PART I

MADRONES

IN

NATURE

1

Pacific Madrone Forests of the Puget Trough, Washington

Christopher B. Chappell and David F. Giglio

Abstract: As part of a larger study of forest vegetation in the Puget Trough of Washington State, forests dominated or codominated by Pacific madrone (*Arbutus menziesii*) were sampled for vegetation, environmental features and disturbance. Two madrone plant associations are described, each of which is usually codominated by Douglas-fir (*Pseudotsuga menziesii*). These madrone plant associations are found on relatively dry sites, often on southerly aspects and often adjacent to saltwater. They are located primarily around Puget Sound and in the San Juan Islands. Madrone also occurs less commonly in other plant associations and environments which are described. The primary natural disturbance in madrone forests appears to be fire. Fires were probably moderately frequent in these dry forests during the presettlement era. The effects of fire, logging and grazing are discussed. Madrone forests are relatively rare in the landscape, especially in unfragmented, unlogged conditions free of nonnative species. Our paper represents a first attempt to describe the vegetation and ecology of madrone forests in Washington.

Forest vegetation of the Puget Trough has been little studied, and Pacific madrone (*Arbutus menziesii*) forests are no exception. Franklin and Dyrness (1973) only briefly mentioned the occurrence of madrone on drier, lower elevation sites within the western hemlock (*Tsuga heterophylla*) zone of western Washington and Oregon. Despite the relatively small area they occupy, forests dominated or codominated by Pacific madrone are a distinctive and noticeable component of the landscape (Kruckeberg 1991). Fonda and Bernardi (1976) described madrone dominated vegetation on Sucia Island, San Juan County. Agee (1987) described some plant communities in which madrone is a component on San Juan Island.

The Washington Natural Heritage Program has been conducting an inventory of high quality natural forests in the Puget Trough since 1992. Simultaneously, we collected data on vegetation in Puget Trough forests to develop a comprehensive vegetation classification for the

area. A preliminary classification was developed, and work is progressing on completion of the project.

Our primary objective with this paper is to describe preliminary findings from the Puget Trough Natural Heritage vegetation inventory and classification that are most relevant to madrone. This involves describing plant associations dominated or codominated by madrone and discussing data and observations on the role of disturbances in madrone forests. We also discuss the conservation significance and status of madrone forests.

METHODS

Study sites are located throughout the Puget Trough of Washington State. The Puget Trough is a mostly low elevation physiographic province located between the Cascade Range and the Olympic Mountains. Climate is mild and moderately dry to moderately moist (43–175 cm annual precipitation). Madrone sample sites are in portions of Whatcom, Skagit, San Juan, Island, Clallam, Jefferson, Kitsap, Pierce, King, Mason and Thurston Counties (Figure 1-1). We sampled wherever stands meeting the sampling criteria were accessible.

The sites consist of forests or forest fragments dominated or codominated by madrone (generally >20% canopy cover) with little or no evidence of past human disturbance (usually logging). In addition, plot samples contain few or no nonnative species. Species composition of forests with evidence of past logging was noted, but plot data were collected at only one such site.

Data were collected on 400 m^2 circular plots located nonrandomly to represent the vegetation present on a site. On each plot, all vascular plant species were identified and placed in percent cover classes (<1%, 1–5%, 5–10%, 10–25%, 25–50%, 50–75%, 75–100%). Tree canopy layering was noted, and one or more tree cores were collected to ascertain dominant stand age class (young 40–100 years, mature 100–200 years, old growth >200 years or multi-cohort). Evidence of disturbance was noted. Aspect, slope, slope position and soil parent material were noted at each site. A total of 59 madrone plots were sampled from May through September mostly during the years 1992–95. Some data were collected also between 1981 and 1991.

We used detrended correspondence data analysis for ordination and a divisive hierarchical classification technique (TWINSPAN). After ecological interpretation of quantitative data analysis, we classified over 600 Puget Trough vegetation plots (of which madrone plots were a portion).

