# The Environmental and Cultural History of the North Fork Eel River Watershed and Yolla Bolly Country

## Chapter 2

## Climate History

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### Preface

This is the second chapter in a series of papers for what is anticipated to be an update of my book published in 1995: *Environmental History and Cultural Ecology of the North Fork of the Eel River Basin, California***.** Since then, I have published numerous articles, presented professional papers, and compiled, organized, and catalogued for future researchers, the existing historical archival data on the North Fork Eel River watershed and the surrounding Yolla Bolly country of southwestern Trinity, northern Mendocino, and southeastern Humboldt Counties. Most of these papers and publications can be found on my website; *solararch.org*. The Trinity County Historical Society in Weaverville also has copies of these papers and publications, as well as all the original homestead records, historical maps, historic and contemporary interviews with local residents, and other historical documents referred to in this study. The collection is available to researchers and is filed at the Historical Society under the heading; Trinity County Compendium (TCC).

Each "chapter" in this series focuses on a single topic and includes a bibliography. To date, the first chapter *Origins: A Thumbnail History of the Geology and Soils of the Yolla Bolly Country*, has been completed and presents a brief overview of the geologic "Origins" of the Yolla Bolly country and North Fork Eel River watershed and is now available on my web site: Pdf at: https://solararch.org/wp-content/uploads/2022/06/Chapter-1-Geology-and-Soils-NFER-final.pdf

This second chapter presents an overview of the climatic history of northwestern California focused on the Yolla Bolly country. In 1995, I formulated a paleoclimatic model for the North Fork Eel River watershed (Keter 1995) based on previous palynological (pollen) studies for northwestern California. Chapter 2 expands on my original research to encompass the surrounding Yolla Bolly country, and includes regional climatic and palynological data--from a number of locations on the Six Rivers and Mendocino National Forests. The goal of this chapter is to provide a diachronic climate model for the Yolla Bolly country during the Pleistocene and Holocene[1]. Future chapters will include synopses of the area's prehistory, ethnography, history, and an overview and discussion of the natural history of the flora and fauna found in the region.

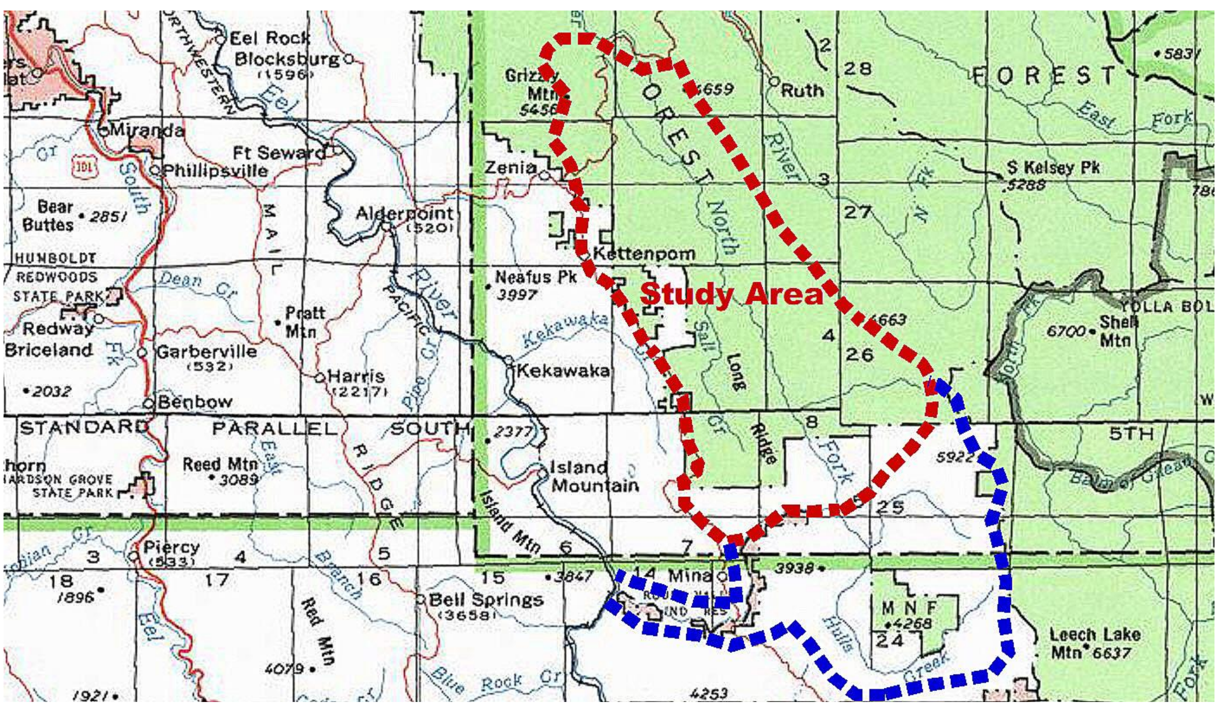
[1] For a more in-depth overview of the past climate of California see *Late Pleistocene and Holocene Environments* (West, et al 2007: 11-61)

## Introduction

[To provide locational and contextual information the Introduction repeats for each Chapter.]

The North Fork Eel River watershed is located roughly in the center of what is referred to as the "Yolla Bolly country" by local residents, and in the histories of this still remote region. The term Yolla Bolly comes from the Nomlaki Wintun language and roughly translates as "high snowy mountains." The Yolla Bolly country stretches from Round Valley into southeastern Humboldt and southwestern Trinity Counties. It is a vast region of deep-cut canyons and steep almost-never-level terrain. It includes the highest mountains in the Coastal Ranges of California, the Yolla Bolly Mountains with several peaks over 7,000' in elevation. The majority of the land in the Yolla Bolly country is federally owned and is managed by the Six Rivers, Mendocino, and Shasta Trinity National Forests (Green shading on Map 1).

The North Fork Eel River watershed to the north of Hulls Creek (Map I-1 red dashed line) was the focus of ongoing environmental studies by the author in the 1980s and 1990s (Keter 1992, 1994, 1995, 1996, 1997, 2013, Keter and Busam 1996). The southern portion of the North Fork Eel River watershed, below the mouth of Hulls Creek, lies within Mendocino County (Map 1: blue dashed line). A large part of this area is owned by the Round Valley Indian Reservation and several private land holders. There are also a few isolated tracts of public lands within the North Fork watershed managed by the Bureau of Land Management and the Mendocino National Forest.




Map 2-1
(CA Topo: 2000)

## The Climate during the Pleistocene Epoch 2.58 Ma to 11,700 BP

During the Pliocene Epoch (2.58 Ma[2] to 11,700 BP), as a result of plate tectonics (see Chapter 1) the Coast Ranges of California were uplifted forming the terrain (land mass) that today is referred to as the Franciscan Formation of the North Coast Ranges. It was during this Epoch, that the Earth's climate entered an extended phase of alternating between a warmer drier climate and a cooler wetter climate.

By the middle of the Pleistocene, the California Current began to form in the Pacific Ocean off the coast of California. The California Current resulted in a Mediterranean climatic regime dominated by cool wet winters and dry warm summers for cismontane California[3], and is also responsible for maintaining California's cool coastal fog belt. Climate researchers working in the Sierra Nevada (Millar and Woofenden n.d.: 64) have provided an explanation of why there was such a wide variation in the climate during this period. They note that the California Current:

> ...promotes favorable conditions for upwelling of cold water throughout much of the year, particularly in the summer months. During the peaks of glacial periods, however, continental ice sheets reached a large enough size to reorganize the wind systems over the North Pacific Ocean. These perturbations to wind fields caused the California Current to weaken, triggering large differences in ocean-surface temperatures relative to those of interglacial times. Collapse of the California Current during these millennia translated to weakening of the Mediterranean climate regime over California, reducing thermal gradients from coast to inland, and diminishing fog belts along the California coastal zone as warmer waters came near the coast.

