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WHY DO GEOGRAPHERS USE MAPS, AND WHAT DO MAPS TELL US?

Maps are an incredibly powerful geographic tool, and **cartography**, the art and science of making maps, is as old as geography itself. (For details on cartography, see Appendix A at the end of this book.) Maps are used for countless purposes, waging war, promoting political positions, solving medical problems, locating shopping centers, bringing relief to refugees, and warning of natural hazards, to name just a few. **Reference maps** show locations of places and geographic features. **Thematic maps** tell stories, typically showing the degree of some attribute or the movement of a geographic phenomenon.

Reference maps focus on accuracy in showing the **absolute locations** of places, using a coordinate system that allows for the precise plotting of where on Earth something is. Imagine taking an orange, drawing a dot on it with a marker, and then trying to describe the exact location of that dot to someone who is holding another orange so she can mark the same spot on her orange. If you draw and number the same coordinate system on both oranges, the task of drawing the absolute location on each orange is not only doable but simple. The coordinate system most frequently used on maps is based on latitude and longitude. For example, the absolute location of Chicago is 41 degrees, 53 minutes North Latitude and 87 degrees, 38 minutes West Longitude. Using these coordinates, you can plot Chicago on any globe or map that is marked with latitude and longitude lines.

The establishment of a satellite-based **global positioning system (GPS)** allows us to locate things on the surface of Earth with extraordinary accuracy. Researchers collect data quickly and easily in the field, and low-priced units are encouraging fishers, hunters, and hikers to use GPS in their activities. New cars are equipped with GPS units, and dashboard map displays help commuters navigate traffic and travelers find their way. **Geocaching** is an increasingly popular hobby based on the use of GPS. Geocachers use their GPS units to play a treasure hunt game all over the world. People leave the treasures (“caches”) somewhere, mark the coordinates on their GPS, and post clues on the Internet. If you find the cache, you take the treasure and leave a new one. Many mobile phones and “smart” devices are also equipped with GPS units, and applications such as Google Maps have helped to spread the use of GPS even further.

Relative location describes the location of a place in relation to other human and physical features. Descriptors such as “Chicago is on Lake Michigan, south of Milwaukee” or “Chicago is located where the cross-country railroads met in the 1800s” or “Chicago is the hub of the corn and soybean markets in the Midwest” are all descriptors of Chicago relative to other features. In the southern Wisconsin, northern Illinois, and western Indiana region, all major roads lead to Chicago (Fig. 1.10). Within this region, people define much of their lives relative to Chicago because of the tight interconnectedness between Chicago and the region. Northwestern Indiana is so connected to Chicago that it has a time zone separate from the rest of Indiana, allowing people in northwestern Indiana to stay in the same time zone as Chicago.

Figure 1.10 All Major Roads Lead to Chicago.

Network of Midwestern roads that lead to Chicago, reflecting the dominance of Chicago in the region. © E. H. Fouberg, A. B. Murphy, H. J. de Blij, and John Wiley & Sons, Inc.

Absolute locations do not change, but relative locations are constantly modified and change over time. Fredericksburg, Virginia, is located halfway between Washington, D.C. and Richmond, Virginia. Today, it is a suburb of Washington, D.C. with commuter trains, van pools, buses, and cars moving commuters between their homes in Fredericksburg and their workplaces in metropolitan Washington, D.C. During the Civil War, several bloody battles took place in Fredericksburg as the North and South fought over the land halfway between their wartime capitals. The absolute location of Fredericksburg has not changed, but its place in the world around it, its relative location, certainly has.

Mental Maps

We all carry maps in our minds of places we have been and places we have merely heard of; these are called **mental maps**. Even if you have never been to the Great Plains of the United States, you may have studied wall maps and atlases or come across the region in books, magazines, and newspapers frequently enough to envision the states of the region (North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas) in your mind. Regardless of whether you have visited the Great Plains, you will use your mental map of the region. If you hear on the news that a tornado destroyed a town in Oklahoma, you use your mental map of the Great Plains region and Oklahoma to make sense of where the tornado occurred and who was affected by it.

