *Pieces of Map, Pieces of Music* (1986).

Some authors created successful and influential maps of their own. Fourteen years after *The Wonderful Wizard of Oz*, L. Frank Baum published his map of the Land of Oz in *Tik-Tok of Oz* (1914) (see fig. 606). Tolkien drew Thror's map for *The Hobbit* (1937); William Faulkner included a Yoknapatawpha County map in *Absalom, Absalom!* (1936), and later updated it for *The Portable Faulkner* (1946); and Juan Benet inserted his topographical "Mapa de Región" (1983) in one of his Región novels (Padrón 2007, 280–83). As a rule, however, someone other than the author creates or modifies the maps for publication. Consider two celebrated maps, those of Thomas Hardy's mythical Wessex and Tolkien's Middle-earth. The frontispiece of *The Return of the Native* (1878) displayed one of Hardy's own maps; and, based on another of Hardy's maps, in 1912 Emery Walker engraved the iconic "Map of the Wessex of the Novels and Poems" for *The Life and Death of the Mayor of Casterbridge*. Tolkien assembled a working sketch map of Middle-earth over many years, yet gave the job of drawing its publishable form to his son. Christopher Tolkien also drew the remaining maps for Tolkien's publications and, after his father's death, gathered Tolkien's unpublished maps in the twelve-volume History of Middle-earth series (1983–96). *An Atlas of Fantasy* (Post 1979, 209) contains a brief list of map illustrators, including Ernest H. Shepard (A. A. Milne's *Winnie-the-Pooh*, 1926) and cartoonist Jules Feiffer (Norton Juster's *The Phantom Tollbooth*, 1961). Though many maps remain unsigned and unacknowledged, Ruth Belew is credited with drawing at least 150 of the 577 Dell mapbacks (Lyles 1983, 84–85).

Visual and concrete poets have taken special delight in mapping (Haft 2000). After World War II, several drew upon the graphic arts to create poems shaped like regional maps, including Eugen Gomringer's "Geographic Europa" (1960), Earle Birney's "up her can nada" (1967) (fig. 479), Richard Kostelanetz's "The East Village" (1970–71), Paul Muldoon's "[Ptolemy]" (1989), and geographer/poet Howard Horowitz's "Manhattan" (1997). Along with poetic collections-as-maps, such as Charles Olson's *The Maximus Poems*, written over two decades (Olson 1983, esp. 150–56), and C. S. Giscombe's *Giscome Road* (1998), all these critically acclaimed works reveal the generalizing, simplifying, and selective nature of the process of mapping.

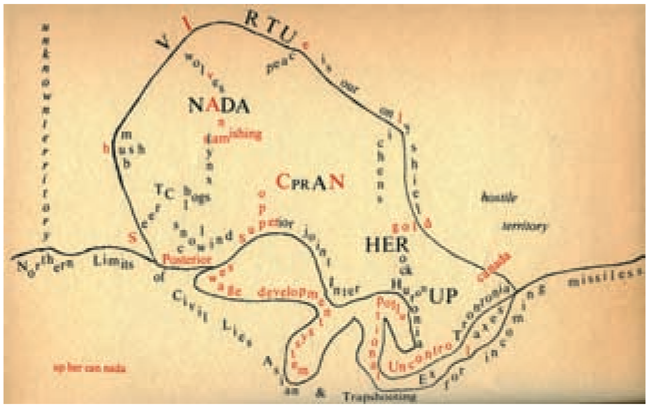



FIG. 479. EARLE BIRNEY'S "UP HER CAN NADA" (1967). Although this visual poem like/as a map shows the boundaries of present-day Ontario, its title and details also allude to Upper Canada, the official name of Ontario from 1791–1841.
Size of the original: ca. 12.3 × 19.6 cm. From Earle Birney, *Rag and Bone Shop* (Toronto: McClelland and Stewart, 1971), n.p. Permission courtesy of Wailan Low, executor of the estate of Earle Birney.


FIG. 480. NICHOLAS GARLAND'S ILLUSTRATION ACCOMPANYING "GEOGRAPHY LESSON." "Geography Lesson," a rhymed children's poem by John Fuller (1983), turns a geography lesson into a game of associating geographical regions with places on the nurse's body. An extreme form of the pictorial maps common in children's literature, Garland's anthropomorphic map complements Fuller's "Geography Lesson" in depicting England as a "sloppy nurse" who drops baby Ireland into the Irish Sea.
Size of the original: 10.2 × 10 cm. From *Come Aboard and Sail Away: Poems* by John Fuller, illustrated by Nicholas Garland (Edinburgh: Salamander Press, 1983), 8. Permission courtesy of Nicholas Garland.

Besides locating the story, map illustrations serve many functions. Some are genre specific. In children's literature, maps often teach map-reading skills (fig. 480); in historical fiction, they stop time; in science fiction, they suggest a future; in fantasy, they provide verisimilitude; in mysteries, they offer clues to the puzzle (Muehrcke and Muehrcke 1974; Zanger 1982). Most map illustrations fulfill such functions while simultaneously stimulating the imagination. They offer readers a sense of control and order. They establish imaginative hierarchies based on size and centrality, boundaries and margins, and, depending on the work, they suggest relationships: between the story and the "real" world, between one edition and another, between the mapped work and other works by the author, or between the map itself and the narrative.

## Maps as Objects of Discussion

Maps are discussed in literary texts far more than they are illustrated. Some overlap may occur when the cartographic image is part of the plot, as is the case with Stevenson's *Treasure Island* (1883) and Tolkien's *The Hobbit*, both of which exhibit a rare map that inspires their hero's adventures. Occasionally an author credits a character with creating the map that accompanies the story (Arthur Conan Doyle's "The Adventure of the Priory School," 1904; Kōbō Abe's *Moetsukita chizu* [1967; trans. *The Ruined Map*, 1969]). Even when maps are central to their plot (J. R. L. Anderson's *Death in a High Latitude*, 1981) or characterization (Maya Sonenberg's story "Cartographies" in *Cartographies*, 1989), most works contain no illustrative map.

To introduce what maps "mean" as objects of discussion in twentieth-century literature, Phillip and Juliana O. Muehrcke (1974), followed by Jules Zanger (1982), explained how maps function as metaphors and identified the following recurring motifs: the lure of blank spaces, the artificiality of mapping conventions, the silence of maps with regard to many landscape features, and the use of maps to distance generals from a strike's human toll. Two decades later, Graham Huggan's ambitious *Territorial Disputes* (1994) surveyed the map topos in "postcolonial" Canadian and Australian fiction from 1975 to 1990. His opening chapters offer an analytic framework that incorporates a range of critical theory influenced by, and influencing in turn, twentieth-century literary maps with feminist, ethnic, or regional perspectives. After considering the map as a model, document, or claim, Huggan argues that literary maps are often metaphors "of guidance and transformation" (xv), "of structure (arrangement, containment) or of control (organization, coercion)" (24); and that "literary cartography" must investigate "territorial strategies" that characterize mapping (31)—"strict codification, definition, enclosure, exclusion" (12). More recently, Peta Mitchell's *Cartographic Strategies of Postmodernity* (2008) highlights ten twentieth-century novels that demonstrate how "the map metaphor functions to suggest not the boundedness of knowledge and the objectivity of the author-cartographer, but rather the impermanence of boundaries, and the experiential and subjective nature of understanding" (Mitchell 2008, xi).

