CHAPTER 2

The Physical World

The physical world of the Klamath Mountains is the template upon which its biological diversity has been built. The physiography of the Klamaths is very rugged but less uplifted than the Sierra Nevada. Whereas the peaks of the Sierra Nevada rise to over 14,000 feet, the highest peak in the Klamath Mountains, Mount Eddy, is a whopping 9,025 feet. Thompson Peak, at 9,002 feet, is a close second, but anyone who has climbed it (I've only come close, never having been much of a rock climber) knows that it is more challenging than many peaks thousands of feet higher. Thompson Peak protects the only glaciers left in the range, which are more properly described as glacierets, being not much more than permanent snowfields. Most of the ridgelines across the region range from 5,000 to 7,000 feet, forming a relatively level series of ridges that geologists call accordant summits. This formation helps to center visitors: one always feels in the middle, and usually in the middle of steep country. One finds very little flat country in the Klamaths, which is why the people of the Klamaths have always been and will always be people of the rivers. The alluvial land adjacent to streams has not only provided resources but offered a flat place to establish villages. Typical upriver tributary settlements, such as Sawyer's Bar and Cecilville, cling to the flatter ground next to the river's edge. The only four broad valleys of note within the Klamath region are Hayfork and Scott Valleys, both primarily agricultural centers; the upper Trinity River, now the bed of Trinity Lake; and Hoopa Valley, on the west edge of the Klamath Mountains.

The rugged terrain is so difficult to navigate that significant landscape features are still being discovered. In summer 2005, Superintendent Jim Milestone of Whiskeytown National Recreation Area announced the discovery of a 400-foot cataract along Crystal Creek that was not on any U.S. Geological Survey topographic maps and was known to only a few individuals. The cataract had been hidden by steep terrain and thick vegetation, although the Indians and early gold miners likely knew about it. It is such a spectacular falls, clearly among the largest in the entire Klamath range, that a trail has now been constructed to it.

The major rivers of the Klamath Mountains flow transverse to the orientation of the geology. Whereas the major geological formations are oriented north-south, Clear Creek, which flows into Whiskeytown Lake, eventually empties east into the Sacramento River; the Klamath and Trinity Rivers generally flow westerly in a convoluted serpentine to the Pacific; and the Applegate River flows into the westerly trending Rogue River in southern Oregon. This “flow to nowhere” has meant little protection, until recently, for the Klamath and Trinity rivers, as natural river flows have been considered a waste of water. Hydraulic mining was not curtailed here, as in the Sierra Nevada, because the Klamaths had few downstream farmers. The sheer volume of water wasting to the west had water engineers yearning for dams for most of the twentieth century. The abundant, clear water has created complex drainage patterns and equally complex names. Poor McClaron had his gold mine on the East Branch of the East Fork of the North Fork of the Trinity River. The water knows where it’s going, but the miners probably had a tough time getting their directions right. We know the country was tough because of all the “gulches” knifing into steep mountains: it is the real West. Some names are repetitive (two Bear Gulches lie within 7 miles of each other east of Trinity Lake), some are hopeful (Rich Gulch), and some are rueful (Drunken Gulch). We can be grateful that not a single “brook” appears in the Klamath Mountains, except the obvious nonnative interloper, the eastern brook trout. The region has plenty of creeks, and they are pronounced the way they are spelled, eschewing the pseudotough “crick” of the Rocky Mountains.

Scientists typically describe the climate of the Klamath Mountains as Mediterranean, but like many classifications, this one is not a totally accurate. Watching the sunset in the Trinity Alps, one is not struck by a climatic resemblance to true Mediterranean regions like Barcelona or

Los Angeles, although on my last trip to Barcelona, I was greeted by a foot of snow, so maybe the classification isn't so bad after all. A Mediterranean climate offers cool, wet winters and warm, dry summers, with a pronounced summer drought. These elements the Klamath Mountains have. But there is a lot of variation across the region, and the higher elevations have a much shorter growing season and cooler summer temperatures than do other parts of the region. A montane Mediterranean climate is perhaps the most accurate descriptor.

