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Questions to Discoveries, Exploring Temperate Grasslands and Temperate Forests

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by Stacy-Ann Morrison Thomas

Introduction/Rationale

The unit titled “Questions to Discoveries: Exploring Grasslands and Temperate Forests” aligns perfectly with the seminar topic “Asking Questions in Biology.” This unit is designed for a diverse population of 6th-grade science students at Stanton Middle School in Wilmington, Delaware. The unit is relevant because these students are naturally curious and eager to learn more about their environment through purposeful questioning and discovery. The goal is to boost their confidence in science and to motivate and encourage strong, meaningful academic discourse as they investigate living and non-living things, their environments, interactions, and sustenance. This will spark curiosity and enthusiasm in science among 6th graders, which will ultimately lead to a better understanding of science and improved academic discourse. The unit will also focus on developing scientific inquiry skills and science content knowledge through the study of these two major biomes. Students will be encouraged to use questioning, observation, research, data analysis, and collaborative inquiry as the avenue for scientific investigation.

The unit will complement the middle school OpenSciEd curriculum that is used across the state of Delaware. It was developed by leading science researchers and educators and is a model that is designed to align with how students learn best. The OpenSciEd curriculum is phenomenon-based and centers on student-led questioning, investigation, and problem solving.[1] Sixth graders are naturally curious but often find it difficult to create the questions that will assist them in finding answers. Students are often taught to find answers to various questions but not to generate their own questions. Hence, emphasis will be placed on positioning these students to perform the role of scientists as they learn to formulate and refine questions, gather evidence, and develop explanations based on their results. This unit about grassland and temperate forest biomes is ideal for inquiry-based learning in science since they exhibit distinct biodiversity, climate conditions, and ecological relationships. They will try to find answers to questions such as: Why do different ecosystems support different types of organisms? How do environmental factors influence biodiversity? What happens when ecosystems experience disturbances caused by natural events or human activity?

In addition, this curriculum unit is not only relevant to my 6th graders whose environmental literacy is rapidly increasing, but it’s also important to me as I have a responsibility as an educator to help students to become responsible environmental stewards and informed citizens. In a world where we are faced with a plethora of

issues such as habitat destruction, climate change, pollution and biodiversity loss that are detrimental to us and our planet, many students are oblivious to this pertinent information. They may encounter snippets of the information through social media or online games but seldom possess the scientific understanding needed to critically analyze these issues. Having the opportunity to engage students in this unit will not only develop their content knowledge and scientific inquiry skills but also their critical thinking skills and help them to make informed decisions about protecting and preserving our world. The ultimate goal is to meet every student where they are, to have them realize that science is not merely a collection of information but an ongoing process of discussions, observations, collaborative problem-solving, modeling, etc. These activities effectively lend themselves to strong communication skills, which is an important aspect of acquiring scientific literacy.

In teaching this unit, students will be reminded that science is not about being right or wrong but more about formulating and searching for evidence to support claims while embracing mistakes and the opportunity to learn and grow. The unit complements the goals of the Yale National Initiative Seminar *Asking Questions in Biology* by emphasizing the role of questioning as a driving force in scientific discovery. Teachers, especially those of science, should be intentional and purposeful in teaching students not to be fearful about asking questions and participating in class activities. Hence, the learning environment in the classroom should encourage them to be structured in the way they think, talk, listen, read, and write within the context of science

Demographics

This unit will be created for sixth-grade students at Stanton Middle School in the Red Clay Consolidated School District in Wilmington, Delaware. According to the Delaware Report Card data, as of September 30, 2026, Stanton serves a culturally and linguistically diverse population of 496 students in grades 6 through 8. Hispanic or Latino students make up 53.02% of the student population, 21.77% are Black or African American and 20.77% are White. The remaining student population identifies as Multiracial, which is 2.82%, 1.41% are Asian American and 0.20% are American Indian or Alaska Native. English Learners (ELs) comprise approximately 35.08% of the student population, 25% receive special education services and 37.7% are classified as low-income earners.[2] More than half of the students in my classroom are Multilingual Learners (MLLs). This demographic represents a range of English language proficiency levels and educational experiences. It also significantly influences the design and the topic of this curriculum unit as it builds on their backgrounds, experiences and natural curiosity about their environment. Many students are simultaneously developing scientific understanding and academic English proficiency.

Content Objectives

Living in Delaware gives students many opportunities to get up close and personal with nature. The very tall deciduous trees that are home to the birds chirping from the forest canopy, the mushrooms growing on huge fallen logs, and streams that support a variety of fish, amphibians, and aquatic insects are all visible during an evening stroll through the White Clay Creek State Park or Brandywine Creek State Park. Students may find

themselves in wide meadows where grasses predominate and butterflies, bees, and other pollinators thrive after taking a little trip past these woodlands. Despite their apparent differences, all habitats have one crucial thing in common: they are living systems where creatures constantly interact with the nonliving environment and each other. These interesting observations about the natural world give rise to one of the essential questions that help to guide the development of this curriculum unit: How does climate shape life in grassland and temperate forest biomes?

Biomes and Ecosystems

What makes some parts of the Earth thrive with endless grasslands while other parts are filled with a variety of towering trees? To answer this question, we will take a closer look at the factors that shape these biomes. These factors include climate, soils and seasons, human activity, and environmental factors such as fire frequency. As we consider the possible responses to this question and others, it is important to step back and focus on the bigger picture to understand the basics of biome, ecosystem and habitat. According to the National Geographic Society, scientists currently disagree on what makes up a biome; however, it is argued that biomes are typically characterized by the resident biota within them and the climate that drives the area.[3] Biota refers to all the plants (flora) and animals (fauna) living within a biome that are adapted to the conditions. Biomes differ by the climate, soil type and the types of organisms that live in the area. The area itself can extend thousands of square miles and span across continents. There are several types of biomes, for example, tropical rainforest, temperate forest, desert, tundra and grassland. Each biome has its own distinct climate, animal community and plant life. In this unit, the focus will be on both temperate grasslands and temperate forests.

