# Hawai'i Physical Geography: Biogeography - Treelines and Plant Succession

ⓘ This is a preview of the published version of the quiz

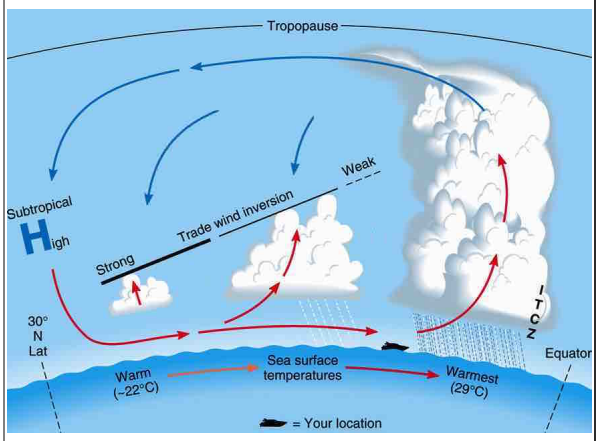
Started: May 18 at 1:56pm

## Quiz Instructions

BEFORE YOU START, A WARNING ON DIFFICULTY AND TIME: This lab has complicated questions, especially the first one on treeline. The questions are time consuming. Like much in science, it involves gathering data, compiling data and analyzing data. The questions also involve interpretations. Rather than "dumb down" the material, we simply want to **remind you that not doing this lab will NOT HURT YOUR GRADE, and that getting an incorrect answer will NOT HURT YOUR GRADE**. An important aspect of point accrual grading is to encourage students to challenge themselves to do more difficult work, but with no risk of harming their grade. So please, give these a try. They are definitely 100-level concepts and material, but you'll need time.

WHY COMBINE THESE TOPICS: Biogeography is a core aspect of physical geography. Understanding how and why plants and animals are distributed across Earth is vitally important. The distinctive treelines of the Big island and the topic of Primary Plant Succession are classic themes in biogeography. So we combine them into one lab.

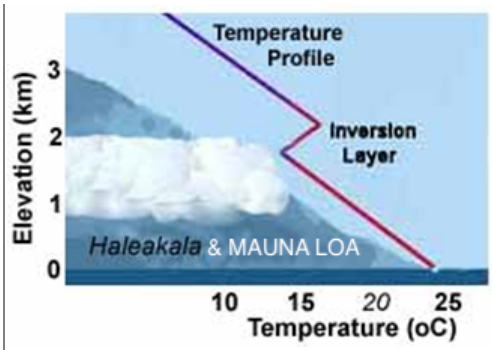
BACKGROUND ON TRADE WIND INVERSIONS AND HAWAI'I TREELINE:

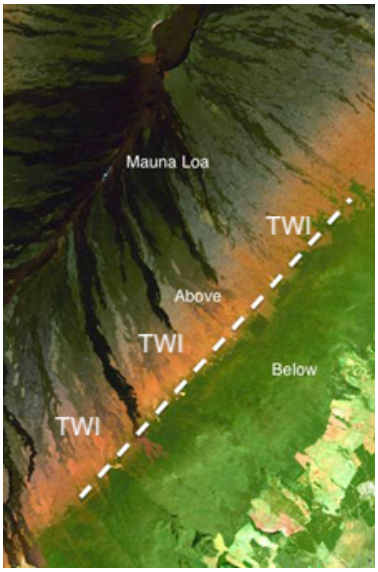
| | |
|---|---|
| The image to the right shows the latitudes between the equator and just north of Hawaii at the subtropical high (on the right). Hawaii is between. All of the basic presentations about the Earth's general circulation systems show this circulation cell (trade winds converge on the equator as the red lines and then return as the dark blue line to the subtropical high) called the Hadley Cell.<br><br>However, reality is more complicated. The air starts to descend in the latitudes of Hawaii, but it just down not reach the surface. It typically reaches an elevation that ranges from 1800 to 2400 meters (6000 to 8000 feet). Then, this descending air creates a **TRADE WIND INVERSION.** |  |
| What is the significance of the trade wind inversion? An inversion is where temperature begins to increase with elevation. The normal condition is the reverse, and that's why its called an "inversion". Increases in temperature with height is not at all conducive to rainfall. The moist-warm trade winds reach this inversion, and the clouds evaporate as the air warms up (as the air is pushed up slope). Thus, forests stop suddenly, and the vegetation comes scrub and then | |

quickly desert-like, because of the great reduction in rainfall.