At the coast, summer fog mediates the warmth, and the trees intercept the fog and turn it into rain, a phenomenon called fog drip. Fog drip can actually increase annual precipitation 10 to 20 inches in locations where fog is common in the summer, such as the redwood belt along the coast. Interior warming essentially sucks marine air up the coastal valleys, and until the valleys warm sufficiently late in the day to evaporate the fog, the mist keeps the valleys cool and moist. Mark Twain reportedly said that the worst winter he ever spent was a summer in San Francisco, because of the fog. The coast also tends to be wet. Honeydew, along the southern coast of Humboldt County, is the wettest place in California, averaging over 104 inches of precipitation per year. But the rain doesn't come all at once; instead it drips in day by drippy day, a quarter inch here, and a half inch there. Even in flood times, only 5 to 8 inches fall in a day. But if the rain is warm and falls on snow, world-class floods can result. The state record for one day of precipitation is elsewhere: in Southern California, where a whopping 26 inches fell in one wet January day at Hoegees Camp in 1943. No one keeps weather records there anymore, so perhaps the station washed away. The Klamaths do have the state record for number of consecutive days with measurable precipitation: in 1998, Gasquet Ranger Station had 63 straight days with enough rain to record in a rain gauge.

Inland a few miles, the climate is more typically Mediterranean, except that the winters tend to receive more precipitation than is typically Mediterranean (see figure 3). Willow Creek, Orleans, and Happy Camp all receive over 50 inches a year, mostly as rain. Annual precipitation tends to decrease as one moves inland. Weed, Yreka, and Callahan, for example, receive only 20 to 25 inches a year, because they are in the rain shadow of mountains to the southwest, where most of the storms come from. They are also colder in the winter, so some of this precipitation comes as snow, as it does in higher mountainous areas. In the eastern Klamaths is an "island" of higher precipitation that bucks the

