

Chapter 3

Elevation: a geographic “big idea” and some consequences in South America

Elevation is important, because rising air becomes colder and more likely to cause rain or snow.

These facts have consequences that can be seen when you look at many maps of South America: maps that show temperature, rainfall, plant cover, human land use, historic empires, languages, modern country capitals, exports, and issues such as deforestation or energy policy.

Our goal in this chapter is to learn how to interpret maps like these.



Ausungate, a mountain in Peru – the snow is a good hint about the temperature up there!

Photo by Edubucher

Introduction. Stand up. Bend over and reach down toward the floor. Pretend that you are holding a ball about the size of a softball. Now slowly bring your hands up. As you do that, gradually move your hands away from each other.

When your hands are at eye level, you should look like you are holding a volleyball.

When your hands are far above your head, it should look like you are holding a basketball.

Question: What does this have to do with geography?

Answer: This exercise shows what air does when it moves upward.

As air rises, it expands. The same amount of air fills a larger volume. This fact has a lot of consequences. As a result, it is an important part of the geography of many places.

This is the big idea of this chapter:

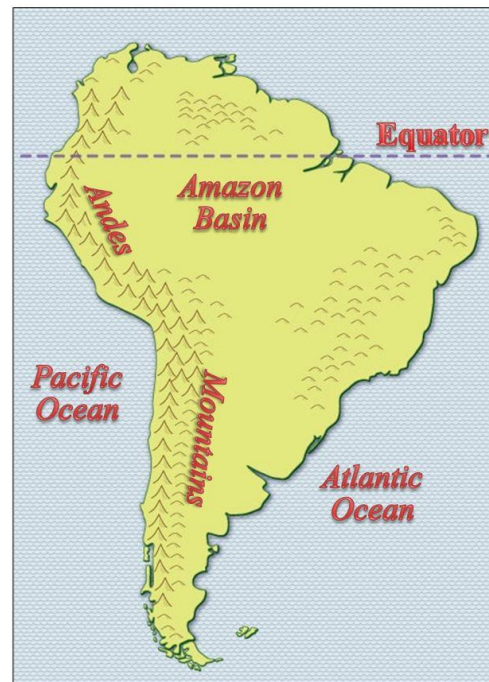
Big Idea: *Elevation is important, because rising air expands, and expanding air gets cooler.*

A geographical “laboratory” to investigate some consequences of elevation.

South America is a good place to explore the consequences of elevation. This continent has a simple pattern of mountains.

Here’s why. South America is moving slowly toward the west. It is “colliding” with the rocks under the Pacific Ocean. This collision is pushing up a long line of high mountains near the west coast.

East of the Andes Mountains is fairly low land. Geologically, this is because most of eastern South America is made of really old rock. This old rock has had plenty of time to get worn down by wind and rain. Geologists call this kind of worn-down old rock a *shield* or *craton*.



Definition: a **shield** is a mass of very old rock (also called a **craton**).

Young mountains and shield rocks are alike in two ways – they both can have useful metals in them, but neither of them is likely to have oil or gas. The good news is that South America has many valuable deposits of gold, silver, copper, tin, even uranium. The bad news is people are not likely to find much oil or gas on this continent.

Exceptions: There is some oil in younger rocks near the edges of the ancient shield – in eastern Peru, northern Venezuela, and under the ocean near the coast of Brazil.

The chapters on Russia and Southwest Asia will look at geologic resources in more detail. Geology is obviously important in South America, but in this chapter we will focus on the effects of rising air.

So what are some consequences of this big idea?

Consequence #1: The tops of high mountains are cool, even near the Equator.

Air expands and gets cooler when it rises. Here is the general rule of thumb:

When you go up a thousand feet, the air gets 2-4 degrees cooler.
 (The actual decrease depends on the starting temperature
 and the amount of water in the air.)

This decrease in temperature as you go up is really obvious in a country close to the equator, like Ecuador (the name of this country means “equator” in Spanish). Quito (KEE-toe), the capital of Ecuador, has an average temperature of 56 degrees in January. Its average temperature in July is exactly the same – 56 degrees.

To someone from England, China, or the United States, the weather in Quito is really strange. It does not get hot in summer. It does not get cold in winter. Some people try to remember this fact by calling Quito “a city of permanent spring.” If you like spring weather and hate winter and summer, Quito is a good place to live.

