

A Soil Survey of Serpentine Landscapes in the Lassics Area

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Soils and Geoecology

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The Lassics area is of special botanical interest because of rare plants that occupy soils with serpentine and some associated parent materials. A soil survey was conducted as an aid for management of the botanical treasures in the area. A small area of about 50 ha was mapped in great detail on sheets obtained by scanning 1:16,000 aerial photographs (Fig. 1). A larger area of about 250 ha was mapped in ordinary order 2 detail on transparent plastic covers over the color 1:16,000 aerial photographs, and polygons delineated on the photograph covers were plotted on a USGS topographic map of the Black Lassic quadrangle (Fig. 2).

Two key features that determine suitable habitats for the sensitive (current Forest Service designation) plant species are the soil parent materials and natural (not accelerated by management) erosion in the landscapes. Both fluvial erosion and mass wasting have been important processes in the serpentine soil parent materials of the Lassics area. The more drastic erosional features are discussed in the soil map unit descriptions. The soil maps and descriptions of the map units are the main parts of this report.

Geology

Kaplan (1984) mapped the geology of the Lassics area in detail and Krueger (1990) described the major geological events. The Lassics are in the central Franciscan belt of the California Coast Ranges (Bailey et al. 1964) where rocks from the Pickett Peak terrane of the eastern Franciscan belt were thrust over it, followed by the thrusting of melange from Coast Range ophiolite and sedimentary rocks from the Great Valley sequence over the Coast Ranges fault onto the Franciscan complex (Krueger 1990). The Coast Ranges fault is now about 75 km east of the Lassics area.

Red Lassic (1,803 m altitude) is basalt and Black Lassic (1,798 m altitude) is mostly sedimentary rocks of the Franciscan complex. Most of the peridotite in the Lassics exposure of Coast Range ophiolite has been so thoroughly serpentinitized that it is now serpentinite.

Fluids circulating through the rocks millions of years ago have altered some of the rocks

and perhaps made some of the nonserpentine rocks suitable for some of the rare plant species. Many small exploratory excavations in hydrothermally altered or “mineralized” zones are evident on the south side of the small peak just east of Signal Peak. Evidently no exploitable minerals were found, because there has been no mining in the Lassics area.

Map Units

The soil map units are all on serpentinized peridotite, or colluvium that is predominantly serpentinized peridotite, except one on clastic sedimentary rock that has Lassics lupine on it. Each map unit is designated by a two letter symbol and named by the one or more most extensive soils in it. The soils are assigned series names, if there are appropriate ones, or soil group names from Soil Taxonomy (Soil Survey Staff 1999). Additional landscape information, other than soil designations, is added to the map unit names in the legend (Table 1) in order to make them more descriptive. All of the map units are on mountain slopes, except units LS and SL that are on colluvial, or landslide, deposits.

Table 1. Lassics soil survey legend.

CM	- sparse conifer trees and deciduous shrubs/rocky, very shallow Entisols/clastic sedimentary rocks, very steep slopes (60 to 75%)
CS	- barren/very shallow Entisols/clastic metasedimentary rock colluvium over serpentinite, moderately steep slopes (12 to 30%)
N	- nonserpentine, not mapped
LS	- variously forested, gently to moderately sloping (slopes < 15%), landslide deposits with very deep serpentine soils and minor amounts of other soils—no map unit description
SD	- open forest/moderately deep Hyampom variant, cold, and deep to very deep Hungry family complex/serpentinite, steep slopes (25 to 60 %)
SH1	- barren to sparse trees and shrubs/very shallow Entisols/serpentinized peridotite, gentle to moderately steep slopes (3-30%)
SH2	- open conifer forest and shrubs/shallow Alfisols and very shallow Entisols/serpentinized peridotite, gentle to moderately steep slopes (3-30%)
SL	- open forest/very deep Hungry family/serpentinite colluvium, closed depressions to steep slopes (0 to 60%)
ST	- barren to sparse trees and shrubs/very shallow Entisols, shallow Inceptisols, and shallow Mollisols/serpentinite, moderate to steep slopes (12 to 65%)
SX	- sparse conifer trees/shallow Inceptisols/serpentinite on very steep S-facing slopes and open conifer forest/deep to very deep Hungry family on colluvial footslopes, slopes 15 to 75%

Soil map units are described on the following pages.

