

Plants

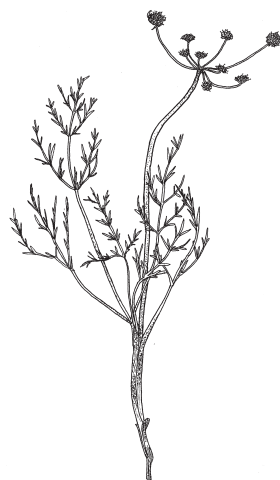
The striking mosaic of plant communities at the McLaughlin Reserve includes mixed chaparral, cypress chaparral and grassland on serpentine soils; mixed and chamise chaparral, blue oak woodland and grassland on nonserpentine soils; rich riparian woodlands; and human-created plant communities on the sites disturbed and reclaimed by Homestake. This chapter describes these communities, their major species, and the environmental factors that govern their distribution in the landscape.

The reserve lies within the California Floristic Province, and has a Mediterranean climate with hot dry summers from April to October and cool wet winters from November to March. Summer temperatures may reach as high as 40°C (104°F), while winter temperatures occasionally fall below freezing. Mean annual precipitation is roughly 75 cm (30 inches). Yearly variability is the rule in Mediterranean climates, and variation in the amount and timing of rainfall and temperature translates into large differences in the composition of the springtime annual flora.

Our map of plant communities, Map 4, comes from the pre-goldmine surveys by the D'Appolonia company. The plant species list is a composite of information from several sources, primarily the D'Appolonia report and botanist Joseph Callizo who (with Glen Clifton) has conducted Homestake's annual rare plant monitoring. Standard references on the California flora are the *Jepson Manual* (Hickman 1993) and *Terrestrial Vegetation of California* (Barbour and Major 1977). Regional botanical references include the Napa County plant list (Ruygt 1995) and the on-line Napa County Flora (Muth, Ruygt, and Callizo 2000). Rare species on serpentine soils in Napa and Lake County are described by McCarten (1988) and Callizo (1992).

Serpentine plant ecology

The McLaughlin Reserve's abundance of serpentine is perhaps its most significant botanical feature. Plants on serpentine in California have been the subject of innumerable studies and an entire book by botanist Arthur Kruckeberg (1984). As described in the geology chapter, the soils derived from serpentinite rock tend to be highly infertile because of their extremely high levels of magnesium, chromium and nickel, low concentrations of nutrients such as calcium and nitrogen, and low water-holding capacity. Serpentine areas can generally be distinguished by their gray-green or reddish rocky soils and shrubby or stunted vegetation with small leathery leaves.



Lomatium marginatum

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Plant responses to serpentine have been categorized by Kruckeberg as avoidance, indifference, and endemism. Avoiders include such taxa as live and blue oaks (*Quercus wislizenii* and *Q. douglassi*) that cannot grow on serpentine. Most exotic species in California are also serpentine avoiders, and therefore the flora on serpentine is as pristine as any that can be found in the state. Indifferent taxa, those that grow both on and off serpentine, include toyon (*Heteromeles arbutifolia*), California bay (*Umbellularia californica*), chamise (*Adenostoma fasciculatum*), and gray pine (*Pinus sabiniana*). (However, large pure stands of chamise are found only on sandstone or gabbro, not on serpentine.) Studies of a number of supposedly “indifferent” species have shown that populations on serpentine are actually serpentine-tolerant races, or ecotypes.



Leather Oak
Quercus durata

Serpentine endemism, or restriction to serpentine, has long fascinated evolutionary biologists. Two evolutionary pathways are thought to have produced serpentine endemics. So-called paleoendemics are widespread species such as leather oak (*Quercus durata*) and MacNab’s cypress (*Cupressus macnabiana*), found on serpentines throughout California. These are believed to have descended from ancestral species that grew in many different habitats, until climate change caused the nonserpentine populations to become extinct. In contrast, neoendemics or “insular” taxa are species with ranges often as small as a single county or less (e.g. several *Ceanothus* and *Arctostaphylos* spp.), which are believed to have arisen more recently from ancestors on nearby nonserpentine soils.

