Shaping Our Environment

Imagine a secluded valley, ringed by a teardrop-shaped ridgeline. Half a dozen springs break to the surface, flowing downhill to eventually join a creek that flows out the point of the tear. The valley bottom has deep, rich soils, with the hill sides sometimes sandy and droughty. Summertime is warm, sometimes over 100 degrees, sporting day after day of blue skies. The winter, on the other hand, causes temperatures to sometimes drop down to 28 degrees and accumulate as much as 50 inches of rain.

This is the foundation for the 15 diverse habitats and the historic ranch operations that have made the 300-acre, Quail Hollow Ranch County Park their home. The geology, hydrology, soils, and climate all combine to produce the necessary requirements for life in this sheltered valley.

Geology

Whether it's a delicate columbine flower, an annoying mosquito, a majestic oak, or thundering pack of coyote, all life needs the non-living, inorganic world to survive. **Geology** is the study of these non-living parts of the earth and how their movements and cycles provide the materials for living things. In this section we will discuss some of these geologic aspects of the environment including elements, minerals, rock types, plate tectonics, and theories as to how this land was formed.

All matter is made of different combinations of 102 **elements**. These elements link together into sometimes very complex molecules which become the building blocks for life. Most living things, whether a simple, single-celled amoeba, or an incredibly complex human being, are made mostly of four elements: hydrogen (H), oxygen (O), nitrogen (N), and carbon (C). Ninety-nine percent of all rocks on this planet are made up of combinations of eight elements: silicon (Si), oxygen, aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg).

These elements link together to create approximately 2,000 **minerals** which are the building blocks of the geologic world. Minerals are one or more chemical elements that must fulfill five criteria:

- ✓ They must be inorganic,
- ✓ be solids,
- ✓ occur naturally,
- ✓ have a similar chemical make-up wherever they are found,
- ✓ and be bonded in a repeating crystalline pattern.

As an example, look at a grain of salt up close. Each crystal is made of an orderly arrangement of sodium and chloride (NaCl). On the other hand, some minerals are made up of only one element as in the example of gold (Au) or silver (Ag).

When you have a substance occurring in mass, and made up of one or more minerals, then you have what is called a **rock**. For example, if you were to find a collection of three minerals: quartz, mica, and feldspar fused together in certain proportions, then you'd have the rock called granite. Contrast this with another rock, limestone, which is made of one mineral, calcium carbonate ($CaCO_3$), and you can begin to see how the different rocks come from different combinations and proportions of minerals.

Rock Types

Rocks can be formed in three distinct ways. One way has to do with the fact that the earth's interior is very hot and under a great amount of pressure, which causes rocks to melt. As these molten rocks cool, minerals form through crystallization. These rocks are called **igneous**, coming from the same root word as *ignite* and refers to fire. If the rock cools at a slow rate, then large crystals will form, producing rocks called *plutonic*. If the substance is cooled quickly, as in *volcanic* rocks, then a tinier grain will be seen.

Texture	Color		
Fine-grained (volcanic)	Rhyolite (light)	Andesite (medium)	Basalt (dark)
Coarse-grained (plutonic)	Granite (light)	Diorite (medium)	Gabbro (dark)

*taken from *A Natural History of California*, Schoenherr, 1992.

A second type of rock is called **sedimentary**. As the name suggests, these are rocks that have been weathered by wind, ice, or water; broken down into sediments like pebbles, sand, silt, clay, or mud; transported to another location and piled up to produce enough heat and pressure to compress the mixture into another rock. Only 5 percent of the earth is made of sedimentary rock, but 75 percent of the rocks on the surface are this type.

Sedimentary rocks can become layered through mechanical, chemical, or biological means. If they are created through mechanical origins, they are called **clastic**. These are rocks made up of at least 50% of a certain size particle, for example sand, and have been laid down by mechanical means, for example through water deposition. Sand particles compressed into a sedimentary rock are called sandstone, mud particles create mudstone, pebbles make a rock called conglomerate, and angular pebbles will become a type of conglomerate called breccia.

Other sedimentary rocks can have a chemical origin. This occurs when a chemical solution cannot hold any more of that substance so that the excess precipitates or settles out and accumulates into a sedimentary rock. For example, halite is a rock that is formed when there is so much sodium chloride (the same substance as table salt) trying to dissolve in a liquid, that the extra which can't be absorbed, piles up and is pressed together into a rock. Likewise, gypsum is made of calcium sulfate (which is later mined for plaster of paris), and chert comes from silicon dioxide or quartz.

The third type of sedimentary rock are ones with biological beginnings. Think of marine animals like mollusks, choral, or sponges that collect calcium carbonate from the water to make their shells. Eventually they die, and if there are enough to accumulate and become buried, then they can become a sedimentary rock like limestone, which often contain fossils. Coal is made in a similar fashion, when vegetative matter is slowly decomposed and then buried and compressed.

This brings us to the third type of rock-forming process, which produces **metamorphic** rocks, a term that means "after-form". These rocks are made by taking an igneous or sedimentary rock and burying it deep in the earth once again, but this time it is buried so deeply that the heat and pressure change the mineral composition and/or size. The rocks become plastic but not molten so that the characteristics of the parent rock can still be seen. These are the oldest rocks around, some dating back 3.5 billion years!

Metamorphic Rock	Appearance	Original Rock
Slate	Fine grain, laminar, splits easily.	Shale
Quartzite	Tough, visible grains, many colors.	Quartz sandstone
Schist	Splits easily, many fine layers, often rich in mica.	Slate
Gneiss	Thick banding, resembles granite.	Granite
Marble	Many colors, variously banded, fizzes with acid.	Limestone
Serpentine	Green to black in color, waxy surface.	Basalt, gabbro

*taken from *A Natural History of California,* Schoenherr, 1992.

