

## Chapter 4

# 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.



Ausungate, a mountain in Peru - photo by Edubucher

Stand up. Bend over and reach your hands 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. Then, when your hands are far above your head, you should look like you are holding a basketball.

Question: What does this have to do with geography?

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

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

That is the big idea of this chapter:

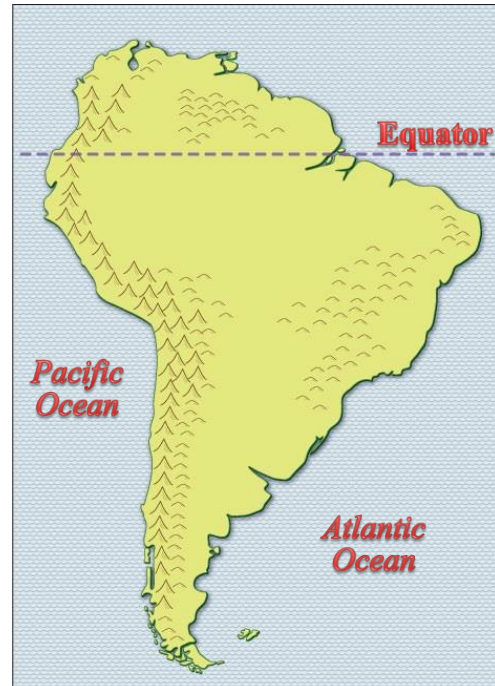
**Big Idea:** *Elevation is important, because rising air expands, and expanding air gets cooler.*

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

South America is a good place to use as a “laboratory” to explore the consequences of elevation. This continent has a simple pattern of mountains, hills, and plains.

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

Most of the rest of the continent is fairly low land. Geologically, this is because eastern South America is an ancient *shield* – a mass of rock that has been around for a very long time. As a result, it has had plenty of time to get worn down by wind and rain. All that is left are low hills. You could describe them as the “stumps” of ancient mountains.



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

Young mountains and shield rocks can have useful metals in them, but they rarely have oil or gas. The chapters on Russia and Southwest Asia will look at these resources in more detail.

The good news is that South America has valuable deposits of gold, silver, iron, 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.

Those geologic facts will interact with our big idea to help explain some economic patterns in South America. In other words, geology is 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 gets cooler when it rises. Cold mountaintops are an obvious result of this big idea.

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 humidity). This is really obvious in a country close to the equator, like Ecuador (Ecuador 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. The city does not get hot in summer. It also 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. 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.*

The highest mountain on earth is Mt. Everest. It is 29,000 feet above sea level. At that elevation, the air is really cold. The ground is covered by snow and ice all the time.

Here is a practical application of the basic rule:

If you know the height of some mountains and the temperatures at sea level, you could predict exactly how high on a mountain you are likely to see permanent snow and ice. You could also predict which mountains are likely to lose their 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 other factors, such as wind and humidity. Those 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?

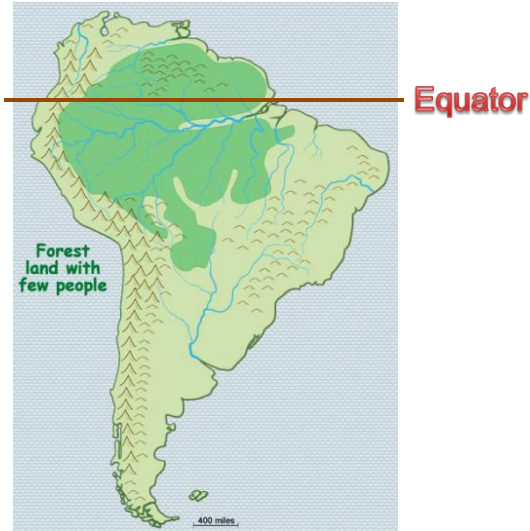
Answer: South America.

The vast expanse of low, hot land in South America is covered by the largest rainforest on earth.

A rainforest is what grows when it rains every month in a place that also has high temperatures 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. There are no tornadoes or ice storms near the Equator.

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.”

Actually, there is a better way to say it: “grow tall, or learn how to live without much sunlight.” 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 plants can even “eat” insects.

These “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?  
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 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 lowlands near the equator in South America.

Definition: **Deforestation** is the process of cutting trees down without planning 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 in 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 big 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 in 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 equipped to live in hot rainforests.

Few people have learned how to live in a rainforest. They 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.*

This generalization applies to similar lowlands near the equator in other parts of the world.

Our focus in this chapter, however, is on South America. So where do South Americans live? Specifically, where did they live in the past, and where do they live today? The answers to those questions are related to the big idea of this chapter. 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 good 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:** They all were located on floodplains near big rivers flowing through dry regions.

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 there were. 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 find food.

- Some people could live in villages near the west coast and catch fish. The west coasts, from Canada to Chile, had 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 near the west coast, 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 has fewer kinds of large, easy-to-hunt animals.

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

**Question:** Why were these places better for human use?

**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 like to 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 small plants such as potatoes 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 clay structure, cation exchange, soil leaching, and so forth.

