4 Vegetation

> Crossing the treeless plains of the Sacramento and San Joaquin from the west and reaching the Sierra foot-hills, you enter the lower fringe of the forest, composed of small oaks and pines, growing so far apart that not one twentieth of the surface of the ground is in shade at clear noon-day. After advancing fifteen or twenty miles, and making an ascent of from two to three thousand feet, you reach the lower margin of the main pine belt, composed of the gigantic Sugar Pine, Yellow Pine, Incense Cedar, and Sequoia.

John Muir, *The Mountains of California, 1894*

As described by Muir, the grassland, oak woodland, and chaparral of the foothills give way at higher elevations to the conifer forests of the mountains' heights. This transition, however, is not uniform. Rather, the complexities of slope, aspect, soil, and history are superimposed on the effects of elevation. The result is a large area in which foothill and montane vegetation are intermixed, and the study area of this report extends to the upslope margins of this area. Table 4-1 describes the major foothill and montane vegetation types and figure 4-1 summarizes the portions of each region consisting of foothill versus montane vegetation.

Although montane vegetation is well represented within the Foothills Area, we emphasize foothill plant communities in this analysis because these communities are most characteristic of the region. Also, unlike montane conifer and hardwood forests, foothill communities are not well represented in the national forests at higher elevations.

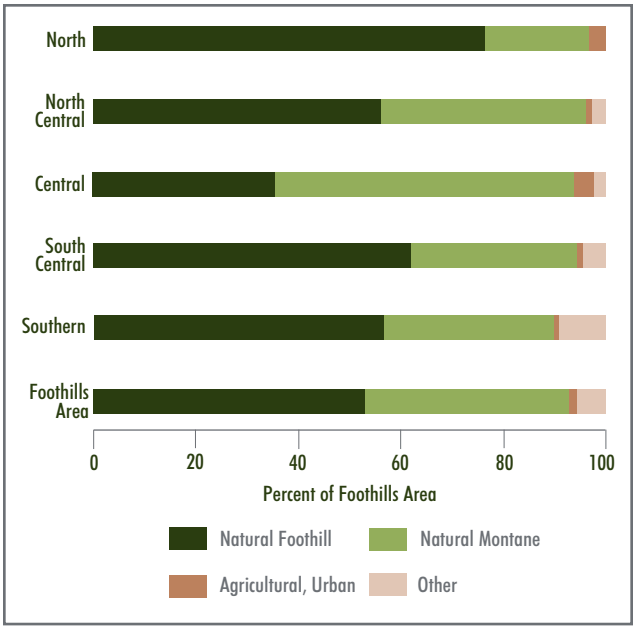


Figure 4-1. Proportions of Foothill and Montane Vegetation Types in the Foothills Area

4.1 Major Foothills Vegetation Types and Botanically Significant Landscapes

The major vegetation types characteristic of the Foothills Area include the following:

- Foothill Grassland;
- Blue Oak Savanna and Woodland;
- Foothill Hardwood and Conifer Woodland;
- Foothill Riparian; and
- Foothill Chaparral.

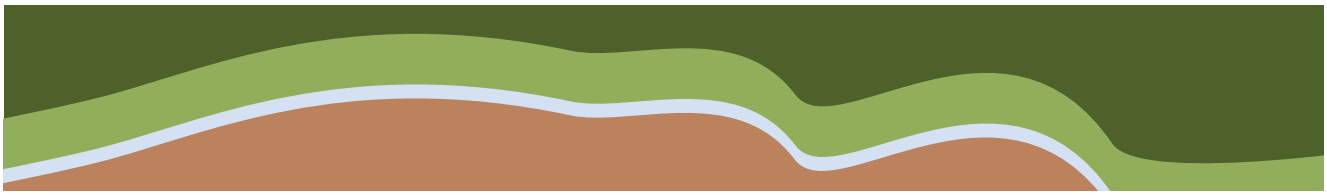
Each of these vegetation types is described below. Several botanically significant landscapes of the foothills are also described; these are areas where distinctive substrates of rock and soil support unique vegetation and assemblages of endemic plants.

Table 4-1. Major Vegetation Types of the Foothills Area

MAPS V-1–V-5 Vegetation Type	Description
FOOTHILL GRASSLAND	Open herb community dominated by nonnative annual grasses, primarily of Mediterranean origin, but also containing numerous (but generally less abundant) native and nonnative forbs, and several native perennial grasses that dominate only relatively small patches.
FOOTHILL CHAPARRAL	Moderate to dense cover of broadleaved, evergreen shrubs, supporting a rich mixture of woody species (although including extensive areas dominated by chamise) and typically a very sparse or no herb layer. Structure varies with time since last fire.
BLUE OAK SAVANNA AND WOODLAND	A broadleaved, deciduous community dominated by blue oak trees. The tree canopy is generally open but may be dense on some sites, and may include other trees, particularly foothill pine. The shrub layer varies from lacking to dense, and is generally sparse. The understory is characterized by moderate to dense herbaceous cover, primarily of annual grasses and forbs.
FOOTHILL HARDWOOD AND CONIFER WOODLAND	
Closed-Cone Pine-Cypress Woodland	Woodland and forest communities with a discontinuous to dense tree canopy dominated by knobcone pine, McNab cypress, or Piute cypress, with varied understory vegetation. The dominant trees are all smaller conifers with closed-cones that are opened by fire.
Foothill Hardwood-Conifer Woodland	Woodlands dominated by evergreen or deciduous oak trees other than blue oak: coastal oak, live oak, and valley oak woodland. Other abundant tree species include California buckeye and foothill pine. Shrub and herbaceous layers vary in cover and species composition.
MONTANE CHAPARRAL	Moderate to dense cover of shrubs, dominated by evergreen shrubs of varied height, and understory sparse except in years following fire. Dominants are different than in Foothill Chaparral.
MONTANE HARDWOOD AND CONIFER FORESTS	
Montane Hardwood/ Hardwood-Conifer Forest	Forest communities dominated by evergreen and/or deciduous, broadleaved trees (primarily oaks), that also may have an upper coniferous tree layer. The shrub and herbaceous layers are generally sparse.
Lower Montane Conifer Forest	Forests with discontinuous to continuous tree layers that become multilayered in late-seral stands, and are dominated by a mix of large, long-lived conifer species, including ponderosa pine, Douglas fir, and white fir. Shrubs are typically abundant, particularly in openings, and native grasses and forbs are typically present.
Upper Montane Conifer Forest	Forests that are generally similar in structure to lower montane forests, but that are dominated by different conifer species (e.g., red fir, lodgepole pine, and Jeffrey pine) and support different assemblages of shrubs and forbs.