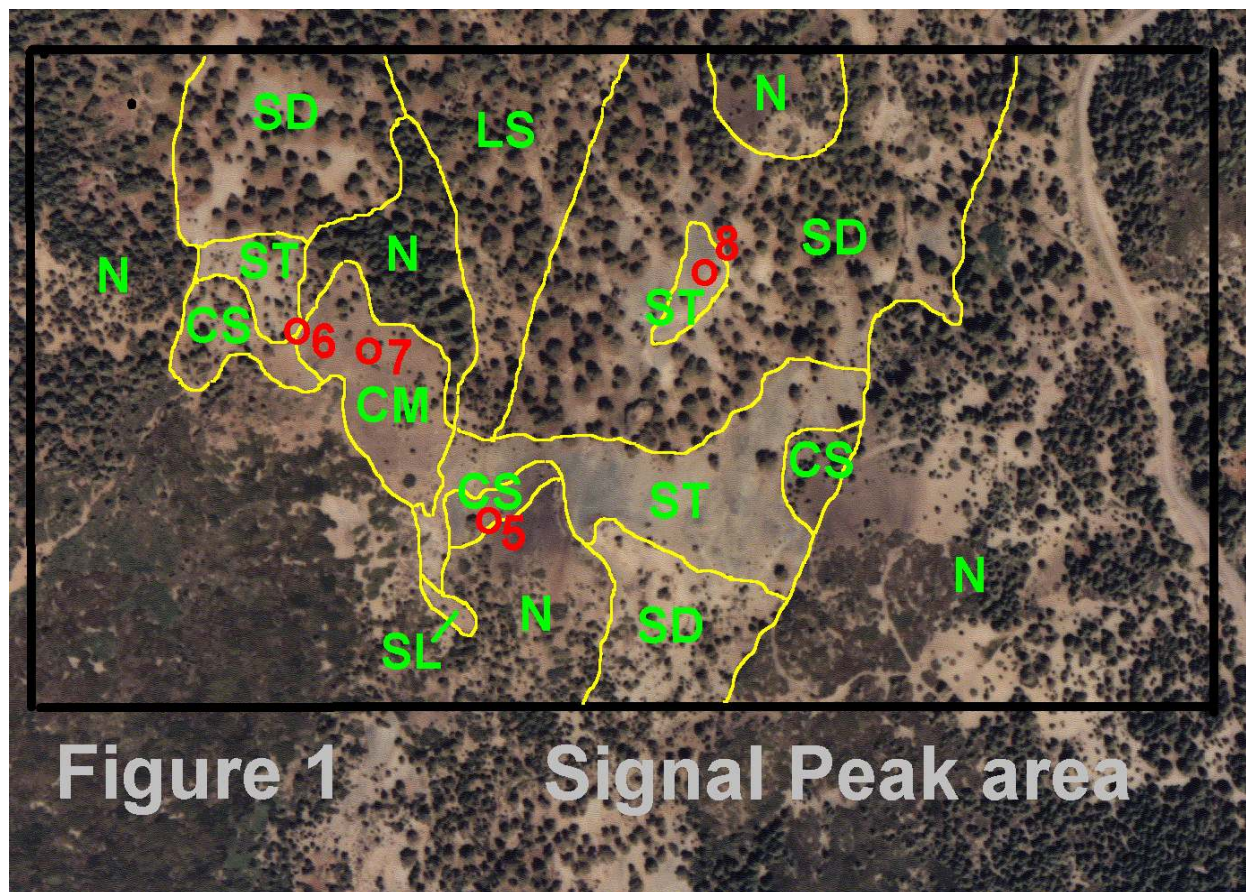


Figure 1. Detail for the area indicated on figure 2. The map unit names are given in Table 1 and the map unit descriptions follow on subsequent pages. The circles are the locations of pedon sites L05, L06, L07, and L08.

CM - sparse conifer trees and deciduous shrubs/rocky, very shallow Entisols/clastic sedimentary rocks, very steep slopes (60 to 75%)

2/3 very shallow stony Lithic Xerorthents and 1/3 clastic sedimentary rock outcrop, slopes > 60%

This a sparsely vegetated unit that is on metamorphosed sandstone and shale, with minor chert. It is on a very steep northeast-facing linear slope, or “backslope”, between chaparral on the summit of Signal Peak and mixed conifer forest north of the mountain. The soils are predominantly very shallow Entisols, with much rock outcrop. Mass wasting and fluvial erosion are the dominant geomorphic processes. The vegetative cover is sparse conifer trees; sparse to common shrubs that are mostly creambush and mountain whitethorn; sparse forbs, mostly a bedstraw other than *G. ambiguum*; and traces of squirreltail. Traces of Lassics lupine are present.

Pedon L07 on northeast slope from Signal Peak, about 0.1 km from the summit

Classification: sandy-skeletal, mixed, frigid, Lithic Xerorthents

Location: 123.554°W, 40.335°N

Soil PM: metamorphosed sandstone and shale

Landform: linear mountain sideslope

Elevation: 1750 meters; slope - 65% northeast (40° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees (3%) - sparse white fir (*A. concolor*) and yellow pine (*Pinus* sp.); shrubs (3%) - sparse to common *Holodiscus* sp. and *Ceanothus cordulatus*; grasses (trace) - squirreltail (*Elymus elymoides*); forbs (2%) - sparse bedstraw (*Galium* sp.) and traces of *Lupinus constancei*, *Eriogonum nudum*, and *Lomatium* sp.

Surface stoniness: 1% “stones”, 5% cobbles, 80% gravel

A1 0 to 3 cm: very dark grayish brown (10YR 3/2, 5/2 dry) extremely gravelly sand; 1% stones, 5% cobbles, 60% gravel; single grain, structureless; loose, nonsticky and nonplastic; many very fine intergranular pores; negligible roots; slightly acid (pH 6.4); clear, smooth boundary

A2 3 to 10 cm: very dark grayish brown (10YR 3/2, 5/2 dry) very gravelly loamy sand; 1% stones, 5% cobbles, 40% gravel; single grain, structureless; loose, nonsticky and nonplastic; common to very few, very fine, fine, and medium roots; slightly acid (pH 6.2); clear, irregular boundary

Bw 10 to 14 cm: dark brown (10YR 3/3, 5/3 dry) very gravelly loamy sand; 1% stones, 5% cobbles, 40% gravel, massive, structureless; soft, very friable, slightly sticky and nonplastic; very few, very fine, fine, and medium roots; slightly acid (pH 6.3); a discontinuous horizon in open fractures in bedrock, only; abrupt boundary

R 14+ hard, moderately fractured bedrock

Remarks: pH by bromothymol blue indicator; A1 and A2 sampled as one composite horizon; insufficient organic matter (0.89% LOI in a composite A-horizon sample) for a Mollisol.

