KAMIAK BUTTE ECOLOGICAL REPORT

Patrick McCornack

11/11/2019

Contents

List of Figures

List of Tables

Acronyms Used

Kamiak Butte

Located 14 miles from Pullman, Washington, Kamiak Butte is home to both a forest ecosystem and a remnant of Palouse Prairie. Rising high above the surrounding agricultural land, the Butte provides numerous recreational opportunities and a place to connect with nature.

Geology

Coming up almost 1,000 feet above the landscape, this ancient mountain peak is a glimpse into what the geology of the area looked like before the formation of the Columbia River Basalt Group. Kamiak Butte is composed of a different substance than the adjacent area and this has allowed a distinctly different type of ecosystem to exist there.

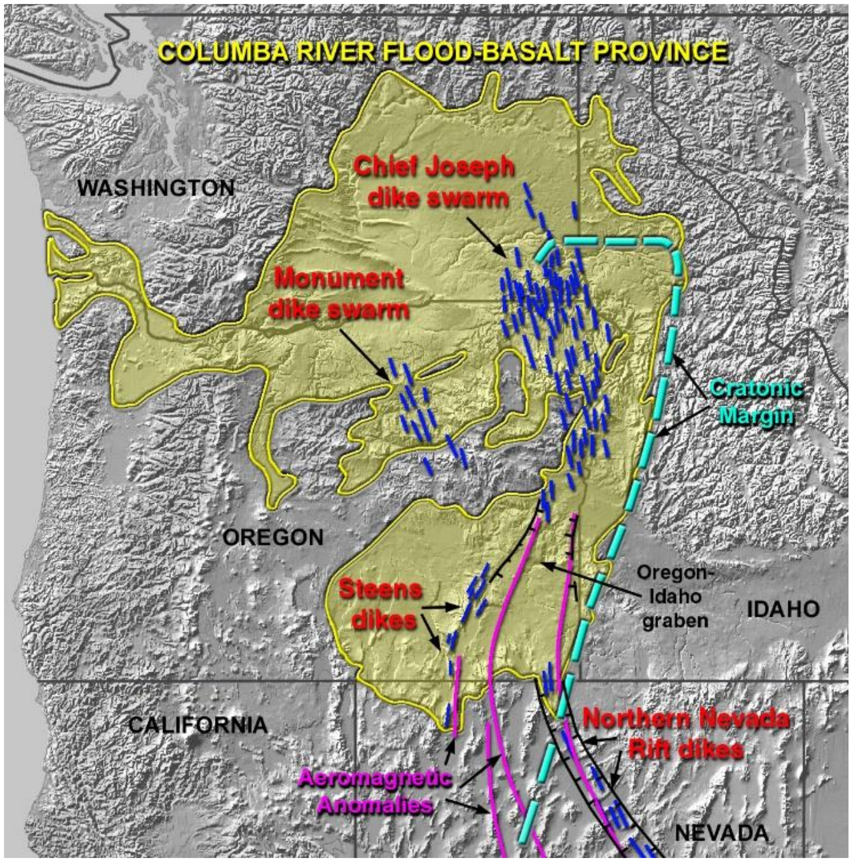
Basement Geology

The butte is the peak of a mountain composed of Precambrian quartzite that is otherwise buried underneath a sea of basalt (Schlosser, Glaciation and Flooding, 2019). Long ago the Palouse was covered by a shallow sea where quartz sands settled. These quartz sands became sandstone and this sandstone was then heated by the earth's interior and compressed to become quartzite. That ancient sea floor was then pushed upward by geological processes to become a mountain range (Whitman County, 2018). Both Kamiak Butte and Steptoe Butte are the peaks of this mountain range which was covered under layers of basalt during the Cenozoic lava flows (Schlosser, Glaciation and Flooding, 2019). This quartzite is very permeable compared to the surrounding basalt. Any precipitation that falls and gets trapped on Kamiak Butte is able to seep through the rock and is lost to the ecosystem. This makes the area unproductive for growing crops and is the reason that it has not been converted for agricultural purposes.

The Basalt Flows

Around 17 million years these basaltic lavas began to erupt out of fissures in the ground. Over 300 distinct flow events continued to occur up until 6 million years ago (Zentner, Flood Basalts of the Pacific Northwest, 2017). In total, these flows produced approximately 41,800 cubic miles of basalt which covered around 63,200 square miles of the Pacific Northwest as shown in Figure 1. This lava is up to 3 miles thick in places. Over 90% of this basalt was released in a 400,000 year period between 16 and 15.6 million years ago. The volume of lava produced by these events, which occurred thousands of years apart, is so large that the weight caused the crust in the Columbia Basin to sink a significant distance into the mantle. The fissures that supplied these lava flows can be seen today as feeder dikes throughout the Pacific Northwest (Figure 1). These vertical sheets of basalt cut through the horizontal layers and indicate places where lava poured out of the ground. Sometimes the lava came out with enough force that it went airborne and resulted in spatter in places (Zentner, Flood Basalts of the Pacific Northwest, 2017). These floods of basalt buried almost 40% of Washington and shaped the topography of much of the Pacific Northwest both East of the Cascades and down the Columbia River (Zentner & Foster, Ice Age Floods, Lake Missoula, Bonneville Flood and Columbia River Basalts, 2014). This layer of basalt is largely impermeable and doesn't allow water to seep through unless there is a crack present. This property is partially responsible for the agricultural productivity of the region as the basalt acts as a bathtub and helps trap any precipitation.

Figure 1. Extent of Columbia River Basalt Group (Camp & Ross, 2003).



Glacial Floods

The land was later scoured by floods released when Lake Missoula broke through the ice dam created by the Purcell Trench glacial lobe. Glacial Lake Missoula covered over 3,000 square miles and was up to 1,900 feet deep in places. This water breached the ice dam and surged across the landscape, all the way to the Pacific Ocean. In order to get there, the water had to pass through the chokepoint at Wallula Gap then flow down the Columbia River Gorge. The flood left its mark in a variety of ways. The energetic water tore up the crust and left erosional chasms, potholes, and coulees. The chokepoint at Wallula Gap created Lake Lewis. This back-up of water was calm and full of suspended sediment that the flowing water had picked up. As Lake Lewis slowly drained, these were able to settle out of the water and create a slack water sediment layer (Zentner & Foster, Ice Age Floods, Lake Missoula, Bonneville Flood and Columbia River Basalts, 2014). Lake Missoula formed time and time again and each time the flood occurred another sediment layer was deposited. These sediment layers remain today as evidence of the Missoula floods and the creation of Lake Lewis each time. During this time, boulders frozen in glacial icebergs were transported west where they were deposited as glacial erratics which remain today (Zentner & Foster, Ice Age Floods, Lake Missoula, Bonneville Flood and Columbia River Basalts, 2014). The net result of these floods was massive erosion that laid bare the layers of lava flows, layers of slack water sediments, and ripple currents along valley floors that are only recognizable as such from the air. The silt deposited at Eureka Flat near the Wallula Gap is especially important. This silt was picked up by strong winds and spread over the Palouse, forming the agriculturally important rolling hills that remain today (Schlosser, Glaciation and Flooding, 2019).

Loess Deposition

Loess covers around 19,000 square miles of the Pacific Northwest. In the Palouse, this loess can be almost 250 feet deep. The loess accumulation happened episodically as indicated by at least 19 identifiably separate beds. The accumulation that caused these beds is associated with dry and windy glacial episodes that occurred after the last of the Missoula floods. The Columbia River Gorge and Wallula Gap act as a focus for wind that then crossed Eureka Flat, suggesting that it could be the source of the loess covering Eastern Washington (Sweeney, Gaylord, & Busacca, 2006). The rolling hills created by this eolian sediment developed rich and fertile soil. This allowed the Palouse Prairie ecosystem to develop in the aftermath of the devastating floods. However, the same fertile soil also led to rapid agricultural development in the area which has endangered the Palouse Prairie ecosystem (Looney & Eigenbrode, 2012). This rich and fertile loess is another factor that allows the region to practice dry land agriculture. The fine particles act as a sponge for precipitation due to the tiny pores between particles. This, coupled with the underlying basalt bathtub means that the region is able to hold onto moisture and allows very high agricultural productivity.