Table 4-1. Major Vegetation Types of the Foothills Area

MAPS V-1–V-5 Vegetation Type	Description
RIPARIAN, FRESH EMERGENT WETLAND, AND WET MEADOW	
Foothill Riparian	A variety of forest and scrub communities dominated by deciduous trees and shrubs. Willow species and Fremont cottonwood are the typical dominants of earlier successional patches, but a mixture of tree species typically dominates later successional patches. Shrub and herbaceous layers are often dense.
Montane Riparian	Forest dominated by deciduous trees including white alder, thinleaf alder, aspen, bigleaf maple, and black cottonwood; with an understory that often consists of dense shrub and/or herbaceous vegetation.
Fresh Emergent Wetland	Dense, tall herbaceous community dominated by perennial plant species, typically monocots up to 7 feet tall, and that may be rooted in submerged sediment with shoots and leaves extending above-water (e.g., cattails).
Wet Meadow	A dense herbaceous community dominated by rushes, sedges, and grasses; typically containing a wide variety of forbs.
Desert Riparian	Communities that vary from forests and woodlands dominated by Fremont cottonwood, willows, and the nonnative tamarisk, to open woodlands of varied trees and shrubs including mesquite and tamarisk. (In Maps V-1–5, Alpine Dwarf Shrub is included in Other Vegetation.)
AGRICULTURAL	Human-created and maintained vegetation that includes irrigated row and field crops, pasture, vineyard, and orchard.
URBAN	Developed land cover with structures, pavement, and varied vegetation that includes disturbed areas, small remnant patches of natural vegetation, and landscaping that is generally irrigated and may include large trees.
OTHER/UNLABELED	
Alpine Dwarf Shrub	Higher elevation communities with a dense layer of perennial grasses, forbs, and short shrubs.
Barren	Nonvegetated. Composed of rock, gravel, or bare soil, including mine tailings, which can be extensive at some locations (e.g., the Yuba Gold Fields).
Desert Scrub and Woodland	Open woodlands dominated by pinyon pine, juniper, or Joshua tree; and scrubs dominated by bitterbrush, sagebrush, and other shrubs.
Lacustrine	Aquatic habitats that are in inland depressions or dammed river channels containing standing water.
Riverine	Aquatic habitats that are in sloped stream channels with intermittent or continually flowing water.



4.1.1 Foothill Grassland

Each year, the color of grass-covered slopes and valleys throughout the Foothills Area cycles from the vibrant green of new growth during winter and spring to the tan of dead, standing shoots and leaves in summer and fall. This visually striking cycle corresponds to the life cycle of the Mediterranean grasses that now dominate Foothill Grassland. Although Foothill Grassland is dominated by a small number of nonnative annual grasses, this vegetation type includes a large number of species; particularly species with an annual life history, both natives and nonnatives (Bartolome et al. 2007). These species differ substantially in the timing and duration of germination, growth, and reproduction. As a consequence, grassland structure and species composition varies substantially as the growing season progresses. In response to annual patterns of temperature and rainfall, grassland structure and species composition also varies from one year to the next.

The composition of Foothill Grassland prior to European settlement is not known, but has long been considered to have been dominated by bunch grasses, particularly purple needlegrass, and to a lesser extent other bunch grasses: blue wildrye, Sandberg bluegrass, deergrass, and giant ricegrass. However, forbs and annual and rhizomatous grasses may also have been important or dominated Foothill Grassland (Hamilton 1997, Holstein 2001).

We have so little information about the original grassland because of how rapidly it was altered by nonnative species. Adobe bricks of the missions contain seeds of some nonnatives (Bartolome et al. 2007); when Captain John C. Fremont led his first expedition down the canyon of the American River in 1843, he encountered Native Americans gathering the Eurasian forb stork's-bill, which was apparently already abundant in the foothills (Fremont 1846). As additional nonnative species have been introduced to and spread through the Foothills Area, many have become abundant in Foothill Grassland. Currently, more than half of invasive plants in the Foothills Area that are moderate or high ranked by Cal-IPC occur in Foothill Grassland vegetation, and a number of other nonnative species locally dominate grassland (Cal-IPC 2006).

Currently, about 21% of the Foothills Area is Foothill Grassland (Appendix C-V). These grasslands provide habitat for 20 endemic species (which is about 20% of the endemic flora of the Foothills Area; table C-3). These endemics are most concentrated in the Central Subregion, where the richness of endemic plants is greatest relative to grassland area.

The current distribution of Foothill Grassland differs somewhat from its distribution prior to 1849. Conversion to agricultural and developed uses has eliminated some Foothill Grassland; however, management practices may have increased the extent of Foothill Grassland in other areas. Historically, woodcutting, grazing, fire, and mechanical treatments have converted other vegetation types to Foothill Grassland. Although agricultural and urban development in recent decades has caused the loss of some acreage, there has still been a net increase in Foothill Grassland acreage, at least locally (Thorne et al. 2008).

4.1.2 Blue Oak Savanna and Woodland

In the Sierra Nevada and Cascades of California, Blue Oak Savanna and Woodland is the vegeta-

tion type most closely associated with the foothills. These visually appealing woodlands account for roughly 21% of the Foothill Area's vegetation.

Blue oak is a long-lived, deciduous tree that grows to more than 60 feet in height (Sawyer et al. 2009). Blue oaks survive low intensity fire but are often top-killed by more intense fires. Top-killed trees often sprout new shoots from their stem bases.

Woodlands dominated by blue oak vary from widely spaced trees, with grass-dominated understories similar to Foothill Grassland, to continuous tree canopies with sparse understories of shrubs and herbaceous plants. These woodlands intergrade with Foothill Grassland in savannas of widely spaced trees, and also intergrade with dense woodlands still dominated by blue oaks but with other trees also present in the canopy; particularly foothill pine, interior live oak, and California buckeye.

Blue Oak Savanna and Woodland, together with other woodlands, provide habitat for roughly 80% of the plants endemic to the Foothills Area. These endemics are primarily herbaceous plants, and many of these endemics also grow in Foothill Grassland or Foothill Chaparral. Similar to Foothill Grassland, in Blue Oak Savanna and Woodland, endemics are most concentrated in the Central Subregion.

The extent of Blue Oak Savanna and Woodland has been reduced both through conversion to developed and agricultural land uses, and through land management practices; in particular, woodcutting and historical efforts to improve grazing land. This historical conversion is illustrated by figure 4-2, a photograph taken in El Dorado County during the Vegetation Type Mapping (VTM) of the 1930s and which notes "cutting followed by grazing," and other photographs have similar notes (Wieslander Vegetation Type Mapping Collection 2005).The magnitude of this reduction has been greatest in the North Central, Central, and South Central subregions.

