Chapter 34
The Biosphere: An Introduction to Earth’s Diverse Environments

PowerPoint Lectures
REECE • TAYLOR • SIMON • DICKEY • HOGAN

 Lecture by Edward J. Zalisko
Introduction

Did you ever think a river could catch fire?

In June, 1969, fire broke out on the Cuyahoga River in Cleveland, Ohio.

- For a century, oil refineries, steel mills, rubber factories, and other industries in Cleveland and Akron, 40 miles upstream, had dumped wastes directly into the river, along with raw sewage from both cities.
- The stretch of river between the two cities was devoid of fish, and the most heavily polluted sections lacked any signs of life.
- When the river caught fire, Clevelanders were not surprised—it had happened several times in the past!
Introduction

• Public outrage over the toxic conditions of the nation’s waterways, along with growing awareness of widespread environmental abuse, spurred a flurry of legislation, including the creation of the Environmental Protection Agency.

• Today, Cuyahoga Valley National Park surrounds a stretch of the river between Akron and Cleveland.
Chapter 34: Big Ideas

The Biosphere

Aquatic Biomes

Terrestrial Biomes
Introduction

• Environmental concerns are among the most pressing issues we face today.
• How can we manage Earth’s resources in ways that meet the needs of people today without compromising the ability of future generations to meet theirs?
THE BIOSPHERE
Ecologists study how organisms interact with their environment at several levels.

- **Ecology** is the scientific study of the interactions of organisms with their environments.
- Organisms can potentially be affected by many different variables, grouped into two major types.
  1. **Biotic factors** include all of the organisms in an area, the living component of the environment.
  2. **Abiotic factors** are the environment’s nonliving component, the physical and chemical factors.
- An organism’s **habitat** includes the biotic and abiotic factors present in its surroundings.
34.1 Ecologists study how organisms interact with their environment at several levels

- Ecologists study environmental interactions at the levels of the
  - **organism,**
  - **population,** a group of individuals of the same species living in a particular geographic area,
  - **community,** an assemblage of all the populations of organisms living close enough together for potential interaction, and
  - **ecosystem,** both the abiotic and biotic components of the environment.
Figure 34.1b
34.1 Ecologists study how organisms interact with their environment at several levels

• Some ecologists take a wider perspective by studying *landscapes*, arrays of ecosystems usually visible from the air as distinctive patches.

• The *biosphere*
  
  • extends from the atmosphere several kilometers above Earth to the depths of the oceans and
  
  • is all of Earth that is inhabited by life.
34.2 SCIENTIFIC THINKING: The science of ecology provides insight into environmental problems

- In the 1950s, the prevailing view of the environment was that “Nature” was a force to be tamed and controlled for human purposes, in the same way that livestock had been domesticated.
- Chemical pesticides were an innovation that was enthusiastically embraced.
34.2 SCIENTIFIC THINKING: The science of ecology provides insight into environmental problems

• The most widely used chemical pesticide was DDT.
  • DDT is an insecticide that was employed against crop pests and disease-carrying insects such as mosquitoes (which transmit malaria), body lice (typhus), and fleas (plague).
  • But it was considered harmless to vertebrates, including people.
34.2 SCIENTIFIC THINKING: The science of ecology provides insight into environmental problems

• By the late 1950s, however, a heated debate was raging over the widespread use of chemical pesticides.
  • Consumers raised questions about chemical residues in their food.
  • Scientists also found that DDT remained in the soil or water long after application of the pesticide.
  • Birds of prey seemed to be especially vulnerable.
34.2 SCIENTIFIC THINKING: The science of ecology provides insight into environmental problems

- The publication of a book called *Silent Spring* in 1962 brought widespread attention to the pesticide issue.

- Rachel Carson, a former marine biologist and writer with the U.S. Fish and Wildlife Service, compiled all of the available evidence about the consequences of widespread pesticide use.

- Awareness of the problems caused by pesticides quickly developed into concern for a host of environmental issues.
34.3 Physical and chemical factors influence life in the biosphere

- The most important abiotic factors that determine the biosphere’s structure and dynamics include the
  - energy source, usually solar energy,
  - temperature,
  - abundance and type of water,
  - inorganic nutrients,
  - other aquatic factors such as availability of oxygen, and
  - other terrestrial factors including wind and fire.
34.4 EVOLUTION CONNECTION: Organisms are adapted to abiotic and biotic factors by natural selection

• One of the fundamental goals of ecology is to explain the distribution of organisms.