To better frame the topic, it must be established that biomes differ from ecosystems and habitats, as these terms are generally misused. This can compromise scientific information and meaningful scientific discourse. While biomes are the larger geographical areas, within them are more localized geographical ecosystems, which are communities of organisms interacting with their physical environments (biotic and abiotic components).[4] Abiotic components include water, soil, atmosphere, temperature, etc. Biotic components refer to the living organisms in the ecosystem or anything that was once alive. Examples of ecosystems are rivers, freshwater lakes and deserts. Within ecosystems, there are even more localized areas called habitats. A habitat is an organism’s home that supports its needs; it is where they reside. For example, a polar bear has a habitat in the Arctic where it hunts for seals on ice, while a kangaroo has a habitat in the Australian outback. Habitats are organism-specific and relate to the presence of a species, population, or individual animal or plant to an area's physical and biological characteristics. Habitat implies more than vegetation or vegetation structure; it is the sum of the specific resources that are needed by organisms.[5]

As students continue to learn more about biomes, it is important to recognize that they can differ significantly based on their region or where they are located geographically. Biomes exhibit distinct climates and support a variety of different plants and animals that may be unique to that particular biome. These regional differences influence the biodiversity and human interaction with these environments. For example, grasslands in different parts of the world such as Africa, Asia or South America are not all identical. They may share similar defining characteristics such as open landscapes dominated by grasses and relatively few trees, but each has its own communities of flora and fauna. Biodiversity refers to the variety of life on Earth. It includes variation at all levels of biological organization, from the genetic variation within a single population or species to the species living in a particular ecosystem and the communities of ecosystems that make up a biome or the entire biosphere.[6] Biodiversity contributes to a healthy and resilient ecosystem. Students will better understand this concept by explaining a scenario about pollinators such as bees, butterflies or birds and their

role in the environment. An abundance of these pollinators will result in increased flowering plant reproduction, as organisms that depend on these plants will benefit significantly and ultimately the entire food web is stronger. Any small change in a single species can affect balance and have a rippling effect through the entire food web. Students will then understand and recognize that protecting every organism, regardless of their size, is significantly important since it can have ecological implications.

For students to fully understand the importance of biodiversity, they will need to have an understanding of ecology. Ecology is the scientific study of the distribution and abundance of organisms and the interactions both with each other and with their physical environment.[7] It focuses on the study of the ecosystem, and so an ecologist may choose to explore a single predator-prey relationship or an entire biome and how these organisms may interact with each other and with the environment. Imagine a pocket gopher living in a temperate grassland or a European badger who lives in the temperate forest; they certainly do not live in isolation. They eat the vegetation and seeds, aerate the soil by digging tunnels through it and create homes for other animals that live in it. They also serve as food or prey for predators such as hawks, foxes and coyotes. This creates balance in the environment as the soil benefits tremendously from it being fertilized due to the introduction of organic matter as the soil turns. An abundance of plants will be able to grow, which then provides food and serves as a home to various organisms. Here we see how interactions can determine abundance.

The Grassland Biome

With a deeper understanding of predator-prey relationships and how it shapes an ecosystem, students will now learn more about the grassland biome with a focus on temperate grassland. Students will also be exposed briefly to the other types of grassland for comparison, such as tropical and montane grasslands. In general, Grasslands are biological communities containing few trees or shrubs, distinguishable by their vast, concentrated ground cover of mixed herbaceous vegetation dominated by grasses.[8] Grasslands vary greatly and can be found on every continent across the world. They differ widely in climate, vegetation, soil profiles and animal life. For instance, there are the temperate grasslands that represent one of the Earth's major biomes; they are largely treeless and historically have been one of the most productive and diverse terrestrial biomes. Temperate grasslands are predominantly located in the Northern Hemisphere, stretching across vast regions of North America, South America, Eurasia, Africa, and Oceania.[9] Temperate grasslands are often referred to by different names and vary in size. The larger temperate grasslands include prairies in the United States and Canada, pampas found in Argentina and Uruguay, steppes in Russia and Central America as well as the veldts in South Africa. These generally experience extreme seasonal temperatures with hot summers and extremely cold winters. There are smaller grasslands found in Hungary, which is called puszta and the downs and tussock found in Australia and New Zealand.

In contrast, tropical grasslands, which are also called savannas, remain warm all year round but often experience dramatically wet and harshly dry seasons alternately. This gives rise to the growth of drought-resistant trees, which grow sparsely among tall grasses when compared to temperate grasslands that are treeless due to climate conditions. A few tropical grasslands are the Serengeti (East Africa), the Cerrado (Brazil), and the Northern Australian Savannas. While the overarching definition of a tropical grassland highlights its seasonal climate, exploring specific regional variations such as the mammalian-dominated Serengeti or the fire-adapted Cerrado shows how complex these open landscapes truly are.[10] The long-term distribution and stability of tropical savannas depend heavily on the dynamic interactions between highly seasonal rainfall, soil nutrient availability, recurring wildfires, and intense herbivore grazing.

While the other grasslands differ greatly in climate, vegetation and animal species, montane grassland presents another set of climate and ecological adaptations. They are characterized by cool temperatures, thin soil layers, and unique plant and animal life. Montane grasslands are found at extremely high elevations in mountains, beneath the snowline but above the tree line. Because it is too windy and cold for trees to survive at this elevation, grasses take over.[11] Located high in the northern Andes Mountains of South America, the páramo is the best-known example. Millions of people who live downstream receive water from its moist, spongy soil, which absorbs rain and snowfall like a sponge and gradually releases it into rivers.[12] Because the páramo is a relatively young ecosystem, having only formed in the last two to three million years when the Andes became tall enough to support it, scientists have also discovered that páramo plants change into new species more quickly than plants in nearly every other location on Earth.[13] Many of the flora and animals that inhabit alpine grasslands like this are unique to the globe because they are dispersed and isolated, resembling islands in the sky.[14]

How Climate Influences Temperate Grasslands

The defining climatic feature of temperate grasslands is contrast. Summers are hot, winters are cold, and the annual swing between the two is much sharper than in tropical grasslands.[15] Annual precipitation is moderate, generally somewhere between 25 and 89 centimeters (roughly 10 to 35 inches) per year, which is enough to support dense grass cover but too little, combined with periodic drought, to allow most trees to establish and survive.[16] This precipitation total also varies meaningfully across the biome and directly shapes what kind of grassland forms: wetter regions closer to 75–89 cm of rain tend to grow tall, dense grasses, while drier regions produce shorter, sparser grass cover. In North America, this gradient produces a recognizable pattern moving west to east, from short-grass prairie in the rain-shadow of the Rocky Mountains to mixed-grass and finally tall-grass prairie in the wetter eastern Great Plains.[17]