CS - barren/very shallow Entisols/clastic metasedimentary colluvium over serpentinite, moderately steep slopes (12 to 30%)

very shallow, slightly stony to stony Lithic Xerorthents in clastic metasedimentary colluvium over serpentinite bedrock, deeper soils in swales

This is a barren or sparsely vegetated unit with colluvium of metamorphosed sandstone and shale over serpentinite bedrock. It is on moderately steep slopes below clastic metasedimentary rocks on Signal Peak and the first peak east of Signal Peak. The soils are predominantly very shallow Entisols, with deeper soils in swales. Mass wasting and fluvial erosion are the dominant geomorphic processes. The vegetative cover is sparse serpentine phacelia and traces of Lassics lupine and naked buckwheat.

Pedon L05, about 150 meters east of Signal Peak

Classification: loamy, magnesian, frigid, Lithic Xerorthent

Location: 123.552°W, 40.334°N

Soil PM: metamorphosed sandstone and shale colluvium over serpentinite bedrock

Landform: mountain footslope

Elevation: 1740 meters; slope - concave 18% southwest (230° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees, none - Jeffrey pine (*P. jeffreyi*) at margin of site; shrubs, none - buckbrush (*C. cuneatus*) at margin of site; forbs (1%) - sparse *Phacelia corymbosa* and traces of *Lupinus constancei* and *Eriogonum nudum*

Surface stoniness: 70% gravel (20% serpentinite, 80% metasedimentary, minor chert and quartzite), 3% cobbles, 1% stones

A1 0 to 2 cm: very dark grayish brown (2.5Y 3/2, 5/3 dry) very gravelly loamy sand; 1% stones, 3% cobbles, 35% gravel; massive, structureless; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; no roots; neutral (pH 7.0); abrupt smooth boundary

A2 2 to 7 cm: very dark grayish brown (2.5Y 3/2, 5/3 dry) gravelly sandy loam; stones < 1%, 1% cobbles, 30% gravel; weak, very fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine roots; neutral (pH 7.2); abrupt wavy boundary

A3 7 to 10 cm: very dark grayish brown (2.5Y 3/2, 5/3 dry) gravelly sandy loam; stones < 1%, 1% cobbles, 30% gravel; massive, structureless; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; few very fine, fine, and medium roots; neutral; abrupt irregular boundary

R 10 to 25+ hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator; soil depth range 9 to 12 cm; insufficient organic matter (0.64% LOI in a composite A1 and A2 horizon sample) for a Mollisol.

LS - conifer forest/very deep Inceptisols/landslide deposits, gentle to moderate slopes (3-15%)

This map unit was delineated on aerial photographs without characterizing it by close field observations. Only the margins of the map unit polygon were traversed on the ground. Very deep serpentine Inceptisols of the Hungry family (Typic Haploxerepts) are presumed to be the dominant soils.

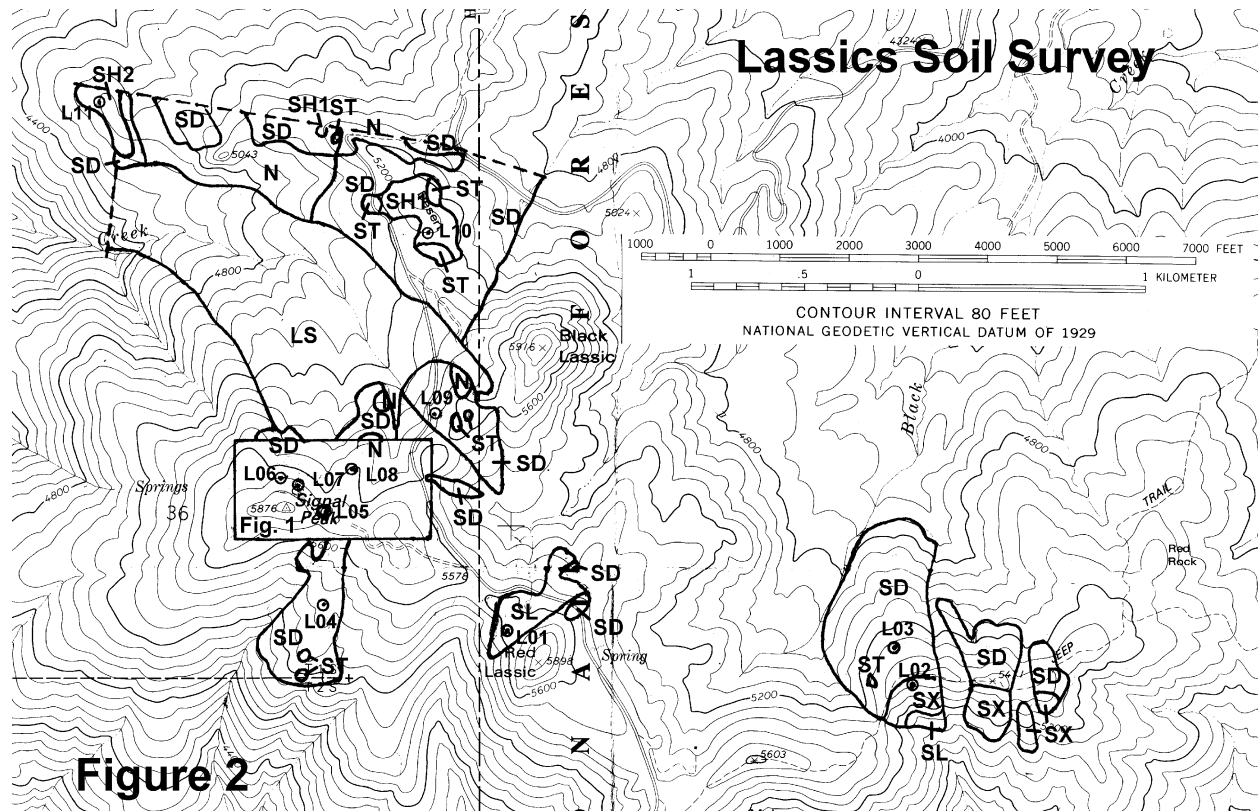


Figure 2. Serpentine soil landscapes of the Lassics area. The map unit names are given in Table 1 and the map unit descriptions follow on subsequent pages.