Meanwhile, less than 200 miles away, there is a city called Porto Viejo (Vee-ay-ho, “old”). Average temperature in January is 79 degrees. In July, it is 75 degrees. These numbers are typical of low land near the equator. In short, Porto Viejo is a land of permanent summer.

What accounts for the difference?

- Quito is located high in the mountains. It is more than nine thousand feet above sea level.
- Porto Viejo is on low land, close to the ocean shore.

Quito 9200 feet	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
	56	56	56	56	56	56	56	56	56	55	55	56	56
Ospina Perez 5550 feet	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
	65	66	66	66	66	66	67	67	67	66	65	65	66
Porto Viejo 150 feet	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
	78	79	79	79	78	76	75	75	75	76	76	77	77
Chicago 600 feet	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
	23	27	38	50	60	69	74	72	66	54	41	28	50

These numbers illustrate the basic rule:

Rule: The air gets a few degrees cooler for every thousand feet you go up.

Here is a practical application of the basic rule:

If you know the height of a mountain and the temperature at sea level, you could predict exactly how high on the mountain you are likely to see permanent snow and ice. You could also predict if the mountain is likely to lose its snow cover in the future, if global warming continues.

Like any rule of thumb, this is a simplification. In the real world, the pattern of temperature is complicated by things like wind and humidity. These complications, in turn, make it harder to predict the exact consequences of global warming in every place. The resulting uncertainty makes it easier for some people to say that global warming is not a problem yet.

But that’s a topic for another day.

In this chapter, we are looking at the consequences of elevation.

Consequence #2: Lowlands near the equator have ideal conditions for rainforests.

The Equator gets more solar energy than anywhere else on earth. As a result, average temperatures are high. Low land near the Equator is a land of permanent summer.

Question: Which continent has the largest area of low land near the Equator?

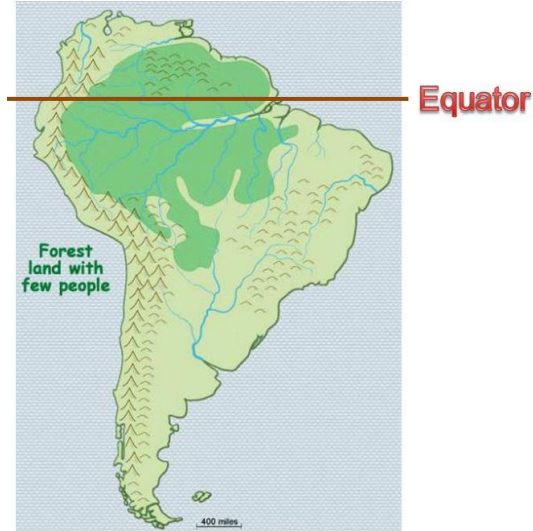
Answer: South America.

The Amazon Basin, a vast expanse of low, hot land in South America, has the largest *rainforest* on earth.

A rainforest is what grows in a place that has high temperatures and a lot of rain in every month.

Question: What does a rainforest look like?

Answer: A rainy forest! Duh!



Trees in a rainforest can grow really tall, because conditions are nearly ideal for fast growth. There is no cold season to freeze the leaves or twigs. There is no dry season to cause fires.

In short, rainforests do not have seasons like other forests. They do not have a colorful autumn like New England, when leaves turn bright red and yellow. They do not have fires like California. They do not have massive migrations of animals like Alaska.

Because the rainforest in Brazil has no distinct seasons, the trees have just one big challenge: “Can you grow fast enough to get your share of sunlight?”

Here is the bumper sticker of a rainforest tree:

GROW TALL OR DIE

Here is a more scientific way to say it: “grow tall, or learn how to live in dark places.”

Some plants, like vines, grow on the trees. Others make really large leaves to catch light. Still others live on the ground and suck energy out of the roots of other plants.

A few rainforest plants can even “eat” insects.

These different “lifestyles,” however, just underline the main point. In a place that has no cold or dry season, the main stress on plants comes from other plants. As a result, rainforest trees usually grow several hundred feet high. These tall trees block most of the sunlight.

Science question: Why don’t trees grow taller than about 300 feet?

Answer: Because the “biological pumps” in plants can’t lift water any higher.

