PRINCIPLES OF PHYSICAL GEOGRAPHY

An Introduction to Natural Phenomena

Revised Printing

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Principles of Physical Geography

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Preface

The primary motivations behind writing this textbook are economic and personal. Economically, textbooks for university students have become so expensive that students in this country are required to write a check at college bookstores equal to (or greater than) the average annual per capita income of many developing nations. In order to reduce the cost of required readings, this textbook is printed in black and white containing no elaborate color photographs or plates which substantially add to the expense of a textbook. Essential figures and tables are designed by a fellow university student using the latest in computer graphics. An effort has been made to limit elaborate explanations without eliminating important principles keeping the narrative of the text to a minimum thus reducing the number of pages required to complete an introductory treatise.

The second motivation is personal involving a desire to share my deep respect for our earth's natural environment and the awe of the physical phenomena evident in it. This book is intended to assist readers in gaining an appreciation of our earth as a wondrous combination of interrelated physical spheres. The text is written for college students having a limited background in the natural sciences; no previous knowledge of physics or chemistry is assumed or prerequisite. This text is purposefully designed to be required reading for students in introductory physical geography.

Though much debate exits concerning the proper sequence of topics traditionally discussed in a textbook such as this, I have chosen to present the "big four" topics in an order most natural to me: the atmosphere, the biosphere, the lithosphere, and the hydrosphere. After briefly describing the earth in its planetary setting and establishing the geographic grid, the natural properties of the earth's atmosphere are presented focusing on its composition and behavior. Following the concepts of weather and climate, an introductory treatment of vegetative processes is presented including a brief description of the earth's primary terrestrial biomes. Physically and nutritionally sustaining vegetation, soils are discussed next including soil development, soil characteristics, and global distribution. Because the primary component of soil is soft-rock material, the discussion of soils is followed by a presentation of how lithosphere is created including the notion of plate tectonics. The final chapters in this textbook deal with the various physical processes responsible for shaping and lowering the earth's landscape.

Any work of this magnitude requires a substantial effort. I wish to thank the editorial staff at Kendall/Hunt Publishing Company for their assistance in this project. Thanks is expressed to student Duane Runyan for agreeing to design and produce the illustrations and tables appearing in this textbook. I acknowledge and appreciate John

McGregor and Paul Mausel at Indiana State University, and Don Ash (desceased) for sparking the interest in me to attempt a project of this nature. Finally, a special thanks is given to my family who have patiently endured throughout the continuance of this project without a functional husband and father.

Ted J. Alsop
April, 1993

Contents

Chapter 1

Introduction

The study of geography ("geo" meaning earth; "graphicus" meaning to describe) has always attracted individuals curious about our planet, its physical environment, and the people who occupy it. The variety of geographic study ranges from descriptive records of early travelers who assisted in completing the first maps to theoretical and technical research developed by today's professional geographers. While varied in content and quality, these writings have a common theme; they engage in studies of the complex spatial patterns evident in the natural environment and in human activity across the globe.

As we begin our geographic study of natural phenomena, the realization at the onset must be that geography does not begin nor end with "where" things are. As a discipline, **geography** is involved with the global distribution or spatial organization of phenomena on the earth's surface and the factors which influence that global pattern. Professional geographers are involved with the analysis of how space is occupied on the earth's surface attempting to answer questions concerning the implications of geographic location.

geography: systematic study of the spatial arrangement of global phenomena

Modern Geography

Today, geographic studies can be categorized into two groups: human geography and physical geography. Within **human geography** are the specializations of economic, cultural, political, historical, and industrial geography to name a few. Studies in human geography encompass topics dealing with human activity and occupancy on the earth focusing on the interaction of human populations.

human geography: geographic subdiscipline dealing with cultural activities of mankind

The study of **physical geography** involves descriptions of the relationships between the natural realms of the earth's surface, i.e., the atmosphere, hydrosphere, biosphere, and lithosphere. Research in physical geography deals with the intricate

physical geography: geographic subdiscipline involving the distribution of earth's natural realms spatial relationships of the natural elements of weather, vegetation, soils, water, and landforms. During our study of physical geography, we will become familiar with the occurrence of natural phenomena including the dominant factors influencing our natural environment.