The upper right image shows the Trade Wind Inversion's influence on the temperature with height, in this diagram over volcanoes like Mauna Loa (& Haleakala(=). What this means is that the orographic effect of cloud formation and the associated rainfall is often STOPPED at the Trade Wind Inversion, capping any clouds or precipitation that would occur.

This is the reason why the upper treeline can be so straight on the Big Island - like the lower right Landsat Image of Mauna Loa. The Trade Wind Inversion caps rainfall and the rainforest.




QUESTION ON THE UPPER HAWAI'I TREELINE

In the geovisualization, using the Landsat composite overlay, you will be directed to specific locations in the video game. These locations are near the boundary between the dark green and the brown above. The dark green is forest. The dark brown is a mix of shrubs and dwarf trees, and above that is just shrubs. This change from forest to non-forest above is called the treeline. In this case, it coincides with the trade wind inversion.

**EXAMPLE QUESTION**

1. **Fast travel to the locations below. What is the mean and range elevation for the treeline formed by the trade wind inversion?**
2. **Observe the mean annual precipitation (MAP) at this elevation. Round off to the nearest 100.**
3. **Move your character to an elevation 500 m above the treeline locations. How much has the average precipitation declined from the treeline? Round off to the nearest 100.**

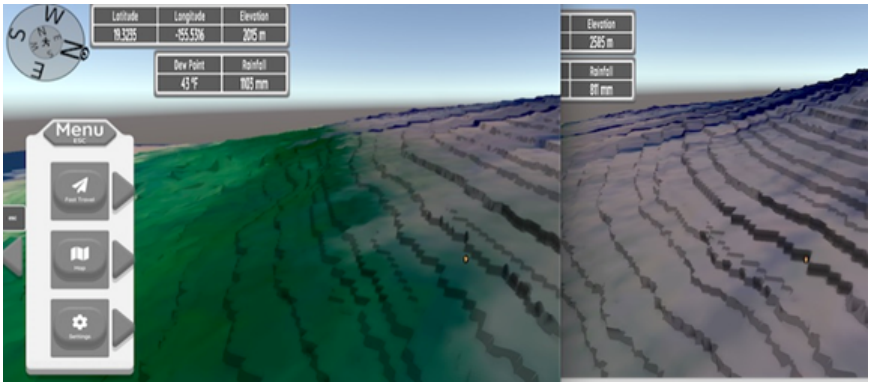
This is a video that walks you through how to answer this complicated question, made by a former student. He refers to the question as A5 (but that is an old designation).

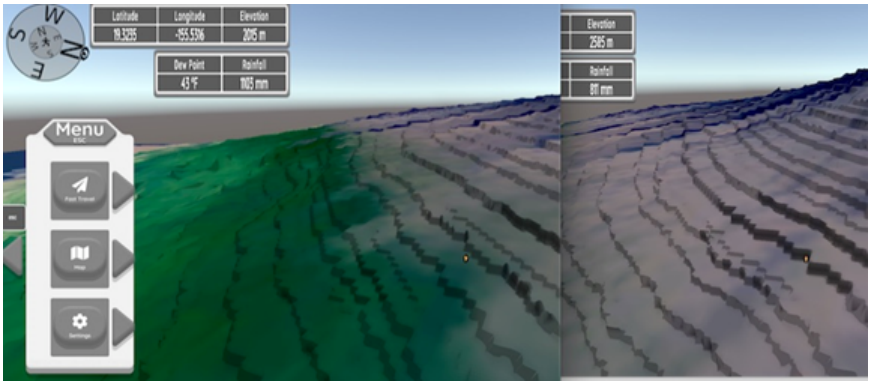
GPH 112 Hawaii Physical Geography Question on Treeline

There will be a complication -- that lava flows have periodically wiped out the vegetation, and then the trees gradually re-establish themselves. Thus, you are to walk to the highest dark green nearby. Write down the elevation, and also switch to precipitation and write down those values.

