AN ABSTRACT OF THE THESIS OF

GLENN MARTIN HAWK for the DOCTOR OF PHILOSOPHY

in PLANT ECOLOGY (BOTANY) presented on 27 Sept 1976

Title: COMPARATIVE STUDY OF TEMPERATE CHAMAECYPARIS FORESTS

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Abstract approved: ______________________

Donald B. Zobel

The objectives of this study include: (1) analysis of Chamaecyparis lawsoniana, C. taiwanensis, and C. formosensis forests including the structure, composition, and dynamics of plant communities and their environmental relationships; and (2) comparison of the temperate Chamaecyparis forests of Taiwan and the Pacific Northwest with emphasis on structural and successional characteristics.

One vegetation zone with four communities in Taiwan and three zones with eight communities in the Pacific Northwest are described. All communities are defined on the basis of their vegetative differences which arise primarily in response to changes in climate and/or soils.

The Chamaecyparis communities show varying degrees of site specificity. The two Taiwan species are sympatric over most of their ranges. Chamaecyparis taiwanensis occurs on high elevation, well drained landforms and on many aspects. The soils are typically podzolized or undifferentiated. Most vigorous forests tend to be in northwestern portions of the generic range. Chamaecyparis formosensis is found at lower elevations, on less well drained and more commonly podzolized soils, and is more restricted to north and northwestern aspects. The most vigorous stands are in the southeastern portion of its range. Climatic variation is more pronounced in the Pacific Northwest, and Chamaecyparis lawsoniana communities reflect this. In the north, middle and low elevations are occupied by the Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana community on more mesic areas and by the Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon community on better drained sites.

Both communities occur on sedimentary parent materials within the Tsuga heterophylla Zone. On ultramafic parent material in this zone the Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax community occurs. South and east of the range of Tsuga heterophylla, mixed soils support the Chamaecyparis lawsoniana/Lithocarpus densiflora community as a closed forest, while pure ultramafic substrates are occupied by the open Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax community (both in the Mixed Evergreen Zone). At the transition of the Tsuga heterophylla and Abies concolor Zones is the Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community, the lower member of the Abies concolor Zone. South and inland from this transition area and at higher elevations, are the other Abies concolor Zone communities, Abies concolor-Chamaecyparis lawsoniana/herb and mixed Abies-Chamaecyparis lawsoniana/herb. The first of these occurs on mixed soils which include some ultramafics, while the second is primarily on granitic parent materials.

Chamaecyparis taiwanensis reproduces well in mature forests, although with much less success in the bamboo community than in the shrub community. Chamaecyparis formosensis reproduces poorly in all mature forests. Hardwoods and bamboo are strong competitors with Chamaecyparis formosensis, which is also less shade tolerant than Chamaecyparis taiwanensis. Chamaecyparis lawsoniana reproduces better than either Taiwan species, in all zones, and in all communities studied. Chamaecyparis lawsoniana density in most size classes is significantly different among communities. Chamaecyparis lawsoniana appears to be relatively better adapted to sub-mesic sites on mixed ultramafic soils than to more mesic sites on other substrates.

Chamaecyparis taiwanensis and C. formosensis are interpreted as being quasi-climax species which persist because of their longevity and ability to colonize disturbed areas. Chamaecyparis lawsoniana is interpreted as being a climax species in mesic communities on sedimentary and granitic substrates along with Tsuga heterophylla or Abies concolor, and as a climax dominant on ultramafic substrates where other tree species are relatively more inhibited than Chamaecyparis lawsoniana.

A Comparative Study of Temperate *Chamaecyparis* Forests

by

Glenn Martin Hawk

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

June 1977

APPROVED:

Redacted for Privacy

Associate Professor of Botany
in charge of major

Redacted for Privacy

Head of Department of Botany and Plant Pathology

Redacted for Privacy

Dean of Graduate School

Date thesis is presented 27 Sept 1976

Typed by Kathy McMurtry for Glenn Martin Hawk

ACKNOWLEDGEMENTS

One of the most difficult parts of the preparation of this thesis has been the attempt at acknowledging all of the people and agencies which have contributed to its completion. I would like to thank the many personnel of the Coos County Forest; Powers, Gold Beach, Brookings, Galice, Cave Junction, Orleans, Mt. Shasta, Gasquet, and Corvallis United States Forest Service installations; the National Park Service; Menasha Corporation of Coos Bay; Taiwan Forestry Bureau, Taiwan Forestry Research Institute and the Japanese Forestry Bureau for their general assistance in locating sample areas, transportation facilities on occassion, and other services rendered to me or to various members of my party.

Special acknowledgement is given to Mr. Valiant T. Liu, Yueng Po Yang, and Kuo Shih Hsu all of the Taiwan Forestry Research Institute (and their families) for technical assistance in the field and domestic enlightenment during my stay in the most hospitable of countries, Taiwan; Keith Reynolds for his persistence in the face of tyranny during U.S. field studies; to Ben and Lola Gardner and Viva Stansell (all of the Gold Beach area) for their assistance in locating field study areas, informative discussions, and friendship which will not be forgotten; and to all of the members of my graduate committee, to whom I have rarely made my existence known during the course of this study, for their patience and guidance. I thank my good friend David Canoy for his assistance in photography of figures. I take this opportunity also to acknowledge the help of my good neighbor and friend Mrs. Kathy McMurtry for her aid in the final preparation and typing of this thesis; neighbors and friends have parted under less strain.

Throughout this study as well as during my entire academic career, there has been one person who has given me a reason to strive forward during times of doubt. I wish to give the deepest thanks to my wife Mary Lou for standing by and giving of herself in so many ways so that I would be enabled to complete this study. I shall always be aware of the debt to Mary Lou, my daughter Marcia Lynn, and my son Anthony David for the hours, days, and months of separation that have been necessary to complete the field work.

This thesis is dedicated to my family.

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INTRODUCTION

Pierre Dansereau (1957) states that the reaction of floristic stocks to environments is a predictable reaction that depends on the exactness of replication of the total biotic and abiotic factors of two or more separate regions. This investigation has been designed to measure some quantitative aspects of *Chamaecyparis* forests in both Taiwan and the United States and to make comparisons between the two temperate forests.

The conifer genus *Chamaecyparis*, the false cypresses, is limited to islands or coastal regions (Florin, 1963; Liu, 1966). It extends inland over 320 km in only two instances, both involving *Chamaecyparis nootkatensis* (Little, 1971). This study of the *Chamaecyparis* of Taiwan and of *Chamaecyparis lawsoniana* in Oregon and California allows a comparison of the floristic and structural responses to the environment of related, widely separated temperate forests. Simultaneously, the genus is studied in contrasting conditions since the two areas differ widely in both the seasonal distribution and the total amounts of precipitation. Taiwan is wet essentially the year round while the Pacific Northwest has a pronounced summer dry period. *Chamaecyparis nootkatensis* of the Pacific Northwest has not been included in most of this study since its habitat is primarily subalpine, markedly different from that of other *Chamaecyparis* species.

Relatively little has been published about the ecology of *Chamaecyparis* forests in either study area. Two species in Japan have been studied more thoroughly (Sato, 1974) and furnish comparison for the *Chamaecyparis* forests studied here.

An international study of the genus is timely. Natural *Chamaecyparis* forests of Taiwan are rapidly disappearing due to logging and poor regeneration (Doverspike *et al.*, 1961; Wang, 1961; Lee, 1962; Wang, 1968; and Liu, 1972). *Chamaecyparis lawsoniana* is diminishing in Oregon and parts of northern California because of fatal root rot caused by Phytophthora lateralis (Tucker and Milbrath, 1942; Torgeson, 1954; Roth et al., 1957; Trione and Roth, 1957; Hunt, 1959; and Roth et al., 1972). The invasion by root rot results in an increased cutting rate to remove infected stands as well as endangered adjacent stands.

The economic worth of Chamaecyparis wood is great, particularly among the Oriental cultures where it is used in toy making, home architecture and religious ornamentals. It is also highly valued for its natural chemical resistance to decay organisms and its aromatic qualities. Chamaecyparis taiwanensis and C. formosensis are the most valuable timber species in Taiwan (Doverspike et al., 1961). Chamaecyparis lawsoniana is a valuable United States export to Japan. Darr (1971) reports a 270% rise in log prices from 1961 to 1970 to an average of $330/thousand board feet, and the price has since soared in some instances to over $2000/thousand board feet. Chamaecyparis is widely used as an ornamental shrub or tree.

This thesis reports the results of three field seasons, the summer of 1974 and 1975 in the Pacific Northwest, with six months in Taiwan in between. The investigation has centered in forests dominated in part by Chamaecyparis lawsoniana, C. formosensis, or C. taiwanensis. Chamaecyparis taiwanensis is here considered to be a separate species rather than as Chamaecyparis obtusa var. formosana, as indicated by Li (1963). Sixty-one analytical study plots were established in Taiwan at 11 geographical areas spanning the generic range. One-hundred-eight plots were established within the range of Chamaecyparis lawsoniana.

The objectives of this study include: (1) quantitative analysis of forests including Chamaecyparis lawsoniana, C. taiwanensis, and C. formosensis including the structure, composition and dynamics of plant communities and their environmental relationships; and (2) a comparison of these temperate Chamaecyparis forests, emphasizing structural and successional relationships.

THE STUDY AREA

The United States

Distribution of Chamaecyparis lawsoniana

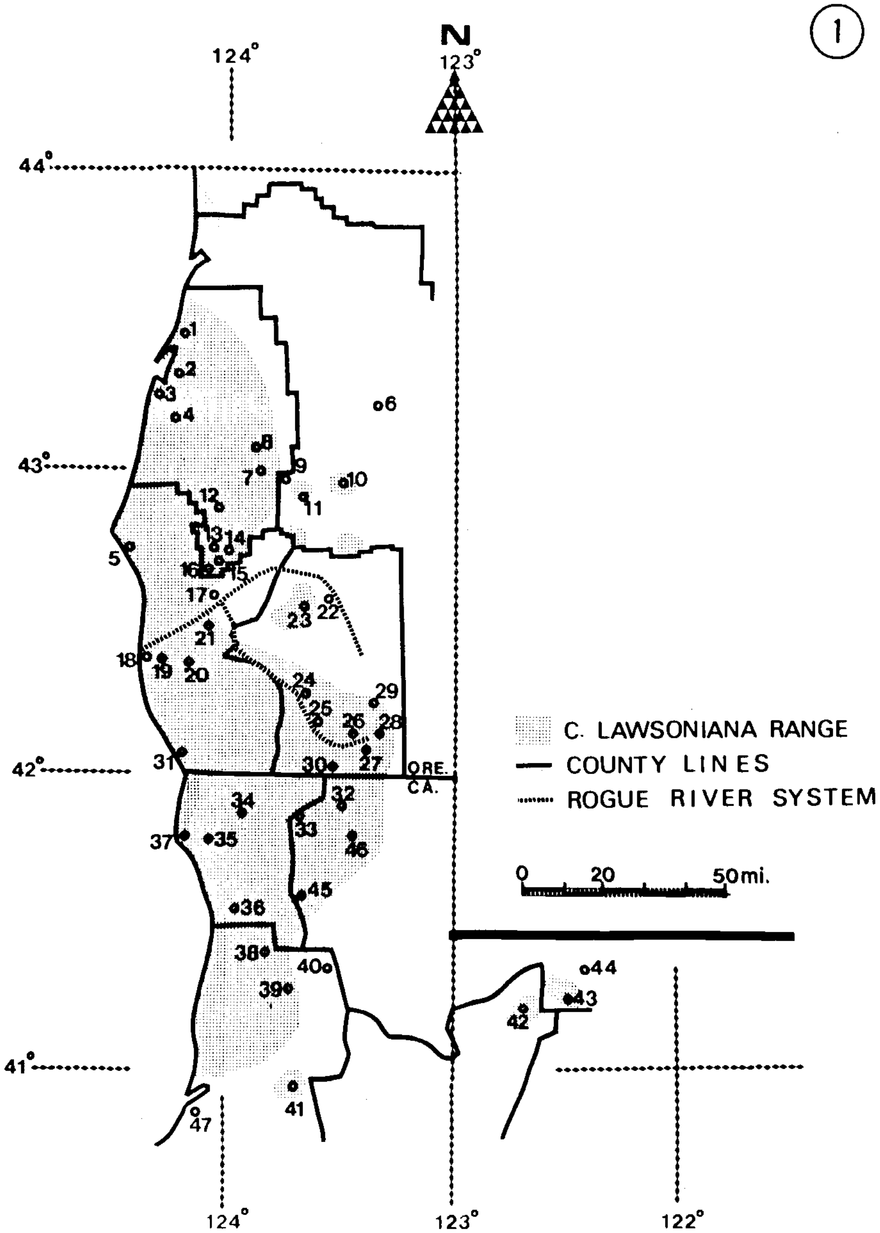
Chamaecyparis lawsoniana (Port Orford cedar) is a temperate forest conifer limited to a coastal strip in southwestern Oregon and northwestern California. It is occasionally a dominant and is distributed in disjunct populations within the range mapped by Little (1971), as illustrated for California by Griffin and Critchfield (1972). It occurs from a few kilometers south of Reedsport, Oregon, to the Mad River area north of Eureka, California (Sudworth, 1907). In the north it is confined to a coastal strip 5 to 15 km wide. To the south the range increases to about 55 km at the latitude of Powers, Oregon, but becomes narrow in the Rogue River Valley near Agness, Oregon. At this latitude small populations occur inland at Boulder Ridge and Doe Creek (Figure 1).

Populations of Chamaecyparis lawsoniana are larger in the north. Near the Rogue River, stands are more restricted to protected parts of the terrain and are dendritic because of their restriction to drainages. South of Panther Ridge (Figure 1) stands are more sparse and usually smaller. The south facing slope of Panther Ridge (which forms the north wall of the Rogue River Valley) forms an apparent boundary to Chamaecyparis lawsoniana as well as to many other species (Shelford, 1926).

South of the Rogue River, populations spread inland. Actual coastal stands south of Port Orford, Oregon are difficult to find, small, and disturbed. Larger stands can be found east of Pistol River and Gold Beach, Oregon, at 6 to 10 km and 19 to 32 km inland. South of the Pine Point and Game Lake study areas (Figure 1) relatively few large populations of the species are known, but scattered stands occur along perennial streams in some drainages. Southeast and east of the Game Lake and Snow Camp populations Chamaecyparis lawsoniana stands have been observed on the east boundary of the Kalmiopsis Wilderness Area. East and south

Figure 1. Range map of Chamaecyparis lawsoniana with study sites numbered, my climatic stations underscored, and major cities.

1. Saunders Lake
2. Coos Bay
3. Seven Devils study site
4. Coos County Forest site
5. Port Orford
6. Roseburg
7. Remote
8. Remote study site
9. Bear Creek study site
10. Doe Creek
11. Boulder Mountain
12. Powers
13. Port Orford Cedar Research Natural Area
14. Coquille River Falls Research Natural Area
15. Agness Pass
16. Iron Mountain-Panther Ridge
17. Agness
18. Gold Beach
19. Pine Point study site Hunter Creek Bog
20. Snow Camp study site
21. Game Lake study site
22. Galice
23. Galice study site
24. Kerby study site
25. Cave Junction
26. Grayback Creek Campground
27. Oregon Caves
28. Grayback Mountain study site
29. Rabbit Lake-Brewer Spruce Research Natural Area
30. Page Mountain
31. Brookings
32. Sutcliffe Creek
33. Youngs Valley study site
34. Gasquet
35. Jedediah Smith Redwood State Park
36. Red Mountain study site
37. Crescent City
38. Onion Mountain, Laird Meadow study sites
39. Orleans study site
40. Orleans
41. Willow Creek study site
42. Trinity River sites
43. Castle Lakes study site
44. Mt. Shasta (town)
45. Dillon Mountain study site
46. Happy Camp
47. Eureka



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of this point only small populations remain in very mesic locations. Small populations occur on the border of the interior valley of the Illinois River near Cave Junction, Oregon (Figure 1). Populations in the Illinois River Valley are few and small just as in the Rogue River Valley.

Southeast of the Illinois River Valley, as the elevation increases, larger populations occur. These are usually limited to high elevation north slopes such as at Brewer Spruce Research Natural Area, Grayback Mountain, Page Mountain, Sutcliffe Creek and the Youngs Valley study areas (Figure 1). Low elevation populations along tributaries of the upper Illinois River occur upon terraces and alluvial deposits of Grayback Creek and Elk Creek. Similar terrace populations are found on the Smith River near Gasquet, California.

Inland distribution of populations is maximal at the California and Oregon border. From here, the range begins to narrow towards Eureka, California. Major populations still occur at upper elevations in protected areas or along the narrow coastal strip. Additional populations occur 150 km inland near the headwaters of the Trinity and Sacramento Rivers. The distribution map included here (Figure 1) still shows a solid belt along the coastal areas but includes disjunct locations in addition to those of Little (1971).

Physiographic Locations

Hayes (1958) states that Chamaecyparis lawsoniana occurs on all physiographic locations from sea level to 5000 feet on the seaward slopes of the Coast Range and the Klamath Mountains. The range of Chamaecyparis lawsoniana is thoroughly dissected by sharp changes in elevation, slope, aspect, precipitation and geologic continuity. This has led to a variety of habitats. In the extreme northern parts of its range, Chamaecyparis lawsoniana exists in few situations where moisture is lacking due to the ameliorating effects of high humidity, relatively low temperatures, high cloud cover, and frequent fogs during the summer months. Moving south, inland, or up in elevation places further restrictions on the success of Chamaecyparis lawsoniana.

Climate

The proximity of the Pacific Ocean has a great influence on the total climate. The area has wet winters and dry summers. Annual precipitation measured at low elevation stations near the study sites is between 1000 and 2300 mm (Table 1). Most stations in Oregon and California report less than 80 mm precipitation from June through August. In most cases the precipitation at my study sites is greater due to orographic effects. Precipitation isoheyets are between 1000 and 2000 mm in California Chamaecyparis forest areas and from 1200 to 3000 mm annually over Oregon sites. Annual precipitation over most coastal areas is 1500 mm increasing to nearly 3000 mm on higher slopes. In Oregon there is a decrease in precipitation to 1000 to 1200 mm annually in the interior valleys, followed by a gradual increase east of the Illinois River Valley (U.S. Weather Bureau, 1965). A line passing through Galice, Oregon and Redding, California would delimit the eastern boundary of Chamaecyparis lawsoniana and coincides with Waring's (1969) demarcation between eastern and western Siskiyou Mountains; these two areas are well differentiated in terms of the common species, with many of those of the more mesic western Siskiyou Mountains not found in the eastern Siskiyou Mountains. Plant moisture stress of test species is greater in the eastern Siskiyous than in the western Siskiyous (Waring, 1969).

Temperature is moderate and shows less tendency for marked daily fluctuations in the western Siskiyous than in the eastern Siskiyous (Waring, 1969). Temperature variations over most of the range of Chamaecyparis lawsoniana are summarized in Table 1. Seasonal mean minima and maxima for Oregon and California study areas are similar to each other (Table 2). Temperatures recorded in upland communities are from two to ten degrees C cooler than the nearest stations in Table 1 (Table 2). Although the climate is under the influence of the Pacific Ocean many inland locations may also be affected by continental air masses.

Table 1 shows only small amounts of snow for most weather stations, but there is snow accumulation, particularly within the Klamath Mountains. Areas above about 1000 meters elevation accumulate considerable

Table 1. Weather Bureau climatic data of United States study area, 1951-1960.

Region	Station	Lat. (N)	Dist. from coast (km.)	Elev. (m)	Precipitation (mm)		Snow (mm)	Mean Temperatures (C)		
					Annual	Jun-Aug		Ann.	Coldest Monthly Min.	Warmest Monthly Max.
Coast	North Bend FAA AP	43 25	5	3	1579	64	3	11.2	4.2	19.0
	Brookings	42 03	1	24	2052	73	nd*	11.9	5.1	19.7
	Klamath	41 31	3	8	2185	62	nd	11.6	4.1	19.8
	Eureka WB	40 48	3	13	1041	29	7	11.2	5.4	16.1
Coast Range and Klamath Mountains	Sitkum 2 SW	43 08	43	173	2159	73	201	11.6	1.7	25.5
	Powers	42 53	34	92	1655	56	nd	11.9	2.5	24.3
	Elk Valley	42 00	41	357	2187	44	nd	10.4	-0.3	30.1
	Happy Camp	41 48	63	332	1546	41	826	13.2	0.4	35.9
Interior California	Mt. Shasta WB City	41 19	149	1081	1019	37	3550	9.8	-3.3	29.7

* nd = no data available

Table 2. July and January mean temperature data for Oregon and California sites (degrees C).

U.S. Weather Bureaudata	Oregon	California
July mean minimum	7 to 12	8 to 12
July mean maximum	20 to 32	18 to 33
January mean minimum	-2 to 5	-3 to 5
January mean maximum	6 to 12	6 to 12

On site thermograph data	Plot Number							
	33	38	12	21	58	7	60	51
Community 1/	Tshe Chla Pomu Oxor	Chla Lide	Chla Lide	Abco Chla herb	Abco Chla herb	Abies Chla herb	Pinus Chla Quva Xete	Chla Lide
Reference to Figure 1.	14	15	19	21	43	28	24	39
July mean minimum	8.9	7.8	9.4	10.2	6.5	10.7	11.1	10.2
July mean maximum	22.1	24.1	20.8	19.9	23.1	19.2	35.5	21.5
January mean minimum 1975	1.4	-0.4	---	-0.6 2/	---	---	0.7	-0.6
January mean maximum 1975	6.1	4.4	6.3	3.0 2/	---	---	7.2	3.4
January mean minimum 1976	2.2	1.3	2.5	---	-4.1	1.5	.1	.1
January mean maximum 1976	8.0	7.4	9.2	---	3.1	5.2	9.8	4.8

1/ see Appendix I for definitions of community names
2/ data from only 18 days during the month

snow pack in some years. Snowfall is important in terms of mechanical damage to the plants as well as for the water it contains. Sato (1974) states that Chamaecyparis obtusa of Japan is restricted to those areas below the common snow line since it cannot recover from the damage of heavy snows. Snow is of increasing importance in some United States study areas since it elongates the period of abundant ground water in the midslope Chamaecyparis lawsoniana forests.

Hayes (1958) has stated that the main range of Chamaecyparis lawsoniana has frequent summer fogs. This may be the case in the narrow coastal portions of the range. At inland populations, experience makes me conclude that summer fog is lacking. Fog may be important in maintaining Chamaecyparis lawsoniana as a part of the forest along with other tree species which compete more strongly or to the exclusion of Chamaecyparis on more xeric sites.