These wide swings in temperatures and precipitation continued throughout the middle to late Pleistocene. During the cooler wetter glacial periods (often lasting thousands of years), water locked up in the glaciers lowered sea level along the California coast by as much as 450 feet. During warmer interglacial periods the sea level rose, and at times, the sea flooded into portions of low coastal plains and river valleys, and portions of the Great Valley. Modern, high-resolution methods to detect past temperatures from stratified ice in polar ice caps and deep-ocean sediments reveal more than forty cycles of long glacial (cold) and interglacial (warm) intervals beginning about 2.6 Ma, with each lasting 40,000 to 100,000 years (see Chapter 1, Millar and Woofenden n.d.: web site: 151).

During the periods of cooler temperatures and increased precipitation, large lakes like Lake Bonneville in Utah and Lake Lahanton in northwest Nevada flooded the

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[2] MA--million years ago, BP--years before present

[3] Cismontane California is comparable to Jepson's California Floristic Province and includes all of the state to the west of the Cascade/Sierra Nevada/Peninsula Range watershed divides. The Transmontane consists of the regions to the east of the divide: the Great Basin, Modoc Plateau, and the desert regions of the state.

intermountain valleys of the Great Basin, as well as some of the interior basins of California--including the Mojave Desert (Lake Mojave), and Death Valley (Lake Manly). At higher altitudes in California, massive glaciers formed on north facing slopes in the Sierra Nevada, Cascade Range, Klamath and Siskiyou Mountains. This resulted in the excavating of hundreds of cirque lakes, and the sculpting of dozens of long U-shaped canyons (like Yosemite Valley).

Evidence also shows that at various times in the past glaciers formed in the North Coast Ranges on the north facing slopes of Snow Mountain, Black Butte, Anthony Peak, Solomon Peak, North Yolla Bolly Peak (Image 2-7), Black Rock Mountain, and Mount Linn (South Yolla Bolly Peak). One researcher, Mark Dewitt (1991), noted that within the high Yolla Bolly country he found 27 cirques and valleys in an area of 11 square kilometers. These areas displayed erosional and depositional features including moraines that measured as much as 45 feet high and 1,000 feet long; the lowest elevation of a glacial feature was 5,960 feet (Dewitt 1991, Guyton 1998).

During the late Pleistocene, the California Current System fluctuated in intensity. In California average temperatures appear to have fluctuated by as much as seven to eight degrees centigrade (Adam and West 1983). As a result of ice buildup on land during glacial periods, between about 140,000 and 20,000 years ago, global ocean levels declined as much as 120 meters relative to its present level. Along the Pacific coast, the maximum California coastline retreat 20,000 years ago was about 50 miles, with the shoreline retreating to a position west of the Farallon Islands; turning San Francisco Bay, Eureka Bay, and other low elevation basins into dry land (see Chapter 1).

Then, about 14,500 years ago, the Earth's climate again began to shift back to a warmer interglacial period. As a result, in North America glaciers were rapidly melting; adding freshwater to the ocean. Partway through this transition about 12,900 BP to 13,000 BP, temperatures in the Northern Hemisphere, again, suddenly (in geological terms) returned to near-glacial conditions. Climatologists refer to this as the Younger Dryas, named after a flower (*Dryas octopetala*) that grows in cold conditions, and that became common in Europe at that time. Evidence of this colder period includes abrupt shifts in varved lake sediments in Europe (NOAA web site)[4].

During the Younger Dryas glacial period much of the coastline of northwestern and central California again extended out more than 20 miles further to the west. With, for example, in the San Francisco Bay region, the coast lying at about what are now the Farallon Islands. The Younger Dryas cooling period was short lived and ended abruptly after little more than a millennia; about 11,500 BP. For example, in Greenland temperatures rose 10° C in only about a decade (NOOA web site).

Studies of the extinct species recovered from the La Brea Tar Pits in Los Angeles indicate that during the Late Pleistocene several large carnivores including saber- tooth cat, dire

[4] A varve is an annual layer of sediment or sedimentary rock laid down by weathering or other geologic processes.

wolf, short-faced bear, and jaguar inhabited the western part of the state. Moreover, grazing animals were at one time commonly found in the grasslands and oak woodlands of the interior valleys of the state including mammoth, bison, horse, and camel. And, at higher elevations in the rolling hills and upland regions of the interior coast ranges, solitary browsers, such as mastodon, tapir, shrub ox, and ground sloth (Rosenthal and Fitzgerald 2002: 71)

It appears that the disappearance of the mega fauna that inhabited California about 13,000 BP to 12,500 BP is roughly coincidental with the ending of the Younger Dryas and the final transition to the beginning of the Holocene and the Altithermal period of warmer and drier conditions.

## Climate during the Holocene Epoch 11,700 BP to the Present

By the beginning of the Holocene the climate had warmed and was comparable to the interglacial periods of the mid to late Pleistocene. Climate during the Holocene was once considered to be fairly stable--especially in comparison with the climate variations of the Pleistocene. More recent investigations, however, have found that there were multiple cooling events during the Holocene; including, for example, the most recent, the "Little Ice Age." Ending about 100 to 150 years ago (see below) this wetter and colder period resulted in some growth in the surviving glaciers found in the Trinity Alps and Siskiyou Mountains (Kaufman 2020: Web site).

The low productivity of the closed canopy conifer forests during the Pleistocene for both animals and humans as compared to the higher productivity of the evolving oak woodlands and grasslands vegetation associations during the early Holocene suggests that the changing environment and climatic weather patterns that led to their establishment may very well have played a part in the migration of the first humans into the region.

Numerous subsistence resources not found in closed canopy forests (or found in lesser amounts) than would have become available for procurement in the oak woodlands and grasslands include: acorns, grass seeds, bulbs, and many other sun-loving plants (see Keter 1995, Chapter 4 this series). Deer, small game, and birds like grouse and quail would also have been increasingly plentiful. This assertion is supported by studies on the productivity of the oak woodland, grassland, brush, and conifer forest vegetation associations by researchers in northern Mendocino County (Longhurst 1969, in Anderson 1974: 271), who found that the number of deer that conifer dominated sites can support (20 per square mile) is only about 25% of the number (80 per square mile) of deer that the oak woodlands can support.

### The Pollen Record for Northwestern California

Some of the oldest and best-dated pollen core samples in northwestern California come from Clear Lake (located about 50 air miles to the south and east of Yolla Bolly country). The pollen data from this sample provides for a continuous climatic record for the past 130,000 years (Adam et al 1981). The pollen record reflects migrations of tree species into the California Coast Ranges in response to climatic changes taking place during the late Pleistocene and early Holocene. During drier and warmer interglacial periods the Clear Lake pollen samples were dominated by oak (*Quercus*) pollen. During cooler periods, oak pollen was replaced by pollen of coniferous species. This research provides evidence of the long-term cyclical changes in the distribution of conifers and the oak woodlands (Adam 1988) in the Clear Lake region long before the entrance of humans into the region.

Researchers also noted (Byrne et al n.d.: 182) that the pollen percentages found in the sample suggest that during the early and middle Holocene (approximately 10,000- 6,000 BP) oaks were more abundant than at present. This finding matches up well with the pollen data recovered from the sites on Six Rivers and Mendocino National Forests discussed in the next section that suggests warmer and drier conditions than today during the early Holocene. It is also notable that Yurok elder Lucy Thompson citing Yurok oral history made the same observation regarding loss of the oak woodlands in northern Humboldt County. In about 1916, she wrote that: "our legends tell when they arrived in the Klamath [R]iver country that there were thousands of acres of prairie lands and with all the burning that they could do, the country has been growing up in timber more and more" (Young c1916: 31).

