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Ferns Associated With Ultramafic Rocks in the Pacific Northwest[1]

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The unique plant life on serpentine and other ultramafic rock types is a telling reminder to plant ecologists, taxonomists, and plant geographers of the significance of the edaphic factor in plant distribution. Endemism, ecotypic differentiation, serpentinomorphism, singular vegetational physiognomies, and "extra-limital" distributions all contrive to make the floras of these magnesium-rich, calcium-poor areas fascinating and unique botanical areas (Krause, 1958; Whittaker, 1954). During the course of genecological and floristic studies on the plant life of ultramafic outcrops in the Pacific Northwest,[1] I have been struck by the highly predictable recurrence of and restriction to ultramafic soils of three fern species. *Polystichum mohrioides* (Bory) Presl var. *lemmonii* (Underw.) Fern. and *Cheilanthes siliquosa* Maxon

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are almost exclusively found on soils of ultramafic rock origin, while *A. pedatum* L. var. *aleuticum* Rupr. shows a strong preference for the same substrates. What follows, then, is a resumé of the occurrences of these "serpentinophytes" on ultramafics as compared with their nearly uniform absence on adjacent soils of other parent material origin. I have made field observations mainly in the state of Washington; a limited number of visits have been made to similar sites in Oregon, northern California, Montana, and British Columbia.

LOCATION AND DESCRIPTION OF SITES

The term "ultramafic" embraces all those rock types in which the elemental composition is largely silicates of iron and magnesium. The commonest lithological forms of ultramafics are the

FIGURE 1. INGALLS PERIDOTITE AND SERPENTINE IN FOREGROUND; IRON PEAK (HAWKINS GREENSTONE FORMATION) AT END OF RIDGE. NOTE ABRUPT LITHOLOGICAL CONTACT AT THAT POINT. THE THREE "ULTRAMAFIC" FERNS ARE COMMON ON THE NEAREST SLOPES.

igneous rocks, peridotite and dunite, and their metamorphic derivative, serpentine. Soils derived from such rocks are high in magnesium and low in calcium; probably a secondary biological effect is the common deficiency in nitrogen and phosphorus. Such soils are both unfit for agriculture and highly selective for native plant species. The vegetation often is sparse and yet of a unique floristic composition (Krause, 1958).

The ultramafics of Washington occur in three rather well-defined regions. The largest exposure is in montane portions of Kittitas and adjacent Chelan counties. The sites are all in the Wenatchee Mountains which form an easterly extending spur of the Cascade Range. The outcrops occur either as peridotite, dunite, or serpentine; exposures of the rock may be massive—of many square miles in extent—or very local. Old altered volcanics (greenstones), sedimentary rocks, gneisses and schists, as well as acid igneous granodiorite border or even interfinger with the ultramafics. The region is thus lithologically rich and complex (Pratt, 1958). The terrain is rugged, with steep slopes and high ridges that culminate in ultramafic peaks of from 5000 to 7000 feet altitude (Earl, Navaho, and Ingalls peaks). The clearest and most spectacular contact between ultramafic and non-ferromagnesian rock types is along upper Ingalls Creek where the east boundary of peridotite at the creek abruptly gives way to the massive granodiorite (acid igneous) of the Stuart Range.

All of the Wenatchee Mountains ultramafics occur in areas of coniferous forest. At altitudes from 2500 to 4000 feet, the forests consist of open stands of Douglas fir, yellow pine, and western white pine; this forest type grades insensibly upward into a mixture of subalpine fir, mountain hemlock, and whitebark pine (Fig. 1). The stands are invariably open, the barren slopes between the scattered trees lightly populated with grasses and forbs, some of which are highly characteristic of ultramafic soils (Fig. 2).

The next largest series of ultramafic occurrences in Washington is in the northwestern counties of Snohomish, Skagit, San

Juan, and Whatcom. The most outstanding of these is Twin Sisters Mountain, a westerly outlier of the northern Cascade Range; it is pure dunite, an igneous ultramafic composed primarily of the mineral olivine. Rock of similar origin occurs locally at low elevations to the west; Fidalgo Island and Cypress Island have the most extensive of this series of ultramafic outcrops.