Geology and Soils

The range of Chamaecyparis lawsoniana includes portions of three physiographic provinces; the Oregon Coast Range, Klamath Mountains, and California Coast Range Provinces. This is one of the most heterogeneous geologic areas in the western United States (Baldwin, 1964; Irwin, 1966; Dott, 1971; and Hotz, 1971).

During the formation of the Klamath Mountains in the Paleozoic, fine metamorphism of mafic, volcanic tuffs, and sedimentary rocks yielded schists which are now found in northern California and some coastal regions of Oregon. Uplift followed by erosion and volcanism during the Triassic yielded the Applegate Formation over much of southwestern Oregon and adjacent California (Baldwin, 1964). Many areas within this formation have since been metamorphosed.

During the Jurassic, more massive erosion and sedimentation seaward from the rising Klamath complex, as well as increased volcanism, uplift and folding resulted in the formation of the Dothan, Rogue, and Galice Formations in the northern portions of the Klamath complex. Also during the Jurassic, massive igneous intrusion began over most central portions of the study area, occurring in arcuate belts and large plutons throughout the Klamath complex (Figures 2 and 3).

North of the Klamath Mountains occur more recent sedimentary formations deposited and uplifted during Paleocene to recent times. One of the first and most extensive of these is the Umpqua Formation. The Umpqua is successively overlain by the Tyee, Coaledo, Bastendorf, Empire, and Coquille Formations as well as intervening local depositions of high terrace or alluvium, all within a very few kilometers of Coos Bay, Oregon (Baldwin, 1964).

Regional Vegetation

Another complex habitat condition to which *Chamaecyparis lawsoniana* has become adapted is biotic diversity. *Chamaecyparis lawsoniana* can compete well on a wide variety of soil types, and thus comes into contact with a great diversity of plant communities and species. As this is one of the earliest regions emergent in the Pacific Northwest, it is no surprise that the area is considered as a vegetative refugium (Whittaker, 1954). Without doubt, the Klamath Mountains have served as a transient habitat for thousands of generations of multiple floras during periods of environmental fluctuations.

Taiwan

Distribution of *Chamaecyparis formosensis* and *C. taiwanensis*

Chamaecyparis formosensis (red cypress) and *C. taiwanensis* (yellow cypress) were studied in natural stands on Taiwan. Taiwan is located primarily between latitudes 22 and 25 degrees north and is nearly bisected by the Tropic of Cancer (Figure 4). *Chamaecyparis* species occur primarily between 1500 and 2900 meters elevation within the upper portions of the Warm Temperate Montane Conifer Forest Formation (Liu, 1968). In general, C. *formosensis* averages nearly 300 m lower in maximum elevation and about 200 m lower in minimum elevation than *C. taiwanensis* (Liu, Koh, and Yang, 1961).

Figure 2. Oregon study areas with reference to ultramafic and granitic intrusions and major cities (numbers following locations refer to plot numbers).

A. Dunes study sites (69-68)

B. Coos Bay (town)

C. Blacklock soil plot (70) and Coos County Forest sites (66 & 67)

D. Remote study sites (62-63-64-65)

E. Powers (town)

F. Panther Ridge (Agness Pass-Iron Mountain Plots 38-39-40-26-27-28-29-30-31-32-33-34-35-36-37-41-42-43-44-45-46-47-98-99-100-101-102-103-104-105-106)

G. Port Orford (town)

H. Gold Beach (town)

I. Pine Point study site (11-12-13-14-15-16-17-18-19)

J. Game Lake study site (20-21-22-23)

K. Snow Camp Meadow site (24-25)

L. Brookings (town)

M. Galice study sites (79-80-89-90-91-92-93-94-95-96-107-108)

N. Kerby study sites (59-60)

O. Cave Junction (town)

P. Brewer Spruce Research Natural area site (71-72)

Q. Oregon Caves

R. Page Mountain study site (61)

S. Grayback Mountain study site (1-2-3-4-5-6-7-8-9-10)

T. Grayback Creek Campground

(2)

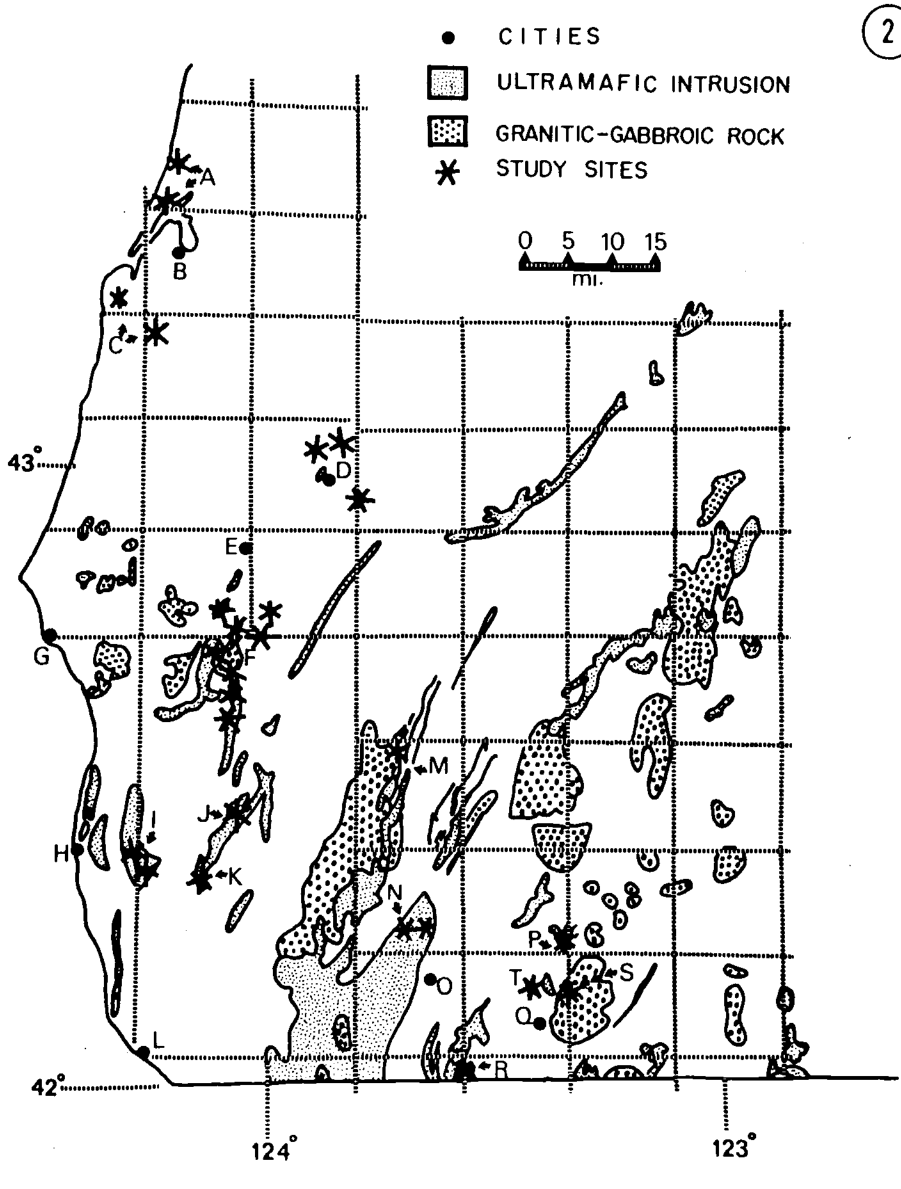
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Figure 3. California study areas with reference to ultramafic and granitic intrusions and major cities (numbers following locations refer to plot numbers).

A. Youngs Valley study area (73 & 97)

B. Sutcliffe Creek study area (48 & 49)

C. Cedar Rustic Campground (78)

D. Jedediah Smith Park (77)

E. Smith River plot (74)

F. Dillon Mountain study site (88)

G. No Mans Creek study site (50)

H. Red Mountain study site (75 & 76)

I. Onion Mountain, Laird Meadow, Cedar Camp study sites (87-86-54)

J. Bigfoot Creek study site (85)

K. Blue Lake-Orleans study site (51-52-53-82-83-84)

L. Gasquet

M. Crescent City

N. Happy Camp

O. Orleans

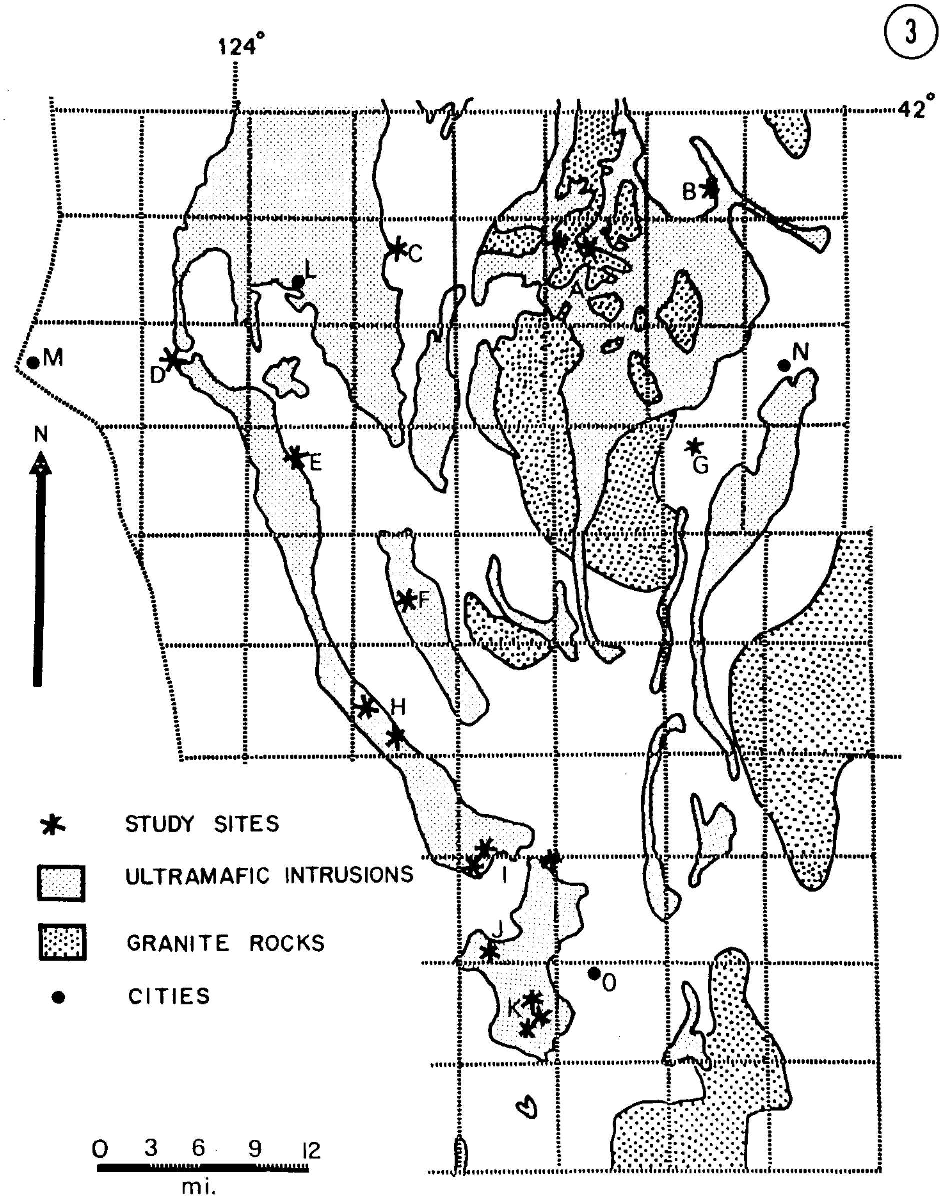
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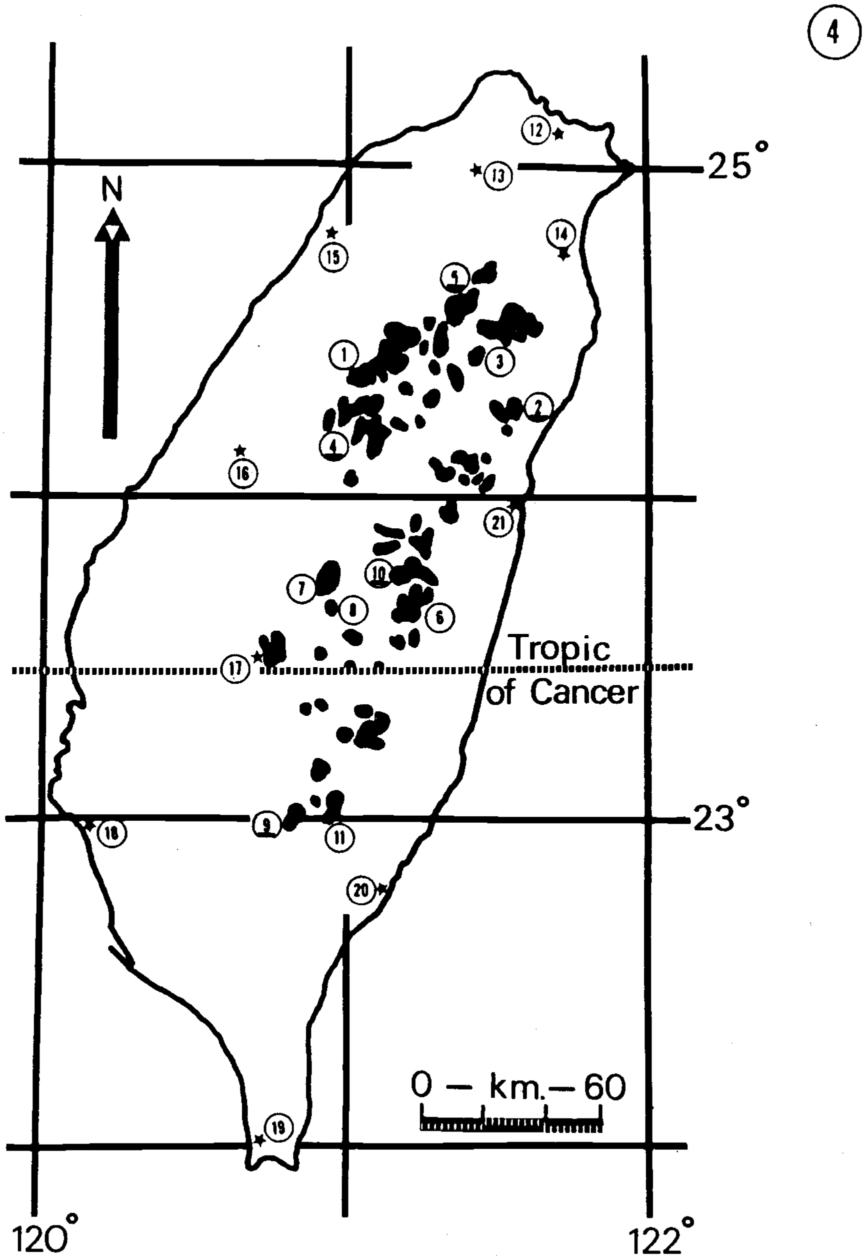
Figure 4. Range map of Taiwan *Chamaecyparis* forests with study sites numbered, major cities starred, and my climatic stations underscored. (Chang, 1972)

1. Ta Hsueh Shan study site
2. Ho Ping Shan study site
3. Tai Ping Shan study site
4. An Ma Shan study site
5. Yuan Yang Lake study site
6. Hua Lien study site
7. Ren Lwun study site
8. Wang Hsiang study site
9. Liu Kuei study site
10. Tan Ta study site
11. Taitung study site
12. Keelung city
13. Taipei city
14. Ilan city
15. Hsinchu city
16. Taichung city
17. Ali Shan village
18. Tainan city
19. Hengchun city
20. Taitung city
21. Hualien city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In 1956 there were approximately 43,000 hectares of *Chamaecyparis* forest; 70% of it was then inaccessible. The inaccessibility appears to be the only major force that has saved much of the *Chamaecyparis* forests in the past, and improved roads are bringing about rapid use of the remaining purer stands of *Chamaecyparis* (Taiwan Forestry Bureau, 1974). In Japan there are virtually no primordial forests of *Chamaecyparis* left (Sato, 1974).

During the Taiwan field study there were only a dozen roads open to us which allowed access to undisturbed *Chamaecyparis* forests. Regular, long term studies are not permitted on many of them because of the seasonal road closures. *Chamaecyparis* species usually inhabit steep and wet areas. Edaphic instability and frequent earthquakes at high elevations, which maintain the opportunity for both primary and secondary succession of *Chamaecyparis*, also close the roads.

Chamaecyparis forests in Taiwan, like those in the United States, are disjunct and restricted to upper or middle slopes of steep mountains. *Chamaecyparis* species of Japan have also been long noted as midslope species (Sato, 1974). In the Taiwan and United States study areas the *Chamaecyparis* forests are more continuous where adjacent mountains join within the elevational range of the genus. The population distribution of the genus in Taiwan (Figure 4) is given by Chang (1972) and shows more or less disjunct patches of *Chamaecyparis* forest located above a matrix of hardwood forests. Along the upper portions of the Central Mountain Range *Chamaecyparis* forests occur below the Hemlock-spruce-fir forests. Larger populations of *Chamaecyparis* species are located in the northern half of the island. Both species of *Chamaecyparis* are sympatric in most regions. *Chamaecyparis taiwanensis* is concentrated on the west side of the Central Mountain Range while *C. formosensis* is found more on the east side of the range. Both species show the typical increase in elevation of occurrence at southern latitudes. The northern range is dominated by *Chamaecyparis taiwanensis-Tsuga chinensis* forests, but *C. formosensis* is also common. To the south *Chamaecyparis* forests become less extensive, and the relative dominance of *C. taiwanensis* decreases while that of *C. formosensis* increases.

Physiographic Locations

Liu (1968) has pointed out that the ecological amplitudes of Chamaecyparis taiwanensis and C. formosensis are similar in many respects, but dissimilar in their distribution over different physiographic positions. This is apparently a response to moisture requirements of the two species of cypress. Chamaecyparis formosensis was found by Liu to be more hygrophilous and to have a greater tolerance for low nutrient soils than C. taiwanensis. Thus C. formosensis is typically found on damp ravine slopes while C. taiwanensis occurs on somewhat drier slopes. In Japan Sato (1974) also notes a difference in the distribution of Chamaecyparis obtusa and C. pisifera with C. obtusa being characteristic of upper slopes while C. pisifera prefers moister valley sites. He also states that C. obtusa seedlings are more drought resistant than C. pisifera seedlings. In their study of Taiwan forest types Liu, Koh and Yang (1961) found C. taiwanensis forest types on many aspects and slopes. C. formosensis forest types were also found on a wide variety of aspects, but they tended to be more common on the northwestern aspects.

Climate

Taiwan has moderate to high temperatures, heavy rainfall, and strong winds. Climate is influenced by proximity to the Asian continent, size and arrangement of the Central Mountain Range, and proximity to the Pacific Ocean. Conditions responsible for the presence of Chamaecyparis species in Taiwan include: (1) high relative humidity, (2) cool temperatures in the mountains, (3) moderate to high annual precipitation, and (4) the seasonal influence of prevailing typhoons and monsoons (Lee, 1962).

From October to March monsoons from the continent strike northern Taiwan and much orographic precipitation results (Figure 5). With the rainfall and winds comes a heavy cloud cover and little evapotranspiration. At this time of the year southeastern Taiwan is within a partial rainshadow created by the Central Mountain Range. From May to September

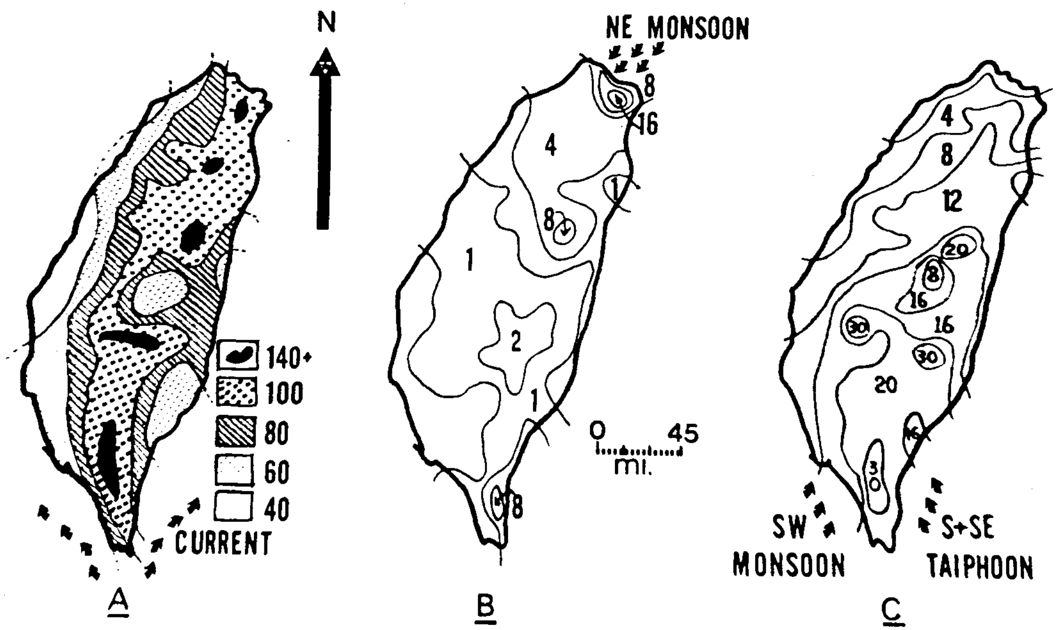


Figure 5. Taiwan precipitation (in inches: A = annual, B = February, and C = July average precipitation (1 inch = 25.4 mm)). (from Hsieh, 1964)

the monsoons come primarily from the southwest, and from July to October typhoons come from the south and southeast, both resulting in large amounts of rain over southern Taiwan primarily, as well as considerable rain over the rest of the island. Chamaecyparis obtusa of Japan is reported to occur in areas where there is a minimum of 200 mm rain in the summer months of July or August (Sato, 1974).

Precipitation patterns in Taiwan differ with seasons (Figure 5). Increased elevation causes a great increase in the amount of precipitation (Table 3). Seasonal distribution of rain may be in part responsible for differences in the regional concentrations of forests dominated by one or the other of the Chamaecyparis species. Studies by Chang (1961, 1963), Lee (1962), and Liu (1963) reveal that rain within Chamaecyparis forests is typically greater than 3000 mm per year. Sato (1974) reports that Chamaecyparis obtusa of Japan grows in areas with annual rainfall of 2000 to 4000 mm. In Taiwan there are no significantly long dry periods. Hsieh (1964) emphasizes this fact when he points out that at Ali Shan it rains 208 days of the year, more than every other day.

