This document provides a lesson outline using a phenomenon from the Global Vegetation Project (gVeg). Our intent is to provide you with a phenomenon from gVeg that you can use to stimulate discussion and lessons within your classroom. Bookmarks are present throughout the document to ease your navigation. Your class may take the phenomenon in many directions; we aim to anticipate a few of those directions and provide resources and ways to utilize gVeg. We also recognize that each educator has specific styles, student needs, time restraints, and outcomes to hit. This is intended to be a resource that fits your needs as an educator while sparking student interest and joy. Use this resource in whatever way best suits you!

Overarching Phenomenon

Why do trees stop growing at a certain point on mountains?

Image credit: https://earthscience.stackexchange.com/questions/7027/what-is-the-name-for-the-forested-areas-in-mountains-below-the-treeline

Introduction and Background

At a global scale, vegetation is largely shaped by precipitation and temperature differences which lead to large groupings of plants that are evolutionarily adapted to survive in the regional climate. These ecological relationships have led to major terrestrial life zones, or biomes, which include grasslands, forests, deserts, and tundra. However, if we take a closer look at individual communities across these climate gradients we see that there are more factors at play. For example, much of Wyoming is classified as desert shrubland yet we still find coniferous forests from place to place within those biomes.

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At a more local scale, plant communities are also shaped by other abiotic (non-living) conditions and biotic (living) interactions that determine species' growth, survival, and reproduction; a group of factors that are collectively called evolutionary fitness. Who "wins" and who "loses" is dependent on whether an individual plant's physical characteristics, or traits, are well adapted to the local environment. Species with waxy leaves do better in desert environments and a low, cushion-like growth form is advantageous in the alpine, for instance.

Elevation is one such abiotic factor that can majorly affect vegetation at local scales within a single biome. As elevation increases, atmospheric pressure decreases, air expands, and temperature decreases in predictable increments. When rising air cools, it also carries moisture which condenses and falls as precipitation at higher altitudes. The result is a series of local climatic conditions that allow one to pass through shrubland, forest, and alpine life zones just by climbing a single mountain. In fact, a distinct treeline can be even seen at the boundary where elevation makes conditions too cold for trees to grow and survive. Climate change seriously affects these local life zones because warming temperatures literally shift zones higher and higher, forcing plants and animals onto an "escalator towards extinction" as they chase suitable habitats upward until the mountaintop is reached.

When considering why trees stop growing at certain points on a mountain, several factors are at play. The one seen to be most critical is temperature, which lowers as elevation gets higher. If a tree is to survive the harsh alpine winters, it must have a sufficient growing season in the summer. The more quickly soil temperatures warm, the more quickly trees can begin acquiring resources for winter. This changes with latitude. In places like Mexico, treeline is much higher than it is in Wyoming. Treeline is also impacted by changes in summer weather conditions. For example, treeline on some Northeastern U.S. mountains occurs much lower than the Rockies because their summers are cool and cloudy. Overall, there are certain conditions where soil temperatures and summer weather conditions prevent tree success, leading to the phenomenon of a treeline.

References

Conniff, C. (2018, November 13). *Escalator to extinction: How mountain species are imperiled by warming.* Yale School of the Environment. https://e360.yale.edu/features/escalator-to-extinction-can-mountain-species-adapt-to-climate-change

Deziel, C. (2018, April 17). *How does elevation affect weather?* Sciencing. https://sciencing.com/elevation-affect-weather-4630.html

Rutledge, K., Ramroop, T., Boudrea, D., McDaniel, M., Teng, S., Sprout, E., Costa, H., Hall, H., & Hunt, J. (2021). Vegetation region. In J. Evers, & K. West (Eds.), *National Geographic Resource Library.* National Geographic. https://www.nationalgeographic.org/encyclopedia/vegetation-region/

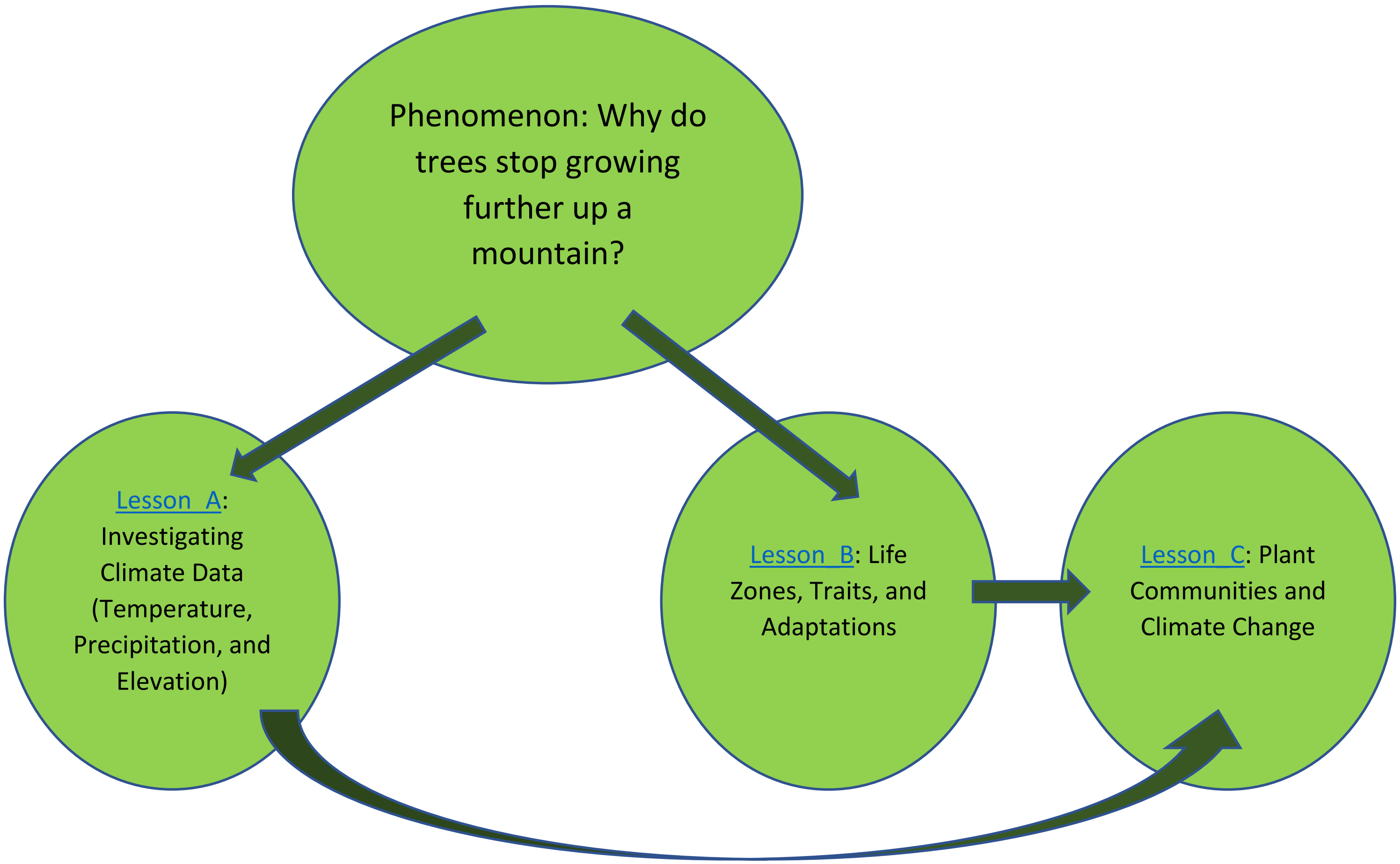
Snyder, M. (2018, September 17). *Why is the treeline at a higher elevation in the tetons than in the white mountains?* Northern Woodlands. https://northernwoodlands.org/articles/article/why_is_the_treeline_at_a_higher_elevation_in_the_tetons_than_in_the_white_m