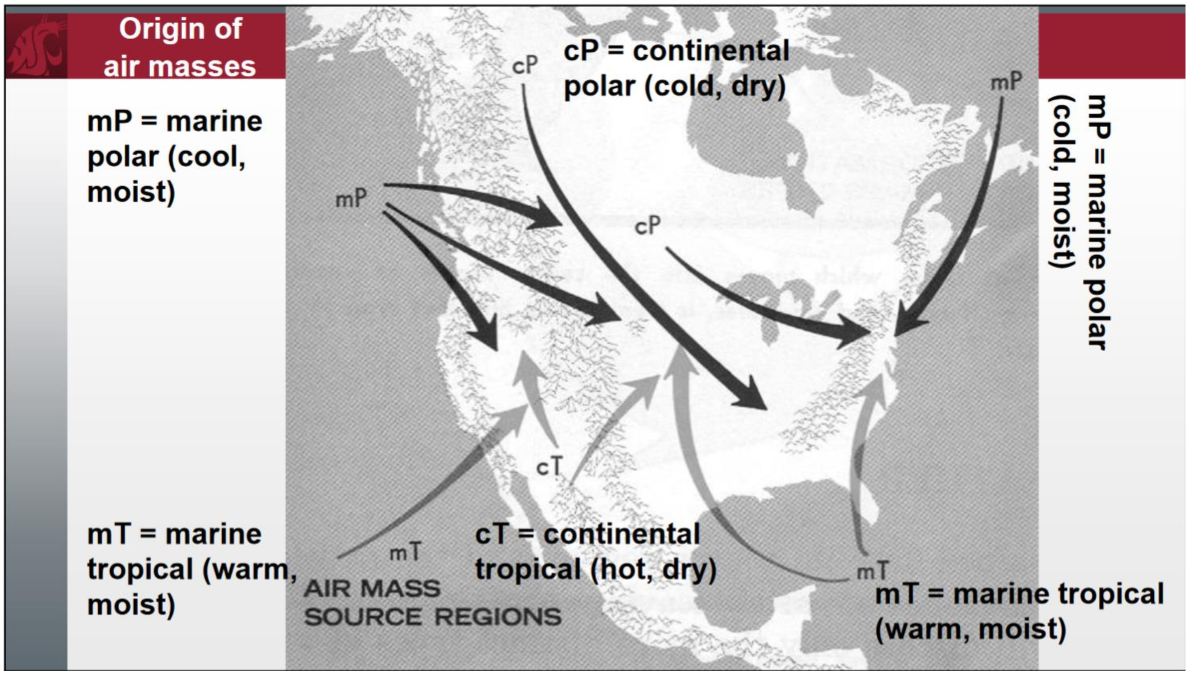
Climate

The climate of an area is a description of the long-term average atmospheric and meteorological conditions of an area. Factors of climate include temperature, precipitation regime, and atmospheric pressure among other considerations. This is not to be confused with weather, which is a local description of atmospheric events at a given time. Climate is a function of various variables that are largely determined by location.

Air Masses

An air mass is an extremely large body of air that can be several thousand miles long. The temperature and level of moisture is relatively consistent throughout the body of the air mass (University of Illinois Extension, 2014). These temperature and moisture properties are how air masses are categorized. The categories are: Continental Polar, Marine Polar, Marine Tropical, and Continental Tropical (Figure 2). The character of the air mass is determined by its origin but as the air mass travels its character will change. Washington is affected most by marine polar air masses. These cold air masses originate in polar regions then travel over the North Pacific Ocean. As the air mass interacts with the ocean surface it picks up heat and moisture which it then carries over Western Washington, over the Cascades, and ultimately all the way to the Palouse. Similarly, the other types of air masses are either cold or warm and dry or moist depending on the origin (Zamora, Climate and its Connection to Ecology, 2018).

Figure 2. Origins of Air Masses (Schlosser, Lecture 9: Climate Part 2, 2019)



Macroclimate

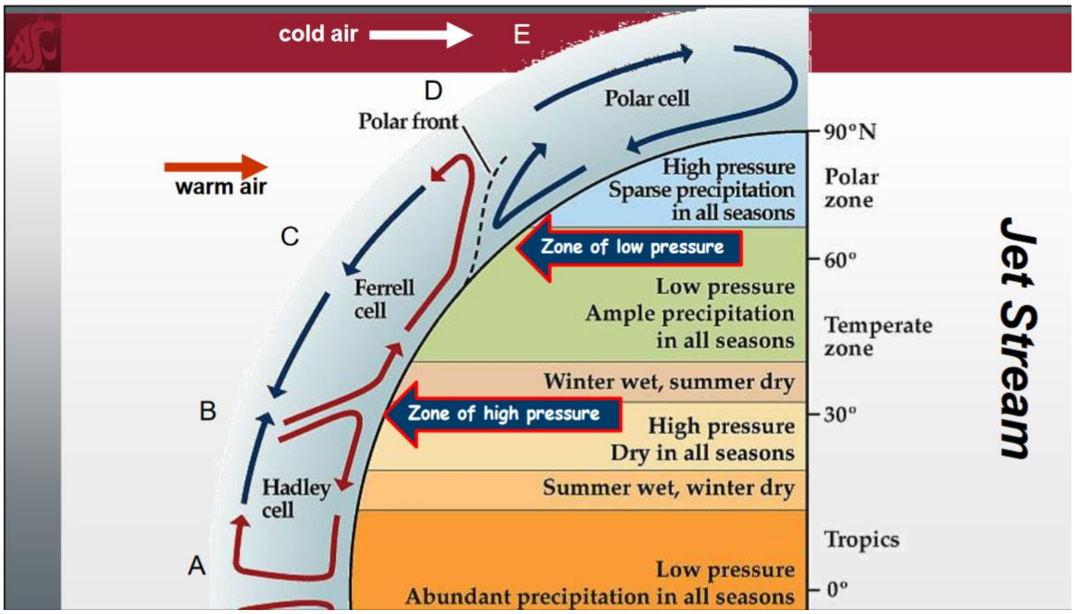
The macroclimate is the second largest climate spatial scale and describes the general climate of a large region. It is the result of the combination of four properties that are all location based (Schlosser, Lecture 9: Climate Part 2, 2019). The latitude of the region under consideration is a description of how far north or south it is from the equator. The higher the latitude, the further north/south it is. Since the earth is a sphere, the latitude affects the degree of insolation that the region gets. When a region is closer to the poles the earth's spherical shape takes effect and the intensity of solar radiation received is reduced. The angle of the incident surface is higher meaning that a larger area is needed to receive the same solar flux as an area near the equator which is nearly perpendicular to the incoming solar radiation (Zamora, Climate and its Connection to Ecology, 2018).

The insolation level will affect the temperature and moisture regimes in an area as well as the vegetative community present. The insolation gradient is the driving factor behind the presence of the belts of high and low atmospheric pressure. At the latitudes of 0° and 60° there are low pressure belts, and at 30° and 90° there are high pressure belts (Figure 3). These drive circulation cells that create distinct weather patterns between these belts that contribute to the macroclimate of a region at a particular latitude (Smith & Smith, 2012).

The origin of air masses that affect the region will heavily affect the macroclimate since it will determine the temperature and moisture regions of that area. A marine tropical air mass can cause a climate to be warm and highly humid. The humidity will then affect the temperature regime by dampening both diurnal and seasonal temperature changes due to the heat capacity of the moisture in the air. Conversely, a continental polar air mass would bring cold, dry air to a region and there will be much larger diurnal and seasonal temperature changes (Schlosser, Lecture 9: Climate Part 2, 2019).

Both topography and continentality also exert strong influence on macroclimate by influencing temperature and precipitation regimes. As air moves east across Washington the effect of the ocean on the temperature of the air will lessen due to the difference in the heat capacities of the ocean and landmass. Additionally, there is a marked difference in the macroclimates of western and eastern Washington due to the rain shadow effect (Zamora, Climate and its Connection to Ecology, 2018).