In addition to the reduced moisture stress in Chamaecyparis forests due to high rainfall, there is also a continually high relative humidity (Chang, 1961, 1963; Lee, 1962; Liu, 1963) (Table 3). Relative humidity of low elevation sites in Taiwan typically averages near 80% while those within Chamaecyparis forests are often above 90%.

The prevailing ocean currents and the trend of the Central Mountain Range result in a general east-west temperature difference. The eastern portions of the island tend to be cooler in the winter and warmer in the summer than west of the mountains. Temperature data from major low elevation population centers and from high elevation Chamaecyparis forests are given in Table 3, and point out the striking difference between low and high elevations which are often very close geographically. Lee (1962) states that the optimum temperature for growth of Chamaecyparis at Ali Shan is between 8 and 14 degrees C. and that an annual average of 5 degrees C. is below the minimum requirements of Chamaecyparis in Taiwan. This temperature range is similar to that reported by Sato (1974) for Chamaecyparis obtusa of Japan which grows best

Table 3. Taiwan climatic data.

Location Reference to Figure 4	Taipei (13)	Tainan (18)	Taitung (20)	Hualien (21)	Ali Shan *(17)	Tai Ping Shan *(3)	Ta Yuan Shan *(3)	An Ma Shan *(4)
Mean monthly temperature (C)								
Jan.	15.2	16.8	18.9	17.2	5.8	5.5	5.7	6.4
Feb.	14.7	17.1	19.0	17.4	6.5	7.0	4.5	8.4
Mar.	17.0	20.7	20.7	19.0	8.3	9.5	7.6	10.6
Apr.	20.7	23.4	23.1	21.6	10.6	12.1	11.8	11.9
May	24.1	26.3	25.3	24.1	12.5	15.8	13.8	14.6
June	26.6	27.4	27.0	26.3	13.7	17.6	14.7	15.4
July	28.2	27.8	27.5	26.2	14.1	17.8	16.8	16.2
Aug.	27.9	27.5	27.3	27.1	13.8	17.8	16.2	16.0
Sept.	26.3	27.1	26.5	26.0	13.3	17.0	13.8	15.6
Oct.	23.1	24.8	24.5	23.6	11.4	13.5	11.2	14.9
Nov.	20.0	21.8	22.0	21.2	9.7	11.1	8.7	12.5
Dec.	16.8	18.5	20.0	18.7	7.6	7.8	6.4	9.0
Annual	21.7	23.2	23.5	22.5	10.6	12.7	10.9	12.6
Mean monthly precipitation (mm)								
Jan.	88.9	18.8	36.8	59.9	66.8	98.9	117.2	46.4
Feb.	139.9	35.8	43.9	89.9	155.9	53.1	133.7	184.7
Mar.	182.9	51.8	63.8	115.8	248.9	116.0	237.8	250.0
Apr.	168.9	67.8	70.9	113.8	262.9	66.1	158.0	293.9
May	226.8	175.8	169.9	207.8	548.9	412.0	350.2	353.0
June	303.8	375.9	197.9	179.8	728.9	270.1	789.3	634.1
July	227.8	422.9	349.0	289.8	794.8	378.4	208.7	460.0
Aug.	299.9	440.9	299.9	229.9	836.9	477.9	337.0	546.0
Sept.	224.8	162.8	288.8	271.8	441.9	474.2	722.2	400.1

(continued on next page)

Table 3. (Continued)

Location Ref. Figure 4	Taipei (13)	Tainan (18)	Taitung (20)	Hualien (21)	Ali Shan (17)	Tai Ping Shan (3)	Ta Yuan Shan (3)	An Ma Shan (4)
Oct.	112.8	34.8	172.9	234.9	130.8	365.2	205.0	42.8
Nov.	59.9	15.7	60.9	112.0	43.9	171.4	276.5	76.9
Dec.	72.9	16.8	35.8	66.8	100.8	92.6	344.2	42.0
Annual	2109	1819	1790	1972	4361	2983	3869	3408
Mean monthly relative humidity (%)								
Jan.	84	79	74	78	80	95	97	81
Feb.	84	79	75	81	82	96	99	79
Mar.	84	79	77	81	84	95	95	79
Apr.	82	79	79	82	85	94	93	85
May	82	81	82	85	88	95	96	83
June	81	84	82	84	90	94	94	88
July	78	83	81	81	90	90	86	85
Aug.	78	84	81	81	90	91	90	88
Sept.	79	82	80	81	89	92	92	86
Oct.	80	78	77	78	86	94	97	77
Nov.	81	78	75	78	82	94	93	75
Dec.	83	79	74	78	78	94	98	72
Annual	82	81	78	81	86	94	94	81

* Chamaecyparis is present at these locations and was studied by: Ali Shan, Hsieh (1964); Tai Ping Shan, Chang (1963); Ta Yuan Shan, Chang (1961); and An Ma Shan, Liu (1963).

in areas where the average annual temperature is 12 to 16 degrees C. but is found also in areas averaging between .5 and 17 degrees C.

Geology and Soils

The main backbone of Taiwan consists of schists and granitic gneiss both of which are linked with the old land mass of Archean rocks of Fukien Province in China (Hsieh, 1964). The formation of a rift valley and the submergence of Taiwan Straits during the Pleistocene led to the separation and isolation of Taiwan from the mainland (Hsieh, 1964). Repeated thrust faulting and uplift has resulted in steep eastern slopes of the Central Mountain Range. Metamorphism of sedimentary rocks and intrusion of pre-Tertiary igneous rocks resulted in a foundation of sedimentary rocks of shallow water origin, with interbedding of sandstones, shale, frequent volcanic rock, and igneous intrusions (Figure 6A).

In the Taiwan climate physical weathering, chemical decomposition and mineral leaching in the soils are active. Podzolization processes are characteristic of most of the cooler upland soils of Taiwan, which are acid in reaction (Hsieh, 1964). Soils occupied by Chamaecyparis in Japan are also characteristically podzolic soils. They are often acid to very acid soils with pH values of less than 5.0 (Sato, 1974). In Taiwan, as the elevation increases, acid lateritic soils are replaced by acid podzolic soils. The accumulation of organic material and high precipitation yields organic acids which bleach the upper horizon. Due to geologic disturbances in upland Taiwan, few areas have well developed soils. The major soil groups of upland Taiwan are shown in Figure 6B.

The gray-brown podzolic group is made up of zonal soils with well developed profiles. They are typically found between 800 and 2000 meters elevation and are only mildly podzolized. They may occur on a variety of parent materials, are generally very acidic (pH 5.0), and have deep mull layers incorporating organic matter (Hsieh, 1964). Liu, Koh, and Yang (1961) report moderately podzolized soils within both C. formosensis and C. taiwanensis forests and a soil pH ranging from

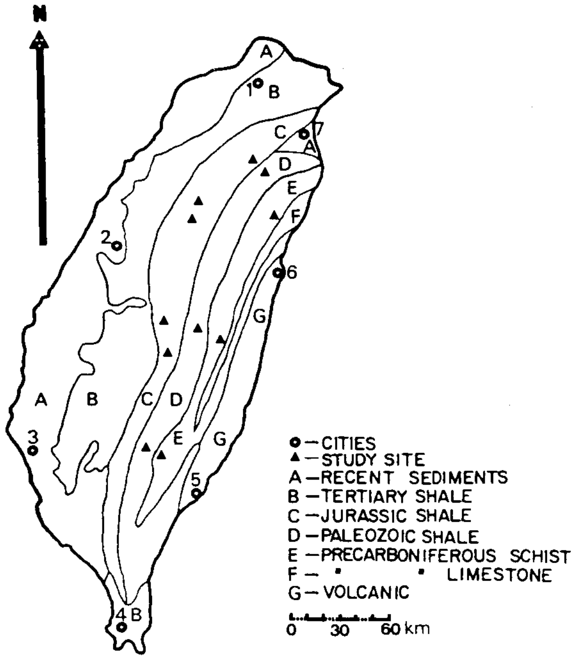


Figure 6A. Geology of Taiwan (1 = Taipei, 2 = Taichung, 3 = Tainan, 4 = Hengchun, 5 = Taitung, 6 = Hualien, 7 = Ilan). (Hsieh, 1964)

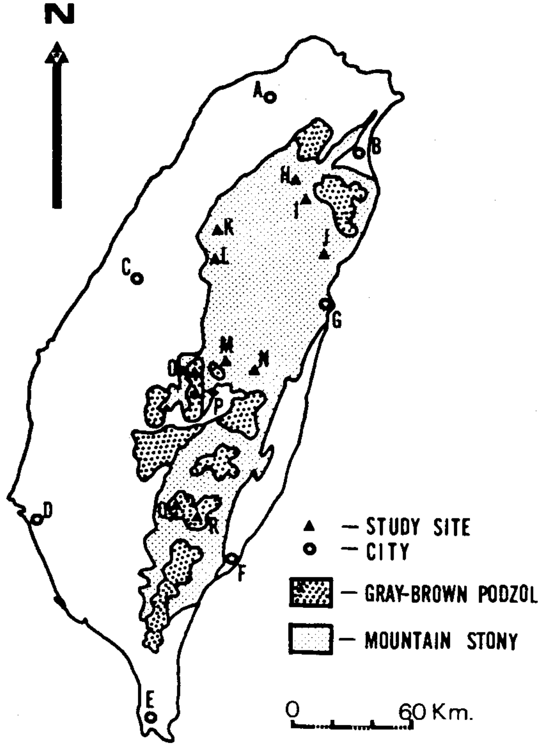


Figure 6B. Major Taiwan upland soil groups; major cities (A = Taipei, B = Ilan, C = Taichung, D = Tainan, E = Hengchun, F = Taitung, G = Hualien); and study sites H = Yuan Yang Lake, I = Tai Ping Shan, J = Ho Ping Shan, K = Ta Hsueh Shan, L = An Ma Shan, M = Tan Ta, N = Hualien site, O = Ren Lwun, P = Wang Hsiang, Q = Liu Kuei, and R = Taitung site. (Chang, 1972)

4.7 to 6.6. Liu and Chang (1962) cite Chamaecyparis forests occurring upon incompletely podzolized, gray-brown podzolic soils of Lu Chang Ta Shan (just to the north of study area number 1, Figure 4). Chang (1963) reports Chamaecyparis forests at Tai Ping Shan (Location number 3, Figure 4) occurring upon gray-brown podzolic soils that are incompletely podzolized and have pH from 4.0 to 5.0.

The Mountain Stony Soils Group consists of immature azonal soils derived from an assortment of parent materials. They often lack well developed profiles. This group of soils is typically found above 3000 m elevation, but it is also typical of lower upland areas where disturbance is common. They may be moderately podzolized if they occur in a region where they are not rapidly eroded.

Zonal Vegetation

In Taiwan, *Chamaecyparis* forests communities occur within or near several floristic zones, as in the Pacific Northwest. *Chamaecyparis* is found primarily within the Warm Temperate Montane Conifer Forest Formation of Liu (1968). Most authors have included *Chamaecyparis* within a zone of its own or with its upper and lower elevations included in subalpine or warm temperate rainforest zones respectively (Figure 7). At lower elevations, *Chamaecyparis* exists in an almost subordinate relationship with mixed broadleaved, evergreen sclerophylls of the Lauraceae and Fagaceae. Dominance relationships are often confusing and complex, with local dominants quite variable. Higher elevation *Chamaecyparis* forests are typically dominated by *Chamaecyparis* species along with *Tsuga chinensis* in the more mature stands.

Source	4000 m		3000 m	2000 m	1000 m		0 m
Wang, 1963	Montane Coniferous Forest mixed conifers				Evergreen Sclerophyll Broadleaved Forest	Tropical Rain Forest	Littoral Forest
Wang, 1968	Alpine Forest Region Juniper scrub		Subalpine Forest Region mixed fir, spruce hemlock, and pines	Temperate Humid Forest Region *Chamaecyparis* spp.			
Liu, 1968	Alpine tundra	Subalpine Conifer Forest Formation *Juniperus* *Abies*	Cold Temperate Montane Conifer Forest Formation *Tsuga*-*Picea*	Warm Temperate Montane Conifer Forest Formation *Chamaecyparis* spp.	Warm Temperate Montane Rain Forest Formation Lauraceae Fagaceae	Tropical Rain Forest Formation	Littoral Forest

Figure 7. Recognized forest zones, regions or formations of Taiwan.

METHODS

Vegetation

Data Collection

The vegetation sampling methods used in Taiwan and the United States were nearly identical. They are modifications of those described by Daubenmire (1959, 1968).

In a study of this nature a logical first step is to become familiar with the distribution of the primary species and with the general variation in plant communities that exists over the range of those species. Such an introduction is typically accomplished by a combination of literature review and field reconnaissance over the region to be studied. In both Taiwan and the Pacific Northwest I was unable to conduct extensive reconnaissance surveys. Instead, I relied on the expertise of local authorities on the forests of all study areas.

In plot selection my primary requirement was that *Chamaecyparis* had to be present in or very near a chosen study site. Secondary requirements were that sites must: (1) represent common regional communities, yet the total sample should include a wide range of apparent successional and structural variation; (2) include minimum disturbance; (3) be relatively accessible; and (4) be located to avoid ecotones.

The primary requirement was closely adhered to in both areas. Secondary requirements were also closely followed, keeping in mind that an apparently rare type could become more prevalent as the study progressed. Thus some of the plots taken are the single representative of a community and thus sample the variation in *Chamaecyparis* habitats. The selection and placement of homogeneous plots was often the hardest requirement to meet, especially where *Chamaecyparis lawsoniana* is confined to narrow drainage or seep areas. The riparian type is very widespread even though so narrow that sampling includes ecotones within the plot. A minimum of six plots have been sampled within each forest type that is representative of a locally common community.

A 15 X 25 m rectangular plot was used throughout the study (Figure 8). Plots were placed perpendicular to the aspect of the slope; across wide, gentle stream bottoms; parallel to streams on steeper footslopes; and randomly on large benches or topslopes with no apparent aspect. A single tree was chosen as a corner tree and a perimeter tape was placed around the plot having square corners. The plot was then divided into three 5 X 25 m strips.

Site characteristics and general vegetation estimates were recorded including date, location, elevation, aspect, slope, landform, and parent material. Estimates were made of the following: (1) total cover of mature trees, immature conifers, stone, litter, mineral soil, and coarse litter; (2) height of vegetation layers in Taiwan plots; and (3) depth of the litter layer. Maps were then drawn showing the major openings of the mature canopy and the location of each tree and sapling was drawn (Figure 9). A tree is here defined as any woody species with a dbh (diameter breast high or 1.37 m high) of 15 cm or more. A sapling is any conifer species less than 15 cm dbh and greater than 1 m tall. Seedlings are conifers less than 1 m tall but greater than two or three years of age.

Quantitative sampling was done in five strata including trees, saplings, seedlings, shrubs, and herbs-mosses. The measurements taken include the dbh and species of each tree; height of trees (estimated in Taiwan, and measured for many trees in the United States); age (estimates and some cores in Taiwan and core samples from most of the U.S. trees that were measured for height); estimated cover of mature and immature trees by species; and the number of seedlings was determined within the whole plot or within a representative subsample never less than 50 m^2.

Shrub species cover was measured by line intercept across the plot (50 m long in Taiwan and 100 m long in the U.S.). Shrub cover is defined as the percentage of the total line covered by a given species. The species cover of herbs and mosses (by species in the herbs and as "moss" for all bryophytes) was derived from cover estimates made within 50 two by five decimeter plots placed at fixed intervals within the macroplot (Figure 8). An attempt was made to list all of the species that

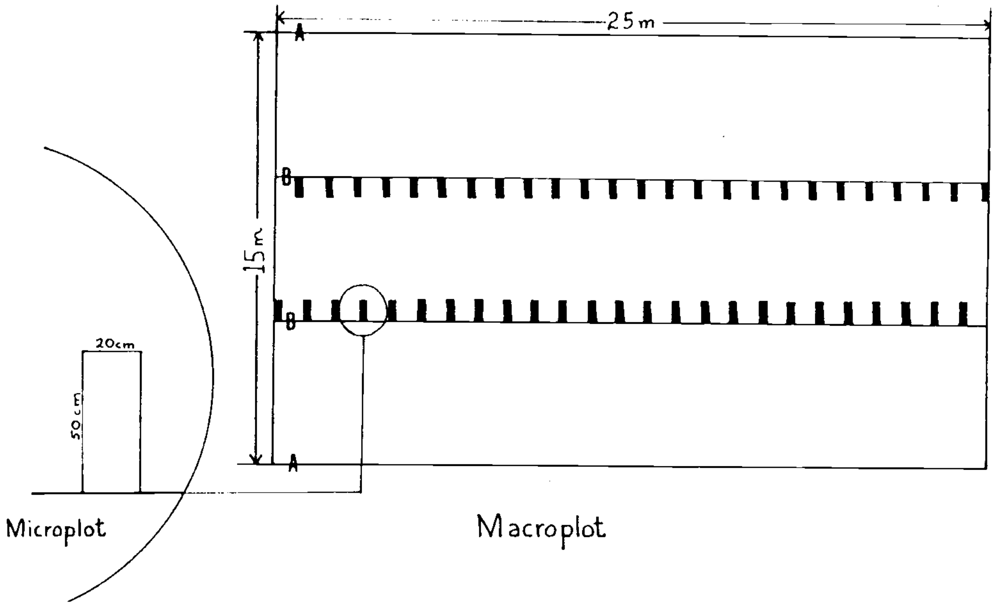


Figure 8. Plot size and arrangement.

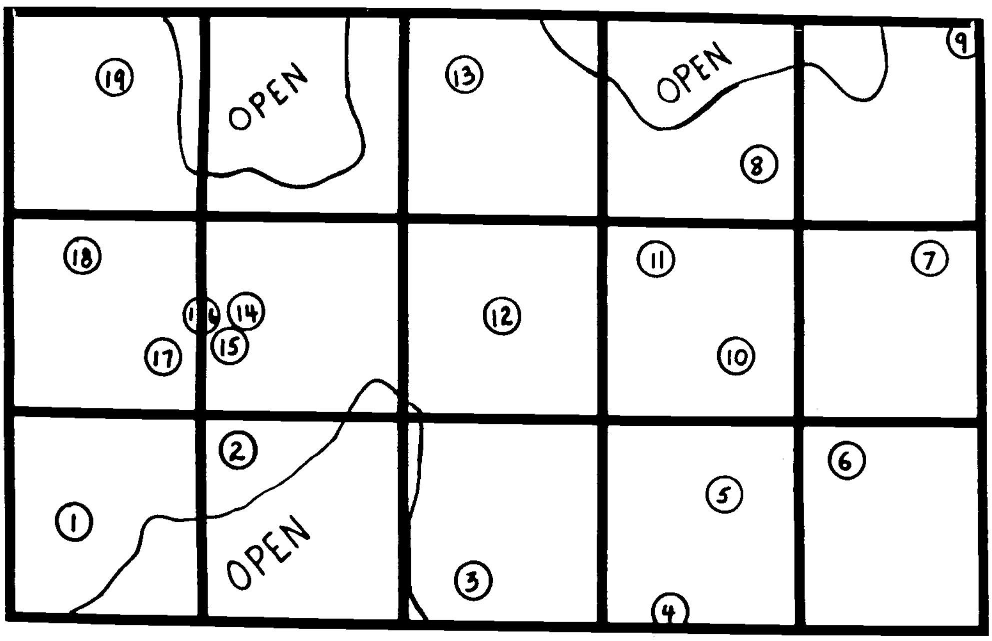


Figure 9. Sample map of major canopy openings (open) and location of trees or saplings (numbered circles).

occurred within the plot.

Further data on large tree age and growth rate were gathered from the stumps of larger trees within clearcuts and roadcuts near known community types. Here basal diameter, diameter at the cut, height of the cut, diameter of wood, and diameter at each one hundred years interval of wood were recorded for the most important species. All tree heights were measured by the abney method (Wilson, 1969).

Data Analysis

The primary objective of this study is the description of communities which contain *Chamaecyparis*. I wish to describe a set of vegetation units which can be discussed and visualized as clearly as possible by the reader.

If an environmental factor or complex should change gradually, then the vegetation in equilibrium with that environment will reflect that change. In mountainous areas the changes in abiotic factors are often abrupt, and one would expect the biota to reflect these changes. I make the assumption that vegetation repeats itself with varying degrees of precision along similar portions of an environmental gradient or gradient complex. It is this repetition that I have attempted to recognize and describe.

Analysis of vegetation data is aimed at establishment of groups of stands which are similar in composition and species importance. I occassionally use the term "indicator species", defined as species which have a high fidelity or maximal development within a particular community. My primary analytical tool has been manual-visual table sorting methods discussed by Ellenberg (1956) and more recently by Mueller-Dombois and Ellenberg (1974). A stand table is constructed which contains all stands (plots) and all species arranged in strata (trees, shrubs or herbs). The data included in the body of the table can be any which are helpful in defining biological units. By changing rows or columns of data within the table, stands with similar species parameters may be grouped. The investigator is free to exercise any preconceived ideas about communities. If the final groupings are not justified by their species composition it will show in the resulting tables.

The final stand table has stands with similar groups of species located adjacent to each other. The groups of stands may then be named. I call them communities, using the least structured definition of the term (a vegetation unit that is defined by the species and amounts of those species present). Comparisons can then be made between biotic or abiotic parameters that have been measured in each stand to see if any parameters may be more useful in defining the limits of the community. Usually when abiotic factors are important, they show a pattern which coincides with the original table by varying more between communities than between stands within the same community.

A set of community tables is constructed, including only the stands within a recognized community. The investigator can then determine the constancy of each species and identify any character or indicator species. Constancy is the percentage of stands within a community which contain a species. The final table is constructed, listing only the species of a minimum constancy and the average cover of those species within each community. This tends to eliminate many of the less important species, including those that are present within the community only by chance. The constancy-cover table is organized according to the similarity of the communities to one another; it arranges the communities in a display that emphasizes their relationships further. In the constancy-cover table, indicator and character species are more obvious and may help in recognizing community-environmental relationships. If indicator species have high fidelity to one community, then they are referred to as character species of that community. If a group of species meet this classification, then the community is much more easily recognized. In the community description I use the term "maximal development" of the species, which refers to the community in which the mathematical product of constancy and cover in the final table is maximized.

If tables are constructed with a knowledge of certain changes in the environment, then they may exemplify a form of gradient analysis (Whittaker, 1967). If many of the site characteristics appear to be anomalous, it may serve well to dissolve the community and place its stands within the nearest neighbor community in the stand table. The time spent in such adjustments is not wasted and the resulting communities have usually stood up to computerized ordination (Mitchell, 1972; Hawk and Zobel, 1974; and Dyrness, Franklin and Moir, 1974). Construction of the constancy-cover table was done with the exclusion of species with less than 25% constancy in the community.