Lesson Ideas

Below is written a framework for presenting the phenomenon, a plan for analyzing data, and several potential lines of student-generated inquiry that may develop. A suggestion for the presentation of the phenomenon is at the beginning. Following that, the Phenomenon Map provides several lines of inquiry that your students may generate. You may choose to go in any of those directions. Allow the students to guide the path of your teaching!

Phenomenon Map

The figure below maps a potential course for engaging students with the phenomenon and given material. The green bubbles are the activities described in this document and support by gVeg. Depending on student lines of inquiry, you may begin with Lesson A or Lesson B. Lesson C is reliant upon both Lesson A and Lesson B.



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Presentation of Phenomenon

Activities	Rationale
Begin with students looking at Phenomenon Pictures (or other pictures of treeline that could be close to home. If mountains are visible from your school, you can have students observe outside!). Have students record what they notice, what it reminds them of, and what they wonder. Have students share answers with a classmate. Then, record student wonderings in a place visible for the whole class.	This is the first step in engaging students with this phenomenon. This allows for you to determine students background knowledge, previous experience, misconceptions, and questions. Recording this for the whole class to see allows transparency in the learning process and provides students' to observe the agency they have in generating knowledge in the classroom.
Ask "Why do the trees stop growing further up the mountains?" Give students a few minutes to think and develop answers and questions they want to investigate. Have them share with a student next to them. Again, record all ideas and student lines of inquiry	If students did not hit on the subject of the trees stopping during the initial observation, this question ensures they begin thinking about this particular phenomenon. You can also begin to get a more clear picture of which lines of inquiry students may be interested in most.
Open the gVeg platform and pull up these two photos: Photo 1-Subalpine: Elevation 10,210 ft; Photo 2 - Alpine: Elevation 11,063 ft. You have the option of showing them in front of the whole class or having students access the pictures on their own. Only tell students the elevation of each picture. Have students look at each photo and make detailed observations for each one, noting the types of plants, where they are growing, plant height, number of plants, etc. You may have students record observations in a T-chart or Venn Diagram to compare similarities and differences between the two sites. When done, have students share answers in small groups	By providing students with a closer in look at snapshots of these environments, you can begin to gain a better understanding of student knowledge and questions. Students may now start thinking about the specific plants that live in these places or the conditions that may be impacting them on a regular basis.
Now that they have looked up close, ask the question again: "Why do the trees stop growing further up the mountains?" with the added context of looking at both of these environments up close. Record new ideas or lines of questioning students generate	By fielding questions here, you will get an idea of what direction students might take this investigation. If students begin talking about weather, climate, precipitation, or elevation, you may choose to continue with Lesson A. If the questions lead more towards the types of plants, their adaptations and characteristics, or climate change, you may continue with Lesson B

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Lesson Ideas

Lesson A

Below are the Performance Expectations, Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas present in this lesson. The color coding is in line with the Next Generation Science Standards (NGSS). The color coding is consistent throughout the document, reflecting where each of the three dimensions are present.

Performance Expectations	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Science and Engineering Practices	**Engaging in Argument From Evidence:** *Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.* **Analyzing & Interpreting Data:** *Analyze and interpret data to provide evidence for phenomena. Use graphical displays of large data sets to identify temporal and spatial relationships.*
Crosscutting Concepts	**Cause & Effect:** *Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.* **Patterns:** *Graphs, charts, and images can be used to identify patterns in data. Patterns can be used to identify cause-and-effect relationships.*
Disciplinary Core Ideas	**Interdependent Relationships in Ecosystems:** *Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.*

Lesson Progression

This lesson takes the two gVeg locations from the phenomenon presentation and provides students with the opportunity to compare temperature and precipitation data. Students can begin to get a better idea of how these sites may differ and how those differences may impact how plants grow there, specifically trees. The higher elevation site is colder and sees more precipitation in the form of snow, limiting tree growth. Students will also begin to investigate how elevation impacts climate. Higher elevation sites will be colder and have snow on them longer. Students will be able to see how sites throughout the world at high elevations have either no trees or very low trees and shrubs. They can connect this to the temperature and precipitation and also consider thinking about other conditions that may impact plant growth at high elevations (such as strong winds).