Figure 3. Effects of Latitude on Climate (Schlosser, Lecture 9: Climate Part 2, 2019)



Continentality

The continentality of a region measures the influence of a landmass on climate. The ocean acts as a thermal reservoir due to the high heat capacity of water. A small change in temperature requires a relatively large amount of thermal flux in comparison to a landmass. The effect of this is that the ocean acts as a buffer to temperature swings in coastal regions. During the winter or cold periods there will be a temperature gradient between the air and the ocean which will cause the ocean to radiate heat into the air and moderate the temperature. The ocean also provides a large amount of moisture to air masses moving across it. The net effect of these factors is that coastal regions tend to have much milder and wetter climates than regions with a high continentality. Since land has a much lower heat capacity a region that is far inland that receives the same insolation as a coastal region will have more extreme temperature shifts since the same amount of thermal flux causes higher changes in temperature (Zamora, Climate and its Connection to Ecology, 2018).

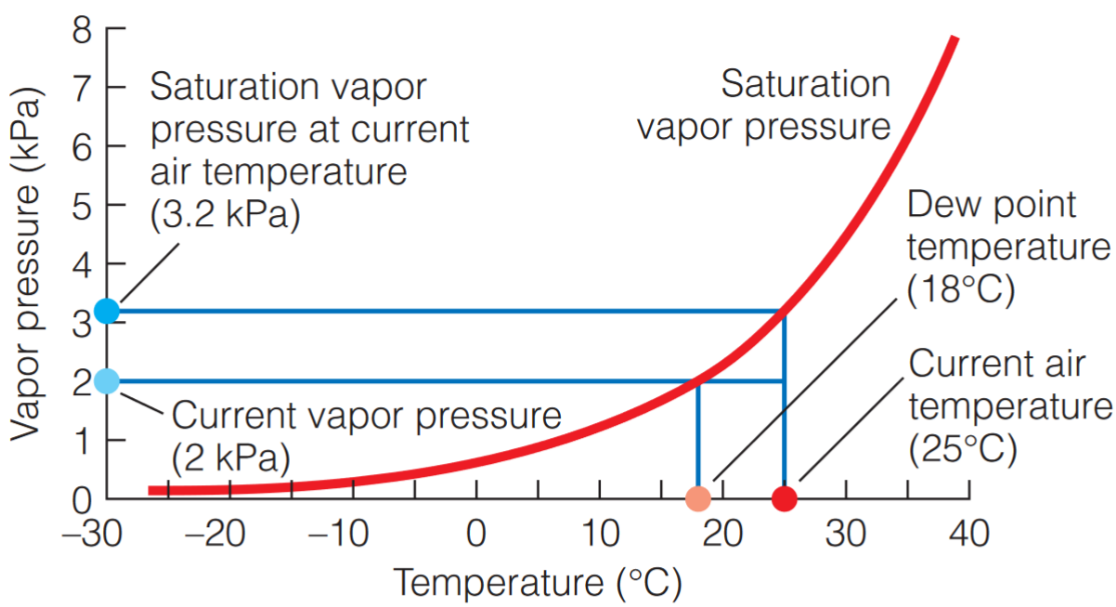
Topography

Climate can be influenced by a variety of topography, but mountain systems have the largest impact. A mountain range with a more drastic relief will have a larger influence on climate than an area that is flat. The origin of air masses that move down into the United States to the east of the Rocky Mountains is continental polar. The region to the west of the Rocky Mountains is affected by marine polar air masses. This discrepancy is due to the relief of the Rocky Mountains. The mountains provide a physical barrier to prevent the continental polar air masses from pushing west under normal circumstances (Zamora, Climate and its Connection to Ecology, 2018). Mountains will also affect climate by creating a rain shadow.

Rain Shadow

Mountain topography can create a rain shadow on the leeward side of the mountain range. These rain shadows are relatively dry zones that can take on a desert-like climate. The cause of this is the altitude change an air mass experiences as it crosses a mountain range. A decrease in pressure will accompany a rise of altitude. As the pressure drops the air expands and the temperature drops. This temperature change isn't associated with heat transfer but with rather with adiabatic cooling which is due to the pressure drop and volume expansion. The saturation vapor pressure of air is the point at which the air can physically hold no more water. When this point is exceeded clouds begin to form which will then cause precipitation. Since the saturation vapor pressure of cold air is lower than warm air (Figure 4) as the air rises and cools the actual saturation pressure will exceed the saturation vapor pressure and it will rain. The air mass will then crest the mountain range and begin to descend. As it descends it warms and compresses, increasing the saturation vapor pressure. Since the air mass already lost most of its moisture content to precipitation there will be very little further precipitation in the low region on the leeward side of the mountain range (Smith & Smith, 2012). This area is under the influence of a rain shadow.

Figure 4. Effect of Temperature on Saturation Vapor Pressure (Smith & Smith, 2012)



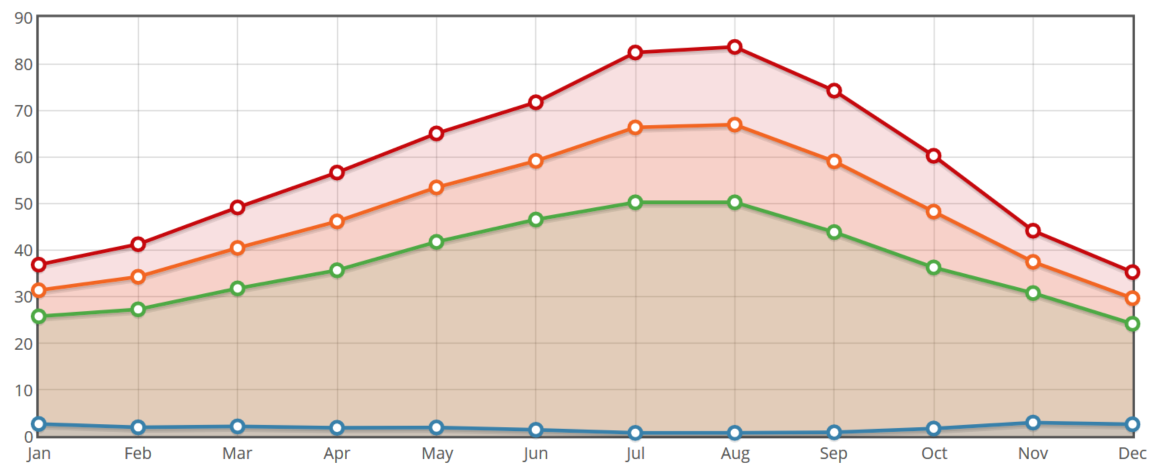
The Climate of Kamiak Butte

The macroclimate of Kamiak Butte is Marine-Modified Continental. Figure 5 shows data provided by the National Oceanic and Atmospheric Administration (NOAA) that describes the average climate of each month in Pullman. This shows the cold, wet winters and hot, dry summers typical to the region. The origin of the air masses affecting the region are marine polar, but Kamiak Butte is located on the eastern edge of the rain shadow. At this point the elevation is beginning to increase moving west to east compared to the relatively flat Columbia Basin. This means that while it doesn't receive as much precipitation as the west side of Washington, it receives more than the region directly west. The region has a high continentality with large temperature shifts from day to night as well as between seasons. Additionally, the topography of Kamiak Butte creates distinct microclimates on the Butte's north and south aspect. Since Kamiak Butte is in the northern hemisphere, the south side receives more photosynthetically active radiation (PAR) which increases the evaporation rate on that side. This leads to overall higher temperatures and lower soil moisture. This results in disparate ecosystems between the north and south sides with the north side having much more dense vegetation (Schlosser, Lecture 9: Climate Part 2, 2019).