While distinguishing between human and physical geography is a useful exercise, people and their physical environment are highly interrelated and inseparable. Providing the natural setting and resources with which mankind can work, the nature of the physical environment so strongly influences all human activities that an understanding of one is partly dependent on the other. The unnatural impression of human activities on nature and the strong influence of the physical environment on the activities of mankind suggest that our planet is one, large system displaying interactions between its components.

Location on the Earth

equator: a line everywhere equidistant from the poles dividing the earth into northern and southern hemispheres

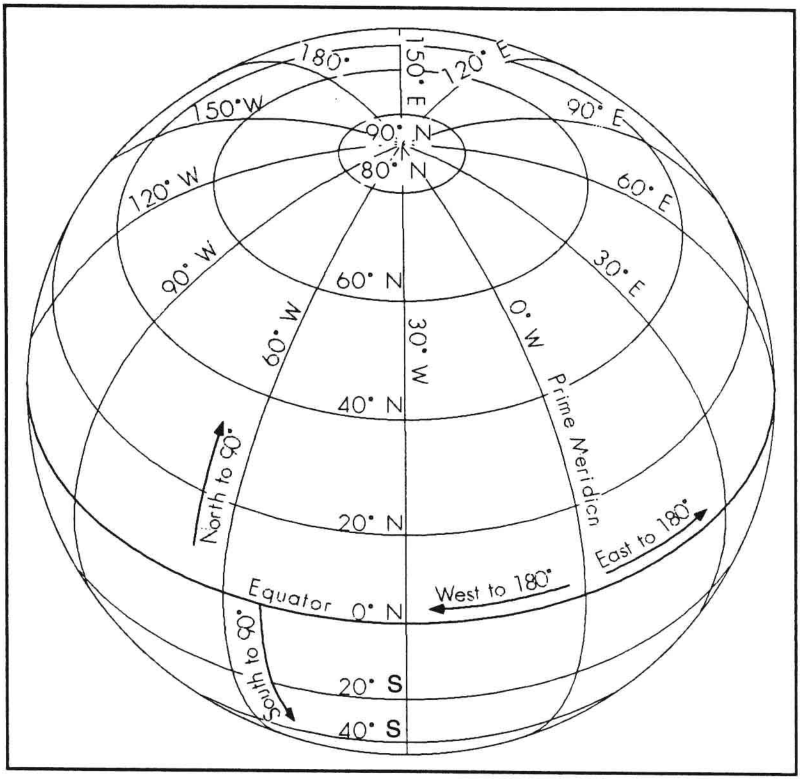
parallels: (latitudes) east-west trending lines everywhere equidistant

meridians: (longitudes) north-south trending lines intersecting parallels at right angles

The sphere we call planet earth is first divided into two hemispheres (northern and southern) based on a surveyed center called the **equator** designed to separate the earth into equal halves (Figure 1.1). Given the vast size of the earth, a method of identifying a precise location was developed based on the concept that the intersection of two lines defines a point in space. One such set of lines trends east-west paralleling the equator. Because these lines are everywhere equidistant, east-west lines are called **parallels** surveyed so that each degree of arc north and south of the equator is 111 kilometers (69 miles) in length. Trending east-west, the latitudes define degrees of northern and southern arcs beginning with zero at the equator and 90 degrees at the poles. Though the distance represented by a degree of latitude is constant, the length of parallel lines becomes progressively smaller poleward until, at the poles, the parallels are reduced to a single point. The length of a parallel at 60 degrees north and south latitude is half the distance length of the equator.