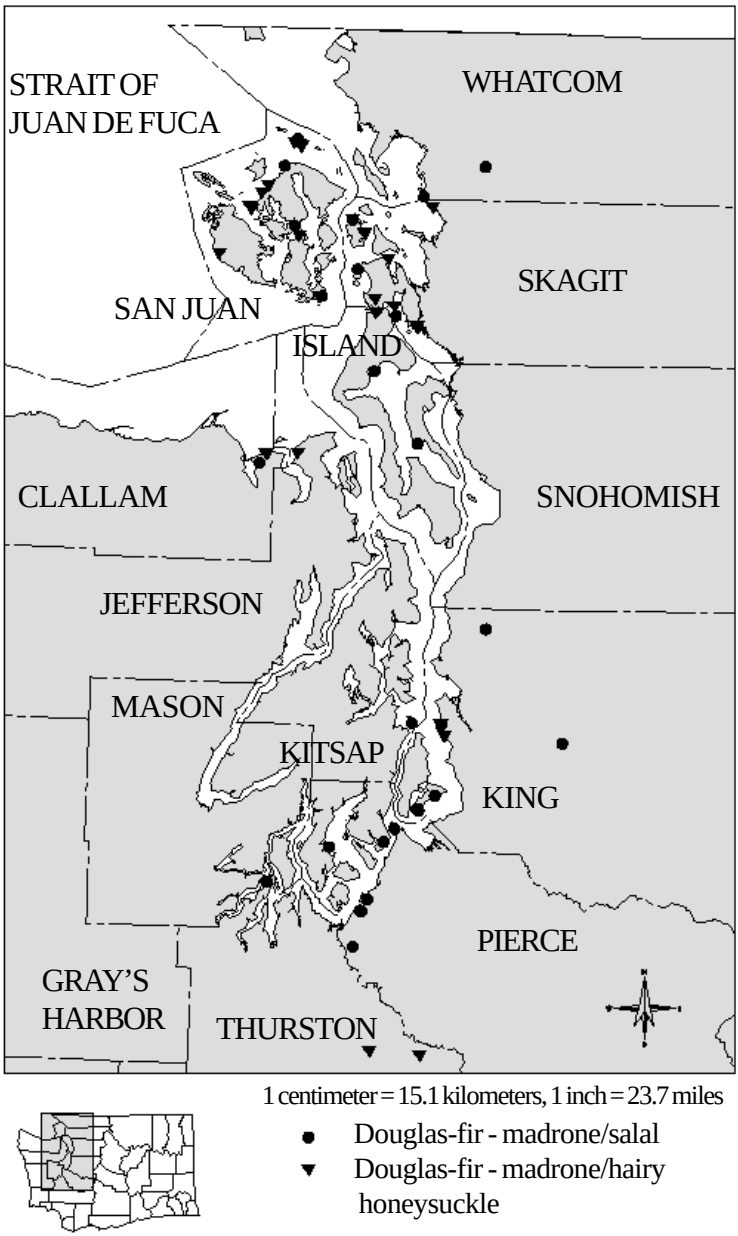

Figure 1-1. Site locations for data collection on Douglas-fir—Pacific madrone plant associations in the Puget Trough of Washington State. County names are given inside their respective boundaries. Data for 1992–95.

RESULTS AND DISCUSSION

Plant Associations

The 2 madrone plant associations identified are usually dominated in the canopy by a mixture of madrone and Douglas-fir (*Pseudotsuga menziesii*) (Table 1-1). Occasionally, madrone may dominate the canopy with little or no Douglas-fir present. Tree seedlings and saplings, when present, are mostly Douglas-fir plus occasional individuals of western red cedar (*Thuja plicata*), grand fir (*Abies grandis*) and/or western hemlock (*Tsuga heterophylla*). Scouler's willow (*Salix scouleriana*) is a common subcanopy tree that occupies low percent cover. The environments containing madrone plant associations are too dry to support an abundance of more shade tolerant conifers; therefore, we classified them as part of the Douglas-fir Series. These associations appear to be relatively stable potential natural vegetation and are capable of supporting mixed Douglas-fir —Pacific madrone forests for hundreds of years. This is supported by the presence of several natural stands dominated by trees 275–500 or more years old (but see Disturbance Ecology section for notes on fire).

