CARTOGRAPHIC COMMUNICATION

Using a dictionary, define the following terms.

1. map

2. atlas

3. cartography

Text assignment – Goode's World Atlas, *Cartographic Communication*, pp. vi-xi.

1. In what two ways does a map differ from a vertical photograph?

2. Describe the four steps of cartographic generalization listed below.

- Simplification

- Classification

- Symbolization

- Induction

3. Define the term “scale”:

4. Give an example of each of the following types of scales.

   a. RF

   b. written statement

   c. bar scale

5. What are the advantages or characteristics of a large scale map?

6. What are the advantages or characteristics of a small scale map?

7. List the four types of distortion which occur on various map projections.

8. What type (large or small scale) has the least distortion?

9. Complete the chart below based on three projections.

	Advantages/strengths	Disadvantages/weaknesses
Mercator		
Conic		
Robinson		

INTRODUCTION

Geography and Maps

The study of geography is the study of the location, description, and interrelations of the earth's features—its people, landforms, climate, and natural resources. In fact, anything on the earth is fair game for geographic inquiry, and mapping. Helping to answer the questions of *where* something is, and *why* it is there, is fundamental to any geographic study.

Maps, photographs, and images based on radar and the electromagnetic spectrum increase one's ability to study the earth. They enable geographers and other earth scientists to record information about the earth through time and to examine and study areas of the earth's surface far too large to view firsthand.

Geographic Education

There are five fundamental themes of geography that help people organize and understand information about the earth. The maps in *Goode's World Atlas* present information that is essential for applying these themes. The themes are as follows:

Theme 1. **Location: Absolute and Relative.** Maps show where places are located in absolute terms, such as latitude and longitude, and where they are in relation to other places—their relative location. By locating and graphically portraying places and things, maps reveal the patterns of the earth's diverse landscape.

Theme 2. **Place: Physical and Human Characteristics.** Maps provide useful information about the physical and human characteristics of places. Landform maps show the surface features of the earth. Climate and natural vegetation maps may be compared to reveal how vegetation responds to climate conditions. Human characteristics include those effects people have on places. Population maps show the density and distribution of people, while maps of language and religion provide information about cultural characteristics.

Theme 3. **Human/Environment Interaction.** People interact with the natural environment, and the extent to which they alter the environment can be studied by viewing maps. The maps in the atlas provide information about current and past conditions of the environment and are useful in making informed decisions about the future effects of people on the land.

Theme 4. **Movement: Interactions Between Places.** The movement of people and products between places results in networks that span the earth. The dynamics of global interdependence are illustrated by maps that show the movement of commodities from places of production to places of consumption. Maps in the atlas depict highways, air traffic corridors, and shipping lanes that use the world's rivers, lakes, and oceans.

Theme 5. **Regions: How They Form and Change.** A *region* is a part of the earth's surface that displays similar characteristics in terms of selected criteria. Climates, nations, economies, languages, religions, diets, and urban areas are only a few of the topics that can be shown regionally on maps. The region is the basic unit of geographic study. It makes the complex world more readily understandable by organizing the earth according to selected criteria, allowing the similarities and differences from place to place to be studied and understood more fully.

Organization of the Atlas

The maps in *Goode's World Atlas* are grouped into four parts, beginning with *World Thematic Maps*, portraying the distribution of climatic regions, raw materials, landforms, and other major worldwide features. The second part is the *Regional Maps* section and main body of the atlas. It provides detailed reference maps for all inhabited land areas on a continent-by-continent basis. Thematic maps of the continents are also contained in this part. The third part is devoted to *Ocean Maps*. In the fourth part, *Major Cities Maps*, the focus is on individual cities and their environs, all mapped at a consistent scale.

Geographical tables, an index of places, a subject index, and a list of sources complete the atlas. The tables provide comparative data, a glossary of foreign geographical terms, and the index of places—a universal place-name pronouncing index for use with the reference maps.

