

Plants That Grow On Serpentine - A Hard Life*

This will not be a tale about plants with reptilian affinities, despite its title! Nor is it about an herbaceous border along a sinuous path. It *is* a story about a curious affinity of certain plants for a most demanding habitat - the magnesium-rich soils derived from serpentine and other ultramafic¹ rock. The only allusion to snakes is the rather fanciful likeness of the lustrous, mottled green serpentine rock to the pattern of a snake's skin. But first, I must put this exceptional union of plant and soil in its proper global setting.

Plants and animals are finely tuned to their local and regional environments. Caged canaries used by miners to sense the quality of air and plants that are sensitive or tolerant to urban pollution are but two examples of the close tracking of environment by organisms - a truism so universal as to appear trite in print. Yet some kinds of biological indicators are much more subtle: plants sensitive or tolerant to heavy metals, DDT resistance in mosquitoes, or plants that can tolerate serpentine.

Botanists recognize three primary environmental conditioners of the response to habitat by plants. Climate is the chief arbiter of plant survival; then comes soil in diverse qualities; and finally other organisms or allies exert their effect on plants. All three act as agents of selection, drawing on the evolutionary potential of plants.

Over the years, my special passion has been to search for examples of plant responses to unusual soils, where they can add variety within the context of a region's pervasive climate (Kruckeberg, 1969a, b). The search has been easy and fully rewarding for, within any given climatic regime, geological events have made strong impressions on the local landscapes. Besides the obvious impact of causing topographic variation - mountains, valleys, north and south slopes, rain-shadow effects, and the like - geological processes and products influence the chemical and physical properties of soils. Gardeners know well the effect of limestone rock, saline substrates, or acid

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peatbogs on the quality of plant growth. Wherever some geological phenomenon makes a bold impact on the habitat, the plants of the region must respond. The response can take several forms: the local vegetation may largely avoid the stressful substrate; or some of the plants of the region may evolve variants that are tolerant of the extreme condition; or evolutionary adjustment may go so far as to yield new species narrowly restricted (endemic) to the severe soil type. All these responses have occurred most dramatically wherever plants encounter soils weathered from serpentine and related rocks.

Serpentine belongs to the ultramafic clan of rocks, in which minerals of iron and magnesium silicate predominate. Besides serpentine (a metamorphic rock²), other ultramafics like peridotite and dunite may outcrop as igneous rocks³, emplaced in the country rock without alteration from their deep-seated origin in the earth's mantle. Serpentine rock is easy to recognize: it glistens as if freshly polished; its color ranges from black through gray and green, often mottled; it is smooth to soapy to the touch; and it is easily splintered or fractured. Fresh dunite is dull, greasy, and grayish-brown, as though it were congealed grease mixed with sand; when exposed to the weather the surface of dunite turns rusty-brown, revealing its iron content. Peridotite is a rusty-brown rock with massive crystals and ribbons of asbestos. All three forms occur in the Pacific Northwest.

Besides the high iron content, serpentines often are laced with heavy metals like chromium and nickel. Minerals other than the iron-magnesium silicate known as olivine may add small amounts of calcium and potassium to the rock. The weathering processes induced by local climates break down or alter the parent rock to yield soil. Although much the same constituents found in the parent rock do persist in the soil, quantities and qualities may change. In the case of serpentine, a clay mineral often forms, one not found in the rock. Iron and magnesium still enrich the soil, and chromium and nickel can be present in large concentrations. But nitrogen, potassium, phos-

1. Ultramafic - rocks with iron-magnesium silicate minerals.
2. Metamorphic rock-formed by the transformation, while in the solid state, of pre-existing rocks beneath the earth's surface through the agencies of heat, pressure, and chemically active fluids.
3. Igneous rock-formed from molten material that solidified on cooling.

phorus and calcium - so essential for plant growth - are usually in short supply. Serpentines are notorious as poor agricultural soils, deficient in the minerals required for the normal growth of crop plants. The mineral imbalances in serpentine, plus instability of the underlying rock, usually creates an austere landscape, often with little or no plant cover. Indeed, the phrase "serpentine barren" is used worldwide to depict the sere aspect of a serpentine landscape. But far from avoiding serpentine altogether, certain plants have "learned" to thrive on the demanding substrate. "Learning" to live on serpentine really means evolving some adaptive structure and function to take advantage of the "Lebensraum" of such a habitat. In the Pacific Northwest, from northern California to northern British Columbia, those few species that can survive on serpentine are either genetic races of wide-ranging species that have evolved a tolerance to the substrate, or they may be distinct species, adapted to exist solely on serpentine.