The second set of surveyed lines are called **meridians** which trend north-south intersecting the latitude lines at right angles. Because longitude lines converge at the poles, the distance represented by a degree of longitude is a function of latitude. The relationship is trigonometric. At the equator, the

Figure 1.1 Latitude and longitude.



distance represented by one degree of longitude is 111 kilometers (69 miles) like the parallels. Distances represented by degrees of longitude decrease as a function of the cosine of the latitude (Table 1.1). For example, the distance represented by one degree of longitude at 30 degrees north and south latitude is 96 kilometers (59 miles).

Used to establish world time zones (discussed later in this chapter), meridian lines are also called longitudes all equal in distance length extending from pole to pole. By international convention, the prime (zero) meridian passes through Greenwich, England. Trending north-south, longitudes define degrees of eastern and western arcs beginning at the prime meridian and ending 180 degrees on the opposite side of the globe from the prime meridian. Used as extensively as northern and southern hemisphere, meridians establish the eastern and western hemispheres with reference to Greenwich, England.

Table 1.1 Lengths of a Degree of Longitude at Various Latitudes.

Latitude (degrees)	Miles	Kilometers
0	69.172	111.321
10	68.129	109.641
20	65.026	104.649
30	59.956	96.488
40	53.063	85.396
50	44.552	71.698
60	34.674	55.802
70	23.729	38.188
80	12.051	19.394
90	0	0

The intersection of all parallels and meridians establishes a single point in space on the earth's surface. New York City, for example, is located at 40 degrees north latitude and 73 degrees west longitude. However, because each degree of latitude and longitude (especially at lower latitude locations) span miles of distance, greater detail is needed. Degrees of arc are conventionally subdivided into 60 minutes each of which is divided into 60 seconds. With this detail, the precise location of the City of New York is obtained at the minute level; 40 degrees 41 minutes north latitude, 73 degrees 58 minutes west longitude. Taken collectively, the system of parallels and meridians constitutes the **geographic grid** used to identify the absolute location of features on the earth's surface.

geographic grid: systematic assemblage of parallels and meridians

Maps and Scale

The spatial location of features on the earth's surface are presented on a **map**. Though there are many definitions for a map usually dependent on purpose, maps are generally used to systematically reduce objects pertaining to the "real" world to manageable size in order to be orderly represented on a piece of paper of limited size. This usually requires real-world features to be scaled down.

map: scaled two-dimensional representation of earth's surface features

Map scale refers to the amount of reduction necessary to make real-world objects small enough to appear on paper of limited size. Scaling is accomplished in such a manner that a unit of distance in any direction from any selected point on a map represents a uniform distance and direction from that point on the earth's surface. Expressed as the ratio of map distance to ground distance, map scale is typically written as a ratio such as 1/24,000 or 1:24,000. At that ratio, one dimensional unit on the map represents 24,000 of the same dimensional units in the real world. At a scale of 1:24,000, a line measuring 2.54 centimeters (1 inch) in length represents a real-world distance of 61,000 centimeters (24,000 inches or 2,000 feet). Scaling or reduction is not the only problem encountered to represent reality on a map.

map scale: amount of reduction on a map

Map Projections

The use of maps is fundamental to geography. Not only is a vast amount of information available on a map, but maps can also be a vital tool in geographic analysis. Developed by professional map-makers called **cartographers**, maps are merely two-dimensional (planar) representations of three-dimensional objects on the earth's surface. Because it is simply impossible to "flatten" a spherical object without distorting it, maps twist out of natural condition some aspect of reality dependent on the projection.