Figure 5. 1981-2010 Climate Normals for Pullman, WA (NOAA, 2019)

PULLMAN 2 NW, WA US

View Station Details | View Station Report

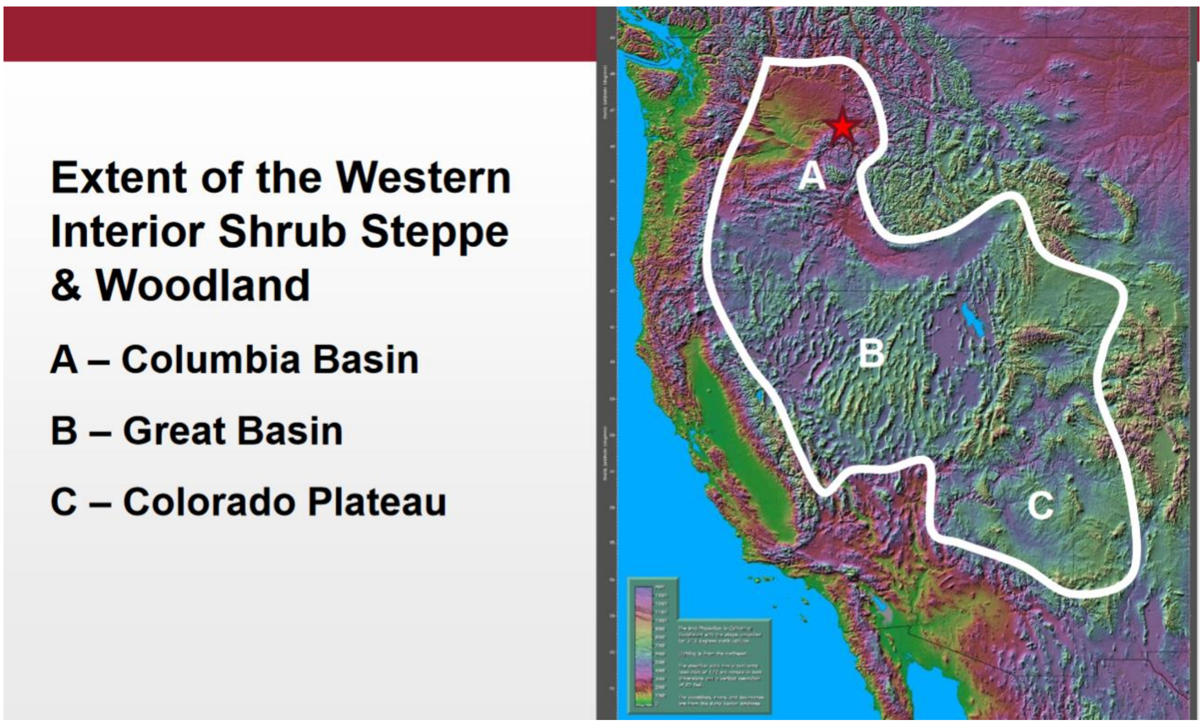


MONTH	PRECIP (IN)	MIN TMP (°F)	AVG TMP (°F)	MAX TMP (°F)
01	2.57	25.7	31.3	36.8
02	1.85	27.2	34.2	41.2
03	2.04	31.7	40.4	49.1
04	1.75	35.6	46.1	56.6
05	1.81	41.7	53.4	65.0
06	1.31	46.5	59.1	71.7
07	0.65	50.2	66.3	82.4
08	0.66	50.2	66.9	83.6
09	0.77	43.8	59.0	74.2
10	1.58	36.2	48.2	60.2
11	2.86	30.7	37.4	44.1
12	2.50	24.1	29.6	35.2

Biome

A biome is the second highest level of ecological organization and is defined as a broad, regional complex of ecosystems and landscapes that is characterized by the influence of a particular climate regime (Schlosser, Lecture 11 - Terrestrial Biomes, 2019). The biome of Kamiak Butte is classified as Western Interior Shrub Steppe and Woodland. This biome extends over a wide swathe of land east of the Cascade and Sierra Nevada mountain ranges and west of the Rocky Mountains (Figure 6). Specifically, this area covers the Palouse, the Columbia Basin, the Great Basin, and the Colorado Plateau (Schlosser, Lecture 12 - Woodlands Biome, 2019). The character of a biome is largely determined by the climate regime and geographic position of the region. Western interior shrub steppe and woodland is under the influence of a marine-modified continental macroclimate.

Figure 6. Extent of Western Interior Shrub Steppe and Woodland (Schlosser, Lecture 9: Climate Part 2, 2019)



Climatic Conditions

The marine modified-continental macroclimate is characterized by cold winters and hot, dry summers with peak precipitation occurring in the winter (Zamora, Climate and its Connection to Ecology, 2018). The character of the climate, and thus the biome, does vary spatially through the extent of the range of the western interior shrub steppe and woodland. While still under the regime of a marine modified-continental macroclimate, the temperature and precipitation vary geographically due to the effect of continentality and topography. For example. the Columbia basin will get less precipitation than the Palouse hills due to the rain shadow effect created by the Cascades. This means that the communities present will vary throughout the biome but are largely connected. The character of these communities are a function of the temperature and moisture regimes (Schlosser, Lecture 11 - Terrestrial Biomes, 2019). Additionally, the composition of the soil in a region will also have a large effect on the biota that develop there since the fate of precipitation in the region in largely controlled by the soil and basement geology (Smith & Smith, The Terrestrial Environment, 2012).

Dominant Growth Forms

The plant community of a biome provides the basis for the character of the biota present in that region. Plants are unable to move and thus must be able to handle environmental pressures that vary temporally. These environmental conditions and the inevitable scarcity of resources drive natural selection processes that result in dominant plant growth forms suited to the area. Desert plants have evolved to be succulent and have thick waxy cuticles to solve the problem of water scarcity. (Zamora, Ecological Adaptation and the Ecological Niche, 2018). Geographically discontinuous biomes share common environmental pressures. This leads to the occurrence of evolutionary convergence where similar features, such as plant growth forms, will develop independently (Schlosser, Lecture 11 - Terrestrial Biomes, 2019). These organisms that developed convergently fulfill the same ecological niche and occupy similar physical and functional roles in an ecosystem (Zamora, Ecological Adaptation and the Ecological Niche, 2018). Plants are the primary source of energy in an ecosystem since they generate carbohydrates through photosynthesis. Therefore, the character of vegetation in an area plays a large role in the what type of animal life is present. Additionally, plants structures provide cover for prey animals and habitats for a variety of animals.

Western Interior Shrub Steppe and Woodland Biome

The shrub-steppe is largely distributed through hot and dry environments. It occurs at lower elevations than woodlands and is dominated by several types of sagebrush. The type of sagebrush depends on the soil character, moisture regime, and disturbance regime with the different kinds fulfilling different niches. Additionally, a bunchgrass steppe layer (Figure 7) will often be present with a few notable species being bluebunch wheatgrass and Idaho fescue. There are different kinds of shrub-steppe that occupy different geological areas. Dwarf shrub-steppe is common in northeastern Oregon and salt scrub shrublands are common in the Great Basin (Chappell, Crawford, & Barrett, 2018). Palouse Prairie is a unique type of shrub-steppe found in the far east of Washington. Each of these types are under the influence of a marine modified continental macroclimate but also have a distinct character based on the local temperature and precipitation regime.