Activities	Rationale
Hopefully a student brought up weather/climate/precipitation and you can engage this line of inquiry, giving students agency. Tell students that there is data they may dig into to investigate their ideas. Provide students with data tables on precipitation and temperature for each site (these are also accessible in the excel document found with the lesson resources). There are also blank graphs available. Have students graph the data. Use the attached Walter-Lieth guide to assist in both yours and students understanding of these diagrams.	Students are provided with an opportunity to make sense of climate data provided to them. Hopefully students will notice that the lower elevation, subalpine site that has trees has generally warmer temperatures and less precipitation than the higher elevation site. Using this as evidence, students may begin making connections to why one site has trees and the other does not.
When finished graphing, have students compare the data from both sites. Pose the questions: "What do the patterns of temperature and precipitation data tell us about these two locations? How might this weather affect the plant life?" Student claims must be backed by evidence. Have students discuss their claims and justifications in pairs or groups of three. Have them pay particular attention to any difference sin their arguments/claims. They all used the same data so why may there be differences? See these discussion prompts for students to use while talking about data.	Students have the opportunity now to both compare their claims to peers and to practice justifying their claims with evidence. Students should be using information from the graph and data tables to show how the alpine site is colder and receives more precipitation. This may get students to start thinking about how trees may not be able to deal with colder temperatures or the amount of precipitation, especially in the form of snow.
When students are done sharing, transition the conversation to elevation (hopefully students brought this up or this was a previous	This activity brings in another set of evidence that students will need to incorporate into their claims. The data shows that

question/observation). Note again the difference in elevation between the two locations. Tell students they will be able to analyze another data set on [temperature and elevation](). Once again, have students observe either the visual or the data table. Have students adjust or revise their previous claims based on new evidence. Students should also be encouraged to discuss new patterns they observe in this data.	temperature decreases with elevation, further clarifying an observation students may have had in the previous activity. This provides additional evidence students can use to reinforce previous claims. If they did not pick up on the connection between temperature and elevation, this gives an opportunity for students to revise claims in light of the new evidence, a valuable skill.
It should be clear to students that elevation plays a role in vegetative growth through temperature. However, there are still many unexplained factors. Now, have students re-engage the gVeg platform. Using the filter setting on gVeg, set the elevation from 3000 m to 4500 m (see [this picture]() for guidance). You may do this in front of the whole class or have students explore themselves. Allow students to view other sites in this elevation range Have them note similarities and differences to the Wyoming sites. Prompt students to think about why these patterns exist and what other factors may be causing them.	This piece of the activity allows students to get a sense of regional and global patterns of elevation and the presence of trees. Students may use this with the previous evidence on temperature, elevation, and precipitation and solidify some of their claims. It may also open up new questions of inconsistencies in the patterns of tree lines. Students will hopefully begin to generate more questions that provide the foundation for future investigations.
In ending, return to the original phenomenon question on why the trees stop at a certain point on mountains. Determine whether students identified anything they think answers the original question. Also record any new questions or lines of inquiry that students now have.	This provides a natural checkpoint that allows you to determine what students have taken from this activity. Hopefully students have a pretty good idea that colder temperatures, more snow, and high elevation impacts the presence of trees. However, this is not the whole story. If students begin discussing tree characteristics, traits, adaptations, or anything related to plant structure, you may continue with [Lesson B]()

Lesson B

*Note: Part of this lesson requires some familiarity with the concept of natural selection. If not, parts can be used to introduce natural selection.

Below are the Performance Expectations, Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas present in this lesson. The color coding is in line with the Next Generation Science Standards (NGSS). The color coding is consistent throughout the document, reflecting where each of the three dimensions are present.

Performance Expectations	MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
Science and Engineering Practices	Engaging in Argument From Evidence: *Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.* Analyzing & Interpreting Data: *Analyze and interpret data to provide evidence for phenomena.*
Crosscutting Concepts	Cause & Effect: *Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.* Patterns: *Patterns can be used to identify cause-and-effect relationships.*
Disciplinary Core Ideas	Interdependent Relationships in Ecosystems: *Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.* Adaptation: *Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common.*

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Lesson Progression

This lesson involves students considering the adaptations and traits plants would need to survive in various conditions, especially at subalpine and alpine elevations. Students will design their own plants that must survive in an alpine environment, thinking through both real and fictitious traits. They will then test these plants out in a simulation like game, having to justify why their plant may survive and why their classmates' plants may not. Finally, students conduct some research on different life zones, participating in a jigsaw that enables them to observe actual plant traits and adaptations.

Activities	Rationale
Open class by having students consider the four seasons. Have them either write or draw a picture for what they would look like if they went outside in each season. You may use this seasons_template for some extra structure.	This opening activity allows students to start thinking about the various conditions living things face in different weather conditions. By thinking about their own experience in the four seasons, it will serve as a connection to when they think about the traits plants must have to survive.
Now, ask students what plants would in the same situations. Have them pick a tree, flower, or other plant. Have students write or draw what this plant is doing in those seasons as well. Have students reflect on the previous activity. You may ask questions such as: • How do the plants deal with changing weather conditions? • How is this different than how you deal with changing weather conditions? • How do you think this affects the way plants look? Introduce a guiding question of "How does the environment affect an organism's traits?" Allow students to discuss this question with a partner.	Now, students can consider plants during these same seasons. Students may start to come to the realization that plants cannot put on a rain jacket, hat, gloves, etc. Plants must have certain features that allow them to survive while they stay in place. These adaptations can be structural (short stature, large roots, etc.) or behavioral (dropping leaves in winter). This guiding question gets students thinking about how the environment will determine an organisms' traits, because if an organism lacks certain traits, it will die.
Show the alpine picture from gVeg again (Photo 2 - Alpine: Elevation 11,063 ft). If you have gone through Lesson_A with your students, you may even bring in the temperature and precipitation data_tables again. Provide students with the seasons_graphic_organizer. Ask "What kind of weather conditions may organisms find up here? Consider all the seasons and factors including wind, sun, snow, etc.	This activity gets students to think specifically about the alpine location, where conditions are the most harsh and trees do not grow. Students can begin thinking about the conditions that exist up here and what plants would need to be able to survive. Later on, you may have students reflect back on this activity and think about the traits they described