Palynologists (Byrne et al n.d. 182) concluded from the Clear Lake pollen data that:

> Of all paleoecological sites in California, the record from Clear Lake presents the best evidence of long-term changes in the distribution of oak woodlands. This record shows that the modern distribution of oak woodlands is a recent development in evolutionary time. The full glacial record indicates the virtual absence of oaks from the drainage basin. Under these colder conditions, pines were dominant, with sagebrush and *Cupressaceae* [undifferentiated species of cedar, juniper, and cypress] were more abundant than at present. With postglacial warming, oak reestablishment commenced ca. 13,000 years ago.

There have been a number of recent palynological studies that provide new insights into the environment of northwestern California during the Pleistocene. A pollen core recovered from Bolan Lake, Oregon, located about 35 miles inland from the coast, and a few miles north of the California Stateline, included pollen, plant macrofossils, and high-resolution charcoal data dating to the late Pleistocene. These samples provide a 17,000 year environmental history of high-elevation forests in the region. The researchers (Briles et al: 2017) concluded that:

> In the late-glacial period, the presence of a subalpine parkland of *Artemisia* {possibly a subspecies of manzanita], *Poaceae*[5], *Pinus* [pine], and *Tsuga* [hemlock] with infrequent fires suggests cool dry conditions. After 14,500 cal yr B.P., a closed forest of *Abies* [true fir], *Pseudotsuga* [Douglas fir], *Tsuga*, and *Alnus rubra* [red alder] with more frequent fires developed which indicates more mesic conditions than before. An open woodland

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[5] *Poaceae*, formerly called *Gramineae*, belong to the grass family a division of the order *Poales.*

> of *Pinus*, *Quercus*, and *Cupressaceae*[6], with higher fire activity than before, characterized the early Holocene and implies warmer and drier conditions than at present. In the late Holocene, *Abies* and *Picea* [spruce] were more prevalent in the forest, suggesting a return to cool wet conditions, although fire-episode frequency remained relatively high.
>
> ...The timing of vegetation changes in the Bolan Lake record is similar to that of other sites in the Pacific Northwest and Klamath region, and indicates that local vegetation communities were responding to regional-scale climate changes.

**The Pollen Record for the North Coast Range**

During the 1980s, several pollen studies were undertaken in the interior North Coast Range by palynologist James West. Relevant to this study are the locations where core samples were collected on Pilot Ridge, Six Rivers National Forest, and at Lily Pond and A-M Lake; both located on the Mendocino National Forest.

<u>Pilot Ridge Pollen Data</u>

In 1982, West (1983a: 3.17) took pollen core samples from four locations during an archaeological excavation of 10 prehistoric sites along the crest of Pilot Ridge, Six Rivers National Forest (see Chapter 3). Cores samples from Big Lake to the north of Pilot Ridge, and at McKay Spring and Lemonade Spring, located to the southeast on the crest of South Fork Mountain, were incomplete, or were not able to provide C-14 dates. West, however, managed to secure a pollen core from a small eutrophic pond or marsh (Image 2-1) located on Pilot Ridge at an elevation of approximately 4,200 feet about 30 miles to the northwest of the North Fork Eel River watershed. Prehistoric site CA-HUM-558 is located adjacent to the pond (see Hildebrandt and Hayes 1983).

Image 2-1
CA-HUM-558: pond/marsh on the crest of Pilot Ridge
(T. Keter 2007)

[6] *Cupressaceae* are in the order *Pinales* that includes redwoods, junipers, cypress, and cedar.

There were two components to the pollen core recovered from the site (Image 2-2). The lower core sample dated from approximately 5,000 B.P. to around 2,600 B.P. It included high pollen counts for oak (Q*uercus* sp.) and pine (*Pinus* sp.--probably ponderosa pine) during the early period--decreasing over time, while the Douglas fir pollen counts increased over time. Also noteworthy is the almost total lack of tanoak (*Notholithocarpus densiflorus*[7]) and chinquapin (*Castanopsis chrysopylla*) pollen until about 2,600 BP.

The upper core sample dates from about 2,600 BP to the present. It is characterized as having high counts for Douglas fir, pine, tanoak (also commonly referred to as tan oak, tanbark, and tanbark oak), and chinquapin. Douglas fir, tanoak, and chinquapin appear to have increased in numbers during this period (green arrows), while Oregon, or the more commonly used name locally, white oak (*Quercus garryana*), black oak (*Quercus kelloggii*), and pine numbers decreased (red arrows).

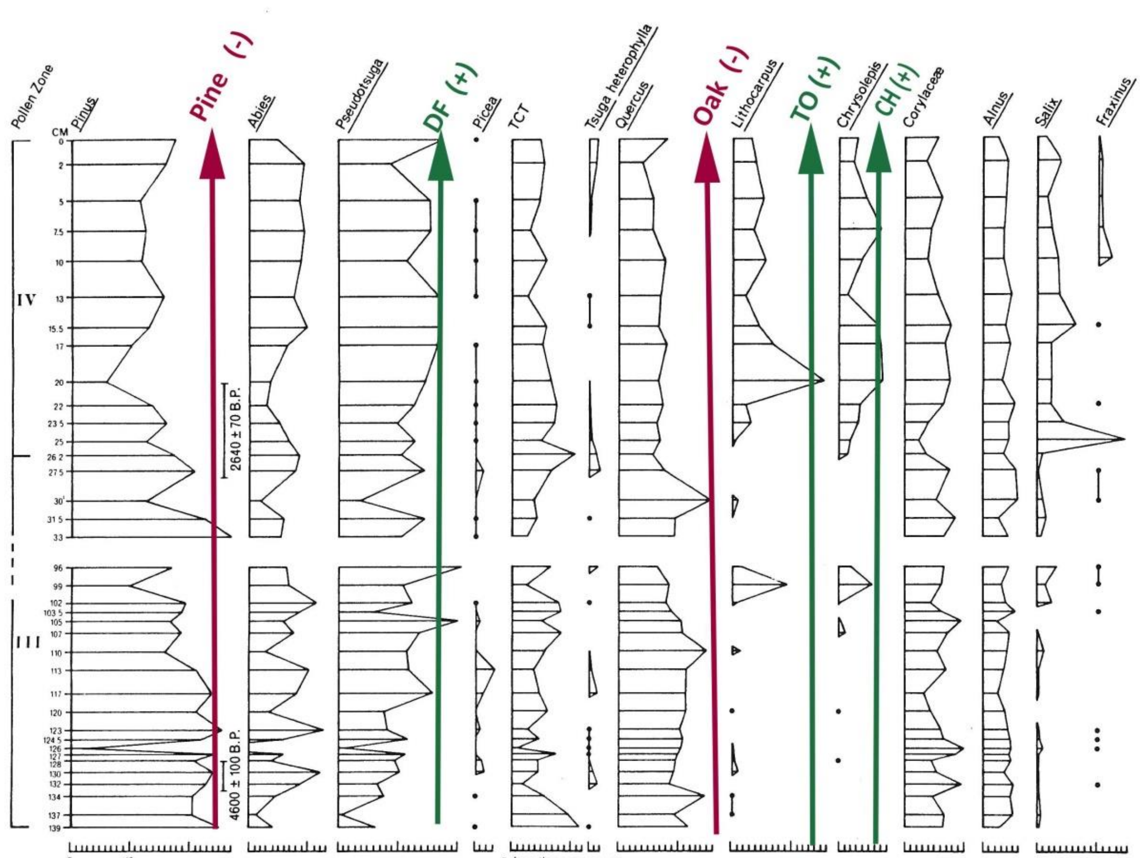


Image 2-2
Pollen Sample taken from CA-HUM-558
DF=Douglas fir/TO=tanoak/CH=chinquapin
(West 1983 3.30)

[7] Tanoak was recently moved into a new genus, *Notholithocarpus* (from *Lithocarpus*), based on the fact that it was more closely related to the north temperate *Quercus* oak and was not as closely related to the Asian tropical stone oaks (where it was previously placed), but instead is an example of convergent morphological evolution (CalFlora Web site Calflora: 11880 ).

