Characterizing the watershed

Geology

The geologic history of the Laguna de Santa Rosa is dominated by the forces of two great tectonic plates whose movements against each other lifted the Coast Range, triggered volcanic activity, and tilted the Santa Rosa Plain towards the west. The two great tectonic plates are the North American Plate—which extends all the way across the continental United States to the middle of the Atlantic Ocean, and the Pacific Plate—which extends from the Sonoma Coast across the Pacific to Asia. The active San Andreas Fault marks the line where these two plates slip past each other: the Pacific Plate moving north, the North Atlantic Plate moving south. A third plate, the Farallon Plate, in former times contributed to the complex interactions that occurred in the present day Laguna as it subducted under the North American Plate forming the Coast Range. A historic remnant of the Farallon Plate can be found today at the triple junction of the two major plates and the small Gorda Plate, located approximately 200 miles northwest of the Laguna on the Mendocino coast.

About five million years ago the area from present-day Sebastopol/Forestville to the area near Bodega was the shallow Wilson Grove Sea. The marine sandstone of the Wilson Grove formation today is exposed along the western and southern edges of the Laguna in what we now call the Gold Ridge hills. At about this same time the Sonoma Volcanics began erupting and in the process spread lava and ash over the Mayacama Range and Sonoma Mountain. Mount St. Helena, in the Mayacamas is a *shield volcano*, so called because the liquid-like lava flowed quickly leaving a low-elevation cone. Sonoma Mountain was more explosive, leaving behind large amounts of tuff. Compressional forces in this area have lifted the eastern sides of the mountains along low angle thrust faults. The remaining bedrock from this volcanic activity can be seen throughout the mountainous regions of the Laguna.

The Franciscan Complex, which in the Laguna lies for the most part hidden beneath the Sonoma Volcanics, is a *melange* of many different common rock types. In the Laguna it is only present, at the surface, in a small band adjacent to the Rodgers Creek fault. West of Forestville this bedrock is present at the surface all of the way to the coast.

The Glen Ellen Formation consists of a partially cemented mixture of gravel, sand, silt, and clay formed through ancient alluvial processes. About two million years ago water ponding on this formation, in the area of the present-day Santa Rosa Plain, dissolved the area's rocks resulting in the precipitation of minerals; these precipitated minerals formed into continuous concrete-like layers, which today results in the vernal pool topography of the area.

The Russian River, which flows in a southerly direction for much of its course, first occupied the down-dropped blocks of the rising Coast Range. Over time the Russian River torqued the direction of its lower reach, in a clockwise motion, in response to the shearing force of the Pacific Plate which had continued to scrape to the northwest. Geologic evidence points to the Russian River as always having flowed directly to the Pacific Ocean, which over eons has itself shifted west as the landmass of the North American Plate grew larger.

Soils

The soils of the Laguna are derived from the erosional actions working against the underlying bedrock. With the Wilson Grove formation extending in a band along the watershed's eastern boundary, the Glen Ellen Formation capping the Santa Rosa Plain, the Sonoma Volcanics dominating the eastern mountains and the underlying Franciscan Complex appearing in a band east of the Rodgers Creek fault, the resultant pattern of soils in the Laguna is very heterogeneous.

Risk factors

The Laguna watershed is no longer host to active vulcanism, but it is host to frequent seismic activity. Geologic risk factors are threefold: earthquake damage, landslides, and liquefaction.

The last major earthquake in the watershed occurred on October 1 1969 with two shocks of magnitudes 5.6 and 5.7 that resulted in severe damage to the city of Santa Rosa. The epicenter of both quakes was about two miles north of downtown Santa Rosa. The earthquake of April 18, 1906 was of magnitude 8.3, and resulted in the most severe damage, in proportion to its size, of any city in California. A comparison of 1906 and 1969 damage reports suggests that both had epicenters near the same locality.

Landslides, while not as dramatic as earthquakes, occur with greater frequency in the watershed. The Blucher Valley slide first moved in 1983, and moved again in the heavy rainfall of the 1997-98 winter season. The December 31, 2005 storm triggered landslides at the Cotati Grade, temporarily closing a portion of Highway 101. Smaller landslides contribute significant amounts of sediment to the watershed's tributaries. The local effect of global warming will be to produce heavier downpours which will likely result in more frequent landslides.

The risk of liquefaction, which occurs immediately after seismic activity, has been assessed for the watershed by the USGS. Soils which are soft, young, water-saturated, and well sorted behave as viscous fluids when seismic waves cause the distortion of its granular structure and a collapse of its pore spaces. At risk of failure are many of the agricultural ponds situated on unconsolidated alluvium. The most significant of these risks is the city of Santa Rosa's Delta Pond.