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

People who do not understand technical details 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.*



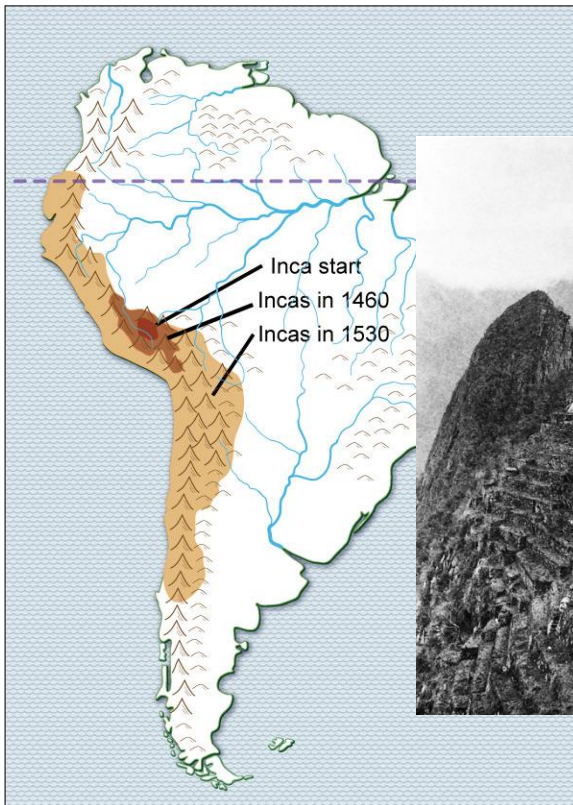
People usually live in places where it is easy to produce food. This was especially true in ancient times, when people did not have modern tractors and other farm machinery.

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

- Low places in South America are hot and rainy.
- Really 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 of nearly flat land 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 had expanded to cover almost all of the favorable highland environments in Central and South America. Then Christopher Columbus landed.

The arrival of Europeans brought really big changes.

**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



A big river meandering slowly across a plain can provide cheap transportation. People who know how to make boats can travel on the slow-moving river.

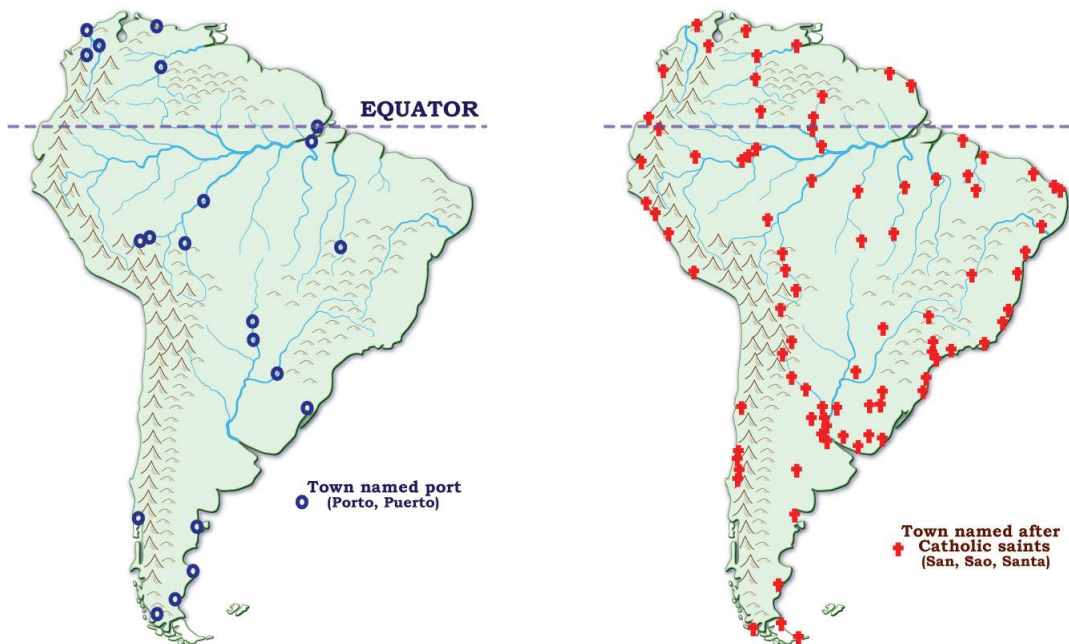
**Geographic fact:** Rivers are not equally “friendly” to boats. Rivers have different characteristics in different environments.

Rivers in mountainous places are likely to have a lot of rapids and waterfalls. These can wreck boats. Rivers in places with distinct wet and dry seasons also have problems. They tend to flood in the wet season and get shallow in the dry season. As a result, people can use boats only in favorable seasons.

A river that floods can also make it hard to choose a site for a town:

- A site close to the river is vulnerable to floods during the wet season.
- A site that is high enough to be safe from floods might be too far from the river when it shrinks during the dry season.