There is no standard set of terms referring to vegetation groupings which has been accepted to the exclusion of others. The final groupings identified here are called communities and are now defined as fairly homogeneous and somewhat repetitous groupings of species. Using the seral classes of Daubenmire (1952), a community capable of maintaining itself in a relatively unchanging state is an association. The collective area that includes actual samples or the seral equivalents of an association is the habitat type. Seral equivalents are the seral stages that have yet to reach climax, but show the potential to develop into the association. Climax here has the same definition as the association.

Further derived data include tree density in mature stands (those over 200 in the U.S. and those over 300 in Taiwan); basal area of trees in mature stands; and the size class distribution of major tree species in mature stands. Analysis of the above has been done with emphasis on Chamaecyparis species with other species included for comparisons of growth rates and environmental and successional interpretations.

Soils

Data Collection

Within a representative portion of each plot a shallow soil pit was excavated. Most soil pits vary between 20 and 150 cm in depth, depending upon the nature of the regolith. Roots were recorded by size and abundance for each horizon. All procedures follow those cited by the Soil Survey Staff (USDA, 1960). Each profile was divided into horizons on the basis of visually detected textural and structural differences. Soil descriptions all include depth limits and composition of organic layers, depth of horizons, moist color, texture, structure, moist and wet consistence and boundary characteristics of each horizon.

Estimation of the coarse fragments (gravel, cobble, and stone) was recorded as percentage volume within each horizon. Additional notes were taken on mottling and presence of charcoal or other organic matter in various horizons; buried profiles in alluviated areas were also recorded. Parent material was determined from coarse fragments taken throughout the profile.

Data Analysis

This study has not included any chemical analysis of soils. However, various aspects of the soil profiles have been used to check the fitness of any given stand within a particular community.

Climatic Data

At selected sites in Taiwan, Oregon and California environmental monitoring systems have been installed. In Taiwan the instruments include 30 day continuous air temperature and relative humidity recorders with the sensors located at 1 m above the ground. Instrumentation within the United States includes 30 day continuous air and soil temperature recorders with sensors mounted at 1 m and -.2 m respectively. There are 5 such stations in Taiwan (Figure 4) and 10 stations in the Pacific Northwest (Figure 1). The sites were chosen within areas thought to be representative of the major community types studied. These stations have already yielded some fine resolution information about on site environmental characteristics which otherwise would have to be extrapolated from distant weather stations.

Temperature charts from Pacific Northwest climatic stations have been digitized. Air temperature averages by months and 5 and 10 day intervals are available for October 1974 through April 1976.

Taxonomic Nomenclature

The taxonomic nomenclature followed during this study is that of Hitchcock and Cronquist (1973) for most species in the Pacific Northwest, supplemented by Munz and Keck (1973) for species which occur beyond the range covered by Hitchcock and Cronquist. The Pteridophyta and Gymnosperms of Taiwan follow Li (1975); other herbs follow Yang (1973), the Acanthaceae follow Hsieh (1972), and hardwood trees and shrubs follow Li (1963).

RESULTS AND DISCUSSION

Introduction

The results of this study have been divided into two sections: (1) a comparison of Taiwan and United States Chamaecyparis forest communities including (a) habitat characteristics such as aspect, elevation, and landform; and (b) community characteristics such as tree density, basal area, and tree heights, stand diversity, litter depth, reproductive density, successional status, and floristic comparisons; and (2) the description of major plant communities of Taiwan and the United States as well as the special habitats with Chamaecyparis lawsoniana.

Vegetation analysis has led to the separation of four plant communities in Taiwan (all in one zone) and eight plant communities within three zones in the range of Chamaecyparis lawsoniana (Appendix I). Constancy-cover tables for the communities are given in Table 16 for Taiwan and Table 17 for the United States.

Ecological Relationships

Physiography

Aspect. Aspect is the direction a plot faces. Taiwan and U.S. plots occur on most aspects. In both areas Chamaecyparis forests occur upon northwestern aspects more often than others, reflecting the mesic nature of Chamaecyparis forests in general (Figure 10). Chamaecyparis formosensis forests are more restricted to north and northwestern aspects than C. taiwanensis forests. In the U.S. only 12 stands occur on aspects between east and south. Higher elevation plots within a given community are less restricted to any given aspect.

In Taiwan 82% and in the U.S. 87% of the plots occur on aspects between 200 and 45 degrees (Figure 10). In Taiwan the Chta/shrub community (see Appendix I for definition of community names) is the least specific in aspect. The aspect modulates such factors as illumination,

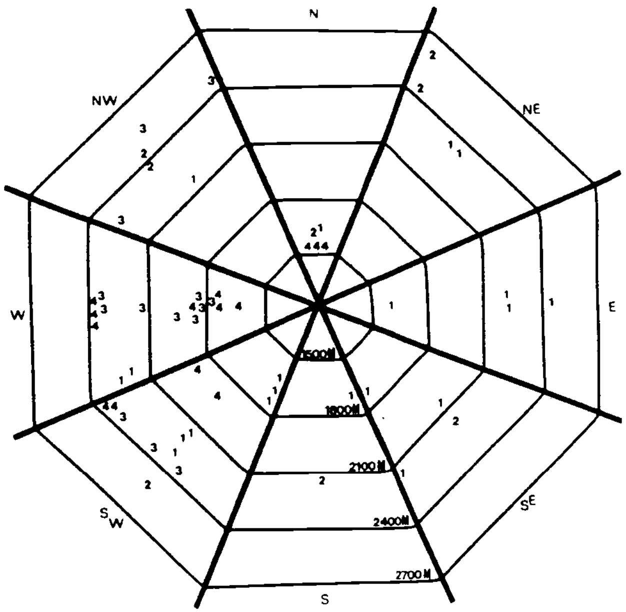


Figure 10A. Aspect and elevation of plots in major Taiwan Chamaecyparis communities (1 = Chta/shrub, 2 = Chta/bamboo, 3 = Chfo/bamboo, and 4 = Chfo/shrub).

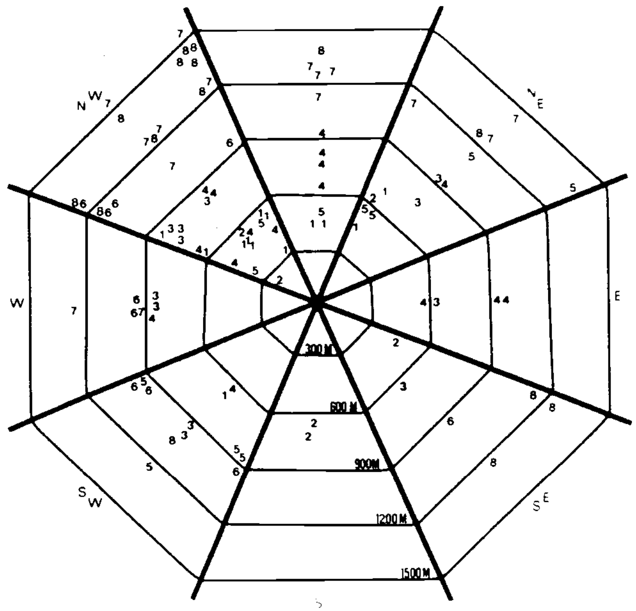


Figure 10B. Aspect and elevation of plots in major U.S. Chamaecyparis communities (1 = Tshe-Chla/Pomu-Oxor, 2 = Tshe-Chla/Rhma-Gash, 3 = Chla-Tshe/Xete, 4 = Chla/Lide, 5 = Pinus-Chla/Quva/Xete, 6 = Abco-Tshe-Chla, 7 = Abco-Chla/herb, and 8 = Abies-Chla/herb communities). See Appendix I for definitions of community names.

precipitation, evapotranspiration, temperature and possibly even structure of the stand with respect to the exposure to typhoons and monsoons in Taiwan.

Elevation. Elevation segregates communities of both Taiwan and the U.S. The two Taiwan species may be found sympatrically over most of their range, but at a given latitude Chamaecyparis taiwanensis communities extend about 200 meters to 500 meters higher than Chamaecyparis formosensis populations. Elevation modulates the total climate. In Taiwan mountains, rainfall presents no apparent barriers to Chamaecyparis growth. However, temperature has often been cited as being important. The optimum temperature for Chamaecyparis growth is 8 to 14 degrees C. (Lee, 1962). Lower elevation areas occupied by hardwoods have higher temperatures, and competition for mesic spots is more restrictive to Chamaecyparis. Higher mountain slopes maintain a fairly low temperature most of the year, with extremes which restrict Chamaecyparis; they are thus much more favorable to Tsuga chinensis and Abies kawakamii or the alpine brush fields of juniper and bamboo (Liu and Chang, 1962). At Ali Shan temperatures stay within 2.2 degrees C. of the optimum temperature for Chamaecyparis forests (Tsou, 1954). Lin, Lin, and Lu (1958) found Chamaecyparis formosensis seedling survival to be poorest at higher air temperatures.

Elevation also plays an important role in the segregation of C. lawsoniana communities. The three vegetation Zones can be differentiated by both latitude and elevation. Lower elevations in the north are within the Tsuga heterophylla Zone. Higher elevations (over 1000 meters, generally) are occupied by the Abies concolor Zone communities (Figure 10 and 27).

Landform. The landform occupied by a plot refers to its physiographic position (ridge, sideslope, bench, drainage), and slope position (topslope, middle slope, or bottom slope). The effects of landform include the modulation of drainage, litter accumulation, insolation, temperature, and disturbance by erosion. Landforms occupied by Chamaecyparis formosensis in Taiwan are lower and wetter than those of C. taiwanensis (Figure 11).

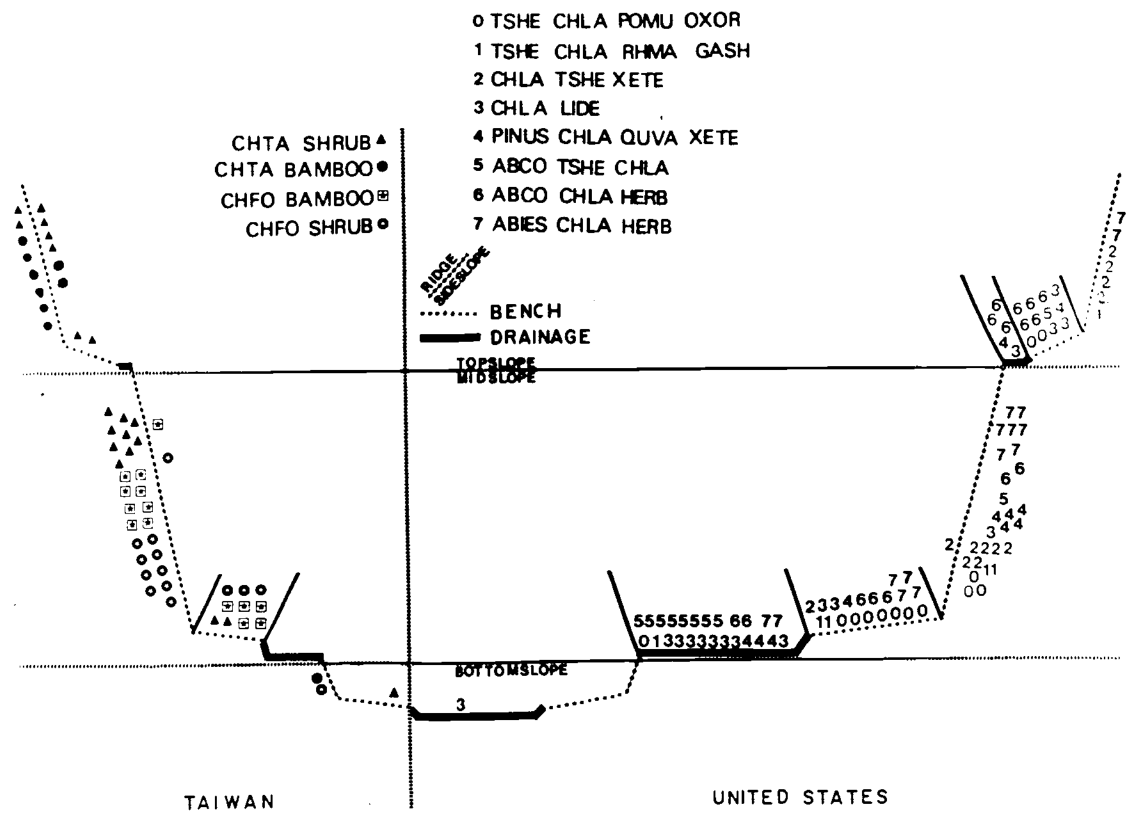


Figure 11A. Landforms occupied by Taiwan *Chamaecyparis* communities.

Figure 11B. Landforms occupied by United States *Chamaecyparis* communities.

In C. lawsoniana forests the landform distinctions between communities are more noticeable. Most Chamaecyparis communities have a higher moisture requirement than the adjacent plant communities. The site requirement for moisture is less restrictive in Taiwan than in the U.S. This is primarily due to the marked summer dry period in the U.S. which is generally lacking in Taiwan. Thus the drainage landform is more commonly occupied by C. lawsoniana than by Chamaecyparis species of Taiwan (Figure 11; Table 4). Whittaker (1960) has pointed out the similarity of vegetation on low nutrient sites to that of low moisture habitats. The Pinus-Chla/Quva/Xete community is not as restricted in landform as other low elevation communities since it occurs on benches and sideslopes of top and middle slope positions. However, stands of the shrub phase of this community are all on sideslopes while those of the herb phase are all in drainages (Figure 11).

Most U.S. and Taiwan Chamaecyparis communities appear to be midslope communities. Many factors could affect the distribution of Chamaecyparis species over the variety of landforms. Some landforms are more disease or fire-prone than others, while some tend to block free air flow resulting in cold pockets. Landform differences may even result in differential accumulation of nutrients and moisture and thus become a source for competitive interactions between Chamaecyparis and other species.

Community Structure

Tree Density. Tree density has been examined only for those plots taken in mature forests. The average tree density of the 12 communities studied is 401.6 trees/ha (hectare) (Tables 5 and 6 and Figure 12). Hardwood density in U.S. communities reaches 11% in only two communities (Tshe-Chla/Pomu-Oxor and the Abco-Tshe-Chla communities), but in Taiwan hardwoods exceed 35% of the tree density in all communities. In Taiwan the relative density of conifers is higher within the bamboo communities than in the shrub communities (Table 6).

Conifer tree density in Taiwan was higher than that of hardwoods in all but the Chfo/shrub community. At least 46% of the conifers were

Table 4. Landforms occupied by <u>Chamaecyparis</u> communities.

Community* name	Landforms: Topslope Ridge	Topslope Side	Topslope Bench	Topslope Drain	Midslope Ridge	Midslope Side	Midslope Bench	Midslope Drain	Bottomslope Ridge	Bottomslope Side	Bottomslope Bench	Bottomslope Drain
	Percentage of plots of a community within a landform type											
Chta/shrub*	20	10	10	--	--	45	10	--	--	--	5	--
Chta/bamboo	22	67	--	--	--	--	--	--	--	11	--	--
Chfo/bamboo	--	--	--	--	7	57	36	--	--	--	--	--
Chfo/shrub	--	--	--	--	7	64	21	--	--	7	--	--
Pinus-Chla/Quva/Xete	--	--	9	9	--	45	9	27	--	--	--	--
Chla/Lide	--	--	19	6	--	6	13	50	--	--	--	6
Chla-Tshe/Xete	--	33	--	--	8	50	8	--	--	--	--	--
Tshe-Chla/Rhma-Gash	--	17	--	--	--	33	33	17	--	--	--	--
Tshe-Chla/Pomu-Oxor	--	--	15	--	--	23	54	8	--	--	--	--
Abco-Tshe-Chla	--	--	10	--	--	10	--	80	--	--	--	--
Abco-Chla/herb	--	--	33	20	--	13	20	13	--	--	--	--
Abies-Chla/herb	--	13	--	--	--	47	27	13	--	--	--	--

* definitions of community names listed here are found in Appendix I

Table 5. Tree density of Chamaecyparis lawsoniana communities (trees per hectare for mature forest stands).

	Plant communities included*							
	Pinus Chla Quva Xete	Chla Lide	Chla Tshe Xete	Tshe Chla Rhma Gash	Tshe Chla Pomu Oxor	Abco Tshe Chla	Abco Chla herb	Abies Chla herb
Number of mature stands	3	12	9	4	11	10	7	12
Trees								
Total	285	389	497	313	342	464	674	396
Conifers	285	371	485	313	304	415	670	367
Chamaecyparis lawsoniana	133	287	273	198	131	221	552	182
Pseudotsuga menziesii	27	78	113	47	51	37	50	76
Tsuga heterophylla	---	---	59	67	114	88	---	---
Pinus spp.	97	7	9	---	---	---	35	7
Abies concolor	---	---	---	---	---	40	23	87
Abies magnifica	---	---	---	---	---	---	---	13
other conifers	28	---	31	7	3	29	12	15
hardwoods	---	18	12	---	38	49	4	16
Saplings (all conifers)								
Total	791	1082	762	373	810	715	2293	1165
Chamaecyparis lawsoniana	133	1008	439	107	218	243	1264	464
Pseudotsuga menziesii	151	40	33	120	5	5	274	131
Tsuga heterophylla	---	---	219	120	567	101	---	---
Pinus spp.	373	18	65	13	---	---	130	18
Abies concolor	107	---	---	---	---	221	483	453
Abies magnifica	---	---	---	---	---	---	---	20
others	26	16	6	14	12	245	142	78
Seedlings (all conifers)								
Total	1076	1033	1019	873	1214	1280	1820	1042
Chamaecyparis lawsoniana	320	636	539	380	313	397	678	347
Pseudotsuga menziesii	222	260	92	20	24	13	57	80
Tsuga heterophylla	---	---	279	440	807	259	---	---
Pinus spp.	417	89	71	7	---	16	80	67
Abies concolor	---	---	---	---	---	301	662	378
Abies magnifica	---	---	---	---	---	---	---	60
others	116	49	39	27	71	294	336	110

* definitions of community names are found in Appendix I

Table 6. Tree density of Taiwan Chamaecyparis communities (trees per hectare for mature forests).

	Plant communities included[1]			
	Chta/shrub	Chta/bamboo	Chfo/bamboo	Chfo/shrub
Number of plots included	14	7	11	14
Trees				
Total	389	309	389	372
Conifers	242	202	212	84
Hardwoods	147	107	177	288
Chamaecyparis taiwanensis	166	156	---	---
Chamaecyparis formosensis	---	---	97	74
Tsuga chinensis	76	31	78	4
Pseudotsuga wilsoniana	---	---	15	---
Picea morrisonicola	---	---	15	6
Pinus spp.	---	15	---	---
Taiwania	---	---	7	---
Saplings (conifers only)				
Total	266	130	65	21
Chamaecyparis taiwanensis	194	107	---	---
Chamaecyparis formosensis	---	---	34	4
Tsuga chinensis	55	8	2	---
Pinus spp.	15	15	29	---
other	2	---	---	17
Seedlings (conifers only)				
Total	1573	384	17	17
Chamaecyparis taiwanensis	950	263	---	---
Chamaecyparis formosensis	---	---	---	---
Tsuga chinensis	594	121	17	---
Pinus spp.	23	---	---	2
other	6	---	---	15

1/see Appendix I for definitions of community names

Chamaecyparis in all Taiwan communities. C. taiwanensis communities contain significantly more Chamaecyparis than do the Chamaecyparis formosensis communities. However, the C. formosensis communities have a greater basal area of Chamaecyparis. Alpine bamboo probably affects density and basal area. The lowest tree density is in the Chta/bamboo community. Within U.S. communities a minimum of 43% of the conifers present are Chamaecyparis lawsoniana.

Basal Area. Taiwan and U.S. communities are more distinct when comparing their tree basal areas along with density (Figures 12 and 13 and Table 7). Basal area of all communities studied ranged from 30 m^2/ha. to 177.3 m^2/ha., with an average of 124.9 m^2/ha. In each case Chamaecyparis species are the dominants. In Taiwan, bamboo communities have less basal area than their respective shrub communities. Basal area of Chamaecyparis formosensis communities is higher than that of C. taiwanensis communities as a result of the great diameters attained by old C. formosensis. Chamaecyparis formosensis is the largest conifer in eastern Asia, reaching 65 m in height and 6.5 m dbh (Li and Keng, 1954).

Within C. lawsoniana communities, which average 116.5 m^2/ha. basal area, the Abies concolor Zone communities average 112.0 m^2/ha., Tsuga heterophylla Zone communities average 138.5 m^2/ha., and Mixed Evergreen Zone communities average 90.2 m^2/ha. (Table 7, Figure 13). In all three zones basal area and total density appear to depend on the density of C. lawsoniana, and the "high" community occurs on mainly ultramafic parent materials. In the Mixed Evergreen Zone, both communities occur primarily on ultramafic parent materials, but the Chla/Lide community is on more mesic habitats than the Pinus-Chla/Quva/Xete community. It has been my observation, as well as that of others (Whittaker, 1960; Waring, 1969) that many species dominating forests adjacent to those like I studied are not nearly so competitive upon ultramafic substrates. Even Pseudotsuga menziesii becomes less important here (Tables 5 and 7). C. lawsoniana is relatively more vigorous on the ultramafic soils. In conclusion then, basal area of the trees in mature stands of each community appears to be a function of the density of Chamaecyparis lawsoniana.

Figure 12. Density of tree species in Chamaecyparis communities (trees per hectare within stands greater than 200 years old in the U.S. and greater than 300 years old in Taiwan). See stand tables in community description for definition of species.

The listing below is for Figures 12 and 13.

