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Arbutus menziesii and Soils of the Puget Trough, Washington

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Abstract: Soils were analyzed, Pacific madrones (*Arbutus menziesii*) evaluated and habitats delineated in central and south Puget Sound of Washington. Results indicate that: 1) madrones grow on a variety of soil types; 2) tree health varies with soil type; and, 3) faster growing madrones in open habitats are less healthy regardless of soil type. Madrones do best in well-drained soil and when sheltered by neighboring trees. Fire influences soils under madrones. In turn, madrones influence soil development after fires.

Herein, I describe: 1) soils of central and south Puget Sound that grow Pacific madrone (*Arbutus menziesii*); and, 2) relationships of soil, succession, fire and urban development to madrone growth and pathology. Madrone occurs from California to Vancouver Island, British Columbia wherein soil parent materials north of Olympia, Washington are from glacial activity 13,000 years ago. Glacial soils have mixed mineralogy ranging from well-drained sandy and loamy textures to compacted till and clay substrata in many places (Mullineaux, *et al*. 1965).

Among pure madrone stands I study (Plate 18-1) are 3 age classes that burned in the 1900's above the Fort Lewis, Washington prairie. Fires maintain madrone stands and may restrict disease (Chappell and Giglio this volume). After fires, madrone trees quickly resprout from root crowns. Fires oxidize organic matter and increase pH. After urban development, exposed madrones grow fast but succumb to fungal infections early. Madrone seedlings establish on denuded prairies where they did not grow previously. Here they also grow fast and die young; thus, this is also why I am studying the prairie soil association.

METHODS

Soil pits [>meter (39 in)] were dug at 14 sites (Table 18-1). Rita Hummel (personal communication) noted that madrone saplings are sick on poorly drained soils; therefore, texture and bulk density which influence water and air permeability and root penetrability are measured.

Plate 18-1 (above). A pure madrone stand growing in coarse-loamy mixed material over sand on a steep slope with a south-western aspect. Arroyos neighborhood, Seattle, Washington. Photo Fall 1995.

Plate 18-2 (lower right). Soil pit under a pure madrone stand on a steep slope at the 1989 burn site at the Fort Lewis pistol range (Figure 18-3, CL-Y). Soil profiles under these stands are characterized by a thin A horizon and yellow-brown B horizon. The coarse-loamy control section below the epipedon results in rapid drainage creating a dry environment on a southeast facing slopes. Charcoal was found in this pit indicating a history of recurring fires. Unlike the Arroyos site, sand does not occur within 1 m of the surface. Shovel is 1.2 m high (~48 in). Photo November 1996.

I determine pH (1:1 soil to deionized water) and organic matter (muffler furnace at 450^{o}C) since they affect plant nutrient uptake, soil microorganisms and soil structure (Soil Survey Staff 1996). A CHN Analyzer combustion method (temperatures >900^{o}C) is used to determine nitrogen from the 4th leaf >2.5 cm from an active spray tip (young leaves) versus leaves from the previous growing season. Tree status, pathology and habitat techniques are in Adams, *et al.* (this volume).

RESULTS

Characterization of Soils

On 3 sites madrones grow on Alderwood series in which topsoil was disrupted by logging and development. Six sites are well drained, coarse loamy material that contain colluvium. Three of these are over sand (Ragnar series) and the other 3 (Plate 18-2) at the Fort Lewis burn sites are thought to be simply Xerochrepts (Zulauf 1979). The prairie (Spanaway) and ecotonal (Everett) sites are somewhat excessively drained. All but one site has recurring pockets of charcoal suggesting fire histories. At 2 Seattle sites (not in Table 18-1) construction projects removed surface soil to impermeable parent material (*e.g.*, to Lawton clay at Warren Magnunson Park). The North Seattle Community College (NSCC) site is a former wetland filled in the 1960's.