Locations of Serpentine and Other Ultramafic Rocks in British Columbia and the Pacific Northwest.

Ultramafic rocks, rich in iron and magnesium are scattered throughout the Pacific Northwest from northern British Columbia to the Oregon-California border. Three major concentrations occur: in the Siskiyou Mountains of Oregon and California, in the Wenatchee Mountains of Washington, and in the Shulaps Range-Yalacom River country northwest of Lillooet in British Columbia. Serpentine leaves its mark on the vegetation of our region most markedly in the more southerly Siskiyou country (Whittaker, 1954), where a substantial number of serpentine species are found and where the contrasts between serpentine and non-serpentine vegetation are the most striking. The display of the serpentine phenomenon is progressively less spectacular as one travels northward. Although fine examples of barrens exist in the Wenatchee Mountains, fewer species have adapted to the stressed habitats. In British Columbia, the effect is largely one of reduced vegetation cover on serpentine, with the occurrence of only two or three faithful plant indicators of the substrate.

In British Columbia, serpentine and other ultramafics appear in both the Coast Range drainages and in the drier interior of the Province (see map, Figure 1). In southern British Columbia the major concentrations are along the tributary drainages of the Fraser River, from Hope to west of Lillooet

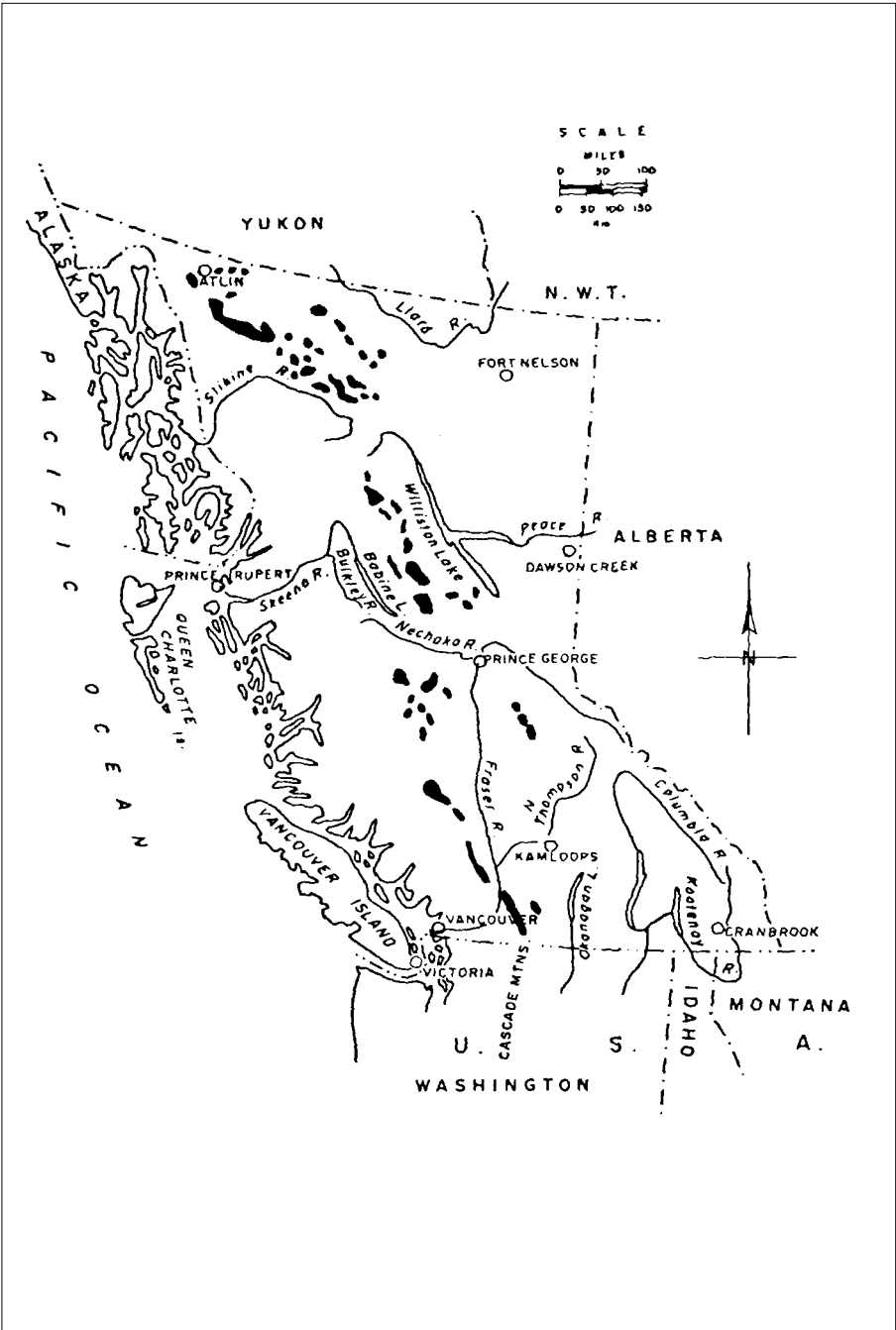


Figure 1. Regions containing serpentine rock in British Columbia.

and southwest to Prince George. North of latitude 54°N, the outcrops are more widely scattered, with the main locations around Taku Plateau, the Takia and Trembleur Lakes country, east of Dease Lake, and in the Cassiar Mountains.

British Columbia serpentines have been of interest to mining concerns and to rockhounds over the years. Besides the traditional search for gold deposits that may associate with serpentine outcrops, explorations for commercial deposits of chromium and nickel have utilized serpentine as a pathfinder rock. Jade, a popular semi-precious stone, is faithfully linked with serpentine in British Columbia, even though the scattered boulders of jade may be displaced many miles from a serpentine source by water or glacial action (Holland, 1961).