Experiments show that serpentine endemics often grow better on nonserpentine soil when grown alone, suggesting that competition with other species is the reason for their restriction to serpentine. Perhaps not surprisingly, then, the degree of endemism varies from species found 100% on serpentine to ones that are sometimes found on other rocky substrates such as volcanic outcrops. An even lesser degree of restriction is shown by so-called indicator taxa, which are restricted to serpentine only in parts of their geographic ranges (e.g. gray pine, *Pinus sabiniana*, also known as ghost or foothill pine). Kruckeberg estimates that there are 215 true endemics and 221 serpentine indicators in California, making this one of the world’s richest serpentine floras (although the list is topped by Cuba with 920 and New Caledonia with about 900 serpentine endemics). Within the state, the North Coast Range is an especially rich region for serpentine plants.

Plants on serpentine have provided abundant research opportunities at the reserve. Some of these studies have focused on evolutionary adaptation of species to harsh soils, and others on the ecological processes by which species persist and coexist in a heterogeneous environment. In 1999, a group of UC Davis researchers began a research and training project on “*Ecological and Evolutionary Responses of Plants to Habitat Mosaics at the University of California’s McLaughlin Reserve.*”

Mixed serpentine chaparral

Mixed serpentine chaparral, found on the thin rocky soils of the Henneke series, is dominated by evergreen shrubs such as leather oak (*Quercus durata*), white-leaved manzanita (*Arctostaphylos viscida*), musk brush (*Ceanothus jepsonii* var. *albiflorus*), silk-tassel bush (*Garrya congdonii*) and fremontia (*Fremontodendron californicum*). Scattered among these endemics or near-endemics are “indifferent” species such as gray pine, toyon, bay laurel and chamise. Understory herbs, which are typically sparse, may include oniongrass (*Melica californica*), squirreltail (*Elymus elymoides*), jewelflowers (*Streptanthus* spp.), dwarf wild flax (*Hesperolinon* spp.), coast range morning glory (*Calystegia collina*), sickle-leaved onion (*Allium falcifolium*), Indian Woolly paintbrush (*Castilleja foliolosa*) and many others.

Almost 20% of the reserve consists of serpentine mixed chaparral. A good place to examine this community is on Research Hill. Much serpentine mixed chaparral on the Knoxville BLM lands burned in the fire of October 1999.



Silk Tassel Bush (male)
Garrya congdonii

Cypress chaparral

McNab’s cypress (*Cupressus macnabiana*) may be found within mixed serpentine chaparral, or may form nearly pure stands. Sargent’s cypress (*Cupressus sargentii*) is found primarily in serpentine riparian areas, but extensive stands may also occur on hillsides (these are more common in the Knoxville BLM lands than on the reserve). Large stands of either species are sometimes referred to as “northern interior cypress forest”, but we refer to them as “cypress chaparral”. The two species can be distinguished by the short, wide stature and light green leaves of McNab’s cypress, in contrast to the darker, taller, and more treelike Sargent’s cypress. The cones of McNab’s cypress also have conspicuous bumps on their scales.

The transition between mixed serpentine chaparral and cypress chaparral may relate to subtle differences in soil chemistry and texture within Henneke-series soils. For example, Sargent’s cypress is found on soils with especially low calcium levels and high water-holding capacity (Koenigs et al. 1982). Cypress cones require fire to open

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and release seeds; consequently, both species are often found in even-aged stands whose age reflects the time since the last fire. A study in the Knoxville BLM lands found most Sargent's cypress stands to be 80-120 years old (Koenigs et al. 1982).

Cypress chaparral is the least diverse of the Reserve's plant communities. Understory herbs include slender bird's beak (*Cordylanthus tenuis* ssp. *brunneus*), phlox-leaved bedstraw (*Galium andrewsii*), dwarf flax (*Hesperolinon disjunctum*), Indian warrior (*Pedicularis densiflora*), and California milkwort (*Polygala californica*).

Cypress chaparral forms 7% of the reserve. A stand of McNab's cypress can be seen on the west side of Research Hill, and both species are abundant on the BLM land along the Knoxville-Devilhead Road. Much cypress chaparral burned in October 1999, and it appears to be recovering very slowly.