Figure 4-2. Grazing of Cut Oak Woodland in El Dorado County in the 1930s
Source: Wieslander Vegetation Type Mapping Collection 2005; courtesy of Marian Koshland Bioscience and Natural Resources Library, University of California, Berkeley

Nonnative invasive species have substantially altered blue oak savannas and many blue oak woodlands. Nearly one-third of the invasive plants in the Foothills Area that are moderate or high ranked by Cal-IPC occur in Blue Oak Savanna and Woodland (Cal-IPC 2006). These include many of the species that dominate Foothill Grassland; and these species also dominate the understory of blue oak savanna and many woodlands.

Also, the regeneration of blue oak, and thus the persistence of these woodlands and savannas, has been an area of concern among scientists

and research managers (Tyler et al. 2006). When canopy oaks die, their replacement through the growth of saplings or the remaining canopy trees is necessary to maintain the tree canopy. Currently, saplings are absent or at low densities on many sites, and at most sites recruitment of saplings seems insufficient to sustain existing densities of canopy trees (Zavaleta et al. 2007). The infrequent recruitment of saplings appears to be a consequence of multiple factors: climate, interactions with herbivores, competition for resources with nonnative herbaceous plants, and the reproductive biology of the oaks themselves. Regional differences in regeneration exist but are relatively small, and considerable variation exists among sites within a region.

4.1.3 Foothill Hardwood and Conifer Woodland

Although much less extensive than Blue Oak Savanna and Woodland in the Foothills Area, woodlands dominated by other oaks and by three closed-cone conifers (knobcone pine, McNab cypress, and Piute cypress) also exist in the Foothills Area (Sawyer et al. 2009), and account for approximately 3% of the vegetation (Appendix C-V). These woodlands are most extensive in the South Subregion.

In addition to blue oak, four oaks dominate woodlands in the foothills: valley oak, California black oak, canyon live oak, and interior live oak. All are long-lived, sprout from their stem bases when cut or top-killed by fire, and reproduce by acorns. Otherwise, there are considerable differences in their ecology. Valley oak is a large deciduous tree that is a dominant of some riparian forests and of open woodlands on fertile, deep soils. Like blue oak, valley oak recently has had only limited recruitment of saplings. It also has been affected

Blue Oak Savanna and Woodland, Nevada County

by the substantial alteration of riparian corridors that has occurred since European settlement. Consequently, valley oak-dominated woodlands and riparian forests are considered sensitive plant communities.

California black oak is a large deciduous tree that dominates some woodlands on upland sites. It is also abundant in Montane Hardwood and Conifer Forests. Canyon live oak and interior live oak are evergreen, and vary in growth form from a shrub to a large tree. Both grow in chaparral and woodlands, and canyon live oak is a conspicuous dominant of woodlands on the steep slopes of river canyons. The woodlands dominated by these species have sparse to dense understories of shrubs, forbs, and grasses.

Knobcone pine, McNab cypress, and Piute cypress are small conifers (up to 40, 20, and nearly 50 feet, respectively). Although relatively uncommon, these conifers dominate woodlands where they occur. All three species produce serotinous cones that remain closed, retaining their seeds until opened by fire, and are readily killed by fire. Thus, intervals between fires must be sufficiently long to

allow a new seed crop to accumulate on the trees, but short enough to assure that viable seed crops are present on aging trees.

In general, the endemic plant species associated with Foothill Hardwood and Conifer Woodland appear to be similar to Blue Oak Savanna and Woodland: plant collection records in herbaria often do not distinguish blue oak woodlands from other woodlands. However, Blue Oak Savanna and Woodland accounts for most woodland in the Foothills Area, and thus, the endemic species occurring in other woodlands probably represents a relatively small subset of woodland endemics.

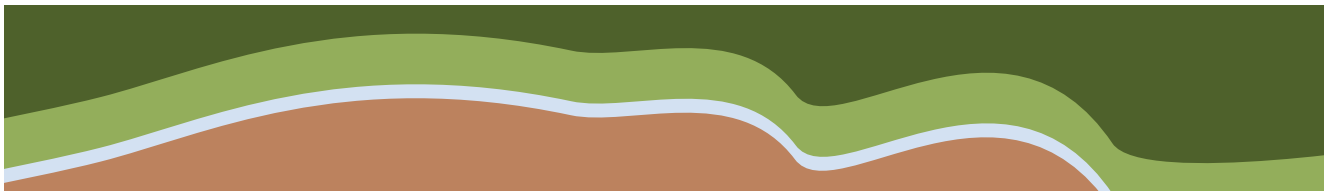
For Foothill Hardwood and Conifer Woodland, historical patterns of loss are also similar to Blue Oak Savanna and Woodland. However, for some Foothill Hardwood and Conifer Woodland (e.g., closed-cone cypresses and pines), historic losses are probably less than for Blue Oak Savanna and Woodland because more Foothill Hardwood and Conifer Woodland is on steeper, rockier sites, or have greater shrub components, or both. Consequently for those woodlands, conversion to grassland for grazing, or to agricultural or developed land uses, probably has been less extensive than for Blue Oak Savanna and Woodland.

Alteration of Foothill Hardwood and Conifer Woodland by nonnative, invasive plants has probably been less than in Blue Oak Savanna and Woodland. Some foothill woodlands are dominated by evergreen plants or have a greater abundance of shrubs than Blue Oak Savanna and Woodland, or both. These are attributes more similar to Montane Hardwood/Hardwood-Conifer Forests, Foothill Chaparral, and Montane Chaparral, which have fewer invasive plants than Blue Oak Savanna and Woodland. Thus, there are fewer invasive species associated with these habitats than with Blue Oak Savanna and Woodland (Cal-IPC 2006).

4.1.4 Foothill Riparian

Riparian areas are transitional zones between terrestrial ecosystems of watersheds and aquatic ecosystems of the rivers and streams that drain them. Where foothill valleys are wide and gently sloping, this transitional zone is largely occupied by riparian forests, which are dominated by plants that require available water throughout the growing season. Where foothill valleys are narrow and steep, riparian forests are confined to a narrow band along the watercourse; vegetation typical of uplands comes close to the watercourse. However, in corridors along rivers and streams, both Foothill Riparian and upland vegetation provide essential habitats for wildlife, and thus, these corridors are discussed in Section 3, "Wildlife." Foothill Riparian has been mapped in only a very small portion of the Foothills Area (much less than 1%; Appendix C-V). The text below briefly summarizes the ecology of these forests.