You could think of rainforest trees as being like basketball players. The tallest ones are often (but not always) the most valuable. The value of rainforest trees, in turn, can lead to another problem. *Deforestation* is a major economic and political issue in the Amazon Basin, the lowlands near the equator in South America.

Definition: **Deforestation** is the process of cutting trees down without doing anything to replace them with other trees.

Consequence #3 – Lowlands near the equator have small animals that can climb or fly.

Rainforests have many animals that know how to live among tall trees:

- **birds**, of course, because they can fly,
- **insects**, especially ones that can fly,
- **snakes** that can wrap themselves around tree branches,
- **monkeys**, squirrels, and other tree-climbing animals.

What kinds of animals do you NOT expect to see in a rainforest? Elephants, deer, bison, or any other large animals that eat grass and other ground plants. You also should not expect to see lions, tigers, or wolves. Animals like these live by hunting other animals that eat grass.

Here is how the big idea of this chapter helps us understand rainforest animals:

- 1) Low places near the Equator are usually hot and rainy.
- 2) Trees usually grow tall in hot rainy places.
- 3) Animals that live in hot rainy places have to be able to live among tall trees.

Human beings are different. Early humans lived in grasslands with dry seasons. Later, they moved into forests that had cold seasons.

In short, humans are biologically not well suited to live in hot rainforests.

People who live in a rainforest have to work hard to get food. Building houses is also hard, because wood can rot quickly in a hot, wet place. As a result, the rainforest areas of South America are good illustrations of a general principle:

Equatorial rainforests are generally areas with few people living in them.

Other places near the equator have rainforests, but our focus in this chapter is on South America. So where do South Americans live? Specifically, where did they live in the past, and where do they live today? You already know one big part of the answer:

South America has a large rainforest, and very few people live in it.

Inside a rainforest.

Actually, this is not a “perfect” picture of the inside of a rainforest.

A rainforest is usually much darker than this. Several large trees died and fell down. This makes a break in the “roof” of trees and allows some light to reach the ground.

(Extra light makes it easier to take pictures! It also supports plants growing on the ground.)



Consequence#4 – The first big “country” of South America, the Inca Empire, started in the high mountains near the Pacific coast.

Think of the really old civilizations of Africa and Asia.

Question: What do Egypt, Mesopotamia, the Indus Valley, and China have in common?

Answer: All of these ancient civilizations were located on floodplains near big rivers.

South America was different. It does not have many places with that kind of environment. That basic difference gives us a way to examine a really important geographic idea.

Basic geographic principle: In every part of the world, people have to find a way of making a living that fits the conditions in their local environment.

(P.S. This rule is just as important for modern city-dwellers as it was to the hunters and farmers of the ancient world.)

When Columbus landed in 1492, many people already lived in the Americas. No one knows exactly how many. Most analysts think the total was about 6 or 7 million in North America. South and Central America had more people, perhaps as many as 25 million.

Why did South America have more people? It has to do with how people could get food.

- Some people could live in villages near the west coast and catch fish. From Canada to Chile, the west coast has cool ocean currents. That’s good for fish.
- Other people chose places where the soil was good and they had enough rain for farming.
- A few people lived in the deserts, in small groups near rivers or other sources of water.
- Some people lived as hunters in the mid-continent grasslands. These grasslands are huge in North America. Hunting was harder in South America, because South America has less grassland. As a result, it had fewer large, easy-to-hunt animals.

By far the most people lived in the highlands of present-day Ecuador, Peru, and Bolivia.

Question: Why were these mountains better places for humans to live?

Answer: Because of the big idea of this chapter. Air gets cooler when it rises.

Near the Equator, low land is good for plants that grow tall and animals that live in tall trees. Humans, however, are not good tree-climbers. Moreover, people like to eat grasses such as wheat, corn, or rice. They also like to eat the roots of plants like potatoes, carrots, or cassava. None of these plants grow well under tall trees.

Science note: It is very hard to make a natural environment into something completely different. It takes a LOT of effort and energy to turn a rainforest into a cornfield. There are many reasons for this. These reasons involve technical facts related to soil clay structure, cation exchange, leaching, and so forth.

Relax – we will not go into those details in this geography book. But that decision (not to explain some facts) does not mean that the facts do not exist!

People who do not know about these technical facts may think that rainforests are “unused” land, which could be turned into food-producing areas in the future.