Cartographic Communication

To communicate information through a map, cartographers must assemble the geographic data, use their personal perception of the world to select the relevant information, and apply graphic techniques to produce the map. Readers must then be able to interpret the mapped data and relate it to their own experience and need for information. Thus, the success of any map depends on both the cartographer's and the map reader's knowledge and perception of the world and on their common understanding of a map's purpose and limitations.

The ability to understand maps and related imagery depends first on the reader's skill at recognizing how a curved, three-dimensional world is symbolized on a flat, two-dimensional map. Normally, we view the world horizontally (that is, our line of vision parallels the horizon), at the eye level about five and one-half to six feet above ground. Images appear directly in front and to either side of us, with our eyes encompassing all details as nonselectively as a camera. Less frequently, when we are atop a high platform or in an airplane, we view the world obliquely, as shown in *Figure 1*, in which both vertical and horizontal facets of objects can be seen. And only those persons at very high altitudes will view the world at a vertical angle (*Figure 2*). Yet maps are based on our ability to visualize the world from an overhead, or vertical, perspective.

A map differs from a purely vertical photograph in two important respects. First, in contrast to the single focal point of a photograph, a map is created as if the viewer were directly overhead at all points (*See Figure 3*). Second, just as our brains select from the myriad items in our field of vision those objects of interest or importance to us, so each map presents only those details necessary for a particular purpose—a map is not an inventory of all that is visible. Selectivity is one of a map's most important and useful characteristics.

Skill in reading maps is basically a matter of practice, but a fundamental grasp of cartographic principles and the symbols, scales, and projections commonly employed in creating maps is essential to comprehensive map use.

Map Data

When creating a map, the cartographer must select the objects to be shown, evaluate their relative importance, and find some way to simplify their form. The combined process is called *cartographic generalization*. In attempting to generalize data, the cartographer is limited by the purpose of the map, its scale, the methods used to produce it, and the accuracy of the data.

Figure 1. Oblique aerial photograph of New York City.

Figure 2. High-altitude vertical photograph of New York City area.

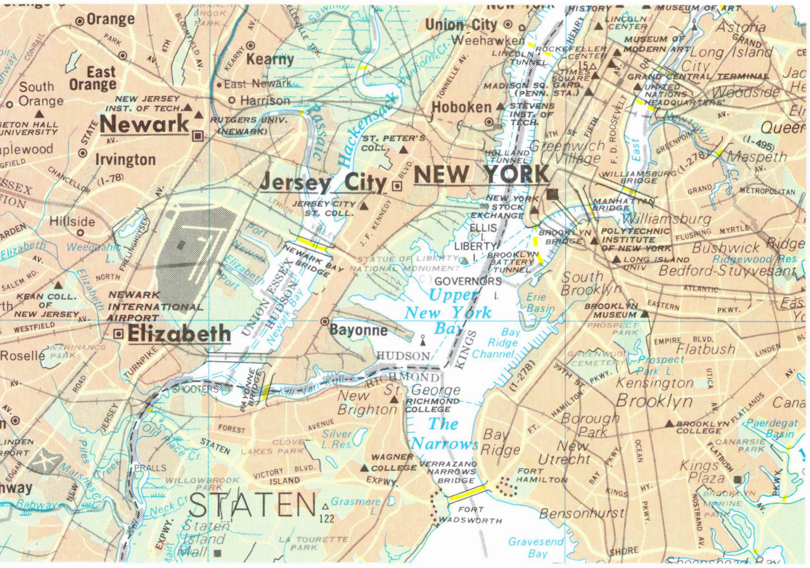


Figure 3. Map of New York City and environs.

Cartographic generalization consists of simplification, classification, symbolization, and induction.

Simplification involves omitting details that will clutter the map and confuse the reader. The degree of simplification depends on the purpose and scale of the map. If the cartographer is creating a detailed map of Canada and merely wants to show the location of the United States, he or she can draw a simplified outline of the country. However, if the map requires a precise identification of the states in New England and the Great Lakes region, the mapmaker will have to draw a more detailed outline, still being careful not to distract the reader from the main features of the Canadian map.