The tree, shrub, and herbaceous layers of Foothill Riparian vegetation vary considerably in their height, cover, and species composition; typically, however, one or more layers of these forests are dense and lianas (woody vines) are often abundant; particularly California grape, blackberries, and poison oak. More than 15 native tree and shrub species occur in Foothill Riparian areas (Vaghti and Greco 2007). Although most of these species require reliable access to readily available water, they differ in several key attributes, such as shade tolerance and longevity. These attributes, in combination with site conditions (e.g., soils and soil moisture) and disturbance events,



determine the abundance of species and the structure of Foothill Riparian vegetation.

The species composition and structure of riparian vegetation typically change with increasing distance from the river channel. In-channel islands, point bars, and areas adjacent to the channel are generally dominated by fast-growing, short-lived species such as Fremont's cottonwood and willow species, which have less shade tolerance, greater tolerance of inundation, and greater tolerance of disturbance than other riparian shrubs and trees. For these species, recruitment (germination, establishment, and growth of new individuals) depends on conditions created by frequent flooding (e.g., exposed, moist mineral soil) (Mahoney and Rood 1998). Higher floodplains farther from the channel are dominated by species that require less water and tolerate more shade, such as Oregon ash and valley oak. These species are less dependent upon disturbance for their recruitment and live longer (e.g., for 250 years or more).

Foothill Riparian vegetation has been affected not only by conversion to agricultural and developed uses, but also by the regulation of flows by dams and diversions on most of the larger foothill rivers and streams. Levees, bank protection, and crossings by roads and utilities have also altered riparian ecosystems. Furthermore, in some watersheds, extensive changes in land use have increased peak flows, or dams and gravel mines have interrupted the movement of sediment downstream, resulting in incision of the stream channel and isolation of historical floodplains from their channels.

Nonnative invasive species have substantially altered the shrub layer of Foothill Riparian vegetation. Nearly one-third of the invasive plants in the Foothills Area that are Moderate or High ranked by Cal-IPC occur in Foothill Riparian vegetation, and a number of other nonnative species are locally abundant (Cal-IPC 2006, Hunter et al. 2003). These include invasive trees, shrubs, forbs, and grasses. However, only Himalayan blackberry is abundant over an extensive area; this species dominates the shrub layer of Foothill Riparian vegetation along many waterways (Hunter et al. 2003).

Foothill Riparian vegetation is part of a continuum that extends along river corridors from higher elevation montane areas to the floor of the Central Valley. Thus, almost no plants associated with riparian corridors are endemic to the Foothills Area, and furthermore, plants of riparian areas are often widely distributed and resilient to disturbance. Consequently, only a few special-status plants are associated with Foothill Riparian vegetation (Appendix C-III).

4.1.5 Foothill Chaparral

Chaparral communities are characterized by dense cover of drought-tolerant, evergreen shrubs, generally 3–9 feet tall. Chaparral communities in the Foothills Area typically have only a sparse herbaceous layer (except in the years immediately following a fire, when herbaceous plants flourish). Chaparral may be dominated by any one of several species of manzanita or ceanothus, or by other species such as chamise, scrub oak, or interior live oak. Foothill Chaparral covers about 9% of the Foothills Area (Appendix C-V).

The dynamics of chaparral are closely related to fire (Keeley and Davis 2007). Because the crowns of chaparral shrubs are at or within several feet of the ground surface, they are killed by fire. How-

ever, many chaparral shrubs sprout new shoots from their shoot bases. Also, many chaparral shrubs (both sprouting and nonsprouting species) have a soil seedbank of dormant seeds that are stimulated to germinate following fire. Some of the species that develop such seedbanks do not sprout new shoots from their base, and are thus dependent on post-fire regeneration from seed. Similarly, a number of herbaceous species also have soil seedbanks: their seed are stimulated to germinate by fire, become abundant and replenish the seedbank, but then are out-competed by shrubs. Following fire, sprouts and seedlings rapidly restore the shrub layer, which after reforming, changes in structure and species composition much more slowly than during the first decade following a fire.

Foothill Chaparral is arguably the most diverse vegetation of the Foothills Area. Although chamise and whiteleaf manzanita dominate large areas of Foothill Chaparral, many other shrub species also dominate patches of chaparral. Also, although chaparral occupies only about 10% of the Foothills Area (about 9% Foothill Chaparral and 1% Montane Chaparral), more than half of all Foothills Area endemic plants are associated with chaparral. Historically, the distribution of Foothill Chaparral has been altered both by the conversion of some chaparral to grassland, agricultural, or developed areas; and by conversion of woodlands and forests to chaparral following timber removal or through natural succession. The balance of these changes since the Gold Rush began is not known for the entire Foothills Area. But in the El Dorado County portion of the Central Subregion, during the twentieth century, these changes have reduced the extent of Foothill Chaparral (Thorne et al. 2011).

Of foothill vegetation types, chaparral is the least altered by nonnative, invasive species. Less than

North Table Mountain, Butte County

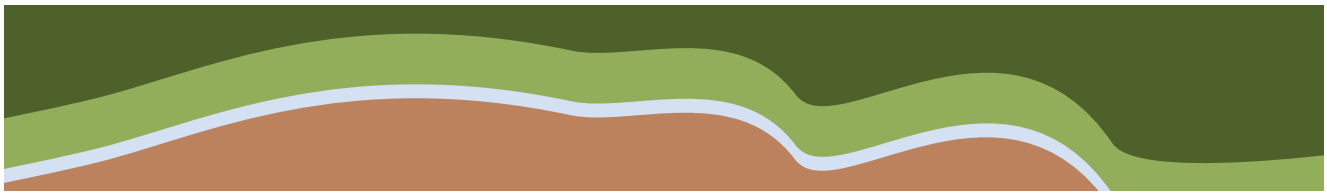
a tenth of the invasive plants in the Foothills Area that are moderate or high ranked by Cal-IPC occur in Foothill Chaparral (Cal-IPC 2006), and none of these dominates extensive areas of chaparral.

4.1.6 Botanically Significant Landscapes

The Foothills Area includes a number of soils with physical or chemical properties, or both, that strongly affect plant growth. Consequently, these substrates often support distinctive vegetation and endemic plants that are only rarely found growing on other substrates. Thus, landscapes underlain by these soils are botanically significant. Four types of such substrates are particularly important in the foothills: vernal pool complexes, serpentinite, gabbro, and the Ione Formation. Each is described further below, and their locations are shown on maps LP 1–5.