The occurrence of important mineral resources in or adjacent to serpentine rocks has led to an unusual approach to prospecting for ores. Dr. Harry Warren, Professor of Geology at The University of British Columbia, has pioneered the use of geobotanical prospecting, or biogeochemistry (Warren, 1972). Analysis of the mineral contents of plants growing on probable mineral deposits often reveals unusually high concentrations of elements that the plants are able to extract from the soil above the rock, or from the parent material. Since plants can take up mineral elements of many kinds, some of which are of no nutritional value to the plant, the elemental composition of the plant tissue then becomes a useful measure of the elemental composition of the soil and underlying rock. Warren and his associates have used the plant “pathfinder” technique for a variety of minerals: copper, zinc, gold, silver, molybdenum, lead, mercury, chromium, and nickel. In the case of nickel, chromium, mercury and other serpentine-associated minerals, geobotanical prospecting would utilize both the field appearance of the vegetation (barrens or stunted forest and brush localities surrounded by the more lush growth on non-serpentine rocks), as well as chemical analysis of plant tissues in the expectation of locating high accumulations of metal elements.

Plant Life on Serpentines in the Pacific Northwest

The ultimate in the reaction of plants to serpentine is a complete avoidance of the substrate - barrens without a sign of life. No such extreme situations are known in British Columbia. Hardly less extreme are vast - or

local - barrens with little or no woody plant cover and with a thin vegetation of grasses and other herbs growing in isolated patches scattered about a sea of green or rusty brown, rocky talus. The nearest approach to this condition is in the Wenatchee Mountains in nearby Washington State (Kruckeberg, 1969b). Here the few plants may indeed be unique to the serpentine substrate. Nearly wholly restricted to these barrens are *Douglasia nivalis* var. *dentata*, a lovely primula-like cushion plant; an umbel (Parsley Family), *Lomatium cuspidatum*; two ferns, *Polystichum lemmonii* and *Aspidotis densa*; and a grass, *Poa curtifolia*. All but the two ferns are endemic to Wenatchee Mountains serpentine. Less restricted, but good indicators of the serpentine habitat, are a few other herbs like the wild buckwheat, *Eriogonum pyrolaeifolium*, *Chaenactis thompsonii* and *C. ramosa*, *Cryptantha thompsonii*, *Erysimum torulosum*, *Arenaria obtusiloba*, and a low shrubby willow, *Salix brachycarpa*.