Serpentine grasslands

Residual or alluvial soils formed from serpentine (Montara and Okiota series) may support grasslands with a high complement of native herbs. Species such as clarkia (*Clarkia purpurea* and *C. gracilis*), birds-eye gilia (*Gilia tricolor*), goldfields (*Lasthenia californica*) and mariposa lily (*Calochortus luteus*, *C. superbis* and *C. vestae*), may form spectacular displays in meadows along Morgan Valley Road and on Little Blue Ridge. There are also native perennial bunchgrasses that have become rare elsewhere in California, such as purple needlegrass (*Nassella pulchra*), squirreltail (*Elymus elymoides*), bluegrass (*Poa secunda*), and onion grass (*Melica* spp.).

Serpentine grasslands are substantially less invaded by exotic annual grasses than those on non-serpentine soils. One study at the reserve estimated the proportion of native species as 80% in serpentine grasslands versus 40% in nonserpentine grasslands, and within serpentine, the proportion of natives increased as the calcium to magnesium ratio declined (Harrison 1999). Serpentine grasslands are truly special places in a California landscape in which other grasslands have been almost entirely taken over by Mediterranean species.

Serpentine seeps and riparian habitats

Serpentine seeps, or springs emerging from serpentine rock, provide highly alkaline water flows whose origin remains a hydrologic mystery. These flows often continue into late summer in an otherwise summer-dry environment. This specialized habitat hosts a diverse array of late-flowering plants, many of which are localized endemics. Five serpentine seep specialists were rare enough to be included in D'Appolonia's pre-mine environmental survey: serpentine sunflower (*Helianthus exilis*), Cleveland's butterweed (*Senecio clevelandii*), Cleveland's milkvetch (*Astragalus clevelandii*), swamp larkspur (*Delphinium uliginosum*), and bare monkey flower (*Mimulus nudatus*). The 140 populations of these five species found in 1980-1981 were resurveyed in 1997-1999, and 40% had disappeared but had been replaced by an equal number of new populations (Harrison et al. 2000).

Riparian zones on serpentine are often dominated by Sargent's cypress (*Cupressus sargentii*) and thickets of Brewer's willow (*Salix breweri*) and azalea (*Rhododendron occidentale*). A riparian stand of Sargent's cypress can be found along the old county road about 100 meters west of the Core Shed. Serpentine riparian habitat may be seen along Hunting Creek south of the Napa/Lake county line, as well as around the Hunting Creek campground on the Knoxville BLM land. However, the banks of Hunting Creek north of the county line are dominated by woody species typical of non-serpentine riparian zones, such as valley oaks, probably because of the admixture of non-serpentine and serpentine sediments.

Non-serpentine plant communities

Blue oak woodlands and annual grasslands tend to occur on the mudstone and clay soils of the Knoxville formation, while chamise chaparral and mixed chaparral occur on excessively drained, nutrient-poor soils derived from sandstones of the Great Valley Sequence (see geology chapter).

Blue Oak Woodland

The reserve is home to three deciduous oak and four evergreen oak species. The deciduous species include blue oaks (*Quercus douglassi*), which have shallowly lobed, blue-gray leaves and scaly light gray bark; black oaks (*Quercus kelloggi*), with deeply furrowed, dark gray-brown bark and very large, deeply lobed and toothed leaves; and valley oaks, which can be very large in stature and have small, dark green, deeply lobed leaves. Evergreen species include canyon live oak (*Quercus chrysolepis*), leather oak (*Quercus durata*), scrub oak (*Quercus berberidifolia*) and interior live oak (*Quercus wizlizenii*), which are described in other sections.

Blue oak woodland covers slightly over 20% of the reserve, forming a partial canopy on the fine-textured soils of the Knoxville formation, especially on cooler north-facing slopes. Large stands are found on the west edge of Davis Creek Reservoir and in Clover Valley. Blue oaks may co-occur with gray pines, with California black oaks in cooler and wetter sites, and with valley oaks on streambanks. On drier and gentler slopes, oak woodlands may grade into savannas. The October 1999 fire burned Clover Valley, but killed few oaks.