Douglas-fir—Pacific madrone/hairy honeysuckle association. The understory of this association is generally dominated by some combination of hairy honeysuckle (*Lonicera hispidula*), western fescue (*Festuca occidentalis*), oceanspray (*Holodiscus discolor*) and common snowberry (*Symphoricarpos albus*) (Table 1-1). Blue wildrye (*Elymus glaucus)* and tall Oregon grape (*Berberis aquifolium*) also have relatively high constancy. Salal (*Gaultheria shallon*) is either absent or present in low abundance. Many other dry site herbaceous species commonly occur with lower frequency but are largely absent from the other madrone association. This association occurs primarily in the northern Puget Trough, especially the San Juan Islands and extends into adjacent British Columbia (Figure 1-1). Very dry sites farther south also support this association. Soils usually are shallow with bedrock near or at the surface, although deep coarse sand also supports this association. Aspects are primarily southerly or westerly and slopes are at least moderate in steepness. Sites are often adjacent to saltwater. These are dry forest sites mostly within a relatively dry climatic area such as the Olympic Mountain rain shadow. Fonda and Bernardi (1976) described a somewhat similar plant association on Sucia Island, the Douglas-fir—Pacific madrone/American vetch (*Vicia americana*) association. These 2 associations appear to be equivalent environmentally. The Douglas-fir—Pacific madrone/American vetch association is probably a local variant of the Douglas-fir—Pacific madrone/hairy honeysuckle association, which is somewhat variable in vegetative composition.

Table 1-1. Vascular plant species composition of Douglas-fir—Pacific madrone plant associations in the Puget Trough, Washington State. Bold indicates species most useful in distinguishing these associations from each other and from other associations. Data for 1992–95.

	Douglas-fir --Pacific madrone/ hairy honeysuckle association n = 28		Douglas-fir -- Pacific madrone/ salal association n = 31	
	Constancy	Relative % Cover	Constancy	Relative % Cover
Trees				
Arbutus menziesii	**1.00**	**44**	**1.00**	**48**
Pseudotsuga menziesii	0.93	42	0.81	46
Salix scouleriana	0.18	2	0.45	4
Tsuga heterophylla	**0.11**	**<1**	**0.16**	**3**
Thuja plicata	**0.07**	**8**	**0.19**	**6**
Abies grandis	**0.07**	**<1**	**0.13**	**5**
Pinus contorta	-	-	0.16	5
Shrubs				
Holodiscus discolor	0.82	15	0.77	10
Rosa gymnocarpa	0.71	9	0.81	4
Gaultheria shallon	**0.46**	**2**	**1.00**	**60**
Lonicera hispidula	**0.79**	**11**	**0.42**	**3**
Symphoricarpos albus	**0.68**	**19**	**0.42**	**3**
Rubus ursinus	0.43	4	0.52	2
Berberis aquifolium	**0.64**	**4**	**0.29**	**<1**
Berberis nervosa	0.32	14	0.52	7
Lonicera ciliosa	0.54	3	0.29	4
Amelanchier alnifolia	0.46	4	0.35	3
Corylus cornuta	0.14	8	0.45	14
Vaccinium ovatum	-	-	**0.35**	**29**
Vaccinium parvifolium	-	-	0.29	2
Herbs				
Polystichum munitum	0.50	<1	0.55	1
Pteridium aquilinum	0.11	3	0.74	3
Elymus glaucus	**0.61**	**4**	**0.10**	**<1**
Trientalis latifolia	0.36	2	0.29	<1
Festuca occidentalis	**0.57**	**9**	**0.06**	**2**
Bromus vulgaris	0.39	3	0.06	2
Galium aparine	0.32	<1	0.10	<1
Goodyera oblongifolia	0.29	2	0.06	<1
Heuchera micrantha	0.29	<1	0.03	3
Lathyrus nevadensis	0.29	2	0.03	<1
Melica subulata	0.25	2	-	-
Fragaria vesca	0.21	2	0.03	<1
Vicia americana	0.21	<1	0.03	<1
Festuca rubra	0.21	7	-	-