Soil Physical and Chemical Properties and Tree Status

Somewhat excessive drainage characterizes all sites where madrones are doing well, but Spanaway soil has excessive drainage with large, sick trees. Sick trees occur on sites shallow to a duripan and/or epipedons that were disturbed by human activity. At Warren Magnunson and Discovery Parks, most young saplings have cankers and are dying from *Phytophthora* root rot. At Warren Magnunson excavation for a former runway removed soil to Lawton clay. At Discovery Park a former asphalt parking lot caused compaction. At NSCC 30 year old madrones are healthy, possibly because the fill is deep, above the water table and was not compacted by vehicles after deposition. At a depth of 15 cm, bulk densities of Alderwood sites and the youngest burn site are all >1 (Figure 18-1). Bulk densities are lower at older burn sites and at sites with coarse, loamy control sections over sand.

Soil pH (Figure 18-2) is lowest on Spanaway soil, highest on the recently burned Dystric Xerochrept soil at Fort Lewis and intermediate on the Everett mixed Doug-fir (*Pseudotsuga menziesii*) site. There is a gradient of pH (6.8–4.6) from the youngest to the oldest burn sites. Alderwood soils under madrones have lower pH's than Ragnar soils with madrones.

Table 18-1. Soil and stand information for sites with natural soil structure. Data for 1996-98.

Site/Stand structure	Classification /Soil series	Drainage	pH 5cm	%Slope/ Aspect	Soil status	Tree status
Magnolia Bluff (MB), Seattle; Shrubland	Loamy-skeletal, mixed mesic, Entic Durochrepts (Alderwood)	moderately well;slow in substratum	5.0	3, S	topsoil & ablational till removed; fire history	poor
Thorndyke Park (TP), Seattle; Mixed broadleaf evergreen	Loamy-skeletal, mixed mesic, Entic Durochrepts (Alderwood)	moderately well;slow in substratum	4.8	5, SE	logged (Ap); fire history	fair
Shoreline Community College (SCC); Mixed broadleaf evergreen	Loamy-skeletal, mixed mesic, Entic Durochrepts (Alderwood)	moderately well;slow in substratum	4.9	3, SW	logged (Ap); fire history;	fair
Shoreview Park (SVP), Shoreline; Immature mixed forest	Coarse-loamy over sandy, mixed, mesic Vitrandic Xero-crept (Ragnar)	somewhat excessive	5.0	6,SW	logged (Ap); fire history; margin of excavation	fair
Arroyos, southwest Seattle; Broadleaf evergreen	Coarse-loamy over sandy, mixed, mesic Vitrandic Xero-crept (Ragnar)	somewhat excessive	5.9	35,SW	fire history	good
Maury Island, southern coast; Broadleaf evergreen	Coarse-loamy over sandy, mixed, mesic Vitrandic Xero-crept (Ragnar)	somewhat excessive	NA	40, S	fire history	good
Fort Lewis;(CL-Y, CL-I, CL-O= recent to oldest burn); Broadleaf evergreen	Coarse-loamy, mixed, mesic, Dystric Xerocrept	well drained	6.0 5.6 5.0	42, SE 35,S 26, SE	logged (Ap); fire history	good
Fort Lewis Prairie; Landscaped grassland	Sandy-skeletal, mixed, mesic Typic Melanoxerands (Spanaway)	somewhat excessive	4.5	<1	some melanic epipedon removed; fire history	poor
Fort Lewis, Doug-fir/prairie ecotone; Immature mixed forest	loamy-skeletal, mixed, mesic Vitrandic Xerochrepts (Everett)	somewhat excessive	5.4	NW,3	logged (Ap);	good