On more stable serpentine outcrops where the soil is deeper, woody plants can colonize. But the way they aggregate into communities is often unique. Tree and shrub species of either higher or lower life zones often coexist on serpentine. Thus, in the Wenatchee Mountains I have found whitebark pine (*Pinus albicaulis*) and ground juniper (*Juniperus communis*), both timberline species, growing side by side with Ponderosa pine (*Pinus ponderosa*) (Figure 8) and Douglas fir (*Pseudotsuga menziesii*), both low montane trees.

In British Columbia, the plant response to serpentine seems to be not as extreme, either in terms of scanty plant cover or diversity of species. First, there are no species wholly restricted to serpentine in the Province. Though the vegetation cover often is sparse and often dwarfed in contrast to the plant cover on normal soils, I have also found situations where a good (high yield) forest is underlain by serpentine (as on the Coquihalla River, northeast of Hope, and at the B.C. Nickel Mines west of Choate). Where forest is replaced by shrub and herb cover on British Columbia serpentines, the little rock brake fern or Indian's-dream, *Aspidotis densa* (Figure 16), is about the only faithful indicator of the substrate. However, the species that do grow on these British Columbia serpentines are more often ones that are known from drier habitats, rather than those of the adjacent normal substrates. This is the case on the serpentines of the Tulameen River country (at Olivine Mountain and Grasshopper Mountain) where xeric species like *Cirsium* sp., *Lygodesmia spinosa*, *Agropyron spicatum* and *Hieracium albiflorum* grow on serpentine, but are not in the more mesic forested habitats of normal soils



Figure 16. Frond of *Aspidotis densa*, rock brake fern or Indian's-dream.

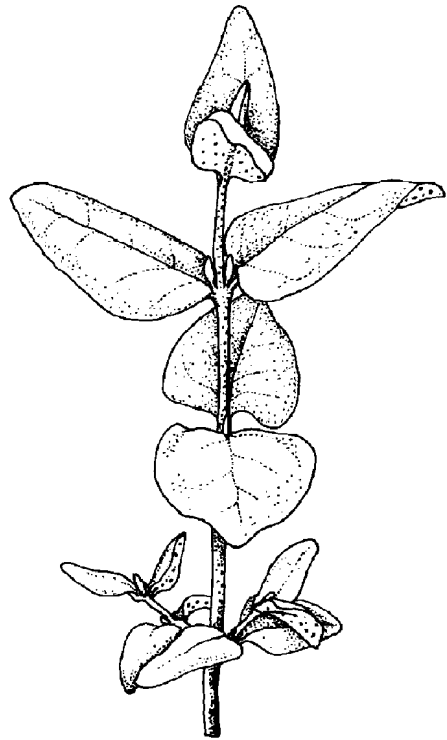


Figure 17. *Shepherdia canadensis*, Soopolallie.

nearby.

The Lillooet District of south central British Columbia has the most impressive serpentine outcrops in the Province. I have reconnoitered one of these (Kruckeberg, 1969b), just above the gold mining settlement at Bralorne in the Bridge River country. The scattered outcrops above Cadwallader Creek are of dunite, nearly pure olivine material. They are visible from a distance only because the surrounding vegetation on argillite-chert-limestone is low and brushy, still recovering from an old burn. Although the surrounding vegetation is regenerating to spruce and lodgepole pine, the dunite outcrop is rather barren: a few stunted pine trees, and a sparse shrub cover of *Juniperus communis*, *Shepherdia canadensis* (Figure 17), *Rubus leucodermis* (Figure 18), *Amelanchier ainifolia*, and *Arctostaphylos uva-ursi*. Several herb species on the dunite outcrop are of interest, as they are unexpected in a forested setting: *Fritillaria lanceolata*, *Phacelia leptosepala*, *Sedum stenopetalum*, *Cirsium* sp., *Silene parryi*, *Senecio pauperculus*, *Penstemon fruticosus* (Figure 19), *Eriogonum umbellatum*, *Saxifraga bronchialis* subsp. *austromontana* and *Sitanion* sp. None of these are peculiar to high magnesium rocks; rather, they are widespread shrubs and herbs in the Pacific Northwest, gaining local foothold on the more arid and stressful dunite. Only two species here are good serpentine indicators, both are ferns; *Aspidotis densa* and *Polystichum kruckebergii* (Figure 20).