West (1983a: 3.21) concluded that the currently composed Mixed Evergreen Forest (dominated by mature stands of Douglas fir) on this portion of Pilot Ridge at about 4,400' in elevation, did not form until approximately 2,700 to 2,800 years ago. Prior to that time there were greater numbers of pine and oak, with fewer Douglas fir. These findings are consistent with the other pollen studies discussed in this chapter.

<u>Lily Pond Pollen Data</u>

The most complete pollen core referred to in this study was taken by West from Lily Pond (Images 2-3 and 2-4) located about 4 kilometers southwest of Fouts Springs in Colusa County, and about 55 air miles to the southeast of the North Fork Eel River watershed. West (1983b Appendix 10: 4) wrote that:

> Lilly Pond: is not really a pond but is a marsh with a dense growth of tules (*Scirous* sp.) and cattails (*Typha latifolia*) with a fringe of willows (*salix* sp.), sedges, mosses, liverworts, rushes, and grasses. The past effects of grazing by domestic animals are evident. A Mixed Conifer Forest (Coast Range Montane Forest) covers the surrounding slope.

This area, like the one on Pilot Ridge at CA-Hum-558, is better characterized as a marsh than a pond and is located at an altitude of approximately 4,000 feet. West estimated--based on carbon 14 dates and sedimentation rates--the base of the core to be about 9,700 year old.


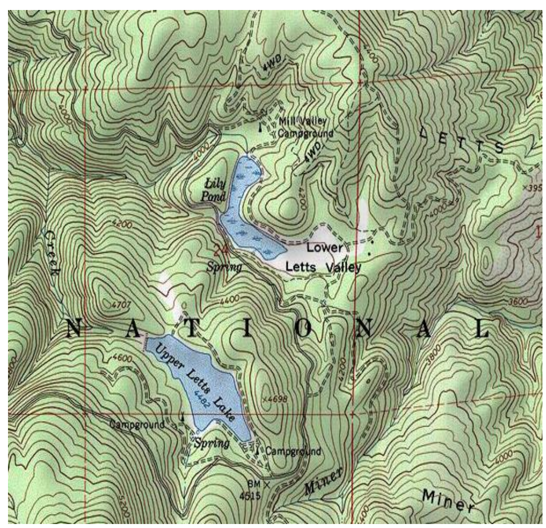


Image 2-3
Lilly Pond is usually dry in the summer
(Google Earth 2021)

Image 2-4
Lilly Pond is located in the upper center
(USGS Fouts Springs 1971: 7.5')

Several samples were radio-carbon dated, with the oldest core dating to 8,700 BP (± 100). The pollen core data for Lily Pond suggests that prior about 8,700 BP, the surrounding area

was an open pine forest with a sparse shrub and herbaceous understory. Oaks (species were not determined from the core sample) were present, but not a major part of the vegetation community (about 5%). West noted high counts for TCT (*Taxaceae* [possibly yew], *Cupressaceae*, and *Taxodiaceae*[8] pollen, consistent with the pre-Holocene sediment studies discussed earlier from Clear Lake (Adam and West 1983).
West indicated that the data suggested the *Cupressaceae* pollen was from incense cedar (*Libocedrus decurrens*). Interestingly, West also found some unidentified pollen grains that appear to have been from a subspecies of lodgepole pine (*Pinus contorta* sp) growing there, which are no longer found in the North Coast Ranges.(West 1983b: 9). Today, the closet lodgepole pines are found about 100 miles to the north in the Marble Mountains.

West also found both white fir (*Abies concolor*) and red fir (*Abies magnifica*) pollen present in the earliest core sample, as well as that of Douglas fir (West 1983b: 6). Some other tree pollen contained in the core--including a species of alder (*Alnus* sp.) and ash (*Fraxius* sp.) suggests that they may have been growing nearby, or the pollen was transported in by the wind. At the time West took the core sample in 1982 a few white firs were still growing near Lilly Pond, and a few red firs were found growing nearby at slightly higher elevations. For a summary of the genus and species of forbs and grasses growing in the area refer to the original report. The report also included information on the plants found growing in and along the edge of the pond--including species of water lily (*Nuphar* sp.), and since the pollen could not be differentiated; either or possibly both burr-reed (*Sparganium angustifolium*) and a species of cattails (*Typha latifolia*).

Based on the pollen data, West concluded that there was a transitional period between about 8,700 BP and 7,500 BP. It was marked by warming and drier conditions, and as a result, the number of conifers growing adjacent to the pond declined, and the number of oaks increased. During this period, Lily Pond became shallower and supported a dense growth of pond weeds. At the same time, the Douglas-fir pollen count becomes almost non-existent in the sample.

From about 7,500 BP to about 3,400 BP the oak woodlands became a major component of the landscape, as true firs retreated upslope. Pine pollen counts remained high while Douglas-fir counts still remained almost non-existent, suggesting a further continuation of a warmer, drier climate. Significantly, true fir pollen (probably white fir) that was present in low amounts in the earlier levels disappears completely from this sample.

After about 3,400 BP, major changes in vegetation distributions began to take place. True firs begin to reappear, and at about the same time, Douglas-fir pollen counts begin to increase steadily, until this species becomes a major component of the forest. Moreover, oak counts drop slightly, while pine counts increase slightly. During the more recent past, West noted that the water level of the pond has started to increase (West 1983b: 10).

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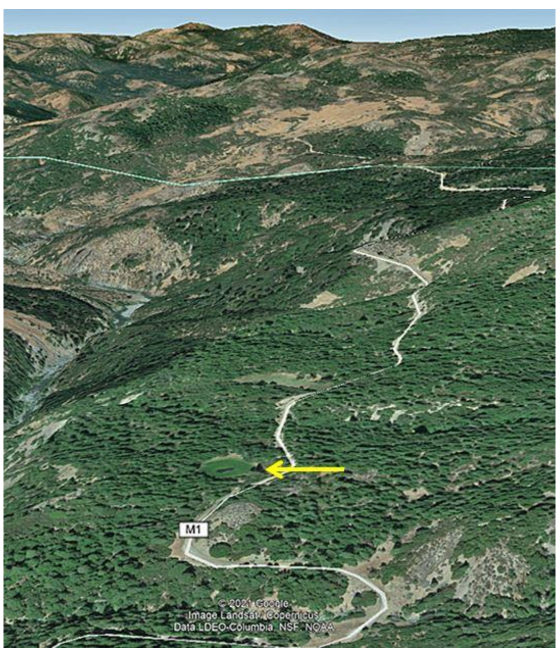
[8] Recent research has shown that the *Taxodiaceae* genera, with the exception of *Sciadopitys*, are phylogenetically part of the family *Cupressaceae*. There are no consistent characteristics by which they can be separated, and genetic evidence demonstrates close relationships.

West's conclusions regarding the climatic history of Lily Pond support the current theory that by the beginning of the Holocene the climate of northwestern California was changing with warmer and longer dry seasons and less annual precipitation.