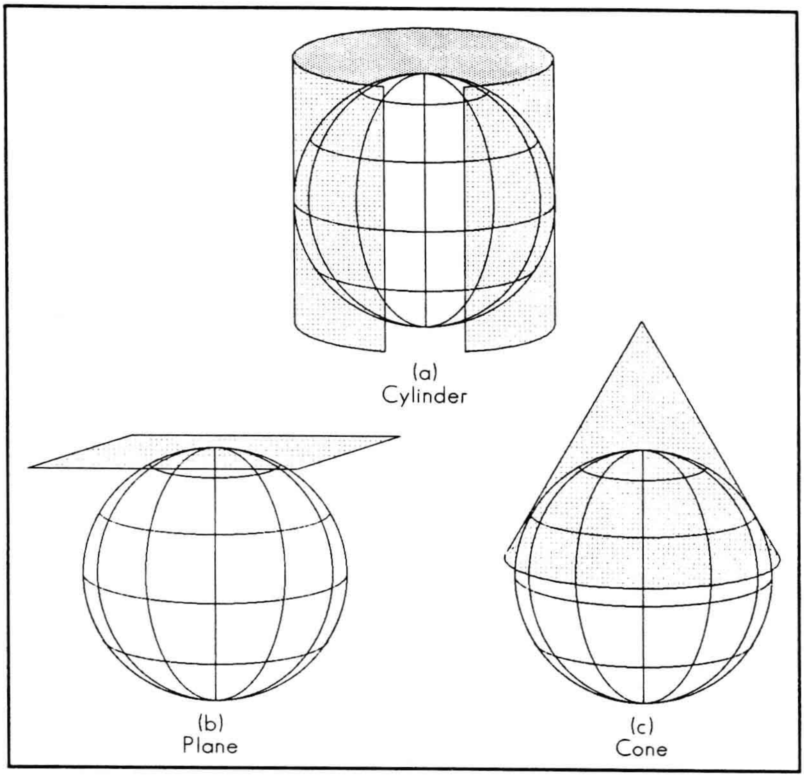
cartographer: professional map-designer

Map **projection** refers to the strategy utilized to portray the three-dimensional earth's surface on planar paper. With its unique arrangement of meridians and parallels, each projection can be thought of as an orderly assemblage of the geographic grid designed to preserve a particular property of the earth, i.e., shape, direction, distance, or area. Though an infinite number of map projections exists, most common projections utilize three geometric configurations, i.e., cylinders, cones, or planes (Figure 1.2).

projection: technique used to represent three-dimensional features on a planar surface

Most people are familiar with the Mercator projection on which all meridians are parallel instead of converging at the poles. Designed to preserve the shape of earth features, the Mercator projection is cylindrical tangent to the equator (Figure 1.2a). This causes the distance between meridians to be stretched in an east-west direction resulting in distortion of map scale poleward. Using a cylindrical projection referenced

Figure 1.2 Most common geometric configurations used for map projections.

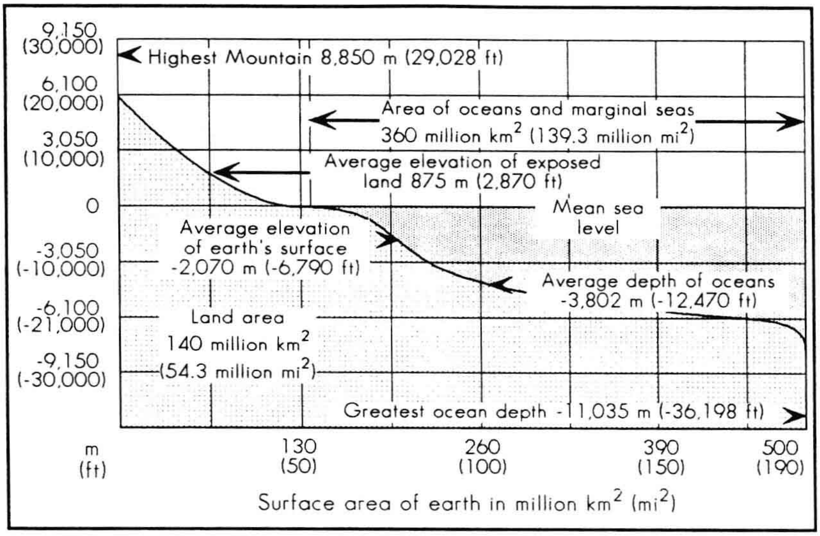


to the equator causes Greenland to appear as a landmass larger than the size of South America. In reality, the area of South America is 82 times the size of Greenland.

