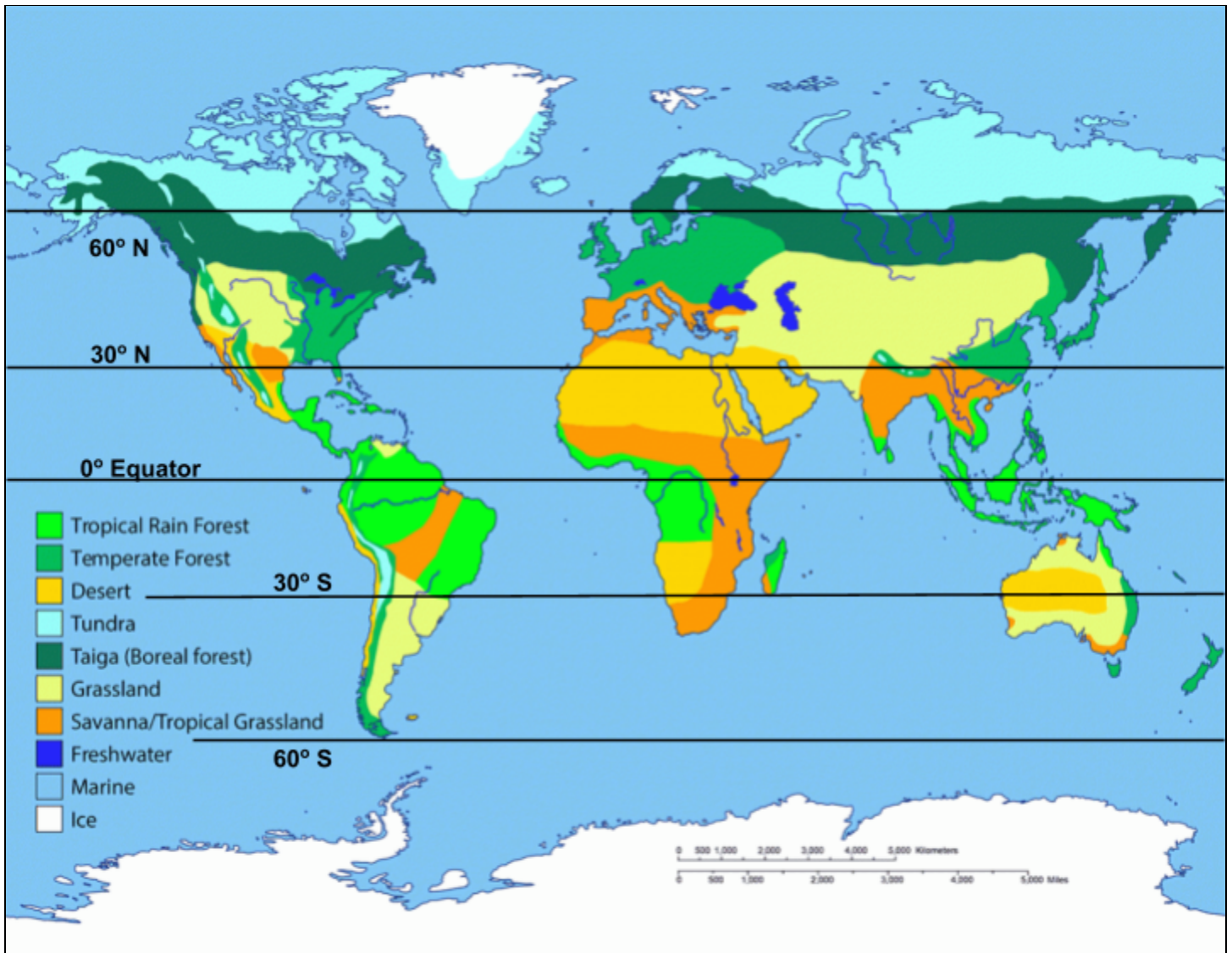


1. The map below shows the biomes on Earth in relation to major latitude lines:



Source: © Arizona Board of Regents / [ASU Ask A Biologist](#). Used under [CC BY-SA 3.0](#) / latitude lines added

- Using the diagram, **identify** a terrestrial biome that exists on Earth at 15°N latitude.
- Identify** the approximate latitude of a biome on Earth that would be dominated by conifer trees such as pine and spruce.
- Describe** how warm air moves away from the equator towards higher latitudes.
- Explain** why hot deserts on Earth exist around 30° N and S latitude.
- Identify** in which layer of the atmosphere greenhouse gasses accumulate.
- Describe** how greenhouse gasses lead to the warming of the Earth.

(g) Researchers collected soil samples from a watershed basin area that includes forests and agricultural areas. The samples were collected over the course of one month, and their proportion of sand, silt, and clay were analyzed to compare with their permeability.

- (i) **Identify** a research question for this study.
- (ii) **Identify** the dependent variable for this study.
- (iii) **Identify** a variable not described that could affect the results of the study.
- (iv) **Describe** a modification that could increase the reliability of the study.