A-M Lake Pollen Data

A-M Lake (Images 2-5 and 2-6) on the Covelo Ranger District of the Mendocino National Forest is located in the far southeastern region of the Yolla Bolly country (Map 2-6). It is a small (approximately one acre) eutrophic pond located within the upper Middle Eel watershed--about five miles to the east of the divide within the North Fork Eel River watershed. Lilly Pond is situated between Alder and Maple Creeks on the southwestern facing slopes of Hammerhorn Peak at an elevation of about 3,320 feet above sea level. The lake has no official name, but was given the name A-M Lake for ease of discussion by West in his report (1991: 1).

West managed to obtain one core that was radiocarbon dated to 1630 +/- 180 BP. This date when combined with the sedimentation rate indicates that the bottom of the core dates to about 2,500 BP; pollen preservation was good, and *Pinus* was the most abundant pollen type in the sample. Douglas-fir had low pollen counts (< 1 percent) in the lower portion of the core, but these increased through time (up to 18 percent) in the upper samples (West 1991: 4-5).



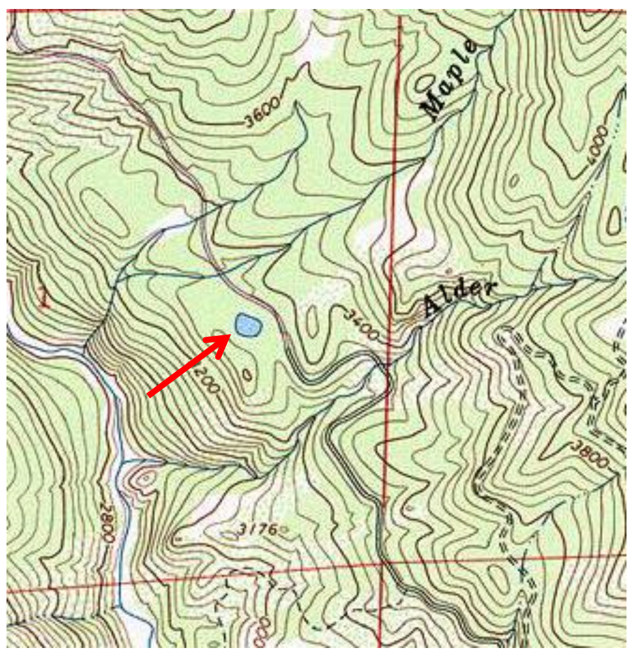




Image 2-5
A-M Lake (yellow arrow)
(Google Earth 2021)

Image 2-6
A-M Lake (red arrow)
USGS Leech Lake: 1988

West also, found that *Pinus* (no differentiation was made between species, probably ponderosa pine) was the most abundant pollen type. As at other locations, West found that: "of all the arboreal taxa represented in the pollen spectra, Douglas fir values show the greatest change through time" (West 1991: 5). The early part of the pollen record suggests that about 1,600 to 1,700 years ago A-M Lake looked much as it does today--a small eutrophic pond ringed by grasses, forbs, and sedges and surrounded by an open park-like pine and oak forest (the exact species of oaks could not be determined from the sample).

It is likely that by this time anthropogenic fire was beginning to play a role in determining the distribution of vegetation across the landscape. However, it is important to note at this point, that when measured in thousands of years; wildfires--as West (1991: 4) concluded--do not significantly alter long-term vegetation successional trajectories, and that the primary changes in the pollen record at A-M Lake, and the other locations sampled in northwestern California, are primarily the result of plants responding to climate change.

## The Yolla Bolly Country during the Early Holocene 11,700 BP to 8,500 BP

Even prior to the arrival of humans, the ecosystem of the North Fork Eel River watershed and surrounding Yolla Bolly country was in a constant state of flux. Over the millennia the migration of new flora and fauna species into the region, changes in the distribution and species, and quite likely, the occasional outward-migration or extinction of a particular plant or animal species, all took place in response to natural processes including changes in climate and naturally occurring fires.

The pollen and climatic data for the North Coast Ranges, as analyzed by West, as well as other climate studies like those discussed earlier (see Taylor 1976) have been presented as a generalized model for northwestern California (West 1988: 8-9; 1990). This model suggests that, during the late Pleistocene and early Holocene, the climate of the North Coast Ranges was cooler and more continental than today, with a weak subtropical high in July and strong westerly flows.

Inland regions experienced colder, longer, and wetter winters than today. Axelrod (1981) documents a near-continuous distribution of coniferous forest extending from the northern California coast as far south as the Channel Islands and Los Angeles. Pollen spectra and macrofossils from the North Coast Ranges also show a more continental and cooler climate during the late Pleistocene. Evidence for glaciation includes cirque lakes located on the north facing slopes of South Yolla Bolly Mountain, North Yolla Bolly Mountain, Black Rock Mountain (Image 2-7), Anthony Peak, and several other locations in the North Coast Ranges (Simons 1983: 3. 3).

Image 2-7
View northeast to Black Rock Lake
(Wiki commons n.d.)

Along with the pollen data presented in the last section, the evidence for an earlier more continental climate in the North Coast Ranges during the late Pleistocene and early Holocene, includes several species of trees and other plants still growing in the Yolla Bolly country today that are found in isolated "islands"--far from their main distributions to the north in the Siskiyou and Klamath Mountains and to the east in the Sierra Nevada Mountains. Climate researcher D. W. Taylor (1976: 307) also noted that it is likely that some Great Basin plant species extended their ranges into the mountains of the North Coast Ranges during the Pleistocene; probably migrating into the region from the volcanic plateaus of northeastern California.

One example of this cooler continental climate, are the scattered remnant stands of western juniper (*Juniperus occidentalis*) found growing throughout the high peaks region of the Yolla Bolly Mountains. Today the nearest stands of juniper to those found growing the Yolla Bolly country are located about 100 miles to the north in the Klamath Mountains. Griffin and Critchfield (1972: Map 32) first documented a few isolated junipers growing on Soldier Ridge in the Mendocino National Forest just to the west of Solomon Peak. Since then, *Calflora* (see web site) also has identified junipers at a few additional locations in the region. Over the years, I have noted junipers growing at numerous locations in the Yolla Bolly Mountains. They are usually found growing above 6,000 feet on serpentine dominated soils throughout the headwaters divide region of the Middle Fork of the Eel River/South Fork of the Trinity River watersheds. For example, a number of large old junipers are growing immediately to the east of Shell Mountain (Image 2-8).

There is also a rather unique black oak-juniper woodland adjacent to Mud Lake. This is not too far from the location of an old Forest Service guard station at Sulfur Camp on the Mendocino National Forest. There are even a few juniper trees just to the south of Forest Road 27 adjacent to the Waterspout trailhead that leads to the guard station (personal observation). The paved road generally follows the watershed divide (about 4,500' and 5,000' in elevation) between the Mad River flowing to the north, and the Middle Fork Eel River flowing south. The closest stand of juniper to the North Fork Eel River watershed identified to date is located on the watershed divide between the Middle Fork Eel River and the North Fork Eel River at Ant Point (Calflora, personal observation). However, during the Travis Fire of 1987, one lone juniper (Image 2-9) was identified by the author along the fire break in the Littlefield Creek drainage of the North Fork Eel River watershed a few hundred meters to the north of Antone Ridge. It was growing on non-serpentine soils at only about 3,000' in elevation.