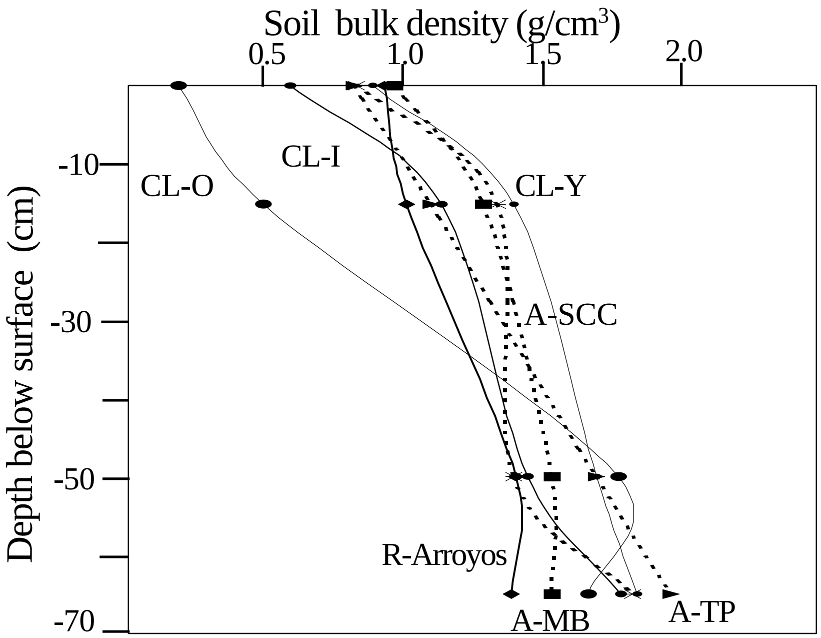

Figure 18-1. Soil bulk density versus depth. Thin solid lines are burn successional sequence (see Table 18-1), dashed lines are Alderwood (A) and thicker line is Ragnar (R) . Data for 1996–98.

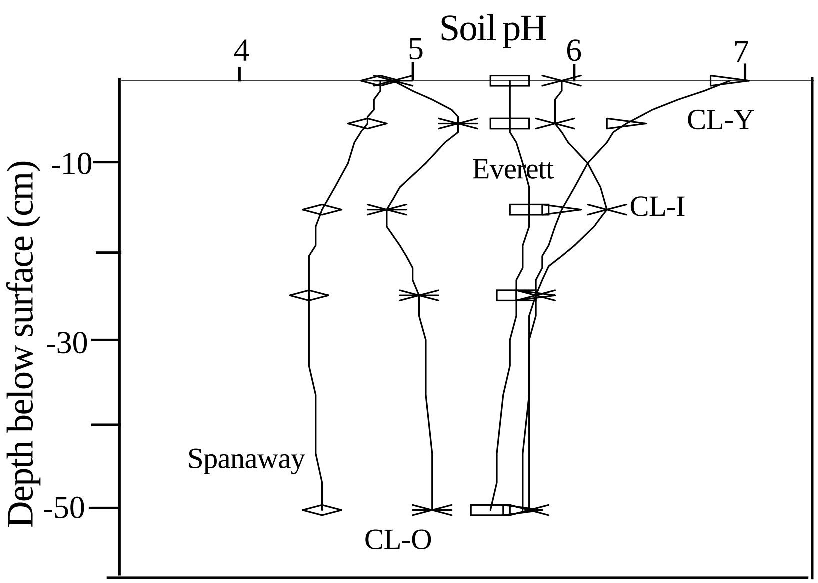

Figure 18-2. Soil reactivity (pH) versus depth at Fort Lewis, Washington. (Table 18-1). Data for 1996.

Organic carbon values and color designations indicate that Spanaway melanic epipedons contain the most organic matter, Ragnar and the youngest burn site (Figure 18-3) the least. Since Everett soil with older, healthier trees (Table 18-2) is adjacent to Spanaway soil with larger, unhealthy trees, per cent leaf dry weight of nitrogen was determined. Nitrogen was higher in both young and old leaves of Spanaway madrones, yet older leaves of trees on Spanaway had a larger drop in the proportion of leaf nitrogen relative to madrones on Everett (mean=3.51 versus 3.12 and 2.47 versus 2.34, respectively). Madrones are healthy on the coarse-loamy, mixed, mesic burned and Ragnar soils; they are less healthy on Alderwood soils.

DISCUSSION

Soils and Madrone Growth and Health

In Puget Sound madrones grow on many soil types, yet their growth rates, life span and vigor vary with soil type. Plant community structure and site history (*e.g.*, fire and urban development) also affect madrones. My study is not designed to separate the effects of soil from disturbance and community structure; nevertheless, good drainage and sheltering trees seem requisite for madrone long-term survival and robustness. Removal