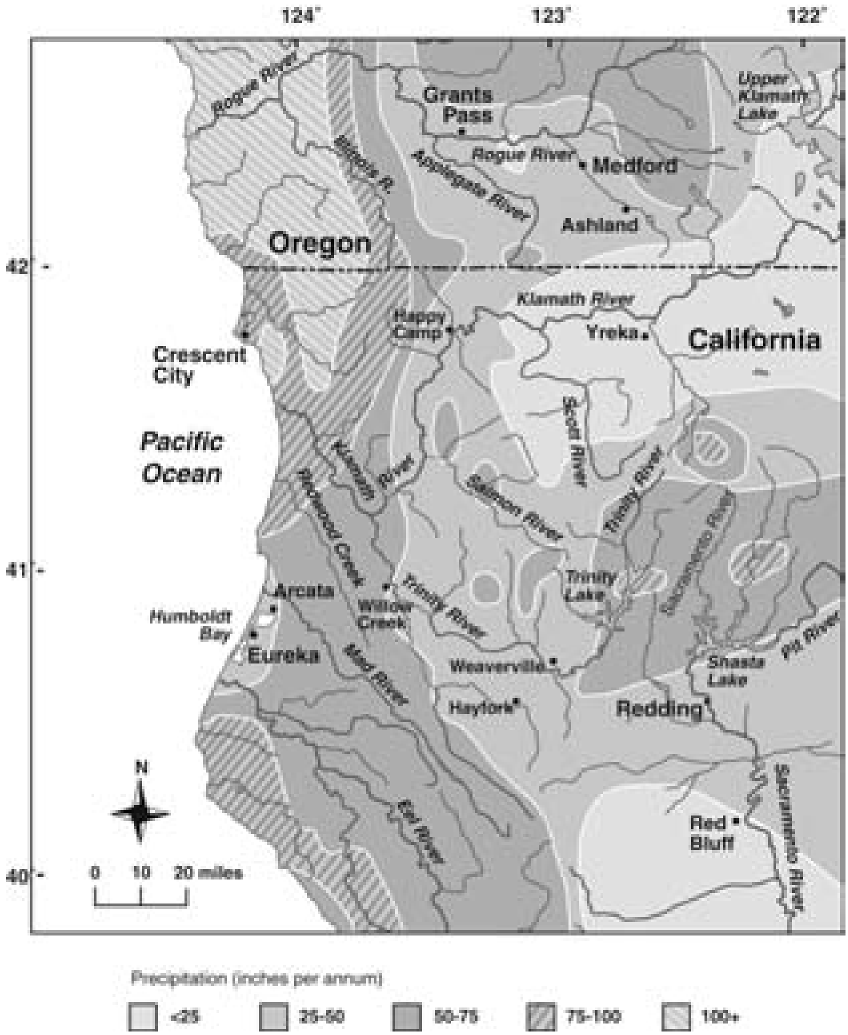

Figure 3. Annual precipitation over the Klamath Region. Rainfall varies over an order of magnitude, from about 10 inches inland to over 100 inches at the western edge. (Source: Western Region Climate Center. Illustrator: Cathy Schwartz.)

trend of decreasing precipitation to the east. Storm masses coming from the northern Sacramento Valley hit the mountains, are pushed up in elevation, cool, and are then less able to hold moisture, so the moisture drops as rain or snow. Weaverville, in the center of the Klamaths, receives only about 35 inches of annual precipitation, but Whiskeytown, at the edge of the Sacramento Valley, receives over 60 inches. The higher elevations in the mountains receive much more precipitation than do the valleys, where all the permanent weather stations reside, and snowpacks as deep as 80 inches are not uncommon by the end of the major snow season in April.

The Klamaths tend to have warm, dry summers away from the coast. This situation makes for an ideal tourist climate but also is an ideal fire climate. Thunderstorms start many lightning fires, and a typical historical summer was probably much smokier than today's typical summer. Average July temperatures across the region exceed 86°F, with record highs topping 118°F.

Climate has not always been so warm in the Klamaths. Like the rest of North America, the Klamaths have been subject to wide swings in climate due to many factors, including oscillations in solar radiation in response to the orientation of the earth's axis. Historically, these changes in the earth's heating led to cycles of glaciation, filling many of the upper valleys of today's rivers with glaciers. In the Trinity Alps, repeated glaciation reached as far down as Deep Creek on the Stuart Fork, the North Fork on Swift Creek, and Dedrick on Canyon Creek. The most recent glacial cycle was about 14°F colder on average than typical temperatures today and had major effects on the roughly thirty glaciers active at the time and on the distribution of plants and animals that were adapted to the cooler climate. The last glacial maximum here was about 22,000 years ago, and it was followed by an abrupt (in geological time) increase in temperature to conditions much like today's. This past 10,000 years or so is known as the Holocene. The mid-Holocene, 8,500 to 4,500 years ago, appears to have been warmer and drier than present conditions, with perhaps as much as 20 inches less annual precipitation, affecting river flow, forest fires, and other natural phenomena. A reasonably stable climate similar to today's has persisted for the past several thousand years. These climatic shifts have had significant effects on the distribution of vegetation and animals and have resulted in remarkable biodiversity in the region. Of course, even earlier, 30 million to 40 million years ago, magnolias and bald cypress grew along the swamps there. Weaverville's La Grange Café, known for offering unusual entrées such as wild boar and venison on recent menus, could have added local ground sloths and mammoths to the menu had it been operating a couple million years ago in the Pleistocene.

Global warming is no longer a wild theory: it is here. But it will interact with the same natural agents that have forced short- and long-term climate change in the past. Most people are now aware of the El Niño phenomenon, a tropical sea-surface temperature anomaly that tends to push tropical storms farther north than usual. In the American Southwest, El Niño is associated with increases in annual precipitation, and the reversed pattern, La Niña is associated with drier years. This pattern repeats every few years. In the Pacific Northwest, a longer-phase pattern known as the PDO, or Pacific Decadal Oscillation, brings multiple decadal cooler-wetter or warmer-drier conditions. The Klamath Mountains are likely to be affected by both El Niño and PDO, but probably less strongly by either than are places much farther north or south.