The vegetation on the Twin Sisters dunite contrasts strikingly with that on the adjacent non-ferromagnesian parent materials. The luxuriance of the Humid Transition forest abruptly gives way to stunted Douglas fir, lodgepole pine, western white pine, and shrubby *Juniperus communis.* The insular ultramafics also support conifers, largely Douglas fir, beach pine, and *Juniperus scopulorum.*

FIGURE 2. TYPICAL SERPENTINE-BARREN SLOPE IN THE CONIFEROUS FOREST REGION OF WENATCHEE MTS. ALL THREE "ULTRAMAFIC" FERNS ARE FOUND ON THIS SLOPE.

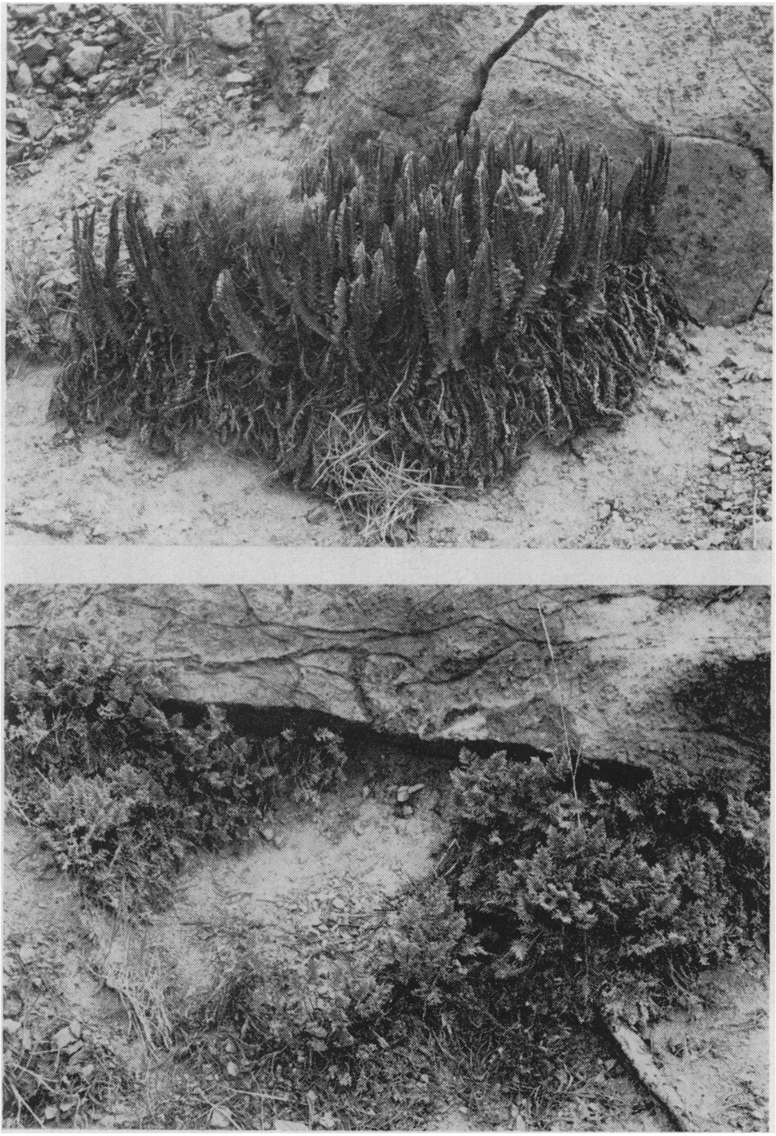

Figure 3. *Polystichum mohrioides* var. *lemmonii* (above) and *Cheilanthes siliquosa* (below) in crevices of massive peridotite boulders; at site of Fig. 2.