• The presence of a species in a particular place has two possible explanations.
  1. The species may have evolved from ancestors living in that location.
  2. It may have dispersed to that location and been able to survive once it arrived.
34.4 EVOLUTION CONNECTION: Organisms are adapted to abiotic and biotic factors by natural selection

- The pronghorn is a highly successful herbivorous running mammal of open country.
- It is a descendent of ancestors that roamed the open plains and shrub deserts of North America more than a million years ago.
- It is found nowhere else and is only distantly related to the many antelope species in Africa.
Figure 34.4
34.4 EVOLUTION CONNECTION: Organisms are adapted to abiotic and biotic factors by natural selection

• A pronghorn’s habitat is arid, windswept, and subject to extreme temperature fluctuations.

• Individuals able to survive and reproduce under these conditions left offspring that carried their alleles into subsequent generations.

• Until around 12,000 years ago, one of their major predators was probably the now-extinct American cheetah, similar to African cheetahs alive today.
34.4 EVOLUTION CONNECTION: Organisms are adapted to abiotic and biotic factors by natural selection

- Ecologists hypothesize that the selection pressure of the cheetah’s pursuit led to the pronghorn’s blazing speed, which far exceeds that of its main present-day predator, the wolf.
- Like many large herbivores that live in open grasslands, the pronghorn also derives protection from living in herds.
- Populations of organisms are adapted to local environmental conditions, which may limit the distribution of organisms.
34.5 Regional climate influences the distribution of terrestrial communities

- Climate often determines the distribution of communities.
- The Earth’s global climate patterns are largely determined by
  - the input of radiant energy from the sun and
  - the planet’s movement in space.
34.5 Regional climate influences the distribution of terrestrial communities

- Solar radiation varies with latitude.
  - Equatorial regions receive sunlight more directly.
  - Higher latitudes receive sunlight at more of a slant.
- Most climatic variations are due to the uneven heating of Earth’s surface.
Figure 34.5a

Low angle of incoming sunlight

Sunlight strikes most directly

Low angle of incoming sunlight

Arctic Circle

60°N

30°N

Tropic of Cancer

0° (equator)

Tropic of Capricorn

30°S

60°S

Antarctic Circle

Atmosphere
34.5 Regional climate influences the distribution of terrestrial communities

• The Earth’s permanent tilt causes the seasons.
  • In June, the Northern Hemisphere of the Earth is tipped toward the sun.
  • In December, the Northern Hemisphere of the Earth is tipped away from the sun.
  • The reverse is true about the Southern Hemisphere, generating opposite seasons during the same time of year.
June solstice (Northern Hemisphere tilts toward sun)

March equinox (equator faces sun directly)

Constant tilt of 23.5°

September equinox

December solstice (Northern Hemisphere tilts away from sun)
The tropics are the region surrounding the equator between latitudes 23.5° north and 23.5° south.

Uneven heating of Earth causes rain and winds.

- The direct intense solar radiation in the tropics near the equator has an impact on the global patterns of rainfall and winds.
- The tropics experience the greatest annual input and least seasonal variation in solar radiation.
As the air rises in the tropics, it
- cools and releases much of its water content,
- produces the abundant precipitation typical of most tropical regions, and
- creates an area of calm or very light winds known as the doldrums.
34.5 Regional climate influences the distribution of terrestrial communities

• After losing its moisture over equatorial zones, high-altitude air masses spread away from the equator until they cool and descend again at latitudes of about 30° north and south.
• This descending dry air absorbs moisture from the land.
• Thus, many of the world’s great deserts—the Sahara in North Africa and the Arabian on the Arabian Peninsula, for example—are centered at these latitudes.
34.5 Regional climate influences the distribution of terrestrial communities

• As the dry air descends, some of it spreads back toward the equator.
  • This movement creates the cooling trade winds, which dominate the tropics.
  • As the air moves back toward the equator, it warms and picks up moisture until it ascends again.
34.5 Regional climate influences the distribution of terrestrial communities

- The **temperate zones** are between the tropics and the Arctic Circle in the north and the Antarctic Circle in the south.
- The temperate zones have seasonal variations and more moderate temperatures than the tropics or the polar zones.
34.5 Regional climate influences the distribution of terrestrial communities