Vernal Pool Complexes

Vernal pools are seasonal wetlands that fill or are filled intermittently or continuously by winter rains and dry out in spring. In California, they



occur on nearly level landforms, where the soil or underlying rock has layers that are relatively impermeable to water. Vernal pools may be isolated from one another, but more often they are interconnected by swales or ephemeral drainages in vernal pool complexes that may extend for hundreds of acres. Vernal pool complexes occur at lower elevations along the length of the foothills (Map LP-1, Map LP-2, Map LP-3, Map LP-4, and Map LP–5), but are most extensive on volcanic mudflows in the northern foothills (Map LP-1). Pool size and the depth, duration, and seasonal timing of ponding are important factors that influence the composition and diversity of plant species in vernal pools (Solomeshch et al. 2007). Consequently, the vegetation of vernal pools can vary substantially from year to year in response to interannual fluctuations in climate.

Management activities such as grazing and burning also influence species composition and diversity. In fact, recent research indicates that the abundance of nonnative grasses, grazing practices, and hydrology are strongly interrelated and can substantially affect the plant communities of vernal pools (Marty 2005).

Foothill vernal pools are similar to those of the adjacent Central Valley, and thus, do not support species endemic to the foothills. However, about 11% of the Foothills Area's special-status plants are associated with vernal pool landscapes, which occupy only about 1% of the Foothills Area.

Serpentinite

Serpentinite is an ultramafic rock (i.e., a rock rich in magnesium and iron) containing large amounts of the mineral serpentine (California's state mineral), which is a hydrated form of magnesium silicate. Outcrops of serpentinite are associated with California's fault lines, and occur in the Foothills Area from the North Central to Southern subregions (Map LP- 2, Map LP-3, Map LP-4, and Map LP–5).

Soils derived from serpentinite (serpentine soils) have relatively little available calcium, which is an essential nutrient for plants, low concentrations of other nutrients, and high concentrations of heavy metals (Kruckeberg 2002). These soils also tend to be shallow and rocky. The vegetation growing on these soils tends to be shorter and more open than similar vegetation on other soils, and dominated by different species.

A number of endemic plants are associated with serpentine soils in the foothills, many of which are also special-status species. This association varies from taxa that are effectively restricted to serpentine soils to taxa that are often, or just sometimes, found on serpentine soils (Safford et al. 2005). Although serpentine landscapes account for only about 2% of the Foothills Area, 23% of foothill endemics and 13% of non-endemic special-status taxa are associated with these serpentine landscapes (Appendix C-III).

Gabbro

Like serpentinite, gabbro rocks are rich in magnesium and iron. Soils derived from gabbro share some commonalities with serpentine soils, but provide less extreme conditions for plant growth. Gabbro-derived soils often support diverse, locally distinct vegetation and endemic plant species. In the Foothills Area, this is the case for several areas, particularly the Pine Hill area of El Dorado County (Wilson et al. 2009, Map LP-3).
In the Pine Hill area, vegetation includes grassland, chaparral, and woodland. The chapar-

ral includes tall dense patches dominated by whiteleaf manzanita, buckbrush, and chamise, which are obligate or facultative "seeders," and patches on mesic sites with abundant resprouting shrubs and small trees, including interior live oak, toyon, poison oak, and redbud (Wilson et al. 2009). Woodlands are dominated by interior and black oaks with abundant poison oak in their understory. An assemblage of seven foothill endemics grows in the chaparral and woodland communities of the Pine Hill Area, which account for about 7% of Foothills Area endemics in much less than 1% of the Foothills Area.

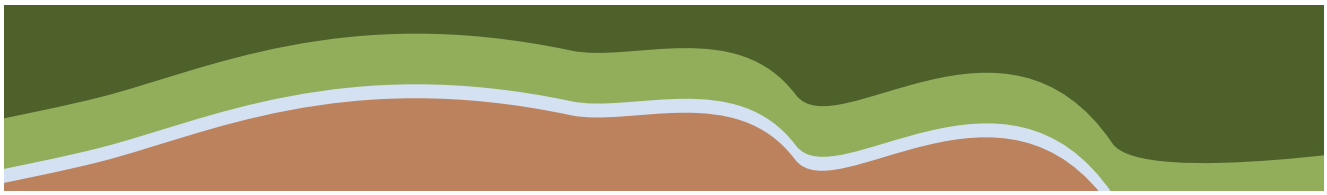
Ione Formation

The soils of the Ione Formation are ancient (Singer 1978). They first formed below an inland sea as varied deposits, including sands and gravels, more than 40 million years ago. After the sea receded, they weathered under a tropical climate into a nutrient-depleted, acidic state before being buried and subsequently exhumed near the base of the foothills. Foothill Chaparral is the predominant vegetation covering the Ione Formation. Although there are outcrops of the Ione Formation from Butte to Merced counties (Map LP-1, Map LP-2, Map LP-3, and Map LP–4), the endemic species associated with this substrate occur primarily in Amador County (Holzman and Meyer 2004). There three endemic species grow in a landscape occupying much less than 1% of the Foothills Area. One of these endemic plants, the Ione manzanita dominates a short chaparral with a discontinuous cover of shrubs.

4.2 Conservation Status of Foothills Area Vegetation

The conservation status of these different vegetation types is similar with regard to land ownership and management. Although developed or agricultural land cover accounts for very little of the landscape (just 2 to 4% of each foothills subregion, as shown in Appendix C-V), the influence of human activities is pervasive because only a small portion of foothill vegetation has been preserved, and in unpreserved areas, housing and roads are widely dispersed over the landscape.

The conservation status of Blue Oak Savanna and Woodland is generally representative of most foothill vegetation types. (Appendix C provides comparable data for all vegetation types in the Foothills Area.) Figure 4-3 summarizes the protection, housing density, and ownership of Blue Oak Savanna and Woodland in each Foothills Area subregion. Only a small percentage (16%) of this major foothill vegetation type is in some sense protected from loss by development or other human activities (Appendix C-VI). A small percentage (18%) also is in urban/suburban, commercial/industrial, and exurban areas (urban-exurban areas), where human influences, and associated disturbance, alteration of ecosystem processes, and invasive species have degraded habitats. Most Blue Oak Savanna and Woodland, however, exists in relatively less disturbed areas that are not preserved. In such areas, parcel size indicates the influence of human activities on habitat conditions, and the difficulty of acquiring larger areas for conservation. Roughly 44% of this acreage remains in larger, privately-held ownerships (Appendix C-VI).