How the Land was Formed

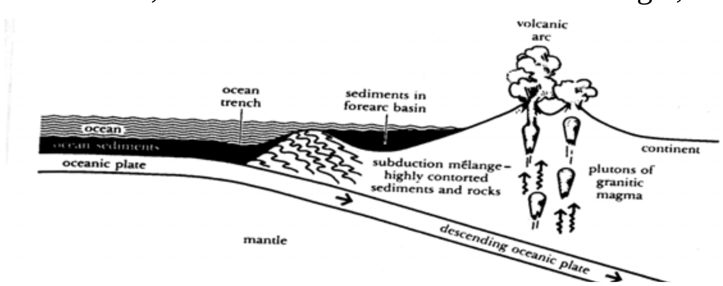
If we were to look at a cross-section of the earth, we would find that it is divided into three parts. The **crust** is the thin skin on which we walk, which measures about 22 miles at its thickest. It is 1/200 of the earth's diameter, which is comparable to a stamp pasted on a billiard ball. Under the crust is the **mantle** which is much hotter and denser than the surface because of the great amounts of pressure bearing down on it from the crust and heat cooking it from the core below. The **core** is where the heavier metals sank with gravity creating an area four to five times more dense than the surface. These three aspects of our planet are important to understand, especially when discussing plate tectonics.

When we talk about plate tectonics, we are referring to the crust and upper mantle which float like icebergs on the lower mantle. These floating plates bump into and pull away from one another resulting in a variety of effects:

✓ Ocean floors spread apart from each other, creating a gap, in which the mantle oozes up from below, giving birth to a new crust. The mid-atlantic ridge is an example of this activity.

✓ Two land masses can collide and produce a mountain range like the Himalayas.

✓ An oceanic plate can collide with a continental plate, forcing the thinner oceanic plate to be pushed under the thicker land mass in a process called **subduction**. The result is a coastal mountain range, as in the Cascades, or if subducted in a more extreme angle, forming volcanic islands like Japan.



✓ Two plates can slide past each other creating a fault line like the San Andreas fault.

✓ Hot spots in the mantle can heat up and "melt" the crust forming a volcano. As the crust moves, the volcano becomes inactive, but new ones are formed in a chain of mountain peaks. The Hawaiian Islands are a good example of this action.

Most geological changes like these happen very slowly, taking sometimes millions of years to occur. Others take place very quickly as in the explosive action of Mount St. Helens or the Loma Prieta Earthquake. **Volcanoes** tend to form along plate boundaries that are either being pushed together or pulled apart. As liquid lava flows from the break in the crust, it creates more land in the form of new igneous rock.

Earthquakes also tend to occur along plate margins. When two plates move in opposite directions, as in the case of the San Andreas fault, there are usually many imperceptible earthquakes happening. A problem arises, however, when the two sides get hung up and stop moving. Pressure builds, causing the two plates to bend like a bow until they snap back to a less stressed position. The resulting shock waves travel through the surrounding rock like ripples in a pond, sometimes causing sizeable damage.

Volcanoes, earthquakes, and other plate-tectonic changes are examples of how the land is built up, but there are other geologic processes that wear down the land. **Weathering** is the process of rocks cracking, crumbling, or chemically breaking down to smaller components. For example, when water freezes, it expands. If water gets into the crack of a rock and later freezes, it acts like a wedge extending the crack, eventually breaking the rock apart. Tree roots create the same action as they grow into the cracks of rocks. And chemicals in the air or water sometimes react with the minerals in rocks, causing the rocks to break down.

Once particles have been weathered, then the process of **erosion** can take place. Erosion occurs when particles are transported to another location, by water, wind, or ice. For example, water erosion happens when a fast flowing stream has enough energy to pick up rocks, sand, or soil and transport them downstream – creating a valley in its wake. It also occurs when ground water erodes bedrock creating caves, as well as when wave action carves coastal bluffs. Wind erosion, like water, occurs when fast moving currents pick up dry particles and propel them against other rocks like a sand blaster. Glacial erosion occurs when snow accumulates year after year, compressing snowflakes into interlocking ice crystals. As the weight of the glacier builds, it begins to move downhill, carving and transporting debris like a icy conveyor belt.

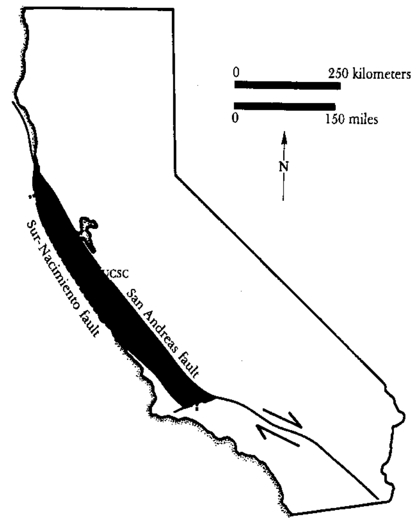
At the end of the process of erosion is another geologic building action called **deposition.** This occurs when water or wind slows and is unable to keep weathered particles in suspension. The material settles out in an alluvial fan at a mountain's base, a flood plain along river and stream banks, moraines along the sides and ends of glaciers, and by currents on the sea floor. With time, as more and more sediment is deposited, they may be cemented together into a rock.

The Formation of California

What does all of this have to do with life here in California? Rock formation, plate tectonics, weathering, and erosion play important roles in how our state began. In order to understand how California was formed, we have to go back in time more than 400 million years. At this time, the state was underwater, part of a shallow continental shelf, and moving away from the coast. Then about 400 million years ago this action reversed and California began moving toward the North American plate. The shore line was along the eastern portion of the state and as the two plates smashed into each other, the oceanic side subducted under the larger land mass.

As the thinner crust thrust itself deep into the underlying mantle, the land above began to "melt", creating volcanic islands off shore that might resemble Japan today. A deep trench emerged off shore as a result of the Pacific plate diving under the North American plate. This trench collected sediments over eons of time, sediments that were buried, formed rocks, and eventually would be uplifted into the coast range. As a result of all these processes the continent was slowly growing westward.