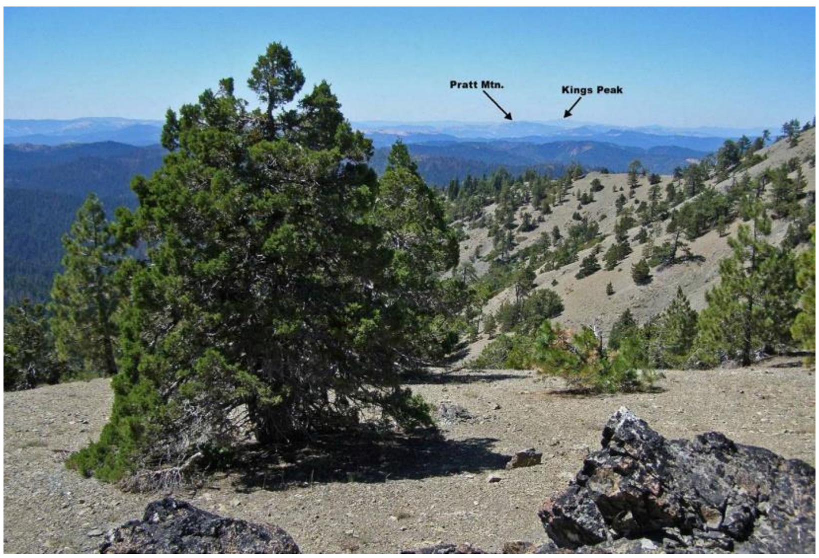



Image 2-8
Juniper on serpentine soils Shell Mountain Yolla Bolly Wilderness--Kings Peak on the horizon is 55 miles to the NW
(T. Keter 2012)

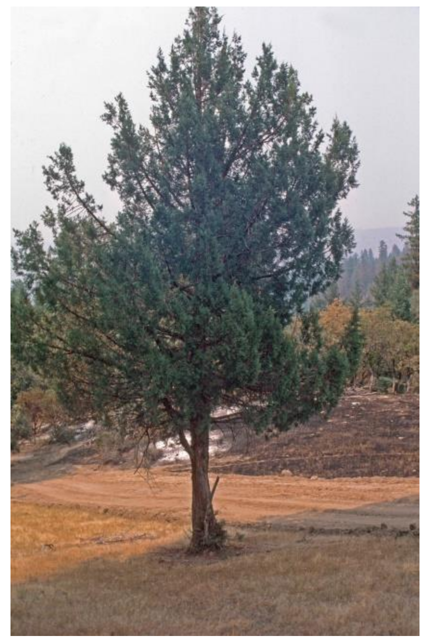
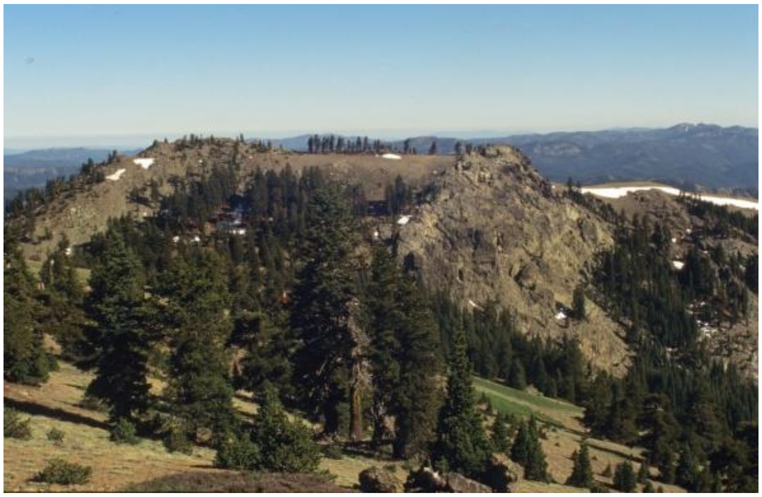


Image 2-9
1987: Lone juniper
North Fork-Littlefield Creek
(T. Keter 1987)

Another isolated tree species, fox-tail pine (*Pinus balfouriana*), is found growing on the upper slopes of North Yolla Bolly Mountain (personal observation, Images 2-10 and 2-11). Researcher Michael Kaufman (2020: web site) noted that he also found fox-tail pine growing on Mt. Linn (South Yolla Bolly Mountain). Today, the closest stands of this tree are located over 100 miles to the north in the Klamath Mountains. A few isolated stands of fox-tail pines are also found in the southern Sierra Mountains near Mount Whitney, and in portions of the upper Kings River, Kaweah River (near Alta Peak--personal observation), and Kern River drainages (Griffin and Critchfield 1972: 25).



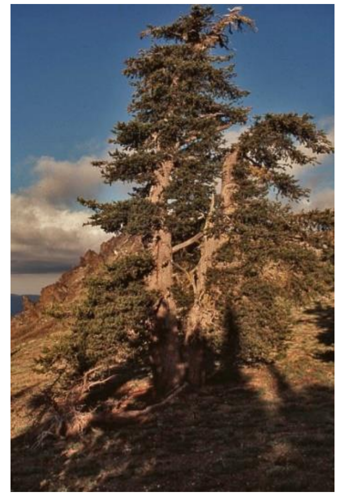


Image 2-10
View east to North Yolla Bolly Peak
and stand of Fox-tail pines

Image 2-11
Fox-Tail pine
Black Rock Mountain

(Both photos T. Keter 1985)

Another species of pine, western white pine (*Pinus monticola*), more commonly found in Oregon, Washington, and the Sierra Nevada mountains, extends it range as far south in to northwestern California as the Trinity Alps region. A few isolated stands of western white pine, however, can still be found growing in the North Coast Range; including on the west facing slopes of North Yolla Bolly Peak (just to the east of Beaver Glade on Fisher Ridge) and in the South Yolla Bolly Peak region (Calflora web site, Griffin and Critchfield 1972: 28).

One of the most interesting threads of evidence for the extension of Great Basin species migrating into the Coast Ranges during the Pleistocene and early Holocene is a small grove of aspen trees (*Populus tremiloides*) that still survives on the southern slopes of North Yolla Bolly Mountain at Beaver Glade (Images 2-12 and 12-13). It is the only surviving grove of aspen trees in the North Coast Ranges (Griffin and Critchfield 1972: 32).

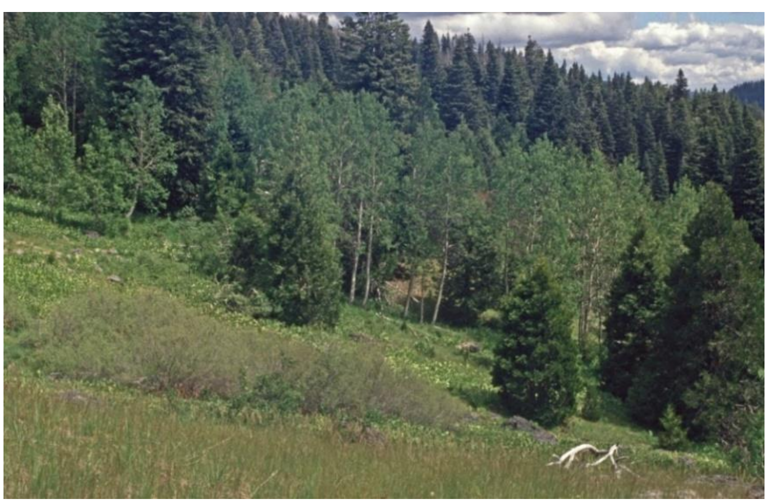


Image 2-12

Image 2- 13

The Humboldt Trail passes through a stand of Aspen trees in Beaver Glade
(T. Keter 1985)

Beavers in the Yolla Bolly Mountains

The following section is summarized from *Beavers in the Yolla Bolly Mountains?* (Keter 2016a, see also 2016b). Recent research has confirmed an earlier hypothesis first made by the author over 30 years ago; that given potentially suitable beaver habitat in the Yolla Bolly Mountains--including willow, alder, and at Beaver Glade aspen trees (the name was probably not coincidental)--it is quite possible that an isolated remnant beaver population survived in the Yolla Bolly Mountains into the early nineteenth century in what could be termed a relic habitat--an isolated vestige of the past--surviving here since the end of Pleistocene.