To help avoid a big and costly misunderstanding, everyone should remember:

You can’t make a rainforest into a cornfield without a LOT of effort and energy.

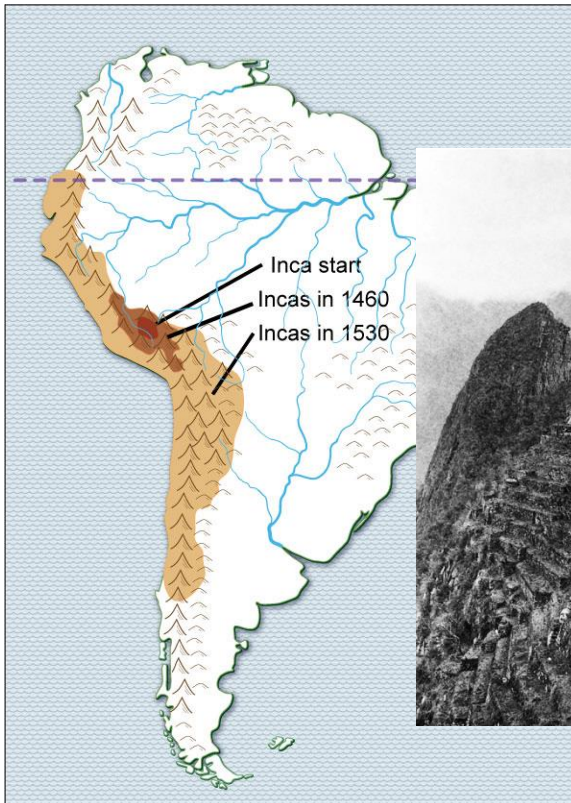
People usually live in places where it is easy to grow food. This was especially true in ancient times, when there were no farm machines or refrigerated trucks.

In most of South America, it was like the children’s story of Goldilocks and the Three Bears. You remember it? One bed was too soft. Another was too hard. The third was just right.

- Low places in South America are hot and rainy.
- High mountains are cold and snowy.
- Medium-elevation land might be just right.

Fortunately, the highlands of Bolivia and Peru have a fairly large area that is just about the right elevation above sea level. This land is called the Altiplano (which means “high, flat land” in Spanish). This is where the Inca Empire started.

As this empire grew more powerful, it expanded nearly a thousand miles north and south. People tried to stay near the ideal elevation. Eventually, the Inca Empire controlled most of the favorable high-elevation land in South America.



The “city” of Machu Picchu in the Inca Empire. Photo taken in 1912 by Hiram Bingham, the man who “discovered” the old ruins.



Project: find a modern photo of Machu Picchu and describe how things have changed.

Meanwhile, the **Aztec** people started another empire in a similar geographic position. They started in the high plateau of central Mexico, near present-day Mexico City.

Definition: a **plateau** is a fairly flat area that is high above sea level.

In time, the Aztec Empire also spread. By 1492, the Aztec and Inca empires controlled almost all of the favorable high land in Central and South America. Then Christopher Columbus landed.

The arrival of Europeans brought really big changes to South America.
That is the next consequence on our list.

Consequence #5: European explorers and colonists took easy ways into South America – they used boats on lowland rivers and horses on highland roads.

The high mountains of South America are near the west coast. Rivers start in the mountains and flow rapidly downhill. Then they *meander* across the lowlands to the Atlantic Ocean.

Definition: to **meander**
is to move in one direction
with many side-to-side curves