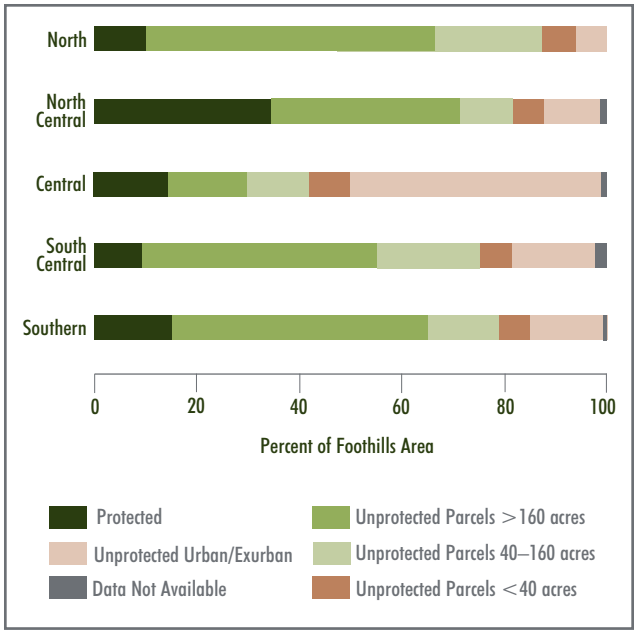


Figure 4-3. Conservation Status of Blue Oak Woodland

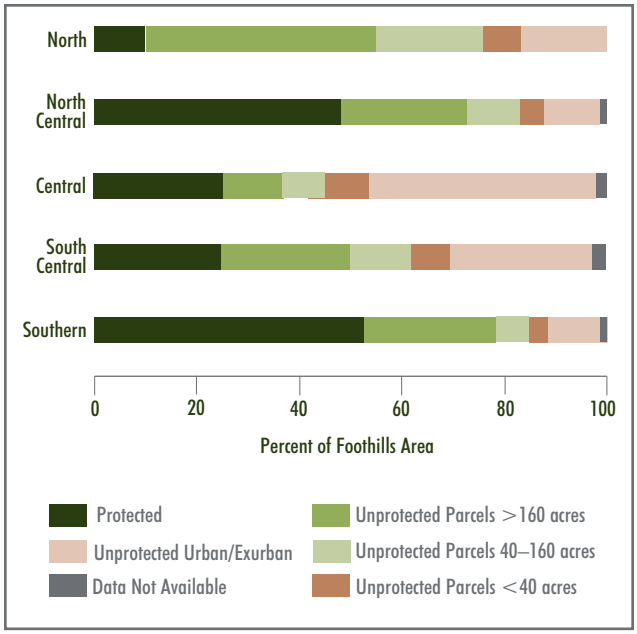


Figure 4-4. Conservation Status of Riparian Corridors

Among foothill vegetation types, there are some important differences in conservation, however. These differences seemingly correspond to greater intensity of human land use at lower elevations and on gentler slopes relative to at higher elevations and on steeper slopes. Foothill Chaparral and Foothill Riparian illustrate the extremes of this pattern (Appendix C-VI). Only about one-tenth of Foothill Chaparral is in urban-exurban areas versus more than one-third of Foothill Riparian vegetation being in such areas. In contrast, more than one-half of Foothill Chaparral is protected from loss by development and other human activities, versus less than one-fifth of Foothill Riparian vegetation being protected from such loss. Relatively extensive degradation by land use conversion and associated human activities, combined with little protection from additional degradation, is characteristic not only of Foothill Riparian but also of other vegetation in the corridors along rivers and streams in the Foothills Area (fig. 4-4; Appendices C-XIII through C-XVII).

Overall, human land uses are dispersed throughout the foothills, however: urban-exurban areas, and small parcels of land less than 40 acres, account for one-quarter of the foothills overall, and 60% of the Central Subregion (Appendix C-IX). The effects of roads, invasive species, fire suppression, groundwater pumping, altered drainage, and human disturbance (and associated habitat loss, simplification, and fragmentation) have been greatest in those areas.

Furthermore, the foothills are expected to have additional spread of human land uses. Approximately one-third of the Foothills Area is publicly owned or otherwise protected (conserved). However, montane vegetation covers much of the

conserved area; foothill vegetation is underrepresented on conserved land. For example, of foothill vegetation in the Central and South Central subregions, only 14% and 16%, respectively, are in public ownership or otherwise conserved (Appendix C-IX and Appendix C-X). In contrast, of montane vegetation in the Central and South Central subregions, 25% and 33%, respectively, is conserved (Appendix C-IX and Appendix C-X).

Similar to foothill vegetation in general, most habitats for endemic and special-status plants remain relatively unprotected. More than 100 plant taxa (species, subspecies, or varieties) are endemic to the Foothills Area and grow nowhere else. Almost half of these plants are critically endangered (i.e., on CNPS List 1B; Appendix C-III) because of habitat loss or alteration. Yet, for many of these species, only a small portion of remaining habitat has been conserved. For example, assemblages of endemic plants are associated with gabbro-derived soils in El Dorado County and Ione formation-derived soils in Amador County. Only 13% and 2% of these botanically significant landscapes have been conserved.

In the Foothills Area, the greatest concentrations of endemic species are in the botanically significant landscapes identified in this report, and in chaparral and woodlands (Blue Oak Savanna and Woodland and Foothill Hardwood and Conifer Woodland) of the Central Subregion and Lower Montane Conifer Forest of the South Central Subregion. These landscapes and vegetation types differ considerably in their conservation status. Of botanically significant landscapes, vernal pool complexes, which are primarily located in the North and North Central subregions,

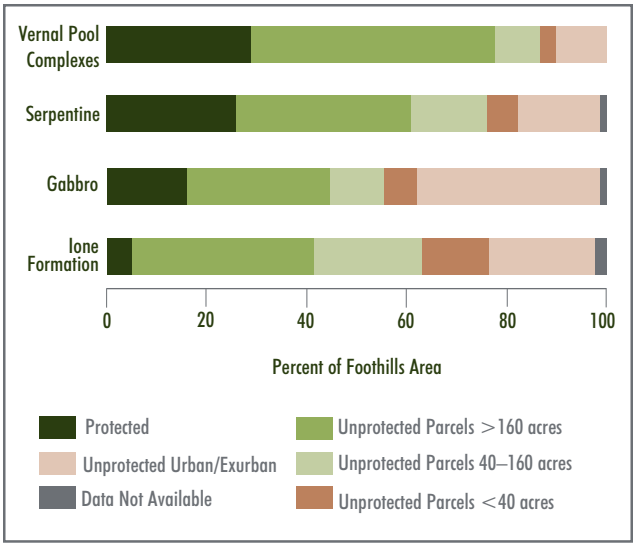
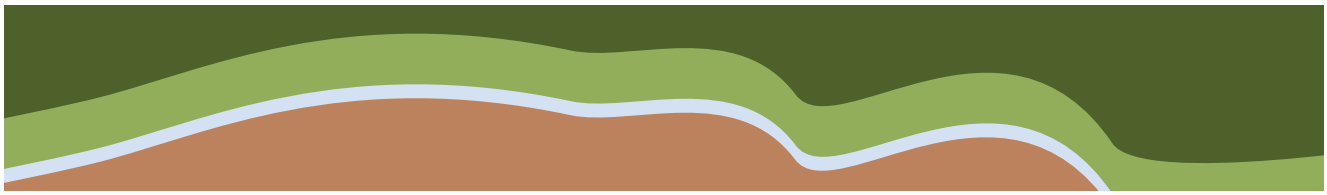