The Shulaps Range, 56 km northwest of Lillooet, is the largest (30 km long by 13 km wide) ultramafic outcrop in the district, and indeed in the Province. It is part of a long, narrow and discontinuous chain of ultramafic intrusions extending northwest through most of British Columbia, east of the Coast Range. The Shulaps Range lies between the Yalacom and Bridge rivers; elevations range from 1525 m at the Yalacom River to 2430-2475 m at the crest, with Shulaps Peak (2877 m) the highest point. Though I have yet to visit this remarkable locality, I have had access to unpublished reports by Professors V. C. Brink and K. Fletcher, botanist and geologist, both of The University of British Columbia faculty (Brink *et al.*, 1976). The Shulaps ultramafics, making up the bulk of the range, are a mixture of dunite, peridotite and pyroxenite (igneous ultramafics) that have been changed to serpentine in varying degrees throughout the entire intrusion. Brink and associates describe the vegetation of the Shulaps ultramafics as “sparse, typical of ultrabasics elsewhere”, and, unlike most other British Columbia localities,



Figure 18. *Rubus leucodermis*, black raspberry



Figure 19. *Penstemon fruticosus*, shrubby penstemon.

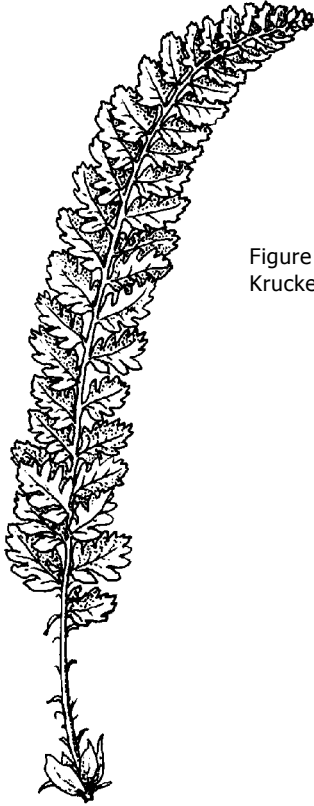


Figure 20. Frond of *Polystichum kruckebergii*, Kruckeberg's sword fern.



Figure 21. *Cerastium beeringianum*, Bering chickweed.

the contrast between the vegetation on ultramafics and the adjacent more luxuriant and diverse plant life on non-ultramafic rocks is striking. The University of British Columbia scientists found a few species that appeared to be restricted to the Shulaps ultramafics; among them are *Chaenactis alpina*, *Cerastium beeringianum* (Figure 21), and the faithful indicator fern, *Aspidotis densa*. From analyses of the mineral contents of some of these plants, it was found that certain species concentrate high amounts of nickel and, less often, of chromium in their tissue.

Professor T. M. C. Taylor has informed me that *Polystichum kruckebergii* is also known from the Shulaps ultramafic intrusion. It is hoped that further botanical explorations will provide a fuller picture of the plant responses to serpentine and related rocks in British Columbia. Only then will it be possible to evaluate my hypothesis that the plant response to these highly mineralized, yet nutritionally impoverished substrates is diminished with increasing latitude.

While the serpentine response of plants is of special fascination in its own right, it provokes a more general interpretation. It reminds us that whenever we try to account for spatial patterns in the plant world, the importance of geological processes and products must be given due respect. Other geological influences - chemical and physical - while often more subtle than serpentine in their effects on plants, do add their impact on determining where plants will and will not grow. I would maintain that local patterns of vegetation and local distributions and abundances of plant species are largely due to the variations in some geological attribute that cause a diversity of land form, terrain and soil, to ever enrich the tapestry of life.

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