Classification of data is a way of reducing the information to a form that can be easily presented on a map. For example, portraying precise urban populations in the United States would require using as many different symbols as there are cities. Instead, the cartographer groups cities into population categories and assigns a distinct symbol to each one. With the help of a legend, the reader can easily decode the classifications.

Symbolization of information depends largely on the nature of the original data. Information can be *nominal* (showing differences in kind, such as land versus water, grassland versus forest); or *ordinal* (showing relative differences in quantities as well as kind, such as *major* versus *minor* ore deposits); or *interval* (degrees of temperature, inches of rainfall) or *ratio* (population densities), both expressing quantitative details about the data being mapped.

Cartographers use various shapes, colors, or patterns to symbolize these categories of data, and the particular nature of the information being communicated often determines how it is symbolized. Population density, for example, can be shown by the use of small dots or different intensities of color. However, if nominal data is being portrayed—for instance, the desert and fertile areas of Egypt—the mapmaker may want to use a different method of symbolizing the data, perhaps pattern symbols. The color, size, and style of type used for the different elements on a map are also important to symbolization.

Induction is the term cartographers use to describe the process whereby more information is represented on a map than is actually supplied by the original data. For instance, in creating a rainfall map, a cartographer may start with precise rainfall records for relatively few points on the map. After deciding the interval categories into which the data will be divided (e.g., thirty inches or more, fifteen to thirty inches, under fifteen inches), the mapmaker infers from the particular data points that nearby places receive the same or nearly the same amount of rainfall and draws the lines that distinguish the various rainfall regions accordingly. Obviously, generalizations arrived at through induction can never be as precise as the real-world patterns they represent. The map will only tell the reader that all the cities in a given area received about the same amount of rainfall; it will not tell exactly how much rain fell in any particular city in any particular time period.

Cartographers must also be aware of the map reader's perceptual limitations and preferences. During the past two decades, numerous experiments have helped determine how much information readers actually glean from a map and how symbols, colors, and shapes are recognized and interpreted. As a result, cartographers now have a better idea of what kind of rectangle to use; what type of layout or lettering suggests qualities such as power, stability, movement; and what colors are most appropriate.

Map Scale

Since part or all of the earth's surface may be portrayed on a single page of an atlas, the reader's first question should be: What is the relation of map size to the area represented? This proportional relationship is known as the *scale* of a map.

Scale is expressed as a ratio between the distance or area on the map and the same distance or area on the earth. The map scale is commonly represented in three ways: (1) as a simple fraction or ratio called the representative fraction, or RF; (2) as a written statement of map distance in relation to earth distance; and (3) as a graphic representation or a bar scale. All three forms of scale for distances are expressed on Maps A–D.

The RF is usually written as 1:62,500 (as in Map A), where 1 always refers to a unit of distance on the map. The ratio means that 1 centimeter or 1 millimeter or 1 foot on the map represents 62,500 centimeters or millimeters or feet on the earth's surface. The units of measure on both sides of the ratio must always be the same.

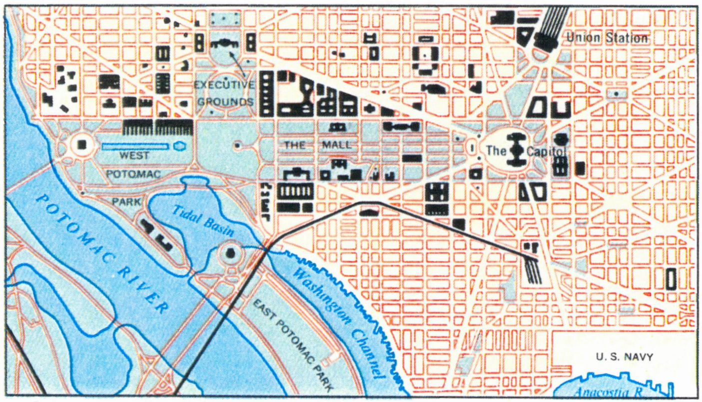
Maps may also include a *written statement* expressing distances in terms more familiar to the reader. In Map A the scale 1:62,500 is expressed as being (approximately) 1 inch to 1 mile; that is, 1 inch on the map represents roughly 1 mile on the earth's surface.