Geomorphology

To the layman, the nomenclature of geology is unfamiliar territory, and talk of eras and eons quickly becomes confusing. But for our study of geological processes, we choose to limit our consideration to the most recent epochs of geologic time: the *Holocene*, which is the most recent epoch, beginning as the glaciers of the last ice age receded (about 11,000 years ago in Sonoma County), and the *Pleistocene*, which is the second most modern epoch, and is the time of the megafauna. Together these epochs are referred to as the *Quaternary* sub-era. They represent the most recent 1.8 million years of Earth's history.

The US Geological Survey has published, in Open File Report 00-444, a study of Quaternary deposits in the nine-county San Francisco Bay Area. Data are presented, in GIS format, on Quaternary deposits, Quaternary faults, and liquefaction susceptibility. A review of this data is as it relates to the Laguna presented here.

At the watershed level, surficial geology is intriguing in its predictive capacity. What appears on the surface to be different regions of vegetative cover frequently turns out to be perfectly matched geologic regions having either the presence or absence of alluvial, terrace, or basin deposits. This connection between geology, soil and vegetation, while being intellectually intuitive, is easily and wonderfully visible to the naked eye. See

Plate 9 for a depiction of the geophysical regions defined for the Laguna watershed.

The correlation between topography and these same geologic deposits is even stronger. Valleys, plains and mountains each reveal some of their hidden nature through this recent layer of geologic deposits. On the surface, what appears to be an indecipherable complex of vernal pools, perennial wetlands, seasonal swales and creeks, becomes a clearly decoded collection of water absorbing and water ponding regions.

Seven of the Laguna's geophysical regions are predominately underlain by these Quaternary deposits; the remaining eleven regions are underlain predominately by older bedrock material (see table 1). The deposits are mostly *alluvial* in nature, having been formed over time by the transport of sediment from the mountainous areas to the plains, and settled, often in a fan-shape, where the base of the mountain meets the plain. A few stream *terrace deposits*, indicative of a rapid drop in a stream channel over time, occur within the watershed. There are also two areas of *basin deposits* present in the watershed: these are localized, inward-flowing, low spots without a natural outlet, which have captured water and its suspended particles and gradually risen in height through their fallout and the consequent build up of soil. Other deposits, typically the older ones, are classified as *undifferentiated* and are not singularly attributable to any one of the above natural processes.

The eighteen geophysical regions are described in detail in Appendix F.

Alluvial deposits

Alluvial deposits are often laid out in a fan shape, and nowhere in the watershed is this more classically represented than in the Cotate Region (see Plate 9) where alluvial fan deposits spread out from Copeland Creek at the juncture of Sonoma Mountain and the Santa Rosa Plain. Interestingly, these fan deposits are situated over the Petaluma/Laguna watershed divide: until recently water which had gathered in Copeland Creek's well-defined mountain valley, fanned out across the plain, with some of the water eventually flowing toward the Russian River and some of it eventually flowing toward San Francisco Bay. Modern day improvements have forced Copeland's waters to remain within the Laguna watershed and the creek's periodic avulsions are quickly repaired. To the north of Copeland Creek, four other named creeks, Hinebaugh, Crane, Five, and Coleman drain off Sonoma Mountain, their waters intermingling with Copeland, and their historic alluvial deposits combining to form a single Oriental fan–shaped region. This feature extends westward across a uniformly even plain, losing, at first, one foot of elevation for every 50 feet of horizontal movement. Coarser and heavier suspended solids are the first to drop onto this portion of the slower moving level plain when the unconfined creek bed overflows its banks and losses its mountain-borne kinetic energy. Gradually, the Cotate Region levels out to about 1:120, near present day Snyder Lane, at which point the alluvial deposits become characteristically finer; this is beyond the point where the heavier particles would have already succumbed to gravity. By the time the region's creeks reach Highway 101, the elevation differential diminishes to 1:300. West of the highway the differential is a mere 1:1000. This final spread of the alluvial fan is where, until recent times, the remaining creek vestiges disappeared into, and formed, the marshlands that dominated the area.

Table 1. Summary of the surface geology for the Laguna's geophysical regions.

Region	*Surface geology*
Cotate	2% bedrock, 98% alluvial deposits, classically distributed fan deposits and fine fan deposits from historic Taylor Creek, with much older undifferentiated deposits from Meacham Hill.
Wright	10% bedrock, 90% alluvial fan deposits, nearly all of it very recent, extending in four tentacles along Colgan Creek, Roseland/Gravenstein Creeks, Irwin Creek, and Santa Rosa Creek.
San Miguel	11% bedrock along Pool Creek hillsides, 13% old basin deposits along Shiloh Creek, 6% recent and old stream terrace deposits along lower Mark West Creek, 70% recent alluvial fan and undifferentiated alluvial deposits along the base of the Foothill Region.
Cabeza	13% bedrock, 87% alluvial deposits, very recent fan deposits in the southern half towards Bennett Valley, much older fan deposits and undifferentiated deposits in Rincon Valley, recent stream terrace deposits along Santa Rosa Creek.
Los Guilicos	20% bedrock in one small hill, 9% basin deposits along Oakmont Creek, 3% stream terrace deposits along Santa Rosa Creek, 68% alluvial fan and undifferentiated deposits along valley sides.
Laguna	28% bedrock mostly along Goldridge Hill, 72% recent undifferentiated alluvial deposits and stream terraces.
Bennett	47% bedrock, 53% alluvial deposits from very old to very modern, evenly split among undifferentiated, fine, and very fine.