RUBRIC:

(a) 1 point for identifying Tropical Rainforest, Desert, Savanna/Tropical Grassland (Unit 4, Skill 2.A)

(b) 1 point for identifying 60°N latitude (Unit 4, Skill 2.A)

(c) 1 point for a description of atmospheric convection: (Unit 4, Skill 2.B)

- **Air at the equator is warmed by direct rays of the sun, which causes air to rise into the atmosphere and move laterally away from the equator towards the poles.**

(d) 1 point for an explanation: (Unit 4, Skill 2.C)

- **Warm, humid air at the equator rises and experiences decreased air pressure, so it expands and cools (adiabatic cooling), releasing its moisture over the tropics. This now dry air is cooler and more dense, so it sinks at 30° latitudes, where it is compressed due to increased pressure and heats up (adiabatic heating), forming deserts.**

(e) 1 point for identifying the troposphere. (Unit 9 & 4, Skill 1.A)

(f) 1 point for describing that the greenhouse gasses absorb/trap infrared (IR) radiation from the Earth's surface. (Unit 9, Skill 1.B)

(g) (i) 1 point for identifying an appropriate research question: (Unit 4, Skill 4.A)

- **How does soil particle size affect permeability?**
- **How does soil composition affect permeability?**

(ii) 1 point for identifying soil permeability. (Unit 4, Skill 4.B)

(iii) 1 point for identifying a confounding variable: (Unit 4, Skill 4.B)

- **Location samples were collected**
- **Initial water content of soil**
- **Presence of living organisms in samples**

(iv) 1 point for a description of one of the following: (Unit 4, Skill 4.E)

- Collecting multiple samples from each site
- Collecting samples during various seasons/times of the year

2. The table below contains water quality data for three sampling sites along a stream in the Midwestern United States taken in June 2019. Site A is located the farthest upstream. Site B is located downstream of Site A, and Site C is located the farthest downstream.

Sampling Site	DO (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Turbidity (NTU)
A	10.0	2.0	1.0	5
B	2.1	11.2	1.2	42
C	6.7	4.6	1.1	7

- (a) Using the data in the table above,
- (i) **Identify** the sampling site with the highest level of dissolved oxygen.
 - (ii) **Describe** the relationship between dissolved oxygen and nitrate levels in this stream.
 - (iii) **Make a claim** using evidence to explain the most likely location of a dairy farm in this area.
 - (iv) **Explain** how the data in the table could be used to predict the biodiversity of the stream.

(b) **Identify** a human activity that can increase phosphate levels in freshwater ecosystems.

(c) **Describe** an environmental problem that can be caused by increased phosphate levels in a freshwater pond.

A large commercial farm applies synthetic pesticides to its crops to prevent insects from consuming crops and reducing their crop yields. Downstream from the farm, a team of researchers is studying the effects of the pesticide runoff on aquatic species.

(d) **Describe** an unintended consequence of the farm applying pesticides to their crops to kill insects.

(e) **Describe** how pesticide runoff from the farm could affect aquatic species downstream, other than causing death.

(f) **Propose a solution** to the environmental problem described in (e).

(g) **Justify** the solution proposed in (f) by describing a potential economic advantage of that solution.

RUBRIC:

(a) (i) **1 point for identifying Site A. (Unit 8, Skill 5.A)**

(ii) **1 point for a description of one of the following: (Unit 8, 5.B)**

- **Dissolved oxygen and nitrate have an inverse relationship.**

- As nitrate increases, dissolved oxygen decreases.
- As nitrate decreases, dissolved oxygen increases.

(iii) 1 point for an explanation of a claim that a dairy farm is most likely located near Sampling Site B, because runoff from the farm containing nitrogen-rich animal waste is entering the stream, increasing nitrate levels and decreasing dissolved oxygen levels. (Unit 8, 5.C)

(iv) 1 point for an explanation of one of the following: (Unit 8, Skill 5.E)

- Site A would have the highest biodiversity, because it has the highest level of dissolved oxygen, meaning the water can support more aquatic species.
- Site B would have the lowest biodiversity, because it has the lowest level of dissolved oxygen, meaning the water cannot support many species.
- Site C would have a medium level of biodiversity, because it is recovering from a disturbance that has decreased the dissolved oxygen at Site B, and can now support more species.

(b) 1 point for identifying synthetic fertilizers, partially treated or untreated sewage, detergents (Unit 1, Skill 1.A)

(c) 1 point for a description of one of the following: (Unit 8, Skill 7.A)

- Increased phosphate will increase productivity of phytoplankton/algae in the pond, causing an algal bloom.
- Increased phosphate will decrease dissolved oxygen levels in a pond as algae blooms die and decompose, using up oxygen in the water.
- Increased phosphate will cause the death of consumers in the pond, as algae blooms will die and decompose, using up the amount of dissolved oxygen in the water.
- Increased phosphate will cause decreased productivity of aquatic plants in the pond, as the algae bloom will block sunlight for other plants.