Arriving at the Stuart Fork each summer, I always head first to the river and its rocks. Most of the rocks have been rounded by the action of the stream, but that feature is about all they have in common. Gold, green, black, blue, and white, they are usually framed by a stunning rock outcrop that temporarily holds them in place on their journey downstream. The diversity in rocks is a symptom of geological diversity and is one of the characters that defines the Klamath region. Its geology is responsible for some of the most diverse plant communities in the western United States. Klamath geology was responsible for the major cultural shift that occurred when Indian cultures were overwhelmed by whites in search of gold. And, like the white man, the rocks came from somewhere else.

Anyone seeking a specific rock in the Klamaths doesn't have to go far to find it, or a version of it that has metamorphosed in response to heat and pressure. Limestone? It's there. Hall City Cave is a spooky limestone cave, once said to contain treasure, although explorers hoping to strike it rich found only a few animal carcasses. Natural Bridge is another limestone feature, although it should probably be called "Natural Tunnel," because water didn't so much build a bridge as excavate a tunnel through it. To find metamorphosed limestone, one can try the Marble Mountains (although they are mostly granite). Sandstone and its metamorphosed form, schist, are both plentiful in the Trinity River canyon west of Junction City. To find granite, one can climb into the Trinity Alps or try the decomposed form at Buckhorn Summit. Serpentine? The Klamaths have more concentrated serpentine country than does anywhere else in North America. The Klamaths are a geologist's candy store, although several geologists likely went mad trying to explain the convoluted geological "knot."

We usually think of the land we walk on as stable and unchanging. People who anchor companies are known as the "bedrock." But in geological time, change has been the hallmark. Terranes, as geologists call these large complexes of rocks, have floated around the earth as large plates, in a process known as continental drift. The westward-moving North American plate is responsible for scraping off and piling up terranes at the western edge of the continent. That most of the mountaintops of the Klamaths are former sea bottom comes as no surprise to any geologist, but an explanation of how they got there has become widely accepted only in the past few decades. Serpentine, the state rock of California, forms from peridotite, probably the most common mantle rock within the earth. Deposits above the serpentine are commonly pillow lavas that formed from basalt that erupted under ancient seas. Above that layer are radiolarian cherts, originally deep-ocean sediment. The island of Cyprus, the Apennines and the Swiss Alps of Europe, and the Marin Headlands north of San Francisco all contain this same three-rock ordered sequence, known as the Steinmann Trinity, which formed the basis of the theory of continental drift and plate tectonics. The Steinmann Trinity is also found in the Klamath Trinities.

Most fifth-grade kids can look at a globe and see how South America and Africa seemingly fit together like pieces of a jigsaw puzzle. When I did this as a fifth grader, my friends considered it a crazy idea, even though such theories first appeared early in the twentieth century, not only because of the jigsaw puzzle fit but because of resemblances between rocks and fossils from different continents. That continents are flexible and capable of floating and crashing (the most impressive example being India's crashing into Asia and forming the Himalayas, which explains why the top of Mount Everest is marine limestone) is now well accepted and has given us a much better understanding of how the Klamath terranes evolved. J. S. Diller, perhaps the best-known Klamath-Shasta geologist, courageously tried to explain the geology of the Klamath Mountains in 1914 but was hampered by the profession's then-static view of the underlying landscape.