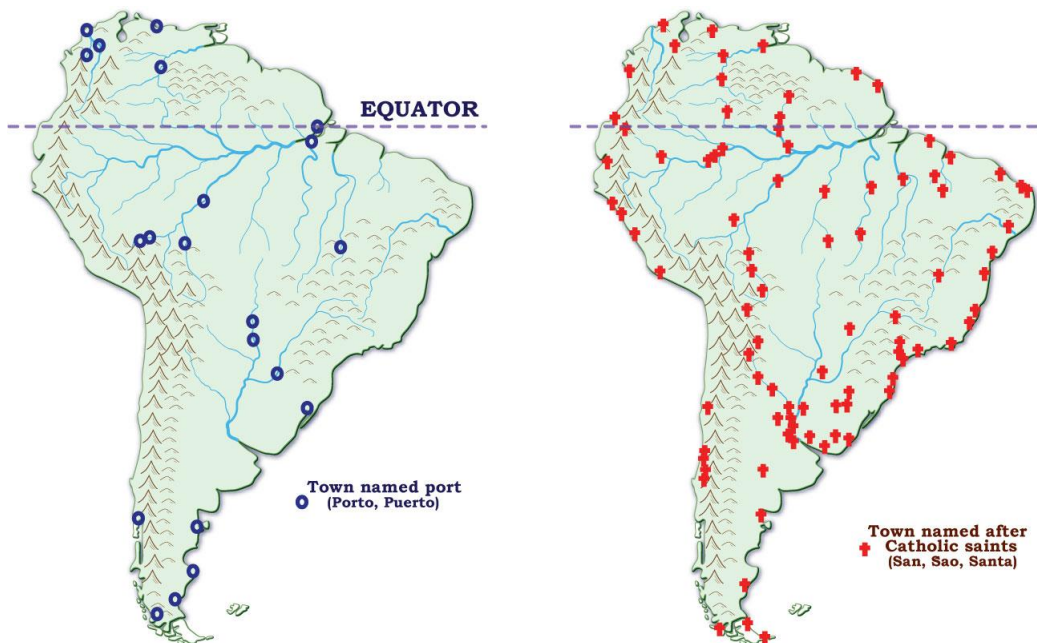
Here is an important geographic fact: *Rivers are not equally “friendly” to boats.*

- Rivers in mountainous places are likely to have a lot of rapids and waterfalls. These can be beautiful, but they can also wreck boats.
- Rivers in places with distinct wet and dry seasons also pose problems for boats. They tend to flood in the wet season and get shallow in the dry season.

The Amazon River drains a large area of rainforest near the equator. Places close to the equator usually get rain in every month. The Amazon, therefore, has a fairly steady flow. This makes it very good for travel by boat. Not surprisingly, explorers from Spain and Portugal often used boats to go into South America. They built forts and trading posts near the rivers.

Spanish armies chose a different way to travel into South America. They used the roads built in the mountains by the Inca and Aztec people. Unfortunately, armies were not the only thing that could move on the roads. Travelers along the roads also helped spread European diseases like smallpox. Many native people died from these diseases even before the Spanish armies arrived. Others were too weak to fight effectively.

If you look at a map of South America today, you can see evidence of where the explorers from Spain and Portugal went. Many of their missions and trading posts were located next to the ocean or rivers. Others are named for saints in the Catholic church. As a result, many town names include the Spanish or Portuguese words for “port” or “saint”.



Elevation and City Location in South America

The capitals and large cities of South America offer a good illustration of the importance of elevation. Some (like Bogota, Quito, Cuzco, La Paz) are high up in the mountains. Others (like Lima or Rio de Janeiro) are next to the ocean.

Remember the big idea. Low land near the Equator tends to be uncomfortably hot, but air gets cooler as you go up. Sao Paulo is the largest city in Brazil. It is located in the southern highlands, about 3000 feet above sea level. This is higher than most of the mountains in Arkansas or Pennsylvania.

The capital of Brazil offers an even better example of the importance of elevation. In 1960, the people of Brazil decided to build a new national capital. They knew where they did NOT want it to be:

- They did NOT want it on hot, low land near the Equator.
- They did NOT want it near an ocean port like Rio de Janeiro.
- They did NOT want it near the large cities in the southern highlands.

So they picked a site toward the middle of the country. There, they built a brand new city. They named the new capital Brasilia.

In choosing a site, they paid attention to the big idea about elevation and temperature. They picked a site that is nearly 4000 feet above sea level. That is one of the highest places in the entire country. As a result, the capital of Brazil is at least ten degrees cooler than it would be if it were down near sea level.

The tradeoff, however, is that the capital is far away. It is far from the coast, far from the Amazon River, and far from the main cities of the country.

Unfortunately (as you learn in the chapters about Australia and Russia), long-distance travel is expensive.

Thought question: do you think it is a good idea for a capital to be far from other centers of population in a country? What are some advantages /disadvantages of that location?

Advantages of the location of Brasilia, the capital of Brazil

Disadvantages of the location of Brasilia, the capital of Brazil

Consequence #6: The middle-elevation plains of South America are food-surplus areas.