Figure 4-5. Conservation Status of Botanically Significant Landscapes

have been the least affected by human land uses and 29% of these landscapes are protected from conversion of natural vegetation to developed or agricultural uses (fig. 4-5).

The other botanically significant landscapes are more widely distributed in the Foothills Area and more affected by human land uses. Gabbro landscapes, in particular, have been substantially affected by human land uses. Similarly, chaparral and woodlands of the Central Subregion have been substantially affected by human land uses: roughly half of woodlands and more than 40% of chaparral are remnants in urban-exurban landscapes (Appendix C-IX). About 15% of woodlands and 30% Foothill Chaparral have been protected, and about 16% and 11%, respectively, remain in larger, privately owned parcels (table C-IX). Of Lower Montane Conifer Forests in the South Central Subregion, one-third are remnants in urban-exurban areas and more than one-third are preserved (Appendix C-X).



4.3 Anticipated Change

Several very different types of threats have been affecting botanical resources in the Foothills Area, including the following:

- resource extraction (primarily mining, wood cutting, and timber harvesting);
- agricultural expansion and intensification (including grazing of natural vegetation and conversion of natural vegetation to pastures, orchards, and vineyards);
- development and associated transportation and utility corridors;
- modification of ecosystem processes, particularly fire regimes and stream flows;
- introduction and spread of invasive species; and
- climate change.

Present conditions are in part a legacy of these threats in the past, and in some form, most of these threats are on-going and shaping future conditions. Effects of invasive species and altered ecosystem processes have been incorporated into the discussion of foothill vegetation types and botanically significant landscapes in the preceding section, "Major Foothills Vegetation Types and Botanically Significant Landscapes." The following sections discuss specific threats related to land uses (resource extraction, agricultural expansion, and development) and climate change.

4.3.1 Land Uses

Most land remains covered by natural vegetation: less than 2% of the region has urban or agricultural land cover, approximately 1.6% has been flooded by reservoirs, and barrens that include extensive mine tailings account for almost another percent. The remaining 96% of the Foothills Area is covered by natural vegetation. However, as described previously in "Conservation Status of Foothills Area Vegetation," and summarized in Appendices C-V through C-XXI, most natural vegetation is not conserved and thus remains vulnerable to loss or alteration by future changes in land uses.

The Gold Rush began the current era of land use with the construction of roads, water distribution systems, timber harvest and wood cutting, sedimentation of rivers, conversion of natural vegetation to cropland and settlements; all to support mining activities and a rapidly growing population. Since that time, resource extraction has been on-going, but recently has been more localized in its effects than historically. In contrast, developed land uses have become progressively more widespread.

During 2000–2030, population and housing density will increase considerably, and this growth will likely be dispersed over much of the Foothills Area. Consequently, the extent of large, privately-owned parcels will decrease: housing density is predicted to increase for about an eighth of all privately-owned, unprotected parcels greater than 160 acres in size. These increases affect a smaller portion of such parcels in the North and South subregions (7 and 11%, respectively) than in the North Central and South Central subregions (15 and 16%, respectively), and affect the greatest portion of such parcels in the Central Subregion (32%). An additional portion of larger, unprotected parcels will be subdivided in anticipation of development. The combination of this dispersed development and associated fragmentation represents a considerable impact and increase

in future threats, and a decrease in opportunities for effective conservation, particularly in the Central Subregion.

In addition to conversion to developed uses, natural vegetation is also affected by mining and by conversion to agricultural uses. Mining is currently a very localized disturbance, but is a major threat to Ione Formation landscapes in Amador County (Holzman and Meyer 2004). The extent of agricultural effects on vegetation is much more extensive than mining, and the potential significance of agricultural conversions is illustrated by recent losses of vernal pool complexes in the Central Valley and Foothills Area. In an assessment of the loss of vernal pool complexes in the Central Valley and eastern portion of the Foothills Area, conversion to agricultural uses accounted for nearly 80% of all loss during recent decades (Placer Land Trust 2009). Foothill Grassland, Blue Oak Savanna and Woodland, and other vegetation types are also lost to agricultural land uses. These losses are in addition to the anticipated development evaluated in this study.

4.3.2 Climate Change

Despite the substantial influence of climate on plant distributions, the effect of climate change on the distribution of any particular vegetation type or plant taxon is moderately to very uncertain. Temperature and precipitation directly affect plant growth, and also affect plants by altering hydrology and patterns of disturbance. In addition to climate, many other environmental factors influence plant distributions, including interactions with other organisms (e.g., herbivores, competitors). It is the combination of these influences that affects distributions. For example, the distribution of plants associated with particular substrates may be as much the product of substrate distribution as it is of relations to climatic conditions.

Also, the distributions of plants and vegetation types are products of historical events, and thus, their current distribution with respect to climate may not be optimal. For example, the Gold Rush and subsequent expansion of human activities in the Foothills Area coincided with, and probably caused, a substantial reduction in the extent of woodlands and conifer forests, and an increase in the extent of Foothill Grassland and Montane Hardwood/Hardwood-Conifer Forest. In El Dorado County, historical observations and vegetation mapping indicates that historical human activities contributed to a decrease in lower elevation Lower Montane Conifer Forest (dominated by ponderosa pine) and Blue Oak Savanna and Woodland, and a corresponding shift in their distribution to higher elevations during the nineteenth and twentieth centuries (Thorne et al. 2008).