Geologists define four major groups of complex rocks, or terranes, in the Klamaths (see figure 4). Each terrane is oriented somewhat north to south, and as one moves east to west across the terranes, they transition from oldest to youngest. The oldest is the Eastern Klamath Belt, created perhaps 450 million years ago, which contains sedimentary and volcanic rocks and old ocean floor. The old ocean floor, on land, is called an ophiolite and often contains serpentinite, which forms when hot peridotite comes in contact with water. Outcrops of serpentinite on land have very unique plant communities, and in road cuts, the rocks often appear quite green and glassy. The Central Metamorphic Belt to the

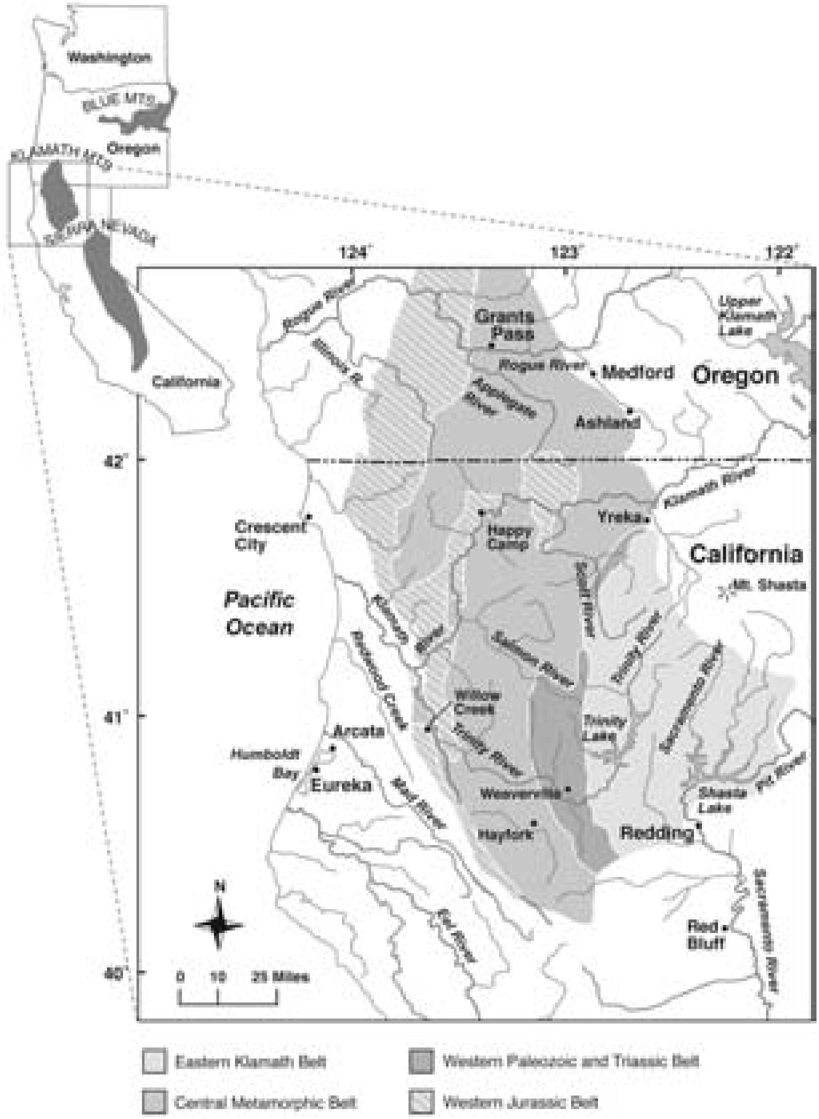

Figure 4. Generalized geologic map of the Klamath province. The map does not show granitic intrusions. The inset shows the relation of the Klamaths to the Sierra Nevada of California and the Blue Mountains of Oregon. Ages of these terranes from east to west range from 450 million years for the Eastern Klamath Belt to 150 million to 200 million years for the Western Jurassic Belt. (Source: Adapted from David Alt and Donald W. Hyndman, *Roadside Geology of Northern and Central California*. Missoula, MT: Mountain Press Publishing Company, 2000. Used with permission. Illustrator: Cathy Schwartz.)