Table 1. Summary of the surface geology for the Laguna's geophysical regions.

Region	*Surface geology*
River	84% bedrock, 15% very recent undifferentiated alluvial deposits along Windsor Creek and 1% stream terrace deposits along Laguna de Santa Rosa.
Blucher	90% bedrock, 10% old, undifferentiated, alluvial deposits along Blucher Valley bottom.
Gossage	92% bedrock, 8% old undifferentiated alluvial deposits along Gossage and Washoe Creeks.
Foothills	96% bedrock, 4% old alluvial deposits in local depressions along Paulin, Mark West, Porter, Pool, Wright, and Windsor Creeks.
Forestville	97% bedrock, 3% old undifferentiated deposits along lower Vine Hill Creek.
Taylor	98% bedrock, 2% alluvial deposits found in three small round valleys.
Matanzas	98% bedrock, 2% old undifferentiated alluvial deposits in four spots along South Fork Matanzas, upper Spring Creek, and an Oakmont Creek tributary.
Llano	98% bedrock, 2% undifferentiated alluvial deposits, recent along Irwin Creek and older along Gravenstein Creek.
Goldridge	99% bedrock, 1% old undifferentiated alluvial deposits found along upper Pine Tree Creek.
Montane	99% bedrock, 1% recent alluvial fan deposits along Mark West Creek between Humbug and Van Buren Creeks.
Piner	100% bedrock.

The fan-shaped alluvial pattern of creek discharges is characteristic all the way up the front edge of the Santa Rosa Plain. To the far north, Pool Creek discharges from the Foothills Region, splaying out over the first mile and a quarter of the plain to just beyond Old Redwood Highway. Mark West Creek, extending much further into the mountains than Pool Creek, carries more water and more sediment onto the plain; its alluvial fan extends two and a quarter miles beyond the front edge of the mountains to an area beyond the railroad tracks.

But the granddaddy of them all is the Matanzas/Santa Rosa discharge at the geographic center of the Laguna watershed. The combined waters of the these two great systems historically spilled out onto the plain carrying more water, more sediment, and traveling more distance than any of the watershed's other three major alluvial fans. This discharge left a hand-shaped imprint on the land. Whereas the Copeland Creek waters evenly spread themselves out forming an intricate lacing of marsh and swale over the level southern plain, and whereas the Pool and Mark West Creeks each eventually settled down and found a single broad valley to call home, the waters of the Matanzas/Santa Rosa system encountered a plain that was neither too flat nor too relief-defined to fit either pattern well. Instead, the alluvial fan extends in four fingers and a thumb onto the plain. The thumb of this system is the Todd Creek area, hugging the Taylor Mountain break-line in the south (this area of alluvial deposits is arguably not a part of the Matanzas/Santa Rosa system since it receives water directly from Taylor's hillside). Colgan Creek forms the index finger of the system, with alluvial deposits extending almost, but not quite to, Bellevue and Stoney Point Roads. The Roseland/Gravenstein Creek system forms the middle finger extending beyond Wright Road at Kirby Lane. The ring finger is the headwaters to Irwin Creek, extending to Wright Road at Highway 12. The pinky, although by no means the shortest of the fingers in the real system, is present day Santa Rosa Creek, whose alluvial deposits extend not quite to Fulton Road before joining the unconsolidated deposits of the Piner Creek system.

Stream terraces

Stream terraces are found in several places within the watershed: a vast area of lower Mark West Creek, several small pockets along middle and upper Mark West within the Foothills and Montane regions, and a narrow ribbon along Santa Rosa Creek at the Cabeza/Los Guilicos frontier. Stream terraces are composed of alluvial material that is left behind when a sudden change somewhere in the lower watershed triggers down-cutting into the floodplain of the upper reach. The new level of the stream, which is markedly lower than its former floodplain level, leaves behind hillside benches, which are no longer subject to the former pattern of inundation, and is thus subject to its own weathering regime.