This climate does more than determine grass height. The same conditions that limit tree establishment, temperature extremes, seasonal drought, and periodic fire, also actively maintain the open character of the grassland once it forms. In other words, temperate grasslands are not simply places where trees have not yet grown; they are actively held in a grass-dominated state by recurring disturbance.[18] The climate of a temperate grassland doesn't just decide how tall the grass grows, it actually keeps the whole landscape from turning into a forest. The three influences are extreme hot and cold temperatures, dry spells during the growing season, and fires that sweep through every few years. Each of these factors makes life hard for tree seedlings, in particular. Grasses can survive extreme heat and cold, bounce back after drought, and regrow quickly after a fire because most of their living tissue is safely underground in their roots. However, young trees can't do any of this nearly as well. Their seedlings are far more likely to dry out, freeze, or burn before they will ever grow tall enough to survive on their own. This is why it is not accurate to think of a grassland as just an empty space where a forest simply has not grown in yet, as if trees are on their way and just haven't arrived. A grassland isn't "unfinished." It's an ecosystem that gets renewed again and again by the same harsh conditions that would kill off any trees trying to take root. Take away the fires, or the droughts, or the temperature swings, and over time trees and shrubs would likely move in and the grassland would slowly disappear. Hence, the "openness" of a grassland, the fact that it's mostly grass with few or no trees, is not an accident, a coincident or a pause. It's something the environment is actively maintaining, year after year, through repeated stress and disturbance.

Fertile Soils of Temperate Grasslands: The Mollisol Advantage.

The significance of temperate grasslands to human civilization may be best explained by their soil. Soil is a

natural resource characterized by the thin layer covering the entire earth's surface, except for open water surfaces and rock outcrops. The properties of soil are determined by environmental factors. Five dominant factors are often considered in the development of the various soils: (a) the climate, (b) parent materials (rocks and physical and chemical derivatives of same), (c) relief, (d) organisms (fauna and flora), and (e) the time factor.[19] This biome's distinctive soil is a member of the Mollisols soil order, which derives from the Latin mollis, which means "soft." A deep, black, organic-rich surface layer known as a mollic epipedon, which can extend 60 to 80 centimeters below the surface and is formed by a process known as melanization. The gradual darkening of soil brought on by the decomposition of organic matter is what defines mollisols.[20] Because grasses have a disproportionate amount of their biomass underground, this dark layer accumulates. Their vast, fibrous root systems, which can extend 1 to 2 meters (3 to 6 feet) into the soil, become dormant and then sprout periodically, continuously depositing organic material below ground.

Over time, burrowing creatures like earthworms, ground squirrels, and prairie dogs deepen and enrich the mollic epipedon by mixing this organic debris further into the soil profile. The end product is some of the most readily cultivated, naturally productive soil on the planet. Despite making up only 7% of the world's ice-free land area, mollisols constitute the foundation of the United States' "breadbasket" agricultural regions. This fertility is a double-edged sword for the biome.[21] This means that the same fertility which makes the mollisol so productive and valuable comes with great risks. Due to the fertility of this rich soil, it results in it being heavily farmed, which can lead to soil degradation, erosion and loss of long-term productivity. It is a benefit but it also requires careful management to avoid exhausting the soil. Temperate grasslands have been the focus of extensive agricultural conversion more than almost any other biome due to the same characteristics that made these soils so appealing to ancient grasses and grazing animals.

Vegetation and Plant Adaptations.

Grasses are not simply the tallest plants that happen to survive in this biome; they are highly adapted to it. Two broad growth strategies coexist across temperate grasslands: sod-forming grasses, which spread laterally through underground stems called rhizomes and create dense, interlocking turf, and bunch grasses, which lack rhizomes, reproduce by seed, and tend to dominate the drier portions of the biome.[22] Both strategies share a common defense against the biome's stresses: massive investment in root tissue relative to visible above-ground growth, which anchors plants against wind erosion, allows them to store water and carbohydrate reserves underground during drought, and lets grasses resprout quickly after fire or grazing removes their leaves. Grasses are not alone in this landscape. Interspersed among them are hundreds of species of non-woody flowering plants known as forbs, including asters, coneflowers, and blazing stars in North American prairies, that add seasonal color and floral diversity without competing directly with grasses for the same root depth. True woody plants, by contrast, are largely excluded except along rivers and streams, where increased water availability allows species like cottonwood, oak, and willow to survive despite the biome's otherwise unfavorable conditions for trees. [23]

Disturbance Ecology: Why Fire and Grazing Matters.

One of the most important ideas about temperate grasslands is that they need to be disturbed to stay healthy. Without regular fires and grazing animals, most temperate grasslands would slowly turn into shrubland or forest over time. Fire has always been part of this system. Long ago, lightning started most fires, and for thousands of years afterward, Indigenous peoples also set fires on purpose. These fires burn away dead grass and plant litter, put nutrients back into the soil, and kill young trees and shrubs before they can grow big. Grasses survive these fires just fine because their roots stay safe underground and can quickly grow new

leaves afterward.[24]

Grazing by large herbivores works alongside fire rather than replacing it. In North America's tallgrass prairie, research at sites such as the Konza Prairie Biological Station and the Tallgrass Prairie Preserve has shown that reintroduced bison (*Bison bison*) create a patchwork of grazed and ungrazed, burned and unburned areas, and this patchiness, rather than uniform grazing pressure, is what supports high biodiversity. Bison also physically disturb the ground through wallowing, rolling in dust to control insects and shed fur, which creates bare-soil depressions that become colonized by different, often short-lived plant species than the surrounding turf, adding yet another layer of habitat variety to the landscape. Studies tracking insects such as grasshoppers and ground beetles across burned and grazed prairie plots have found that this combination of fire frequency and bison grazing significantly increases species diversity and evenness compared to areas managed with only one disturbance type or none at all. Even grassland birds respond to this mosaic: species like the Henslow's sparrow and upland sandpiper favor different combinations of recent fire and grazing intensity, meaning that a variable, patchy disturbance regime supports a wider range of bird species than a uniform one.[25]