By about 210 million years ago the coast had a fairly "Andean" look, with mountains along the coast that would eventually become part of the Sierra Nevada range and a narrow continental shelf with a trench just beyond it. As time proceeded to about 65 million years ago, volcanism would be active along what is today's coast range, especially in the north, and the central valley was under water with about 40 million years worth of deposits filling it.



Then about 25 million years ago, the motion of the plates changed again and they began moving sideways, with the Pacific plate heading north, and the North American plate moving south. This created a fault block zone in which some blocks would rise, some would sink, and some would be carried sideways. One of these sideways moving masses, called the **Salinian block**, would eventually uplift into the central coast range. It is bordered on the east by the San Andreas fault, which has been offset as much as 200 to 300 miles! The central coast range, located on the Salinian block, is one of the most geologically active places on earth, moving about 2.2 inches per year.

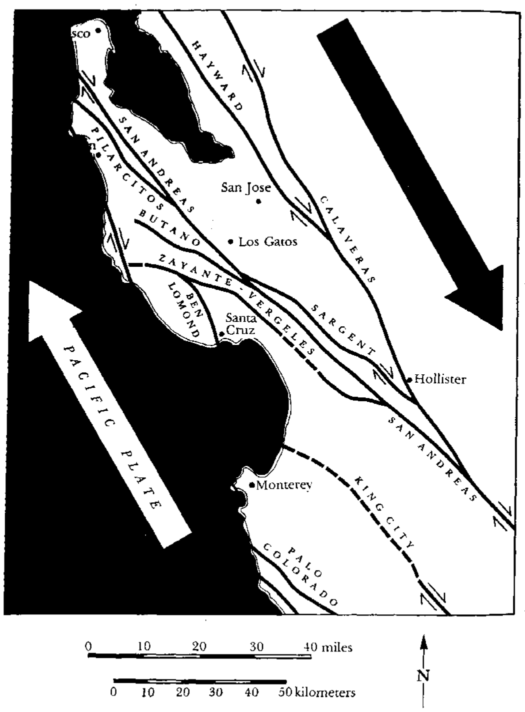
The Formation of the Santa Cruz Mountains

Up to this point, we have been looking at a big picture of how California was geologically formed. Now, let's take a closer look at these same geological processes on a more local level – action that helped shape the Santa Cruz mountains into what we see today.

In order to do this, we have to go back in time to a point about 65 million years ago, after the Pacific and North American plates had been smashed together forming the beginnings of the Sierra Nevada mountains along the ancient coast. At this time, the Santa Cruz mountains were not mountains at all but a shallow, tropical sea bottom. The mountains onshore were being weathered and eroded, with sediment deposited out to sea, accumulating, and compressing into rocks.

Then, about 50 to 35 million years ago, this flat ocean bottom uplifted, folded, faulted, and eroded, sinking back into the shallow sea where it was covered with more sediments. The process was similar to a rug being pushed under a door. As the rug squishes into the thin gap, occasionally it gets hung up and the forward motion piles material up against the door. Likewise, as the Pacific plate dove under the mountains on shore, it would get caught up, and the forward motion would produce a mountain range rising up out of the sea. As the plate started moving again, the mountains dropped and were once again covered with sediment.

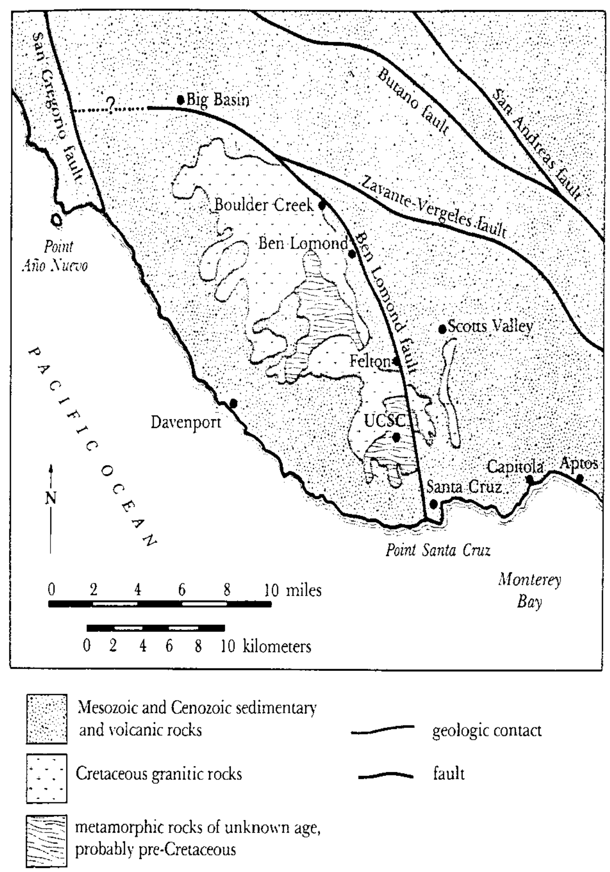
Approximately 25 million years ago, this movement changed and the two plates began running sideways to each other. The 300-mile-long and 30-mile-wide Salinian block, mentioned above, was born at this time, with the San Andreas fault on its eastern flank, and the Nacimiento fault to the west. As the block moved north, its southern, granitic formations from the Sierra, and built-up sediment layers off shore, were torn away. More than 200 miles later, these igneous and sedimentary rocks would find themselves surrounded by a completely different geologic complex.



The next geologic chapter occurred from about 15 to 5 million years ago. It was at this time that this area once again lifted to form a mountain range, eroded, and dropped back into the ocean. However, this time when it sank back into the shallow sea, the material that covered the mountains was at first silt and clay, which would eventually become Monterey shale, and then sand, creating the Santa Margarita sandstone formation. As the sea deepened the deposits became mud, forming the Santa Cruz mudstone layer on top.

Finally, about 3 million years ago, the land uplifted a third time. This time, as the Salinian block moved northward, the land buckled, producing north-south ridges or folds that are present in today's topography. It is estimated that during this last uplifting thrust, these mountains have raised some 1,000 feet and is still rising as we saw in the Loma Prieta earthquake of 1989. Because of this rapid movement, slopes tend to be steep causing accelerated erosion and landslides.