A. Abies concolor-Chamaecyparis lawsoniana/herb community

B. Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax community

C. Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community

D. Abies-Chamaecyparis lawsoniana/herb community

E. Chamaecyparis lawsoniana/Lithocarpus densiflora community

F. Chamaecyparis taiwanensis/shrub community

G. Chamaecyparis formosensis/bamboo community

H. Chamaecyparis formosensis/shrub community

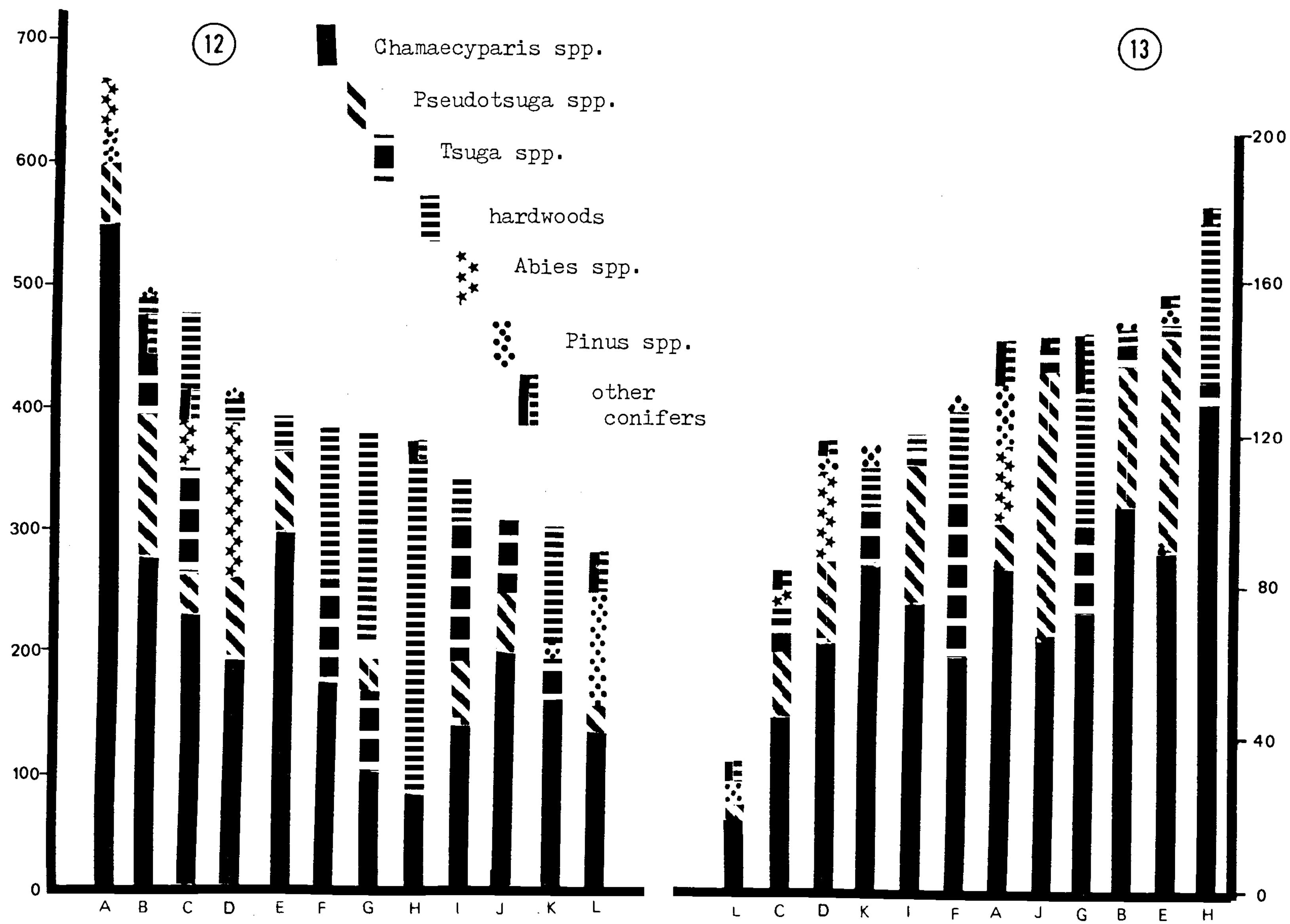
I. Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana community

J. Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon community

K. Chamaecyparis taiwanensis/bamboo community

L. Pinus-Chamaecyparis lawsoniana-Quercus vaccinifolia/Xerophyllum tenax community

Figure 13. Basal area of tree species in Chamaecyparis communities (m^2 per hectare in stands greater than 200 years old in the U.S. and greater than 300 years old in Taiwan). See stand tables in community description for identification of species (most genera are monospecific within a given community). See above list.



12
13
Chamaecyparis spp.
Pseudotsuga spp.
Tsuga spp.
hardwoods
Abies spp.
Pinus spp.
other conifers
700
600
500
400
300
200
100
0
A B C D E F G H I J K L
200
160
120
80
40
0
L C D K I F A J G B E H

Table 7. Tree basal area within Chamaecyparis communities (square meters per hectare for mature forests).

	U.S. Communities[1]								Taiwan Communities[1]			
	Pinus Chla Quva Xete	Chla Lide	Chla Tshe Xete	Tshe Chla Rhma Gash	Tshe Chla Pomu Oxor	Abco Tshe Chla	Abco Chla herb	Abies Chla herb	Chta shrub	Chta bamboo	Chfo bamboo	Chfo shrub
Number of stands sampled	3	12	9	5	12	10	9	12	14	8	11	14
Ave. basal area												
Total	30.0	150.4	150.0	144.4	121.3	83.1	139.1	113.8	127.5	115.4	145.8	177.3
Chamaecyparis[2]	18.9	89.9	102.0	68.4	76.4	46.0	87.0	65.9	62.7	87.8	75.1	128.6
Pseudotsuga	4.8	56.4	38.0	69.0	36.0	20.4	9.9	19.9	-----	-----	2.0	-----
Tsuga	-----	-----	5.1	5.3	6.1	9.2	-----	-----	39.4	12.6	22.9	5.1
Abies	-----	-----	-----	-----	-----	2.1	17.6	22.8	-----	-----	-----	-----
Pinus spp.	3.5	2.8	1.0	-----	-----	-----	15.8	2.1	2.5	4.7	-----	-----
Picea	.2	-----	-----	-----	-----	-----	.8	.7	-----	-----	10.4	2.8
other conifers	2.9	-----	.1	1.6	.5	3.3	7.6	1.7	-----	-----	3.4	-----
hardwoods	-----	1.7	2.5	-----	2.5	1.9	-----	.4	22.6	10.3	31.9	40.8

1/ see Appendix I for definitions of community names
2/ Genera are given for both Taiwan and U.S. (species are given in community descriptions)

This generality results from an apparent superior adaptation of Chamaecyparis lawsoniana to survive, and in some places even thrive, on the ultramafic soils where many of the normal competitors are less successful; the greatest exception to the generality is the Tshe-Chla/Pomu-Oxor community, where the average tree for a given age is much larger than in other communities.

Tree Heights of Chamaecyparis lawsoniana. Tree heights were measured within many C. lawsoniana plots. My data analysis has been directed at determining the importance of C. lawsoniana among communities. There is great variation in C. lawsoniana height growth in both mature and immature stages within any given community. Much of the growth within community variation is accounted for by local differences in degree of suppression by competitors and variation in degree of structural damage sustained by larger trees (i.e. broken leaders). I removed from analysis those trees which I knew to have broken tops and calculated the average height of all C. lawsoniana trees within 10 years of ages 100, 200 and 300 (Table 8). Only the 100 year old category of the Tshe-Chla/Rhma-Gash community had not been sampled adequately for any height determination. Height of C. lawsoniana among communities at 100 years is fairly uniform except that the trees in the Tshe-Chla/Pomu-Oxor community are at least 12 m taller than in any other community. I suspect that there is a little difference between the Tshe-Chla/Pomu-Oxor and the Tshe-Chla/Rhma-Gash communities in this respect. Growth within the Pinus-Chla/Quva-Xete community is also relatively greater in the first 100 years, because Chamaecyparis grows here in very open, usually moist microsites, with little competition. In other communities, many 100 year old trees probably developed as understory trees rather than in the open. By 200 years the difference in C. lawsoniana height among communities is more obvious, and it is even more so by 300 years. C. lawsoniana grows tallest in the three communities located on sedimentary or granitic parent materials; intermediate heights are attained upon soils which include some ultramafic parent material; and the least height is attained upon pure ultramafics.

I have calculated a general importance of Chamaecyparis lawsoniana

Table 8. Height and importance of <u>Chamaecyparis</u> <u>lawsoniana</u> in eight communities.

	Plant communities included 1/							
	Pinus Chla Quva Xete	Chla Lide	Chla Tshe Xete	Tshe Chla Rhma Gash	Tshe Chla Pomu Oxor	Abco Tshe Chla	Abco Chla herb	Abies Chla herb
Average height of Chamaecyparis lawsoniana at:								
100 years ± 10 years	18	12	13	--	30	12	13	12
200 years ± 10 years	21	29	25	45	47	26	25	36
300 years ± 10 years	29	44	31	53	63	41	46	50
Relative height of Chamaecyparis lawsoniana 2/ (based on 300 year olds)	8.1	12.3	8.7	14.8	17.6	11.5	12.9	14.0
Relative density of Chamaecyparis lawsoniana 3/ (based on 200 year old stands or older)	6.7	14.5	13.8	10.0	6.6	11.2	27.9	9.2
Relative basal area of Chamaecyparis lawsoniana 4/ (in stands 200 years old or more)	3.4	16.2	18.4	12.3	13.8	8.3	15.7	11.9
Importance	18.2	43.0	40.9	37.1	38.0	31.0	56.5	35.1

1/ see Appendix I for definitions of community names
2/ average height of 300+ year old trees/total of all averages from eight communities
3/ community density/total density of all communities
4/ community basal area/total basal area for all communities

within each community from the relative height, density and basal area of C. lawsoniana among communities and based only on values from mature stands. Each relative value is a percentage of the sum of that attribute (height, density, or basal area) computed for all eight communities (Table 8). It thus appears that C. lawsoniana is most important in those communities which occur on mixed or solely ultramafic parent materials. The great tree heights within the Tshe-Chla/Pomu-Oxor, Tshe-Chla/Rhma-Gash, and Abies-Chla/herb communities insure that these communities will have moderately high importance of C. lawsoniana. Note, however that this importance value is only a relative importance of Chamaecyparis lawsoniana between different communities and does not take other species into account. This importance value based on the number, basal area, and height of C. lawsoniana should be a fairly accurate estimation of C. lawsoniana volume differences among the communities.

Species Diversity. Taiwan communities contain twice as many tree species as do U.S. communities (Table 9), but the average number of tree species per plot was the same for both areas. There is greater variation between communities in both Taiwan and the U.S. communities with respect to the shrub layer diversity. The shrub layer of Taiwan communities contains considerably greater total diversity than that of the U.S. communities. Within Taiwan communities the shrub communities contained much greater diversity than did the Bamboo communities, apparently a direct result of the strong competition of the alpine bamboo. In the U.S. the communities within the Tsuga heterophylla Zone showed the least diversity in the shrub layer (Table 9). Herb layer diversity follows the pattern set by the shrub layer diversity. In Taiwan the shrub communities contained many more species of herbs than did the bamboo communities. In the U.S. the high elevation Abies concolor Zone communities showed the greatest diversity in the herb layer, although the Pinus-Chla/Quva/Xete community also contains high diversity (actually the latter community spans nearly the entire elevational range of the study and should be expected to show high diversity in all layers).

Total species diversity is much greater for the Taiwan communities

Table 9. Cover and diversity by strata of *Chamaecyparis* forest communities (cover in percent).

	Plant communities included[1/]											
	Pinus Chla Quva Xete	Chla Lide	Chla Tshe Xete	Tshe Chla Rhma Gash	Tshe Chla Pomu Oxor	Abco Tshe Chla	Abco Chla herb	Abies Chla herb	Chta shrub	Chta bamboo	Chfo bamboo	Chfo shrub
Number of plots sampled	11	16	12	6	13	10	15	15	20	9	14	14
Tree Layer												
species/community	10	12	10	10	8	11	10	11	20	22	22	21
species/plot	5	5	5	5	5	7	5	5	5	4	5	5
average actual mature cover	39	80	85	84	83	86	77	75	86	82	90	92
average actual immature cover	34	37	30	33	46	30	37	43	17	10	1	1
Shrub Layer												
species/community	23	30	18	20	19	15	32	36	100	80	80	110
species/plot	11	11	6	9	7	10	10	10	27	17	19	26
average accumulative shrub cover/plot	67	97	30	91	9	50	40	38	122	159	143	101
Herb Layer												
species/community	46	44	40	32	45	53	76	70	65	45	60	93
species/plot	20	14	11	13	18	16	27	25	13	8	13	16
average accumulative herb cover/plot	27	8	25	24	60	16	20	23	28	15	30	32
average accumulative moss cover/plot	6	19	45	40	39	7	1	4	29	23	22	17
Average number of vascular species/plot	35	30	22	27	30	33	42	40	45	29	37	47

1/ see Appendix I for definitions of community names

than for the U.S. communities. Other Oregon and Washington Cascade Mountain communities show varying species diversity which is comparable to the diversity in C. lawsoniana forests in that the high elevation stands typically have greater herb diversity and less shrub diversity, while low elevations have high shrub diversity.

Litter Depth. Taiwan Chamaecyparis forests differ greatly from those in the Pacific Northwest in the depth of the litter layer, in which I include all of the organic layers. Litter depth of most U.S. communities averages one to four centimeters. Taiwan forests have much deeper litter layers (Figure 14). Due to the large amount of leaf litter added annually by alpine bamboo, it was expected that the bamboo communities would have thicker litter layers than their respective shrub community variants. This is less marked in the C. formosensis communities than in the C. taiwanensis communities (Figure 14). This difference is probably due to a combination of the facts that decomposition in the lower elevation, warmer C. formosensis forests is probably faster than in the C. taiwanensis forests at higher elevations, and the total amount of alpine bamboo present in the two types is much higher in the C. taiwanensis community than in the C. formosensis community.

Reproductive Density. Several striking generalities are obvious from the density of tree reproduction (Tables 5 and 6): (1) U.S. communities typically contain many more seedlings and saplings than do the Taiwan communities; (2) there is a sharp difference between regeneration of conifers in C. taiwanensis and C. formosensis communities; and (3) within the C. taiwanensis communities there is a greater density of immature trees within the shrub community than within the bamboo community.

Reproduction within the C. formosensis communities is negligible. Within C. taiwanensis communities there are 2.0 and 4.2 times as many saplings and seedlings respectively within the shrub community as there are in the bamboo community (Table 6). Another significant difference between the shrub and the bamboo communities here is in the amount of overlapping of the shrubs within the shrub stratum; the actual shrub cover in the shrub community is only 66% compared to 99% within the bamboo community. The tree ages of the stands that I sampled are similar, and mature conifers have similar densities, so it appears that the

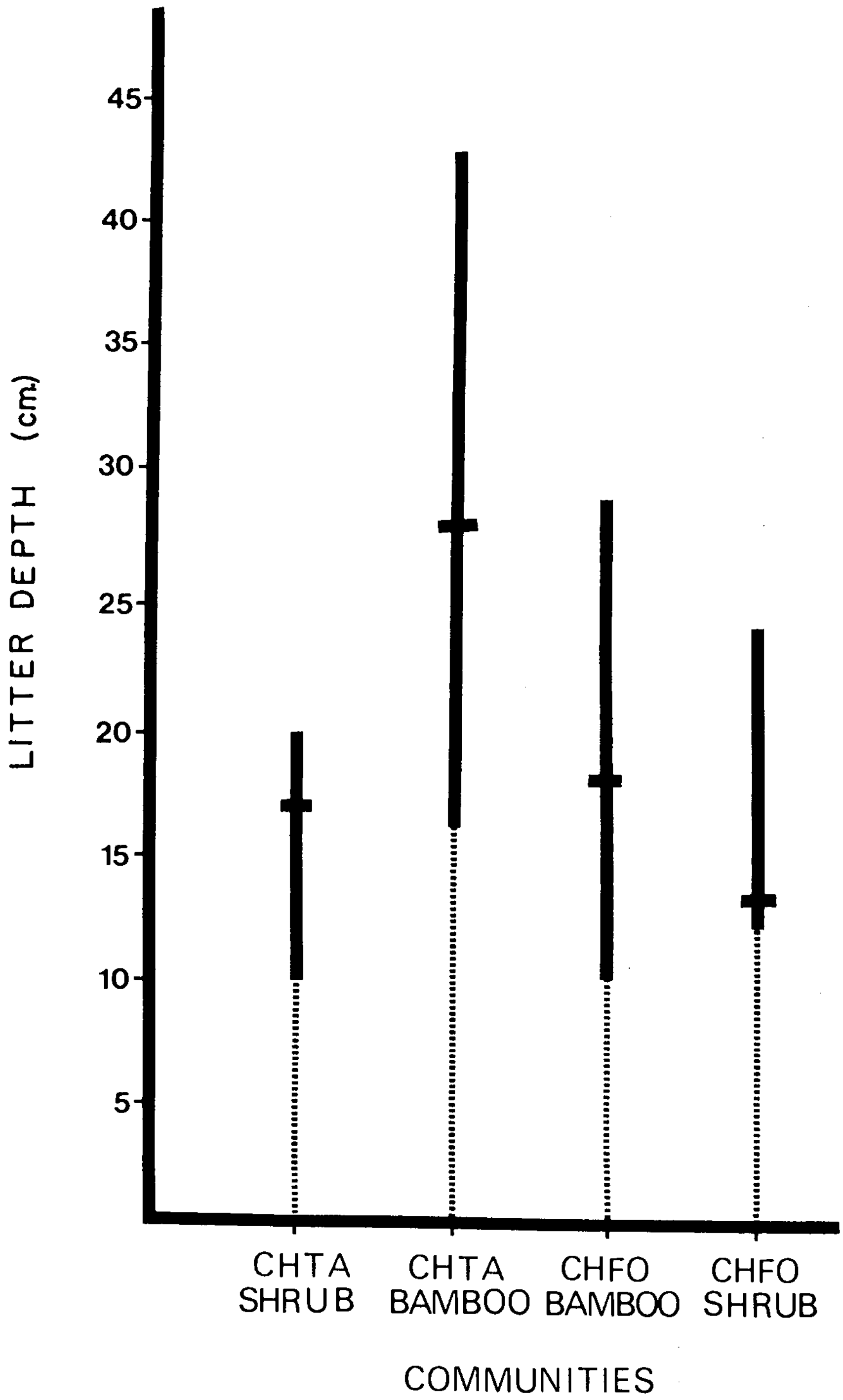


Figure 14. Range and mean of litter depth in Taiwan Chamaecyparis communities.

differences in reproduction are due to the litter layer and shrub density, which are both affected by the alpine bamboo.

Using the stand maps (Figure 9) it was possible to determine the distance of saplings from major canopy openings (Table 10). Here it is seen that C. taiwanensis saplings in mature stands are found predominantly within or near the major canopy openings and that C. formosensis saplings all occurred within one meter of canopy openings. Hung (1971) found that growth form of both Chamaecyparis species and Tsuga chinensis was substandard in stands with alpine bamboo. He also states that seedling density within all natural stands is very low and that competition with bamboo at upper elevations and with hardwood species at lower elevations is reflected in the lower density of conifer seedlings and saplings. Chamaecyparis seedlings were common only to roadsides, bare areas and landslides in a study at Tai Ping Shan (Chang, 1963). Many more seedlings occurred within burned areas than in unburned clearcuts in the same study. Chang concluded that both cypress species are semi shade tolerant. Chamaecyparis formosensis shows its best height growth at 64% light intensity, but the mean diameter growth of plantation saplings was best at higher light intensities (Lin, Lin, and Lu, 1958). They also found that mean growth of branches, leaves, and roots was best at 100% light intensity and decreased with less light. Lee (1962) also contends that C. formosensis and C. taiwanensis are both light demanding species and do not regenerate in dense hardwood forests or other thick canopied forests. Thus, competition with the dense tree canopy, the denser shrub or bamboo layer at high elevations, and with the hardwood trees at lower elevations appear to decrease the density of all conifer reproduction.

Chamaecyparis lawsoniana grows well in the open, but it is much more shade tolerant than the Taiwan species. Chamaecyparis lawsoniana was the most shade tolerant of eight western tree species studied(including five potential competitors of Chamaecyparis lawsoniana) by Baker (1945). Overhead lighting is necessary for rapid growth (Fowells, 1965). In this respect the Chamaecyparis of Japan seem to be more like those of the United States since Sato (1974) reports that Chamaecyparis obtusa

Table 10. Distance of Taiwan Chamaecyparis saplings from major canopy openings.

Species	Distance from vertical projection of opening								Total Saplings
	0m	1m	2m	3m	4m	5m	6m	7+m	
	number of saplings								
Chamaecyparis taiwanensis (stands>250 years old)	30	30	27	26	15	11	1	3	143
Chamaecyparis taiwanensis (stands<250 years old)	189	--	1	--	--	--	--	1	191
Chamaecyparis formosensis (all stands)	38	3	--	--	--	--	--	--	41
All Chamaecyparis saplings	257	33	28	26	15	11	1	4	375

which is very shade tolerant, grows best at 3% light intensities. My data (Table 5) show that C. lawsoniana competes well with Tsuga heterophylla on mesic northern locations and with Abies concolor at higher elevations throughout the range of the genus in Oregon and California. Chamaecyparis lawsoniana regenerates in fairly large amounts in all U.S. communities (Table 5). Parent material variation within Chamaecyparis lawsoniana forests is great. Thus I have grouped seedlings and saplings according to community and soil parent materials within the communities (Table 11). Only mature stands were compared. Sedimentary soils support the fewest saplings and seedlings. In the table, "other" includes such diverse parent materials that it is difficult to compare with specific parent material types; however, it may average more than the density maintained on ultramafic or mixed ultramafic parent materials. When a community contains plots on several of these parent materials, the plots on non-ultramafic types contain more Chamaecyparis than those on ultramafic parent materials (except in the Chla/Lide community where there is no competition from either Tsuga heterophylla or from Abies concolor). Within the Chla-Tshe/Xete community there is considerable competition for understory space with Tsuga heterophylla, and within the Abco-Chla/ herb community Abies concolor is the major competitor for space with Chamaecyparis (Table 5). In the Abco-Tshe-Chla community most parent materials are mixed because of severe alluviation and colluviation, and in most upper horizons ultramafic material does occur. In all three Zones the community which is highest in C. lawsoniana density (both seedlings and saplings) is always the most mesic community of the zone occurring on pure or mixed ultramafic soil parent material (Table 5).

Successional Status. Succession is defined here as change of an ecosystem toward an equilibrium called climax. The concept of climax is hard to convey because of the diverse meanings the word has acquired in ecology. Is it an optimum, a static entity, or an equilibrium system? I define it as an equilibrium vegetation system which is self sustaining and relatively unchanging in its vegetational parameters in the absence of major environmental fluctuations. In agreement with Clements (1916)

Table 11. Density of *Chamaecyparis lawsoniana* tree reproduction in relation to parent materials (trees per hectare, data from stands over 200 years old).