- **Prevailing winds** result from the combined effects of rising and falling air masses and Earth’s rotation.
- In the tropics, Earth’s rapidly moving surface deflects vertically circulating air, making the trade winds blow from east to west.
- In temperate zones, the slower-moving surface produces the **westerlies**, winds that blow from west to east.
Figure 34.5d

- Westerlies
- Trade winds
- Doldrums

Arrows indicate the atmospheric circulation patterns at different latitudes.
34.5 Regional climate influences the distribution of terrestrial communities

- **Ocean currents**, river-like flow patterns in the oceans, result from a combination of
  - prevailing winds,
  - the planet’s rotation,
  - unequal heating of surface waters, and
  - the location and shapes of the continents.
- Ocean currents have a profound effect on regional climates.
34.5 Regional climate influences the distribution of terrestrial communities

- Landforms can also affect local climate. For example, air temperature declines about 6°C with every 1,000-m increase in elevation.

- Rainfall is affected by
  - the location of mountains and
  - prevailing winds.
Figure 34.5f

East Sierra Nevada Coast Range
Pacific Ocean
Wind direction
Sierra Nevada
East Rain shadow Desert
Coast Range

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34.5 Regional climate influences the distribution of terrestrial communities

- Climate and other abiotic factors of the environment control the global distribution of organisms.
- The influence of these abiotic factors results in biomes, the major types of ecological associations that occupy broad geographic regions of land or water.
AQUATIC BIOMES
34.6 Sunlight and substrate are key factors in the distribution of marine organisms

- Aquatic biomes are shaped by the availability of
  - sunlight and
  - substrate.
Video: Shark Eating a Seal
Video: Clownfish and Anemone
Video: Coral Reef
Video: Hydrothermal Vent
Video: Tubeworms
34.6 Sunlight and substrate are key factors in the distribution of marine organisms

• Within the oceans are the
  • pelagic realm, which includes all open water,
  • benthic realm, which consists of the seafloor,
  • aphotic zone, where there is insufficient light for photosynthesis, and
  • photic zone, where light penetration is sufficient for photosynthesis and phytoplankton can occur.
    • Zooplankton are abundant in the pelagic photic zone.
    • Coral reefs also occur in the photic zone.
Figure 34.6a-0

- **High tide**
  - Sea star (to 33 cm)
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Low tide**
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Pelagic realm (open water)**
  - Sea star (to 33 cm)
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Intertidal zone**
  - Sea star (to 33 cm)
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Continental shelf**
  - Sea star (to 33 cm)
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Benthic realm (seafloor from continental shelf to deep-sea bottom)**
  - Sea star (to 33 cm)
  - Oarweed (to 2 m)
  - Brain coral (to 1.8 m)
  - Phytoplankton
  - Zooplankton
  - Man-of-war (to 50 m long)
  - Blue shark (to 2 m)
  - Turtle (60–180 cm)
  - Sea pen (to 45 cm)
  - Sea spider (1–90 cm)
  - Octopus (to 10 m)
  - Sperm whale (10–20 m)
  - Hatchet fish (2–60 cm)
  - Gulper eel (to 180 cm)
  - Anglerfish (45 cm–2 m)
  - Brittle star (to 60 cm)
  - Glass sponge (to 1.8 m)
  - Sea cucumber (to 40 cm)
  - Tripod fish (to 30 cm)

- **Photic zone**
  - 200 m
  - "Twilight"

- **Aphotic zone**
  - 1,000 m
  - No light
  - 6,000–10,000 m
Figure 34.6a-1

High tide

Low tide

Pelagic realm (open water)

Oarweed (to 2 m)

Phytoplankton

Zooplankton

Brain coral (to 1.8 m)

Sponges (1 cm–1 m)

Sea pen (to 45 cm)

Sea spider (1–90 cm)

Intertidal zone

Continental shelf

Photic zone

200 m

“Twilight”

1,000 m

Aphotic zone

No light

6,000–10,000 m

Benthic realm (seafloor from continental shelf to deep-sea bottom)

Octopus (to 10 m)

Brittle star (to 60 cm)
Figure 34.6a-2

Pelagic realm (open water)

Photic zone

Zooplankton

Octopus (to 10 m)

Man-of-war (to 50 m long)

Sperm whale (10–20 m)

Blue shark (to 2 m)

Turtle (60–180 cm)

Glass sponge (to 1.8 m)

Sea cucumber (to 40 cm)

Tripod fish (to 30 cm)

Rat-tail fish (to 80 cm)

Gulper eel (to 180 cm)