The Temperate Forest Biome

Unlike grasslands, temperate forests receive abundant rainfall throughout the year, allowing trees to become the dominant vegetation. Temperate deciduous forests are characterized by four distinct seasons, with warm summers, colorful autumns, cold winters, and mild springs. This seasonal cycle influences every aspect of life within the forest. One of the defining features of temperate forests is the presence of deciduous trees such as oaks, maples, beeches, and hickories. During autumn, these trees shed their leaves in preparation for winter. This adaptation allows trees to conserve water and energy when temperatures decrease and sunlight becomes less available. In spring, new leaves emerge, allowing photosynthesis to resume and supporting another season of growth.[26]

The layered structure of temperate forests creates numerous habitats within a relatively small area. The canopy receives the greatest amount of sunlight and provides habitat for birds, squirrels, and insects. Beneath the canopy, smaller trees and shrubs occupy the understory, while the forest floor supports fungi, mosses, insects, worms, and countless decomposers responsible for recycling nutrients.[27] Students are often fascinated by the idea that fallen leaves are not simply waste but rather an essential part of the ecosystem. As decomposers break down dead plant material, nutrients are returned to the soil, where they become available for new plant growth. This continuous recycling of matter demonstrates one of the fundamental principles of ecology: ecosystems depend upon the cycling of energy and nutrients to remain healthy. Temperate forests support tremendous biodiversity because they provide a variety of habitats and food sources. Deer browse on shrubs and young plants, while black bears consume berries, insects, fish, and small mammals. Woodpeckers remove insects from tree bark, helping maintain forest health, while salamanders, frogs, and countless invertebrates thrive within moist leaf litter. Each organism contributes to the overall functioning of the ecosystem.

Temperate Forest Location and Climate.

Temperate forests are mostly found in the mid-latitudes, approximately between 25° and 50° north and south of the equator, primarily in eastern North America, Western and Central Europe, and East Asia, smaller pockets can be found in southern Chile and southeastern Australia. Nearly all of the world's temperate deciduous forests are located in this region. In contrast to temperate grasslands, with limited moisture and frequent disturbance, temperate forests receive consistent annual precipitation.[28] Usually around 30 to 60

inches or 750–1,500 mm throughout the year, although not universal. This precipitation is distributed fairly evenly throughout the year and is considered a highly dependable water supply, which allows trees to meet the high moisture demands required to grow tall trunks, extensive root systems, and broad canopies, making forests the dominant vegetation in these regions.[29][30]

Temperate forests experience the four distinct seasons, spring, summer, autumn, and winter, which shape nearly every aspect of the ecosystem. The summers are generally warm and wet, while winters are cold and often snowy which creates a period where plants grow approximately 120 to 250 days followed by a dormant period. This seasonal cycle drives many of the adaptations seen in temperate forests.[31] Deciduous trees such as oaks, maples, beeches, and hickories shed their leaves each autumn to conserve water and energy during the colder months when sunlight is limited. In spring, the trees showcase new leaves emerging, once again photosynthesis resumes, and another flourishing season where growth begins. The combination of reliable rainfall and pronounced seasonal change distinguishes temperate forests from grasslands and supports the rich biodiversity characteristic of this biome, setting it apart from other biomes.[32][33]

Temperate Forest Vegetation and Layered Structure

Temperate forests are generally classified into three major types: temperate deciduous forests, temperate coniferous forests, and temperate rainforests. Although all occur within temperate regions, they differ in climate, dominant vegetation, and annual precipitation. Deciduous forests experience distinct seasons and are dominated by broad-leaved trees, such as oak, maple, beech, birch, and hickory, that lose all their leaves for part of the year, while coniferous forests provide year-round greenery and shelter for various species. They include needle-leaved evergreen trees like pine, fir, and spruce, which usually dominate a given region depending on local temperature and moisture conditions. The deciduous forests are the most common type across eastern North America, Europe, and East Asia. Temperate rainforests, found in regions with exceptionally high annual precipitation, support towering coniferous trees, dense understory vegetation, and abundant mosses and ferns.[34][35]

Rather than growing in a single uniform layer, a temperate forest organizes itself into distinct vertical layers, each with its own light levels, humidity, and resident species. At the top sits the canopy, made up of the tallest, dominant trees, whose leaves capture most of the available sunlight and cast shade over everything below. Beneath that is the understory, composed of smaller, shade-tolerant trees and saplings waiting for an opening in the canopy above. Below the understory is the shrub layer, made up of woody, multi-stemmed plants such as dogwood and blueberry that can survive on the reduced light filtering down from above, and beneath that, the herbaceous or ground layer, home to wildflowers, ferns, and mosses adapted to deep shade. Finally, the forest floor itself is covered in leaf litter, fungi, and decomposing organic matter, which breaks down to make temperate forest soils some of the most fertile in the world.[36]

The defining plant adaptation in this biome is deciduous leaf drop. As temperatures fall in autumn, trees stop producing chlorophyll, the green pigment used in photosynthesis, which allows other pigments already in the leaf to show through as the reds, oranges, and yellows of fall color, before the tree seals off and sheds its leaves entirely. This isn't simply leaves dying from cold; it's an active survival strategy.[37] By dropping leaves that would otherwise freeze, tear in winter storms, or lose water the tree can't replace from frozen ground, deciduous trees conserve energy and avoid damage through the coldest months, then regrow a fresh canopy each spring when conditions improve.

Temperate Forests: Animal Life and Food Webs

Just as temperate forest plants have evolved to cope with a hard seasonal boundary, so have the animals that live among them, and their strategies generally fall into three categories: hibernation, migration, and camouflage. Hibernation allows animals like black bears and groundhogs to slow their metabolism dramatically and sleep through the winter months when food is scarce, while some smaller animals, such as chipmunks and certain ground squirrels, rely instead on caching, or hoarding, the food they gathered in autumn to eat gradually through winter without fully hibernating. Migration solves the same problem differently, many forest birds, including robins, warblers, and other songbirds, fly south each fall to reach areas with more available food, then return north each spring to breed. Camouflage is a year-round strategy where the animals blend in with their environment to reduce visibility, making it difficult for predators to detect them.[38] For example, the reddish-brown coat of a white-tailed deer blends into fallen leaves and tree bark, helping it avoid predators. Some animals are also able to change their color seasonally to match snow cover in winter and green or brown vegetation in summer.