Douglas-fir —Pacific madrone/salal association. The understory of this association is always dominated or codominated by salal, an evergreen shrub (Table 1-1). Oceanspray is usually present and may be codominant Baldhip rose (*Rosa gymnocarpa*) is frequent. Evergreen huckleberry (*Vaccinium ovatum*) or California hazelnut (*Corylus cornuta*) are frequent south of the Olympic rain shadow and are codominant in some stands. Bracken fern (*Pteridium aquilinum*) is the most common herbaceous plant, whereas most others occur relatively infrequently. Disturbance history occasionally results in a tree canopy dominated exclusively by madrone with very little Douglas-fir. Distribution occurs throughout the northern and central Puget Trough as far south as the southern end of Puget Sound (Figure 1-1). Soils are, generally, very sandy unconsolidated glacial drift, gravelly-sandy glacial till or are shallow to bedrock. Slopes are usually at least moderate in steepness and aspect tends to be southerly or westerly. Sites are often adjacent to saltwater. These sites are either dry within a moderately moist climatic area or else moderately dry within a dry climatic area. This plant association was previously described from a few plots on Sucia Island (Fonda and Bernardi 1976). Stands with much evergreen huckleberry appear to be located on slightly more moist sites and are now considered the evergreen huckleberry phase of the Douglas-fir—Pacific madrone/salal association. This phase is limited to the central Puget Trough near Puget Sound from Seattle southward.

Other plant associations. Madrones also occur in lesser concentrations in other plant associations or in other situations than the madrone dominated plant associations described above. Forests where western hemlock or western red cedar are numerous as regeneration or codominant in the canopy (Western hemlock or Western red cedar —Grand fir Series) may have some madrones represented, especially on sites with salal or evergreen huckleberry dominant in the understory. Madrones are occasionally prominent early seral species in these other more moist plant associations where they are naturally outcompeted by the conifers within the first 100 years. Madrones also are occasionally codominant in the canopy of Oregon white oak (*Quercus garryana*) woodlands, especially in the transitional area between the Puget Trough and the Willamette Valley (near the Columbia River in Clark and Cowlitz Counties, Washington). Madrones often occur as scattered trees or a narrow fringe of trees along forest edges where site conditions are dry (*e.g.*, rocky shorelines or grassland borders). They also may occur as scattered trees on rocky outcrops or in grasslands located on shallow, dry soils.

Disturbance Ecology

Fire appears to be the major natural disturbance in the areas that support the 2 madrone plant associations. All stands have abundant evidence of past fires. Prior to settlement, moderately frequent, moderately severe fires occurred (*i.e.*, a moderate-severity fire regime) (Agee 1993). Low- and high-severity fires also occur here, but less commonly than moderate-severity fires. Moderate-severity fire results in substantial, but far from complete, tree mortality. Common post-fire age classes in Puget Trough Douglas-fir—madrone forests are 50–70, 110–140 and 250+ years.

Multiple cohorts of Douglas-fir are common in unlogged stands. Each cohort appears to be a result of regeneration for a period of time after a fire. Douglas-fir regeneration between these episodic pulses is apparent, but not particularly abundant. Structural heterogeneity of the canopy in multiple cohort stands is high on both vertical and horizontal scales. Older Douglas-fir often form a discontinuous emergent layer above a more continuous canopy layer of younger madrone and Douglas-fir.

Fires generally top-kill the vast majority of madrone stems. A few large ones sometimes survive fire and usually have fire scars. Top-killed madrones sprout abundantly from the base of the stems after fire. A recently burned site located on Fort Lewis, Pierce County, has abundant madrone seedlings in addition to madrone sprouts. Many Douglas-fir typically survive fire, especially older, larger trees. These survivors are then a seed source for regeneration.

A near pure madrone stand may develop without human intervention if 2 high-severity fires occur at short enough intervals, perhaps up to 50–75 years apart. The first fire would kill the vast majority of Douglas-fir in the stand, and the second fire would kill Douglas-fir regeneration from the few previous survivors. Douglas-fir is undoubtedly capable of growing on all madrone forest sites, but a seed source must be available after high-severity disturbance for the Douglas-fir to maintain itself.

Fire is a part of madrone ecosystems. Madrone stands that are part of the madrone plant associations previously described appear relatively stable in terms of their persistence on a site, at least in the presence of occasional fires. We do not know what happens to madrone stands as they become old in the absence of fire because all madrone stands visited have experienced fire at least once in the last 130 years. At this time we can only speculate about what will happen

over the long term in the absence of fire. Possibly, the decline in madrone is a process related to the lack of fire and there will be more decline in the future as stands age. One natural stand on Lopez Island that has not burned for about 120 years is experiencing significant decline, apparently related to fungal canker infection.