SD - open forest/moderately deep Hyampom variant, cold, and deep to very deep Hungry family complex/serpentinite, steep slopes (25 to 60 %)

This is a forested complex of serpentine Alfisols and Inceptisols on steep mountain slopes, with inclusions of very shallow Entisols on narrow summit slopes and shallow Mollisols on very steep S-facing slopes. It is the most common serpentine map unit in the Lassics area. Most of the soils are moderately deep on serpentinite or deep to very deep in serpentinite colluvium. The geomorphic processes are fluvial erosion on the Haploxeralfs and both fluvial erosion and mass wasting on the Inceptisols. The vegetative cover is open conifer forest with evergreen shrubs in the understory. Both of the major map unit components have similar plant communities that may occur on either of them, but the identified inclusions are barren or with only sparse tree cover.

Component 1 - Hyampom, cold variant (Pedin site L09)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 25 to 60%

Soil: loamy-skeletal, magnesian, frigid Mollic Haploxeralfs

soil depth - moderately deep (50-100 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–incense-cedar/buckbrush

Component 2 - Hungry family (Pedin site L03)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 30 to 65%

Soil: loamy-skeletal, magnesian, frigid Typic Haploxerepts

soil depth - deep to very deep (depth > 100 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–incense-cedar–white fir/pinemat manzanita

Inclusions of barren Lithic Xerorthents on narrow summit slopes, Lithic Haploxerepts on steep N-facing slopes, and sparsely forested shallow Haploxerolls on very steep S-facing slopes > 60%

Pedon L09 about 550 meters southwest of Black Lassic summit

Classification: loamy-skeletal, magnesian, frigid, Mollic Haploxeralf

Location: 123.547°W, 40.337°N

Soil PM: serpentized peridotite

Landform: mountain sideslope

Elevation: 1690 meters; slope - 34% west (250° azimuth), inflection point of a short concave-convex slope

Precipitation: 150 cm/year

Vegetative cover: trees (40%) - plentiful Jeffrey pine (*P. jeffreyi*), and incense-cedar (*C. decurrens*) regeneration; shrubs (7%) - common *Ceanothus cuneatus* and sparse *Amelanchier alnifolia*; forbs (< 1%) - traces of *Pyrola* sp.

Surface stoniness: 1% boulders, 2% "stones", 3% cobbles

Oi 9 to 5 cm: loose fresh over slightly matted and weathered pine needles

Oe 5 to 0 cm: densely matted, partially decomposed, pine needles

A 0 to 7 cm: dark brown (7.5YR 3/3, 4/4 dry) gravelly loam; 2% stones, 3% cobbles, 25% gravel; moderate very fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; slightly acid (pH 6.6); clear, wavy boundary

Bt1 7 to 21 cm: dark brown (7.5YR 3/4, 4/4 dry) very gravelly clay loam; 3% stones, 5% cobbles, 30% gravel; moderate very fine subangular blocky structure; hard, firm, sticky and plastic; many faint clay coatings on ped faces; few fine and medium and very few coarse roots; neutral (pH 6.8); gradual, smooth boundary

Bt2 21 to 42 cm: brown (7.5YR 4/4, 5/4 dry) very gravelly clay loam; 5% stones, 10% cobbles, 40% gravel; moderate very fine subangular blocky structure; hard, firm, very sticky and plastic; common faint clay coatings on ped faces; few fine, medium, and coarse roots; neutral (pH 6.8); diffuse boundary

C 42 to 68 cm: brown (10YR 4/3, 5/4 dry) very gravelly clay loam; 5% stones, 10% cobbles, 40% gravel; weak very fine subangular blocky structure; hard, firm, sticky and plastic; few fine, medium, and coarse roots; neutral (pH 7.0); abrupt irregular boundary

R 68 to 70+ hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator; rock outcrop < 1%; LOI = 7.4% in A horizon.

Pedon L03 about 1.6 km east of Red Lassic summit

Classification: loamy-skeletal, magnesian, frigid, Typic Haploxerept

Location: 123.523°W, 40.328°N

Soil PM: serpentized peridotite

Landform: mountain sideslope

Elevation: 1615 meters; slope - 33% northwest (320° azimuth), convex-convex slope

Precipitation: 150 cm/year

Vegetative cover: trees (30%) - plentiful Jeffrey pine (*P. jeffreyi*), common incense-cedar (*C. decurrens*) and white fir (*A. concolor*), and sparse sugar pine (*P. lambertiana*); shrubs (8%) - common pinemat manzanita (*A. nevadensis*) and sparse *Amelanchier alnifolia* and *Quercus vaccinifolia*; forbs (1%) - traces of *Phlox diffusa*, *Iris* sp., *Galium ambiguum*, and *Lomatium* sp.

Surface stoniness: boulders < 1%, 2% "stones", 5% cobbles

Oi 2 to 0 cm: loose, fresh over slightly matted pine needles

A 0 to 4 cm: dark brown (7.5YR 3/2, 5/3 dry) very gravelly loam; 2% stones, 5% cobbles, 30% gravel; moderate very fine granular structure; soft, very friable, slightly sticky and nonplastic; few very fine roots; slightly acid (pH 6.6); clear, wavy boundary

Bw 4 to 24 cm: brown (7.5YR 4/3, 5/4 dry) very gravelly loam; 2% stones, 8% cobbles, 40% gravel; weak very fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and medium and few coarse roots; neutral (pH 6.8); gradual, smooth boundary

BC 24 to 68 cm: brown (10YR 4/3, 5/4 dry) very gravelly loam; 2% stones, 10% cobbles, 50% gravel; massive, structureless; slightly hard, friable, slightly sticky and nonplastic; few fine, medium, and coarse roots; neutral (pH 7.0); clear, irregular boundary

C 68 to 95+ extremely gravelly loam, originally thought to be a Cr horizon

Remarks: pH by bromothymol blue indicator; no rock outcrop.