Communities[1/]		Parent materials included			
		Sedimentary	Ultramafic	Ultramafic mix	Other (granodiorite, gabbro, volcanics, meta-sedimentary)
Tshe-Chla/Pomu-Oxor	saplings	213	---	---	---
	seedlings	320	---	---	---
Tshe-Chla/Rhma-Gash	saplings	107	---	---	---
	seedlings	373	---	---	---
Chla-Tshe/Xete	saplings	---	400	427	587
	seedlings	---	347	720	933
Chla/Lide	saplings	---	1120	1707	480
	seedlings	---	827	827	427
Pinus-Chla/Quva/Xete	saplings	---	133	---	---
	seedlings	---	320	---	---
Abco-Tshe-Chla	saplings	---	---	160	267
	seedlings	---	---	560	320
Abco-Chla/herb	saplings	---	613	1040	2507
	seedlings	---	640	587	853
Abies-Chla/herb	saplings	---	---	---	453
	seedlings	---	---	---	347

1/ see Appendix I for definitions of community names

it includes nudation, migration, ecesis, competition, reaction, and stabilization stages or processes. Before attaining the climax, the system is noticeably dominated by certain species or stages of vegetation while other species interact with and possibly modify portions of the system along with the dominants in such a way as to prepare the system for entry by other (later seral) species. Following immigration, dominants become evident, and it becomes obvious that proximity to existing floras is an important factor in determining the structure and diversity of all seral stages, as well as climatic, physiographic, or edaphic factors. Succession then, will produce equality in two areas only if the physical, biotic, and historic factors are equivalent in their effect. It is possible that very similar habitats will maintain very different plant associations due to the peculiarities of invading species (proximity of seed source).

In Taiwan, secondary succession within areas occupied by Chamaecyparis species has rarely been discussed within the literature. Chang (1963) and Liu (1963) indicate a similar scheme of secondary succession for communities of both cypress species in Taiwan. Disturbances which lead to secondary succession include wildfire, mass land movements, and more recently clearcutting of forests by man. Burned areas typically develop a thick stand of Miscanthus, often mixed with a variety of stump sprouts of pre-fire shrubs and hardwood tree species. Liu (1963) describes the succession after fire in a Tsuga chinensis-Chamaecyparis taiwanensis forest as being pioneered by mixed Miscanthus and alpine bamboo. He showed a progression of stages, which he feels are representative, through mixed Pinus taiwanensis-Pinus armandii forest, back to Tsuga chinensis and Chamaecyparis taiwanensis forests. He also emphasizes the probability of repeated fires in the early seral stages occupied by Miscanthus or alpine bamboo. In lightly burned areas, large trees may die while the litter layer is only scorched in the fire. Here stump sprouts of hardwoods are common and vigorous. Cover of the sprouts is often greater than in adjacent forests after as little as only one years growth following fire. Within such incompletely burned areas are early successional indicators such as Gaultheria cumingiana, Lonicera acuminata, and Litsea cubeba. The time involved in the transition from grassland to mature Chamaecyparis-Tsuga forests is variable. It appears to take between 200 and 300 years without new fire before a noticeable decrease in Pinus occurs and the domination of the canopy by Chamaecyparis begins.

Chang (1963) has shown fire within C. formosensis forests leading again to a grassy pioneer stage of alpine bamboo, Miscanthus, or both. This grassland, if unburned, then progressed through mixed shrubland until dominated by members of the Lauraceae and Fagaceae in most areas, with a final seral stage being the temperate hardwood forest. He does not mention Chamaecyparis formosensis reentering the community in secondary succession.

Climax forests in Taiwan may take as long as 1000 years to develop if there are no major disturbances. During the late stages of succession forests may develop either a shrub or a bamboo dominated understory. Alpine bamboo may enter any area and get a foothold from which it slowly spreads.

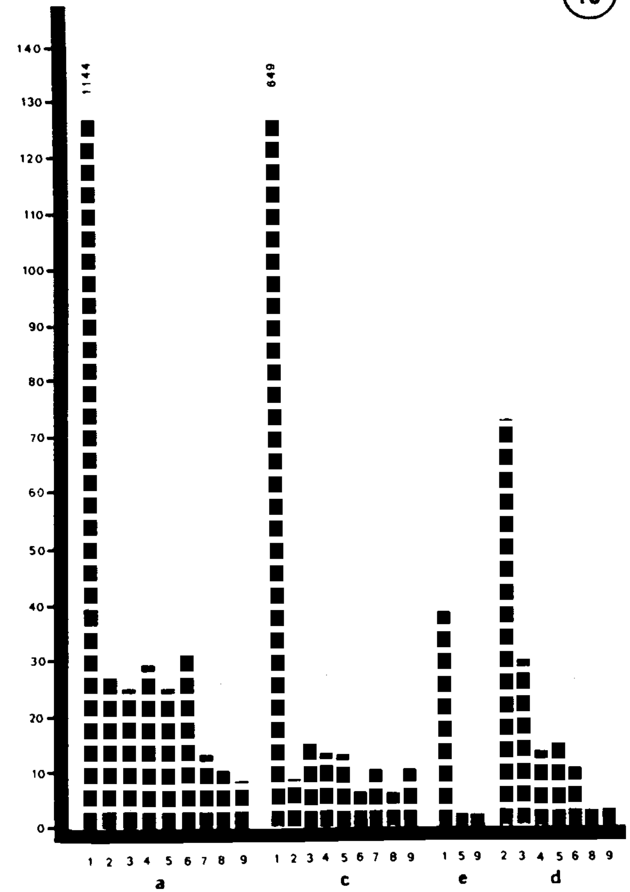
Taiwan foresters have long noted the ability of cypress species to literally inundate roadcuts, fills, and natural landslides or talus fields. Species diversity on natural landslides is quite low compared to that on partially burned sites or adjacent forests. Many species are undoubtedly lost during the disturbance. Forests which have developed upon a large talus field or landslide are typically much more even-aged, and they appear more homogeneous throughout most strata. Rapid invasion by Chamaecyparis on such sites yields the fairly even-aged canopy, and the stand remains homogeneous with only one tree layer for several decades until some suppressed trees begin to fall out, adding to the total diversity of the environment.

If a good correlation between diameter and age of trees exists, then size class distributions of species should be instructive about succession. Both Chamaecyparis species and Tsuga chinensis are present in nearly all size classes in the stands that are over 300 years old (Figures 15 through 18). Most of the species show the J shaped curve of size class distribution, which is the typical curve expected for uneven aged stands (Smith, 1962). Tree size class distribution within Taiwan Chamaecyparis forests indicates that at least C. formosensis is not

Figure 15. Size class distribution of trees within mature stands of the *Chamaecyparis taiwanensis*/shrub community (trees per hectare; a = *Chamaecyparis taiwanensis*, c = *Tsuga chinensis*, e = *Pinus*, and d = mixed hardwoods; each size class represents 15 cm diameter with class 1 = 0-15 cm).

Figure 16. Size class distribution of trees within mature stands of the *Chamaecyparis taiwanensis*/bamboo community (trees per hectare; a = *Chamaecyparis taiwanensis*, c = *Tsuga chinensis*, e = *Pinus*, and d = mixed hardwoods; each size class represents 15 cm diameter with class 1 = 0-15 cm).

15



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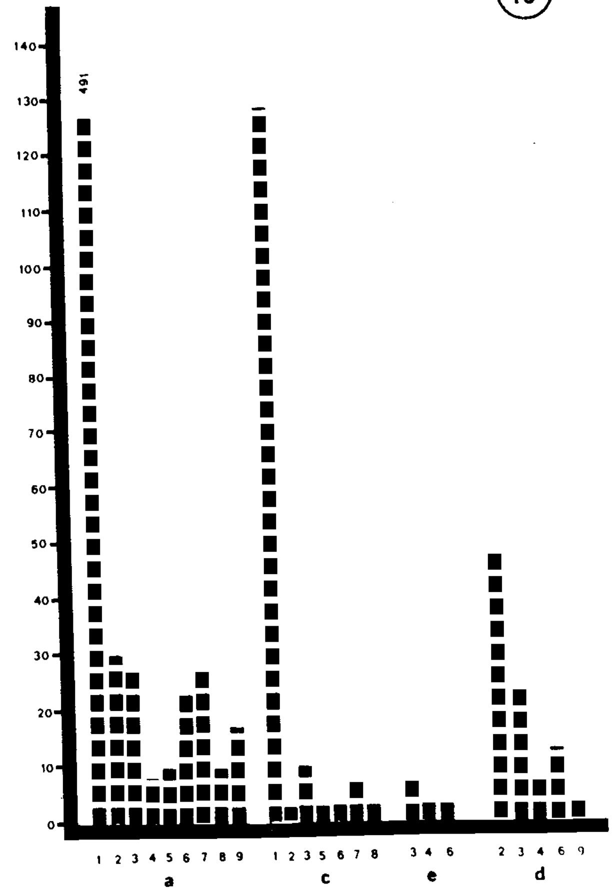
d

16



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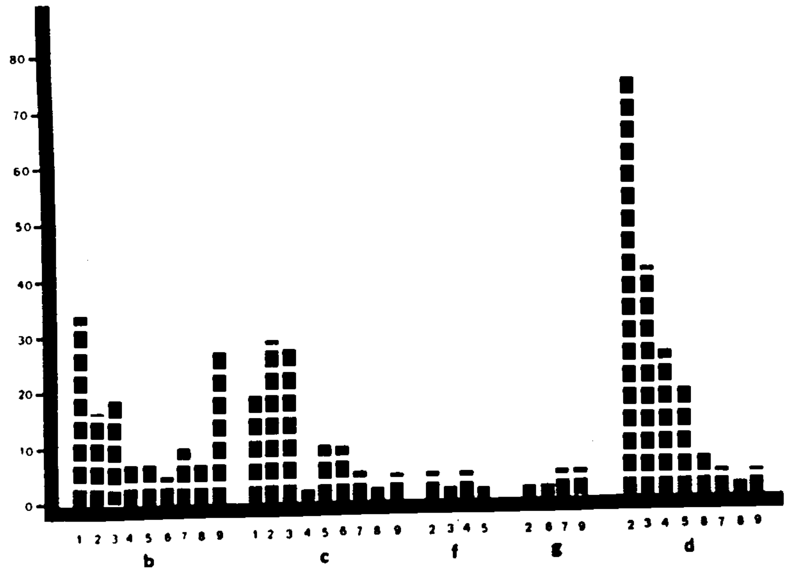
1 2 3 4 5 6 7 8 9
a
1 2 3 5 6 7 8
c
3 4 6
e
2 3 4 6 9
d

Figure 17. Size class distribution of trees within mature stands of the *Chamaecyparis formosensis*/bamboo community (trees per hectare; b = *Chamaecyparis formosensis*, c = *Tsuga chinensis*, f = *Pseudotsuga wilsoniana*, g = *Picea morrisonicola*, e = *Pinus*, and d = mixed hardwoods; each size class represents 15 cm diameter with class 1 = 0-15 cm).

Figure 18. Size class distribution of trees within mature stands of the *Chamaecyparis formosensis*/shrub community (trees per hectare; b = *Chamaecyparis formosensis*, c = *Tsuga chinensis*, g = *Picea morrisonicola*, h = *Cephalotaxus*, e = *Pinus*, and d = mixed hardwoods; each size class represents 15 cm diameter with class 1 = 0-15 cm).

(17)



80
70
60
50
40
30
20
10
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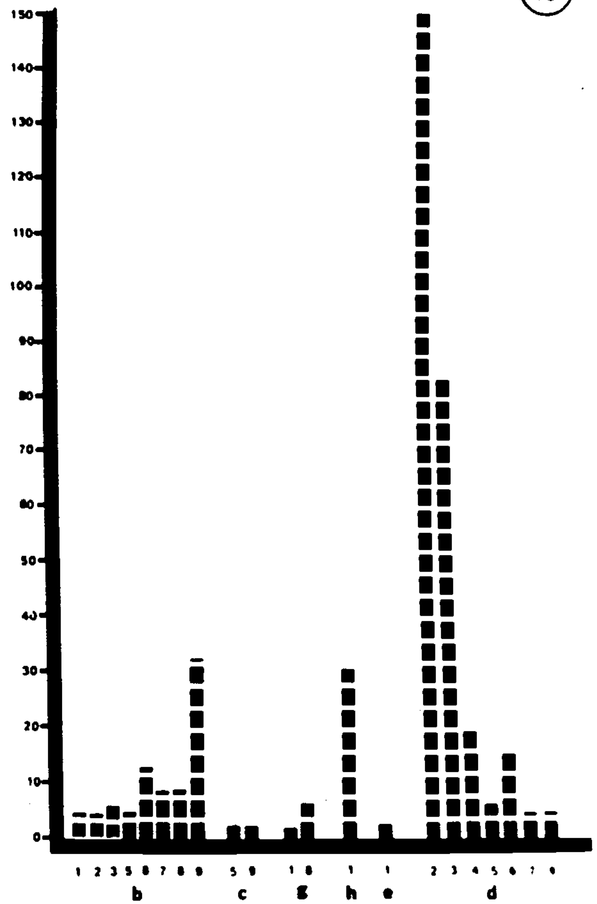
b
c
f
g
d

(18)



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replacing itself sufficiently to maintain dominance in a climax stand (Figures 15 through 18). However, both species in Taiwan are late seral species, perhaps due to the fact that these trees grow to be 2000 or more years old. Within that life span they have adequate opportunity to regenerate since they often may live through three or more generations of their associated species.

The genus should be regarded as a quasi-climax in Taiwan, regenerating slowly but surely. Pure stands of either species in the climax situation will probably be found only in very small patches. The regeneration under forest canopy is a greater problem within the C. formosensis stands than in those of C. taiwanensis. This is more apparent in the size class distribution within the shrub community than in the bamboo community of C. formosensis (Figures 17 and 18). The size class distribution of hardwood species in both of the C. formosensis communities is typical of late seral species. Species such as Pseudotsuga wilsoniana, Picea morrisonicola, and Taiwania cryptomerioides appear to be early seral species, since they are present only in larger size classes and in the older stands.

In the U.S. long lived species with broad environmental tolerances such as Pseudotsuga menziesii function as dominants in early as well as late seral stages of different communities. Chamaecyparis lawsoniana appears to be another such species. Characteristics of the environment which seem to be necessary for the establishment and survival of Chamaecyparis lawsoniana include: (1) low microsite moisture stress; (2) a sufficient growing season length to maintain germination, establishment and growth of seedlings; (3) presence of a seed source; and (4) the lack or reduced vigor of other species which can compete to the exclusion of Chamaecyparis lawsoniana. Chamaecyparis lawsoniana reproduces well in shaded areas, but on open sunny slopes it will also thrive if soil moisture is sufficient. In different parts of the range of the species the different conditions above will interact differently to produce Chamaecyparis communities.

The successional role of C. lawsoniana appears to vary with the environments of the sites. Chamaecyparis lawsoniana exists in ecosystems whose ultimate vegetation has been maintained at least partially by fire: thus the probability of a climax forest forming has been negligible. With fire control it is probable that man will create forest types which have never existed naturally.

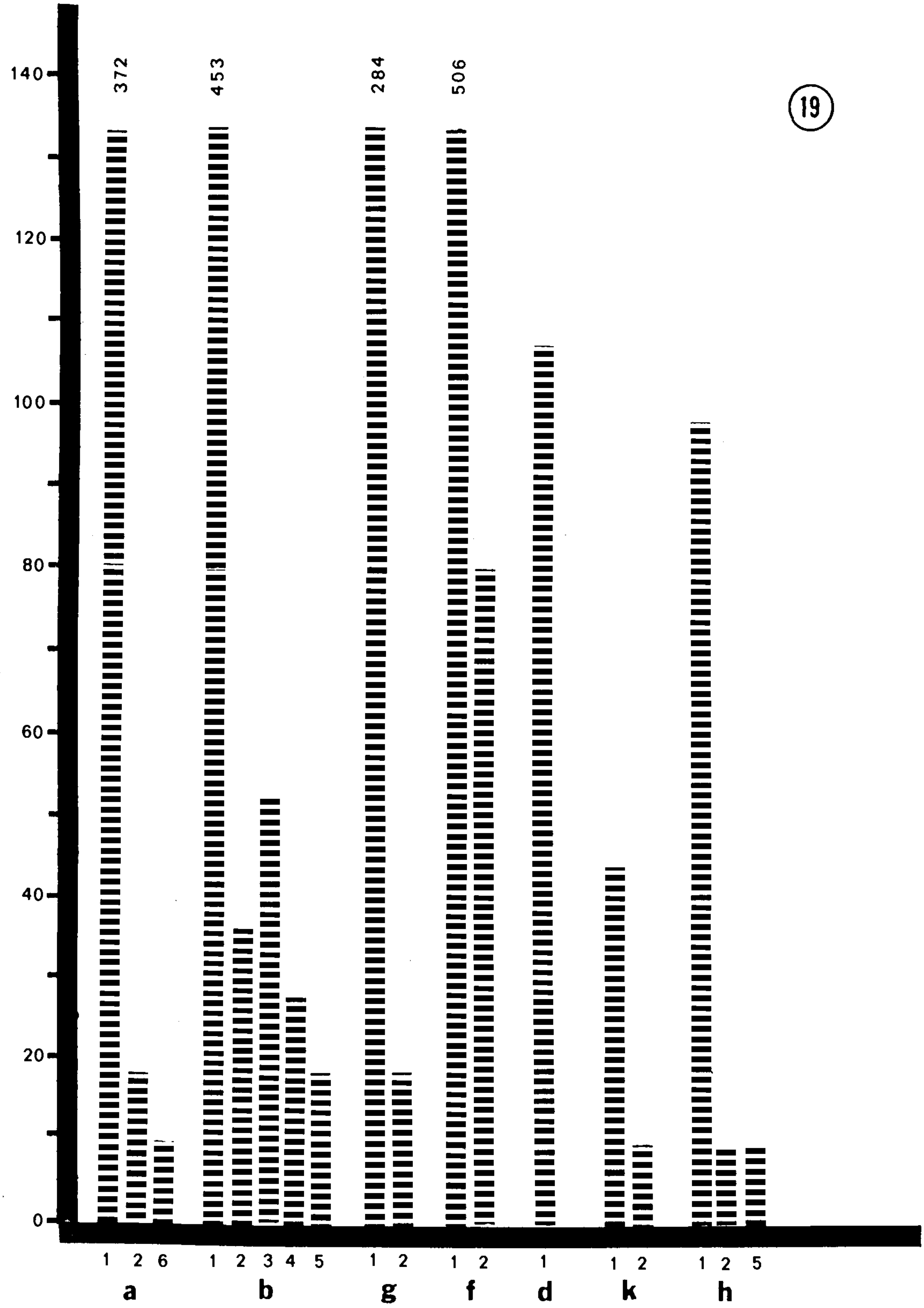
Differences among communities and zones in size class distribution of trees in mature stands are instructive in pointing out the variability in the successional role of Chamaecyparis lawsoniana (Figures 19 through 26). In nearly all of the communities Pseudotsuga menziesii, with a proponderance of large trees in the older stands, appears to be a pioneer. Within the Mixed Evergreen Zone and in the Chla-Tshe/Xete community of the Tsuga heterophylla Zone, there are more smaller Pseudotsuga menziesii as well as larger trees of the species; here it is probably at least a co-climax tree species.

In higher elevation communities C. lawsoniana is well represented in smaller size classes with relatively few large trees (Figures 25 and 26). In the transitional Abco-Tshe-Chla community and those of the Tsuga heterophylla Zone and Mixed Evergreen Zone there are also high relative densities of small trees, but the other size classes are present in multimodal distribution which would appear to develop as a result of periodic establishment of groups of trees. Periodic fires could cause fluctuations like these. Since larger Chamaecyparis lawsoniana have superior fire resistance, the species persits as a seed source for post fire invasion. In the case of incomplete burns, its shade tolerance would give C. lawsoniana an advantage over potential competitors.

Tsuga heterophylla, where it occurs, is a late seral species with mostly smaller individuals present. Only rarely does Tsuga heterophylla have fire scars; in many cases the older Tsuga may be used in dating the last fire. Abies concolor, and Abies grandis, where they occur, act similar to Tsuga heterophylla. In the Abco-Tshe-Chla community of the Galice study area (Figure 1), where both Tsuga and Abies concolor occur, Tsuga appears to precede Abies concolor in the understory and to be eventually replaced by it (Figure 24).

Other tree species are important locally as indicators of various seral stages. Taxus brevifolia, present in most communities, is always a small tree. It is even found on mesic serpentine soils at all elevations. In communities of the Abies concolor Zone and within the high

Figure 19. Size class distribution of trees within mature stands of the _Pinus_-_Chamaecyparis_ _lawsoniana_/_Quercus_ _vaccinifolia_/_Xerophyllum_ _tenax_ community (trees per hectare; a = _Pseudotsuga_ _menziesii_, b = _Chamaecyparis_ _lawsoniana_, g = _Pinus_ _jeffreyi_, f = _Pinus_ _monticola_, d = _Abies_ _concolor_, k = _Picea_ _breweriana_, and h = _Calocedrus_ _decurrens_; each size class represents 15 cm diameter with class 1 = 0-15 cm).