Anglerfish (45 cm–2 m)

Brittle star (to 60 cm)

Hatchet fish (2–60 cm)

No light

6,000–10,000 m

“Twilight”

1,000 m

Aphotic zone

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34.6 Sunlight and substrate are key factors in the distribution of marine organisms

- The marine environment includes distinctive biomes where the ocean meets the land or fresh water.
  - **Intertidal zones** are where the ocean meets the land and the shore is pounded by waves during high tide and exposed to the sun and drying winds during low tide.
  - **Estuaries** are productive areas where rivers meet the ocean.
  - **Wetlands** are transitional between aquatic and terrestrial ecosystems.
34.7 Current, sunlight, and nutrients are important abiotic factors in freshwater biomes

- Freshwater biomes
  - cover less than 1% of Earth’s surface,
  - contain less than 0.01% of its water,
  - harbor 6% of all described species, and
  - include lakes, ponds, rivers, streams, and wetlands.
Video: Flapping Geese
Video: Swans Taking Flight
34.7 Current, sunlight, and nutrients are important abiotic factors in freshwater biomes

- Freshwater biomes fall into two broad groups:
  1. standing water biomes (lakes and ponds) and
  2. flowing water biomes (rivers and streams).
Figure 34.7a

- Photic zone
- Benthic realm
- Aphotic zone
Terrestrial Biomes
34.8 Terrestrial biomes reflect regional variations in climate

- Terrestrial ecosystems are grouped into nine major types of biomes, distinguished primarily by their predominant vegetation.
- The geographic distribution of plants and thus terrestrial biomes largely depends on climate. The key climate factors are
  - temperature and
  - precipitation
- The same type of biome may occur in geographically distant places if the climate is similar.
34.8 Terrestrial biomes reflect regional variations in climate

- The current concern about global warming is generating intense interest in the effect of climate on vegetation patterns.

- Scientists are documenting
  - shifts in latitudes of biome borders,
  - changes in snow and ice coverage, and
  - changes in length of the growing season.

- A high rate of biome alteration by humans is correlated with an unusually high rate of species loss throughout the globe.
Figure 34.8

Key
- Tropical forest
- Savanna
- Desert
- Chaparral
- Temperate grassland
- Temperate broadleaf forest
- Coniferous forest
- Arctic tundra
- Polar ice
- High mountains (coniferous forest and alpine tundra)
34.9 Tropical forests cluster near the equator

• Tropical forests
  • occur in equatorial areas,
  • experience warm temperatures and days that are 11–12 hours long year-round, and
  • have variable rainfall.
34.9 Tropical forests cluster near the equator

• The tropical rain forest is among the most complex of all biomes.
  • Tropical rain forests harbor enormous numbers of species.
  • Large-scale human destruction of tropical rain forests continues to endanger many species.
34.10 Savannas are grasslands with scattered trees

- **Savannas**
  - are warm year-round,
  - have 30–50 cm annual rainfall,
  - experience dramatic seasonal variation,
  - are dominated by grasses and scattered trees, and
  - have insects as the dominant herbivores.
Figure 34.10

Temperature range
Precipitation
Fire
34.11 Deserts are defined by their dryness

- **Deserts** are the driest of all terrestrial biomes.
  - They are characterized by low and unpredictable rainfall.
  - The cycles of growth and reproduction in the desert are keyed to rainfall.
- Deserts can be very hot or very cold.
- **Desertification**, the conversion of semi-arid regions to desert, is a significant environmental problem.
34.12 Spiny shrubs dominate the chaparral

- The **chaparral** is a shrubland characterized by dense, spiny shrubs with tough, evergreen leaves.
- Chaparral experiences
  - cool, rainy winters,
  - hot, dry summers, and
  - vegetation adapted to periodic fires. Firestorms that race through the densely populated canyons of Southern California can be devastating.
34.13 Temperate grasslands include the North American prairie

- **Temperate grasslands**
  - are mostly treeless, except along rivers or streams,
  - are found in regions of relatively cold winter temperatures.
  - experience precipitation of about 25–75 cm per year, with periodic droughts, and
  - in North America have historically been grazed by large bison and pronghorn.

- Very productive farms have replaced most of North America’s temperate grasslands.
Figure 34.13

- Temperature range
- Precipitation
- Fire
34.14 Broadleaf trees dominate temperate forests

- **Temperate broadleaf forests**
  - grow where there is sufficient moisture to support the growth of large trees and
  - experience wide-ranging temperatures (−30°C to 30°C) and high annual precipitation (75–150 cm).