The third ultramafic region consists of widely separated small outcrops, east of the northern Cascades in Okanogan, Ferry, and Stevens counties of Washington. As yet, none of these sites has been visited by the author.

The coniferous forest on ferromagnesian substrata is by no means dense and continuous. The trees are largely stunted and widely spaced; often on steep, stony, serpentinized outcrops there are no trees present (Fig. 2). On such barren, continuously eroding slopes, as well as on talus, in rock fissures and on sparsely forested slopes, one is almost sure to find one or more of the three ferns so characteristic of our Pacific Northwest ultramafics.

OCCURRENCE AND DISTRIBUTION OF FERNS

The frequency and abundance of the fern species in question can be readily extracted from the phytosociological relevés that I have compiled. The floristic composition on ferromagnesian and non-ferromagnesian sites has been recorded for over sixty localities in the Pacific Northwest. The accompanying list of fern distributions presents sample abstracts from relevés recorded for two of the three ultramafic areas of Washington; a summary of all relevés for the Wenatchee Mountain area is also included. Wherever possible, fern records from adjacent non-ferromagnesian localities are given. The following abbreviations are used in the list:

Parent Material

S–ultramafic
NS–non-ultramafic
per.–peridotite
serp.–serpentine

Fern species

ADped–*Adiantum pedatum*
ADpal–*Adiantum pedatum* var. *aleuticum*
ATal–*Athyrium alpestre*
CHgr–*Cheilanthes gracillima*
CHsi–*C. siliquosa*
CRac–*Cryptogramma acrostichoides*
PYvh–*Polypodium vulgare* var. *hesperium*
POlo–*Polystichum lonchitis*
POmol–*Polystichum mohrioides* var. *lemmonii*
POsc–*Polystichum scopulinum*
PTaq–*Pteridium aquilinum*
WOor–*Woodsia oregana*
WOsc–*Woodsia scopulina*

Associates
BP–Beach pine
DF–Douglas fir
ES–Engelmann spruce
JUco–*Juniperus communis*
JUoc–*J. occidentalis*
JUsc–*J. scopulorum*
LPP–Lodgepole pine
LL–Lyall's larch
MH–Mountain hemlock
PP–Ponderosa pine
SAF–Subalpine fir
WWP–Western white pine
WBP–Whitebark pine

LIST OF FERN OCCURRENCES ON FERROMAGNESIAN AND NON-FERROMAGNESIAN SOILS

Locality	Parent material	Fern species	Topography and Associates
Kittitas-Chelan counties, Washington			
1. De Roux Forest Camp, n. fk. Teanaway River	S (per. & serp.)	POmol CHsi ADpal	Steep barrens surrounded by open slopes of DF, LPP, WWP, PP; ground layer of sparse forb-grass cover.
2. Upper Beverley Creek	S (per.)	POmol CHsi	Base of stable talus slope; scattered DF, SAF, WBP, and yew; low forb-grass layer.
3. Ingalls Lake trail	S (per. & serp.)	POmol CHsi PTaq	Steep, SW-facing slope of Teanaway-Turnpike ridge; open forest of SAF, WBP, LL, MH, and ES; subalpine forbs.
4. DeRoux-Boulder Creek trail	S (serp.)	POmol	Raw, barren outcrop of gentle slope, surrounded by closed forest of SAF and MH. Scant cover of endemic forbs.
Total fern occurrences on 29 ultramafic sites (number of occurrences): CHsi-20, POmol-19, ADpal-5, No ferns-4.			
5. Johnson Creek trail	NS (sandstone)	CHsi (rare) CHgr	Sparsely timbered (DF, PP), stable talus with scattered shrubs and forbs.
6. Beverly Creek trail	NS (sandstone)	WOsc	Lower edge of massive rock slide with widely scattered DF, SAF, WWP, PP, and shrubs; sparse grass-forb cover.