Then, have your avatar travel directly upslope of this treeline about 500 m higher and write down the mean annual precipitation (MAP 500m+). Then, calculate an average (mean) and range of all data you collected

These are some examples of some of the coordinates. You can see the treeline and the 500m above the treeline.



| Lat/Long | Treeline Elevation (m) | MAP- at treeline (mm) | Elev 500 m higher | MAP 500 m higher |
|---|---|---|---|---|
| 19.3766 -155.4776 | 1900 | 1200 | 2400 | 900 |
| 19.3772 -155.4928 | 2100 | 1100 | 2600 | 800 |
| 19.3171 -155.5243 | 2000 | 1100 | 2500 | 800 |
| 19.2965 -155.5378 | 2000 | 1100 | 2500 | 800 |
| 19.2686 -155.5672 | 2000 | 1100 | 2500 | 800 |
| Average | 2000 | 1120 | 2500 | 820 |
| Average rounded off to nearest 100 | 2000 | 1100 | 2500 | 800 |
| Range | 1900-2100 | 1100-1200 | 2400-2600 | 800-900 |

**ANSWER:**

The treeline closest to the indicated coordinates averages 2000 m (range 1900-2000 mm) with a mean annual precipitation averaging 1900 mm (range 1750-2100). The precipitation drops off by an average of 300 mm just 500 meters upslope from treeline.

*HINT: What you interpret as the treeline location will be a little bit different from someone else (like the person making this key). This is the reality of science. Even if you were in the field, looking at the treeline, it would be hard for 10 scientists to agree on the precise location. This is because trees become more scattered at treeline. However, when you average five measurements together, and then when you round off that average to the nearest 100 –* ***simply pick the answer that is closest to what you observed and calculated. The incorrect answers will have some piece of information that is quite far off making it obviously incorrect in this 100-level course.***

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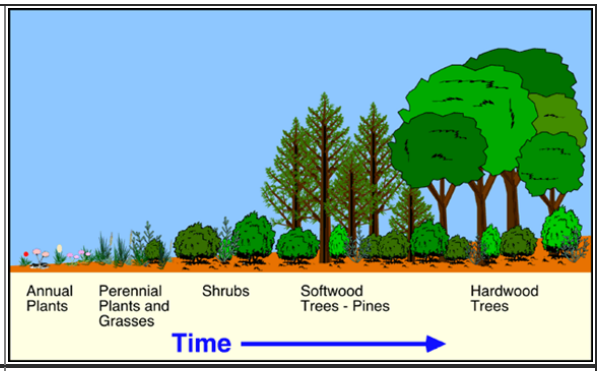
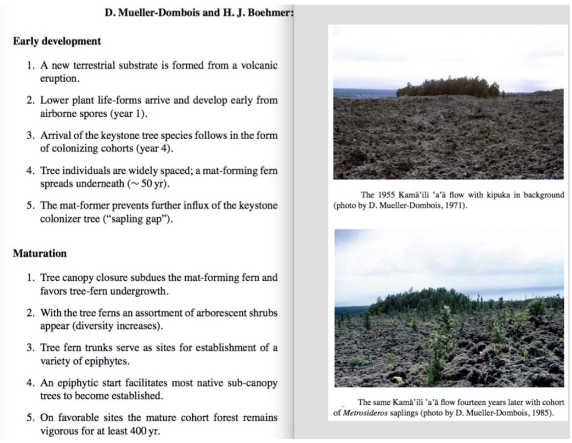
BACKGROUND ON PIONEER PLANT SUCCESSION:

One of the most important basic concepts in the biogeography part of physical geography is **plant succession**. The basic idea of plant succession is that a mature vegetation group of plants will get disturbed by processes such as forest fires, bulldozers, and even lava flows. Then, after the disturbance, a series of changes over time take place. This is a very common type of diagram for the eastern United States:



D. Mueller-Dombois and H. J. Boehmer:

**Early development**

1. A new terrestrial substrate is formed from a volcanic eruption.
2. Lower plant life-forms arrive and develop early from airborne spores (year 1).
3. Arrival of the keystone tree species follows in the form of colonizing cohorts (year 4).
4. Tree individuals are widely spaced; a mat-forming fern spreads underneath (~ 50 yr).
5. The mat-former prevents further influx of the keystone colonizer tree ("sapling gap").

**Maturation**

1. Tree canopy closure subdues the mat-forming fern and favors tree-fern undergrowth.
2. With the tree ferns an assortment of arborescent shrubs appear (diversity increases).
3. Tree fern trunks serve as sites for establishment of a variety of epiphytes.
4. An epiphytic start facilitates most native sub-canopy trees to become established.
5. On favorable sites the mature cohort forest remains vigorous for at least 400 yr.

The 1955 Kamā'ili 'a'ā flow with kipuka in background (photo by D. Mueller-Dombois, 1971).