What About Quail Hollow Ranch?



You may be asking yourself what all of this has to do with Quail Hollow Ranch County Park. Well, after the mountains had descended into the sea the second time, about 10 million years ago, deposits were laid, creating the three main rock types that are found in the park today. First silt and clay were deposited, later to become the layer of Monterey shale; then sand compressed into the Santa Margarita sandstone above, followed by mud, creating the Santa Cruz mudstone on top.

About 3 million years ago these sedimentary rocks rose to form the Santa Cruz mountain range. As this mountain block quickly ascended, faulting and cracking of the crust occurred. Several fault lines developed near the park, including:

- ✓ a surface trace of the San Andreas fault, 15 miles to the north-east
- ✓ the Butano fault, 6 miles to the north-east
- ✓ the Zayante fault, 2 miles to the north-east
- ✓ and the Ben Lomond fault, 1.5 miles to the west.

Where ever you find a fault line, you also find zones of broken rock and easily eroded material. Flowing water, which seeks the easiest way downhill, seem to gravitate toward these cracks in the ground, eroding them into streams and rivers. Locally, the San Lorenzo river is one example of this phenomenon, located near the Ben Lomond fault.

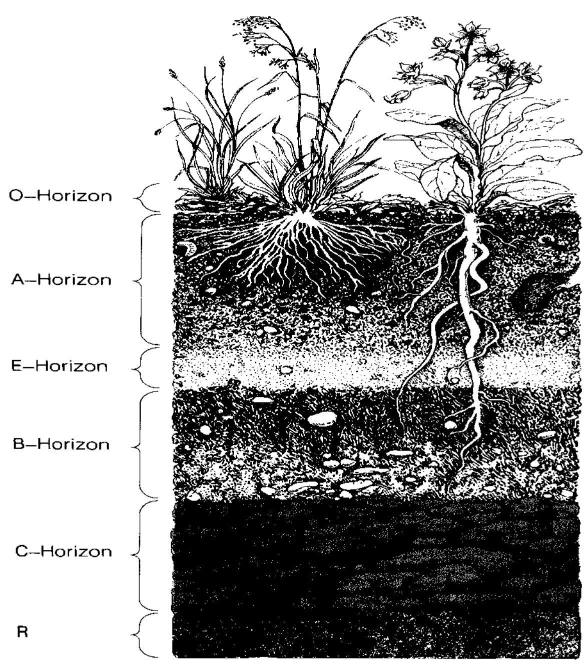
Within the park, one finds the valley bottom containing a bedrock of Monterey shale stretching as far as 300 to 400 feet below the surface. The sides of the ridges are made of Santa Margarita sandstone which makes a great, underground aquifer because it is highly porous and can collect water in spaces between the sand. Along the top of the ridgelines one finds the remnants of Santa Cruz mudstone. Over tens of thousands of years, the upper layers of sandstone and mudstone have eroded into colluvial and alluvial fans with deposits up to 50 feet deep.

So all of this talk about minerals and rocks and plate movement is important in understanding the basis for life here, at Quail Hollow Ranch. The geology of an area has a direct bearing on the soil types and hydrology, and from there the potential habitats that a place can support. Ultimately, the number and variety of flowers, trees, birds, bugs and others, depend on the gradual building up and tearing down forces of rock happening through eons of time – they depend on geology.

Soils

"Below that thin layer comprising the delicate organism known as the soil, is a planet as lifeless as the moon," according to G.Y. Jacks and R.O. Whyte. As you follow this lifeless collection of minerals and rocks up to the surface, eventually it will spring to life in a dynamic layer of organic and inorganic material from which all other terrestrial life is born. Indirectly, it provides us with food to eat, clothes to wear, air to breathe, and, if mismanaged, have been the cause of civilizations collapsing. How can this thin, upper layer of crust have such a tremendous impact on our lives? To answer that, we have to take a closer look at this important foundation of life.

Have you ever looked closely at a handful of soil? If you have, you would see that it was made up of inorganic materials like sand, silt, and clay – or weathered parts of the geologic world – and also organic matter in the process of decomposing. Mixed in between these components you would find living organisms, water, and air spaces. As you dug deeper into the earth, you would find the proportions of living and non-living ingredients changing, sometimes fairly abruptly. These layers are called **soil horizons**, and if we looked at a cross-section of all the horizons, we would have a **soil profile**. Soils can have as many as five horizons, but most have only three or four.



Soil Horizons

The upper-most layer of the soil is called the **O horizon**. Think of "O" standing for "organic" and you have a good start on understanding of what this layer is made. It is comprised mostly of surface litter like newly fallen and partially decomposed leaves, twigs, and animal waste. There are very few inorganic rock particles found here.

As you move down the soil profile, the next layer you find is called the **A horizon**. This is the portion of soil made up of a mixture of eroded minerals, partially decomposed organic matter, and living organisms. It is the topsoil horizon which is dark and loose, and probably where you got that handful of soil to observe at the beginning of this section.

The A and O horizons are the zones where roots grow and organisms like bacteria, fungi, mold, earthworms, insects, and burrowing animals live. These are also the layers where **decomposition** takes place. Decomposers, like bacteria, breakdown organic and inorganic material into water soluble nutrients, which are absorbed by plant roots for use in making food.

Below the A horizon is the **B horizon**, which comprises an accumulation of leached material from it's own layer and from above. As water percolates through the soil, it carries materials from the O and A horizons down to this subsoil level where it accumulates and forms the darkest brown or reddest layers.

The next layer in the soil profile is the **C horizon**, which is slightly altered bedrock. This is the portion that is thought to have been present at the beginning of soil formation.

Soil Formation

If you look at the soil profile here at Quail Hollow Ranch and compare it to the soil profile in Santa Cruz, you would probably find a difference in the type and thickness of the horizons. Soils change from place to place because the environmental conditions that cause them change. There are five factors that influence the development of soils:

- ✓ climate
- ✓ vegetation
- ✓ time
- ✓ parent material
- ✓ and topographic position.