Our mental maps of the places within our **activity spaces**, those places we travel to routinely in our rounds of daily activity, are more accurate and detailed than places where we have never been. If your friend calls and asks you to meet her at the movie theater you go to all the time, your mental map will engage automatically. You will envision the hallway, the front door, the walk to your car, the lane to choose in order to be prepared for the left turn you must make, where you will park your car, and your path into the theater and up to the popcorn stand.

Geographers who study human-environment behavior have made extensive studies of how people develop their mental maps. The earliest humans, who were nomadic, had incredibly accurate mental maps of where to find food and seek shelter. Today, people need mental maps to find their way through the concrete jungles of cities and suburbs.

Geographers have studied the mental map formation of children, the blind, new residents to cities, men, and women, all of whom exhibit differences in the formation of mental maps. To learn new places, women, for example, tend to use landmarks, whereas men tend to use paths. Activity spaces vary by age, and the extent of peoples' mental maps depends in part on their ages. Mental maps include *terra incognita*, unknown lands that are off-limits. If your path to the movie theater includes driving past a school that you do not go to, your map on paper will likely label the school, but no details will be shown regarding the place. However, if you have access to the school and you are instead drawing a mental map of how to get to the school's cafeteria, your mental map of the school will be quite detailed. Thus, mental maps reflect a person's activity space, what is accessible to the person in his or her rounds of daily activity and what is not.

Generalization in Maps

All maps simplify the world. A reference map of the world cannot show every place in the world, and a thematic map of hurricane tracks in the Atlantic Ocean cannot pinpoint every hurricane and its precise path for the last 50 years. When mapping data, whether human or physical, cartographers, the geographers who make maps, *generalize* the information they present on maps. Many of the maps in this book are thematic maps of the world. Shadings show how much or how little of some phenomena can be found on a part of the Earth's surface, and symbols show where specific phenomena are located.

Generalized maps help us see general trends, but we cannot see all cases of a given phenomenon. The map of world precipitation (Fig. 1.11) is a **generalized map** of mean annual precipitation received around the world. The areas shaded in burgundy, dark blue, and vibrant green are places that receive the most rain, and those shaded in orange receive the least rain on average. Take a pen and trace along the equator on the map. Notice how many of the high-precipitation areas on the map are along the equator. The consistent heating of the equator over the course of the entire year brings consistent precipitation to the equatorial region. At the scale of the world, we can see general trends in precipitation, such as this, but it is difficult to see the microscale climates of intense precipitation areas that are found throughout the world.

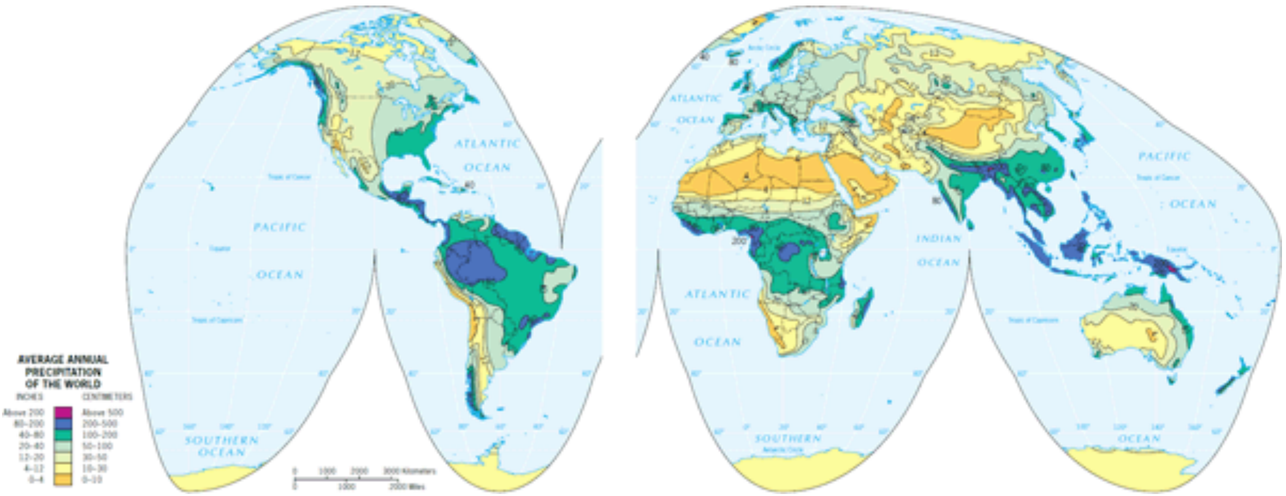

Figure 1.11 Average Annual Precipitation of the World.