But what drives poets and other writers to discuss maps? War is a great popularizer. The Spanish Civil War inspired Stephen Spender's poem "A Stopwatch and an Ordnance Map" (1939). During World War II, Randall Jarrell's duties as a flight instructor informed his poem "Losses" (1945), while Henry Reed's "Judging Distances" (1943) satirized maps in army manuals. During the Cold War, Birney scrawled "incoming missilesss" [*sic*] across "up her can nada" (fig. 479 above). Ciaran Carson's collection *Belfast Confetti* (1989) emphasizes the map's inability to keep pace with Belfast's bombs. As for novels, the paranoid world of Thomas Pynchon's *Gravity's Rainbow* (1973) opens with two maps of wartime London eerily coinciding: Tyrone Slothrop's star map of his sexual exploits and Roger Mexico's map of bomb strikes. Nuruddin Farah's *Maps* (1986) focuses on the 1977–78 Ogaden War between Somalia and Ethiopia to demonstrate the distortions and destructive potential of maps, but also their power to unite and heal.

Antique maps also trigger inspiration. Because they don't mirror "reality," such maps are seen as cultural "texts" that reveal much about the human condition. Birney's "Mappemounde" (1948) uses images from medieval world maps to explore love and loss. Grevel Lindop's "Mappa Mundi" (1987) interprets the Hereford world map. Lucia Maria Perillo's "The Oldest Map with the Name America" (1999) is inspired by Martin Waldseemüller's 1507 map; Marianne Moore's "Sea Unicorns and Land Unicorns" (1924), by Olaus Magnus's *Carta marina*; and Kenneth Slessor's "Post-roads" (1932), by John Ogilby's *Britannia*. Vladimir Nabokov's short story "Perfection" (1932) celebrates the Peutinger map; and Eco's *Baudolino* (2000), Cosmas Indicopleustes's tabernacle world map.

Twentieth-century maps can unlock memories. Denise Levertov opened her "A Map of . . . Essex in England" (1961) to find poetic inspiration in the names of her youthful haunts. Poets often recall the maps they encountered at school. G. K. Chesterton's "Songs of Education; ii. Geography . . ." (1919) parodies England's red spots on the globe. Spender's "An Elementary School Classroom in a Slum" (1939) sees false promises in an "open-handed" school map. To James Reaney, "The School Globe" (1949) represents the lost paradise of childhood. Don Gutteridge's "My Story: Maps" (1977) recalls memorizing a township-naming song. Karl Kirchwey's "The Geographer's Line" (1990) compares his coming of age to the map of the continental United States in 1803. Gloria Oden's "The Map" (ca. 1961) exposes the political and racial ideologies underlying the Rand McNally Cosmopolitan World Map, while Fiona Pitt-Kethley's "Geography" (1986) criticizes the *Philips' New School Atlas* and urges teachers to use classic adventure stories instead.

Furthermore, maps encourage adventure, actual and imaginative. In "A Map of Verona" (1942), a mapped city becomes Henry Reed's future beloved. In "A Map of . . . Essex in England," Levertov admits to having "traced voyages/indelibly all over the atlas" (Levertov 1986, 35). Surveyor/mapmaker Wilson Harris (*The Secret Ladder*, 1963) turned his experiences into fiction; Frank G. Slaughter's *The Mapmaker* (1957) and James Cowan's *A Mapmaker's Dream* (1996) focus on Venetian cartographers Andrea Bianco and Fra Mauro, respectively; while Andrea Barrett's title story in *Servants of the Map* (2002) follows an English surveyor to Kashmir.

Poets and writers often see themselves as mapmakers. Elizabeth Bishop's "The Map" (1935) was revolutionary in bridging artificial divides between poetry and cartography; Bishop recognized that poets and mapmakers are kindred spirits in their powers of observation, technical expertise, and artistry. In *The Lion of Boaz-Jachin and Jachin-Boaz* (1973), novelist Russell Hoban turns his fictionalized alter ego into a cartographer who steals the map he'd made for his son—a map of all maps and desires. Alan Sillitoe, who foregrounds mapmaking in his novels, argues that his training in navigation and study of surveying and mapmaking helped him structure his writing (1975, 71–73). Peter Turchi's *Maps of the Imagination: The Writer as Cartographer* (2004) quotes other writers for whom mapmaking "describes" the creative process and examines links between maps and fiction. John Vernon explores the "map structure of the novel" (1973, 41).

At least two authors have extended the novelist-as-mapmaker metaphor even further. William Least Heat Moon describes *PrairyErth: (a deep map)* (1991) as a "topographic map of words that . . . open[s] inch by inch to show its long miles" (quoted in Russell 2000, 132). Focusing on Chase County, Kansas, near the geographic center of the United States, Heat Moon emphasizes how knowledge of a place involves the making and reading of maps. Like many regional writers, Heat Moon restores

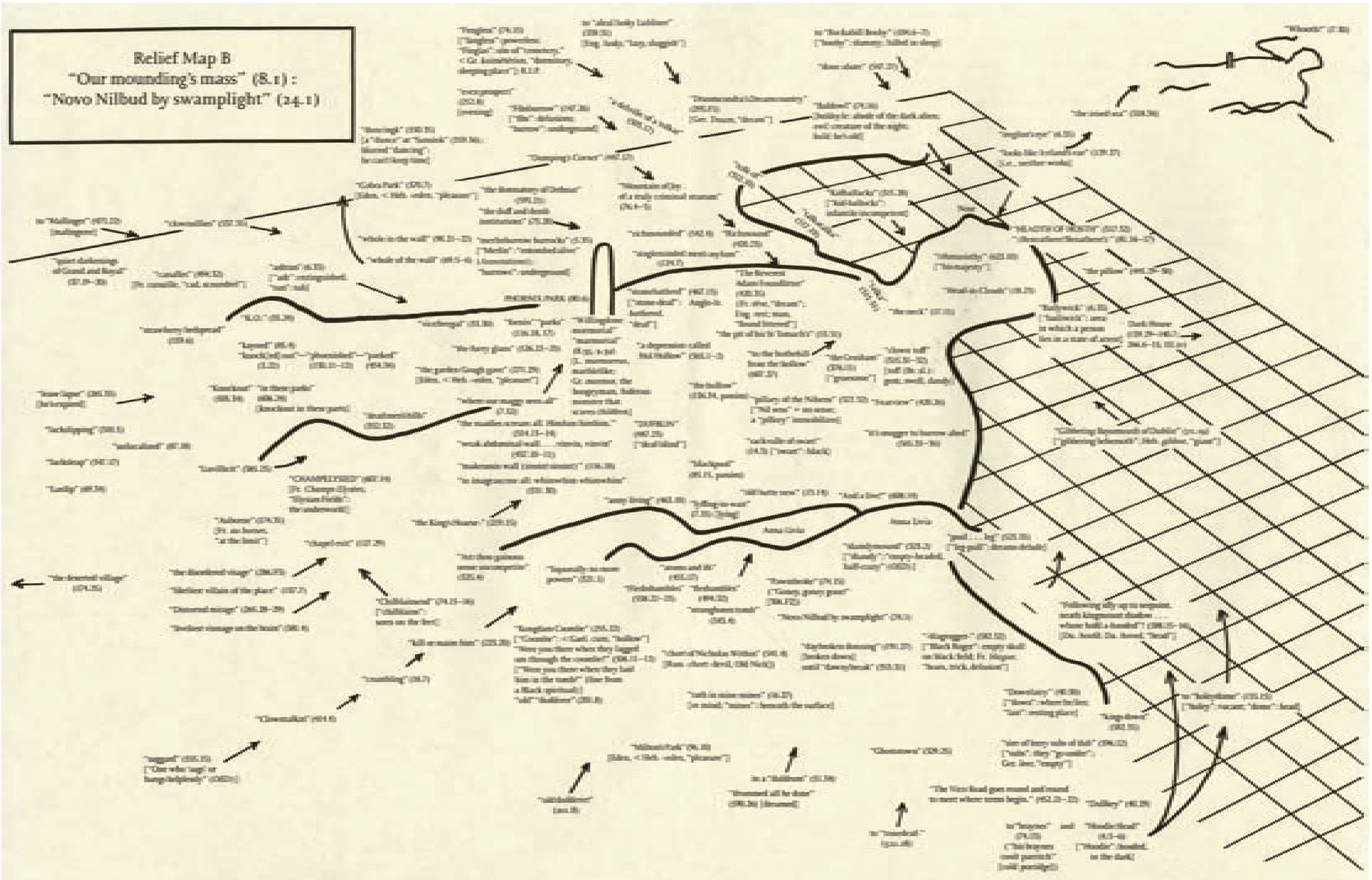



FIG. 481. "RELIEF MAP B 'OUR MOUNDING'S MASS' (8.1): 'NOVO NILBUD BY SWAMPLIGHT' (24.1)," ILLUSTRATING JOHN BISHOP'S STUDY OF *FINNEGANS WAKE*, BY JAMES JOYCE. The most influential twentieth-century novelist-as-cartographer, Joyce used maps to organize *Ulysses* (1922) and *Finnegans Wake*; yet he, like most writers, illustrated neither monumental novel. This illustration—a narrative map representing (1) nighttime Dublin as dreamed by its hero and also (2) the interior anatomy of its sleeping giant—accompanies Bishop's *Joyce's Book of the Dark: Finnegans Wake* (1986), 34–35.