Places near the Equator are hot and rainy in every month. These conditions are good for trees. They are not good for food crops like corn or potatoes. Furthermore, hot, rainy places also have a lot of bugs and weeds. That makes it even harder to grow food there.

The southern part of South America is far from the Equator. It has a distinct cold season. People who live in those areas can produce food in the “typical” human way. They can grow crops in big fields. They can feed grain and hay to cows or other animals. As a result, these countries have become food exporters.

Want some proof? Go to a grocery store almost anywhere in the United States or Europe. You are likely to see foods from Argentina, Chile, Paraguay, and Uruguay.

The pattern of farming in southern South America is basically an “upside-down” version of a map of farms in the United States.

- Paraguay is the warmest country. Its long, hot summers are like those in the southern part of Texas. Like Texas, Paraguay grows and exports cotton, cattle, and soybeans.
- Uruguay is in the middle. Its climate is more like Mississippi and Arkansas. Like those states, Uruguay produces and exports grain and beef.
- Argentina is coldest country. Like Kansas and Nebraska, Argentina sells wheat, meat, and some corn.

Meanwhile, on the western side of the mountains is the long, skinny country of Chile.

Northern Chile is hot and dry, like lowland Mexico.

Southern Chile is cold and mountainous, like western Canada and Alaska.

The middle, however, is like California. It has warm, dry summers and cool, rainy winters. Most Chileans live in this part of the country. There, they can grow the same foods that people grow in California – olives, avocados, oranges, wine grapes, and so forth. Go to any grocery store in the United States in winter, and you will find foods imported from Chile.

(Remember, our winter is their summer, when they can grow food for export!)

Question: What crop is near the top of the list of money-making crops?

Answer: Grapes. If you make grapes into wine, you can make a lot of money per square mile.

Grapes can grow on hilly land. They grow well in places with cool, rainy winters and hot, dry summers. Central Chile has the right combination of conditions. As a result, Chilean wine producers have become internationally famous.

Chilean people also produce and export a lot of fish. They catch some fish in the ocean. They also raise fish in artificial ponds on the land. This is another case where the modern world economy has rediscovered some old facts about the world. Remember that the very first “civilizations” in South America were fishing villages along the Pacific coast.



Consequence #7. The geologic processes that make high mountains also make metal ores.

As we said near the start of this chapter, the landform map of South America is fairly simple. The continent has old, worn-down mountains in the east. It has young, high mountains in the west. The middle is low and almost flat.

The western mountains have a lot of earthquakes and volcanoes. These are still pushing the mountains up. The resulting heat and pressure tends to concentrate metallic minerals in veins and pockets in the rock. As a result, the mountains of South America have a lot of metal *ores*.

Definition: an **ore** is a rock that contains gold, silver, copper, tin, zinc, lead, or any of the other metals that are used in factories around the world.

This was the main message that Spanish explorers brought back to Europe:

“The mountains of Central and South America are full of gold and silver.”

The lure of gold was one of the main reasons why Spanish explorers went to South America. The native people who lived near the coast had gold jewelry and statues. They said they got these by trading with the people in the mountains. Following these rumors, many Spanish explorers went into the mountains to find the gold. By the mid-1500s, hundreds of Spanish ships were traveling back to Europe every year. Many of them were full of gold and silver from the mines of Mexico and South America.

Even today, people in the five mountain countries of South America make a lot of money by digging minerals out of the ground. They sell metals to people in Europe, Japan, the United States, China, and many other countries.



Chuquibambilla Mine, Chile; Photo by Reinhard Jahn, Mannheim

Consequence #8. Large changes in elevation make transportation difficult.

The Incas knew where they could grow food with their technology. It was in the cool high land near the equator, more than a mile above sea level. This kind of land, unfortunately, has a problem for food exporters.

Here is the problem:

Mountains make transportation difficult.

Want proof? Look at this picture of a road in the Andes Mountains.

(Does this picture look familiar? It was also in the first chapter, about world patterns of population.

Photo provided by Connie Weil.)



The highlands of South America are good places to be *subsistence farmers*.

Definition: **subsistence farmers** grow food for themselves, not for sale to others.

Mountains are NOT good places to try to grow food for *export* (for sale to other countries). It's hard to farm on steep land, and transportation is too expensive.

So what can people do to make a living in the rugged highlands?