A generalized map of the mean annual precipitation received around the world. © H. J. de Blij, P. O. Muller, and John Wiley & Sons, Inc.

Remote Sensing and GIS

Geographic studies include both long- and short-term environmental change. Geographers monitor Earth from a distance, using **remote sensing** technology that gathers data at a distance from Earth's surface. Remotely sensed data are collected by satellites and aircraft and are often almost instantaneously available. After a major weather or hazard event, such as the 2011 floods in the Mississippi River Valley, the unprecedented hurricane season in the Gulf of Mexico in 2005 (which included Hurricane Katrina), or the 2010 earthquakes in Haiti and Chile, remotely sensed data show us the major areas of impact (Fig. 1.12). A remotely sensed image surveys the damage of the earthquake, and photos taken on the ground show the impact and destruction (Fig. 1.13).

Figure 1.12 **Concepcion, Chile.**

Satellite image of the cities of Concepcion and Hualpen, Chile hours after an 8.8 magnitude earthquake occurred in 2010. The damage to the city is not noticeable in this satellite image except for the smoke plume from an oil refinery in the lower left corner. © NASA/Science Source/Photo Researchers, Inc.

Figure 1.13 **Concepcion, Chile.**

Chile has broadly adopted engineering and architecture practices that lessen the impact of earthquakes. Although the 2010 earthquake caused over $30 billion worth of damage, it could have been much worse without these building practices. Most of the damage in Concepcion was to residential buildings like this one. © AP/Wide World Photos.

In states that restrict foreign access or that do not reliably allow foreign aid to enter the country, remote sensing can help geographers understand the physical and human geography of the place. Google Earth is a free, web-based user-friendly set of remotely sensed images from around the world woven together and accessible to anyone with Internet access. You can think of Google Earth as a quilt of remotely sensed images, taken all over the world, coming from several sources, and sewn together. As a result, the resolution (the measure of the smallest object that can be resolved by the sensor, the degree of detail) of the images (each piece of the quilt) differs from place to place.

Remotely sensed images can be incorporated in a map, and absolute locations can be studied over time by plotting change in remotely sensed imagery over time. Advances in computer technology and data storage, increasing accessibility to locationally based data and GPS technology, and software corporations that tailor products to specific uses have all driven incredible advances in geographic analysis based on **geographic information systems** (GIS) over the last two decades. Geographers use GIS to compare a variety of spatial data by creating digitized representations of the environment (Fig. 1.14), combining layers of spatial data, and creating maps in which patterns and processes are superimposed. Geographers also use GIS to analyze data, which can give us new insights into geographic patterns and relationships.