Size of the original: 23.2 × 38 cm. 

"depth"—history and intimacy—to a prairie landscape that air travel and maps reduce to a two-dimensional abstraction. Part Native American, Heat Moon draws analogies between maps and stories, between maps imposed from without and those generated from within, between Western and Aboriginal mapmaking, and between representations and the place itself. In *The Atlas* (1996), on the other hand, William T. Vollmann creates a verbal atlas from fragments of journalistic encounters throughout the world and structures them palindromically to represent the outward and return journeys from the central chapter/core of his work and "life" (Russell 2000, 170–72).

Maps are referenced when one work speaks of another. In 1955, Elizabeth Bishop opened *Poems: North & South* with "The Map." No sooner had that collection won the Pulitzer Prize than it encouraged other poets to critique maps (Haft 2001). That maps and mapping are central to Eco's novels derives not only from his training in medieval studies and semiotics but from the map-inspired authors he admires: James Joyce, Jorge Luis Borges ("Of Exactitude in Science," 1946), and Italo Calvino (*Invisible Cities*, 1972). Eco's timing of his characters' conversation to fit precisely the distance traversed (Eco 1984, 25) is a trick associated with Joyce—perhaps the archetypal twentieth-century writer-as-cartographer. Joyce's father once remarked, "If that fellow was dropped in the middle of the Sahara, he'd sit, be God, and make a map of it" (quoted in Ellmann 1959, 28). Although composed during his self exile in "Trieste-Zurich-Paris," Joyce's *Ulysses* (1922) so accurately describes Dublin's topography that it serves as a literary guidebook and as a way to reconstruct—as Joyce himself had hoped (Hart and Knuth 1975, 1:13)—the Dublin of 1904 that he had re-created with the help of maps and a timepiece (esp. episode 10, "The Wandering Rocks"). *Finnegans Wake* (1939) is a narrative map representing (in part) nighttime Dublin as dreamed by its hero and also the interior anatomy of its sleeping giant (Bishop 1986) (fig. 481).

After surveying the seminal texts and genres, a truly unified history would embrace Graham Greene's *Journey without Maps* (1936), Louise Bogan's "Cartography" (1941), Kenzaburō Ōe's *Kojinteki na taiken* (1964; trans. *A Personal Matter*, 1968), Georges Perec's *Espèces d'espaces* (1974), Russell Hoban's *Riddley Walker* (1980), Brian Friel's *Translations* (1981), and Bruce Chatwin's *The Songlines* (1987) and expand the search for undiscovered terrains and masterworks.

ADELE J. HAFT

SEE ALSO: Marketing of Maps, Mass; Narrative and Cartography; Travel, Tourism, and Place Marketing

BIBLIOGRAPHY:

Bishop, John. 1986. *Joyce's Book of the Dark: Finnegans Wake*. Madison: University of Wisconsin Press.

Eco, Umberto. 1984. *Postscript to The Name of the Rose*. Trans. William Weaver. San Diego: Harcourt Brace Jovanovich.

Edwards, Leslie. 2000. "Maps in Detective Fiction." In *Atlas of Crime: Mapping the Criminal Landscape*, ed. Linda S. Turnbull, Elaine Hallisey Hendrix, and Borden D. Dent, 199–207. Phoenix: Oryx Press.

Ellmann, Richard. 1959. *James Joyce*. New York: Oxford University Press.

Haft, Adele J. 1995. "Maps, Mazes, and Monsters: The Iconography of the Library in Umberto Eco's *The Name of the Rose*." *Studies in Iconography* 14:9–50.

———. 2000. "Poems Shaped Like Maps: (Di)Versifying the Teaching of Geography, II." *Cartographic Perspectives* 36:66–91.

———. 2001. "The Poet as Map-Maker: The Cartographic Inspiration and Influence of Elizabeth Bishop's 'The Map.'" *Cartographic Perspectives* 38:37–65.

Hart, Clive, and Leo Knuth. 1975. *A Topographical Guide to James Joyce's Ulysses*. 2 vols. Colchester, U.K.: A Wake Newslitter Press.

Huggan, Graham. 1994. *Territorial Disputes: Maps and Mapping Strategies in Contemporary Canadian and Australian Fiction*. Toronto: University of Toronto Press.

Levertov, Denise. 1986. *Selected Poems*. Newcastle upon Tyne: Bloodaxe Books.

Lyles, William H. 1983. *Putting Dell on the Map: A History of the Dell Paperbacks*. Westport: Greenwood Press.

Mitchell, Peta. 2008. *Cartographic Strategies of Postmodernity: The Figure of the Map in Contemporary Theory and Fiction*. New York: Routledge.

Muehrcke, Phillip, and Juliana O. Muehrcke. 1974. "Maps in Literature." *Geographical Review* 64:317–38.

Olson, Charles. 1983. *The Maximus Poems*. Ed. George F. Butterick. Berkeley: University of California Press.

Padrón, Ricardo. 2007. "Mapping Imaginary Worlds." In *Maps: Finding Our Place in the World*," ed. James R. Akerman and Robert W. Karrow, 255–87. Chicago: University of Chicago Press.

Patton, Jeffrey C., and Nancy B. Ryckman. 1990. "Maps in Children's Literature." *Cartographic Perspectives* 6:3–12.

Post, J. B., comp. 1973. *An Atlas of Fantasy*. Baltimore: Mirage Press.

———. 1979. *An Atlas of Fantasy*. New rev. ed. New York: Ballantine Books.

Russell, Alison. 2000. *Crossing Boundaries: Postmodern Travel Literature*. New York: Palgrave.

Sillitoe, Alan. 1975. "Maps." In *Mountains and Caverns: Selected Essays*, 59–73. London: W. H. Allen.

Turchi, Peter. 2004. *Maps of the Imagination: The Writer as Cartographer*. San Antonio: Trinity University Press.

Vernon, John. 1973. *The Garden and the Map: Schizophrenia in Twentieth-Century Literature and Culture*. Urbana: University of Illinois Press.

Zanger, Jules. 1982. "'Harbours Like Sonnets': Literary Maps and Cartographic Symbols." *Georgia Review* 36:773–90.

***Lobeck, Armin K(ohl).*** Armin Kohl Lobeck was born in New York City on 16 August 1886. He attended Columbia University, where he earned AB and AM degrees in 1911 and 1913. From 1914 to 1917, he was a teaching assistant and doctoral candidate under Douglas Wilson Johnson in the Department of Geology.

In years following World War I, while serving first with the Inquiry and later with the American delegation to the Paris Peace Conference, Lobeck prepared block and physiographic diagrams depicting the physiography of Western Europe, the Austro-Hungarian Empire, the Balkans, Lorraine, Trentino, and Trieste-Isonzo. While in Italy, Johnson praised Lobeck's work in letters to Isaiah Bowman, director of the American delegation: "Don't fail to send me Lobeck's Isonzo diagram"; "the people over here . . . have nothing to approach them in detail and excellence of execution" (1918; quoted in Grandinetti 2003, 115).