Climate and vegetation are closely linked, in that the amount and type of vegetation depends on the climate, or the amount of rain. Both impact the soil: by the amount of organic material, in the case of vegetation, and by the amount of leaching, in the case of climate. Complete soil profiles take a long time to develop. The A horizon can take several hundred years to form in the humid environments, and several thousand years in arctic or alpine habitats. B horizons need anywhere from 1,000 to 100,000 years to mature, and some profiles have been estimated at an age of one million years or more! This explains why it is so important to care for our soils, and hints at the reason why some civilizations have collapsed through neglect of their soil.

The make-up of the parent material, or bedrock, is important because different minerals weather at different rates and provide the soil with different nutrients. Likewise, the topography will impact the rate in which a soil forms, in that steep slopes promote erosion, while valleys accumulate sediment. Soils in Santa Cruz county tend to be thicker and better developed than in other places in central California probably because of its warm, humid climate which causes a lush vegetative growth.

Plant Nutrients

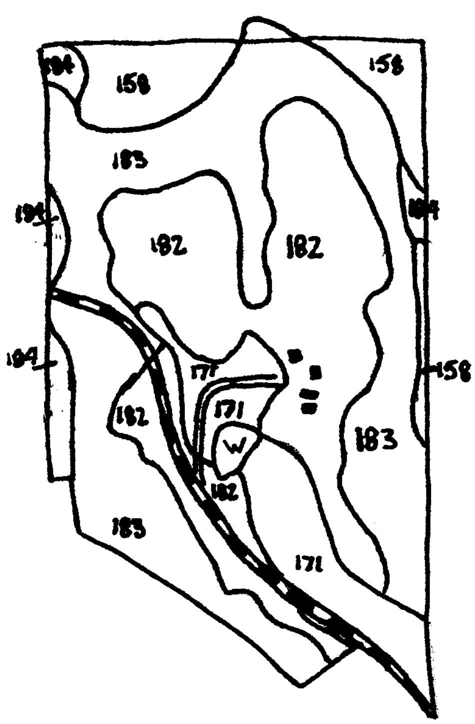
All soils have the mechanical means to support life: they have mineral particles, organic matter, and pore spaces. But that doesn't explain why one lawn is lush and green, while others look more yellow and bedraggled. The difference is because there are a collection of essential plant nutrients that are necessary for healthy growth. It's like eating a balanced meal that provides us with health and vitality – the same is true for plants.

What are these nutrients and why are they important? They are compounds that provides a certain function in plant growth. If lacking, a plant will show a set of "hunger signs" signifying a deficiency. In the past, 16 chemical nutrients were identified as essential, however, it has been estimated that as many as 50 nutrients can be absorbed by a plant. The following list identifies the most common essential nutrients:

- ✓ **Nitrogen** (N) – produces above-ground growth, provides that rich, green color, and influences fruit quality.
- ✓ **Phosphorus** (P) – plays an important role in energy transfer and is abundant in fruits, roots, and seeds.
- ✓ **Potassium** (K) – encourages root development, aids in vigor and vitality, plays a role in starch synthesis and translocation of carbohydrates.
- ✓ **Calcium** (Ca) – provides the structural portion of the plant's cell walls.
- ✓ **Magnesium** (Mg) – stimulates the utilization of phosphorus by the plant.
- ✓ **Sulfur** (S) – is a part of plant proteins and hormones.

Quail Hollow Soils

What about Quail Hollow Ranch, you may be asking. There are three types of soil found in the park: the Zayante complex, Soquel loam, and Nisene/Aptos complex. The most common of these is the Zayante complex which is divided into three sub-categories:



- ✓ Zayante coarse sand which is found on 5 to 30 percent slopes (182)
- ✓ Zayante coarse sand which is found on 30 to 50 percent slopes (183)
- ✓ Zayante rock outcrop complex, found on 15 to 75 percent slopes. (184)

Collectively, these three sub-categories are located on the hill-sides of the park, and were formed from marine sediment like the Santa Margarita sandstone. Because they have a high sand content, water easily permeates and drains through them. The surface layers are a grey to brown color with a medium to strongly acid ph, while the underlying layers are a medium acid to neutral ph. Thin stands of Ponderosa Pine do well in these areas, as do a variety of wildlife. The differences between the three Zayante sub-categories lies in their slopes, runoff rates, and erosion hazards. The Zayante rock outcrop has the highest runoff rates and erosion hazards, with the Zayante coarse sand (5-30%) having only moderate runoff and erosion.

The next type of soil, called Soquel loam (171), is found in the center of the valley, in the relatively flat meadows and stream corridors. They are usually formed on sedimentary alluvial deposits. The upper layers of this brown, slightly-acidic soil is about 21 inches thick, with an underlying neutral silt loam about 16 inches thick over a silty clay loam about 14 inches thick, and the lowest portion being a yellowish-brown neutral loam. Because the sediments in this soil are smaller, water permeates much slower than the Zayante complex. When this soil is managed well, it can be very productive, which explains the historic agricultural uses that have taken place here.

The Nisene/Aptos complex is a combination of more than one soil type, consisting of about 35 percent Aptos fine, sandy loam and 30 percent Nisene loam. When we look at the combination traits of these two soils, we find a deep, well-drained soil formed from sandstone and shale. Its profile would be toped with an inch or two of partially decomposed leaves, twigs, needles and other organic matter. The surface layers would be a greyish-brown, slightly acid, clay-to-sandy loam, with a brown, acid, clay-loam subsoil. These soils are mainly used for timber, recreation, watershed, and wildlife habitat.