7. DeRoux-Boulder Creek trail	NS (sandstone)	CRac	Open forb-grass stony slope surrounded by forest.
8. Stafford Peak, 4100 ft.	NS (sandstone)	CHgr	Open grass-forb summit.
9. Standup Creek, 6500 ft.	NS (conglomerate)	CHgr	Top of high stony ridge; contacts S rock with CHsi and POmol.
10. Upper n.e.-facing slope of Jack Creek	NS (granodiorite)	CRac WOsc POlo ADped	Local granitic outcrop in massive peridotite block (this latter with POmol, CHsi, ADpal); much loose rock and rock crevices.
11. West-facing slope above Lake Cle Elum	NS (sandstone)	CHsi CHgr CRac WOor	Open rocky slopes with shrub-grass-forb cover. CHsi is remarkably common here.

Total fern occurrences on 21 NS sites (number of occurrences): CHgr-9, CRac-7, No ferns-6, ADped-5, CHsi-4 (but usually rare!), POmol-2 (on S-NS contacts!). WOor-1, WOsc-2, POsc-2, PYvh-2, POlo-1, ATal-1.

Snohomish-Skagit-Whatcom-San Juan counties, Washington

12. Upper Orsina Creek basin, Twin Sisters Mts., 4400′	S (dunite)	POmol CHsi	Dry morainic knolls near treeline, with "krummholz" LPP and SAF, heath and sparse forbs.
13. Upper Orsina Creek, Twin Sisters Mts., 3800′	S (dunite)	POmol CHsi ADpal	Steep talus of huge boulders with sparse conifer-forb cover.
14. Scheele Mine area, S. Fk. Nooksack River, 1800′	S (dunite conglom.)	CHsi PTaq	Steep bouldery slope; scattered stunted DF & LPP; ground layer either *Rhacomitrium canescens ericoides* (dense mats) or JUco and ericaceous shrubs).
15. Double Eagle Lakes, 3800′ (S-NS contact at V-shaped steep draw above lakes)	S (per.)	CHsi POmol ADpal	Steep rock ledges and faces; forbs and grasses in rock crevices
16. (Same as 15)	NS	CRac	Steep rocky slopes and walls; Alaska cedar, ericads, forbs and grasses.
17. Southeast tip of Cypress	S (dunite)	CHsi	Open balds and stony slopes

	Isl., 500′			with scattered DF, LPP, madrone, and JUsc. Heavy cover of grasses, forbs.
18.	Fidalgo Head, w. end of Fidalgo Isl., 50′	S (per.)	CHsi	Open sloping headlands with heavy moss - lichen - grass - forb cover; occas. stunted DF.
19.	W. slope of Sumas Mtn., 1000′	S (serp.)	CHsi	Open promontory on wooded w. slope, dwarfed DF, LPP, yew, and grass-forb cover on ledges and slopes.

Grant and Josephine counties, Oregon

20.	Buck Cabin Creek, Grant Co.	S (serp.)	CHsi	Open steep stony outcrop surrounded by DF-PP forest; sparse grass - forb cover.
21.	Murderer's Creek, Grant Co.	S (serp.)	CHsi	Open stony slope with scattered DF, PP, JUoc, and grass-forb cover.
22.	Baldy Mtn., Grant Co. 7634′	S (per.)	CHsi	Massive outcrops and talus on n.-facing slope of summit; rich grass-forb cover.
23.	Strawberry Lake, Grant Co. (ca. 5 mi. e. of #22)	NS (volcanics)	None!	Rock outcrops on w. shore of lake; herb layer luxuriant but poor in spp.
24.	Road to Galice, Josephine Co.	S (serp.)	CHsi	Raw serp. cliffs above Rogue River.