SH1 - barren to sparse trees and shrubs/very shallow Entisols/serpentinized peridotite, gentle to moderately steep slopes (3-30%)

This is a barren of very shallow Lithic Xerorthents (Pedon site L10) on gentle summit slopes to moderately steep sideslopes, with inclusions of rock outcrop and Lithic Haploxeralfs. Krueger (1990) named the bedrock harzburgite, but it is practically all serpentinized, and serpentine is the main mineral in the sand fractions of the soils, with some chlorite and magnetite. The main geomorphic process is fluvial erosion. The vegetative cover is barren to sparse conifer trees and shrubs.

Component 1 - Lithic Xerorthents (Pedon site L10)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 3 to 30%

Soil: loamy-skeletal, magnesian, frigid Lithic Xerorthents

soil depth - very shallow (10-25 cm)

surface stoniness - very stony

drainage class - somewhat excessively well drained

Plant Community, dominant - barren

Inclusions - rock outcrop and Lithic Haploxeralfs

Pedon L10 about 0.7 km northwest of Black Lassic

Classification: loamy-skeletal, magnesian, frigid, Lithic Xerorthent

Location: 123.547°W, 40.345°N

Soil PM: serpentinitized harzburgite bedrock

Landform: hills in mountainous terrain

Elevation: 1610 meters; slope - inflection point of a convex-concave 24° south-southwest (210° azimuth) slope

Precipitation: 150 cm/year

Vegetative cover: trees, trace Jeffrey pine (*P. jeffreyi*); shrubs, none; forbs (1%) - sparse bedstraw (*Galium ambiguum*)

Surface stoniness: 3% boulders, 12% "stones", 15% cobbles

O none

A 0 to 2 cm: black (5Y 2/2, 5/2 dry) very gravelly sand; 12% stones, 15% cobbles, 40% gravel; single grain, structureless; loose, nonsticky and nonplastic; no roots; neutral (pH 6.8); abrupt smooth boundary

C 2 to 12 cm: very dark grayish brown (2.5Y 3/2, 5/2 dry) very gravelly loamy sand; 5% stones, 6% cobbles, 30% gravel; single grain, structureless; loose, nonsticky and nonplastic; no roots; neutral (pH 6.9); abrupt irregular boundary

R 12+ hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator; soil depth range 10 to 12 cm; insufficient organic matter for a Mollisol.

SH2 - open conifer forest and shrubs/shallow Alfisols and very shallow Entisols/serpentinized peridotite, gentle to moderately steep slopes (3-30%)

This is an open to sparsely forested complex of Lithic Haploxeralfs and very shallow Lithic Xerorthents on gentle summit slopes to moderately steep sideslopes, with inclusions of rock outcrop. Krueger (1990) named the bedrock harzburgite, but it is practically all serpentinized, and serpentine is the main mineral in the sand fractions of the soils, with some chlorite and magnetite. The main geomorphic process is fluvial erosion. The vegetative cover is open to sparse conifer trees and shrubs.

Component 1 - Lithic Haploxeralfs (Pedon site L11)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 3 to 30%

Soil: loamy-skeletal, magnesian, frigid Lithic Haploxeralfs

soil depth - shallow (18-50 cm)

surface stoniness - stony

drainage class - somewhat excessively well drained

Plant Community, dominant - open Jeffrey pine/buckbrush–greenleaf manzanita

Component 2 - Lithic Xerorthents (Pedon site L10)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 3 to 30%

Soil: loamy-skeletal, magnesian, frigid Lithic Xerorthents

soil depth - very shallow (10-25 cm)

surface stoniness - very stony

drainage class - somewhat excessively well drained

Plant Community, dominant - sparse Jeffrey pine/buckbrush

Inclusions - serpentinite rock outcrop

Pedon L11 about 2.25 km west-northwest of Black Lassic

Classification: loamy-skeletal, magnesian, frigid, Lithic Haploxeralf

Location: 123.564°W, 40.350°N

Soil PM: serpentinitized harzburgite bedrock

Landform: hills in mountainous terrain

Elevation: 1440 meters; slope - upper convex 18% west (260° azimuth) slope

Precipitation: 150 cm/year

Vegetative cover: trees (15%), common to plentiful Jeffrey pine (*P. jeffreyi*); shrubs (30%), common greenleaf manzanita (*A. patula*) and plentiful buckbrush (*Ceanothus cuneatus*); grasses (< 1%) - sparse squirreltail (*Elymus elymoides*)

Surface stoniness: 1% boulders, 3% "stones", 3% cobbles

Oi 3-1 cm: loose pine needles

Oe 1-0 cm: loose pine needles broken into short (< 2 cm) pieces and weathered black

A 0 to 2 cm: dark reddish brown (5YR 3/2, 5/2 dry) very gravelly sandy loam; 3% stones, 3% cobbles, 30% gravel; strong very fine granular structure; soft, slightly sticky and nonplastic; few very fine roots; neutral (pH 6.7); abrupt smooth boundary

Bt 2 to 12 cm: dark brown (7.5YR 3/4, 5/4 dry) very gravelly loam; 3% stones, 3% cobbles, 45% gravel; moderate fine subangular blocky structure; slightly hard, slightly sticky and slightly plastic; few fine and medium roots; neutral (pH 6.8); clear, wavy boundary

C 12 to 24 cm: dark yellowish brown (10YR 4/4, 6/5 dry) extremely gravelly loam; 6% stones, 6% cobbles, 60% gravel; moderate fine subangular blocky structure; slightly hard, slightly sticky and slightly plastic; common medium and few coarse roots; neutral (pH 6.9); abrupt irregular boundary

Cr 24 to 33 cm: bedrock weathered slightly hard to soft

R 33+ hard, moderately fractured bedrock

Remarks: pH by bromothymol blue indicator.