The *graphic scale* for distances is usually a bar scale, as shown in Maps A–D. A bar scale is normally subdivided, enabling the reader to measure distance directly on the map.

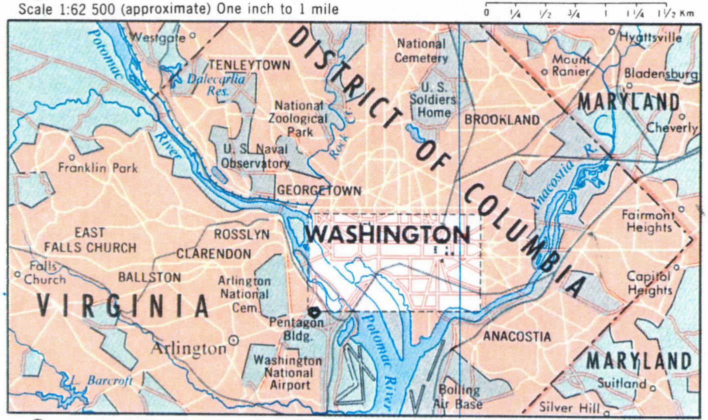
An *area scale* can also be used, in which one unit of area (square inches, square centimeters) is proportional to the same square units on the earth. The scale may be expressed as either 1:62,500^2 or 1 to the square of 62,500. Area scales are used when the transformation of the globe to the flat map has been made so that areas are represented in true relation to their respective area on the earth.

When comparing map scales, it is helpful to remember that the *larger* the scale (see Map A) the smaller the area represented and the greater the amount of detail that a map can include. The *smaller* the scale (see Maps B, C, D) the larger the area covered and the less detail that can be presented.

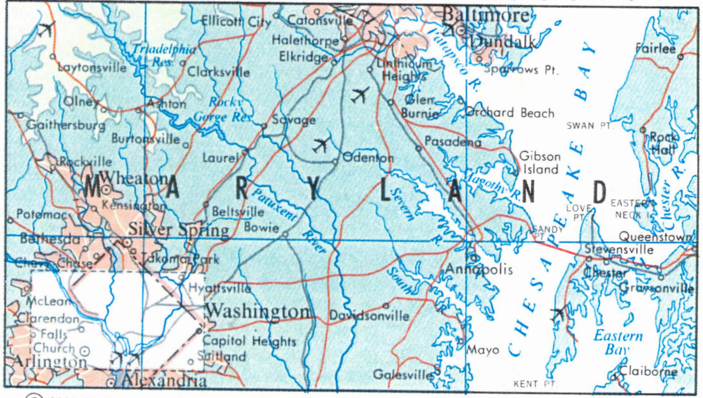
Large-scale maps are useful when readers need such detailed information as the location of roadways, major buildings, city plans, and the like. On a smaller scale, the reader is able to place cities in relation to one another and recognize other prominent features of the region. At the smallest scale, the reader can get a broad view of several states and an idea of the total area. Finer details cannot be shown.



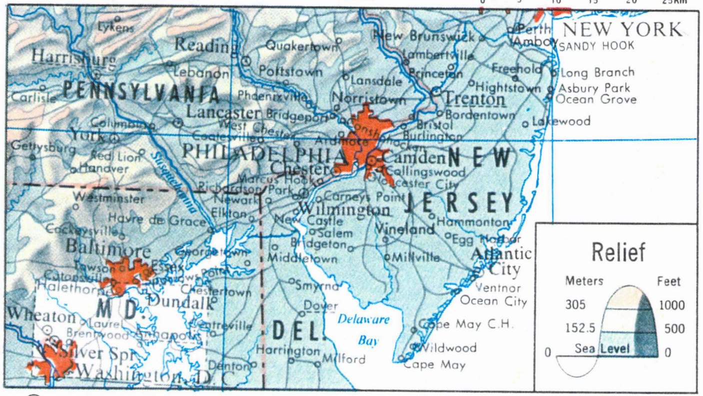
Ⓐ **PART OF WASHINGTON D.C.**
Scale 1:62 500 (approximate) One inch to 1 mile