How do you think plants can survive up there?" Students should fill out the graphic organizer, describing weather conditions for each season along with traits they think plants should have in those conditions. Give students about five-ten minutes to do this and then share with a partner.	and if they apply to trees. This activity is not looking for perfect answers from students but continues to assess what they think and already know.
Design a Plant: Provide students with space to draw (if you have access to supplies for a 3D model like clay or paper mache, that can also be an option). Tell students that they need to make a plant that must survive in the environment of the second picture (alpine). They will have time to design a plant that can withstand the harsh conditions throughout the year. Give as much time as you see fit. Plant traits can be realistic or fictitious. Let them have some fun! Let students know that they will have to justify their decisions.	This activity allows students to engage their more creative side while also continuing to investigate student ideas of alpine weather conditions and the adaptations plants must have in order to survive. Students can also begin to think about how these traits may relate to each other, building a more cohesive and connected picture of plant adaptation.
Put the Plants to the Test: Organize students into pairs. Tell them their plants will be put to the test in different scenarios. When given a scenario, students must defend to their group why their plant will survive or not. They must discuss how specific adaptations cause survival. Their classmates may also comment on whether they agree or not. A model_test_procedure is linked.	Now, students will show how well they can relate their given adaptations to the various weather conditions their plants may encounter. This activity provides students with practice in using evidence to justify their claims along with evaluating the claims of their classmates. There is a rich opportunity from students to learn from each other and to view other ways of thinking.
Explore Plants and Life Zones: Following the last activity suggest to students that alpine environments are not the only habitats on mountains. Ask students to consider other habitats/vegetation patterns they may see on or around a mountain (you may choose to re-engage with gVeg here by allowing students to explore or use gVeg in front of the class). After gathering some answers, show students the Life_Zone_Diagram. Ask them to consider why they think mountains have different life zones.	This begins to introduce the idea that mountains have a variety of different environments present on them. Students just spent a good amount of time thinking of the harshness of the alpine environment and the limiting factors to life there, which may explain once piece of the phenomenon of why trees do not grow up there. However, equally important is why trees *do* grow at lower elevations. This activity begins that investigation.
Students are now tasked with exploring a life zone. Assign each student to a different life zone (students will work independently but then come together). Direct them to this website courtesy of	Students can now compare their thoughts and explanations from the previous activities to external data. They may confirm some of the things they stated before while also

Shelledy Elementary. You also use either this site or this site on plant adaptations. Both sites will have connections to the Rocky Mountain Region. Students should research the following information on their assigned life zone: • How it changes through the seasons • Unique challenges to living there • At least three plants that live there • At least two adaptations organisms have to living there (one plant, one other animal of the individual's choosing) • What plants would *not* survive here? Why would they not survive?	investigate some new ideas. By splitting up students in covering different life zones, it extends the idea of adaptation beyond the harsh alpine conditions they have been discussing and gets at the idea that all plants have adaptations to whatever conditions they live in.
Bring students come together in groups of similar life zones. Students will compare the data and their interpretations. Students collaborate to make a poster/visual to display the information they researched. In doing so, have students identify any patterns they see amongst the adaptations in their group. Students should describe that pattern on the visual.	This activity serves two purposes. One, it allows students to compare their work to their peers. This may validate some of their ideas, lead them to new questions or understandings, and also provide a chance to revise their own thinking or challenge others. They all looked at similar resources but now have a chance to see how peers may have interpreted the same work. The gallery walk also allows for all students to get a feel for each of the life zones instead of just the one they researched.
Gallery Walk: Group visuals are displayed throughout the room. Students will record information from their peers work. You may use the graphic organizer provided.	By recording information, students are continuing to gather evidence on plant traits and particular environments.
Revise Their Plants: Students return to the plants they created before. Now that they have surveyed adaptations to a variety of habitats, students have time to make adjustments to their plants to increase survival.	Students now have the opportunity to use new evidence to make revisions to their previous work. Using evidence to revise thinking is an important process for students to work on.
Plant Survival Game: Use the model test procedure from earlier in the lesson. Students re-engage with their revised plants. Have either a blank whiteboard/poster/open space at the front of the room. Each students' plant is represented on the space (either a colorful dot,	Once again, students have the opportunity to justify their decisions in designing a plant and its survival in various environmental situations. This time, there are stakes and results that students can visualize. Over time, students should

number, or small picture will suffice). This time, if a students' plant survives a scenario, they "reproduce"; their population on the space doubles. With each scenario their population may grow. After several rounds, students can begin to see patterns of the plants that survive and plants that do not.	see that the hardiest plants will survive while the other plants will die out. This is akin to the process of natural selection, where the organisms with favorable traits will survive while others will not.
After the activity, have students reflect on which plants are most represented on the board. Students may share out some of the adaptations to those plants. Ask students to explain why certain plants were most represented and what would happen over long periods of time if the trends in the scenario continue. Prompt them to draw conclusions to natural selection. Evidence from the activity and the research earlier can be used.	This discussion provides the opportunity for students to explore the ideas from this activity. It also invites for a further discussion and exploration into ideas of natural selection. While gVeg does not directly support this, it may be a good transition.
Finally, circle back to the phenomenon question on treeline again. Determine if students can add on to their previous answers or if they have any new questions or lines of inquiry to explore.	By bringing it back to the phenomenon, students can begin to use their understandings from this activity to clarify their explanations. Through an investigation on other plant traits and intersections with the environment, students should begin drawing connections between the traits trees must have to survive at higher elevations. They should have also been able to see some of the traits alpine plants have and may observe that trees do not share some of those traits. This also can serve as a way to investigate new ideas, questions, or explanations. If you have also completed Lesson A with students, you may choose to use Lesson C.