Winter weather, especially the combination of cold temperatures and high winds, can cause significant dieback and mortality of madrone (K. Russell personal communication). In addition, some, but by no means all, madrone stands in undeveloped areas show evidence of significant decline related to fungal infections (cankers). In general, madrone decline appears usually less prevalent in intact forest stands than in urban situations.

Disturbance and mortality factors may be interrelated in ways that are not now understood. Synergistic interactions among weather, fungus and fire are an unstudied possibility. Perhaps fire suppression has had an effect on rates of fungal infection and spread.

Forest stands that have been logged in the past are generally more homogeneous in stand structure and age than unlogged stands. Many 50–80 year old madrone—Douglas-fir stands, especially those part of the Douglas-fir—Pacific madrone/salal association, are a result of regeneration after logging and slash fires. Madrones sprout freely from cut stumps (Fowells 1965). Nearly pure madrone stands sometimes develop after logging activity if a Douglas-fir seed source is removed or if Douglas-fir is selectively removed from the canopy. The majority of pure madrone stands with little to no Douglas-fir are a result of logging disturbance.

Nonnative species often invade the understory of the Douglas-fir—Pacific madrone/hairy honeysuckle association if these dry sites have been grazed in the past or are located close to intensive human disturbances or development. Common velvet-grass (*Holcus lanatus*) and hairy cats-ear (*Hypochaeris radicata*) are 2 of the most common invasive nonnative perennial species. Nonnative annual grasses, especially hairgrass (*Aira* spp.), may also be common in more open stands, especially if they have been grazed.

Conservation Status

The madrone plant associations are rare in a relatively natural condition and uncommon in a more disturbed condition. One of the associations is restricted to the Puget Trough of Washington and adjacent British Columbia, and the other is found as well in the Willamette

Valley of Oregon. The madrone plant associations are important units for the conservation of biological diversity due to their rarity, declining trend, threats and limited distribution.

The madrone forest types have been much reduced in extent, primarily by human residential development. Those that remain are mostly stands that were logged in the past or invaded by nonnative species. The very few stands that were not logged are mostly located in state parks in the northern Puget Trough, including Sucia Island, Jones Island and Deception Pass. Small examples of unlogged stands in the central Puget Trough are located at Point Defiance Park (Pierce County), Penrose Point State Park (Pierce County) and Maury Island (King County). These few good examples deserve protection as relicts of rare vegetation types.

Madrone forests also have conservation significance as habitat for a declining bird species, the band-tailed pigeon (*Columba fasciata*). Band-tailed pigeon breeding populations have declined significantly during the last 25 years (Andelman and Stock 1994). Although many breeding pigeons migrate south for the winter, those that overwinter appear to be strongly associated with madrone (personal observation). Wintering flocks congregate in central Puget Trough madrone stands, where they feed on madrone fruit. Many of these stands have been converted to other uses in the last 20 years. There has been a corresponding decrease in winter populations, at least on the Tacoma Christmas Bird Count. Reasons for the decline in the breeding population of band-tailed pigeon in Washington are unknown at this time.

ACKNOWLEDGEMENTS

Betty Stephens produced the figure, and Rod Gilbert assisted with plot mapping. Rex Crawford, Reid Schuller and Jack McMillen assisted with data collection. Thanks also to all those madrone lovers who suggested sites for field visits.

LITERATURE CITED

Agee, J.K. 1987. The Forests of San Juan Island National Historical Park. National Park Service Cooperative Park Studies Unit; University of Washington, Seattle, Washington. Report CPSU/ UW 88-1.

Agee, J.K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Washington, DC.

Andelman, S. J., and A. Stock. 1994. Management Research and Monitoring Priorities for the Conservation of Neotropical Migratory Landbirds that Breed in Washington State. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, Washington.

Fonda, R.W., and J.A. Bernardi. 1976. Vegetation of Sucia Island in Puget Sound, Washington. Bulletin Torrey Botanical Club 103: 99–109.

Fowells, H.A. 1965. Silvics of Forest Trees of the United States. USDA Forest Service. Handbook #271.

Franklin, J.F., and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. USDA Forest Service. General Technical Report PNW-8.

Kruckeberg, A.R. 1991. The Natural History of Puget Sound Country. University of Washington Press, Seattle, Washington.