Figure 7. Perennial Bunchgrass Layer (Schlosser, 2019)

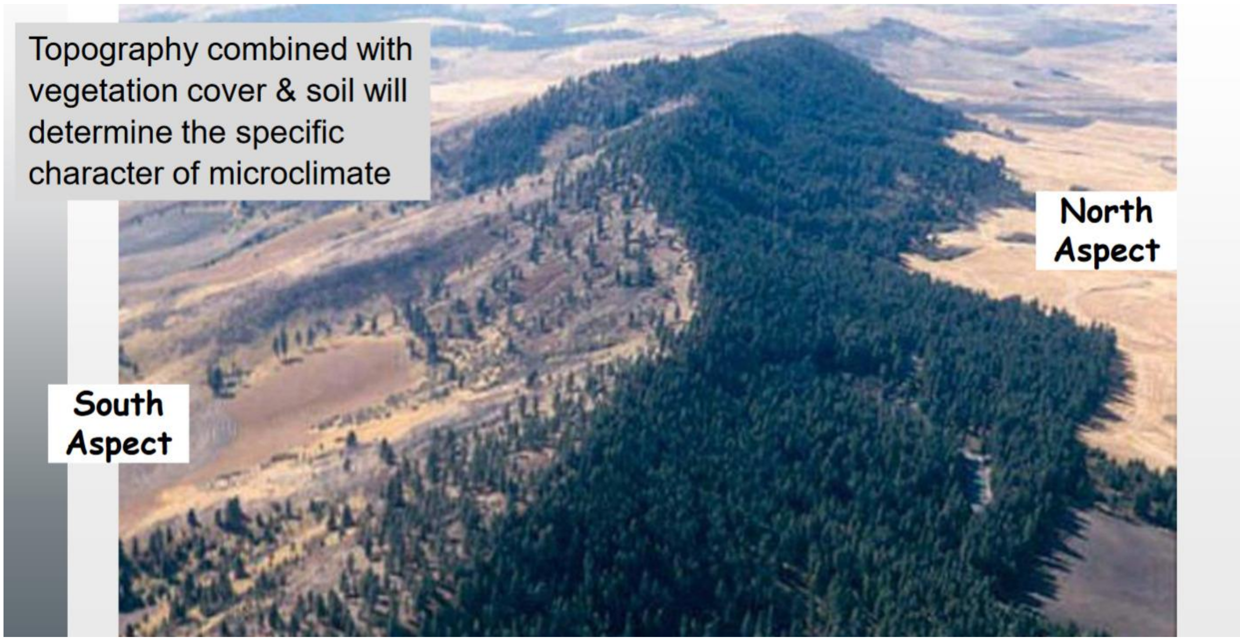
There are several different kinds of woodlands in this biome but the most dominant type in eastern Washington is the ponderosa pine forest. Ponderosa pines are able to grow in dry conditions and have a very versatile habitat range. It can often be found at the transition between shrub-steppe and woodlands and these pines grow in a widely dispersed tree layer. Other conifers including western larch and Douglas-fir will grow in these forests. The structure of the understory can be largely dominated by shrubs or by grasses (Chappell, Crawford, & Barrett, 2018).

Biome of Kamiak Butte

Underlying Kamiak Butte is an island of quartzite rock that is otherwise surrounded by the Columbia River Basalt Group. Laid over the top of this geologic foundation is a fine layer aeolian loess. The permeable quartzite means that Kamiak Butte has different characteristics than the surrounding agricultural area (Schlosser, Lecture 12 - Woodlands Biome, 2019). The tiny pores of fine grained loess allows for large adhesion forces so it is able to hold more water than course grained soil due to capillary forces (Smith & Smith, The Terrestrial Environment, 2012). The geologic foundation and soils on Kamiak Butte have a large influence on the character of the biota. Additionally, the north and south aspects have significantly different types and density of vegetation (Figure 8). The south aspect receives higher levels of PAR which increases evaporation rates and decreases water availability. As a result, the north side consists of ponderosa pine woodlands while the south side more closely resembles shrub-steppe.

Overall Kamiak Butte matches what is typical of the Western Interior Shrub-Steppe and Woodlands in terms of physical conditions like climate as well as the types of plant growth forms.

Figure 8. Kamiak Butte North/South Aspect Disparity (Schlosser, 2019)



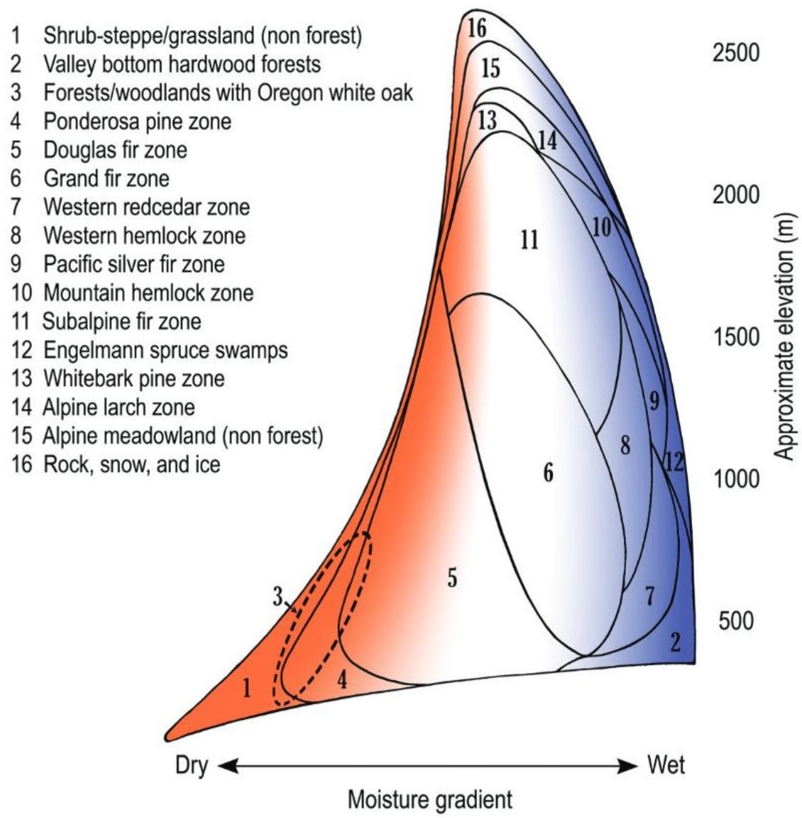
Community Dynamics

The community is the third level up in the ecological hierarchy. A community consists of populations of different species that occupy the same location and interact with each other. These populations can be of any organism including plants, animals, and fungi. Communities are often characterized by the number of different species existing in the community and the relative abundance of populations. This is also known as species richness and diversity (Schlosser, Lecture 20: Community Ecology Part 1, the Nature of Communities, 2019). The composition of a community's structure and the way that individual parts of the community interact with each other and the physical environment determines the community properties. Within a community, the autotrophs, or plants, are the primary producers of energy within the system. Therefore, the plant community controls the structure of the community as a whole. This type of analysis is known as bottom-up control, however it should be noted that predator-prey interactions also influence community structure (Schlosser, Lecture 23: Community Ecology Part 3 - Interaction Webs, 2019). The character of the physical environment, specifically the availability of light, nutrients and moisture, determines the structure of the plant community.

The Fundamental Niche and Species Interaction

Environmental conditions do not remain constant. Resource availability changes as the seasons change as well as spatially throughout a landscape. Every species has a range of conditions which they can tolerate. Within this range of conditions there is an ideal zone where the species can thrive and there are fringes where the species can merely survive. This whole range of conditions is the fundamental niche for that species and will determine the type of vegetation zone present at that location (Figure 9). While some species have broader niches than others, all species have a constrained potential habitat based on the environmental and physical characteristics which that species can tolerate. Therefore the species richness and relative abundance in a given community will be determined by the way that those species' fundamental niches are distributed along an environmental gradient, and any species whose niche falls outside that gradient is precluded from living there (Smith & Smith, Factors Influencing the Structure of Communities, 2012). The fundamental niche provides a broad base for community structure which is then narrowed through biotic interactions.

Figure 9. Environmental Gradients of Eastern WA vegetation zones (Washington State Department of Natural Resources, 2019).