During World War II, Lobeck's cartographic skills were employed by the U.S. military in preparing detailed topographic maps of Africa's northwest coast, France, Italy, Spain, and the Balkans. His relief map of France was used in planning the Allied invasion at Normandy on 6 June 1944. He prepared a similar relief map of Spain in the event a second invasion of Europe was to take place through that country.

Notwithstanding Lobeck's pedagogical ability spanning nearly forty years at the University of Wisconsin (1919–29) and Columbia University (1929–54), his most significant contribution to the field of cartography was the production of more than thirty Geographical Press publications, which by 1954 had been adopted by approximately five hundred colleges and universities in the United States, Canada, and overseas. With the publication of the *Physiographic Diagram of South America* by Guy-Harold Smith (1935), and then Lobeck's own *Physiographic Diagram of Europe* (first large-scale edition, 1944), *Asia* (1945), *Africa* (1946; see fig. 720), *North America* (1948), and *Australia* (1951), Lobeck realized a plan, conceived at the University of Wisconsin in 1921, for worldwide coverage. These physiographic diagrams yielded abundant examples for his popular book *Things Maps Don't Tell Us* (1956).

Despite the earlier use of block diagrams by William Henry Holmes, Albert Heim, G. K. Gilbert, William Morris Davis, Emmanuel de Martonne, Douglas Wilson Johnson, and others, it remained for Lobeck to publish the only extensive treatise on the subject, *Block Diagrams and Other Graphic Methods Used in Geology and Geography* (1924). Of this book, Johnson (1925, 693) wrote: "To say that Professor Lobeck's book on 'Block Diagrams' is the best work of its kind would be inadequate. It is the *only* work of its kind and a most excellent work at that."

Later, Lobeck's *Geomorphology: An Introduction to the Study of Landscapes* (1939) established his preeminence in the art of graphic representation. It was largely through his concerted efforts that the construction of block and physiographic diagrams evolved as an effective scientific tool for portraying the multifarious features of nature. Lobeck died in Englewood, New Jersey, on 26 April 1958 (Grandinetti 1973).

FRED S. GRANDINETTI

SEE ALSO: Physiographic Diagram; Raisz, Erwin (Josephus); Relief Depiction: Relief Map

BIBLIOGRAPHY:

Grandinetti, Fred S. 1973. "The Life and Thought of Armin K. Lobeck." Master's thesis, Southern Connecticut State College.

———. 2003. "Armin Kohl Lobeck, 1886–1958." *Geographers: Biobibliographical Studies* 22:112–31.

Johnson, Douglas Wilson. 1925. "Graphic Illustration in Earth Science." Review of *Block Diagrams and Other Graphic Methods Used in Geology and Geography*, by Armin K. Lobeck. *Geographical Review* 15:693–94.

***London Underground Map.*** The most influential and famous twentieth-century map probably is the official diagrammatic map of the Underground, London's subterranean railway network. The exhibition "Modernism: Designing a New World 1914–1939" at the Victoria and Albert Museum (6 April–23 July 2006) highlighted this map, known as the Diagram, as the epitome of modernist design. By 2007 many experts hailed the Diagram as a product of genius, the standard for efficient subway maps, and many other subway system maps imitated its style. At the same time the populace developed a positive affection for the Diagram. It became a universal symbol of London and came to adorn every kind of English souvenir.

Opened in 1863, London's Underground railway is the world's oldest, as well as one of the longest and most complex: thirteen lines connect 306 stations via 272 miles of track (Ovenden 2007, 20). Subway lines crisscross under irregular city streets, numerous interchange stations serve two or more lines, and in the hinterland the tracks rise to the surface and run far outside the city. The need for a map is obvious, but, as demonstrated by the one in use in 1932 (fig. 482), it is difficult to make a conventional topographic map of the system that is complete, clear, and accurate (Garland 1994, 13).

The author of the London Underground Diagram was Henry Charles (Harry) Beck. In 1931, at the age of twenty-eight, while employed as a temporary draftsman by Underground Group, he conceived the idea of streamlining and clarifying the existing Underground route map by converting its twisting route lines and unevenly spaced symbols and names into something more "tidy." He worked out the design at home and submitted a hand-drawn prototype to the transport agency's Publicity Department, which handled maps and posters. Initially, reviewers rejected it as "too 'revolutionary,'" but a resubmission in 1932 succeeded (Garland 1994, 17). No copy survived the trial printing in the fall of 1932 (500–800 copies of the ephemeral, pocket-size map), but the response must have been encouraging: the print run in January 1933 was 750,000, plus another 100,000 in February (fig. 483) (Garland 1994, 19).

Several factors may have promoted rapid popular acceptance. Comparing the 1932 topographic map