The stream terraces of the San Miguel Region, concentrated along the southern side of lower Mark West Creek, are the largest such formations in the watershed. They extend westward from Bisordi Lane to Slusser Road, southward to the area between River and Woolsey Roads, and northward to just shy of Laughlin Road. It encompasses an 1100-acre area. Just downstream of these terrace deposits, an unnamed, four and a half mile long fault, slices across the valley in a northwest/southeast alignment. This fault, which lies alone as a rare occurrence outside the watershed's mountainous regions, is the probable trigger for the creek's sudden down cutting and resultantly high-and-dry terraces. A much smaller, second terrace is situated east of Mark West Creek and west of Oakwild Lane, below this fault line. Its presence, at the confluence of the recently altered southward course of Mark West Creek and the Laguna de Santa Rosa, speaks clearly to the change over time of the Laguna's floodplain. This stream terrace should properly be considered a *Laguna* terrace, not a *Mark West Creek* terrace. It was most likely formed from the geologic backwaters of the Laguna caused by the constriction of its northward progress between Ballard Flat (at the end of Denner Ranch Road) and the Goldridge Hills of the Forestville Region. The elimination of this constriction during the final period of the Pleistocene, reduced the level of the area's floodplain, leaving behind a dry bench sitting approximately 20–35' above the present-day Laguna floodplain.

Additional stream terraces are found in small patches along Mark West Creek. The first is an area at the mouth of the creek's alluvial fan where Mark West Springs Road enters the foothills; a feature likely caused by activity along the Rodgers Creek fault line which cuts across the creek below Wikiup Bridge Way. A second, much smaller patch, occurs close by, near Quietwater Lane, just above an unnamed fault that runs east of, and parallel to, the Rodgers Creek Fault. A third patch, by far the largest and the most diverse in terms of age, begins near the intersection of Mark West Springs Road and Porter Creek Road. It is arranged in a long shelf running north of Mark West Creek until it parts ways with Porter Creek's combined waters. Above this confluence, shelves are found on both banks of Mark West, Porter and Mill Creeks. The action of the Alexander Hill fault is the likely cause of these terraces. The last of these montane stream terrace deposits occurs along Humbug Creek and at Humbug's confluence with Mark West. Here the likely cause for the shift in floodplain elevation is not as clear, but is most likely related to Maacama fault activity. All considered, the middle reach of Mark West Creek, in the Foothills and Montane regions, has demonstrated a repeated propensity to alter its floodplain level.

The watershed's only other stream terraces are found along Santa Rosa Creek. The oldest of these terrace deposits are situated both upstream and downstream of its confluence with Oakmont Creek. The most recent stream terraces are contiguous with these older ones, situated downstream to include Skyhawk Creek's confluence and further extending up to the commingling of waters with Brush Creek. Whether these terraces are caused by the Bennett Valley fault, the Rodgers Creek fault, or geologic fluctuations in the vast Matanzas/Santa Rosa alluvial fan, is not clear.

Basin deposits

Two historic sedimentary basins occur within the watershed, one in the San Miguel region, and the other in the Los Guilicos Region. Basin deposits are formed over time when a topographic depression captures incoming sediment-laden waters. The largest area of such basin deposits is along the western edge of the Windsor/Pool/Shiloh alluvial fan. This basin covers approximately 1300 acres, is centered on Highway 101 from Old Redwood Highway in the north to Aviation Blvd in the south. Without the presence of hills to west or other nearby topographic or geologic features of note, this basin's origin is somewhat clouded. The historical egress for the region's waterways possibly taking a northern shortcut to the Russian River via present-day Los Amigos Road, may be the basin's secret.

The second basin, situated along the easternmost edge of the Los Guilicos Region, straddles the divide between the Sonoma Creek watershed and the Laguna de Santa Rosa watershed. Rainfall from present day Matanzas Region drains north and rainfall from the present day Foothills Region drains south to meet at Oakmont Creek. Even today, water in this area is hard pressed to decide whether to seek out the Pacific Ocean via the Russian River or San Francisco Bay via Sonoma Creek. The basin deposits here are testimony to history's third option, which was to capture and hold the water at its point of indecision.

Sedimentary deposits that are not classically defined as alluvial fans, stream terraces, or basins, are identified here as *undifferentiated* alluvial deposits. They are widely found directly under the Laguna de Santa Rosa's main stem, all along the Windsor/Pool Creek system, along lower Santa Rosa Creek, and along the older valleys of the Goldridge hills.

In the south, a band of these undifferentiated alluvial deposits is found along Washoe Creek from the Laguna up to the creek's upper reaches near Meacham, Stony Point, and Roblar Roads. A similar band flanks Gossage Creek to an area south of Roblar between Peterson and Orchard Station Roads. These two creeks, which today are conjoined into a single flood control channel, appear to have met the Santa Rosa Plain of the Pleistocene epoch together with a broad swath of old Goldridge Hill sediment. The hills which today skirt the southwestern side of the Laguna channel from Cotati Creek to Turner Creek are among the oldest alluvial deposits of the watershed.