Ⓑ **WASHINGTON AND VICINITY**
Scale 1:250 000 (approximate) One inch to 4 miles



Ⓒ **WASHINGTON TO BALTIMORE**
Scale 1:1 000 000 (approximate) One inch to 16 miles



Ⓓ **WASHINGTON TO NEW YORK**
Scale 1:4 000 000 one inch to 64 miles. Conic Projection

Map Projections

Every cartographer is faced with the problem of transforming the curved surface of the earth onto a flat plane with a minimum of distortion. The systematic transformation of locations on the earth (spherical surface) to locations on a map (flat surface) is called projection.

It is not possible to represent on a flat map the spatial relationships of angle, distance, direction, and area that only a globe can show faithfully. As a result, projection systems inevitably involve some distortion. On large-scale maps representing a few square miles, the distortion is generally negligible. But on maps depicting large countries, continents, or the entire world, the amount of distortion can be significant. Some maps of the Western Hemisphere, because of their projection, incorrectly portray Canada and Alaska as larger than the United States and Mexico, while South America looks considerably smaller than its northern neighbors.

One of the more practical ways map readers can become aware of projection distortions and learn how to make allowances for them is to compare the projection grid of a flat map with the grid of a globe. Some important characteristics of the globe grid are found listed on page xi.

There are an infinite number of possible map projections, all of which distort one or more of the characteristics of the globe in varying degrees. The projection system that a cartographer chooses depends on the size and location of the area being projected and the purpose of the map. In this atlas, most of the maps are drawn on projections that give a consistent area scale; good land and ocean shape; parallels that are parallel; and as consistent a linear scale as possible throughout the projection.

The transformation process is actually a mathematical one, but to aid in visualizing this process, it is helpful to consider the earth reduced to the scale of the intended map and then projected onto a simple geometric shape—a cylinder, cone, or plane. These geometric forms are then flattened to two dimensions to produce cylindrical, conic, and plane projections (see Figures 4, 5, and 6). Some of the projection systems used in this atlas are described on the following pages. By comparing these systems with the characteristics of a globe grid, readers can gain a clearer understanding of map distortion.

Mercator: This transformation—bearing the name of a famous sixteenth century cartographer—is conformal; that is, land masses are represented in their true shapes. Thus, for every point on the map, the angles shown are correct in every direction within a limited area. To achieve this, the projection increases latitudinal and longitudinal distances away from the equator. As a result, land *shapes* are correct, but their *areas* are distorted. The farther away from the equator, the greater the area distortion. For example, on a Mercator map, Alaska appears far larger than Mexico, whereas in fact Mexico's land area is greater. The Mercator projection is used in nautical navigation, because a line connecting any two points gives the compass direction between them. (See Figure 4.)

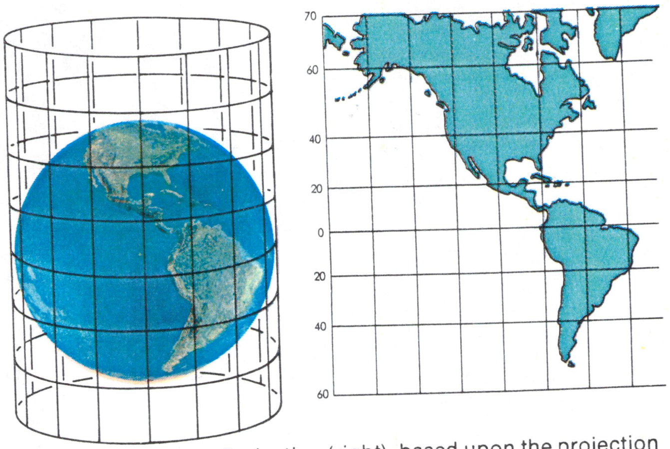


Figure 4. Mercator Projection (right), based upon the projection of the globe onto a cylinder.