These adaptations connect into a single, interlocking food web. In an Appalachian deciduous forest, for example, oak and hickory trees produce acorns and nuts that feed seed-caching animals like squirrels and chipmunks; those small mammals, along with insects and amphibians on the forest floor, in turn support mid-level predators such as foxes and owls; while apex predators like black bears and, in areas where they've been reintroduced, wolves, help keep deer and smaller mammal populations in check. Every level of this food web, from the trees at the canopy down to the fungi and insects decomposing leaf litter on the forest floor, is tied to the same seasonal rhythm of growth, dormancy, and regrowth, temperate forest biodiversity depends on the whole system moving through its yearly cycle together.[39]

Human impact and the Importance of Conservation.

While temperate grasslands experience moderate rainfall with hot summers and cold winters, which reduces plant growth and affects grazing animals that depend upon grasses for food, temperate forests experience warmer winters, earlier springs, and increased outbreaks of insect pests that damage trees. Some species usually migrate into new regions while others decline due to the unavailability of suitable habitat. These changes illustrate one of ecology's most important principles: altering one part of an ecosystem often affects many other components. As human activities continue to alter the natural landscapes, many conservation efforts are in motion to help protect grassland and temperate forest biomes. National parks, wildlife refuges, conservation easements, and habitat restoration projects preserve important ecosystems while providing opportunities for scientific research and environmental education. Restoration projects often involve removing invasive species, replanting native vegetation, restoring wetlands, and using prescribed burns to maintain healthy grassland ecosystems.[40][41] These efforts demonstrate that humans can play a positive role in protecting biodiversity when scientific knowledge guides environmental decision-making. Conservation also begins with individual actions. Middle school students may feel that environmental problems are too large for them to influence, but small actions can collectively make a meaningful difference. Recycling, reducing waste, planting native species, conserving water, participating in community clean-up projects, and supporting local conservation organizations all contribute to healthier ecosystems. Encouraging students to see themselves as environmental stewards helps them understand that science is not only about learning facts but also about making informed decisions that improve the world around them.

Conclusion: From Questions to Discoveries

The story of grasslands and temperate forests is, in many ways, the story of scientific inquiry itself. Early

observers asked simple descriptive questions such as why does this place look different from the other or how do the weather and the plants in this Biome help it stay balanced and support the animals that live in it? In teaching this unit, students are invited to exercise their curiosity and formulate their own questions. Over generations, ecologists refined questions into testable ones. The discoveries covered in this unit, the fertility of grassland soils, the layered structure of forest canopies, the seasonal strategies of forest animals, the fire thresholds separating grassland from forest did not emerge all at once. They accumulated across decades of careful observation, data collection, and comparative study, much like the inquiry process students are asked to practice in their own investigations. The questions that remain open, how these biomes will respond to a changing climate, how conservation can balance human land use with ecological health are the discoveries the next generation of scientists, including today's students, will be responsible for making.

An understanding of how temperate grasslands and temperate forests function and how human activities influence them will prepare students to make evidence-based decisions about environmental stewardship. By investigating these biomes through scientific inquiry, students develop a deeper appreciation of biodiversity and recognize their own role in protecting ecosystems at both local and global scales

Teaching Strategies

Graphic Organizers

Graphic organizers give students a visual structure for holding onto complex, comparative information, which makes them especially useful in a unit built around cause-and-effect relationships and cross-biome comparisons. Students will use a cause-and-effect chain that is well suited to understanding the disturbance ecology content in this unit, since so much of what happens in a temperate grassland depends on a sequence of triggered events rather than a single isolated fact. Students will use map, for instance, how fire leads to the release of nutrients and the death of young woody seedlings, which in turn allows grasses to resprout from their intact root systems, which then supports the patchy, high-biodiversity landscape described in the disturbance ecology section. The same tool works equally well for the keystone species material, where students can trace how prairie dog burrowing leads to soil aeration and altered vegetation, which then creates the specific habitat conditions that species like burrowing owls and black-footed ferrets depend on. By requiring students to draw an explicit arrow from one step to the next, this organizer pushes them past simply listing facts about an ecosystem and toward explaining how that ecosystem actually functions.

They will also use a Venn diagram, is most useful anywhere in the unit that calls for careful distinction rather than sequence, particularly the comparison between montane and temperate grassland. These two biomes share some genuinely overlapping features, such as a dependence on disturbance to remain open, and vulnerability to climate change, but differ in more fundamental ways, including their location and temperature shift. A Venn diagram gives students a structured way to sort what is truly shared from what only appears similar on the surface. This is also a natural tool for reinforcing the terminology precision this unit emphasizes throughout, since it forces students to decide, feature by feature, whether a given characteristic belongs in the overlapping middle section or in one of the two outer circles.

Building Models

Building models allows students to externalize the structure of a system rather than simply describe it in

writing, which makes this strategy particularly valuable for content in this unit that is fundamentally about layers, connections, and structure. Students will create a soil profile model, students construct a labeled cross-section, using layered materials such as clay and sand or a carefully drawn diagram, that represents the depth and organic content of a Mollisol soil beneath a temperate grassland, then compare that structure to the more shallow, differently organized soil profile found beneath a temperate forest. This exercise makes an otherwise abstract concept, the depth of grass root systems and the process of melanization that builds up a mollic epipedon over time, into something students can see and physically measure, it reinforces why grassland soil became some of the most agriculturally valuable soil on Earth.

Students will also make a food web model where they will be placed in small groups to construct a physical or diagrammed web. Before creating the model, they will receive a handout with information and examples of food webs and food chains. They will then connect producers, consumers, and decomposers with string or drawn arrows, using either the prairie food web (grasses, prairie dogs, black-footed ferrets, and decomposers) or the Appalachian forest food web (oak and hickory trees, seed-caching mammals, mid-level predators, and decomposers) as the example system. What makes this model especially effective is that it allows students to physically remove or tug on a single node, such as the prairie dog or the acorn-producing oak, and observe how that disruption ripples outward through the connected strings, giving them a tactile, immediate demonstration of the same ecological principle that keystone species research describes: that a single species can have an influence on ecosystem stability that is disproportionate to its size or numbers.