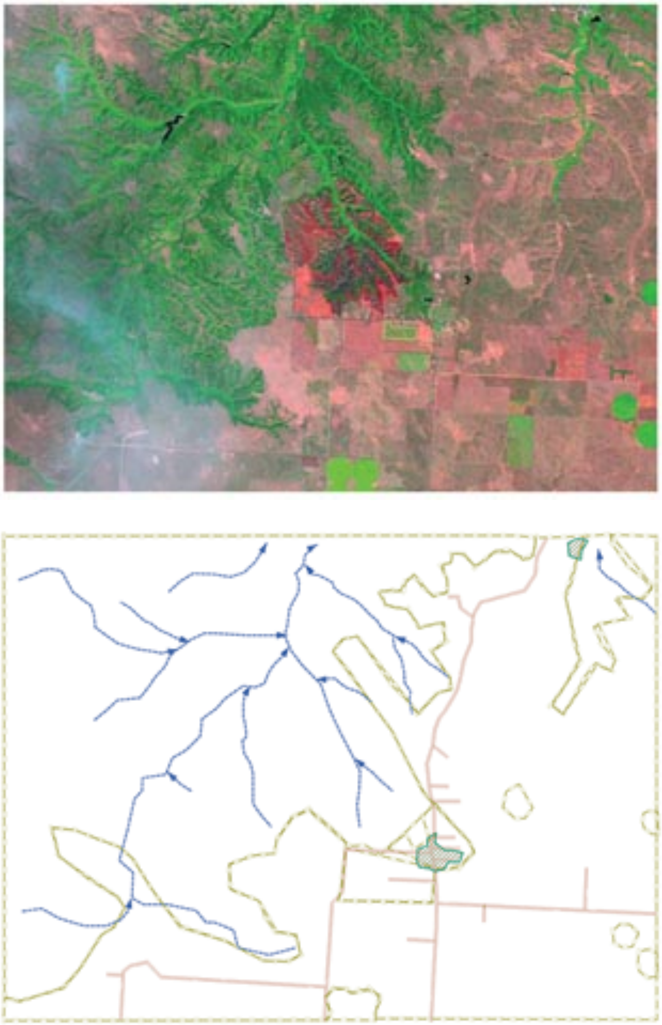

Figure 1.14 **Two Representations of St. Francis, South Dakota.**

(top) panchromatic raster satellite image collected in 2002 at 10 m resolution during a grassland wildfire; (bottom) vector data —,rivers, roads, cities, and land use/land cover digitalized from the image. *Courtesy of:* Joseph J. Kerski using ArcGIS software from Environmental Systems Research Institute, Inc.

Geographers use GIS in both human and physical geographic research. For example, political geographers use GIS to map layers showing voters, their party registration, their race, their likelihood of voting, and their income in order to determine how to draw voting districts in congressional and state legislative elections. In this case, a geographer can draw a line around a group of people and ask the computer program to tally how many voters are inside the region, determine what the racial composition is of the district, and show how many of the current political representatives live within the new district's boundaries.

Geographers trained in GIS employ the technology in countless undertakings. Students who earn undergraduate degrees in geography are employed by software companies, government agencies, and businesses to use GIS to survey wildlife, map soils, analyze natural disasters, track diseases, assist first responders, plan cities, plot transportation improvements, and follow weather systems. For example, a group of geographers working for one GIS company tailors the GIS software to serve the branches of the military and the defense intelligence community. The vast amounts of intelligence data gathered by the various intelligence agencies can be integrated into a GIS and then analyzed spatially. Geographers working in the defense intelligence community can use GIS to query a vast amount of intelligence, interpret spatial data, and make recommendations on issues of security and defense.

The amount of data digestible in a GIS, the power of the location analysis that can be undertaken on a computer platform, and the ease of analysis that is possible using GIS software applications allow geographers to answer complicated questions.

For example, geographer Korine Kolivras analyzed the probability of dengue fever outbreaks in Hawaii using GIS (Fig. 1.15). The maps Kolivras produced may look as simple and straightforward as the cholera maps produced by Dr. John Snow in the 1800s, but the amount of data that went into Kolivras's analysis is staggering in comparison. Dengue fever is carried by a particular kind of mosquito called the Aedes mosquito. Kolivras analyzed the breeding conditions needed for the Aedes mosquito, including precipitation, topography, and several other variables, to predict what places in Hawaii are most likely to experience an outbreak of dengue fever.

A new term of art used in geography is GISci. Geographic information science (GISci) is an emerging research field concerned with studying the development and use of geospatial concepts and techniques to examine geographic patterns and processes. Your school may have a program in GISci that draws across disciplines, bringing together the computer scientists who write the programs, the engineers who create sensors that gather data about the Earth, and the geographers who combine layers of data and interpret them to make sense of our world.

thinking geographically

Use Google Earth to find a place where a humanitarian crisis is occurring today (such as Haiti or Pakistan) and study the physical and human geography overlaid on Google Earth in this place. How does studying this place on Google Earth change your mental map of the place and/or your understanding of the crisis?