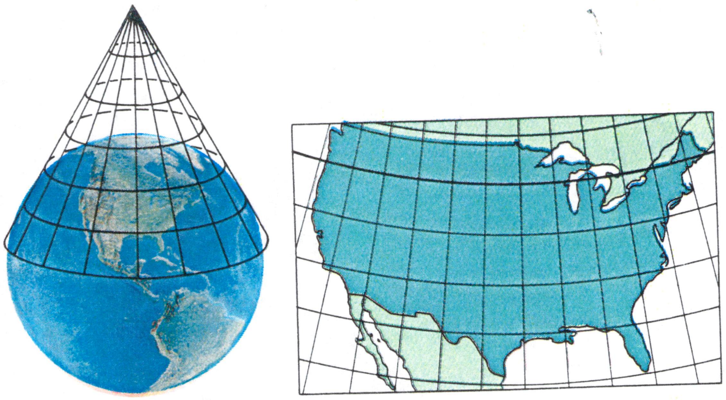


Figure 5. Projection of the globe onto a cone and a resultant Conic Projection.

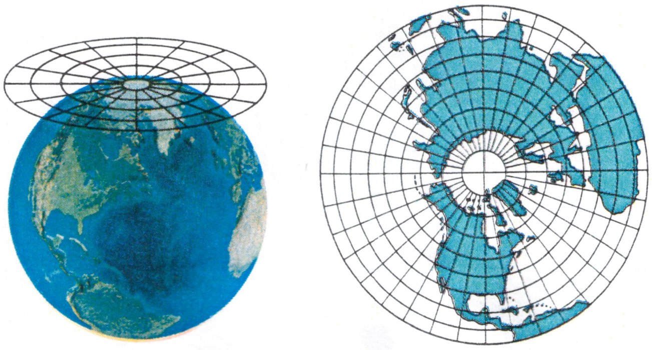


Figure 6. Lambert Equal-Area Projection (right), which assumes the projection of the globe onto a plane surface.

Conic: In this transformation—a globe projected onto a tangent cone—meridians of longitude appear as straight lines, and lines of latitude appear as parallel arcs. The parallel of tangency (that is, where the cone is presumed to touch the globe) is called a standard parallel. In this projection, distortion increases in bands away from the standard parallel. Conic projections are helpful in depicting middle-latitude areas of east-west extension. (See Figure 5.)

Lambert Equal Area *(polar case):* This projection assumes a plane touching the globe at a single point. It shows true distances close to the center (the tangent point) but increasingly distorted ones away from it. The equal-area quality (showing land areas in their correct proportion) is maintained throughout; but in regions away from the center, distortion of shape increases. (See Figure 6.)

Miller Cylindrical: O. M. Miller suggested a modification to the Mercator projection to lessen the severe area distortion in the higher latitudes. The Miller projection is neither conformal nor equal-area. Thus, while shapes are less accurate than on the Mercator, the exaggeration of *size* of areas has been somewhat decreased. The Miller cylindrical is useful for showing the entire world in a rectangular format. (See Figure 7.)

Mollweide Homolographic: The Mollweide is an equal-area projection; the least distorted areas are ovals centered just above and below the center of the projection. Distance distortions increase toward the edges of the map. The Mollweide is used for world-distribution maps where a pleasing oval look is desired along with the equal-area quality. It is one of the bases used in the Goode's Interrupted Homolosine projection. (See Figure 8.)

Sinusoidal, or Sanson-Flamsteed: In this equal-area projection the scale is the same along all parallels and the central meridian. Distortion of shapes is less along the two main axes of the projection but increases markedly toward the edges. Maps depicting areas such as South America or Africa can make good use of the Sinusoidal's favorable characteristics by situating the land masses along the central meridian, where the shapes will be virtually undistorted. The Sinusoidal is also one of the bases used in the Goode's Interrupted Homolosine. (See Figure 9.)