Next north along the Goldridge Hills, is Turner Creek, which together with Blucher Creek, has a nearly identical footprint of alluvial deposits. Both widen towards the Laguna before meeting the relatively recent alluvial underlayment along this part of the main stem. Walker

Creek, which is approximately the same length as nearby Turner Creek, has a more stub-like shape to its alluvial deposits. Two ghost-like alluvial nubs at the base of Turner, without clearly definable modern-day creeks, suggest that changes to the local hydrology have recently occurred in this area.

Gravenstein Creek enters the Laguna from the east, its ribbon-like 300′ wide swath of adjacent alluvial deposits extends fully across the Santa Rosa Plain to meet the Matanzas/Santa Rosa fan. Only four creeks break the Santa Rosa Plain in this fashion; this is the southernmost of the four. The maze of crisscrossing waterways which form the Laguna near the Roseland/Windmill/Calder floodplain sit atop a wide patch of recent alluvial deposits.

Pine Tree Creek, which today goes almost unrecognized as it slips under High School Road near East Hurlbut Avenue, has a surprisingly well-defined alluvial foundation. Its confluence with the Laguna has been moved north of its former location sometime in modern history.

Irwin Creek enters the Laguna from the east, just north of Occidental Road, after following a 700–800′ wide depression of alluvium which reaches across the plain and beyond Piezzi Road.

Santa Rosa Creek is the second of the four creeks whose alluvial underlayment reaches fully across the plain. It averages about 2000′ in width, is older as it approaches the mountains and younger as it approaches the Laguna. The alluvial deposits extend to connect with Piner and Steele Creeks as well as Santa Rosa Creek itself. Older alluvium is also present in a small patch south of present-day Delta Pond, and in an even smaller patch at Guy Creek.

North of Guerneville Road, three short, narrow, recent alluvial fingers extend east along Illingsworth, Atkinson and Bailiff Creeks. Vine Hill Creek, which enters from the west in this zone, makes its way through a 500′ wide valley that extends well beyond Laguna Road. Just beyond Ballard Flat, an alluvial stub reaches westward up Clark Creek a short ways beyond Laguna Road. On the east side of the Laguna, where present day Mark West Creek dips deeply south, in the area between Ballard Flat and Hinkley Hill, alluvial deposits extend south to Denner Ranch Road, a short way up Rued Creek, and a short way up Woolsey Creek. North of Hinkley Hill, alluvial deposits fill the flat, broad, 2000–3000′ wide valley of 19th century Mark West Creek. These deposits meet, in a contiguous fashion, the stream terraces just east of Slusser Road.

After passing Ritchurst Knob and the confluence of Windsor Creek, the remainder of the westward trending Laguna is underlain by a slightly narrower band of alluvium, nearly all of it situated north of River Road.

Windsor Creek's alluvial underlayment is approximately 1000' to 1500' wide near its confluence with the Laguna at Trenton-Healdsburg Road, behind Ritchurst Knob. Three separate arms of narrow alluvial deposits reach across the northern end of the Santa Rosa Plain in the San Miguel Region, where Windsor Creek splits into three, following the course of present-day Laughlin, Pool, and Windsor Creeks. A thin north-trending extension of alluvium, which bifurcates at the Starr/Jacobson creek split, parallels Starr Road and reaches up to Windsor River Road.

Rainfall

Rainfall within the Laguna de Santa Rosa watershed flows through byways and creeks that trend north and west towards their eventual exit at the Russian River confluence near Forestville. Precipitation falls throughout the watershed each year between early November and late May. The amount of rainfall that typically occurs each year varies from place to place (see Plate 8). The Montane Region receives the greatest amount of precipitation, typically more than 60 inches per year. Taylor Mountain, situated in the elevated western arm of the Matanzas Region also receives a greater amount of precipitation than its surrounding neighborhood, typically more than 40 inches per year. On the other hand, the San Miguel, Piner and northern Llano regions are much drier, receiving only 30 to 35 inches of precipitation annually. The driest part of the watershed is in the south where the southern Llano and Cotate regions typically receive between 25 and 30 inches of rain each year.

Region	*Annual precipitation*
Llano	27–35"
Cotate	27–38"
Wright	28–37"
Gossage	30–33"
Laguna	30–36"
Piner	31–34"
Cabeza	31–39"
Foothills	32–55"
Blucher	33–37"
Los Guilicos	33–37"
San Miguel	33–43"
Bennett	34–41"
River	34–41"
Matanzas	34–46"
Taylor	34–47"
Goldridge	35–37"
Forestville	35–41"
Montane	39–62"

Table 2: Annual precipitation

The effect that global warming will have on this rainfall pattern is uncertain, however it is thought that higher temperature spikes will occur in the summer while more severe storms will occur in the winter.