This marginal, and what appears to have been a slowly vanishing habitat, provides evidence for what is termed "vegetation inertia," i.e. the tendency of vegetation communities (and ecosystems) to strive to maintain themselves (homeostasis) overtime; despite changing environmental conditions. The following email message was sent from a geologist, who previously to working in the Yolla Bolly Mountains, had worked in areas inhabited by beaver. He indicated that:

> ...it sure looked like the area has been influenced by beaver ponding in the past. Indicators are gradient, changes in stream directions, and points along the channel where possible dams were. Also, there are name places and streams etc. with "beaver" names, a possible indication that these critters were here at one time. The introduction of domestic cattle [and sheep] into the area would have reduced the willow and alder etc. sprouts the beaver would have fed on. [Personal communication forwarded by Arnold James Mendocino National Forest.]

The question then becomes--if beaver were here-- when and why did they disappear? One possible reason to explain their demise is that it somewhat coincides with the end of the Little Ice Age (see below). This change to a warmer drier climate may have dealt a fatal blow to a species inhabiting an already marginal habitat. Another possibility, however, is that they may have been "eradicated" for political reasons (Keter 2016b). In the late 1820s and early 1830s, the British owned Hudson Bay Company's trappers made an effort to extirpate beaver from entire watersheds in California, in order to discourage American explorers and fur trappers from entering the region. Given the good habitat, but limited areal extent, it would not be surprising if a small and isolated beaver population could have been trapped out in a visit or two.

More recently, however, documentation has surfaced that confirms the hypothesis not only that beaver once inhabited the Yolla Bolly Mountains, but that a few managed to survive into the 1870s. A book published in 1997; *Families: A Pictorial History of Round Valley 1864 to 1938,* (Bauer and Barney 1997:153-154), provided significant new information regarding the presence of beavers in the Yolla Bolly Mountains. Eric Bauer and coauthor Floyd Barney (a long time Forest Service employee and personal friend) who was born in the 1930s on a homestead near Hulls Valley--located just to the west of the high peaks region of the Yolla Bolly Mountains wrote that:

> Walter James, an old time hunter and trapper in this locality, is said to have caught beaver along what is now known as Beaver Creek in the late 1860s and early 1870s and there was a local belief that he did so. William and James Foster--uncles of Walter, who lives in Barney Meadows--said that during the 1870s they found remains of beaver dams and stumps of beaver-cut trees along the creek.

It is likely a combination of factors--including trapping and a decline in habitat due to a changing climate--could account for the extinction of beaver from the high Yolla Bolly Mountains. One more explanation, however, is possible. With the introduction in the early 1870s of over 100,000 sheep into this region every summer, it would not have taken long for the sheep to have totally destroyed critical beaver habitat (Keter 1994).

## The Yolla Bolly Country during the Mid Holocene
## 8,500 BP to 3,500 BP

By about 8,500 BP the North Coast Ranges began a slow transition to a warmer and somewhat drier climate (longer summers and less yearly precipitation) than that of today. The middle Holocene is sometimes referred to as the Altithermal Period[9] and has long been characterized as being distinctly warmer and drier than today. The pollen data cited earlier show increasingly high oak and chaparral values beginning at this time; indicating an increase in drought-tolerant species (West 1993, 2001). During the Altithermal Period the average yearly temperatures in northwestern California were about 1.3 to 2.1 degrees centigrade warmer than today (West 1983a: 3.19); resulting in somewhat milder winters and warmer, drier, summers--probably persisting somewhat longer. In response to the changing climate in the Coast Range conifer forests retreated some 300 kilometers northward as warmer conditions caused arid and semiarid plant communities to expand; while some plant species (for example Douglas fir, white fir, and red fir) migrated up slope as much as 1,000 feet (300 meters) in elevation.

The changing climate and environment may have been a factor influencing the migration of the first humans into the region. Carbon-14 evidence from archaeological excavations on Pilot Ridge in the early 1980s (Fitzgerald and Hildebrandt: n.d.) suggests that it was about this time that people first settled within the interior regions of northwestern California (see Chapter 3: Prehistory). Based on the above evidence, it appears that during the Altithermal, gray pine {*Pinus sabinlana*) would have been somewhat more widespread than today. Only a few remnant populations of gray pine can still be found today in the Yolla Bolly country. Most of these trees are located at lower elevations to the east of the North

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9 Although it is also been commonly referred to as the Xerothermic Period (Simons 1983, Keter 1995), West has indicated that this term may over emphasize somewhat the severity of the Altithermal (James West personal communication 1995).

Fork Eel River on dry south and west-facing slopes with poor serpentine dominated soils, and are often associated with manzanita (*Arctostaphyos* sp.) and other brush or shrub species. The more continuous distribution of gray pine only begins in Round Valley and extends southward throughout the lower elevations of the interior Coast Ranges (Griffin and Critchfield 1972: 89).

As the climate became drier (and with periodic wildfires) it is likely that Douglas-fir and other species of the Mixed Evergreen Forest vegetation type retreated upslope. They were mostly found above about 3,500'- 4,000' and were limited at lower elevations to some north facing slopes, or other locations that provided topographical shading and the conservation of soil moisture (Keter 1995). Overall, it is likely that Douglas fir was only a minor component of the landscape throughout much of the North Fork watershed. However, Jeffery pine (*Pinus jeffreyi*), usually associated with serpentine soils, ponderosa pines (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), and incense cedar were probably a bit more widespread (especially above about 3,000 to 4,000') at that time.

With longer and drier summers, blue oak (*Quercus douglasii*) and valley oak (*Quercus lobata*), would have extended their range further north. Today, the Yolla Bolly country marks the northern boundary for blue oak in northwestern California; where a few can still be found growing on the slopes of the southwestern facing hills a few miles north of Round Valley (Griffin and Critchfield 1972: Map 70). The northern limit of valley oak, today, is in the southwestern portion of the North Fork Eel River watershed. Here, a few trees are still found growing in an open grassland/oak woodland (Image 2-14) about one mile north of Mina (Personal communication Brett Lovelace, environmental scientist, see also *Calflora*, Taxon Report 6983, date recorded: 2018-05-01; Record Detail po88071).


*Image 2-14*
*Location of a valley oak growing within the North Fork Eel watershed*
*(Google Earth 2021)*

Canyon live oak (*Quercus chrysolepis*) may have been somewhat more widespread than today during the Altithermal, as the main characteristic of these oaks and their associated vegetation species, when compared to the white and black oak woodlands that dominate the Yolla Bolly country today, is that they are better adapted to a slightly drier and warmer climatic regime with a longer dry season.

White oak is the only species of oak in California that extends its range beyond the state (Pavlik et al 2002: 19). It can be found from western Oregon and Washington as far north as Vancouver Island (Pavlik et al 2002:21). It is hypothesized that, given the warmer drier climate, white oak may not have been as widely distributed--especially at lower elevations. Today in the Yolla Bolly country white oak tends to dominate the oak woodlands below about below 4,000' (Pavlik et al 2002; Keter and Busam 1997). The range of the white oak is limited by rainfall--needing four to ten inches during its growing season from April to September (West 1988: 8). Today white oak extends south in the Coast Range to about central Sonoma County, with disjunct populations extending somewhat further south. For example, there are two small populations of white oaks in the Santa Cruz Mountains (Griffin and Critchfield 1972: 100).