Soil	Permeability	Effective Rooting Depth	Available Water Capacity	Runoff Rate	Erosion Hazard
Zayante Complex	rapid	60 inches	2.5 to 5.0 inches	rapid	slight to very high
Soquel Loam	moderately slow	60 inches	8.5 to 10.5 inches	slow to medium	slight to moderate
Nisene/Aptos Complex	moderate	20 to 60 inches	2.5 to 10.5 inches	rapid to very rapid	very high

As we look from soil type to soil type, we find that the soil is the foundation from which any given habitat will arise. If a soil is deep and rich with a well-developed profile, it will support a more lush, green forest than a shallow, sandy, well-drained soil. It is that magic place where the organic and inorganic worlds meet to create a dark, moist womb from which the rest of terrestrial life springs.

Hydrology

Loren Eisley said, "If there is magic on this planet, it is in water." Indeed, this is a water planet, covering nearly 3/4, or 71 percent of the surface. All living things contain anywhere from 50 to 97 percent water, with the human body made up of 70 percent of this amazing compound. What's so special about water, and what does it have to do with Quail Hollow Ranch? The answer to these questions lead us into a discussion not only about the properties of water, but also about its connection to life.

Water Properties

The physical properties of water are ones that hint at the life-giving traits of this incredible substance:

✓ It has a high boiling point (100ºC or 212ºF) and a high melting point (0ºC or 32ºF). This means that water does not turn to a gas unless it is a very high temperature, higher than the earth's temperature, which allows for the existence of oceans, lakes and streams.

✓ It has a high heat of vaporization, which has a double meaning: it absorbs heat when it evaporates, which is why we cool when we perspire, and it gives off heat when it condenses and rains, allowing heat to be distributed throughout the world.

- ✓ Water has a high heat capacity, meaning it can absorb large amounts of heat without reflecting this in its temperature. This allows large bodies of water to remain at a fairly constant temperature, providing a moderate climate, and preventing the shock of temperature change for animals.
- ✓ Water is a good solvent. It is able to carry nutrients through the soil to plants, it flushes waste from tissues, and is an all round cleanser.
- ✓ It has a high surface tension and a high wetting ability, which means that its molecules can link together and can be pulled upwards into plants, carrying along with it dissolved nutrients, in a process called **capillary action.**
- ✓ Finally, water expands and does not contract when it freezes, giving it the ability to weather rocks down into gravel, as mentioned in the geology section above. It also has a lower density when it is frozen, allowing ice to float and not freeze from the bottom of a lake to the top.

As we can see, water is an amazing substance. Yet, we tend to take it for granted. When we look at how much water is available for us to live, we find that the amount is surprisingly small. Seventy-one percent of the surface of the earth is covered with water, and of that amount, 97 percent is salt water. The remaining 3 percent finds 2.5 percent unavailable because it is locked up in glaciers or too deep underground to use. That leaves us with 0.5 percent available in rivers, streams, lakes, and wells. If we subtract the amount that is polluted or too expensive to tap, then we have 0.003 percent remaining. To put this into perspective, if we were to compare the total amount of water on the earth to a 100 liter container (about 26 gallons), then the useable 0.003 percent would equal ½ teaspoon!

Local Hydrology

The fresh water that is available locally, can be found in the San Lorenzo watershed. A **watershed** is an area of land that includes a river and all its tributaries. Imagine a drop of rain falling on the ground, eventually to flow underground, through the soil, into a creek, and from there into streams, rivers, and eventually the ocean. Anywhere that rain falls, eventually joining the ocean from a given river, is part of the watershed. The San Lorenzo river is one of the many north-south running waterways that tend to follow north-south-running ridge lines typical of the Salinian block.

When we take a closer look at the 300-acre Quail Hollow Ranch, we find the entire park is part of the state protected waterway of the San Lorenzo watershed. Most of the property drains into the Quail Hollow creek, and from there to the Zayante creek, to the San Lorenzo river, and on to the Pacific ocean. The north-west corner drains into Newell creek, and the north-east portion find its way into Lompico creek, both of which eventually join the San Lorenzo river.

You may remember the geologic discussion describing the formation of the sedimentary rocks in the park. The bottom layers are comprised of Monterey shale with a layer of Santa Margarita sandstone above, and Santa Cruz mudstone along the tops of all the ridge lines. The Santa Margarita sandstone is an excellent **aquifer**, which is a rock formation with a high capacity for holding water in its pore spaces. This sandstone layer is not just a good aquifer for the park, but collectively it provides 90 percent of the drinking water for the San Lorenzo and Scotts Valley water districts. The Monterey shale underneath becomes a base with the permeable sandstone accumulating water between the sand grains. Essentially, these rock layers act like holding tanks, accumulating water from the rainy season, releasing it into springs and creeks during the dryer times of year.

A drop of water that lands along the ridges of the Quail Hollow valley could be absorbed into the Santa

Margarita sandstone and held there for quite a while, until it made its way to a well, spring, pond, or creek, and from there, eventually on to the sea. According to the park's Environmental Impact Report (EIR), there are 2 wells located on the property: one near the southern end of the ranch, containing unknown water quality, and the other near the water tanks to the west of the road. This second well was constructed in 1955 and acted as a water supply for the pond and irrigation. It contained excellent water quality when tested in 1975 but by 1987 had become contaminated.

In the park, several springs exist, some contained by a concrete vault at their source. One is located at the turn in the entry road, another along the lower chaparral loop, a third in the willows next to the parking lot, and a fourth about 200 ft north of the main ranch house in the eucalyptus trees. There are several other springs on the property that are less accessible.

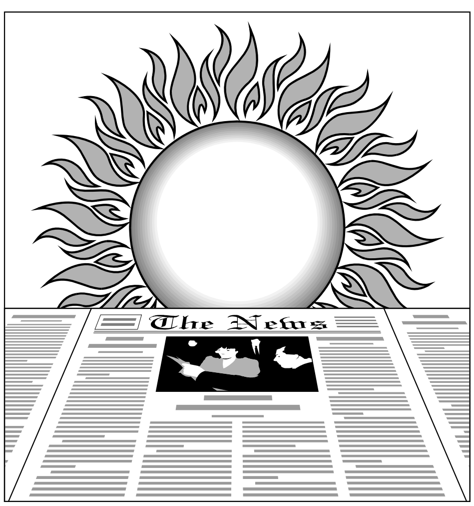
The pond was created in 1952 at an area described as "boggy" by the construction crews who built it. It was created for domestic and irrigation uses, fed by springs whose runoff is currently diverted into drainage ditches running to the pond. Overflow from the pond empties into the Quail Hollow creek.