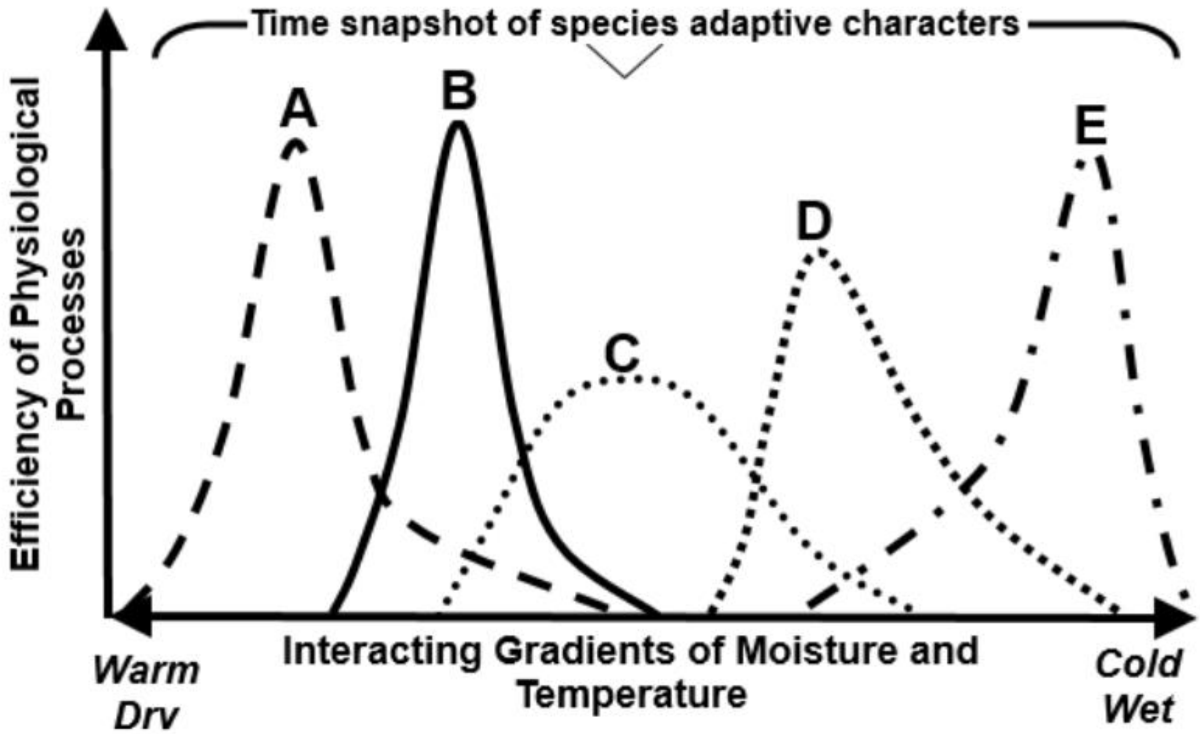


The populations in a given area will interact with each other both directly and indirectly and in doing so will impact the actual distribution and abundance of each species within its fundamental niche. This niche that each species occupies as a result of biotic interactions is called the realized niche and is a subset of the fundamental niche (Zamora, Ecological Adaptation and the Ecological Niche, 2018). Each species has a function within the ecosystem and this function determines the role which that species plays within the community and the interactions that take place involving that species. These interactions can have a range of effects on both parties involved. There are a variety of different classifications based on the type of interactions and the effects can be beneficial, detrimental, or some combination of the two to each of the parties involved in the interaction.

Types of Interactions

The two broad classifications for species interactions are intraspecific and interspecific. An interaction that takes place between different species is an interspecific interaction while an interaction between individuals of the same species is intraspecific. Within these categories, organisms can cooperate to obtain resources, compete for those limited resources, or utilize each other as a resource through consumption. In competition either both species will be detrimentally affected, or one species will be detrimentally affected while the other is unaffected, which is known as amensalism. In cooperation, either both species will be beneficially affected or one species will be beneficially affected while the other is unaffected, which is amensalism. Generally, these interactions will take place when the ecological niche of both species overlaps with the other (Figure 10). When this happens both species share a common pool of limited resources which they must obtain to survive and reproduce. These resources could include light, water, nutrients, space, or food (Schlosser, Lecture 21 - Community Ecology: Part 2 Biological Interactions within a Community, 2019).

Figure 10. The ecological niche and niche overlap (Zamora, Ecological Adaptation and the Ecological Niche, 2018).

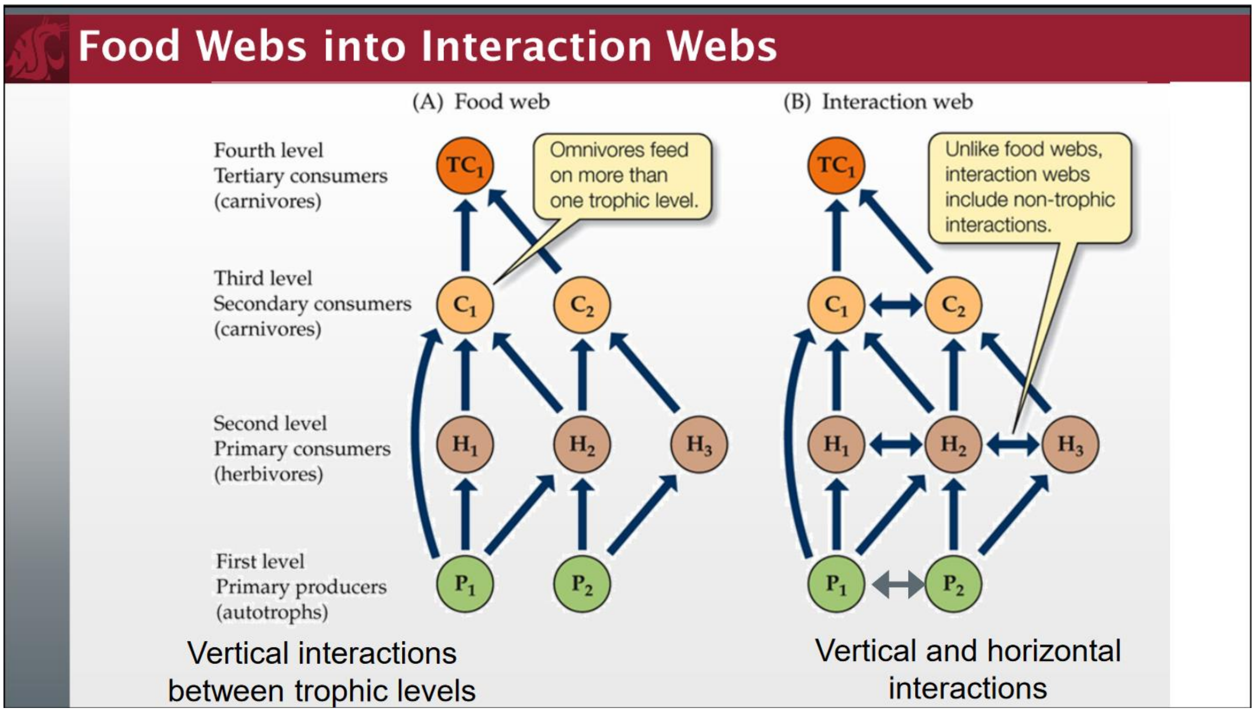


Community Structure Controls

At any given time, there are many interactions taking place between many different organisms of many different species within a community. Each of these interactions has a direct effect on at least one species and often can affect many species. With so many different cause and effect relationships occurring within a community the interaction between two species may also influence another species that is not directly involved in the interaction. This network of relationships creates a complex interaction web where it becomes apparent that one direct interaction could potentially affect the entire community (Smith & Smith, Factors Influencing the Structure of Communities, 2012).

These complex interaction webs can be organized using the concept of trophic levels, which are used to show the flow of energy through a community. The first trophic level consists of autotrophs which obtain their energy from the sun. The first trophic level is the ultimate source of energy for all organisms and the reason that the plant community is considered the base for ecosystem character. The second trophic level is herbivores, the third is carnivores, the fourth is secondary carnivores, and so on. The interactions between trophic levels can be organized into a food web, which is similar to an interaction web but doesn't include the lateral relations which are known as non-trophic interactions (Figure 11).