Think-Ink-Pair-Share

Think-ink-pair-share extends the familiar think-pair-share routine by inserting a private writing step before any discussion occurs, and this addition matters most for the parts of this unit that invite genuine interpretation or require students to reason through cause and effect rather than simply recall a definition. In the think stage, the teacher poses a question designed to surface a misconception or provoke real reasoning, such as whether a grassland is simply a forest that has not yet grown, or why removing bison from a prairie might eventually change which bird species live there. In the ink stage, students are given a few quiet minutes to write down their own answer before hearing from anyone else, a step that matters because it requires every student to commit to their own reasoning rather than defaulting to whatever answer the most vocal student offers first, and it produces a written record the teacher can later use to gauge individual understanding. In the pair stage, students exchange their written answers with a partner, comparing reasoning, identifying disagreements, and revising or defending their original position in light of their partner's argument. Finally, in the share stage, selected pairs present their reasoning to the larger class, which gives the teacher an opportunity to surface and directly address common misconceptions built into this unit, including the assumption that an open, treeless landscape is simply an underdeveloped forest.

Classroom Activities

Chain Reaction: Tracing the Ripple Effects of Fire

Objective: Students will explain how disturbances such as fire or grazing influence temperate grassland ecosystems.

After the students have learnt about this topic through readings and discussions, the activity will begin with a

provocative question: how can one wildfire actually increase biodiversity in a grassland? In groups of four, students will receive a set of cards describing individual ecological events such as a fire removing dried grass, nutrients being released into the soil, woody seedlings dying off, sunlight reaching new grasses, deep grass roots surviving, native grasses regrowing, herbivores returning, and biodiversity increasing. They will work in their groups to arrange these cards into a cause-and-effect chain, connecting each event with arrows and explaining the relationships using transition language such as *because*, *therefore*, and *as a result*. The groups will then move around the room to compare their finished chains and debate which single event, if removed, would have the greatest impact on the overall outcome. In the end, each student will demonstrate his/her understanding by writing a Claim-Evidence-Reasoning (CER) response explaining why fire is considered an essential natural disturbance in temperate grasslands.

Biome Showdown: Grassland vs. Forest

Objective: Students will compare the characteristics of temperate grasslands and temperate forests.

The students will work in pairs for this activity. Each pair receives a set of materials representing both biomes; this could include photographs, climate graphs, soil profiles, and species cards. First, students will look closely at all the materials for both the grassland and the forest. As they examine each item, they will think about which biome it belongs to and what it tells them about that biome. Next, they will sort their evidence into a Venn diagram where one side of the diagram is labeled "Grassland," the other side "Forest," and the middle section is for things both biomes have in common. They will then organize their evidence under categories such as climate, precipitation, soil, plants, animals, disturbances, and human uses. Once the diagram is finished, students will answer a question together: which biome would better support large grazing mammals and why? They must use specific evidence from their Venn diagram to support their answer, not just a guess. For example, a student response may look like this: Grasslands provide open space, constant sunlight, and fast-regrowing grasses, all of which support the food needs and herd behavior of large grazing mammals. Forests, on the other hand, block sunlight with their tree cover or leaf cover (canopy) and don't provide the same open terrain or abundance of ground-level food, making them less suitable for large grazers. Finally, the class will come together for a short discussion. Each pair shares their answer and explains their reasoning, using the evidence they gathered to defend their choice to their classmates.

Dig Deep: Modeling Soil Beneath Two Biomes

Objective: Students will model and compare grassland and forest soil profiles.

Working in small groups of four or five, the students will construct two soil profiles side by side using clear plastic cups, dark potting soil, sand, clay, yarn to represent grass roots, and pipe cleaners to represent tree roots. One cup represents the deep, dark Mollisol typical of temperate grassland soil, while the other represents the more shallow, layered horizons of temperate forest soil. The students will compare the two models across root depth, organic matter content, soil color, and water retention. They conclude the activity by explaining, in writing, why temperate grassland soils rank among the most productive agricultural soils on Earth. An example of a Sample Student Response is: "Grassland soil is so good for farming because it has really deep roots, like our yarn showed. The roots go down really far, so when the grass dies, it adds a lot of dark, rich stuff called organic matter deep into the soil, not just on top. This makes the soil dark and full of nutrients that plants need to grow. Grassland soil also holds water well, so plants don't dry out. Forest soil doesn't have as much organic matter mixed in deep down, because the leaves and stuff just build up on top instead of getting mixed into the soil like grass roots do. That's why farmers like to plant crops in grassland soil, it already has everything plants need to grow big and healthy."

The Web We Weave: Modeling Interdependence

Objective: Students will model how organisms depend on one another.

Each student is given a card representing an organism such as grass, prairie dog, grasshopper, snake, hawk, or bacteria, after which the class will form a circle. Using yarn, they will then connect themselves to classmates according to real feeding relationships, building a physical food web. The teacher then removes one organism from the web, for instance, the prairie dog, after which students should then observe how many yarn connections go slack as a result. A class discussion follows, focusing on which organisms were affected and why removing a single species had such wide-reaching consequences. Students repeat the exercise with a different organism, such as an oak tree in a forest food web, and can extend the activity further by introducing an invasive species or a drought scenario and predicting how the web would change in response. Sample Student Response: "When the teacher removed the prairie dog, a lot of yarn went loose, not just one piece. The hawk's yarn went slack because hawks eat prairie dogs, so now the hawk doesn't have as much food. The snake's yarn went loose too, because snakes eat prairie dogs. Even the grass was affected in a different way, because prairie dogs dig burrows that help the soil, and other animals use those burrows too. This showed me that prairie dogs are connected to a lot of other organisms, not just one. If one animal disappears, it doesn't just affect that one animal; it affects everything connected to it, kind of like knocking down one domino and a bunch of others fall too. That's why removing just one species from an ecosystem can cause big changes for a lot of other living things."

Grassland or Forest-in-Waiting? A Silent Debate

Objective: Students will use evidence to explain why grasslands remain treeless.