The same Kamā'ili 'a'ā flow fourteen years later with cohort of *Metrosideros* saplings (photo by D. Mueller-Dombois, 1985).

However, plant distributions after a disturbance varies by location, and is heavily influenced by climate. The Big Island is a wonderful place to understand plant succession and how long it takes, because the ages of the lava flows are known using radiocarbon dating.

A classic study of plant succession by Mueller, Dombois and Boehmer studied lava flows on the east-facing windward side of the Big Island. This is where the tradewinds are uplifted orographiclly and the rain is abundant. The adjacent graphic is a series of screenshots from their paper with their basic conclusions that the transition from a new lava flow to a tropical rainforest occurs by 400 years.

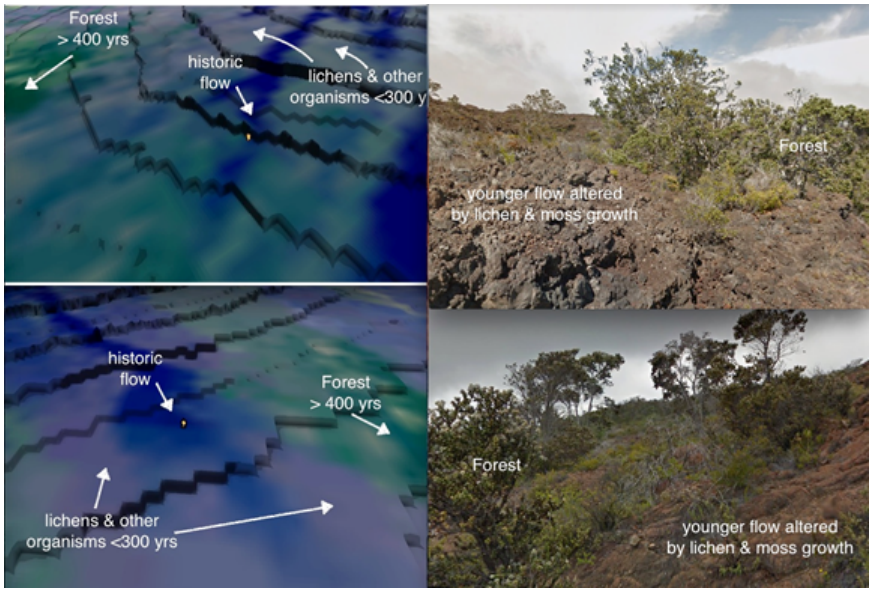
Generally, stages 2-4 in the "Early Development" phase can be described in the pictures on the right side of the image below. Organisms like lichens, mosses, fungi, ferns and bryophytes start to cover the lava flow surfaces, but

the flow surfaces are still very noticeable.

Then, in about 50 years, trees start to come in and the density of trees continues to increase until the lava flow is covered with a tropical rainforest by about 400 years. **Thus, there are three general stages:**

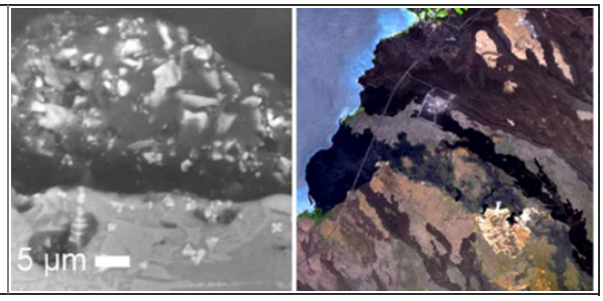
1. New lava flows remove past vegetation
2. Lichens and other epilithic (rock surface) organisms cover the surface
3. Forest takes over

The geovisualization shows the basic changes from this study. The screenshots of the geovisualization at different places are compared to what is seen on the ground. Take note of how these succession changes look on the windward (trade wind facing east side) side of the Big Island, because you will be answering a matching question on this.




The rainshadow side of the Big Island also has plant succession, but it is much slower. It takes over 10,000 years to go from a fresh lava flow to the end-vegetation type of desert scrub and small trees some times called kiawe (or the tree of life in its native South America).