Pedon L10, refer to map unit SH1.

SL - open forest/very deep Hungry family/serpentinite colluvium, closed depressions to steep slopes (0 to 60%)

This is a forested complex of well drained serpentine Inceptisols in landslide deposits, with poorly to very poorly drained soils in depressions. It is adjacent to Red Lassic on the west side of it. Mass failure was a major geomorphic process that resulted in hummocky topography with closed depressions. Currently the main geomorphic process is fluvial erosion, with deposition in the closed depressions. The vegetative cover of the major map unit component is open conifer forest—mostly Jeffrey pine and incense-cedar with buckbrush in the understory.

Major Component - Hungry family, very deep (Pedon site L01)

Lithology: serpentinite (serpentinized peridotite) colluvium

Slopes, dominant: 3 to 60%

Soil: loamy-skeletal, magnesian, frigid Typic Haploxerepts

soil depth - very deep (depth > 150 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–incense-cedar/buckbrush

Inclusions - ephemeral ponds with very deep Entisols (Aquents) in barren centers and Mollisols (Aquolls) in graminoid covered margins

Pedon L01 about 200 m northwest of Red Lassic summit

Classification: loamy-skeletal, magnesian, frigid, Typic Haploxerept

Location: 123.543°W, 40.329°N

Soil PM: serpentinized peridotite colluvium

Landform: hummocky landslide

Elevation: 1712 meters; slope - 38% southwest (210° azimuth), linear slope

Precipitation: 150 cm/year

Vegetative cover: trees (30%) - common Jeffrey pine (*P. jeffreyi*) and sparse incense-cedar (*C. decurrens*); shrubs (5%) - common *Ceanothus cuneatus*; forbs (< 1%) - traces of *Eriogonum* sp.

Surface stoniness: boulders < 1%, 3% “stones”, 6% cobbles

Oi 2 to 0 cm: loose, fresh over slightly matted, slightly weathered pine needles

A 0 to 3 cm: very dark grayish brown (10YR 3/2, 5/3 dry) very gravelly loamy sand; 3% stones, 6% cobbles, 30% gravel; weak medium platy structure; soft, very friable, nonsticky and nonplastic; few very very fine roots; slightly acid (pH 6.6); abrupt, smooth boundary

Bw 3 to 22 cm: dark brown (10YR 3/3, 5/3 dry) very gravelly sandy loam; 3% stones, 6% cobbles, 50% gravel; weak very fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; few very fine, medium, and coarse roots; neutral (pH 6.8); diffuse boundary

C 22 to 110+ cm: brown (10YR 4/3, 5/3 dry) extremely gravelly sandy loam; 5% stones, 10% cobbles, 60% gravel; massive, structureless; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; neutral (pH 7.0); clear, irregular boundary

Remarks: pH by bromothymol blue indicator; a 4 cm diameter root at 95 cm depth; LOI = 2.46% in A horizon.

ST - barren to sparse trees and shrubs/very shallow Lithic Xerorthents, shallow Inceptisols, and shallow Mollisols, moderate to steep slopes (12 to 65%)

This is a barren to sparsely vegetated complex of very shallow Lithic Xerorthents on narrow summit slopes, Lithic Haploxerepts on steep N-facing slopes, and shallow Typic Haploxerolls on steep S-facing slopes with sparse serpentine rock outcrop. The main geomorphic processes are fluvial erosion on moderately steep slopes and both mass wasting and fluvial erosion on steep slopes. The vegetative cover is barren to sparse conifer trees and shrubs.

Component 1 - Lithic Xerorthents (Pedon site L08)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 12 to 30%

Soil: loamy-skeletal, magnesian, frigid Mollic Haploxeralfs

soil depth - very shallow (10-25 cm)

surface stoniness - stony

drainage class - somewhat excessively well drained

Plant Community, dominant - barren

Component 2 - Lithic Haploxerepts (Pedon site L06)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: N-facing 25 to 60%

Soil: loamy-skeletal, magnesian, frigid Lithic Haploxerepts

soil depth - shallow (18-50 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–white fir/buckbrush

Component 3 - shallow Typic Haploxerolls (Pedon site L04)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 30 to 65%

Soil: loamy, magnesian, frigid Typic Haploxerolls

soil depth - moderately deep (10-50 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–incense-cedar/huckleberry oak–buckbrush

Inclusions - serpentinite rock outcrop

Pedon L08 about 350 m northeast of Signal Peak summit

Classification: loamy-skeletal, magnesian, frigid, Lithic Xerorthent

Location: 123.551°W, 40.335°N

Soil PM: serpentinite bedrock

Landform: narrow mountain summit slope

Elevation: 1700 meters; slope - 24% west-northwest (300° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees > 1%, Jeffrey pine (*P. jeffreyi*); shrubs, none; forbs < 1% - bedstraw (*Galium* sp.)

Rock outcrop 2%; Surface stoniness: 1% "stones", 5% cobbles, 70% gravel

A1 0 to 3 cm: dark olive gray (5Y 3/2, 5/2 dry) extremely gravelly loamy sand; 1% stones, 5% cobbles, 60% gravel; single grain, structureless; loose; many very fine intergranular pores; no roots; neutral (pH 7.0); abrupt smooth boundary

A2 3 to 10 cm: dark olive gray (5Y 3/2, 5/3 dry) very gravelly sandy loam; 1% stones, 5% cobbles, 30% gravel; massive, structureless; soft, very friable, slightly sticky and nonplastic; many very fine interstitial pores; no roots; neutral (pH 7.0); abrupt irregular boundary

R 10 to 25+ hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator; soil depth range 9 to 12 cm; insufficient organic matter (0.41% LOI in a composite A1 and A2 horizon sample) for a Mollisol.