Students begin by silently considering the question of whether a grassland is simply a forest that hasn't grown yet. There will be an "Ink" phase where they will write their own answer independently, along with two supporting pieces of evidence and one lingering question. They then pair up to compare responses, identifying similarities, differences, and the strongest evidence between their two answers, revising their own thinking as needed. Pairs share their reasoning with the class, and the teacher records the evidence on the board under two headings, "Evidence For" and "Evidence Against." At the end of the lesson, students revisit the original question one final time and revise their initial response using the new scientific evidence they've gathered. Example of a student sample response: Students begin by silently considering the question of whether a grassland is simply a forest that hasn't grown yet. There will be an "Ink" phase where they will write their own answer independently, along with two supporting pieces of evidence and one lingering question. They then pair up to compare responses, identifying similarities, differences, and the strongest evidence between their two answers, revising their own thinking as needed. Pairs share their reasoning with the class, and the teacher records the evidence on the board under two headings, "Evidence For" and "Evidence Against." At the end of the lesson, students revisit the original question one final time and revise their initial response using the new scientific evidence they've gathered.

Resources

Student Reading List

- National Geographic Society. “What Makes a Biome?” National Geographic Education. https://education.nationalgeographic.org/resource/what-makes-biome/
- University of California Museum of Paleontology. “The Grassland Biome.” https://ucmp.berkeley.edu/
- Biology LibreTexts. “5.4.8: Temperate Grasslands and Temperate Forests (Prairie).” https://bio.libretexts.org

Classroom Materials

- Colored yarn/string for food web modeling
- Organism cards (plants, animals, decomposers)
- Food web and ecosystem diagrams
- Chart paper and markers
- Soil samples
- Clear plastic cups for soil profile investigations
- Organic matter samples
- Magnifying glasses
- Soil profile diagrams
- Biome maps
- Climate graphs
- Plant and animal picture cards
- Ecosystem disturbance scenario cards (fire, drought, human impact, invasive species)
- Student science notebooks
- Graphic organizers
- Vocabulary cards/word wall materials
- Bilingual dictionaries and translation tools
- Computers/tablets for research and simulations
- Ecosystem images and videos
- Poster paper and presentation materials

Annotated Bibliography

Anderson, Roger C. “Evolution and Origin of the Central Grassland of North America: Climate, Fire, and Mammalian Grazers.” *Journal of the Torrey Botanical Society* 133, no. 4 (2006): 626–647. https://doi.org/10.3159/1095-5674(2006)133[626:EAOOTC]2.0.CO;2. *Annotation:* Explains the historical development of North American grasslands and the ecological roles of fire and grazing.

Animalia. “Montane Grasslands and Shrublands.” Accessed July 14, 2026. https://animalia.bio/montane-grasslands-and-shrublands/1000. *Annotation:* Describes the characteristics, biodiversity, and distribution of montane grasslands.

Banaras Hindu University. *An Overview of Micropedological Features of Different Soil Orders*. PDF. Accessed July 14, 2026. https://bhu.ac.in/Images/files/SSC-604(1).pdf. *Annotation:* Provides information about soil orders and soil characteristics.

Begon, Michael, Colin R. Townsend, and John L. Harper. *Ecology: From Individuals to Ecosystems*. 4th ed. Malden, MA: Blackwell Publishing, 2006. *Annotation:* Introduces core ecological concepts and ecosystem interactions.

Biology LibreTexts. "5.4.8: Temperate Grasslands (Prairie)." Accessed July 14, 2026. https://bio.libretexts.org. *Annotation:* Explains the climate, vegetation, and wildlife of temperate grasslands.

Buytaert, Wouter, et al. "Human Impact on the Hydrology of the Andean Páramos." *Earth-Science Reviews* 79, nos. 1–2 (2006): 53–72. *Annotation:* Examines how human activities influence páramo ecosystems and water systems.

Cain, Michael L., William D. Bowman, and Sally D. Hacker. *Ecology*. 5th ed. Sunderland, MA: Sinauer Associates, 2020. *Annotation:* Covers ecological principles related to organisms, populations, and ecosystems.

Chakravorty, Jennifer, John A. Harrington, and Elizabeth M. Bach. "Bison Grazing in Eastern Tallgrass Prairie Does Not Alter Plant Diversity after Five Years." *Natural Areas Journal* 44, no. 4 (2024): 215–222. https://doi.org/10.3375/2162-4399-44.4.215. *Annotation:* Investigates the effects of bison grazing on tallgrass prairie plant diversity.

Coder, Kim H. *Structure and Function of Mature Temperate Deciduous Forests*. Athens: Warnell School of Forestry and Natural Resources, University of Georgia, 1999. *Annotation:* Describes the structure and ecological functions of mature temperate deciduous forests.

Coder, Kim H. *Temperate Deciduous Forest Biome*. Athens: University of Georgia Warnell School of Forestry and Natural Resources, 2007. *Annotation:* Provides an overview of temperate deciduous forest characteristics and processes.

EBSCO Research Starters. "Range Management." Accessed July 14, 2026. https://www.ebsco.com/research-starters/environmental-sciences/range-management. *Annotation:* Explains the principles and practices of managing grassland ecosystems for sustainable use.

Estrella, Nicole, Elisabeth Menzel, and Annette Menzel. "Recent and Future Climate Effects on Spring and Autumn Phenology in Europe." *International Journal of Biometeorology* 51, no. 5 (2007): 413–424. *Annotation:* Examines how climate change affects seasonal plant development.

Gann, George D., et al. "International Principles and Standards for the Practice of Ecological Restoration." *Restoration Ecology* 27, no. S1 (2019): S1–S46. https://doi.org/10.1111/rec.13035. *Annotation:* Outlines internationally recognized principles for ecological restoration.

Geiser, Fritz. "Metabolic Rate and Body Temperature Reduction During Hibernation and Daily Torpor." *Annual Review of Physiology* 66 (2004): 239–274. *Annotation:* Explains physiological adaptations that enable animals to survive cold conditions.

Global Bioenergy Partnership. "Temperate Grasslands Biome." Accessed July 14, 2026. https://www.globalbioenergy.org/temperate-grasslands-biome/. *Annotation:* Describes the climate, vegetation,

and ecological importance of temperate grasslands.