Lesson C

Below are the Performance Expectations, Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas present in this lesson. The color coding is in line with the Next Generation Science Standards (NGSS). The color coding is consistent throughout the document, reflecting where each of the three dimensions are present.

Performance Expectations	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Science and Engineering Practices	**Engaging in Argument From Evidence:** *Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.* **Analyzing & Interpreting Data:** *Analyze and interpret data to provide evidence for phenomena. Use graphical displays of large data sets to identify temporal and spatial relationships.*
Crosscutting Concepts	**Cause & Effect:** *Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.* **Patterns:** *Graphs, charts, and images can be used to identify patterns in data. Patterns can be used to identify cause-and-effect relationships.*
Disciplinary Core Ideas	**Interdependent Relationships in Ecosystems:** *Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.* **Ecosystem Dynamics, Function, and Resilience:** *Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.* **Humans and Biodiversity** *Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on— for example, water purification and recycling.*

Lesson Progression

This lesson involves a combination of concepts from Lesson A and Lesson B. It begins by looking at a trend of mountain species and climate change, where warming temperatures allow lower-dwelling species to move up mountains. Eventually, species living near the top of mountains are outcompeted and threatened with extinction. Students investigate this idea and back it up with climate data from gVeg. They compare recent climate data to the historic data they analyzed in Lesson A. Following that analysis, they use their knowledge of life zones from Lesson B to sketch out how life zones on mountains may change with 100 years of continuing climate change. Students can think dynamically about how treeline may change with a changing climate as well.

Activities	Rationale
Open by reframing the phenomenon question, potentially showing the Phenomenon Pictures. Provide a new question: “What do you think will happen to the trees if the climate continues to warm?” Have students generate ideas and questions.	This gets students thinking in alignment with the goal of this activity. It also allows students to consider the idea that maybe treeline is not permanent and is something that can change with time and new circumstances.
Introduce the Escalator to Extinction diagram. This is from a study in Peru. Explain that the left side shows bird data collected in 1985 for the Common Scale-backed antbird (light green), the Versicolored Barbet (yellow) and the Variable Antshrike (blue). The population was sampled at different elevations on a mountain. Ask students “Why do you think these populations and ranges changed between 1985 and 2017? What may have changed on the Earth since then?”	This diagram illustrates well the idea that as the climate changes and gets warmer, species tend to move up mountains, pushing the species at the top to extinction. Student shoulder generate ideas on why this has happened, hopefully honing in that since 1985, global temperatures would have risen, leading to increased temperature and perhaps changes in precipitation (drought, less snow, more rain than snow).
Allow students to share and compare answers with a partner. Explain that this trend may be found in plant species on mountains as well and will continue as the climate continues to change and warm.	Students have the chance to voice their opinion and also compare their answers to a peer’s, perhaps learning or considering a different explanation.
Return back to the photos on gVeg: Photo 1- Subalpine: Elevation 10,210 ft; Photo 2 - Alpine: Elevation 11,063 ft.. Students looked at historic climate data in Lesson A (1961-2009). Now they will compare that to data from 2010-2018. You may have them look at the recent data tables or compare the recent Walter Lieth diagrams (information can be found here or on excel sheet). Prompt students to think about the major differences and patterns in the climate data	This activity provides an opportunity for students to explain through data how climate has changed in Wyoming over the last several decades. Instead of just speaking about climate change, students can see the numerical backing, especially in terms of rising temperatures and changes in precipitation.

and how it has shifted. You may choose to have students share with a partner or in small groups once they have analyzed the data.	
Provide students with two copies of the blank mountain diagram. You may also have them draw two blank triangles. Explain that students will be drawing the life zones for the mountains covered by the gVeg photos (Wind River Mountains). Show or hand out the Life Zone Diagram for a refresher. For the first one, they will shade in the alpine, subalpine, montane forest, foothills, and deserts/grasslands. The first should have relatively equal shading.	Students now have the opportunity to visually represent the life zones on a mountain. This sets up for the next activity in which they will determine how these will change with changing climate over the next 100 years.
For the second diagram, have students imagine that 100 years have passed and the trends that they observed in the data has continued. What effects would this have on the life zones? Have students predict what the zones would look like in 100 years. They can refer to the evidence from previous classes to determine how plant communities might adapt. See this example for an idea of what students should be aiming for.	Students should be able to show on the second diagram that the life zones would move up, potentially showing that the alpine or even subalpine were much smaller or ceased to exist. This connects ideas from this lesson (data backing up climate change), life zones, and plant adaptations. This also begins to connect in to the human role in climate change and protecting certain ecosystems.
Have students pair up. Students share their diagrams. One partner asks questions and critiques the other's diagram. The other partner must defend their rationale, using evidence from the climate change data and research on plant adaptations/life zones from the previous class.	Through this process, students can have practice defending their own arguments using evidence while also critiquing another individuals argument. Students have a wealth of evidence to choose from to support their decisions.
Students now have the opportunity to dig into climate change here. First, ask students to think about how the loss of alpine environments may impact humans. After brainstorming, give students time to investigate these impacts. Some resources are provided below: Threats to Alpine Nature Climate Change in Wyoming	Students can now compare their own thoughts and findings to research being done in the scientific world, especially relevant to Wyoming and other alpine environments. While students may see themselves as separate and disconnected from alpine environments, this research shows that there are important connections to the alpine and that their loss would impact the state, especially in terms of water availability. This process enables students to see the interdependent nature of humans with the ecosystems surrounding them.