Pedon L06 about 150 m north of Signal Peak summit

Classification: loamy-skeletal, magnesian, frigid, Lithic Haploxerept

Location: 123.555°W, 40.335°N

Soil PM: serpentinite bedrock, minor clastic sedimentary rock fragments in colluvium

Pebble lithologies: 88% serpentinite, 12% clastic metasedimentary (sandstone and shale, minor chert)

Landform: mountain sideslope

Elevation: 1730 meters; slope - linear 45% northwest (320° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees (2%), sparse Jeffrey pine (*P. jeffreyi*) and white fir (*A. concolor*); shrubs (2%), buckbrush (*C. cuneatus*); forbs < 1% - *Phacelia corymbosa* and *Lupinus constancei*

Rock outcrop, none.

Surface stoniness: boulders < 1%, 2% "stones", 10% cobbles

A1 0 to 5 cm: dark brown (10YR 3/3, 5/3 dry) very gravelly loamy sand; 2% stones, 10% cobbles, 30% gravel; massive, structureless; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; no roots; neutral (pH 6.8); abrupt wavy boundary

A2 5 to 12 cm: dark brown (10YR 3/3, 5/3 dry) very gravelly sandy loam; 1% stones, 5% cobbles, 40% gravel; weak, very fine granular structure; soft, very friable, slightly sticky and nonplastic; common very fine and very few fine roots; neutral (pH 7.0); clear wavy boundary

Bw 12 to 22 cm: dark brown (10YR 3/3, 5/4 dry) very gravelly sandy loam; 2% stones, 12 cobbles, 30% gravel; weak, very fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; few fine and medium roots; neutral (pH 7.0); abrupt irregular boundary

R 22 to 25+ hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator; soil depth range 20 to 24 cm; LOI = 1.06 in a composite A1 and A2 horizon sample, but less organic matter in Bw horizon may make the overall OM content too low for a Mollisol.

Pedon L04 about 450 m south-southeast of Signal Peak summit

Classification: loamy, magnesian, frigid, shallow Typic Haploxeroll

Location: 123.5525°W, 40.330°N

Soil PM: serpentinite bedrock

Landform: mountain sideslope

Elevation: 1640 meters; slope - linear 64% south-southwest (210° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees (20%), common Jeffrey pine (*P. jeffreyi*) and sparse incense-cedar (*C. decurrens*); shrubs (3%), sparse *Quercus vaccinifolia* and *Ceanothus cuneatus*; forbs < 1% - *Galium* sp.

Rock outcrop < 1%; Surface stoniness: boulders < 1%, 1% "stones", 3% cobbles

Oi/Oe 3-0 cm: loose fresh over slightly matted weathered pine needles

A 0 to 3 cm: very dark grayish brown (10YR 3/2, 4/2 dry) gravelly loamy sand; 1% stones, 3% cobbles, 30% gravel; massive, structureless; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; few very fine roots; neutral (pH 7.0); abrupt smooth boundary

Bw 3 to 12 cm: very dark grayish brown (10YR 3/2, 4/3 dry) gravelly sandy loam; stones < 1%, cobbles < 1%, 30% gravel; weak, very fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; very few fine and fine and few medium and coarse roots; neutral (pH 7.0); abrupt irregular boundary

Cr 12 to 48+ massive green bedrock

Remarks: pH by bromothymol blue indicator; LOI = 2.78 in A and 1.32 in Bw horizon.

SX - sparse conifer trees/Lithic Haploxerepts on very steep S-facing slopes and open conifer forest/deep to very deep Haploxerepts on colluvial footslopes, slopes 15 to 75%

Component 1 - shallow Lithic Haploxerepts (Pedon site L02)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 60 to 75%

Soil: loamy-skeletal, magnesian, frigid Lithic Haploxerepts

soil depth - shallow (15-50 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine

Component 2 - Hungry family (Pedon site L03)

Lithology: serpentinite (serpentinized peridotite)

Slopes, dominant: 15 to 60%

Soil: loamy-skeletal, magnesian, frigid Typic Haploxerepts

soil depth - deep to very deep (depth > 100 cm)

surface stoniness - stony

drainage class - well drained

Plant Community, dominant - Jeffrey pine–incense-cedar/buckbrush

Inclusions - Lithic Xerorthents on narrow summit slopes

Pedon L02 about 1.8 km east of Red Lassic summit

Classification: loamy-skeletal, magnesian, frigid, shallow Lithic Haploxerept

Location: 123.521°W, 40.326°N

Soil PM: serpentinite bedrock

Landform: mountain sideslope

Elevation: 1640 meters; slope - linear 72% south-southeast (160° azimuth)

Precipitation: 150 cm/year

Vegetative cover: trees (5%), common Jeffrey pine (*P. jeffreyi*); no shrubs; forbs (3%) - *Phacelia corymbosa* and bedstraw (*Galium* sp.)

Rock outcrop < 1%; Surface stoniness: no boulders, 1% “stones”, 5% cobbles

Oi sparsely scattered pine needles

A1 0 to 4 cm: dark grayish brown (10YR 4/2, 5/3 dry) very gravelly sandy loam; 1% stones, 5% cobbles, 30% gravel; massive, structureless; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; very few very fine roots; neutral (pH 6.8); clear wavy boundary

Bw 4 to 17 cm: dark brown (10YR 4/3, 6/4 dry) very gravelly sandy loam; 1% stones, 5% cobbles, 50% gravel; weak, very fine subangular blocky structure; soft, friable, slightly sticky and nonplastic; few fine, medium and coarse roots; neutral (pH 7.0); abrupt irregular boundary

R 17 to 30+ moderately hard (slightly weathered) to hard, highly fractured bedrock

Remarks: pH by bromothymol blue indicator.