Hall, L. S., Paul R. Krausman, and Michael L. Morrison. “The Habitat Concept and a Plea for Standard Terminology.” *Wildlife Society Bulletin* 25 (1997): 173–182. *Annotation:* Discusses the definition of habitat and the importance of consistent ecological terminology.

Harkiolakis, Nicholas. “Ecosystems.” In *Encyclopedia of Corporate Social Responsibility*, edited by Samuel O. Idowu, Nicholas Capaldi, Liangrong Zu, and Ananda Das Gupta. Berlin: Springer, 2013. https://doi.org/10.1007/978-3-642-28036-8_382. *Annotation:* Defines ecosystems and explains their essential components and functions.

Henwood, Jonathan M. “The World’s Temperate Grasslands: A Beleaguered Biome.” *Parks* 8, no. 3 (1998): 31–36. https://parksjournal.com/wp-content/uploads/2017/06/parks_8_3.pdf. *Annotation:* Discusses the global distribution, importance, and conservation challenges of temperate grasslands.

Kimmins, J. P. *Forest Ecology: A Foundation for Sustainable Forest Management and Environmental Ethics in Forestry*. 4th ed. Boston: Pearson, 2004. *Annotation:* Examines forest ecology, ecosystem processes, and sustainable forest management.

Knapp, Alan K., John M. Briggs, David C. Hartnett, and Scott L. Collins, eds. *Grassland Ecology*. New York: Oxford University Press, 1998. *Annotation:* Explores the ecological processes, biodiversity, and functioning of grassland ecosystems.

Madriñán, Santiago, Andrés J. Cortés, and James E. Richardson. “Páramo Is the World’s Fastest Evolving and Coolest Biodiversity Hotspot.” *Frontiers in Genetics* 4 (2013). *Annotation:* Describes the unique biodiversity and evolutionary characteristics of páramo ecosystems.

National Geographic Society. “What Makes a Biome?” Accessed July 14, 2026. https://education.nationalgeographic.org/resource/what-makes-biome/. *Annotation:* Introduces the characteristics used to define and classify biomes.

Olson, David M., Eric Dinerstein, Eric D. Wikramanayake, et al. “Terrestrial Ecoregions of the World: A New Map of Life on Earth.” *BioScience* 51, no. 11 (2001): 933–938. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2. *Annotation:* Presents a global classification system for terrestrial ecosystems and ecoregions.

OpenSciEd. “About Us.” Accessed July 14, 2026. https://openscied.org/why-openscied/about-us/. *Annotation:* Provides information about OpenSciEd’s approach to science curriculum development.

Pan Geography. “Temperate Grasslands Biome: Location, Climate, Plants, & Animals.” *Global Bioenergy Partnership*. Last modified August 7, 2025. https://www.globalbioenergy.org/temperate-grasslands-biome/. *Annotation:* Provides an overview of temperate grassland locations, climate, and organisms.

“Range Management.” *EBSCO Research Starters*. Accessed July 14, 2026. https://www.ebsco.com/research-starters/environmental-sciences/range-management. *Annotation:* Provides information about managing rangelands and grassland resources.

Richardson, Andrew D., et al. “Influence of Spring and Autumn Phenological Transitions on Forest Ecosystem Productivity.” *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, no. 1555 (2010):

3227–3246. https://doi.org/10.1098/rstb.2010.0102. *Annotation:* Examines how seasonal changes influence forest productivity and ecosystem processes.

Ricklefs, Robert E., and Rick Relyea. *The Economy of Nature*. 8th ed. New York: W. H. Freeman, 2014. *Annotation:* Covers foundational ecological concepts, interactions, and ecosystem dynamics.

Samson, Fred, and Fritz Knopf. *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*. Washington, DC: Island Press, 1994. *Annotation:* Discusses prairie conservation, threats, and preservation strategies.

Smith, Robert Leo, and Thomas M. Smith. *Elements of Ecology*. 10th ed. Boston: Pearson, 2019. *Annotation:* Introduces major ecological principles and environmental relationships.

Soil Survey Staff. *Keys to Soil Taxonomy*. 13th ed. Washington, DC: U.S. Department of Agriculture, Natural Resources Conservation Service, 2022. https://www.nrcs.usda.gov/resources/guides-and-instructions/keys-to-soil-taxonomy. *Annotation:* Provides a classification system for identifying and describing soils.

Solbrig, Otto T., Ernesto Medina, and Juan F. Silva, eds. *Biodiversity and Savanna Ecosystem Processes: A Global Perspective*. Dordrecht: Springer Netherlands, 1996. *Annotation:* Examines biodiversity and ecological processes in savanna ecosystems.

Stephenson, Nathan L. "Climatic Control of Vegetation Distribution: The Role of the Water Balance." *The American Naturalist* 135, no. 5 (1990): 649–670. https://doi.org/10.1086/285067. *Annotation:* Explains how climate and water availability influence vegetation patterns.

Urry, Lisa A., et al. *Campbell Biology*. 12th ed. New York: Pearson, 2021. *Annotation:* Provides comprehensive biological concepts related to organisms, ecology, and evolution.

University of California Museum of Paleontology. "The Grassland Biome." Accessed July 14, 2026. https://ucmp.berkeley.edu/. *Annotation:* Describes grassland characteristics, climate, and biodiversity.

Van Dyke, Fred. *Conservation Biology: Foundations, Concepts, Applications*. Dordrecht: Springer Netherlands, 2008. *Annotation:* Discusses conservation biology principles and approaches to protecting ecosystems.

Woodward, S. "Temperate Grasslands." Radford University. Accessed July 14, 2026. https://php.radford.edu/~swoodwar/biomes/. *Annotation:* Provides information about temperate grassland climate, plants, and animals.

Appendix on Implementing District Standards

The unit is aligned with the following Next Generation Science Standards (NGSS):

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Notes

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[2] https://reportcard.doe.k12.de.us/detail.html#aboutpage?scope=school&district=32&school=282

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[18] Pan Geography, "Temperate Grasslands Biome: Location, Climate, Plants, & Animals," *Global Bioenergy*, last modified August 7, 2025, https://www.globalbioenergy.org/temperate-grasslands-biome/

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