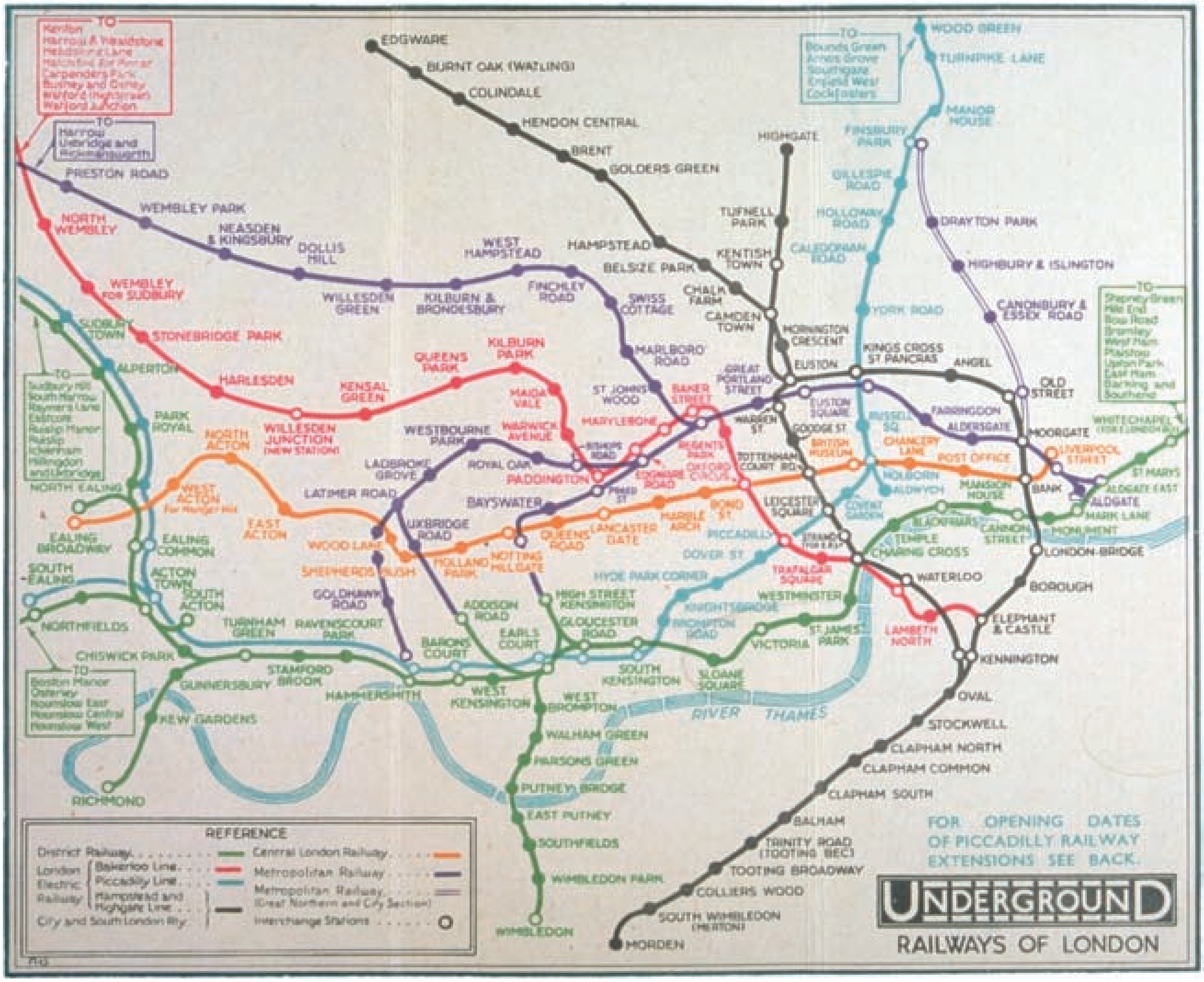



FIG. 482. F. H. STINGEMORE, *UNDERGROUND RAILWAYS OF LONDON*, 1932. This is the folding map in conventional topographic style that was in official circulation when Beck designed his Diagram; it was Beck's inspiration and source. Size of the original: 14.4 × 16.2 cm. © TfL from the London Transport Museum Collection.

and the Diagram shows that Beck repeated many features from the traditional map, including its orientation (north), stations located on the correct sides of the River Thames, color-coded routes, lack of scale, and lack of other features except the Thames. Second, Beck's changes improved readability: he rearranged symbols and names and identified stations with tick marks instead of solid circles; the ticks clarified connections to names (all names arranged horizontally) and increased the number of outlying stations and names plotted on the map. Third, some riders probably became familiar with the diagrammatic style from route diagrams that some English railways used in their signs (Dow 2005, 21–43; Ovenden 2007, 8–9). Fourth, the Underground had a reputation for successful and innovative designs; riders may have expected new maps to be good ones. Last was aesthetics: Beck's composition pleases the eye. As Ken Garland wrote, Beck's Diagram "achieved both visual distinction and proven usefulness in equal measure" (Garland 1994, 62).

That is not to say Beck failed to create a new map. By itself, limiting all lines to verticals, horizontals, and 45-degree diagonals—Beck's principal stylistic legacy to mapmakers and artists everywhere—produced an original, dramatic image. Of course, rearranging symbols and names ad hoc to open the crowded parts near the city center and condensing them for the suburbs threw off the correspondence between stations and related places


FIG. 483. HENRY CHARLES BECK'S *MAP OF LONDON'S UNDERGROUND RAILWAYS*, 1933. This folding map was the first version of Beck's diagram for official general distribution; compare to Stingemore's 1932 topographic map (fig. 482).

Size of the original: 16 × 22.8 cm. © TfL from the London Transport Museum Collection.

on the surface. As Edward R. Tufte (2002) observed, whereas the topography of greater London had organized earlier maps, Beck's Diagram organized London for the riders. (Janet Vertesi's 2008 study of how Underground riders find their way around London reported that most regular riders used the Diagram to conceptualize and navigate the city on the surface.) Technically, Beck had converted a conventional topographic representation of the Underground into a semitopological one. On a pure topological surface, only the connections among stations and routes would remain correct, and apparent distances and directions would be meaningless. On his Diagram, Beck distorted positions of stations and lines, but only as needed to reduce crowding and maximize legibility. His distortions were not systematic, as they would have been if generated by a projection. Also, he maintained a rough correlation between the underground network and the geography of the surface, e.g., north orientation for the map, stations plotted on the correct sides of the river.

Many commentators have reinforced the Publicity Department's initial judgment of the Diagram as too radical by focusing on the Diagram's topological qualities and on the theoretical impossibility of inferring anything about the surface from the diagram of the Underground. There is no evidence that Beck ever heard of topology, and it is clear that he tried to minimize the distortions. There is no evidence of Beck weighing those design choices, so he probably acted instinctively.

For regular Underground riders, those distortions may not have mattered because they learned the relationships between underground stations and places on the surface that were important to them, but for tourists and other strangers, there could be a serious problem. In the United States, for example, travel writers warned London-bound Americans to beware of the misleading Diagram.

After he introduced the diagrammatic map, Beck remained an employee of London Transport—transferred to the Advertising Department but not made permanent staff until 1937—but in matters related to his Diagram he became a freelancer. The agency agreed that Beck would retain control of the map and perform or oversee future modifications, but that arrangement was not formalized in writing. Beck continually experimented with the Diagram to improve it. In the 1940s he prepared a diagram of the Paris Metro, a clear, attractive composition, but the French rejected it. He left the Advertising Department in 1947 to teach full time at the London School of Printing and Kindred Trades. In 1960, the Publicity Department issued a new, confusing, and less graceful version of the London Diagram drawn by the head of the department. Harry Beck protested at length but in vain; he never regained control of his creation (Garland 1994, 50–53).

Paul E. Garbutt, a London Transport administrator, rescued the Diagram in 1962. He fixed the problems with the 1960 version and for the next decade guided all updates. In the process he introduced a feature that became permanent: the "vacuum flask" configuration of the eastern end of the Circle Line. Garbutt worked on the Diagram in addition to his regular job as Assistant Secretary and New Works Officer, but he was less interested than Beck in drawing and tinkering with the graphics. Early in the 1970s, London Transport finally transferred care of the Diagram from its latest amateur to an outside firm of professional artists and mapmakers. Garbutt's name remained on the map until 1984, but his role was advisory (Garland 1994, 56–59; Roberts 2005, 25–49).

Although Beck's name appeared on the Diagram for nearly three decades, he was practically unknown throughout his working years. His Diagram may have been ahead of its time and the men who ran London Transport may have failed to appreciate qualities that later seemed so obviously important, but other factors also contributed to his lack of recognition. For example, he neither wrote nor lectured about his work, and his working arrangements—freelance, part time, at home, outside regular hours—resembled those of a hobbyist immersed in a pet project of modest consequence. Ephemera lack status, and Beck's most common products were disposable folding pocket maps. In a hierarchical society like England's, a novel product conceived outside an established institution or profession (cartography was in its professional infancy) by an uncredentialed, unproven amateur and perfected part-time as a second job drew little serious attention. What recognition Beck might have earned had to come from other graphic artists, but at that time "information graphics" was an unknown term of the future, and even the graphic arts needed more development before many practitioners could give the Diagram its due (Garland 1994, 42).

If anyone should have appreciated Beck's Diagram, it was Frank Pick. Pick became manager of the Underground railways in 1908 and was promoted to chief executive of the newly organized London Passenger Transport Board (London Transport for short) in the summer of 1933, just months after Beck's Diagram was adopted by the Publicity Department. In addition to his role as a successful manager, Pick was a patron of the arts, founding chairman of the Council for Art and Industry (1934), and prominent in the modernist movement. He dedicated himself to excellence in every facet of the Underground and to making it an institutional leader in modern design, particularly the applied arts. In 1913 he had persuaded Britain's leading calligrapher, Edward Johnston, to design a typeface especially for the Underground's signs and posters. Known as Johnston Sans, a variant of that face remained in use by the Underground into the twenty-first century and continued to influence designers worldwide (Howes 2000, 25–29, 60–70). Pick commissioned posters that introduced many Londoners to abstract art and built stations that exemplified the latest architecture, yet he never mentioned Beck's Diagram in his public remarks about modern map design. Somehow, Harry Beck and his Diagram never found standing in Frank Pick's field of artistic vision.

The first major public recognition of Harry Beck's work came in 1969 when London designer and journal editor Ken Garland wrote an illustrated article for the *Penrose Annual*. There was nothing more until the 1980s, when the map was mentioned in a comprehensive history of graphic design (Meggs 1983), a book on information graphics, and a few articles concerning topology and cartography. In 1987, as part of a television series on British design, the British Broadcasting Company broadcast a thirty-minute show about the Diagram and its creator. Twenty years after Beck died, Garland published a book-length biography (1994). By that time, interest in Beck and the map had acquired momentum of its own, but it was not until 2004 that the *Dictionary of National Biography* carried a biography of Harry Beck.