Blue Oak
Quercus douglassi

Soils are especially fertile beneath blue oak canopies, where litter and leachate form nutrient-rich islands. This “crown effect” can last for decades after trees die or are removed. The understory in drier sites is dominated by exotic annual grasses such as soft chess (*Bromus hordeaceus*), rip-gut brome (*Bromus diandrus*) and medusa head

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(*Taeniatherum caput-medusae*). On cooler slopes and under dense oak cover there are more native grasses, and forbs such as serrated onion (*Allium serratum*), four-spotted godetia (*Clarkia purpurea* ssp. *quadrivulnera*), bicolored linanthus (*Linanthus bicolor*), downy navarretia (*Navarretia pubescens*), and buttercup (*Ranunculus californicus*).

Blue oaks are believed to be in danger of disappearing from California's hillsides. In many areas, blue oak regeneration appears to have all but ceased during the past century. Experiments show that oak seedlings and saplings experience enormous depredation by rodents, deer and livestock. Competition for water and light between oak seedlings and exotic annual grasses may also play a role. Researchers are continuing to study the decline in oak regeneration and to search for effective restoration techniques.

Annual grassland

Grasslands on non-serpentine soils can be seen in valley floors along parts of Davis, Knoxville, and Hunting Creeks. They are dominated by Mediterranean annual grasses such as soft chess (*Bromus hordeaceus*), medusa head (*Taeniatherum caput-medusae*), oat grass (*Avena fatua* and *Avena barbata*), wild rye (*Lolium multiflorum*), and rattail fescue (*Vulpia myuros*). Forbs include natives such as annual miniature lupine (*Lupinus bicolor*) and rusty popcorn flower (*Plagiobothrys nothofulvus*) and aliens such as yellow starthistle (*Centaurea solstitialis*), filaree (*Erodium cicutarium* and *Erodium botrys*), black mustard (*Brassica nigra*), and bur clover (*Medicago polymorpha*). In spite of extensive invasions by exotic species, these grasslands are surprisingly diverse; the D'Appolonia survey recorded over 170 species.

In the Morgan Valley and Knoxville area, the replacement of native bunchgrasses by exotic annuals probably began in earnest in the 1860's with the influx of mercury miners and homesteaders. Livestock and crops soon became common on relatively flat sites with favorable soils, and vineyards were even established in the southwest portion of the reserve, where relic cultivated grapes (*Vitis vinifera*) can still be found. Settlers cut down trees on a massive scale to fuel the mercury furnaces. In the twentieth century, as mining and farming subsided, livestock grazing became the primary use of the grasslands. Grazing was removed from some parts of the reserve in 1985, and from other parts in 2001.

It is important to remember that in many areas of the reserve, especially grasslands, vegetation patterns still reflect long-ago land uses. For example, the large flat meadow between the Homestake entrance and the Core Shed was once a hayfield, and the lines of old irrigation ditches can still be seen from the air. Typically for California grasslands, this meadow did not revert to native species after cultivation ceased. As another example, it is unknown how much the distribution of grassland versus blue oak woodland was affected by woodcutting in the past century.

Chamise chaparral

Chamise (*Adenostoma fasciculatum*) forms nearly pure stands on well-drained sandstone and gabbro soils on south and west-facing slopes and ridgetops. Chamise chaparral covers about 7% of the reserve. The fire of October 1999 burned vast areas of chamise chaparral to the south and east of the reserve. Regeneration was extremely fast; three years later, the effects of the fire on this community were scarcely visible except for the burned skeletons of dead shrubs.

**Chamise***Adenostoma fasciculatum*

Chamise can be identified by its 1 to 3 meter tall, many-branched canopy, small white flowers, and stiff needle-like leaves that turn burnt orange in fall. The lack of herbs in its understory may be due not only to the dense canopy cover, but also to allelopathic chemicals that accumulate in the soil from fallen chamise leaves. Chamise communities are fire-dependent, with typical fire return intervals of 15-20 years; shrubs quickly resprout from their root crowns. For several years after a fire, the pulse of nutrients and light plus the depletion of allelopathic chemicals from the soil allow the establishment of fire-following species including yerba santa (*Eriodictyon californicum*), common rush-rose (*Helianthemum scoparium* var. *vulgare*), pitcher sage (*Lepechinia calycina*), and deerweed (*Lotus scoparius*).