west of the Eastern Klamath Belt is younger and separated from it by a thrust fault. It's a much narrower belt that is composed of gneiss, marble, schist, and likely the same rocks as in the Eastern Klamath Belt, only more metamorphosed because they were dragged under the Eastern Klamath Belt. Large domes of granitic rocks, batholiths, intruded under these rocks and emerged as Shasta Bally and the Canyon Creek pluton that forms the central Trinity Alps (although they do not appear individually in figure 4). The next terrane to the west is the Western Paleozoic and Triassic Belt, which contains mostly dark rocks of oceanic origin and sedimentary rocks, and farthest west is the Western Jurassic Belt, a slightly metamorphosed group of oceanic crust and sediments that is only 150 million to 200 million years old. It contains the Josephine ophiolite, one of the best preserved chunks of old ocean crust in North America and one of the most widespread sets of serpentinite plant communities anywhere. Serpentinite forms soils with very low calcium and very high magnesium content, and the plants that can tolerate such conditions form unique plant communities, including species that are found nowhere else (endemics) and stunted individuals of species that are more widely distributed.

The Klamath Mountains appear to have once been part of the northern Sierra Nevada (figure 4, inset). They somehow migrated about 60 miles to the west perhaps 100 million years ago, and the sequence of terranes matches those in the Sierra Nevada and the Blue Mountains of northeastern Oregon very well. Deposits of gold are as common in the Klamaths as in the Sierra Nevada for this reason. They formed within dikes of quartz, mostly in slate but some in metamorphosed volcanic rocks. Some of this gold became entrained in stream gravel deposits. Many of the gold deposits are on ridges that are uplifted ancient streambeds, created 50 million years ago when they drained a low-lying, coastal, tropical landscape. These ancient river deposits became known as auriferous gravels because of their gold content. The largest one in the Klamaths forms a broad crescent several miles wide that parallels the west side of present Trinity Lake, beginning at the East Fork of the Stuart Fork and continuing southwesterly to Weaverville and Oregon Mountain, where its southern terminus became famous as the La Grange hydraulic mine.

The coastal Franciscan terrane later formed on the western edge of the Klamath terranes, eventually shaping the landscape we know today. South Fork Mountain serves as the boundary between the coastal Franciscan complex and the Klamath terranes. Geologist David

Alt describes the Franciscan complex as "one of the world's grand messes" (Alt and Hyndman 2000, 117). The rocks are so scrambled that geologists describe them as a "mélange," a word more common to vintners today, who use it to describe wines that mix many varietal grapes (of course, the southern mélange country in Napa and Sonoma is also the original California wine country). Sandstones and schists are the most common rocks of the Franciscan terrane, and they are often pulverized along active northwest-trending earthquake faults. The Franciscan terrane is unusually unstable; erosion from natural landslides and conditionally unstable hillslopes is often accelerated by activities like road building and logging. Berry Summit along Highway 299 is the dividing line between the Franciscan and Klamath terranes.

Mount Shasta borders the eastern edge of the Klamath Mountains and is the youngest large feature on the landscape. It and the other Cascade volcanoes are the surface expression of the thrust of an oceanic plate under the North American plate. The sinking oceanic plate is the source of the magma, or molten rock, that erupts and has built the stratovolcanoes that line the crest of the Cascades. Whereas the rocks to the south and west range from 200 million to 400 million years old, Shasta is less than 1 million years old. Shastina, the small cone just west of the summit, formed less than 10,000 years ago, and hot pyroclastic flows buried forests where Weed and Mount Shasta City sit today. Mount Shasta was not active in the twentieth century, but its southerly neighbor Mount Lassen erupted violently in 1915. About five small earthquakes occur each year within the mountain, providing evidence of continuing volcanic life. With ten eruptions in the past 3,500 years and three in the past 750 years, future eruptions are likely to occur, sending streams of superheated rocks or mudflows toward neighboring towns.

The Klamaths are essentially old terranes surrounded by much younger ones. They have been inundated, uplifted, eroded, intruded upon by great granite domes, and carved by glacial action. Because of their geological diversity and age, they have supported a degree of biodiversity unknown elsewhere in the western United States. Even at a semicontinental scale, the Klamaths are recognized as "central," in the middle of things—as they should be.