Pedon L03, refer to map unit SD.

Botanical Implications

Lassics lupine is found on shallow soils, only. They are not all serpentine soils, however. One site (L07) is on a very shallow nonserpentine soil in map unit CM that has a surface soil exchangeable Ca/Mg ratio > 1.0 , even though the exchangeable Ca is low because of low cation-exchange capacity (CEC). Perhaps a very shallow soil with minimal organic matter and lacking competition from other plants is more important than that the soils be serpentine ones. A combination of factors such as very shallow soils and low exchangeable calcium that limit plant competition are important, along with accidents of seed distribution and predation by animals. Rodents that live in soils do not dwell in very shallow soil; they must pass overland to reach the Lassics lupine plants, risking the threat of raptorial birds.

The Lassics minuarta is found on very deep serpentine soils of soil map unit SL; soils that limit plant competition. Being on such very deep soils with more vegetative cover than the very shallow soils of units CS, CM, and ST, they may tolerate more plant competition than the Lassics lupine.

This soils investigation did not reveal any soil chemical differences that might be responsible for Lassics lupine growing on some serpentine soils and not on others. If the search for chemical differences is continued, the next step might be to sample plants such as a bedstraw (for example, *Galium ambiguum*) that grow both with the lupine and in areas where there is no lupine for foliar analyses. Naked buckwheat (*Eriogonum nudum*) might be a good choice for foliar analyses, because it grows on both serpentine and nonserpentine soils. Foliar analyses are not too expensive, so analyses of several specimen samples for many elements (perhaps 20 or 30) may cost no more than one or two hundred dollars. For comparison, plants must be sampled at the same time of year and washed free of dust particles.

Table 2. Exchangeable calcium and magnesium and weight loss on ignition (LOI).

Pedon-sample	Horizon designation	Depth cm	LOI g/kg	Ca mmol ₊ /kg	Mg mmol ₊ /kg	Ca/Mg molar ratio
L01-1	A	0-3	2.46	7	77	0.09
L01-2	Bw	3-22	—	9	113	0.08
L02-1	A	0-4	—	4	43	0.10
L02-2	Bw	4-17	—	4	54	0.08
L03-1	A	0-4	—	41	133	0.31
L03-2	Bw	4-24	—	19	145	0.13
L04-1	A	0-3	2.78	9	67	0.14
L04-2	Bw	3-12	1.32	7	55	0.13
L05-1,2	A1,A2	0-7	0.64	7	51	0.14
L06-1,2	A1.A2	0-12	1.06	9	67	0.14
L06-3	Bw	12-22	—	11	79	0.14
L07-1	A	0-10	0.89	16	12	1.33
L08-1	A	0-10	0.41	1	25	0.04
L09-1	A	0-7	7.43	44	141	0.31
L09-2	Bt1	7-21	—	31	159	0.20
L09-3	Bt2	21-42	—	28	141	0.20
L10-1	A	0-2	—	2	16	0.12
L10-2	C	2-12		1	15	0.07
L11-2	Bt	2-12	—	15	171	0.09
L11-3	C	12-24	—	7	94	0.07

Note: extraction of cations with molar NH₄-chloride and titration with EDTA (Heald 1965).

Table 3. Elemental analyses from aqua regia digestion by Inspectorate America Corporation.

Soil	⁵ B	¹³ Al	¹⁵ P	¹⁹ K	²⁰ Ca	²³ V	²⁴ Cr	²⁵ Mn	²⁶ Fe	²⁷ Co	²⁸ Ni	²⁹ Cu	³⁰ Zn
Hor.	µg/g	g/kg	µg/g	g/kg	g/kg	µg/g	µg/g	µg/g	g/kg	µg/g	µg/g	µg/g	µg/g
L01-1	48	13.7	129	0.9	8.1	57	1409	1062	92.5	99	1345	60	45
L01-2	48	15.9	219	1.4	8.0	59	1159	1230	96.2	110	1323	45	37
L02-1	38	12.5	100	<.1	7.2	37	1042	734	63.0	67	1142	29	20
L02-2	34	9.7	97	<.1	4.9	30	936	821	58.6	80	1220	20	13
L03-1	54	18.0	270	0.6	19.8	72	1892	1351	>100	128	1198	40	29
L03-2	54	15.0	218	0.1	15.7	67	1591	1066	>100	113	1487	35	17
L04-1	34	6.5	71	<.1	2.1	26	1018	667	62.3	77	1402	25	17
L04-2	36	6.9	65	<.1	2.1	27	1070	684	71.7	81	1589	20	11
L05-1,2	35	13.9	174	2.9	2.6	44	797	622	67.7	56	1065	49	52
L06-1,2	38	19.7	259	3.0	1.7	61	691	772	72.4	62	925	51	60
L06-3	37	18.5	215	2.8	1.6	58	672	779	67.9	64	922	54	58
L07-1	28	26.8	297	7.5	2.3	73	93	629	50.0	18	101	66	99
L08-1	33	7.2	116	<.1	3.0	31	929	685	59.3	80	1245	26	16
L09-1	62	16.7	219	1.1	4.9	72	1633	1473	>100	148	1458	39	41

Note: Superscripts are atomic numbers, rather than the usual atomic weights. ⁴²Mo <1 g/kg in all samples.

g/kg=parts/thousand, µg/g=parts/million

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