California mixed chaparral

California mixed chaparral occurs in slightly moister habitats than those dominated by chamise chaparral, but is still found on dry, rocky slopes and shallow sandstone soils. About 7% of the reserve supports this community. A large area of California mixed chaparral, including much that burned in October 1999, is found on the north and east sides of Davis Creek Reservoir.

This community is characterized by a continuous canopy 2-3 meters in height and a sparse ground cover. Shrubs are mostly evergreen with small thick leaves. Dominant shrubs are common buckbrush (*Ceanothus cuneatus*), toyon (*Heteromeles arbutifolia*), chaparral pea (*Pickeringia montana*), scrub oak (*Quercus berberidifolia*) and a shrub form of interior live oak (*Quercus wislizenii* var. *frutecens*). (The two oaks can be distinguished by their smooth bark versus furrowed and checkered bark, respectively.) These shrubs are well adapted to fire and drought, with most species able to quickly resprout from their crowns following fire.

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Riparian woodland

Riparian zones at the reserve can be found along Davis, Knoxville, and Hunting Creeks. They support broad-leaved deciduous trees including valley oak (*Quercus lobata*), Fremont's cottonwood (*Populus fremontii*), Oregon ash (*Fraxinus latifolia*), California buckeye (*Aesculus californica*), redbud (*Cercis occidentalis*), and red willow (*Salix laevigata*). Beneath the canopy are shrubs such as squaw bush (*Rhus trilobata*) and California rose (*Rosa californica*). Herbs may include dogbane (*Apocynum cannabinum*), mugwort (*Artemisia douglasiana*), white sweetclover (*Melilotus indica*), and false lupine (*Thermopsis macrophylla*).

On the reach of Davis Creek above the reservoir is a strip of riparian forest denoted as "mixed evergreen forest" on the map. This contains several tree species characteristic of cooler and wetter climates, notably canyon live oak (*Quercus chrysolepis*) and California nutmeg (*Torreya californica*). Nearby on the western edge of the reservoir are a few yellow pines (*Pinus ponderosa*). This is an example of a community near its southern range limit, perhaps a remnant of wetter Pleistocene times.

Riparian woodlands at the reserve are important habitats for wildlife, especially songbirds and raptors. Some of the reserve's riparian woodlands have been damaged by livestock grazing, which reduces vegetation cover and destabilizes streambanks. Restoration efforts are now underway along the upper reach of Hunting Creek. Another important restoration goal is the removal of tamarisk (*Tamarix pentandra*), an aggressive invader that has taken over some heavily grazed areas along Knoxville Creek. Tamarisk removal began in winter 2002 under the auspices of the California Department of Fish and Game.

Revegetated disturbed sites and roadsides

About 20% of the reserve consists of human-created plant communities on Homestake's revegetated waste rock piles, dam abutments, roadsides, and other disturbed areas. Reclamation began in 1985 and continues today, following a plan that was approved by the three counties. The species used for reclamation are non-natives chosen because they are readily available, fast-growing, and not considered to be invasive. In both serpentine and non-serpentine habitats, the seed mix includes Blando brome (*Bromus hordeaceus*), Wilton rose clover (*Trifolium hirtum*), tall fescue (*Festuca arundinaceae*), and pubescent wheatgrass (*Agropyron tricophorum*). Red brome (*Bromus rubens*) is planted only on serpentine substrates, while orchard grass (*Dactylis glomerata*) and annual ryegrass (*Lolium multiflorum*) are used only on non-serpentine substrates.

Eventual colonization of these areas by native plants and animals will be an interesting subject for research. The results of the annual monitoring of the reclaimed areas can be found in the Annual Report. In future phases of reclamation, the aim will be to create structurally diverse plant communities with native trees and shrubs. An odd-looking "community" can be seen on the west side of Berryessa-Knoxville Road, south of the truck shop entrance, where many woody species have been planted in a test plot.