The circle of slopes that drain into Quail Hollow creek range in elevation from 400 to 1080 feet. Average annual rainfall in nearby Ben Lomond is 48.7 inches with a range from 22 to 98 inches. As all that rain is caught in the palm of this valley, the soils and aquifer are recharged, sometimes held in the Santa Margarita sandstone aquifer, sometimes held in the pond until it makes its way back to the ocean where it is recycled again.

Everybody Talks About the Weather…

By Janet Wood Duncan

Aside from an occasional look at old weather records to see if is really *is* hotter, or colder, or wetter that it has ever been before, we rarely think of weather as having a history. But in the natural world where – as John Muir assures us – everything "is hitched to everything else in the universe", we discover that even a quick look at the geologic history of the Santa Cruz mountains can provide us with an excellent starting place for understanding the unique and remarkably varied weather conditions of our area.



Some time during the Pleistocene Epoch (over a million years ago), a period of extensive faulting and uplifting broke the back of the Santa Cruz range in several places and the "pieces" were shifted and tilted like trapdoors. (Ben Lomond mountain and Butano ridge which form the primary boundaries of the Big Basin are two of these pieces.) While all this shifting and jumbling of rock eventually resulted in what geologists fondly refer to as the "Coast Range nightmare", it also left us with a strange and wonderful terrain where valleys and ridges run in complicated patterns at odd angles to each other. This, coupled with our location on the western edge of a mighty continent, smack up against the eastern edge of the planet's greatest ocean, has set the stage for some often rather bizarre weather conditions. At certain times of the year, a docent may find that although a thick, dreamy fog is creeping up the canyons of Nisene Marks, sunshine is blazing on the meadow at Cowell, and only 6 miles away a steady rain is falling on the floor of the Basin.

Despite the fact that meteorology is an unpredictable and complicated field, there are actually only a handful of fundamental principles that shape the raw materials of temperature, moisture, barometric pressure, and air currents into what we call "the weather".

An understanding of the weather of the Santa Cruz mountains begins with four of these basic principles:

1. Warm air is light and rises, while cold air is heavy and sinks.
2. Warm air can hold more moisture than cold air.
3. Nature abhors a vacuum.
4. The earth is spinning.

Let's start with the spinning earth.

The minute we set a planet in axial motion, we guarantee that it will present one face to the sun's rays during the day – allowing its surface and atmosphere to be heated, and turn away at night – when everything has a chance to cool down. If we tilt our planet 23.5 degrees off its axis, we have added another factor – our days and nights will vary in the duration depending on the time of year. Already we have set our air currents in motion. (See principle number 1.)

Now, close you eyes and imagine trying to draw a straight vertical line on a spinning ball. When you open them, you will find that no matter how steady your hand, the line is curved. This tendency for straight lines to curve on a spinning surface (to the right in the northern hemisphere), is known as **Coriolis force**. Even air currents respond to Coriolis force, so now we have introduced "spin" into our up/down patterns. We are now ready to return to the Santa Cruz mountains.

As spring approaches, the air over the Pacific equator is heated by the sun and heads northward toward the Arctic. Some of it cools and begins to sink back to earth, creating a column of cool air pressing down on the surface. This "high pressure" area settles down and typically holds a position about 1000 miles off the coast of central California throughout the summer, spinning merrily away in a clockwise direction, sending all rain and storm patterns bouncing up into the northwestern U.S. and pushing the surface of the ocean southward down the California coast. These ocean currents are also subjected to Coriolis force and so they begin to curve away from the continent. Since nature abhors a vacuum, cold water wells up from the depths and creates a condition well known to surfers and divers – the waters off the coast of Northern California are much colder in summer than in winter.

Although we share a Mediterranean climate (hot, dry summers and mild, moist winters) with several other spots on earth, this upwelling of cold water adds a wrinkle that is ours alone – one that affects air travelers, tourists and songwriters, and allows a relict species of conifers from the age of the dinosaurs to survive here for a few millennia more – when the warm, moisture-laden Pacific air contacts and is cooled by this offshore current, it condenses into fog. (see principle #2)

Meanwhile, as this little drama is being played out by the Pacific high, something quite different is taking place in the inland valleys. Here, the spring and summer sun is warming the air, causing it to rise. Sheltered by the mountains to the west, it, too, forms a column of air but this time it is floating upward, creating an area of low pressure which rotates in a counter-clockwise direction. The warm, rising air creates a void and nature rushes to fill it (principle #3). If the coast range behaved like most selfrespecting mountain ranges, it would form a barrier to the west and nature would fill her vacuum with continental air masses. But in the Bay Area, the ocean and continental masses meet in a wild dance thanks to the imposing gap we call the Golden Gate. The massive, coastal fog bank (which may be as much as 100 miles wide) that has been resting comfortably off the shoreline, is suddenly pressed into service, and begins streaming not only through the Gate, but into the many passes and gaps in the Santa Cruz mountains. As soon as equilibrium is more or less restored, it dissipates or recedes. Throughout the long, hot, rainless summers, this so-called "natural air conditioning" not only keeps our temperatures delightfully moderate, but condenses on leaves and branches and provides life-giving moisture to the shallow roots of our magnificent Coast Redwoods in a process known as "fog drip".

With the onset of autumn, the massive Pacific high begins to drift slowly southward with the sun. The inland valley temperatures drop off and the cold upwelling of water along the coast ceases. The rest of the continent slips slowly into winter, but because the Pacific Ocean absorbs the sun far more slowly than the continent, it reaches its maximum temperature in September and October, rather than July and August. In the Santa Cruz mountains – along with the rest of the central California coast – the sun shines uninterrupted, sending temperatures soaring, the natives to the beaches, and fire lookouts to their towers.