Guest Field Note

The diffusion of diseases carried by vectors, such as the *Aedes* mosquito that transmits dengue, is not solely a result of the environmental factors in a place. I use disease ecology to understand the ways in which environmental, social, and cultural factors interact to produce disease in a place. Through a combination of fieldwork and geographic information systems (GIS) modeling, I studied the environmental habitat of the *Aedes* mosquito in Hawaii and the social and cultural factors that stimulated the outbreak of dengue in Hawaii.

When I went into the field in Hawaii, I observed the diversity of the physical geography of Hawaii, from deserts to rainforests. I saw the specific local environments of the dengue outbreak area, and I examined the puddles in streams (Fig. 1.15 A) in which the mosquitoes likely bred during the 2001–2002 dengue outbreak. I talked to public health officials who worked so hard to control the dengue outbreak so that I better understood the local environmental factors contributing to the disease. I visited a family that had been heavily affected by dengue, and I saw their home, which, by their choice, lacked walls or screens on all sides. In talking with the family, I came to understand the social and cultural factors that affected the outbreak of dengue in Hawaii.

I created a GIS model of mosquito habitat that considered not only total precipitation in Hawaii (Fig. 1.15 B), but also seasonal variations in precipitation (Fig. 1.15 C) and temperature (Fig. 1.15 D), to help explain where the *Aedes* mosquito is able to breed and survive on the islands. I also studied seasonal fluctuations in streams and population distributions in creating my model of dengue potential areas (Fig. 1.15 E).

Figure 1.15 A **Maui, Hawaii.**

Aedes mosquitoes breed in artificial and natural water containers, such as the standing puddles left behind when streams dry up during a drought as shown in this photograph along the northeast coast of Maui.

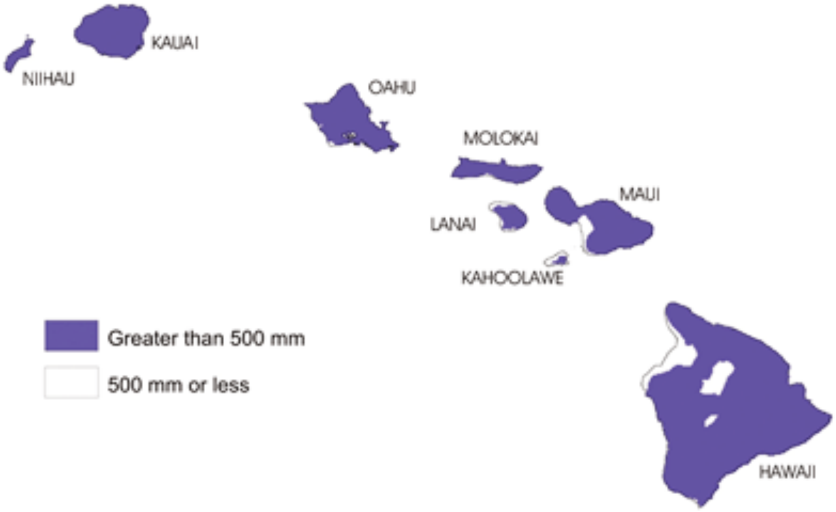

Figure 1.15 B
Total annual precipitation.

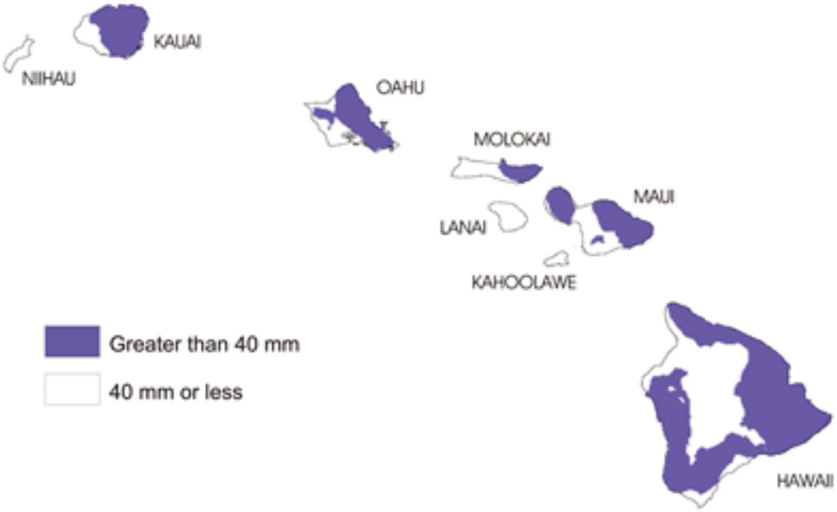

Figure 1.15 C

Average June precipitation.