One option is to dig for minerals, like silver or tin. Remember – young mountains are good places to find metals. Other options include two of the most valuable crops in the world. One of them grows on trees. It is legal, and it is the second most valuable export crop in the world.

The other crop is a tall shrub. Growing it is illegal, but it is even more profitable.

The names of these crops, in case you haven't already guessed, are coffee and cocaine.

Compared to most crops, coffee and cocaine are worth a lot of money per pound. It is much easier to transport a hundred dollars' worth of coffee or cocaine than an equal value of a cheap grain like corn or a heavy root crop like potatoes. This fact makes it possible to grow coffee or cocaine in places that do not have river boats, railroads, or even good roads.

The big idea of this chapter is the influence of elevation on things like temperature and transportation. This idea can help us understand why the highland countries of Bolivia, Peru, Ecuador, and Colombia are important producers and exporters of coffee and cocaine.

Finally, let's take a quick look at the northern coastal countries of Venezuela, Guyana, and Suriname. These places are hot. Transportation is easy, because most of the land is flat and low. This makes it possible to sell heavy things that grow in a hot climate. Examples include wood from rainforest trees and heavy fruits like bananas, mangoes, and papayas.

Lowland people can also grow a product that is so important in the world economy that we will treat it as a separate consequence of the big idea. That product is sugar. It is used for chemicals and fuel as well as food.

Consequence #9: Sugarcane from hot lowlands can provide cheap renewable energy

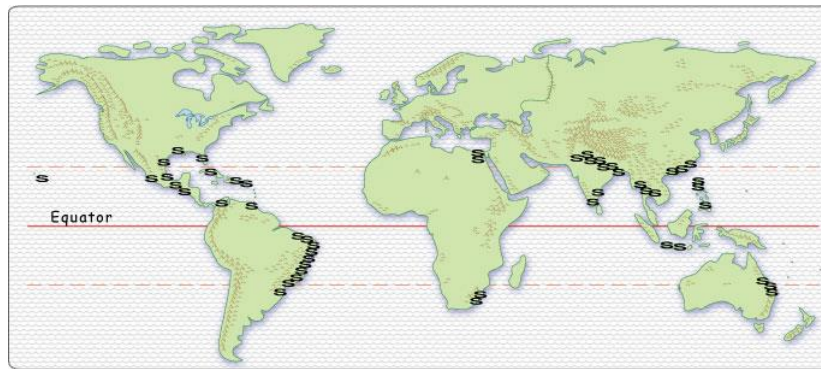
Sugar is really important in the history of European colonialism.

Sugarcane is a grass. It grows in places that do not get cold. People plant it in large fields like corn or wheat. Unlike grain crops, however, sugarcane is grown for its stem, not its seed. People can harvest it several times a year. Moreover, sugarcane does not need to be planted every year. It can keep growing for years in places that have no cold or dry season. For this reason, sugarcane is cheaper to grow than a crop that has to be planted every year, like corn.

People in many countries near the Equator grow sugarcane. Important producers at various times in the past include central Africa, Cuba, other Caribbean islands, the Philippines, Hawaii, and Vietnam. In the old days, sugar growers usually had slaves, because harvesting sugar is hard, dangerous work.

People in many of those places still grow sugar today, but now they use machines.

Areas that
produce
cane sugar.



Unfortunately, because sugar can be grown in many places, the world price is low. This is a problem for a country like Brazil, which has a lot of land that is good for growing sugarcane.

Complication: some people in the United States think that sugar is vital for national security. To encourage production, the government pays growers in states like Florida, Louisiana, and Hawai'i. It also pays sugarbeet farmers in cold states like Michigan and Minnesota. People can also turn corn into high fructose syrup. As a result, the United States does not import as much sugar as it would if there were no government subsidies.

Here is one more fact about Brazil. In the past, people had to import fuel to run automobiles and farm machinery. Recently, Brazil discovered some large deposits of petroleum. These deposits are under deep water off the east coast.

All these facts about climate, machinery, sugar prices, government policy, and oil production might seem unrelated. But then some people in Brazil “connected the dots” and got a brilliant idea:

“We can use low-cost sugar to make ethanol – a good motor fuel!”

Fast forward a few years, and you have this fact: Brazil is a large country that can run most of its cars and trucks on ethanol. It makes ethanol from sugarcane. The sugarcane grows in hot lowlands near the Equator. And you know Brazil has a lot of hot lowlands near the Equator.