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Wyoming Grassland and Tundra Threats Rocky Mountain Climate Change Climate Change in Alps	
After research, tell students that they will oversee the protection of the alpine and subalpine environments in the Wind River Mountains (or if relevant, closer mountain range to the school) for the next 50-100 years. Based on what you have discussed and researched, what would their plan be? What could they do to protect these life zones? How will this preserve certain human resources/activities? Why do they think this is important?	Students can now take this research and consider what humans can do to alter it. While things are not always trending in a positive direction, it is important for students that change to mitigate human impacts and the effects of climate change are possible.
In pairs or small groups, have students compare their plans. Have them reflect on the variety of answers given a similar prompt. Students may have the opportunity to critique and ask questions of each others plans. Give students the options to revise their plans in lieu of feedback or to combine their plan with a classmate's To extend this activity, have students present their plans to the class.	This is another chance for students to justify and defend their own work while evaluating a peer's work. They will be able to learn form each other while also practicing using evidence to back their work.
Finally, connect back to the original phenomenon. See if students have refined their answers or come up with any new questions. Have students make predictions as to what will happen to the treeline as the climate continues to warm and change. They can use all relevant information from previous lessons.	At this point, hopefully students should have a pretty good idea of what is responsible for treeline. A combination of weather conditions (trees cannot tolerate extremely lower temperatures or certain levels of snow), adaptations (trees lack some of the hardier adaptations that other alpine plants have, including ways to retain water and grow low), and climate change (warmer temperatures may be pushing trees up the mountain, potentially resulting in a world where there is no treeline). Students may have some of these understandings but not all of them. Depending on where students still have questions or misconceptions, you may choose to continue exploring these ideas.

Resources

Phenomenon Pictures

Wind River Range, Wyoming
Image credit: https://www.americansouthwest.net/wyoming/wind-river-range/index.html

Sheep Mountain, Wyoming
Image credit: https://en.wikipedia.org/wiki/Sheep_Mountain_(Teton_County,_Wyoming)

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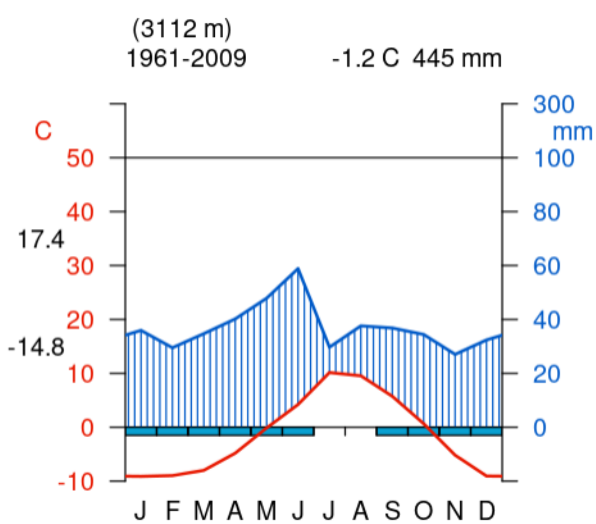
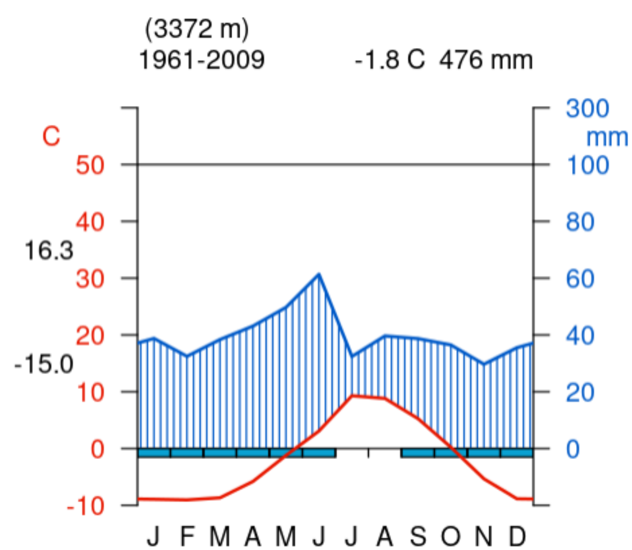
Temperature and Precipitation Data Tables: 1961-2009

All data collected between the years 1961-2009								
Photo 1 (Subalpine)	Month	Temperature (°C)	Precipitation (mm)		Photo 2 (Alpine)	Month	Temperature (°C)	Precipitation (mm)
	J	-10	35			J	-10	40
	F	-9	30			F	-10	35
	M	-8	33			M	-9	40
	A	-5	40			A	-6	43
	M	0	50			M	-2	53
	J	4	55			J	3	61
	J	10	28			J	9	32
	A	8	38			A	8	40
	S	6	36			S	6	38
	O	2	35			O	1	37
	N	-4	25			N	-5	30
	D	-10	35			D	-10	37

Walter Lieth Diagrams (1961-2009)





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Student Data Discussion Prompts

The data for the subalpine site showed me that the weather there is [insert claim]. I know this because [insert evidence].

The data for the alpine site showed me that the weather there is [insert claim]. I know this because [insert evidence].

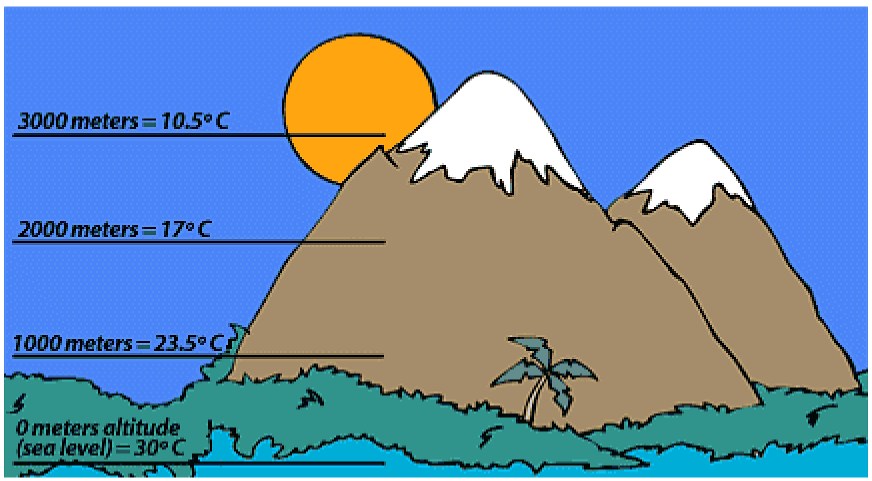
Some patterns I saw in the data were [insert evidence].