Biological communities

Historical Roots of Laguna Diversity

The geologic origin of the Laguna channel and surrounding uplands is in many ways responsible for the watershed's extraordinary biodiversity. Aging soils in the deep alluvium produced hardpans and thick clay-layers in some areas, creating the underlayment for a vast seasonal wetland ecosystem, with thousands of vernal pools and swales covering the Santa Rosa Plain. The geographic isolation of these wetlands and the Santa Rosa Plain fostered the evolution of plants and animals found nowhere else. Grasslands—grading into oak savannah and woodland—grew on loamy alluvial soils above stream courses and in upland areas around vernal pools, while rich riparian forests developed in lower portions of floodplains. The Laguna's slow currents created pools of water that provided habitat for water birds. Freshwater marshes, rich with plants and animals, formed in low areas bordering the channel. From the Plain to the steep eastern hills, vegetation changes abruptly. Here, the narrow canyons and mountain creeks are lined with white alder, bay, bigleaf maple and the occasional redwood. North-facing slopes are cloaked with Douglas-fir, and deciduous oak forests, while drought-tolerant chapparal and coast live oak dominate the drier south and west-facing slopes.

Immediately following the last ice age, which in Sonoma County ended about 11,000 years ago, the Laguna's wildlife was dramatically different from today. Bison, ground sloths, horses and camels grazed the hills and grasslands; mastodons and mammoths ate trees and other large plants; and all were prey for saber-toothed cats, dire wolves, short-faced bear and American lions. These animals disappeared from California sometime around the arrival of humans; but abundant deer, elk, and pronghorn antelope remained.

Community types

Environmental conditions vary within the Laguna watershed: hot and dry conditions—exaggerated by the rainless summers of the Mediterranean climate—grade to cool, shaded channels and wetlands that are continuously covered with water. Different environmental conditions favor different suites of plant species, or *communities*, which then provide home and shelter for a diversity of wildlife. Plant communities are loose, dynamic species-assemblages, but can be grouped into a few general types: riparian forest, grassland, oak savannah, oak woodland, seasonal wetlands, freshwater marsh, coniferous forest.

These plant communities have no fixed boundaries and their precise location can shift through time as a result of meandering channels, fire regimes and changing climate factors. Throughout these communities or *habitats*, the life histories of plants and animals are deeply interdependent. Predators and prey, seeds and nutrients move between them. Patches are colonized by new species, others disappear only to recolonize as conditions change and opportunities arise. There is no truly stable ecological state, but a dynamic interplay of species and resources creating broad patterns in the web of life.

Riparian Forest

Mark West and Santa Rosa creeks traverse the Santa Rosa Plain extending to the Laguna; these two creeks carry water throughout the year. To a lesser extent, Windsor, Pool, Irwin and Gravenstein creeks also extend across the Plain, and they remain water-filled through all but the driest of summers. Under natural conditions, riparian forests develop along the banks and floodplains of these waterways. Channel banks are often lined with white alders with tall canopy that shade and cool the water. Wind-borne seeds of cottonwoods and willows take hold in deposits of fresh sand or silt, forming very dense stands of tiny seedlings which over decades thin naturally to provide more high shade canopy. As willow and cottonwood stands mature, other plants come in: oregon ash, box elder, and black walnut, and begin to dominate wetter areas; bay, maple and oaks establish along higher stream banks. Blue elderberry is common in riparian forest edges; as are many small trees and shrubs, especially mugwort, California blackberry, twinberry, spicebush, and pipe vine.

Abundant plants provide ample food and shelter for wildlife. Insects, seeds and fruit abound in all layers of the forest. Woodpeckers create hollows in aging trees, and provide homes for many other birds. Belted kingfishers and northern rough-winged swallows make their homes in burrows along cut-banks. Stream-living insects like midges, caddisflies and stoneflies thrive on detritus from the surrounding forest, providing food for native fish like steelhead trout, threespine stickleback, California roach and prickly sculpin. The California freshwater shrimp, now federally listed, can still be found in Blucher Creek. Upper reaches of streams in the eastern hills are home to yellow-legged frogs.

The most widespread understory weeds, in these riparian forests, are Himalayan blackberry, and periwinkle—which both form dense, smothering canopies which dominate entire forest floors. Giant reed, perennial pepperweed and purple loosestrife are emerging threats to the ecosystem.

Grassland

The Santa Rosa Plain is still cloaked in grasslands; which can be divided into dry or wet-phase types, characterizing their tolerance to drought or seasonal flooding. Significant stands of dry-phase native grassland are rare on the Plain, but they can still be found on mountain slopes to the east of the plain. On these hillsides, native needlegrasses are interspersed with California brome, and native lupines and lilies make showy displays in spring. In many places, this community has been invaded or displaced by non-native annual grasses and herbs that thrive under the same conditions: soft chess, ripgut brome, filaree, wild mustard, wild radish, and Italian thistle.