Goode's Interrupted Homolosine: An equal-area projection, Goode's is composed of the Sinusoidal grid from the equator to about 40° N and 40° S latitudes; beyond these latitudes, the Mollweide is used. This grid is interrupted so that land masses can be projected with a minimum of shape distortion by positioning each section on a separate central meridian. Thus, the shapes as well as the sizes of land masses are represented with a high degree of fidelity. Oceans can also be positioned in this manner. (See Figure 10.)

Robinson: This projection was designed for Rand McNally to present an uninterrupted and visually correct map of the earth. It maintains overall shape and area relationships without extreme distortion and is widely used in classrooms and textbooks. (See Figure 11.)

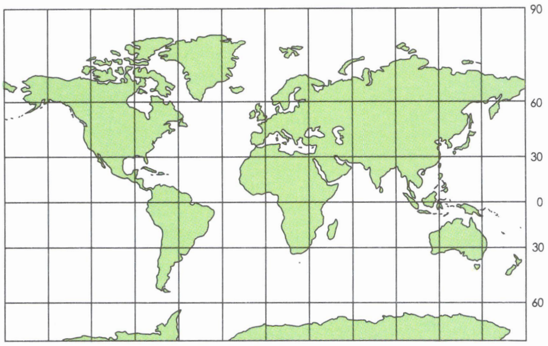


Figure 7. Miller Cylindrical Projection.

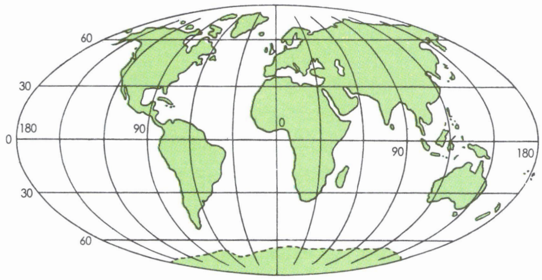


Figure 8. Mollweide Homolographic Projection.

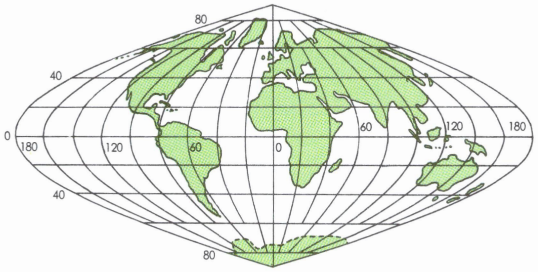


Figure 9. Sinusoidal Projection.

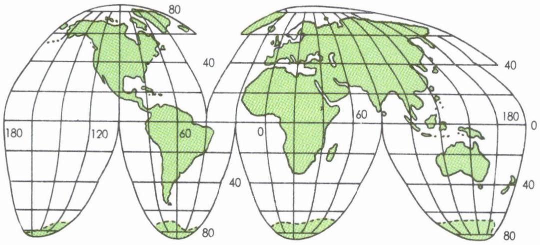


Figure 10. Goode's Interrupted Homolosine Projection.

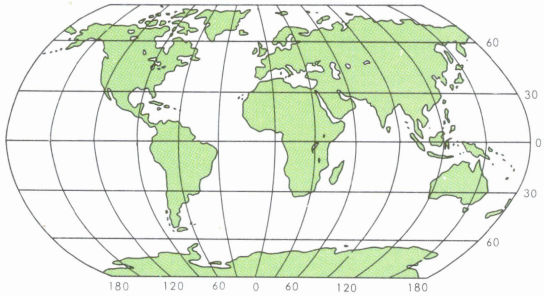


Figure 11. Robinson Projection.

Bonne: This equal-area transformation is mathematically related to the Sinusoidal. Distances are true along all parallels and the central meridian. Farther out from the central meridian, however, the increasing obliqueness of the grid's angles distorts shape and distance. This limits the area that can be usefully projected. Bonne projections, like conics, are best employed for relatively small areas in middle latitudes. (See Figure 12.)

Conic with Two Standard Parallels: The linear scale of this projection is consistent along two standard parallels instead of only one as in the simple conic. Since the spacing of the other parallels is reduced somewhat between the standard parallels and progressively enlarged beyond them, the projection does not exhibit the equal-area property. Careful selection of the standard parallels, however, provides good representation of limited areas. Like the Bonne projection, this system is widely used for areas in middle latitudes. (See Figure 13.)