The two sites were similar because [insert claim]. I know this because [insert evidence].

The two sites were different because [insert claim]. I know this because [insert evidence].

The weather may impact the plant life there by [insert claim]. I think this because [insert evidence].

Elevation and Temperature



Standard Atmosphere			
Altitude (ft)	Pressure (Hg)	Temperature (°C)	Temperature (°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	-0.9	30.5
9,000	21.38	-2.8	26.9
10,000	20.57	-4.8	23.3
11,000	19.79	-6.8	19.8
12,000	19.02	-8.8	16.2
13,000	18.29	-10.8	12.6
14,000	17.57	-12.7	9.1
15,000	16.88	-14.7	5.5
16,000	16.21	-16.7	1.9
17,000	15.56	-18.7	-1.6
18,000	14.94	-20.7	-5.2
19,000	14.33	-22.6	-8.8
20,000	13.74	-24.6	-12.3

Figure 4-3. *Properties of standard atmosphere.*

Image credit: https://scied.ucar.edu/learning-zone/atmosphere/change-atmosphere-altitude

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Elevation Filter

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Seasons Template

Image credit: https://inflammatoryboweldisease.net/living/change-seasons-ibd

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Seasons Graphic Organizer

Season	What do you think the conditions are like?	What types of traits would plants need to have to live there?
Fall		
Winter		
Spring		
Summer		

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Putting Plants to the Test Activity

Step 1: Read the weather scenario
Step 2: Student 1 has one minute to explain why their plant will survive.
Step 3: Student 2 has 30 seconds to explain whether they agree or not
Step 4: If Student 2 disagrees, Student 1 has 30 seconds for rebuttal
Step 5: Repeat Steps 2-4 but reverse roles.

This can continue for several scenarios. Some options for weather scenarios are given below:

- A late fall storm brings winds over 80 mph
- During a dry summer, no rain falls for three weeks and the sun hits plants for nearly 16 hours per day!
- An early snowstorm drops four feet of snow at once!
- Winter temperatures drop below -20°F

Life Zone Diagram

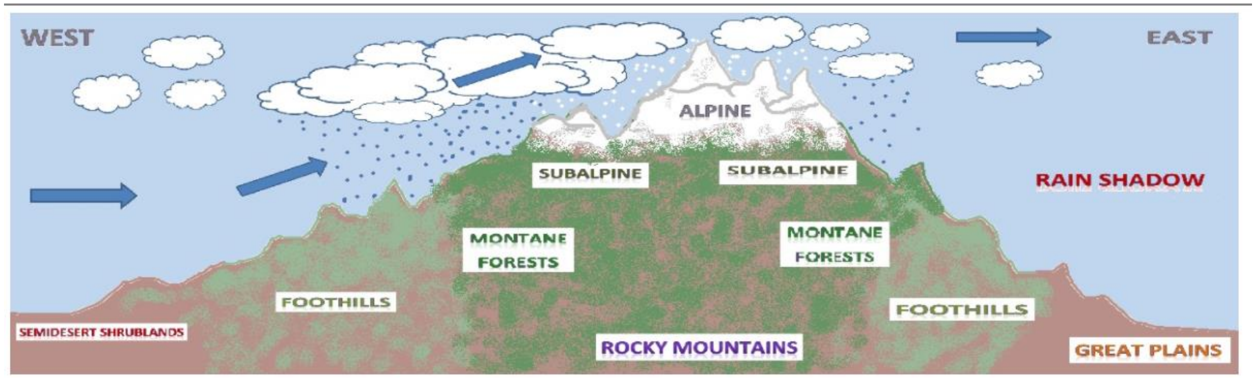

Image credit: https://shelledy.d51schools.org/cms/One.aspx?portalId=29651893&pageId=30065499

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Gallery Walk Graphic Organizer

Life Zone	Challenges to Living in this Life Zone	A Plant that Lives Here	What Adaptation(s) do plants have to surviving in this Life Zone?
Desert Canyonlands/Shrublands			
Great Plains/Grasslands			
Foothills			
Montane Forests			