Created by projecting the geographic grid on a flat surface, planar projections are commonly tangent to a pole (Figure 1.2b). Planar polar projections cause meridians to radiate from the tangential point at the poles while parallels appear as concentric circles. Most planar projections preserve direction and are important navigational maps.

Finally, conic projections are created by projecting the geographic grid onto a cone tangent at a desired parallel (Figure 1.2c). In conic projections, meridians appear as straight lines radiating in a uniform fashion from the point of the projection cone. Parallels also are nearly linear and intersect with meridians at nearly right angles. Limited to smaller geographic areas, conic projections have the advantage of generally preserving all physical dimensions at the parallel of

Figure 1.3 Hypsographic curve of earth's surface.



tangency. This textbook makes use of various map projections, each employed to systematically represent earth feature-space with a limited amount of distortion.

Planet Sea

The prime function of a map is to graphically represent the spatial distribution of features on the earth's surface. Figure 1.3 presents a smoothed curve illustrating the distribution of the earth surface as a function of elevation. Referred to as the **hypsographic curve** (height curve), the generalized curve illustrates that most of the earth's surface (some 72%) is covered by oceans leaving slightly more than one fourth (some 28%) to represent the continents. With these percentages, it would seem just as appropriate to refer to our planet as "planet sea" instead of planet earth. The average elevation of landmass above mean sea level is observed to be a mere 875 meters (2870 feet) while the average depth of the oceanic area is -3800 meters (-12,470 feet). During our study of "planet sea," we will discover the processes behind forces elevating land surfaces and the natural mechanisms accountable for lowering the elevated surfaces. The earth will be viewed as a dynamic earth-atmosphere system with highly intricate relationships among its components.

hypsographic curve: line graph utilized to represent distribution of earth's surface feature space

The Systems Approach

systems theory: analytical strategy to study relationships

open system: an assemblage of components subject to inputs and outputs

closed system: an assemblage of components not subject to inputs and outputs

The idea that complex interrelationships characterize both human and physical phenomena is hardly new to the discipline of geography. Yet, new analytical techniques and concepts are constantly developed. One of the most useful approaches to the investigation of natural phenomena is known as **systems theory**. In systems theory, natural phenomena occurring within a specified boundary are reduced to processes analyzed as the sum of the relationships between all system components and their attributes. Our earth can be thought of as a system composed of elements with particular attributes establishing the nature of relationships between the elements.

An **open system** is one in which the boundaries are permeable to inputs and outputs while a closed system does not allow for such. We will discover that the earth's energy system is an open system with inputs of solar radiation and outputs of reflected solar energy and emitted terrestrial energy. Though the earth receives minor material inputs from outer space, the earth's mass is considered a **closed system** because no appreciable earthen material is lost to outer space either.

At a closer level of investigation, the earth's physical environment can be thought of as a set of subsystems composed of the atmosphere, hydrosphere, biosphere, and lithosphere. Because of close interrelationships, the alteration of an element in one subsystem will likely result in a disturbance of the elements in another subsystem. For example, if a parcel of land is cleared of its vegetation, the bare soil material would be more vulnerable to be transported from one place to another resulting in a general lowering of the landscape.

The effects of disturbances clearly extend to human subsystems also. New crop production could represent an initial benefit accompanied by changes in the geographic pattern of human occupancy. Economic productivity and settlement patterns may be modified as well as the diversity of natural elements of the remaining in physical environment. While this example is simplistic, the concept of alterations within systems and subsystems is not. None of the components in a system at any level exists in isolation.