Wet-phase native grasslands are found where soils are saturated by winter rainfall or floodwater. California wild oat and meadow barley dominate these areas, with thick scattered stands of creeping wild rye. These grasses are accompanied by water-loving wildflowers; white hyacinth, creamcups, coast sun cup, purple sanicle, and others. Like the dry grassland, this community has been invaded by its own suite of alien plants. Perennial Harding grass is common, as are Italian ryegrass and Mediterranean barley; rough cat's ear, curly dock, and cutleaf geranium replace the native herbs.

Wildlife make little distinction between wet and dry phases of the native grassland, and even invaded areas support many animals. Plants feed seed-eating birds, pocket gophers, California voles and blacktail hares; while the insects of the grassland feed birds like the western meadowlark. These birds and small mammals provide prey for hawks, owls, and predators like the bobcat and gray fox. White-tailed deer are very abundant, and provide prey for mountain lions which are once again becoming common. In some meadows and pastures you can still find the large burrows of the American badger, and sometimes colony-sites of burrowing owls.

Valley oak savannah and woodland

There are no clear delineations between oak savannah and woodlands, which differ mainly in density. The oak woodland habitat type hosts the largest species diversity of any habitat in California, and is one of the most diverse habitats in North America. Oak woodlands are able to support a great variety of life for several reasons. Abundant acorns provide the base of the oak food web, and are consumed by birds, animals and insects. Oak leaves are browsed by deer and insects, and the annual leaf-drop contributes to a rich soil-invertebrate community. Individual oak trees are a mosaic of living and dead branches; woodpeckers, and wood-boring insects create cavities of many sizes that are used by many species—including oak titmouse, western bluebird, and American kestrel—for nesting and storage of acorns. Tree canopies provide nest sites for birds like raptors, crows, and mourning doves.

Oak savannah tends to have a grassland understory like those described above, and thus are also host to many grassland-associated plants and animals. In the woodlands where tree density is high, and below individual trees of the savannah, more plant species appear: blue wild rye, a tall perennial grass, and herbs like miner's lettuce, baby blue eyes, and milk maids.

Although mature trees produce massive acorns crops, one of the biggest threat to oak habitats in the Laguna is a lack of regeneration. Oak seedlings are vulnerable to grazing by cattle, deer and rodents, and are lost through continuous tillage and mowing. Sudden Oak Death, an invasive fungal disease, is deadly to many oak species in the upper watershed, though the valley oak is mostly immune.

Seasonal wetlands

In open areas, where water sits on the ground surface in the winter and early spring, grasslands grade into seasonal wetlands: shallow vernal pools and swales, and the annually-inundated floodplain. Where water stands for long periods, the vernal pool flora thrives. Different species favor different water depths, producing colorful striations or bulls-eye floral patterns around pond edges. Douglas' and Sebastopol meadowfoam may form spectacular displays of white in spring, with yellow swaths of Burke's goldfields and Sonoma sunshine. Most vernal pool annuals begin their growth while still underwater, but put on height, and flower as pools dry. As the season progresses, heavily spine-armored tarweeds and coyote thistle emerge in the pools, and meadow barley grows in the vernal swales. In deeper pools and floodplains, perennial rushes and sedges dominate. These wetlands can also host dense stands of Lobb's buttercup: a seemingly fragile plant, with floating leaves and flowers, who's branched aquatic leaves create a complex underwater habitat resembling a miniature kelp forest. Deeper water ponds are fairly resistant to invasive plants but Harding grass and wild rye can crowd out natives in shallow areas, and perennial pepperweed is an emerging threat to this system.

Rain-fed pools are breeding habitat for the Pacific treefrog, and deeper ones support breeding by the California tiger salamander. Treefrog tadpoles are herbivores and are thought to encourage the growth of flowering plants by eating algae in the water. Tiger salamander larvae eat these tadpoles and other aquatic invertebrates, like clam shrimp. As tadpoles metamorphose into frogs, they are eaten in large numbers by wading birds, waterfowl and garter snakes. Tiger salamander larvae are choice prey for river-fish, so they are almost never found in areas inundated by floodwater.

Freshwater marsh

Marshes develop where water stands all year long. Plant diversity is often low, with single-species stands of cattail and bulrush most common, interspersed with water plantain and spike rush, but freshwater marshes are home to a great variety of aquatic insects, snails and other invertebrates as well as small, warm-water fish. These perennial wetlands are thus rich feeding-grounds for dabbling mallards and wading birds like the great egret. As aquatic insect larvae metamorphose into swarms of midges, mayflies, and dragonflies, they sustain large numbers of bats, swallows, and other insect-eating animals. Marsh-nesting birds like marsh wren and redwing blackbird also take advantage of these rich food sources. In the winter, the Laguna's marshes become lake-like, hosting great flocks of birds migrating along the *Pacific Flyway*.