Polyconic: In this system, the globe is projected onto a series of strips taken from tangent cones. Parallels are nonconcentric circles, and each is divided equally by the meridians, as on the globe. While distances along the straight central meridian are true, they are increasingly exaggerated along the curving meridians. Likewise, general representation of areas and shapes is good near the central meridian but progressively distorted away from it. Polyconic projections are used for middle-latitude areas to minimize all distortions and were employed for large-scale topographic maps. (See Figure 14.)

Lambert Conformal Conic: This conformal transformation system usually employs two standard parallels. Distortion increases away from the standard parallels, being greatest at the edges of the map. It is useful for projecting elongated east-west areas in the middle latitudes and is ideal for depicting the forty-eight contiguous states. It is also widely used for aeronautical and meteorological charts. (See Figure 15.)

Lambert Equal Area *(oblique and polar cases):* This equal-area projection can be centered at any point on the earth's surface, perpendicular to a line drawn through the globe. It maintains correct angles to all points on the map from its center (point of tangency), but distances become progressively distorted toward the edges. It is most useful for roughly circular areas or areas whose dimensions are nearly equal in two perpendicular directions.

The two most common forms of the Lambert projection are the oblique and the polar, shown in Figures 6 and 16. Although the meridians and parallels for the forms are different, the distortion characteristics are the same.

Important characteristics of the globe grid

1. All meridians of longitude are equal in length and meet at the Poles.
2. All lines of latitude are parallel and equally spaced on meridians.
3. The length, or circumference, of the parallels of latitude decreases as one moves from the equator to the Poles. For instance, the circumference of the parallel at 60° latitude is one-half the circumference of the equator.
4. Meridians of longitude are equally spaced on each parallel, but the distance between them decreases toward the Poles.
5. All parallels and meridians meet at right angles.

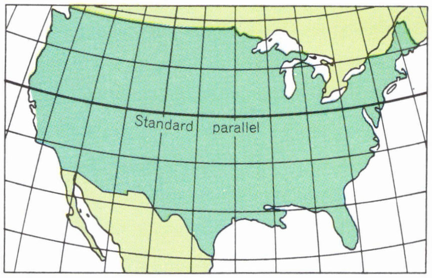


Figure 12.
Bonne Projection.

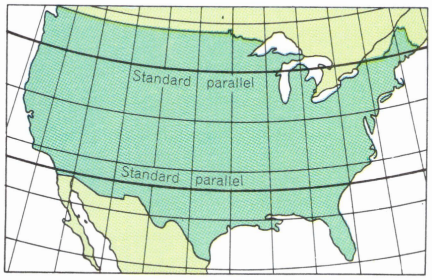


Figure 13.
Conic Projection with Two Standard Parallels.

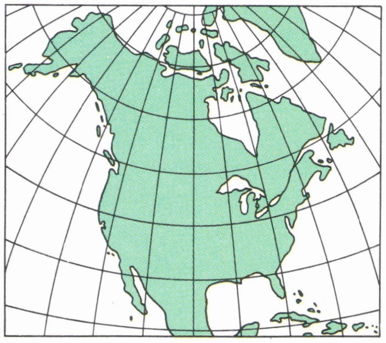


Figure 14.
Polyconic Projection.

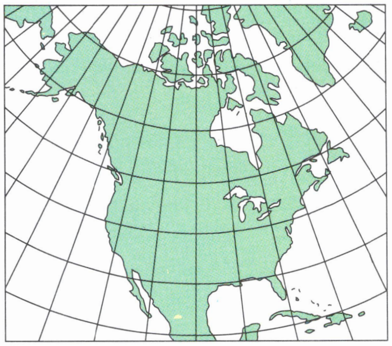


Figure 15.
Lambert Conformal Conic Projection.

Figure 16.
Lambert Equal-Area Projection (oblique case).

Edward B. Espenshade, Jr.
John C. Hudson