- Nearly all of the original broadleaf forests in North America have been drastically altered by agriculture and urban development.

- These forests typically have a growing season of 5 to 6 months and a distinct annual rhythm of leaf drop in the fall and the production of new leaves in the spring.
Figure 34.14

Temperature range

Precipitation
34.15 Coniferous forests are often dominated by a few species of trees

- Cone-bearing evergreen trees, such as spruce, pine, fir, and hemlock, dominate **coniferous forests**.

- The northern coniferous forest, or **taiga**, is the largest terrestrial biome on Earth. The taiga is characterized by
  - long, cold winters and
  - short, wet summers.

- **Temperate rain forests** of coastal North America are also coniferous forests.
34.16 Long, bitter-cold winters characterize the tundra

- The **tundra** covers expansive areas of the Arctic between the taiga and the permanently frozen polar ice.
- The treeless arctic tundra
  - is characterized by **permafrost**, continuously frozen subsoil, and
  - may receive as little precipitation as some deserts.
34.17 Polar ice covers the land at high latitudes

• **Polar ice** covers
  • land north of the tundra,
  • much of the Arctic Ocean, and
  • the continent of Antarctica.

• Temperatures are extremely cold year-round and precipitation is very low.

• The terrestrial polar biome is closely intertwined with the neighboring marine biome.
Figure 34.17

Temperature range

Precipitation
34.18 The global water cycle connects aquatic and terrestrial biomes

• Ecological subdivisions such as biomes are linked by
  • nutrient cycles and
  • the water cycle.

• Water in the form of precipitation and evaporation moves between the land, oceans, and atmosphere.
  • Over the oceans, evaporation exceeds precipitation.
  • Over the land, precipitation exceeds evaporation and transpiration.
34.18 The global water cycle connects aquatic and terrestrial biomes

- Human activities affect the global water cycle.
  - The destruction of tropical rain forests reduces the amount of water vapor in the air.
  - Pumping large amounts of groundwater to the surface for irrigation can increase the rate of evaporation over land, resulting in higher humidity and depleting groundwater supplies.
Figure 34.18

Solar heat

Water vapor over the sea

Net movement of water vapor by wind

Water vapor over the land

Precipitation over the land

Precipitation over the sea

Evaporation from the sea

Evaporation and transpiration

Oceans

Flow of water from land to sea

Surface water and groundwater

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You should now be able to

1. Define and distinguish between the different levels within ecosystems.
2. Distinguish between the biotic and abiotic components of an ecosystem.
3. Summarize the subject and impact of Rachel Carson’s influential book *Silent Spring*.
4. Describe the abiotic factors that influence life in the biosphere.
5. Describe the adaptations that enable pronghorns to survive in the open plains and shrub deserts of North America.
You should now be able to

6. Explain how global climate patterns are influenced by solar energy input and the movement of Earth through space.

7. Explain how landforms affect local climate.

8. Explain why the seasons of the year, prevailing winds, and ocean currents exist.

9. Describe the abiotic and biotic characteristics of the different ocean zones, adjacent aquatic biomes, and freshwater biomes.

10. Describe the different types of freshwater biomes.
You should now be able to

11. Explain how the properties of a river change between its source and its outlet.

12. Explain why species in widely separated biomes may have similar features.

13. Describe the characteristics used to define terrestrial biomes.

14. Explain how all parts of the biosphere are linked by the global water cycle.
Figure 34.UN01

Organismal ecology (individual) → Population ecology (group of individuals of a species) → Community ecology (all organisms in a particular area) → Ecosystem ecology (all organisms and abiotic factors)
34.9 Tropical forests cluster near the equator.

34.10 Savannas are grasslands with scattered trees.

34.11 Deserts are defined by their dryness.
34.12 Spiny shrubs dominate the chaparral.

34.13 Temperate grasslands include the North American prairie.

34.14 Broadleaf trees dominate temperate forests.
34.15 Coniferous forests are often dominated by a few species of trees.

34.16 Long, bitter-cold winters characterize the tundra.

34.17 Polar ice covers the land at high latitudes.
Figure 34.UN05

June solstice

March equinox

September equinox

December solstice

Constant tilt of 23.5°
Mean annual temperature (°C)

Mean annual precipitation (cm)

Figure 34.UN07

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