Although there are many native plants and animals that thrive in the Laguna's freshwater marshes, these communities are probably quite different than those prior to European settlement. Bullfrogs, introduced for bait and as a source of frog-legs, are a heavy predator of other amphibians and have probably displaced native frogs species. Introduced crayfish are also voracious and omnivorous consumers, eating plants, amphibians and small fish. Both crayfish and bullfrogs are extremely abundant in the Laguna. Water primrose (*Ludwigia*), an ornamental plant likely introduced from South America, has taken over vast areas of Laguna wetlands, filling the water column with dense mats and crowding out all other plant species.

Coniferous forest

West of the Laguna, from Sebastopol north, areas now planted to grapes and apples were once covered by coniferous forest dominated by redwoods and Douglas fir. Conifers also line the canyons to the east of the plain. Douglas fir is a late-successional species, which can slowly displace mixed oak and deciduous forests when forest-fires become very infrequent.

These coniferous forests have their own characteristic suite of bird and animals, though in general, there is less species diversity than in the oak woodlands they displace. Perching birds like nuthatches and fox sparrows feed on small insects on tree-trunks and the forest floor. Owls and other raptors roost in lofty nests or cavities of older trees. Deer are sometimes very abundant, browsing on shrubs and herbaceous plants. Wild ginger, valerian, and violets emerge in springtime. In wetter areas, sword ferns, liverworts and mosses line stream-banks, trails and roadsides. Wildlife from these forested hills often travel to the lowlands to feed. For example, predatory birds and bats may nest or roost in forests, but forage nightly on small animals and insects of the Plain; in the streams, salmon and trout spawn in the gravelly headwaters of the Laguna tributaries, then migrate to the Pacific to grow fat on ocean fish.

Though historically cleared for timber, and now for agriculture, in many parts of the upper watershed coniferous forests are once again expanding. Park managers must often decide whether to allow this succession to take place—facilitated by the human-caused reductions in forest-fire frequency—or to actively thin-out conifers to manage for a higher-diversity woodland.

Geophysical regions

A full treatment of the eighteen geophysical regions appears in Volume II, Appendix E.

Region	*Elevation range (feet)*
River	21–277
Laguna	46–191
Llano	52–219
Forestville	57–517
Piner	60–178
Goldridge	62–355
Wright	63–361
San Miguel	65–274
Cotate	82–475
Blucher	84–731
Gossage	106–688
Foothills	143–1935
Taylor	162–2463
Cabeza	192–451
Matanzas	195–2463
Bennett	298–720
Los Guilicos	309–623
Montane	492–2730

Table 3: Elevation ranges

Region	*Area* (mi^2)
Los Guilicos	2.5
Bennett	2.7
Goldridge	3.0
Forestville	3.4
Cabeza	6.9
Gossage	7.5
River	9.7
Piner	10.5
Laguna	11.6
Blucher	12.1
Taylor	12.7
San Miguel	14.9
Cotate	15.2
Matanzas	19.0
Wright	19.7
Llano	22.8
Montane	36.3
Foothills	43.2

Table 4: Regional areas

Principal sources

California Dept. Water Resources Planning and Local Assistance. North Coast Hydrologic Region, Santa Rosa Valley Groundwater Basin. “Santa Rosa Valley, Healdsburg Area Subbasin” Accessed June 21, 2006. Available at www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/1-55.02.pdf

Cloud, W. K. et.al. California Geology, “The Santa Rosa Earthquakes of October, 1969”, March 1970, Vol. 23, No. 3.

Cordell, Kim. pers. comm. May 2004-April 2005.

Hochstaedter, Alfred. “Earthquakes: Liquefaction”, Accessed June 21, 2006. Accessible at http://www.es.ucsc.edu/~es10/fieldtripEarthQ/Damage1.html

Northen, Philip. “Biological Communities” appearing in chapter 9 *Enhancing and Caring for the Laguna*, Joseph Honton and Anna Warwick Sears, Laguna de Santa Rosa Foundation, 2006. Published herein for the first time.

Press Democrat. “When the Earth moved”, September 6, 1998, Eileen Clegg.

USGS. “This Dynamic Earth: The story of plate tectonics”. Accessed June 21, 2006. Accessible at http://pubs.usgs.gov/gip/dynamic/Farallon.html

Wright, Terry. “Overview of Sonoma County Geology” Accessed June 21, 2006. Available at http://www.sonoma.edu/geology/wright/overview.html

GIS Data sources

See chapter 8, “Mapping Geographic Data”, for citations related to the data used in this chapter.