The theme of Mark Ovenden's *Transit Maps of the World* (2007) is that the success of Beck's Diagram in London is the standard for other cities. None surpassed London and only a few, like the 2007 maps of Boston and Paris, came close to measuring up. New York's struggle to produce a useful map exemplified one obstacle. That system, the largest and most complicated in the world, commissioned a striking abstract diagram—Massimo Vignelli's 1972 beauty—but riders rejected it because it did not adequately relate the underground system to the surface streets. Its 1979 replacement was a topographical map that appears too dense and cluttered but in 2007 still worked for the riders (Ovenden 2007, 32–35).

One of the implicit lessons to be drawn from Ovenden's collection is that too much information can weaken a diagram. For example, the 2007 diagram for Berlin combined its underground and surface transit systems, a practice followed by other German cities. The results were clear but dense and more complicated than the London Diagram. Similar problems of density burdened maps for Tokyo and other cities that used two languages or alphabets on each diagram. So few other underground maps worked as well as London's that the reader may agree with Tufte's conclusion that Beck's Underground Diagram is less a model for others than it is a brilliant solution to the problem of handling a unique set of data.

JOHN H. LONG

SEE ALSO: Cartogram; Wayfinding and Travel Maps: Public Transportation Map

BIBLIOGRAPHY:

Baigent, Elizabeth. 2007. "Beck, Henry Charles [Harry] (1902–1974)." In *Oxford Dictionary of National Biography*. Oxford: Oxford University Press. Online edition.

Dow, Andrew. 2005. *Telling the Passenger Where to Get Off: George Dow and the Evolution of the Railway Diagrammatic Map*. Harrow, U.K.: Capital Transport.

Garland, Ken. 1969. "The Design of the London Underground Diagram." *Penrose Annual: The International Review of the Graphic Arts* 62:68–82.

———. 1994. *Mr Beck's Underground Map*. Harrow Weald, U.K.: Capital Transport.

Howes, Justin. 2000. *Johnston's Underground Type*. Harrow Weald, U.K.: Capital Transport.

Letch, Anne. 2004. *London Transport Maps & Guides: A Collectors' Reference Guide*. Hailsham, U.K.: Anne Letch and L.B.R.T.

Meggs, Philip B. 1983. *A History of Graphic Design*. New York: Van Nostrand Reinhold.

Ovenden, Mark. 2007. *Transit Maps of the World*. 2d rev. ed. Ed. Mike Ashworth. New York: Penguin.

Roberts, Maxwell J. 2005. *Underground Maps after Beck: The Story of the London Underground Map in the Hands of Henry Beck's Successors*. Harrow, U.K.: Capital Transport.

Tufte, Edward R. 2002. Review of Ken Garland, *Mr Beck's Underground Map*. Online publication.

Vertesi, Janet. 2008. "Mind the Gap: The London Underground Map and Users' Representations of Urban Space." *Social Studies of Science* 38:7–33.

***Lunar and Planetary Mapping.*** Before the 1960s lunar and planetary maps were merely syntheses of astronomical observations. Many, perhaps most, have now become tools to help select landing sites, plan expeditions, and portray the scientific results of exploration, largely in the context of geology and other planetary sciences rather than astronomy. The U.S. National Research Council (1978) has asserted that global maps are basic to any advance in understanding the planets, and indeed cartography has played a substantial role in the exploration of the solar system.

By 1900 five solid-surfaced worlds beyond Earth had been mapped: Mercury, Venus, the Moon, Mars, and Ganymede, a satellite of Jupiter. A century later the number had grown to about sixty-five—an uncertain count because the definition of map at cartography's fringes raises questions about what qualifies. While it seems reasonable to exclude an unmodified astronomical observation, should a composite or annotated version be considered a map? And even though a sketch of possible surface features is appropriately considered a map, can some sketches be too simple to justify the term? Moreover, should maps derived from wholly erroneous interpretations or maps invented to illustrate works of fiction be included? Fictional maps are maps, to be sure, but it seems misleading to add them to a list of mapped worlds. Objects without solid surfaces (the sun, other stars, and gas planets such as Jupiter) have been mapped, including in 2006 the first planet orbiting another star. Adding these brought the number of mapped bodies to over 200. Over thirty worlds, including many satellites of the planets, have been charted systematically in considerable detail relative to the size of the body. The last proviso is necessary because these worlds vary in diameter from less than 1 kilometer (small asteroids) to over 12,000 kilometers (Venus). Localities observed by landed spacecraft on the Moon, Mars, and Venus have been mapped at scales as large as 1:20. In contrast to terrestrial mapping, which evolved from local to global scales, planetary maps tend to progress in the opposite direction.

Almost no lunar or planetary mapping was undertaken in the first half of the twentieth century. Nothing was to be gained by replicating nineteenth-century lunar cartography (Whitaker 1999), but variable markings on Mars were remapped as it approached Earth at two-year intervals, and three large satellites of Jupiter were added to the list above. The pace of mapping accelerated in later decades, greatly expanding the reach of cartography. Four factors contributed to this increase. New analytical techniques (rotational lightcurve and occultation analyses, modeling of cometary activity) revealed features on heretofore unresolved objects including Pluto, asteroids, and comet nuclei. Higher angular resolutions achieved by successive innovations (speckle interferometry, adaptive optics, and orbital telescopes) resolved smaller or more distant objects, including Pluto and several large asteroids. Infrared and radar observations extended the reach of imaging to new targets such as Venus, Titan, and small asteroids. Finally, spacecraft obtained close observations of remote objects beginning with the first images of the lunar far side in 1959.

The long-neglected Moon attracted new attention in the 1960s when Gerard Peter Kuiper (University of Arizona) and colleagues assembled a series of photographic atlases, and the U.S. Army and Air Force, contemplating military lunar bases, began independent mapping projects (Kopal and Carder 1974). Noteworthy products included 1:1,000,000-scale Lunar Astronautical Chart (LAC) series by the U.S. Air Force Aeronautical Chart and Information Center, portraying much of the near side of the Moon with airbrushed relief. Another influential development was the preparation of geological maps by the U.S. Geological Survey (USGS), plotted on LACs using methods of image interpretation devised by Eugene M. Shoemaker and colleagues (Shoemaker and Hackman 1962; Greeley and Batson 1990). Earlier maps had shown supposed systems of fractures in the lunar crust, but these new maps based on stratigraphic principles were more useful for classifying and interpreting surface materials. High-resolution images enabled large-scale mapping of selected areas, essential for the National Aeronautics and Space Administration (NASA) Apollo landing site selection and mission planning. Ranger spacecraft impact sites (1964–65) and most Surveyor landing sites (1966–68) were mapped using Lunar Orbiter images at scales up to 1:500. Similar maps were used for Apollo crew training and carried to the Moon to assist orbital and surface operations. These were not widely distributed or well documented. Small-scale mapping extended coverage to the region never visible from Earth.

A later generation of maps and orthophotomosaics was compiled using Apollo data (fig. 484) with systematic topographic mapping at 1:250,000 scale by the U.S. Defense Mapping Agency. The Department of Defense abandoned this work in the late 1970s and planetary mapping was taken up by the USGS. Feature locations were determined by measuring networks of control points on images, especially by Merton Davies at the RAND Corporation before the work passed to the USGS. Lunar elevations, initially derived from a combination of weak stereoscopy from Earth and numerous shadow measurements, were greatly improved in later years by stereoscopic imaging and orbital altimetry from the Apollo and Clementine missions. The International Astronomical Union (IAU) standardized lunar nomenclature in 1935, a function continued and extended to other worlds by their Working Group for Planetary System Nomenclature and documented online by the USGS. Another IAU Working Group (Cartographic Coordinates and Rotational Elements) documented rotational and shape data and defined prime meridians in its triennial reports (e.g., Seidelmann et al. 2005).