The summer honeymoon eventually ends around early November when, with no Pacific high to bar the way, the rain storms begin marching in bands across the ocean to strike the coast. These low pressure systems with their counterclockwise rotations, suck warm, moist, southern air along their leading edges. When they strike the continent, they are cooled and drop their moisture (principle #2).

And now we return to the beginning of our story and the "coast range nightmare" of the Santa Cruz mountains, with their jumbled assortment of irregular ridges and valleys. The mountains, which may have received no rainfall at all for the previous 6 months, are suddenly inundated. Quirky shifts in wind velocity and direction are magnified by the quirks of the convoluted topography itself. Valleys opening to the south into Monterey Bay funnel the southerly winds up their canyons, cooling the air as it goes and often increasing rainfall with each mile. The town of Boulder Creek, for example, located at the north end of the San Lorenzo valley, occasionally receives several inches of pouring rain while Felton (only 6 miles to the south in the same valley) is wrapped in a light mist. The San Lorenzo valley has an annual average rainfall of 60 inches, nearly all of it falling between November through April. In contrast, the Santa Clara valley, which runs parallel barely 15 miles to the east, but beyond the last ridge and opening to the north, receives a mere 13 inches on average.

The impact of all this meteorological diversity and unpredictability on the ecology of the mountains is written all around us. Nature will fill her niches no matter how unusual the conditions seem to us. Hike the chaparral to see what she has fashioned to survive the long months of blazing sunlight followed by the winter months of seemingly endless rains. Spend some time in the redwood forests and see if you can identify the canyons where the fogs tend to "pool" in the summertime and which ones are rarely touched. Check out her handiwork on the beaches where there is salt air, plenty of moisture but little summer sun.

And remember: if you don't like the weather where you are – take a hike.

A Note on Fires

The message "only you can prevent forest fires" was delivered to a generation of people by an orphaned brown bear topped with a ranger hat. At the time, fire was looked on as destructive; something that destroyed plants, animals, and property; and was to be stopped at all costs. Today we know differently. It is not destructive, but an agent of change. Just as the process of photosynthesis converts light energy to chemical energy, fire converts chemical energy to heat energy. The amount of heat produced depends on the amount of chemical energy burned.

What happens when a fire burns is the breaking down of complex molecules to simple ones. It is similar to our own food digestion. Chewing and stomach acids break up food into smaller, simpler molecules which are used by the body to rebuild tissue. Likewise, burning fire breaks up wood and other fuel into water soluble nutrients which are absorbed into the soil and from there to plants.

Fire is cyclic, with some areas having fires every 30 to 100 years, while others occurring every 200 to 300 years. Over eons of time, as periodic fires stressed habitats over and over, these various ecosystems not only recovered, but adapted to, and in some cases began to require fire. The knobcone forest is an example, which requires fire to open their cones, thus releasing seeds to fall on a newly cleared forest floor, allowing a new generation of trees to grow.

A forest is not just trees. It is a complex relationship between trees, shrubs, grasses, flowers, animals of different sizes, microbes, bacteria, soil, minerals, nutrients, air, and more. When a fire enters the picture, it helps keep the forest and other habitats dynamic by opening up the canopy and allowing a new succession cycle to begin. **Succession** is the process of an ecosystem changing and evolving from meadow, to shrub, to forest, to fire, to meadow again.

Approximately 85 percent of all wild fires are started by people, which explains why the Smokey Bear message became popular. However, it is important to understand that there are two different types of wild fires: crown fires and ground fires. **Crown fires** burn where the name suggests: up in the tree crown. These are fires that are so hot that they burn the entire habitat – grasses, shrubs, trees, roots, animals... everything. They occur where fires have been prevented for long enough to allow an accumulation of dead wood, ground litter, and other combustible fuel. Eventually the fuel ignites and burns intensely enough to ignite tree tops.

On the other hand, **ground fires** burn only the undergrowth and usually do not harm trees or animals. They provide many benefits:

- ✓ They reduce the amount of undergrowth and fuel which could accumulate and become a crown fire.
- ✓ They release and recycle plant nutrients, which were tied up in dead and decomposing material.
- ✓ Ground fires increase the activity of nitrogen-fixing bacteria adding more of this valuable nutrient to the soil.
- ✓ They help control pests and disease.
- ✓ Ground fires are necessary for some species of plants to germinate their seeds.
- ✓ And, finally, they help many species of animals by maintaining their habitat and providing food that sprouts after the blaze.

"Natural" ground fires are bound to burn as soon as certain conditions exist: there is enough combustible fuel, enough air, and an ignition source. In the past, when these condition had been met, the area would burn. Frequency determined readiness. With the advent of the "Smokey-the-Bear syndrome", fires were deterred, but it was impossible to completely eliminate them. Thus began the reign of the crown fires.

Today, we have learned yet another lesson in the value of allowing "mother nature" to do her thing. The "prevention of forest fires" did curb the human caused ignitions, but at the cost of thousands of acres of denuded habitat. These days prescribed burns are common, allowing natural cycles of succession to continue and to provide for a healthier more dynamic natural world.

Conclusion

If we were to fly over Quail Hollow Ranch County Park to get a bird's eye view of the place, we would see a lovely, green valley, lined by a ring of ridges, drained by several springs and a creek, occasional landslide scaring the hills. All of these things – the geologic recipe that provided the rocks in the ridges, the erosion of rocks into a collection of life-giving soils, the "sponge-like" qualities of the hills creating a reservoir of water for the dry season, the many changing moods of the weather, and even the possible effects of that "agent of change": fire – they all provide the backdrop for the type of flora and fauna that will inhabit the place.

The natural world is a dynamic, changing relationship between its living and non-living parts. Each part influences the whole, but the inorganic ingredients provide the foundation. The title of this section, Shaping the Environment, describes it well. The geology, soils, hydrology, weather, and even fire shape and influence the environment in order to provide for life.

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