140
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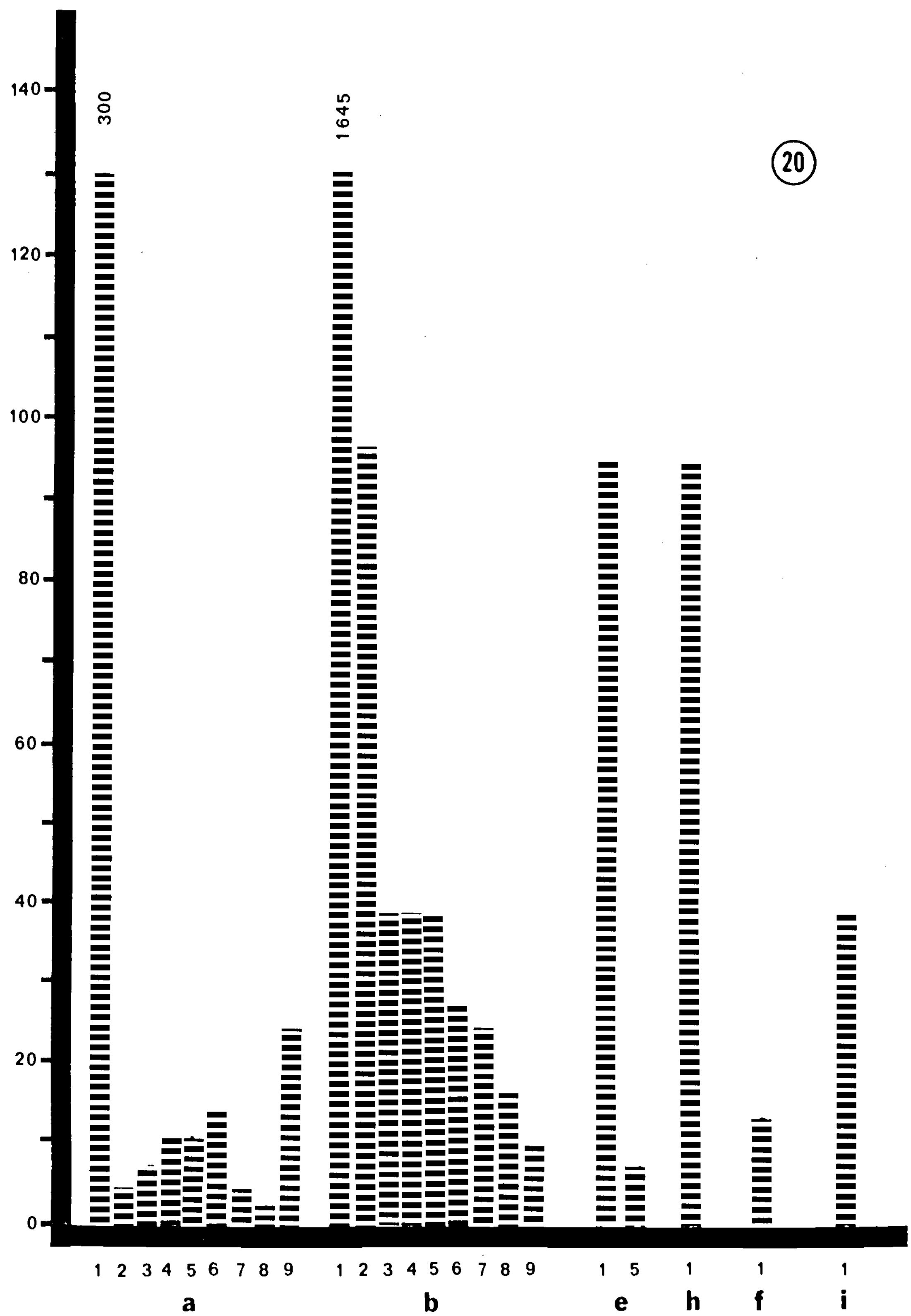
372
453
284
506
19
1 2 6
1 2 3 4 5
1 2
1 2
1
1 2
1 2 5
a
b
g
f
d
k
h

Figure 20. Size class distribution of trees within mature stands of the *Chamaecyparis lawsoniana*/*Lithocarpus densiflora* community (trees per hectare; a = *Pseudotsuga menziesii*, b = *Chamaecyparis lawsoniana*, e = *Pinus lambertiana*, h = *Calocedrus decurrens*, f = *Pinus monticola*, and i = *Taxus brevifolia*; each size class represents 15 cm diameter with class 1 = 0-15 cm).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120
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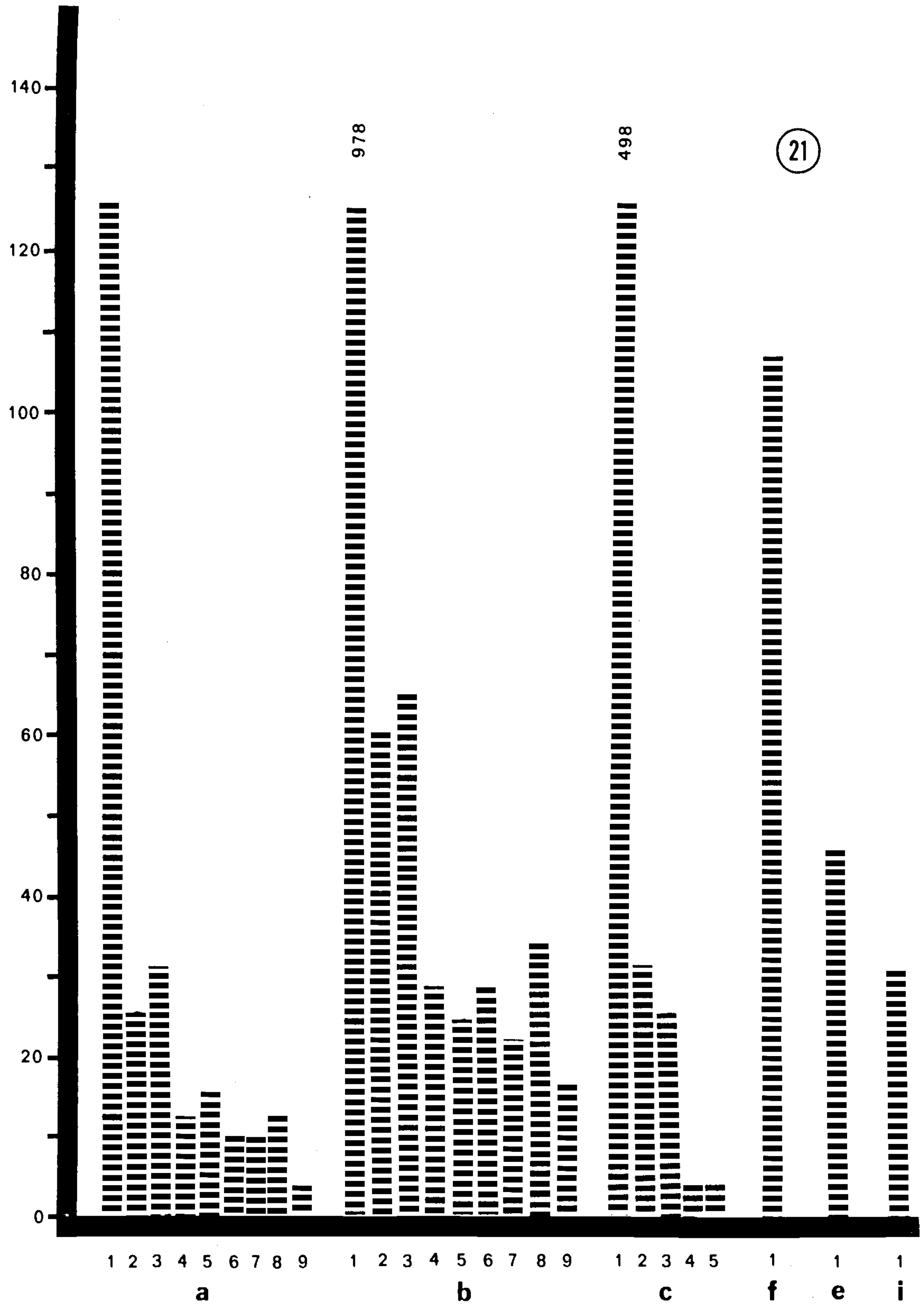
80
60
40
20
0
300
1645
20
1 2 3 4 5 6 7 8 9
a
1 2 3 4 5 6 7 8 9
b
1 5
e
1
h
1
f
1
i

Figure 21. Size class distribution of trees within mature stands of the Chamaecyparis lawsoniana-Tsuga heterophylla/ Xerophyllum tenax community (trees per hectare; a = Pseudotsuga menziesii, b = Chamaecyparis lawsoniana, c = Tsuga heterophylla, f = Pinus monticola, e = Pinus lambertiana, and i = Taxus brevifolia; each size class represents 15 cm diameter with class 1 = 0-15 cm).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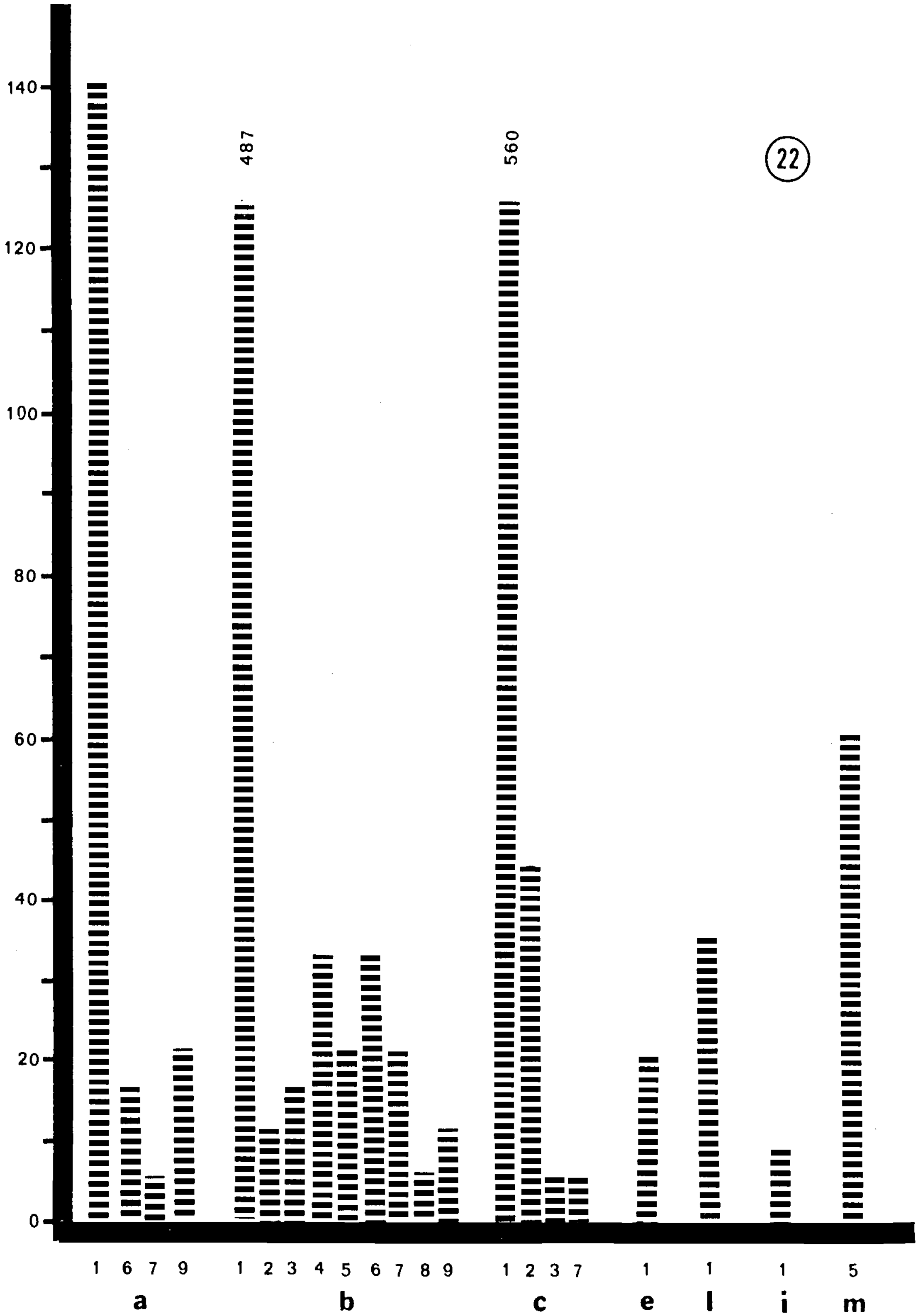
120
100
80
60
40
20
0
978
498
21
1 2 3 4 5 6 7 8 9
a
1 2 3 4 5 6 7 8 9
b
1 2 3 4 5
c
1
f
1
e
1
i

Figure 22. Size class distribution of trees within mature stands of the Tsuga heterophylla-Chamaecyparis lawsoniana/ Rhododendron macrophyllum-Gaultheria shallon community (trees per hectare; a = Pseudotsuga menziesii, b = Chamaecyparis lawsoniana, c = Tsuga heterophylla, e = Pinus lambertiana, l = Abies grandis, i = Taxus brevifolia, and m = Thuja plicata; each size class represents 15 cm diameter with class 1 = 0-15 cm).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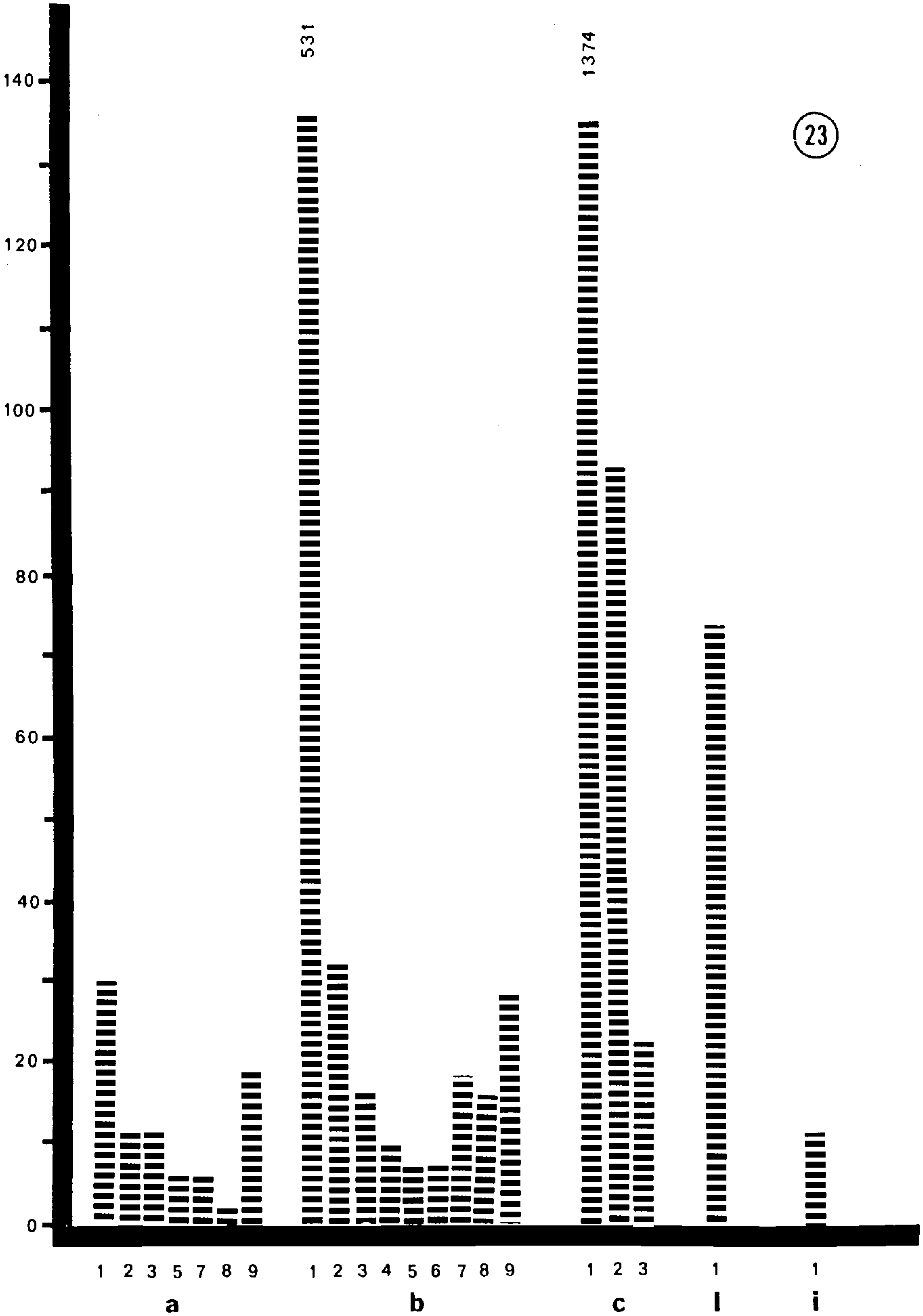
60
40
20
0
487
560
22
1 6 7 9
a
1 2 3 4 5 6 7 8 9
b
1 2 3 7
c
1
e
1
l
1
i
5
m

Figure 23. Size class distribution of trees within mature stands of the _Tsuga_ _heterophylla_-_Chamaecyparis_ _lawsoniana_/_Polystichum_ _munitum_-_Oxalis_ _oregana_ community (trees per hectare; a = _Pseudotsuga_ _menziesii_, b = _Chamaecyparis_ _lawsoniana_, c = _Tsuga_ _heterophylla_, 1 = _Abies_ _grandis_, and i = _Taxus_ _brevifolia_; each size class represents 15 cm diameter with class 1 = 0-15 cm).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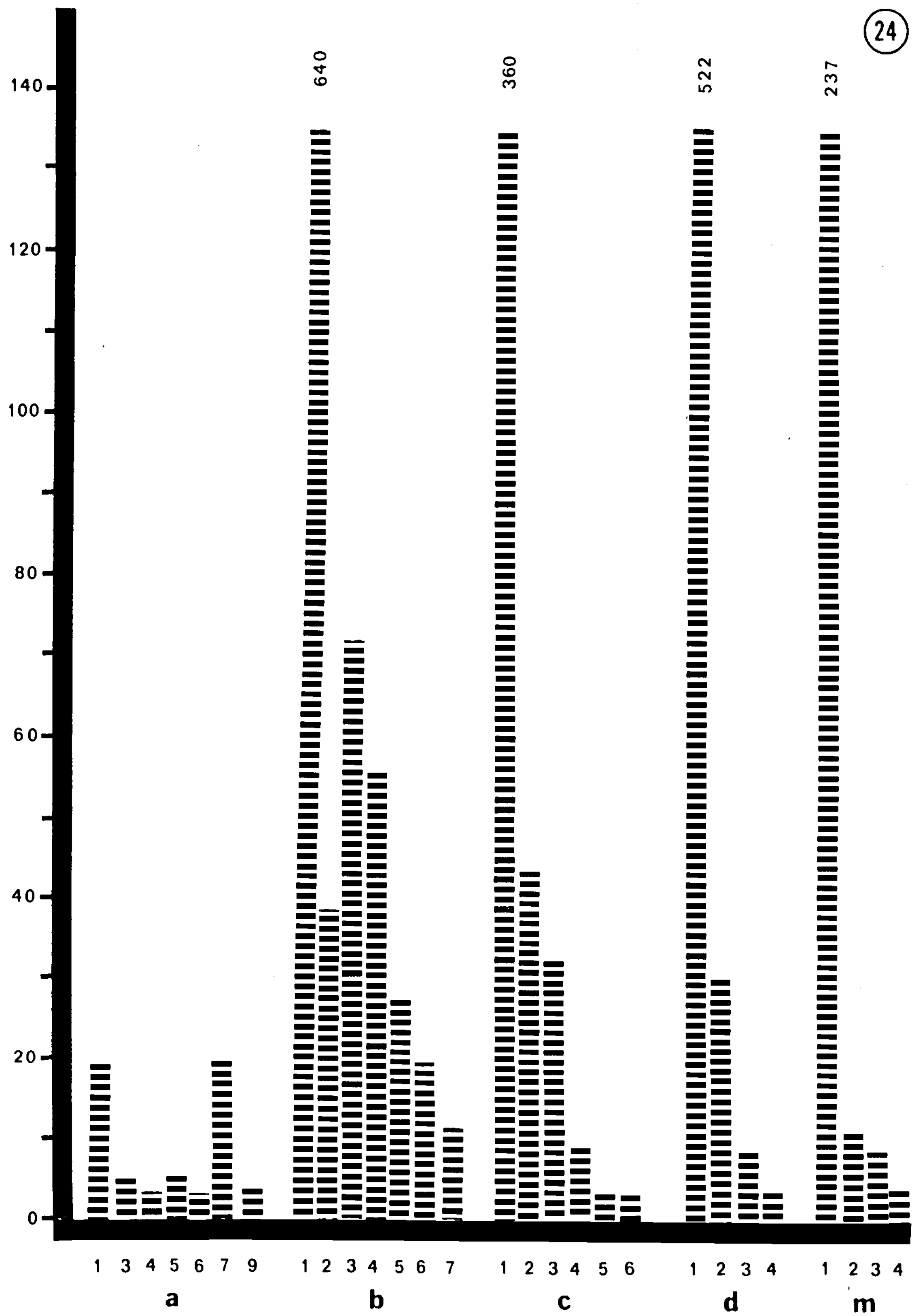
1374
140
120
100
80
60
40
20
0
1 2 3 5 7 8 9
a
1 2 3 4 5 6 7 8 9
b
1 2 3
c
1
l
1
i

Figure 24. Size class distribution of trees within mature stands of the Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community (trees per hectare; a = Pseudotsuga menziesii, b = Chamaecyparis lawsoniana, c = Tsuga heterophylla, d = Abies concolor, and m = Thuja plicata; each size class represents 15 cm diameter with class 1 = 0-15 cm).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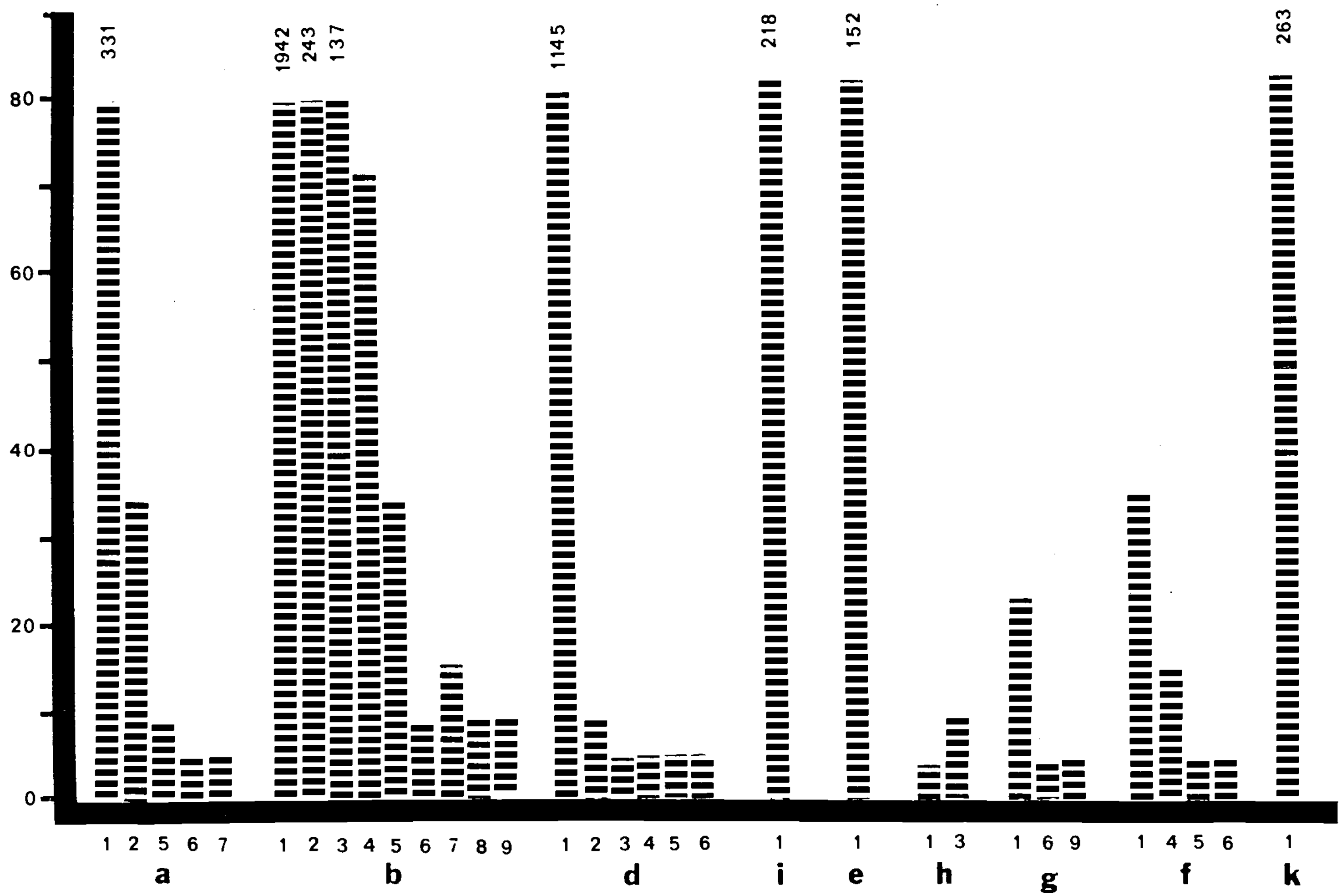
60
40
20
0
640
360
522
237
1 3 4 5 6 7 9
a
1 2 3 4 5 6 7
b
1 2 3 4 5 6
c
1 2 3 4
d
1 2 3 4
m

Figure 25. Size class distribution of trees within mature stands of the *Abies concolor*-*Chamaecyparis lawsoniana*/herb community (trees per hectare; a = *Pseudotsuga menziesii*, b = *Chamaecyparis lawsoniana*, d = *Abies concolor*, i = *Taxus brevifolia*, e = *Pinus lambertiana*, h = *Calocedrus decurrens*, g = *Pinus jeffreyi*, f = *Pinus monticola*, and k = *Picea breweriana*; each size class represents 15 cm diameter with class 1 = 0-15 cm).