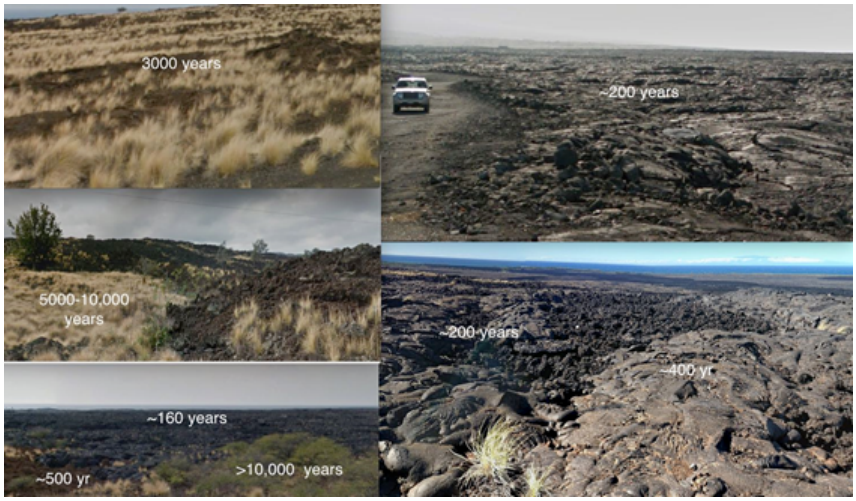
**The first step** you can see in the geovisualization is still fresh lava (0-400 years).

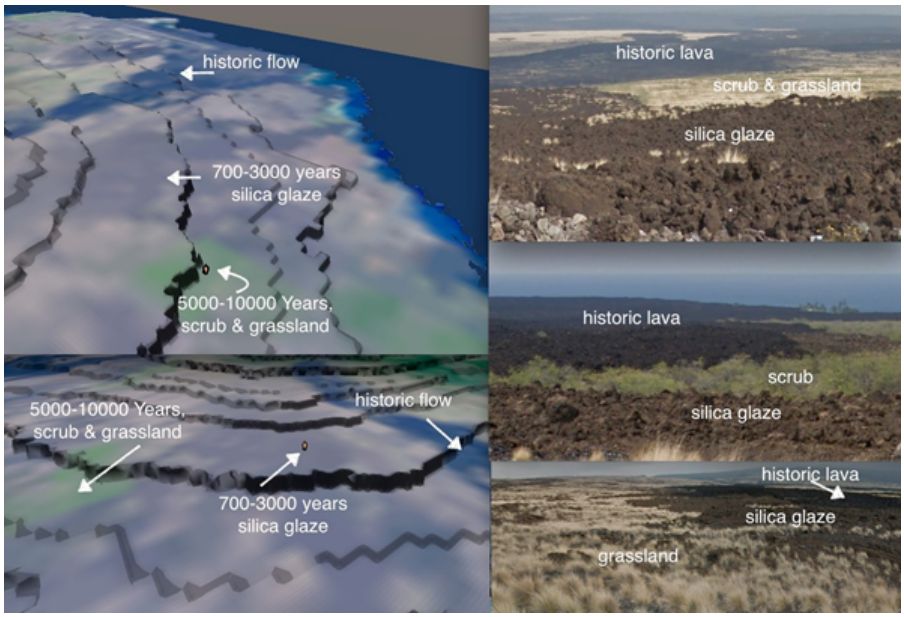
| | |
|---|---|
| **The second step** is the coating of silica glaze (its too dry for lichens and plants like mosses and ferns) that lasts from ~400 years to 3000 years. The right image shows an electron microscope view and a landsat view. Just 0.005 millimeters of this coating changes the lava flow color from fresh black to orange brown. |   |

From 3000 to 5000, grasses come in but the silica glaze covered lava is obvious. Then, grasses and some desert scrub gradually increase from 5000 to 10,000 years.

On lava flows older than 10,000 years, the local scrubland-dwarf tree plant association can be dominated by a type of mesquite tree called *Prosopis pallida*. This mesquite is also called kiawe. It originated in Peru and arrived in Hawai'i in 1828 in a churchyard in Honolulu. It has since spread and grows on the rainshadow sides of the Big island. Its seed pods can be a food source for people and livestock, brewed into a tea or sometimes used to make beer

The images below show the changes from fresh lava, to silica glaze, to desert scrub vegetation over 10,000 years, as well as a view from the geovisualization of these landscapes.

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There are two questions on primary (on lava flows) plant succession: the rainshadow side and the rainforest side of the Big island.