Soviet lunar data emphasized physical or chemical measurements over systematic imaging and contributed less to cartography than its American counterpart. Early images of the far side resulted in the first complete map of the Moon, *Polnaya karta luny*, at 1:5,000,000 scale, drawn in 1967 under the supervision of Yu. N. Lipskiy at the Sternberg astronomical institute, Gosudarstvennyy astronomicheskiy institut imeni Shternberga, Moscow. Later editions used U.S. data to improve the far side portrayal. The Moskovskiy institut inzhenerov geodezii, aerofotos"yëmki i kartografii (MIIGAiK) also produced lunar maps. Soviet lunar cartography included global geomorphologic maps, coverage at 1:1,000,000 scale of the near side equatorial zone for possible use by cosmonauts, special maps of the Lunokhod 2 landing area and the region photographed by Zond 8, and large-scale charts of two landing sites and the routes of two rovers. Beyond the Moon, the only world mapped systematically by Soviet cartographers was Venus in the late 1980s. Russian work since then has included an atlas of the terrestrial planets and their satellites (fig. 485) and a series of multilingual maps of the same subjects for educational purposes, much of this work being performed at MIIGAiK. Soviet maps were not widely distributed and remain poorly documented.

Every mapped world has a unique cartographic history reflecting the evolution of astronomical innovation and exploration. Mars has a long history, from the first map drawn by William Herschel published in 1784 to large-scale charts used to plan surface activities by robotic rovers (Flammarion 1892; Blunck 1982; Blunck and Zögner 1993). Astronomers still map Mars at each opposition (close approach to Earth) to document changes in its surface markings, clouds, and polar caps. The first in situ images of a restricted region from the U.S. spacecraft Mariner 4 in 1965 resulted in the first maps showing topographic features. Since then successive missions including Mariner 9 (1971, the first orbiter) and Viking 1 (1976, the first successful lander) have revealed the entire surface, permitting several generations of global maps at many scales and the compilation of image mosaics and depictions of geology and elevation. These have supported the selection of spacecraft landing sites and future mission planning.

Another example illustrates a contrasting cartographic history. Although a cartoon-like map was used in 1940 to illustrate the adventures of the fictional "Captain Future" (Post 1973, 274), the first true map of Pluto was made in 1977 by observing changes in the brightness of the planet's unresolved disk as it rotated and as changing seasons revealed different latitude zones. Several refinements to this study appeared in the 1980s. Another method involved transits of the large satellite Charon across the planet's disk, which occurred between 1985 and 1990. As Charon moved in front of Pluto it covered different parts of the surface at different times, allowing the brightness of the hidden portion to be estimated. By this means maps of the still unresolved disk could be compiled. Maps have also been made from low-


FIG. 484. DETAIL FROM *MARE UNDARUM*, LUNAR MAP LM 62, SCALE 1:1,000,000, 1st ED., SEPTEMBER 1978. This lunar chart by the U.S. Defense Mapping Agency Aerospace Center is typical of U.S. lunar mapping of the 1960s and 1970s. It incorporates Apollo orbital data and shows the landing site of the Soviet Union's Luna 24 robotic sample return mission.
Size of the entire original: ca. 56 × 74 cm; size of detail: ca. 15.2 × 15.6 cm.

resolution Hubble Space Telescope images (fig. 486). NASA's plans for the New Horizons spacecraft, launched in 2006, included the first close observation of Pluto in 2015 and the promise of further data for a new generation of maps. Chronologies like this could be compiled for many worlds.

For each spacecraft mission, maps are used for planning purposes before the flight, for operational support during the mission, as a record of new observations, and as scientific tools to help synthesize geological and other interpretations. Often the final map from one mission becomes the planning map for the next. For any one world, maps record the growth in knowledge over time as successive spacecraft missions have extended surface data coverage or increased the resolution or type of data available. Although the mapping of the Moon has been well documented and that of Mars has been summarized, the whole field has never been subjected to thorough scholarly documentation and analysis. Ronald Greeley and Raymond M. Batson (1990) briefly summarized its history from the USGS perspective. Terrestrial atlases often included lunar maps during the Apollo

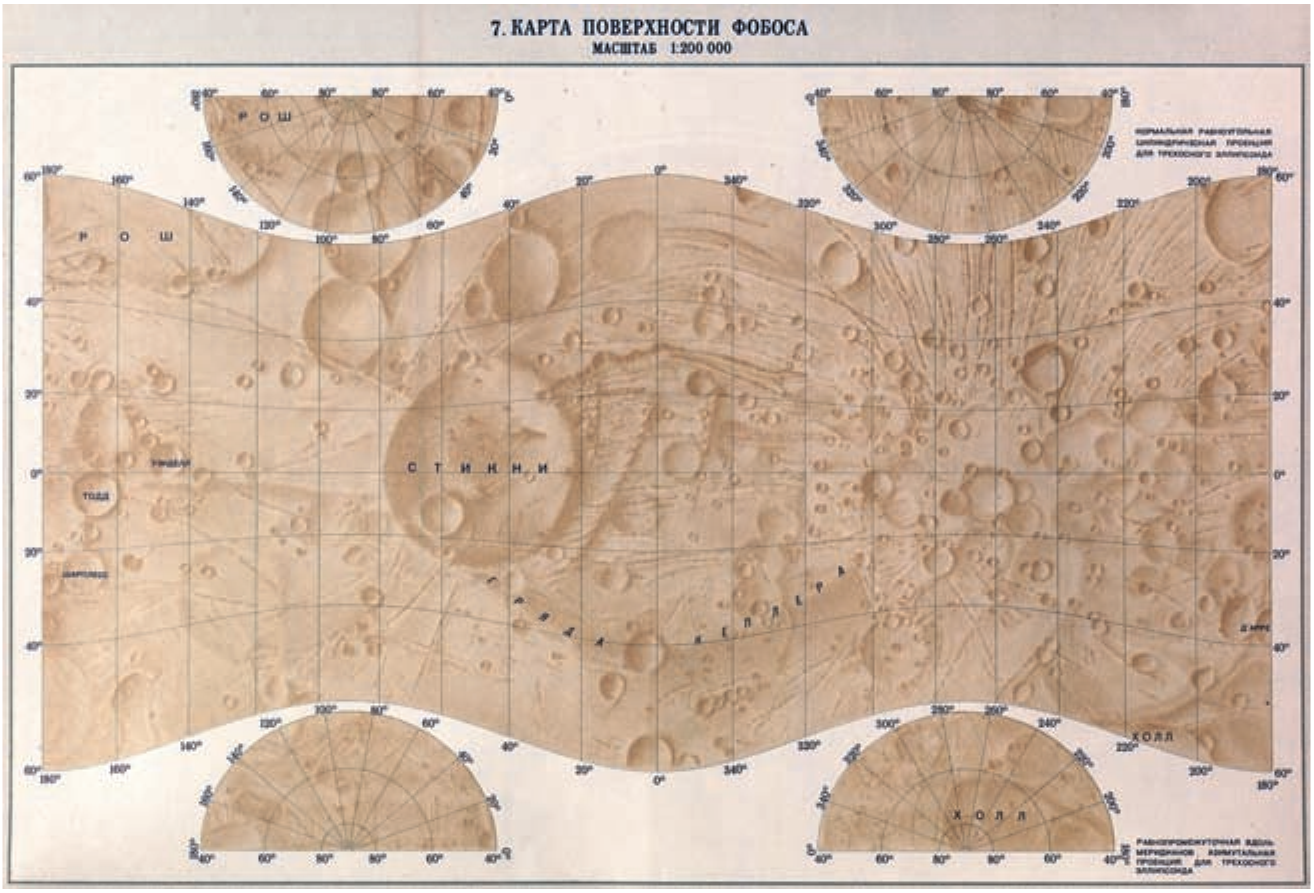



FIG. 485. *KARTA POVERKHNOSTI FOBOSA*, 1:200,000. Russian map of the surface of Phobos, a small (roughly 20 by 30 km) satellite of Mars, based on U.S. image data and illustrating a map projection devised by Lev M. Bugayevskiy for such irregularly shaped bodies.
Size of the original: ca. 20.3 × 32 cm. From *Atlas planet zemnoy gruppy i ikh sputnikov* (Moscow: MIIGAiK, 1992), 44. Permission courtesy of the Moskovskiy institut inzhenerov geodezii, aerofotos"yëmki i kartografii.