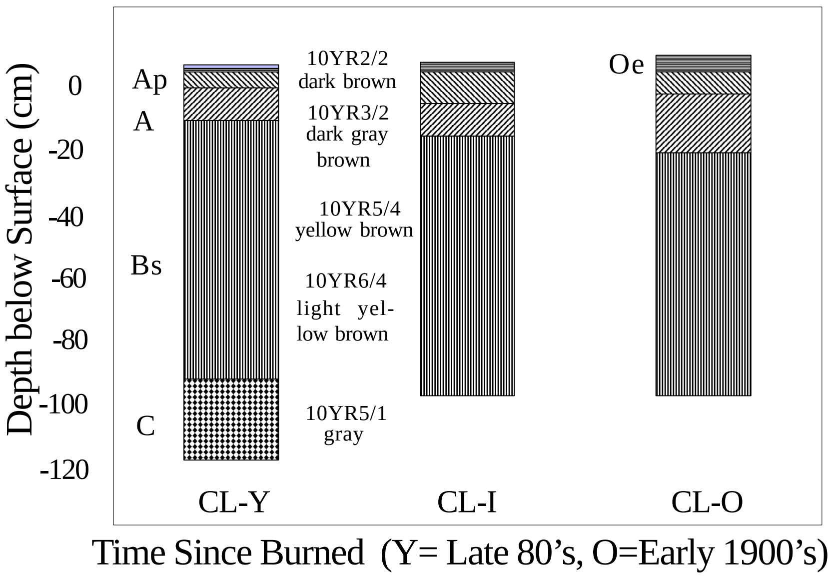

Figure 18-3. Soil profiles versus time for 3 pits dug at Fort Lewis sites burned over coarse-loamy, mixed, mesic, Dystric Xerocrepts. Colors for horizons are given (Munsell 1992). Data for fall 1996.

Table 18-2. Madrone pathological symptoms at Fort Lewis. See Table 18-1 for site descriptions. S = Spanaway series; E = Everett series; CL-Y–O = Coarse-loamy burn sites, young to old. Data for fall 1996.

Symptom	S (N = 8)	E (N = 13)	CL-Y (N = 20)	CL-I (N = 20)	CL-O (N = 20)
Mean area butt rot (m^2)	0.067	0.002	0.001	0	0
Mean heart rot (% total height)	15.63	5.20	0.25	0.38	0
Mean number trunk cankers	5.00	1.95	0	1.31	0.15
% trees appearing burnt	13	5	0	0	10

of soil epipedons, compaction and exposure are associated with rapid infestation of saplings as well as the decline of older madrones.

High soil nitrogen and increasing light availability result in fast growth of madrones, but these trees succumb to disease later. In the case studied, fast growing trees have leaves with high nitrogen contents. My earlier research found that high nitrogen is often accompanied by lower levels of phenolic compounds. If future madrone research were to find that lower leaf nitrogen in slower growing trees cooccurs with higher phenolic levels, then it may be that madrones divert amino acid biosynthesis to phenolics thereby perhaps providing trees protection from fungal pathogens.

Effect of Fires and Plant Succession on Soils.

My results support the supposition that madrones are a fire adapted species. Wells, *et al*. (1979) noted that after fires pH increases >2 units in forests of the Pacific Northwest. Fungi suffer greater mortality than bacteria after fires (Killham 1994). Since soil pH decreases with time after fire in madrone stands, one can reasonably propose mechanisms by which pathogen and mycorrhizal relationships change resulting in a dynamic scenario of healthy, dominant stands of madrones that give way to Doug-fir. The suggestion by Chappell and Giglio that fire plays a role in controlling madrone pathogens merits research. Another intriguing question is why, before settlement, did madrones not establish on prairies after fire. Perhaps surviving grass roots inhibited establishment or outcompeted madrone seedlings. Maybe grazing was intense on the prairie resulting in madrone seedlings and saplings being eaten or trampled.

Madrone Preservation and Restoration As It Relates to Soils

The trees at NSCC indicate that sheltered and well-drained urban soil can grow healthy madrones. With plant succession soil development occurs under madrones on steep slopes making them good trees for unstable slopes. Since I found that healthy trees occur on coarse substrates, transplanting madrones to well-drained, raised mounds is recommended. The role of pH in madrone health is not clear; however, unhealthy madrones often occur on sites with low pH's. It may be best to fertilize with nitrate (not ammonium) in order to prevent soils from becoming too acidic; however, any fertilization may disrupt mycorrhizal relationships.

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