Nonetheless, predicted changes in climate are likely to alter the distribution and abundance of many plant species in the Foothills Area. Studies using different approaches have predicted substantial changes to the distribution of plants and vegetation types in the Foothills Area (Lenihan et al. 2003, Loarie et al. 2008, California Energy Commission 2008). For many species, future temperatures at most currently occupied sites will become warmer than current temperatures at any sites they currently occupy. Consequently, analyses based on maintaining the current relationship between a species' distribution and climatic conditions predict that many species will shift their distribution to the north and to higher elevations. However, shifts in distribution depend on dispersal to and establishment at newly suitable sites; in the

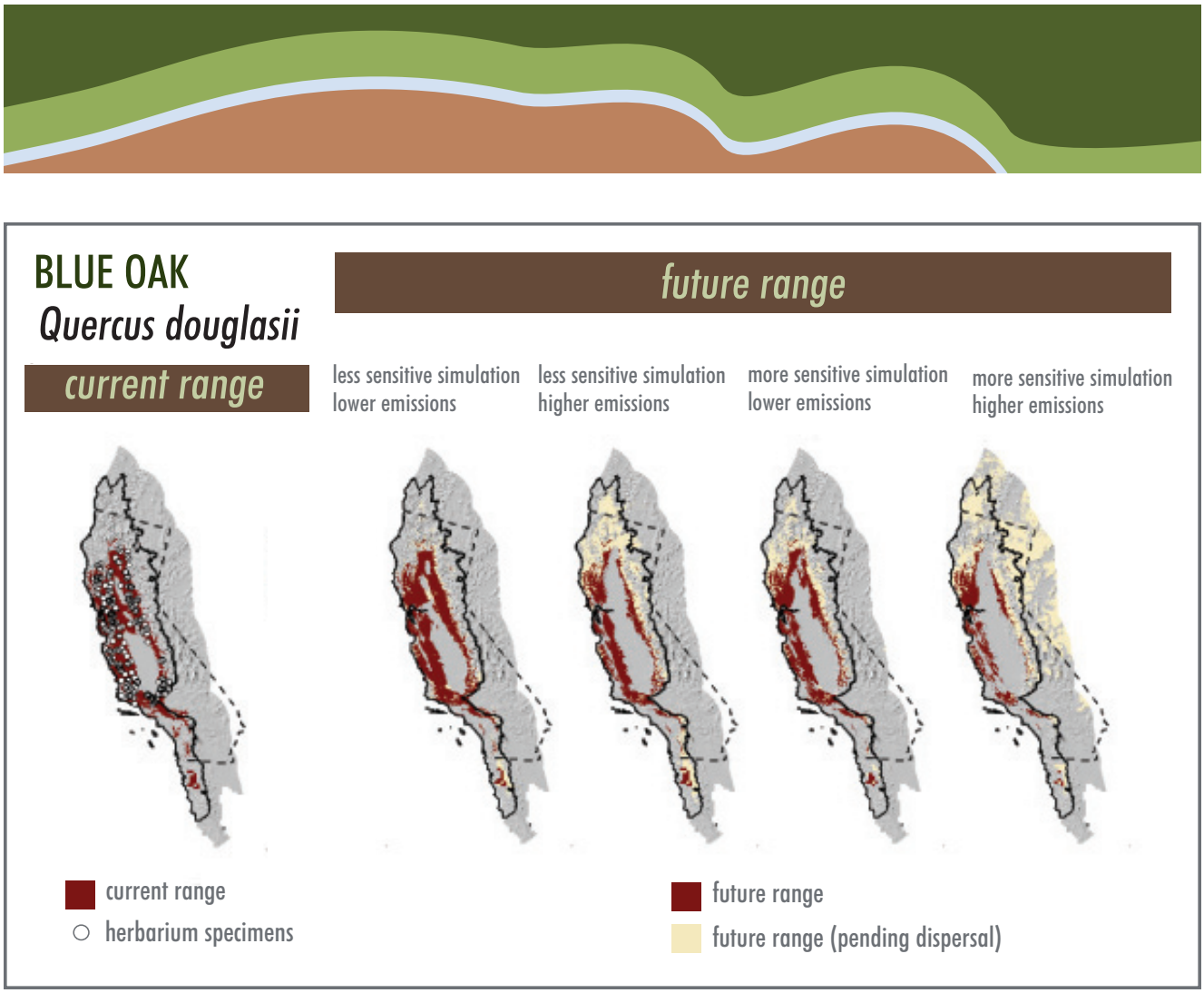


Figure 4-6. Predicted Change in Blue Oak Distribution in Response to Climate Change Scenarios
Source: Loarie et al. 2008, Loarie unpublished data; courtesy of S. R. Loarie

absence of such dispersal and establishment, a species' geographic range would be reduced (Loarie 2008). Furthermore, sites that become climatically suitable for a plant taxon are already occupied by plants, and are climatically suitable for a number of other plants. Thus, disturbances and competitive interactions influence distributions by affecting maintenance at existing sites and establishment at newly suitable sites.

The future distribution of Blue Oak Savanna and Woodland has been simulated by recent modeling that considered some or all of these influences (relationships to climatic conditions, competitive interactions, fire effects, and dispersal and establishment). These studies all predicted substantial changes to the distribution of blue oaks, and a decreased abundance of blue oak at lower elevations. Modeling of climate change effects based on current relationships between climatic conditions and blue oak distribution predicted a substantial change in the distribution of blue oak, and in the absence of successful establishment at newly suitable sites, a substantial contraction in geographic range (fig. 4-6). Modeling that considered competitive interactions among growth forms and fire ef-

fects predicted an increase in the extent of Foothill Grassland and Montane Hardwood and Conifer Forests and a decrease in Blue Oak Savanna and Woodland during the next 110 years (Lenihan et al. 2003). Modeling that considered competitive interactions, fire effects, and also dispersal and establishment, predicted reduced blue oak abundance at lower elevations and only limited success in blue oak establishment at higher elevations during the twenty-first century (California Energy Commission 2008).

During the twentieth century, the distribution of a number of foothill plants, including blue oak, changed; apparently in response to climate (Crimmins et al. 2011). In contrast to recent predictions, the predominant shift in distribution was downslope to lower elevations. (Blue oak is one of the plants whose optimum elevation decreased.) These shifts in distribution correspond to the tendency for water availability during summer and fall to be greater in the later than in the earlier twentieth century. As a result, despite warmer temperatures, a climate-related limitation on the lower elevation distribution of these species was reduced. The contrast between these changes in distribution during the twentieth century and recent predictions of changes during the twenty-first century illustrates our still limited understanding of the effects of climate change on species distribution of plants and vegetation types.

The uncertainty regarding ongoing changes increases the importance of conserving land that represents the full range of physical landscapes and ecological communities in the Foothills Area, and that provides connectivity of those landscapes, both within the foothills and to conserved areas at higher elevations.