Black oak (*Quercus kelloggii*) may have been more widespread during the Altithermal as they prefer slightly warmer summers and colder winters than white oak. Today Black oaks are commonly found throughout the Yolla Bolly County; they dominate the oak woodlands above about 4,000', and can be found in the high Yolla Bolly up to about 6,000' on southwest facing slopes. Contrasting with white oak, and providing some insight into their preference for slightly a drier habitat, black oaks can be found as far south in the South Coast Range as Monterey and San Luis Obispo Counties (Griffin and Critchfield 1974: Map 73). They are more commonly found on somewhat drier growing sites, often in association with ponderosa pine, incense cedar, and sugar pine in what can be termed a pine/oak parkland habitat (widely spaced conifers and oaks separated by grasses and forbs). Reflecting the low count numbers in the pollen data for tanoak cited earlier from nearby locations at Pilot Ridge and AM Lake, it is likely that few if any tanoaks were growing within the Yolla Bolly country during the Altithermal Period.

To summarize, it is hypothesized that with the onset of a warmer drier climate, vegetation associations would have been similar to the more open oak woodlands (blue oak, black oak, gray pine vegetation communities) that today are found to the east of the Yolla Bolly Mountains in the Coast Range foothills along the western edge of the Sacramento Valley. It is likely that at lower elevations (below about 3,000' to 3,500') gray pine would have been somewhat more abundant than today, and the oak savanna (possibly dominated by blue oak at lower elevations), and open savanna grasslands vegetation associations were probably major components of the landscape.

The Altithermal would also have affected all aquatic forms of life. Because of the warmer, longer, and drier summers (and in all probability diminished yearly rainfall and snowpack), stream flows within the North Fork watershed would have been greatly reduced. Also, given less annual precipitation, the number and strength of perennial springs within the North Fork watershed--already relatively few in number--would also have been greatly reduced. With reduced stream flows in the summer and somewhat longer dry seasons, the density and distribution of riparian vegetation would also have been affected--further raising water temperature. It is likely, therefore, given marginal to poor habitat, that during the Altithermal there was a significant reduction in the number of anadromous fish (or possibly none) and resident fish the North Fork Eel River watershed (Keter 1992).

The lack of the availability of desirable terrestrial and aquatic subsistence resources (see Chapter 4) could have been a primary reason for the lack of a large aboriginal population inhabiting the Yolla Bolly country at this time. Archaeological evidence (see Chapter 3) suggests that unlike Pilot Ridge to the north, where, some sites date to almost 8,000 BP, this area was not heavily populated until the late Holocene about 3,000 to 3,500 years ago as the Altithermal Period transitioned into a somewhat cooler climate regime with shorter summers and more precipitation**.**

## The Yolla Bolly Country during the Late Holocene 3,500-3,000 BP to the Present

Beginning approximately 3,000 years ago a stronger California Current creating maritime conditions began to prevail along the north coast of California, while inland the climate began to change from a warmer, drier climactic regime to a slightly cooler, moister one. Average yearly temperatures cooled about 1.3 to 2.1 degrees centigrade and precipitation increased. Just to the east of the coastal redwood belt, the mixed evergreen forest with tanoak became more widespread and expanded further inland. These moderating conditions, including a shorter dry season, also increased the flow of creeks and rivers and the number of perennial springs, resulting in the climate becoming similar to that of today.

Recent research, however, has provided a more fine-grained chronology of the late Holocene climate; indicating a much more complex pattern of yearly temperature variation in long term climate trends. Researchers working in the Sierra Nevada (Millar and Woolfenden n.d.: 66) noted that:

> Climate cycles paced by fluctuations in solar activity and in ocean cycling rendered significant climate variability at century and shorter scales within this time. The Medieval climatic anomaly, about 700 to 1,100 years ago (900–1350 CE), was a worldwide interval of temperature and precipitation divergence... In California, abundant evidence documents two major droughts each lasting more than a century... evidence [also] exists for increased warmth relative to present (as much as 3°C). Shifts occurred in response to this interval, with upslope movements of mountain taxa and considerable rearrangement of vegetation communities.

The Medieval climatic anomaly was then followed by what scientists refer to as the Little Ice Age. There is no definitive date for the beginning of the Little Ice Age and it appears to have varied somewhat across the globe. In some parts of Europe it began in the early 1300s and ended about 1850. In California it began about 1400 and ended in about 1925 (Millar and Woolfenden n.d.: 66). It appears to have been caused by shifts in the solar cycle, and marked a return to somewhat cooler conditions (with somewhat more precipitation and shorter dry seasons). The cooler temperatures at this time were magnified by the coincidence of several significant volcanic eruptions (for example Mt Krakatoa in 1883) that injected abundant ash into the atmosphere, and by the occurrence of several anomalous sunspot events (Millar and Woolfenden n.d.: 66).

In California, the Little Ice Age triggered the largest glacial advance in over 11,000 years, with the growth of existing glaciers in the Sierra Nevada, Cascade, and Klamath Mountains. The coldest part of the Little Ice Age in California was during the late 1800s and into the early decades of the 20th century. In *Geologic, Climatic, and Vegetation History of California*, the authors (Millar and Woolfenden n.d.: 66) noted that:

> The Little Ice Age ended about 1925 in California as solar cycles shifted once again, triggering warming trends and drought that are known from the 1930s and 1940s. Temperatures plateaued in the mid 20th century and began to climb sharply in the early 1970s. The impact of anthropogenic greenhouse gases became significant during these decades, compounding climatic processes and forcing conditions beyond natural variability.

As a result of the warming trend since the 1920s--especially over the last few decades--all but one of the surviving glaciers in northwestern California has completely disappeared. Today the only remaining glacier is found in the Trinity Alps on the north facing slope of Thompson Peak (9,001')--and it is rapidly disappearing. Michael Kaufman (Kaufman: Web site) who has studied the Trinity Alp glaciers for several decades noted that:

> Grizzly and Salmon glaciers represent the largest of the LIA [Little Ice Age] glaciers and the only two persisting into the 21st century. Unfortunately, beginning during the catastrophic five-year California drought of 2012-2016, Salmon Glacier melted away and Grizzly Glacier partially broke apart (stagnated) by fall 2015 but still persists in 2020.

No data could be found regarding the possibility that glaciers may have been reestablished in the Yolla Bolly Mountains and during the Little Ice Age. From personal observations at both Mt. Linn and North Yolla Bolly Peak, it appears that although snow fields may have remained well into the summer months during some of the coolest wettest years, it is unlikely given the ages of the mature (old growth) red fir (they have a life span of 500 to 600 years) growing on the mountain's north facing slopes in the early 1980s.

<u>Summary of the Effects of Climate to the Environment during the Late Holocene</u>

In the Yolla Bolly country by the late Holocene as a result of the changing climate:

* There was an increase in riparian vegetation and stream flows
* There was a reduction in stream water temperatures
* Improved aquatic habitat probably resulted in an increase in resident and anadromous fish populations

* Plant species like blue oak, valley oak, and gray pine began to retreat to the south

* White oaks began to move downslope and increase in numbers coming to dominate the oak woodlands at lower elevations

* Douglas-fir began to move downslope and increase in numbers and distribution especially in areas of oak woodlands dominated by white oak

* It is likely that grasses, herbaceous plants, and bulbous plants, increased in both numbers and species diversity--making for a more resources rich habitat for both humans and animals.

It appears that an extended period (measured in centuries) was needed for plants and vegetation communities to respond to changing climatic conditions. As noted earlier, this is due to vegetative inertia--the tendency for a biotic community to strive for homeostasis and thus to resist change. Natural fire also played a role in slowing the rate of change taking place within plant communities in response to the moderating climate, as well as favoring the growth of species of plants adapted to periodic wildfires. Moreover, as discussed in Chapter 3, sometime by the late Holocene, aboriginal land-use activities--including anthropogenic burning and subsistence resource procurement activities--became major factors influencing the environmental dynamics of the North Fork watershed and the Yolla Bolly country.

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