Trinity county, California

25.	Deer Lake, Trinity Alps	S (serp.)	POmol	Open rocky slopes with scattered MH and WWP.

British Columbia

26.	Christina Lake	S (serp.)	CHsi WOor	Steep cliffs and talus bordered by DF forest
27.	Near Eholt	S (perid.)	CHsi	Local barren outcrop bordered by DF-LPP-larch forest
28.	Grasshopper Mountain, upper Tulameen River	NS (shale)	WOor	Outcrop and talus with sparse shrub and forb-grass cover

29.	Same area as 28	S (perid.)	CHsi	Outcrop and talus with JUco and sparse grass-forb cover
30.	Olivine Mountain, upper Tulameen River	S (perid.)	CHsi POsc	Steep talus with grass-forb and shrub cover
31.	Piebiter Creek above Bralorne	S (dunite)	CHsi POsc CRac (rare!)	Barren local outcrop surrounded by dense brush and forest (on NS)
32.	B. C. Nickel Mines above Choate	S (pyroxenite)	CHsi ADpal CRac	Open treeless talus bordered by MH and Alaska cedar

The high constancy and fidelity of *Cheilanthes siliquosa* and *Polystichum mohrioides* var. *lemmonii* for ultramafics in the Pacific Northwest suggests a close conformity of plant to substrate (Fig. 3). Only rarely does *C. siliquosa* occur on non-ultramafic outcrops, and I have yet to find *P. mohrioides* var. *lemmonii* on other substrates than ultramafics. On the other hand, the rather characteristic ferns of nearby non-ultramafic rock outcrops — *Cryptogramma acrostichoides, Cheilanthes gracillima, Polypodium vulgare* var. *hesperium,* and *Woodsia scopulina* rarely, if at all, grow on soil of ultramafic origin. Of the two species commonly found on ultramafics, *C. siliquosa* is the most frequent, and through a wide altitudinal range. It is at sea level in the San Juan Islands and on up to 4000 feet in the Wenatchee Mountains and even higher in Oregon and northern California. *P. mohrioides* var. *lemmonii,* however, does not occur below 3000 feet in the areas I have visited. We may invoke an explanation to account for narrow restriction of these ferns to ultramafics that has been exploited in connection with angiospermous serpentine endemics (Kruckeberg, 1951, 1954, and Walker, 1954). Survival on soils high in ferromagnesian minerals but deficient in calcium requires a physiological capability for efficient withdrawal of what little calcium is present and as well to accumulate other essential elements in low supply; failure to expand their range onto adjacent non-ferromagnesian soils may be due to the increased biotic (microbial and higher plant) competition encountered on more fertile soils. It should be possible to test the latter hypothesis in spore germination tests on the two soil types and in the presence of competition. Sporelings of *Cheilanthes siliquosa* frequently occur spontaneously on serpentine soils that I have used in the greenhouse for testing edaphic responses.

Dispersal and establishment of ferns with such a disjunct distribution and fastidious preference for substrate present a host of attendant problems. One is led to assume that spores of these "serpentinophytes" are widely dispersed or at least in a regionally broad "chain-mail" fashion, but only establish populations following germination on soils of ultramafic origin. The distribution of *C. siliquosa* spans the North American continent. The easternmost point in its distribution—Mount Albert on the Gaspé Peninsula—is a world-famous alpine serpentine area. In the known localities intervening between Quebec and the Pacific Coast states, I cannot find accounts of the substrate. The same species is common on serpentines of the Coast Ranges in California (personal observation), but apparently it is not restricted to ultramafics. It has been collected on granite in the Sierra Nevada and from other areas unlikely to have ultramafic substrates.

Polystichum mohrioides, as represented by variety *lemmonii* in the Pacific Northwest, appears to be exclusively on serpentine. Therefore I am suspicious of the granitic habitat ascribed to it by Maxon in Abrams (1923) and repeated by Munz (1959). The type of var. *lemmonii*—"near Mount Shasta"—could easily be on ultramafic rock; serpentine is common in the lithology of northwestern California. I can find no mention of substrate preference for the subantarctic and western South American congener, *P. mohrioides*,[2] though its unique bihemispheric distribution is frequently mentioned (Gams in Verdoorn, 1938, Christ, 1910).