Now think about the big idea of this chapter, about temperature and elevation. This idea can help us understand why the ancient Incas lived high in the mountains. It can also help us see how a huge Equatorial country like Brazil can grow sugar and run cars on ethanol. This helps them make money by selling oil to countries that need oil but are too cold to grow sugarcane.

Summary – how the big idea of elevation can help us understand South America

Ultimate cause: Rising air expands, and expanding air gets cooler.

Big idea: Elevation is important, because rising air gets cooler, and cooling air is more likely to make rain or snow.

Study area: Why is South America a good place to study the consequences of elevation? This continent has a fairly simple pattern of mountains. Recent crustal movement is pushing up a long line of young mountains near the west coast. The northern and eastern areas have the worn-down “stumps” of much older mountains.

Consequence #1: Mountaintops are cool even near the Equator. Lowlands near the equator are uncomfortably hot and humid, unless they are close to a big river or the ocean.

Consequence #2: Lowlands near the equator have the right conditions for rainforests.

Consequence #3: Rainforests have a lot of small animals that can climb big trees or fly. Humans cannot climb big trees or fly. They also like to eat grasses (grains) and the meat of large grass-eating animals. As a result, few people live in rainforests.

Consequence #4: The first big “country” of South America was the Inca Empire. It started in the high mountains near the Pacific coast.

Consequence #5: European colonists came into South America in two ways. They used boats on lowland rivers. They rode horses on highland roads. Many of the placenames in South America are evidence of these ways of traveling.

Consequence #6: The middle-elevation areas of South America are food-surplus areas. The geographical pattern of food production resembles an “upside-down” United States.

Consequence #7: The geologic processes that make mountains also tend to concentrate metal ores. The people of South America sell a lot of metal to the rest of the world.

Consequence #8: Elevation still has a strong influence on how people make a living in many parts of South America. For example, coffee and cocaine are high-value, low-weight crops. They can be grown in mountains where transportation is hard.

Consequence #9: Growing sugarcane in hot lowlands can make cheap renewable energy.

Putting it all together: Until recently, the large country of Brazil was an energy importer. Most of its rocks are part of an ancient shield. As a result, they do not contain coal, gas, or oil.

The vast lowlands close to the Equator, however, are covered by valuable rainforests. Moreover, people can grow soybeans for export (or biodiesel) in the southeastern highlands. They can also grow sugarcane (for ethanol) on lowland areas near the equator, where there is plenty of rain and no cold season.

As a result, Brazil in the 21st century is a large country full of people who know how to live without using much oil. On top of this good fortune, people just discovered some offshore oil that Brazil can sell to the rest of the world.



Science addition

Air expands and gets cooler when it rises. That is really important, but it is not the only way to make air temperature go down. Evaporating water can also make things cooler.

Science fact: Every gram of water takes in more than 500 calories of heat when it evaporates. That's more heat than it takes to warm the water all the way from freezing (32°F) to the boiling point (212°F). You take advantage of this physical fact when you sweat. Basically, your body moves water to the surface of your skin, where it can evaporate and make you cooler.

At a geographical scale, the result is a simple rule – in hot places or seasons, large bodies of water tend to cool the surrounding land

Big exception: Large bodies of water have a different effect in cold places.

1. Water is a good absorber of sunlight – that tends to make it warmer.
2. Evaporation is less at low temperature – that keeps water warmer.
3. Water has a higher *specific heat* than dirt – that keeps its temperature steady.

Bottom line: In a cold place or season, a wind that blows across a large body of water can make nearby land warmer. That fact, however, is not important in most of South America, so in this chapter we focus on the cooling effect of water in hot places. Just remember that this chapter's rule about water in hot places has an important exception in cold places.

In addition to a cooling influence, a big lake or river has other effects in a rainforest. For one thing, trees can't grow in deep, moving water! The resulting break in the forest cover allows sunlight to reach the ground alongside the river. A river also adds new soil when it floods.

As a result, the land near a river is often more fertile than land farther away. The combination of sunlight and fertility can create a narrow strip where people can grow plants for food.

This had an important side-effect during the Age of Exploration. If explorers travel on boats on rivers, they see only what is going on near the rivers. This might give them a wrong impression of how many people live in an area and what kind of life they have.