Seasonal changes are not a huge problem with a river like the Amazon. It drains a large area of Equatorial rainforest. It rains every month in places close to the equator. The river, therefore, has a fairly steady flow. This makes the Amazon a very good “road” for travel by boat. Not surprisingly, many explorers from Spain and Portugal used boats to go into South America. These European people traveled on the Amazon and other rivers. They built forts and trading posts near the river. As a result, many towns next to the coast or the rivers have Spanish or Portuguese names.





Spanish explorers and armies chose a different way to travel into South America. They used the roads built by the Inca and Aztec people.

These highland roads made it easier for the armies to invade. 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 of these diseases even before the Spanish armies arrived.

If you look at a map of South America today, you can see evidence of where the explorers traveled. Many towns in Brazil, for example, are located next to the Atlantic Ocean. Others are located along the Amazon River and its tributaries. And, as you know, many of them are named “Porto.”

The really large cities of Brazil, however, are far from the equator. They are in the southeastern highlands and the nearby ocean coast.

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 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 the low land close to the ocean.
- They did NOT want it on the low land along the Amazon River
- They did NOT want it near the existing cities in the southeastern 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 higher than 99 percent of the country. As a result, the capital of Brazil is at least ten degrees cooler than it otherwise would be.

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. Hot, rainy places also have a lot of bugs and weeds.

The southern part of South America is far from the Equator. For this reason, it has distinct cold and dry seasons. 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 southern part of Texas. Like south 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 corn, grains, and beef.
- Argentina is coldest country. Like Kansas and Nebraska, it 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 just like California, France, or Italy. 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 or Italy – olives, avocados, and citrus fruits. 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 them into wine, you can make a lot of money per square mile.

Grapes can grow on hilly land. They like cool, rainy winters and hot, dry summers. Central Chile has the right combination of conditions, and 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 same geologic processes that make high mountains also tend to concentrate 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 fairly flat.

These western mountains have a lot of earthquakes and volcanoes. These geologic forces are still pushing the mountains up. They also cause a lot of heat and pressure. This tends to concentrate metallic minerals in veins and pockets in the rock. As a result, the mountains of western 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 the Spanish explorers went into South America. 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. Rapid changes in elevation make transportation difficult.**

The Incas knew where they could grow food with their technology. It was in the cool highlands 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.*

You remember this picture  
of a road in the Andes Mountains?

The picture was 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. It's hard to work the 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. This crop 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 a simple rule about elevation, 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 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 combination of conditions makes it possible for people to sell heavy things that grow in a hot climate. One example is specialty wood from rainforest trees. They can also sell 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.

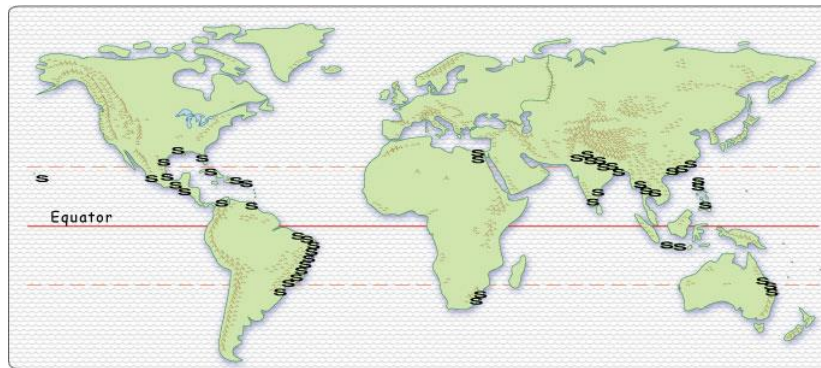
**Consequence #9: Sugarcane from hot lowlands can provide cheap renewable energy**

Sugar is really important in the history of European colonialism. Sugar growers usually had slaves, because harvesting sugar is hard, dangerous work. (Modern growers use machines.)

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 have tried to grow sugarcane. Important producers at various times in the past include central Africa, the Canary Islands, Cuba, other Caribbean islands, Hawaii, the Philippines, and Vietnam. Many of those places still grow it today.

Cane sugar  
producing  
areas.



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. Sugar could make a lot of money, if people in countries like the United States bought more.

**Complication:** many 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 Hawaii. 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. Brazil has not been a major oil producer until very recently. In the past, it 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, 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 – that can be 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 big 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 run a modern economy without using all of their oil. They can grow sugar and make ethanol to run their cars. This allows them to make money by selling oil to countries that need oil and cannot produce sugarcane.

**Summary – how can the big idea of elevation 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? Because 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 parts of the continent 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 small animals that can climb big trees or fly. Few people live in rainforests. Humans cannot climb big trees or fly. They also like to eat grasses (grains) and the meat of large grass-eating animals.

**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 of 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 same geologic processes that make high mountains also tend to concentrate metal ores. The people of South America make a lot of money by digging metal ores for sale 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 provide cheap renewable energy.

**Putting it all together:** Until recently, the large country of Brazil was an energy importer. Most of its rocks 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 21<sup>st</sup> 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.





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## 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. In a cold place or season, a wind coming from a large body of water can make surrounding 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.

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.