(d) 1 point for a description of pesticide resistance in the pest insect species (Unit 8 & 9, Skill 7.C)

(e) 1 point for a description of the pesticide acting as an endocrine disruptor or causing HABs/hypoxia downstream from the farm (Unit 8 & 9, Skill 1.B)

(f) 1 point for describing using IPM practices, reducing pesticide use, using crop rotation to reduce the amount of pesticide sprayed on the crops (Unit 8 & 9, Skill 7.E)

(g) 1 point for a description of an economic advantage: (Unit 8 & 9, Skill 7.F)

- Less pesticides used saves money in materials & labor costs
- Crop rotation improves/maintains soil quality, which could also increase crop yields
- Money saved during farming process could mean lower food costs for consumers

<https://www2.ipm.ucanr.edu/agriculture/floriculture-and-ornamental-nurseries/Managing-Pesticide-Resistance/>

3. According to the [US Department of Agriculture](#), there were 58 million irrigated acres of cropland in the United States in 2017. The most irrigated crops were corn and soybeans grown for livestock feed and biofuel.

- (a) **Identify** a type of irrigation that uses water inefficiently.
- (b) **Describe** how the amount of water used for irrigation could be reduced.
- (c) **Describe** one environmental problem related to water use that can be caused by an increasing human population.
- (d) **Make a claim** that proposes a solution to an environmental problem described in (c).
- (e) **Describe** a potential disadvantage of the solution proposed in (d).

(f) In 2019, the country of France had a crude birth rate of 12.0 per thousand, a crude death rate of 9.6 per thousand, and a net migration rate of 1.1 per thousand. The total population of France in 2019 was approximately 67.6 million people.

Sources: https://www.cdc.gov/globalhealth/infographics/food-water/water_use.htm, [US Census International Database](#)

(i) **Calculate** the total growth rate of France. Show all work.

(ii) **Calculate** the doubling time for France. Show all work.

(iii) In the US, the average water use per capita is 709 liters. By comparison in France the average resident only uses 291 liters of water per person per day. If there are 3.78 liters in a gallon, **calculate** how many gallons of water the entire population of France would use per year. Show all work.

RUBRIC:

(a) **1 point for identifying flood, furrow, or spray irrigation (Unit 5, Skill: 1.A)**

(b) **1 point for a description of spray or drip irrigation (Unit 5, Skill: 1.B)**

(c) **1 point for a description of one of the following: (Unit 5 & 9, Skill: 7.A)**

- **Groundwater depletion/land subsidence/lowering of water table/saltwater intrusion**
- **Waterlogging of soils/soil salinization from overirrigation**
- **Water diversion projects/habitat loss**

(d) 1 point for a claim: (Unit 5 & 9, Skill: 7.E)

Problem	Solution
Groundwater depletion/land subsidence/lowering of water table/saltwater intrusion	<ul style="list-style-type: none"> • Water conservation practices • Legislation/laws that impose limits on water withdrawals • Fines/taxes on overuse of water • Using rain barrels
Waterlogging of soils/soil salinization from overirrigation	
Water diversion projects/habitat loss	<ul style="list-style-type: none"> • Dam removal • Installation of fish ladder

(e) 1 point for an explanation of a disadvantage: (Unit 5 & 9, Skill: 7.B)

Solution	Disadvantage
<ul style="list-style-type: none"> • Water conservation practices • Legislation/laws that impose limits on water withdrawals • Fines/taxes on overuse of water • Using rain barrels 	<ul style="list-style-type: none"> • Difficult to enforce water restrictions • Introducing & passing legislation can be a lengthy process • Some states prohibit use of rain barrels to collect rainwater
<ul style="list-style-type: none"> • Dam removal 	<ul style="list-style-type: none"> • Can cause unintended habitat loss due to downstream flooding/removal of a reservoir • Expensive process
<ul style="list-style-type: none"> • Installation of fish ladder 	<ul style="list-style-type: none"> • Expensive process

(f) (i) 2 points - 1 for setup and 1 for a correct answer: (Unit 3, Skill 6.B)

$$\frac{(CBR - CDR) + \text{net migration rate}}{10} = \frac{12.0 - 9.6 + 1.1}{10} = \frac{3.5}{10} = 0.35\%$$

(ii) 2 points - 1 for setup and 1 for a correct answer: (Unit 3, Skill 6.B)

$$\text{Doubling time} = 70/r = 70/0.35 = 200 \text{ years}$$

(iii) 2 points - 1 for setup and 1 for a correct answer: (Unit 3, Skill 6.C)

$$291 \frac{\text{liters}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times 1 \frac{\text{gallon}}{3.78 \text{ liters}} \times 67.6 \text{ million people} = 1.9 \text{ billion gallons of water per person}$$