Figure 11. Trophic level and the relation between food webs and interaction webs. (Schlosser, Lecture 23: Community Ecology Part 3 - Interaction Webs, 2019)



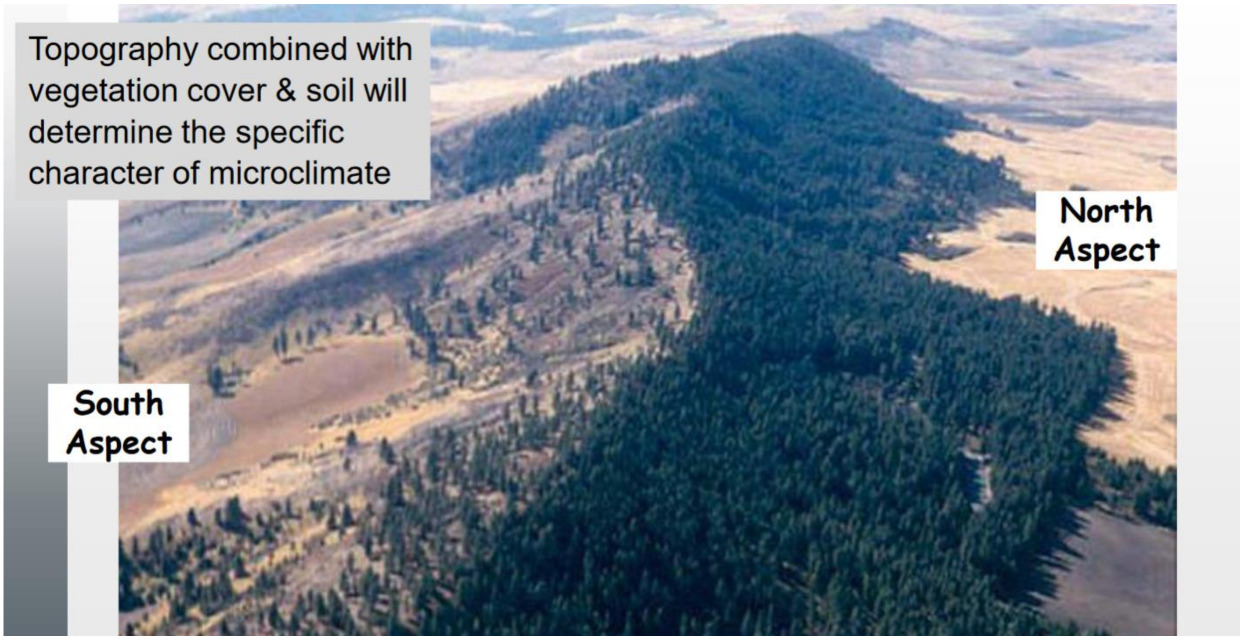
Trophic levels within an interaction web can be used to show how trophic cascades occur. In a trophic cascade, indirect interactions arising from a single direct interaction can be shown to affect all trophic levels within the community. An example of this is the predation of an herbivore will detrimentally affect the herbivore population but will benefit the autotroph population as there will be fewer herbivores to consume the autotrophs. Similarly, if the predator of the herbivore is consumed the herbivore population will benefit while the autotroph population will be negatively affected.

The structure of a community can be viewed either as a bottom-up system or top-down system. In a bottom-up system the structure is controlled by the plant community as the source of energy for the rest of the community. In a top-down system the predators control the community structure through trophic cascade effects of predation (Schlosser, Lecture 23: Community Ecology Part 3 - Interaction Webs, 2019).

The Community Dichotomy of Kamiak Butte

The overall biome of Kamiak Butte is Western Interior Shrub Steppe and Woodlands. Kamiak Butte can be considered a single landscape with two distinct communities. On the north aspect a ponderosa pine forest thrives while the south side is home to a community more typical of Palouse prairie. The ridge forms a sharp dividing line between these communities because of the different abiotic conditions of each side (Figure 12).

Figure 12. The disparity between the north and south aspects of Kamiak Butte (Schlosser, 2019)



The stark contrast between the communities supported by the north and south aspects of Kamiak Butte is largely due to topography resulting in different physical characteristics on each side (Table1). There are several factors contributing to this. The south aspect receives a much higher amount of PAR than the north aspect due to the latitude of Kamiak Butte. Additionally, the south aspect is affected more by wind while the north side is sheltered from it. As a result, the mesoclimate of the south and north aspects are different with the south aspect having a dry moisture regime. The soil on the south aspect is dry and rocky because evaporation rates are higher and the less dense plant community means that water will drain more quickly. In contrast, the soil on the north aspect is dark, moist, and loamy. There is plenty of plant matter to contribute to the humus layer and this soil is much more fertile.

The north aspect is sheltered from the wind due to topography, but the canopy cover further shelters the understory making it partially protected. This shelter and the transpiration of the large plant community makes the microclimate on the south aspect warmer and more humid than the north aspect.

Table1. Physical attributes of two sites at Kamiak Butte

Site Attributes	**Site 1**	**Site 2**
Ecosystem Name	Forest	Palouse Prairie
Aspect (cardinal direction)	20° North	171° South
Slope (%)	10	15
Slope Position	Middle $\frac{1}{3}$	Upper $\frac{1}{3}$

Table1. Physical attributes of two sites at Kamiak Butte		
Site Attributes	**Site 1**	**Site 2**
Exposure	Partially Protected	Fully Exposed
Soil Properties	Loamy, dark brown, deep, water retaining	Dry, rocky, light tan
Elevation (ft)	2882	3582

The Community of the North Aspect

The north aspect harbors a forest ecosystem with several types of trees and various shrubs and herbaceous plants (Table2) (Figure 13). This community is typical of a mid-successional stage ponderosa pine forest (Figure 13). These forests can be classified as either dry or moist. At Kamiak Butte, the community is typical of the dry ponderosa pine forest classification and has western larch and Douglas-fir as the associated species (Graham & Jain, 2005). Despite being classified as a dry forest, the site at Kamiak Butte has a moderate amount of moisture available. In a system such as this, ponderosa pine is considered a mid-seral species and Douglas-fir is the late-seral species that will eventually displace the ponderosa pine. The understory of the Kamiak Butte community is dominated by nine-bark with some clearings that are home to grasses such as pine grass as well as herbaceous plants such as hounds-tongue (Graham & Jain, 2005).

This ponderosa pine plant community creates a home for a variety of birds, mammals, and insects. The understory provides protective cover for various herbivores such as mice, voles, porcupines, chipmunks and deer. In addition to cover, the vegetation provides various resources for these animals, such as food and space for shelter. In some cases, there is little overlap between the niches these animals fit. The ruminant deer and foraging mice have distinct food sources. However, the mice and voles may utilize similar food sources which results in competition. This competition has negative consequences for both species and limits them.

In the overstory house wrens, flycatchers' sparrows, finches, woodpeckers, owls, and warblers among others can be seen. Some of these species utilize separate parts of the forest overstory for food and habitat while some may have to compete for the same resources. Additionally, a variety of spiders that feed on numerous insects call the forest home (Whitman County, 2018).

Figure 13. The plant community at site 1 on the north aspect of Kamiak Butte (McCornack, 2019)

As

In this community, the *Empidonax* flycatchers are two variants of a species of bird that are exemplary of how species will partition resources by occupying different niches. The Willow Flycatcher and Western Flycatcher are sympatric during the breeding season when they occupy Kamiak Butte. While these species occupy the same geographic area, they utilize different habitats. The willow flycatcher nests in the ninebark brush while the western flycatcher nests in rocky ledges and boulders near stands of Douglas fir. The two species had distinct feeding zone preferences with some overlap. The willow flycatcher prefers to feed away from the trees, but also feeds in the herb and brush layers. The western flycatcher prefers to feed in and under the tree canopy and frequently hunts for insects on the ground. Some overlap occurs between their niches because the western flycatcher also sometimes uses the brush layer. Thus there is some niche overlap between the species, but overall each type of bird fits their own niche both in hunting habits and nesting site preference (Frakes & Johnson, 1982).