Ferns which are characteristic on ultramafic rocks elsewhere

[2] Sr. José Diem, of Villa la Angostura, Neuquén, Argentina has informed me that "This fern prefers open or semiopen sites at the base of or in fissures in granitic rocks and other formations, but also is found in rather open woods and at the edges of arroyos where it has developed other varieties and forms."

in the world have intrigued botanists repeatedly through the years. The degree to which fern species are restricted to serpentine varies widely. Some are apparently true endemics at the species level, others are morphological and ecological variants of species possessing broader tolerance. Then some occurrences on serpentine are merely unusual range extensions wherein the ferromagnesian substrate somehow extends the distribution of a species. Still other species are apparently indifferent to changes in substrate; these have been called serpentine-wandering ubiquists ("serpentinvagen ubiquisten," Krause, 1958).

I have compiled in the following table a list of those ferns which are known to inhabit soils of ultramafic origin. The list includes species which show varying degrees of edaphic restriction, from endemics to ubiquists. This compilation undoubtedly will be incomplete; reports of additional instances of ferns inhabiting ultramafics will be welcomed by the author.

OCCURRENCES OF FERNS ON ULTRAMAFIC ROCKS ELSEWHERE IN THE WORLD

Asplenium adiantum-nigrum L. (incl. var. *cuneifolium*)	Sweden (Rune, 1957), Balkans (Krause & Ludwig, 1956), Italy (Messeri 1936, Pichi-Sermolli 1948)
A. adulterinum Milde.	Sweden (Rune 1957)
A. onopteris L. var. *davallioides* Heufl.	Italy (Messeri 1936)
A. ruta-muraria L. var. *brunsfelsii* Heufl.	Italy (Pichi-Sermolli 1948)
A. trichomanes L.	Japan (Kitamura 1950), Italy (Messeri 1936, Pichi-Sermolli 1948)
A. viride Huds.	Sweden (Rune 1953), but calcicole in Quebec (Scoggan 1950), Finland (Launamaa 1956)
Adiantum pedatum L. var. *aleuticum* Rupr.	Quebec (Scoggan 1950)
Cheilanthes siliquosa Maxon	Quebec (Scoggan 1950)
Ceterach officinarum Lam. & DC.	Italy (Messeri 1936, Pichi-Sermolli 1948)

Dicranopteris dichotoma (Thunb.) Bernh. (=*Gleichenia linearis* (Burm.) Clarke, var.)	Japan (Kitamura & Momotani 1952—probably of low fidelity)
Notholaena marantae (L.) R. Br.	Italy (Pichi-Sermolli 1948)
Polystichum scopulinum (D.C. Eat.) Maxon[3]	Quebec (Scoggan 1950, Rune 1953)
Polypodium vulgare L.	Italy (Messeri 1936)
Gymnocarpium robertianum (Hoffm.) Newm.	Japan (Yamanaka 1952)
Cryptogramma crispa R. Br. var. *japonica* Miyabe & Kudo	Japan (Kitamura 1952)
Pteridium aquilinum Kuhn var. *latiusculum* (Des.V.) Underw.	Pennsylvania (Wherry 1932)

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[3] *P. scopulinum* is occasionally found on or adjacent to ultramafics in the Pacific Northwest (Wagner & Kruckeberg, personal observation).

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Rediscovery of Polypodium virginianum forma brachypteron (Ridlon) Fernald

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In 1921 H. C. Ridlon, of Bennington, Vermont, described *Polypodium vulgare* L. f. *rotundatum*, a peculiar, probably abnormal form, in which the segments of the blade are reduced to semicircular or deltoid lobes, toothed at the apex. It was soon found that the name f. *rotundatum* had already been used, so it was changed to f. *brachypteron* (Weatherby, 1921). Ridlon did not give the origin of the specimen upon which the form was based, except to say that it came from Vermont. He neglected to record if a type specimen had been preserved.

This has been a very rare form and nothing quite approaching it seemed to have been collected since its description until two