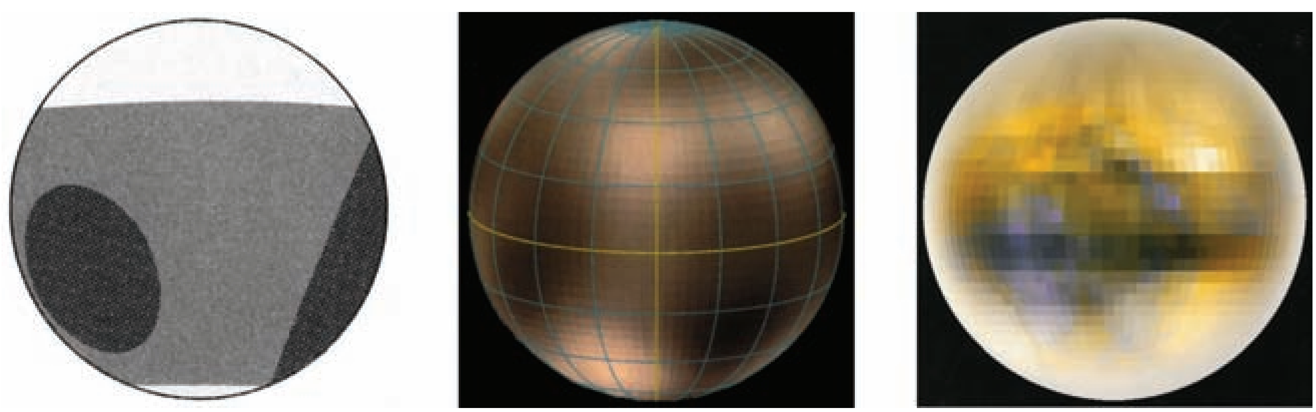


FIG. 486. COMPARISON OF THREE MAPS OF PLUTO. These maps were made using three different methods: light-curve inversion (left), direct imaging by the Hubble Space Telescope (middle), and occultations by Pluto's satellite Charon (right), showing increasing detail provided by improvements in astronomical methods.
From left to right: Robert L. Marcialis, "Spotting Pluto," *Sky and Telescope* 75 (1988): 6, permission courtesy of Robert L. Marcialis; S. A. Stern, M. W. Buie, and L. M. Trafton, "*HST* High-Resolution Images and Maps of Pluto," *Astronomical Journal* 113 (1997): 827–43, pl. 26, © American Astronomical Society, reproduced with permission; and Eliot F. Young, Richard P. Binzel, and Keenan Crane, "A Two-Color Map of Pluto's Sub-Charon Hemisphere," *Astronomical Journal* 121 (2001): 552–61, fig. 7, © American Astronomical Society, reproduced with permission.

period, and some map publishers prepared their own maps. Since 2000, readily available computer software and Internet access to data have replicated the long history of amateur involvement in astronomy by allowing enthusiasts to prepare and distribute maps for monitoring planetary exploration missions. The geographic information system (GIS) became an important mapping tool late in the twentieth century for planning missions and selecting landing sites—apparently without a systematic effort to archive these digital maps for future historical studies.

Many satellites, asteroids, and comet nuclei smaller than about 400 kilometers in diameter have very irregular shapes. Novel map projections have been devised for mapping of these objects at MIIGAiK (fig. 485 above), USGS, Cornell University, and the University of Western Ontario (Stooke 1998). Several cylindrical and azimuthal projections have been modified for this purpose, some truly conformal or equivalent and others designed to portray global shape at the expense of local distortion. Some worlds are so irregular that a radius may intersect the surface more than once, thereby confusing the meaning of latitude and longitude and possibly requiring nonplanetocentric coordinate systems. Much remains to be done in this field.

Another neglected genre of planetary mapping concerns its relationship to works of science fiction by authors such as Edgar Rice Burroughs and Kim Stanley Robinson. Maps may appear in the original texts or in related fan publications, reflecting popular conceptions of the planets such as canals on Mars earlier in the twentieth century or oceans on a terraformed Mars (made Earthlike) in later decades. Some examples are included in J. B. Post's *Atlas of Fantasy* (1973), an eclectic gallery of maps in fiction. Similar maps are used as backgrounds for some space-themed role-playing games, and a further category might include maps of purported artificial structures on Mars and elsewhere (e.g., the "face on Mars").

Although space exploration was initially dominated by the Cold War superpowers, Europe, Japan, India, and China have become active in the twenty-first century. Because cartographers will no doubt continue to map new worlds and support further space exploration, a dedicated effort is needed to preserve this aspect of cartographic history in an age of ephemeral digital maps, fragmented international efforts, and expanded interest in space exploration in popular culture.

PHILIP J. STOOKE

SEE ALSO: Astrophysics and Cartography; Geodetic Surveying: For the Planets; Geographic Names: Gazetteer; Mathematics and Cartography; National Aeronautics and Space Administration (U.S.)

BIBLIOGRAPHY:

Blunck, Jürgen. 1982. *Mars and Its Satellites: A Detailed Commentary on the Nomenclature*. 2d ed. Smithtown: Exposition Press.

Blunck, Jürgen, and Lothar Zögner. 1993. *Der Rote Planet im Kartenbild: 200 Jahre Marskartographie von Herschel, Beer und Mädler bis zur CD*. Gotha: Justus Perthes.

Flammarion, Camille. 1892. *La planète Mars et ses conditions d'habitabilité: Synthèse générale de toutes les observations*. Paris: Gauthier-Villars et Fils.

Greeley, Ronald, and Raymond M. Batson, eds. 1990. *Planetary Mapping*. Cambridge: Cambridge University Press.

Kopal, Zdeněk, and Robert W. Carder. 1974. *Mapping of the Moon: Past and Present*. Dordrecht: D. Reidel.

National Research Council (U.S.). 1978. *Strategy for Exploration of the Inner Planets: 1977–1987*. Washington, D.C.: National Academy of Sciences.

Post, J. B., comp. 1973. *An Atlas of Fantasy*. Baltimore: Mirage Press.

Seidelmann, P. Kenneth, et al. 2005. "Report of the IAU/IAG Working Group on Cartographic Coordinates and Rotational Elements: 2003." *Celestial Mechanics and Dynamical Astronomy* 91:203–15.

Shoemaker, Eugene M., and Robert J. Hackman. 1962. "Stratigraphic Basis for a Lunar Time Scale." In *The Moon*, Proceedings of Symposium No. 14 of the International Astronomical Union, ed. Zdeněk Kopal and Zdenka Kadla Mikhailov, 289–300. London: Academic Press.

Stooke, Philip J. 1998. "Mapping Worlds with Irregular Shapes." *Canadian Geographer* 42:61–78.

Whitaker, Ewen A. 1999. *Mapping and Naming the Moon: A History of Lunar Cartography and Nomenclature*. Cambridge: Cambridge University Press.

Wilhelms, Don E. 1993. *To a Rocky Moon: A Geologist's History of Lunar Exploration*. Tucson: University of Arizona Press.