**RAINSHADOW QUESTION**

**The three coordinates below are close to one another on the RAINSHADOW side of the Big Island. They represent the three stages in plant succession typically found on the drier semi-arid/desert slopes on the leeward sides of the volcanoes. Select the best matches between location and the stage.**

You may explore these locations below for yourself. The example choices represent the correct choice for the coordinates.

| Locations | Choices |
|---|---|
| 19.7698 , -155.6601 | Basalt lava flow less than 200 years |
| 19.7539 , -155.6669 | Lava flow about 2000-3000 years old that has been coated with silica glaze giving it a brownish coloration, instead of the original black of the underlying basalt flow. |
| 19.7448 , -155.6831 | Lava flow that is older than 10,000 years. It has been colonized by a mixture of grassland and desert scrub vegetation including mesquite. |

**RAINFOREST QUESTION**

**The three coordinates below are close to one another on the RAINFOREST (windward) side of the Big Island. They represent the three stages in plant succession typically found associated with proximity to a rainforest, but on a fresh lava flow Select the best matches between location and the stage.**

You may explore these locations below for yourself. The example choices represent the correct choice for the coordinates.

| Locations | Choices |
|---|---|
| 19.1866 , -155.7600 | Basalt lava flow less than 50 years |
| 19.1905 , -155.7659 | Lava flow about 150 years old that is covered with lichens, ferns, mosses, and scattered trees. |
| 19.1900 , -155.7991 | Lava flow that is about 800 years old, and it is covered in rainforest. |

## Question 1

4 pts

Using Fast Travel, please visit in the geovisualization at the indicated locations. You will not be sent to the exact location of the treeline. Part of the question involves you looking for the highest elevation of the dark green trees, using the Landsat Composite layer.

There will be a complication -- that lava flows have periodically wiped out the vegetation, and then the trees gradually re-establish themselves. Thus, you are to walk to the highest dark green nearby. Write down the elevation, and also switch to precipitation and write down those values.

Then, have your avatar travel directly upslope of this treeline about 500 m higher and write down the mean annual precipitation (MAP 500m+). Then, calculate an average (mean) and range of all data you collected.

There is a table like this in the PDF file that will help you take notes.

PLEASE ROUND TO THE NEAREST 100 (precipitation and elevation) when you make your observations.

| Lat/Long you are sent to | Treeline Elevation nearby in meters | MAP- at treeline in mm | Elev 500 m higher | MAP 500 m higher |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Average | | | | |
| Average rounded off to nearest 100 | | | | |
| Range | | | | |

These are the locations you will be studying in the geovisualization:

19.1874 -155.6576

19.2105 -155.6307

19.2465 -155.5986

19.2623 -155.5802

19.2962 -155.5395

**QUESTION: Part 1: What is your mean and range for the trade wind inversion treeline on the eastern slopes of Mauna Loa – in terms of its elevation and mean annual precipitation (MAP). Round off to the nearest 100.**

**Part 2: 500 m above the treeline locations, how much has the average precipitation declined from the treeline? Round off to the nearest 100.**

- ◯ The treeline closest to the indicated coordinates averages 2000 m (range 1900-2000 mm) with a mean annual precipitation averaging 1400 mm (range 1100-2000). The precipitation drops off to average of 1200 mm just 500 meters upslope from treeline.
- ◯ The treeline closest to the indicated coordinates averages 2000 m (range 1900-2000 m) with a mean annual precipitation averaging 1900 mm (range 1750-2100). The precipitation drops off to average of 900 mm just 500 meters upslope from treeline.

- ◯ The treeline closest to the indicated coordinates averages 1900 m (range 1800-2000 m) with a mean annual precipitation averaging 1800 mm (range 1600-2000). The precipitation drops off to an average of 900 mm just 500 meters upslope from treeline.
- ◯ None of the answers listed are even close. Thus, this is the best answer.

## Question 2

2 pts

**The three coordinates are near to one another on the rainshadow side of the Big Island.** They represent the three stages in changes to a lava flow over age (plant succession) typically found on the drier semi-arid/desert slopes on the leeward sides of the volcanoes. Select the best matches between location and the stage.

| | |
|---|---|
| 19.7981 -155.9386 | [ Choose ] |
| 19.7988 -155.9485 | [ Choose ] |
| 19.7931 -155.9593 | [ Choose ] |

## Question 3

2 pts

**The three coordinates are near to one another on the windward side of the Big Island.** They represent the three stages in plant succession typically found on wetter slopes of the Big Island. Select the best matches between location and the stage.

| | |
|---|---|
| 19.2179 -155.7837 | [ Choose ] |
| 19.1950 -155.7656 | [ Choose ] |
| 19.2071 -155.7808 | [ Choose ] |

Not saved Submit Quiz