Subalpine			
Alpine			

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Escalator to Extinction

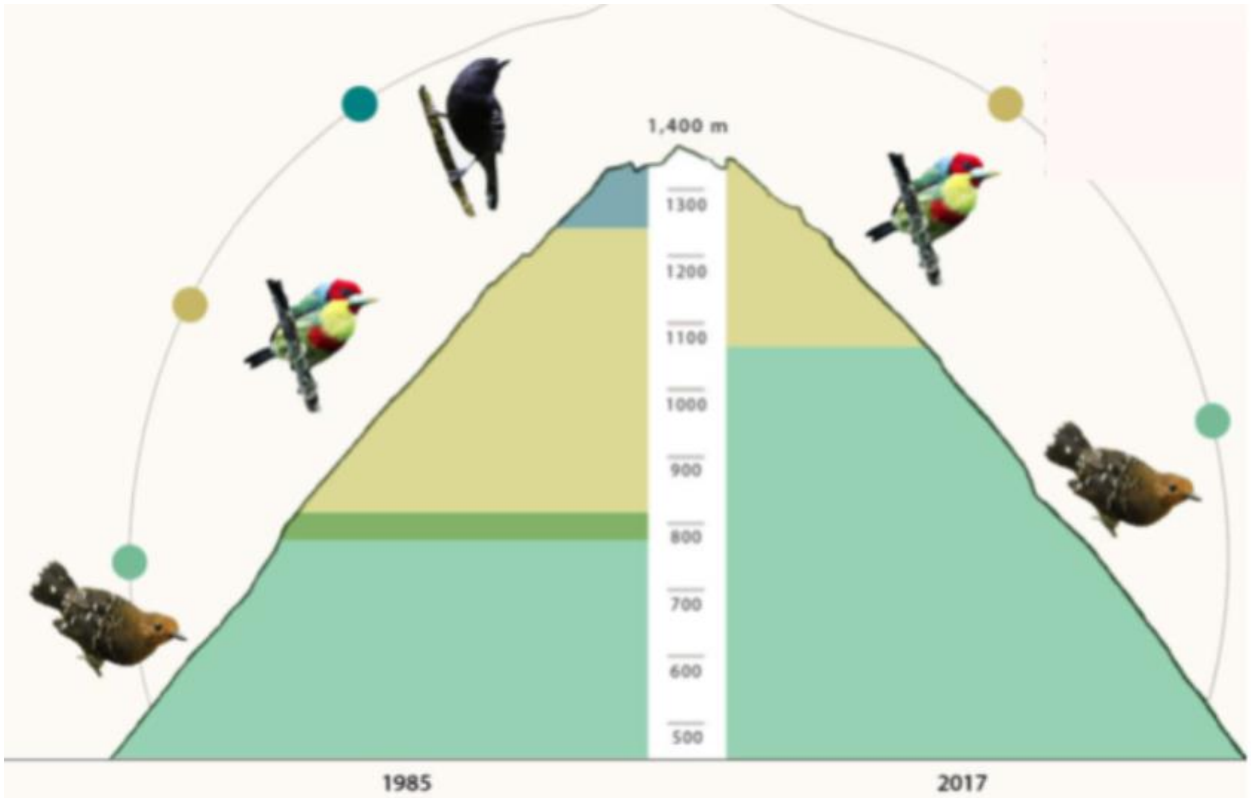

Image credit: https://e360.yale.edu/features/escalator-to-extinction-can-mountain-species-adapt-to-climate-change

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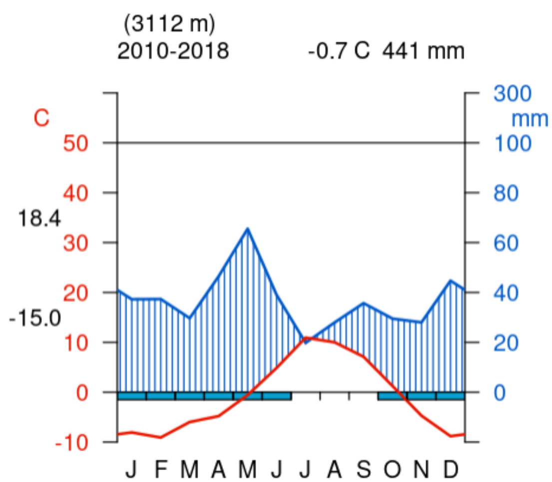
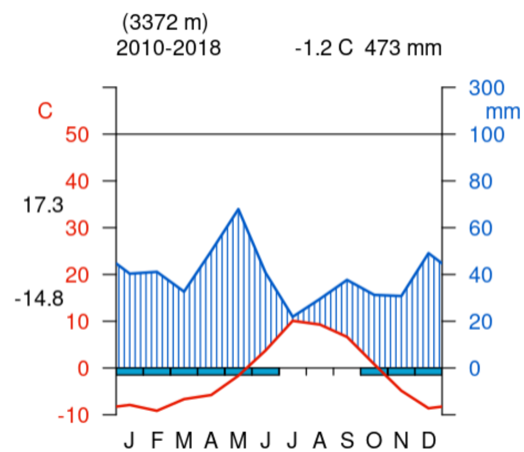
Temperature and Precipitation Data Tables: 2010-2018

All data collected between the years 2010-2018								
Photo 1 (Subalpine)	Month	Temperature (°C)	Precipitation (mm)		Photo 2 (Alpine)	Month	Temperature (°C)	Precipitation (mm)
	J	-8	38			J	-8	40
	F	-10	38			F	-9	41
	M	-6	30			M	-7	35
	A	-5	45			A	-6	50
	M	-1	67			M	-3	70
	J	5	40			J	4	40
	J	11	20			J	10	22
	A	10	30			A	9	30
	S	8	37			S	7	38
	O	4	30			O	1	32
	N	-5	28			N	-5	30
	D	-9	45			D	-8	50

Walter Lieth Recent





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Blank Mountain Diagram

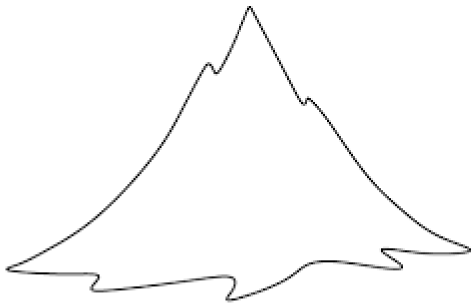

Image credit: https://patternuniverse.com/download/mountain-pattern/

Example Mountain Diagrams

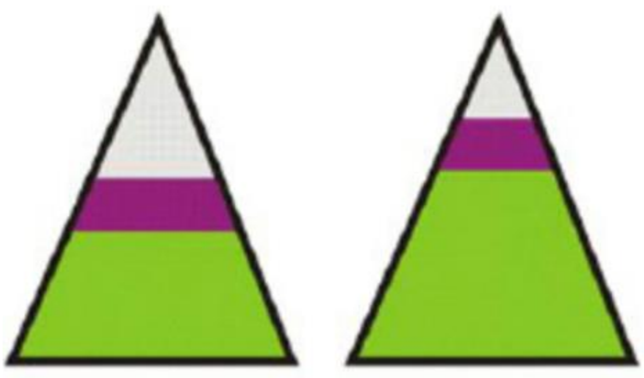

Image credit: https://www.researchgate.net/figure/Schematic-illustration-of-vegetation-zones-on-a-mountain-determined-by-an-elevation_fig3_291165203

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