Table2. Community Characteristics at Site 1				
Community		North-Side Forest		
Physiognomy		Shrub covered gentle slope		
Overstory Species	**Growth Form**	**No. Trees**	**Distribution**	**Regeneration Evident**

Table2. Community Characteristics at Site 1				
		per Hectare		
Douglas Fir	Tr	N/A	Dispersed	Yes
Ponderosa Pine	Tr	17	Dispersed	Yes
Western Larch	Tr	N/A	Patchy	Yes
Understory Species	**Growth Form**	**Canopy Cover**	**Distribution**	**Regeneration Evident**
Nine Bark	S-sh	80%	Dispersed	Yes
Snowberry	T-sh	5%	Patchy	Yes
False Hellebore	S-sh	2%	Patchy	Yes
Hounds-tongue	P-Fb	1%	Patchy	Yes
Lichen	Lichen	<1%	Restricted	Yes
Rose	S-sh	<1%	Restricted	No
Sword Fern	Fern	<1%	Restricted	No

The Community of the South Aspect

The shrub-steppe community on the south aspect resembles that of Palouse prairie (Table3) with scattered ponderosa pine trees. This side of the butte receives a large amount of PAR which creates a drastically different abiotic conditions that shape the character of the community. Both western larch and Douglas fir are precluded from living on this aspect because they require more moisture than is available. Ponderosa pine can survive on this aspect but cannot thrive because they are on the fringe of their livable niche. Palouse prairie traditionally consists of perennial bunchgrasses with a variety of forbs and scattered shrubs. The south aspect of Kamiak Butte largely fits that archetype and is home to several bunchgrasses as well as a variety of plants suited to an arid environment such as biscuit root plants, arrowleaf balsamroot, and tragopogon (Whitman County, 2018). However, the invasive annual grass *Ventenada dubia,* or North Africa grass, has displaced much of the native bunchgrass. The dry and rocky soil possesses low water retention which leads a sparser community despite that the variety of species living there are drought tolerant (Figure 14) (Schlosser, Succession Part 2 - Lecture-25, 2019).

The typical animal community of Palouse prairie consists of small mammals and a variety of birds. Grouse and the Brewer's sparrow occupied Palouse prairie along with ground squirrels, gophers, and voles. Predators of the Palouse prairie are hawks, owls, badgers, and coyotes (Palouse Prairie Foundation, 2003). The interaction between these predators and the smaller species is that the predators consume the prey species. This benefits the predator species and harms the prey species.

Figure 14. The community at site 2 on the south aspect (McCornack, 2019)

Table3. Community Characteristics at Site 2				
Community		Palouse Prairie		
Physiognomy		Grassy moderately steep slope		
Overstory Species	**Growth Form**	**No. Trees per Hectare**	**Distribution**	**Regeneration Evident**
Douglas Fir	Tr	N/A	Restricted	No
Ponderosa Pine	Tr	15	Patchy	Yes
Understory Species	**Growth Form**	**Canopy Cover**	**Distribution**	**Regeneration Evident**
Lomatium	A-Fb	50%	Dispersed	Yes
Arrowleaf Balsamroot	A-Fb	10%	Patchy	Yes

Table3. Community Characteristics at Site 2				
Woods Rose	S-Sh	2%	Patchy	No
Bunchgrass	P-Gr	80%	Dispersed	Yes
Lichen	Lichen	1%	Restricted	Yes
Sandwort	A-Fb	<1%	Restricted	No

Conclusions

The ecosystem present at Kamiak Butte is influenced by a complex web of factors. The geology of butte sets it apart from surrounding farmland in terms of water retention while the temperature and precipitation regimes are governed largely by location and the topography that directs the air masses. The moisture regime is affected both by precipitation and the geology of the Butte but there is also a dichotomy between the north and south aspects. Due to the south aspect's high level of exposure to PAR and wind the site is much drier with poorer soil quality leading to a completely different community than the north side possesses. Additionally, the establishment of the forest on the north side further modifies the microclimate through the transpiration of the plants and the shelter that they provide. This makes the distinction between aspects even larger. Within the communities there is a web of interactions that begin with the plant community but is also modulated by the populations of predators. At each step in forming and maintaining these communities and this landscape there is a large network of interrelated factors. These complex web makes understanding these ecosystems fully extremely difficult. It is even harder to predict what effect a disturbance event would ultimately have on the ecosystem because it's almost guaranteed that there will be indirect effects that will cause unforeseen consequences. Therefore, when managing these systems, one must realize that removing a part of the ecosystem can likely have disastrous and far reaching consequences down the line.

Works Cited

Camp, V., & Ross, M. (2003). Extent of the Columbia River Flood-Basalt Province.

Chappell, C., Crawford, R., & Barrett, C. (2018). *Wildlife Habitats: Descriptions, Status, Trends, and System Dynamics.*

Frakes, R., & Johnson, R. (1982). Niche Convergence in Empidonax Flycatchers. doi:10.2307/1367370

Graham, R., & Jain, T. (2005). Ponderosa Pine Ecosystems.

Looney, C., & Eigenbrode, S. (2012). Characteristics and Distribution of Palouse Prairie Remnants: Implications for Conservation Planning. *Natural Areas Journal*.

NOAA. (2019, September). Data Tools: 1981-2010 Normals. Pullman, Washington, United States of America.

Palouse Prairie Foundation. (2003, March). What is Palouse Prairie. Moscow, Idaho, United States of Ameriac.

Schlosser, W. (2019, August). Glaciation and Flooding. Pullman, WA, United States of America.

Schlosser, W. (2019, September). Lecture 11 - Terrestrial Biomes. WA, United States of America.

Schlosser, W. (2019, September). Lecture 12 - Woodlands Biome. Washington, United States of America.

Schlosser, W. (2019, October 21). Lecture 20: Community Ecology Part 1, the Nature of Communities. Pullman, WA, United States of Americasss.

Schlosser, W. (2019). Lecture 21 - Community Ecology: Part 2 Biological Interactions within a Community. Pullman, WA, United States of America.

Schlosser, W. (2019, October 25). Lecture 23: Community Ecology Part 3 - Interaction Webs. Pullman, WA, United States of America.

Schlosser, W. (2019). Lecture 9: Climate Part 2. Pullman, WA, United States of America.

Schlosser, W. (2019, November). Succession Part 2 - Lecture-25. Pullman, WA, United States of America.

Smith, T. M., & Smith, R. (2012). Climate. In T. Smith, & R. Smith, *Elements of Ecology* (pp. 18-35). Pearson Education, Inc.

Smith, T., & Smith, R. (2012). Factors Influencing the Structure of Communities. In Smith, & Smith, *Elements of Ecology* (pp. 336-352).

Smith, T., & Smith, R. (2012). The Terrestrial Environment. In Smith, & Smith, *Elements of Ecology.*

Sweeney, M., Gaylord, D., & Busacca, A. (2006, December 21). Evolution of Eureka Flat: A dust-producing engine of the Palouse loess, USA. *Quaternary International*. doi:https://doi.org/10.1016/j.quaint.2006.10.034

University of Illinois Extension. (2014, December 7). Rain Shadow. Illinois, United States of America. Retrieved from https://youtu.be/iMu4dShS74w

Washington State Department of Natural Resources. (2019). Forested Vegetation Zones Eastern Washington.

Whitman County. (2018). *Kamiak Butte County Park.* Retrieved from Whitman County Parks and Recreation: http://www.whitmancounty.org/ssi.aspx?ssid=81

Zamora, B. (2018). Climate and its Connection to Ecology. In B. Zamora, *The Nature of Ecology.*

Zamora, B. (2018). Climate and its Connection to Ecology. In B. Zamora, *The Nature of Ecology.*

Zamora, B. (2018). Ecological Adaptation and the Ecological Niche. Washington, Unites States of America.

Zamora, B. (2018). Ecological Adaptation and the Ecological Niche. Washington, Unites States of America.

Zentner, N. (2017, January 25). Flood Basalts of the Pacific Northwest. Ellensburg, WA, United States of America. Retrieved from https://www.youtube.com/watch?v=VQhjkemEyUo&feature=youtu.be

Zentner, N., & Foster, T. (2014, December 8). Ice Age Floods, Lake Missoula, Bonneville Flood and Columbia River Basalts. Washington, United States of America. Retrieved from https://www.youtube.com/watch?v=i1BFb_uYlFQ