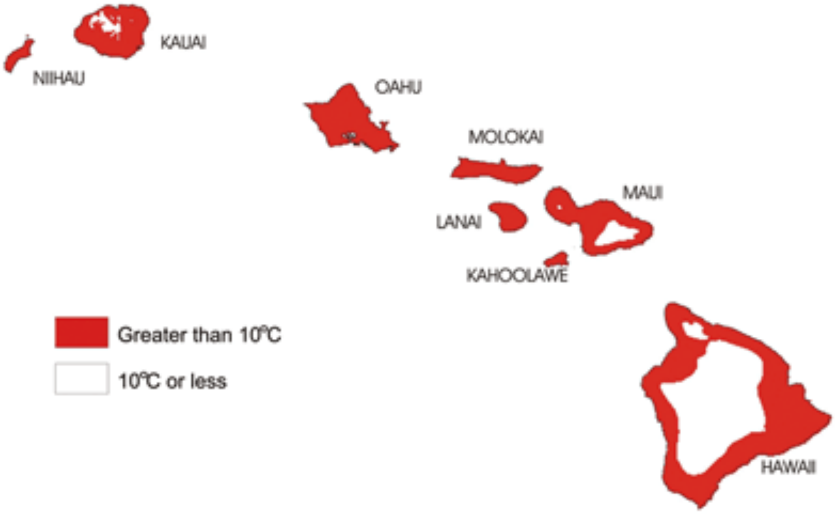

Figure 1.15 D
Average February minimum temperature.

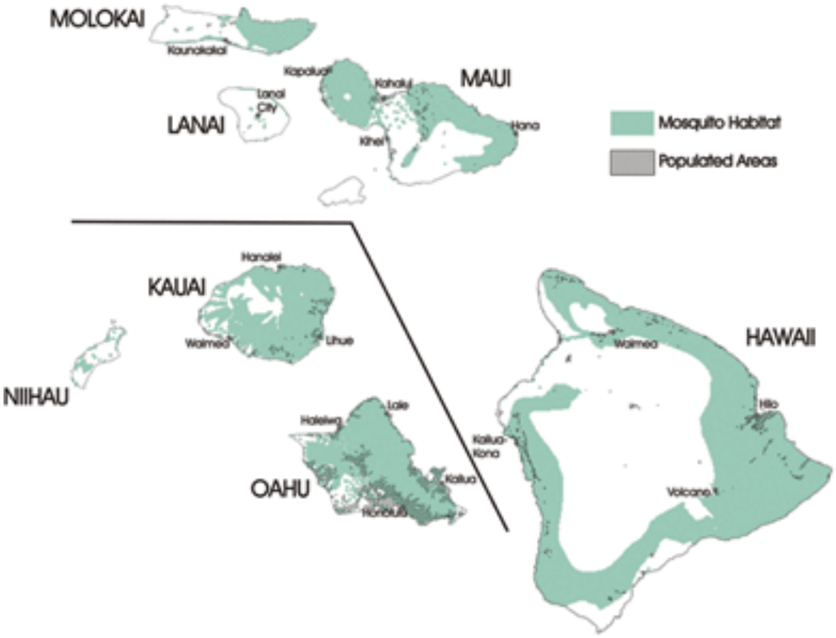

Figure 1.15 E
Dengue potential areas.

The GIS model I created can now be altered by public officials in Hawaii to reflect precipitation and temperature variations each year or to incorporate new layers of environmental, social, and cultural data. Officials will be able to better predict locations of dengue outbreaks so they can focus their efforts to combat the spread of the disease.

Credit: Korine N. Kolivras, Virginia Tech

Global Positioning SystemsGeographic Information Systems