(25)



80
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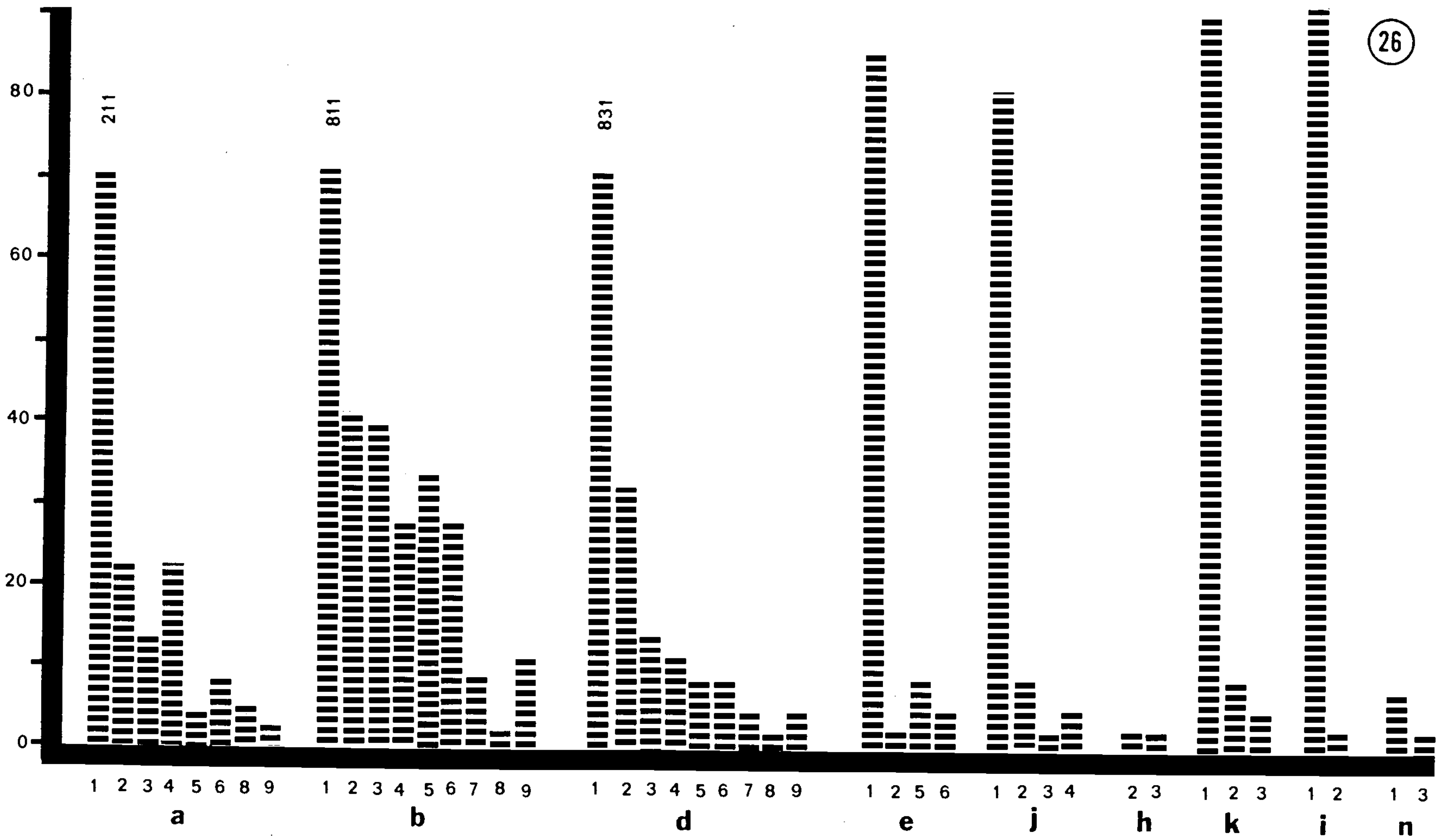
331
1942
243
137
1145
218
152
263
1 2 5 6 7
a
1 2 3 4 5 6 7 8 9
b
1 2 3 4 5 6
d
1
i
1
e
1 3
h
1 6 9
g
1 4 5 6
f
1
k

Figure 26. Size class distribution of trees within mature stands of the Abies-Chamaecyparis lawsoniana/herb community (trees per hectare; a = Pseudotsuga menziesii, b = Chamaecyparis lawsoniana, d = Abies concolor, e = Pinus lambertiana, j = Abies magnifica, h = Calocedrus decurrens, k = Picea breweriana, i = Taxus brevifolia, and n = Tsuga mertensiana; each size class represents 15 cm diameter with class 1 = 0-15 cm).


26
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811
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1 2 3 4 5 6 8 9
a
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d
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1 2 3 4
j
2 3
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1 2 3
k
1 2
i
1 3
n

elevation Pinus-Chla/Quva/Xete stands, Calocedrus decurrens is present in several size classes but appears as a late seral species (Figures 19, 25, and 26). Most Pinus species appear azonal and of primary importance in early seral stages. On the more xeric habitats, however, this genus is also an important late seral to climax species. Pinus appears to be quite important in many stages of the ultramafic habitats.

Picea breweriana is a late seral species of specialized habitats within the Abies concolor Zone and some high elevation stands of the Pinus-Chla/Quva/Xete community. Thuja plicata is found at the Galice study area and at the Port Orford Cedar Research Natural Area within this study. It apparently has nearly the same requirements as Chamaecyparis lawsoniana with respect to habitat types, but it appears to be more dependent on a constant water supply.

Floristic Comparisons of Chamaecyparis Forests

In a comparison of two communities it is difficult to agree on the degree of similarity between them. However, similarity can be expressed mathematically and limits of acceptability may then be determined (Mueller-Dombois and Ellenberg, 1974). The simplest expression of similarity is the community coefficient of Jaccard (1912) and of Weaver and Clements (1929). It is based on the presence or absence of species in two communities being compared. It expresses the ratio of common species to all species found in any two samples. The use of presence, however, may result in indistinct differences between communities. Therefore, I have calculated constancy coefficients rather than actual community coefficients. The constancy coefficient is based on presence and absence, but only includes species with constancies greater than 24% in either of the communities being compared. Thus it distinguishes between communities on the basis of presence of those species important in at least one of the two communities. This method is an expansion of the community coefficient, but it is not as sophisticated, time consuming, or as expensive as other methods which have been developed since Jaccard's work (Mueller-Dombois and Ellenberg, 1974, list many of them). The constancy coefficient serves as a useful mathematical check on the final constancy-cover tables (Tables 16 and 17). It has been used to construct the similarity matrices shown in Tables 12 and 13.

The similarity matrix for C. lawsoniana forests (Table 12) indicates that communities are related to each other in varying degrees, but that those communities located on similar parent materials are more similar to each other than they are to other communities within their same zone but which occur on other parent material types. The matrix is arranged to show similarity of communities as the communities are arranged within vegetation zones. The similarity of the three zones to one another is also given (Table 12).

Constancy coefficients of Taiwan communities (Table 13) reveal that the two communities of each Chamaecyparis species are more similar or equally similar to each other than to communities of the other Chamaecyparis species. The two bamboo communities are more similar than are the two shrub communities. The least similar stands are those of the Chta/bamboo and the Chfo/shrub communities. This is reasonable since the higher elevation plots more commonly have alpine bamboo while low elevation plots are usually occupied by C. formosensis and hardwood forests.

There are 273 vascular plant species in U.S. and 267 species in Taiwan Chamaecyparis forests. These include 60 families in the U.S. and 71 in Taiwan: 33 of these families are common to both areas. There are 168 genera in the U.S. and 152 in Taiwan communities; 33 genera are common to both. Only two species are found within Chamaecyparis forests of both Taiwan and the United States; they are Monotropa uniflora and Parnassia palustris, and neither is abundant in either location.

The Ericaceae, tall and low shrubs, and the Liliaceae, mostly woody vines in Taiwan and small upright herbs in the U.S., are common in both areas (Table 14). Rubus and Vaccinium are the most common genera occurring in both areas (Table 15).

Indicator species are plants which occur with high fidelity within a given set of circumstances (Tansley and Chipp, 1926). In defining plant communities one finds many species having varying degrees of indicator significance. All species are essentially phytometers of

Table 12. Constancy coefficients of <u>Chamaecyparis</u> <u>lawsoniana</u> communities and zones.

Zones			Mixed Evergreen I		*Tsuga heterophylla* II			*Abies concolor* III		
Communities1/			Pinus Chla Quva Xete	Chla Lide	Chla Tshe Xete	Tshe Chla Rhma Gash	Tshe Chla Pomu Oxor	Abco Tshe Chla	Abco Chla herb	Abies Chla herb
			1	2	3	4	5	6	7	8
		Main parent material2/	U	MU	U	S	S	O	MU	G
I	1	U	100	35	26	14	9	14	25	10
	2	MU	100*	100	67	44	34	48	49	34
II	3	U			100	46	38	39	42	31
	4	S				100	53	43	39	37
	5	S	44*			100*	100	37	29	33
III	6	O						100	40	39
	7	MU							100	55
	8	G	39*			47*		100*		100

1/ see Appendix I for definitions of community names
2/ U = ultramafic, MU = ultramafic mix, S = sedimentary, G = granitic parent material , O = other
* Constancy coefficients between zones

Table 13. Constancy coefficients of Taiwan *Chamaecyparis* communities.

Communities[1/]	Chta/shrub	Chta/bamboo	Chfo/bamboo	Chfo/shrub
	1	2	3	4
1	100	41	28	36
2		100	42	25
3			100	45
4				100

All Chta vs. Chfo = 40

1/ see Appendix I for definitions of community names

Table 14. Most common families within *Chamaecyparis* forests.

Rank	Taiwan family	Number of species	Rank	United States family	Number of species
1	Ericaceae	19	1	Lilaceae	27
2	Theaceae	16	2	Rosaceae	20
3	Polypodiaceae	12	3	Ericaceae	15
3	Liliaceae	12	4	Pinaceae	14
5	Symplocaceae	11	5	Orchidaceae	12
5	Fagaceae	11	6	Pyrolaceae	11
5	Lauraceae	11	7	Compositae	10

Table 15. Most common genera of *Chamaecyparis* forests.

Rank	Taiwan genus	Number of species	Rank	United States genus	Number of species
1	Symplocos	11	1	Pinus	6
2	Ilex	10	1	Lilium	6
2	Rubus	10	3	Rubus	5
4	Smilax	9	3	Berberis	5
5	Rhododendron	8	5	Vaccinium	4
6	Vaccinium	7	5	Arctostaphylos	4
6	Viburnum	7	5	Brodiaea	4
8	Eurya	6	5	Viola	4

their integrated environment (Waring and Major, 1964), but some species are more useful to the ecologist since they are more specific phytometers of environmental factors which are both apparent and measurable. An indicator species, greatly restricted to one community, with high constancy, cover, or frequency is defined here as a character species following Braun-Blanquet and Pavillard (1930).

The best indicator species for Taiwan Chamaecyparis communities are Chamaecyparis formosensis, C. taiwanensis, and alpine bamboo. The indicator significance of other Taiwan species is not nearly so high due to the variation in local dominance. Many species, however, appear to react to an elevational temperature gradient, moisture gradient, or more likely to a combination of the two. Cleyera japonica, Lithocarpus amygdalifolius, and Castanopsis carlesii are typically in higher elevation communities which are drier than most adjacent forests. In this respect they are fairly good indicators of Chta/shrub habitat type.

Within Chamaecyparis taiwanensis forests, high cover of the fern Plagiogyria formosana indicates comparatively wet sites, while Plagiogyria dunnii replaces it on drier micro-habitats in less mesic forests. There is more Tsuga chinensis reproduction on drier sites as well. More Tsuga chinensis typically occurs within older forests, which are also relatively drier forests. Thus it is possible that the indicators here are merely signalling the differences in seral stages, with the Tsuga chinensis being a later seral species than Chamaecyparis taiwanensis.

Within Chamaecyparis taiwanensis/shrub habitat type a gradient from exposed, very wet, pioneer stands to more mesic climax forests has been sampled. Middle seral stands are still quite moist and productive, indicated by high cover and frequency of Plagiogyria formosana, Hymenophyllum polyanthos, and Monachosorum henryi, all of which are also important in lower, more moist C. formosensis forests. Miscanthus, Gaultheria cumingiana, Hicriopteris glauca, Lycopodium species, Lonicera acuminata, Stransvesia niitakayamensis and Litsea cubeba are azonal indicators of early seral stages found at most elevations, and within all Chamaecyparis communities of Taiwan. Pinus species play a similar role in early succession of Chamaecyparis forests (Wang, 1961).

Chang (1963) stated that Plagiogyria euphlebia and Pellionia scabra in the understory indicated a higher probability of natural regeneration following logging. Taiwan foresters have long recognized that alpine bamboo indicates poor management possibilities for a site. Other indicators of forest communities can easily be seen in the constancy-cover table for Taiwan communities (Table 16). Those species found only within one column of the table are fairly good indicators, specially if they have very high constancy or cover values within the community. Tsuga chinensis and Barthea formosana thus become very reliable indicators, when used together, of the Chta/shrub community; and Symplocos arisenensis is a good indicator of the Chfo/shrub community.

A greater number of habitat types have developed in the more variable environment of C. lawsoniana, while most species present are widespread in at least trace amounts. Several statements may be made about the indicator significance of species or species groups in the constancy-cover table of C. lawsoniana communities (Table 17). The first 35 species listed indicate high elevation environments (low temperature, shorter growing season, reduced moisture stress, adaptation to winter stress). Included are very good indicators such as Pyrola secunda, Rubus lasiococcus, Vaccinium membranaeceum, and Clintonia uniflora. The bottom 39 species in Table 17 are good to fair indicators of ultramafic parent materials, specially the group of species from Pinus jeffreyi through Holodiscus discolor, which are common to ultramafic parent materials in all three zones. Some of the best indicators of this edaphic character include Rhododendron occidentale , Iris innominata, Xerophyllum tenax, Quercus vaccinifolia, Amelanchier pallida, and Trillium rivale, all with high constancy and relatively high cover within their respective communities. The last 24 species in Table 17 include many excellent indicators of the xeric sites of the Pinus-Chla/Quva/Xete community (e.g. Ceanothus pumilus, Rhamnus californica, Festuca californica, Brodiaea elegans, and B. bridgesii, Viola cuneatus, and Arctostaphylos nevadensis). The 24 species may be considered character species of the Pinus-Chla/Quva/Xete community within the limits of the

Table 16. Constancy-cover (%) in Taiwan Chamaecyparis communities (includes trees, T; shrubs, S; and herbs, H which have constancy greater than 24% in the community: cover values are nearest whole percent unless less than .5% cover which is given as t, for trace amount).

Taxon		Community[1]							
		Chta/shrub		Chta/bamboo		Chfo/bamboo		Chfo/shrub	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.
Cleyera japonica	T	35	6	--	--	--	--	--	--
Pinus taiwanensis	T	30	11	--	--	--	--	--	--
Lithocarpus amygdalifolius	T	25	7	--	--	--	--	--	--
Elaeocarpus japonicus	S	45	1	--	--	--	--	--	--
Damnacanthus angustifolius	S	35	t	--	--	--	--	--	--
Tsuga chinensis	S	80	4	--	--	--	--	--	--
Viburnum integrifolium	S	35	2	--	--	--	--	--	--
Berberis alpicola	S	25	1	--	--	--	--	--	--
Barthea formosana	S	70	12	--	--	--	--	--	--
Ternstroemia gymnanthera	S	50	2	--	--	--	--	--	--
Ilex sugeroki	S	25	1	--	--	--	--	--	--
Rhododendron formosanum	S	30	5	--	--	--	--	--	--
Lithocarpus amygdalifolius	S	35	1	--	--	--	--	--	--
Symplocos heishanensis	S	35	2	--	--	--	--	--	--
Skimmia arisanensis	S	35	4	--	--	--	--	--	--
Stranvaesia niitakayamensis	S	25	1	--	--	--	--	--	--
Hugeria lasiostemon	S	35	1	--	--	--	--	--	--
Ardisia japonica	S	30	3	--	--	--	--	--	--
Hicriopteris glauca	H	40	4	--	--	--	--	--	--
Ariostegia perdurans	H	30	t	--	--	--	--	--	--
Ainsliaea morrisonicola	H	35	1	--	--	--	--	--	--
Plagiogyria dunnii	H	40	2	--	--	--	--	--	--
Lepisorus oligolepidus	H	25	t	--	--	--	--	--	--
Acrophorus sp.	H	25	1	--	--	--	--	--	--
Chamaecyparis taiwanensis	T	85	47	100	61	--	--	--	--
Chamaecyparis taiwanensis	S	95	17	78	8	--	--	--	--
Smilax raindaiensis	S	25	1	44	1	--	--	--	--
Eurya glaberrima	S	60	2	44	1	--	--	--	--

(continued on next page)

Table 16. (Continued)

Taxon		Community							
		Chta/shrub		Chta/bamboo		Chfo/bamboo		Chfo/shrub	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.
Rhododendron morii	S	45	8	44	8	--	--	--	--
Castanopsis carlesii	S	40	2	33	t	--	--	--	--
Symplocos stellaris	S	40	1	33	1	--	--	--	--
Asplenium normale	H	25	t	33	t	--	--	--	--
Tsuga chinensis	T	70	24	67	14	36	19	--	--
Microtropis fokiensis	S	30	t	78	t	43	t	--	--
Lonicera acuminata	S	30	1	--	--	29	1	--	--
Miscanthus transmorrisonensis	S	35	9	--	--	21	16	--	--
Rhododendron ellipticum	S	--	--	33	4	--	--	--	--
Pleioblastus niitakayamensis	S	--	--	100	89	100	62	--	--
Plagiogyria euphlebia	H	--	--	33	1	43	t	43	t
Taiwania cryptomerioides	T	--	--	--	--	29	4	--	--
Pieris taiwanensis	S	--	--	--	--	36	2	--	--
Eurya crenatifolia	S	--	--	--	--	36	2	--	--
Monachosorum sp.	H	--	--	--	--	36	2	--	--
Asarum blumei	H	--	--	--	--	29	t	--	--
Chamaecyparis formosensis	T	--	--	--	--	79	42	100	58
Chamaecyparis formosensis	S	--	--	--	--	29	3	--	--
Castanopsis stellatospina	T	--	--	--	--	36	18	29	14
Persea thunbergii	S	--	--	--	--	29	4	71	7
Schizophragma integrifolium	S	--	--	--	--	29	1	29	t
Actinodaphne morrisonensis	S	--	--	--	--	29	1	36	1
Hedera rhombea	S	--	--	--	--	29	t	57	t
Hydrangea angustipetala	S	--	--	--	--	29	t	50	6
Castanopsis stellatospina	S	--	--	--	--	36	6	29	5
Hymenophyllum badium	H	--	--	--	--	36	1	29	1
Pilea sp.	H	--	--	--	--	36	t	29	t
Pellionia scabra	H	--	--	--	--	29	t	57	t
Ophiorhiza japonica	H	--	--	--	--	29	t	50	t
Microsorium buergerianum	H	--	--	--	--	36	t	57	t

(continued on next page)

Table 16. (Continued)

Taxon		Community							
		Chta/shrub		Chta/bamboo		Chfo/bamboo		Chfo/shrub	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.
Daphniphyllum membranaceum	T	--	--	--	--	--	--	29	6
Daphniphyllum membranaceum	S	--	--	--	--	--	--	36	1
Rubus kawakamii	S	--	--	--	--	--	--	50	t
Cinnamomum japonicum	S	--	--	--	--	--	--	29	3
Osmanthus lanceolatus	S	--	--	--	--	--	--	29	1
Litsea acutivena	S	--	--	--	--	--	--	29	t
Rubus shinkoensis	S	--	--	--	--	--	--	29	1
Symplocos lancifolia	S	--	--	--	--	--	--	79	2
Cyclobalanopsis morii	T	25	10	33	9	29	10	57	18
Cyclobalanopsis morii	S	25	t	33	4	50	4	64	2
Smilax oxyphylla	S	90	2	33	1	64	1	79	1
Neolitsea acuminatissima	S	90	9	78	6	64	4	86	6
Dendropanax pellucipunctata	S	85	4	56	4	64	5	29	1
Eurya acuminata	S	40	2	44	4	29	3	51	8
Viburnum taiwanianum	S	90	4	56	1	29	t	36	t
Plagiogyria formosana	H	50	8	89	7	79	8	86	20
Monachosorum henryi	H	60	2	67	4	64	3	57	4
Pellionia trilobulata	H	30	1	33	1	36	1	79	1
Goodyera velutina	H	50	t	44	t	36	t	43	t
Trochodendron aralioides	T	30	5	--	--	50	17	57	27
Eurya leptophylla	S	55	6	--	--	29	t	57	2
Actinodaphne mushaensis	S	40	2	--	--	29	1	29	t
Trochodendron aralioides	S	50	2	--	--	50	5	43	3
Ardisia crenata	S	40	1	--	--	64	t	43	t
Damnacanthus indicus	S	25	1	--	--	50	1	79	4
Sarcopyramis delicata	H	60	1	--	--	71	1	64	1
Hymenophyllum polyanthos	H	55	7	--	--	57	t	--	--
Oxalis griffithii	H	30	t	--	--	36	t	50	t
Illicium tashuroi	S	65	10	33	2	--	--	43	1
Hydrangea integra	S	50	4	33	t	--	--	71	1

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Table 16. (Continued)

Taxon		Community							
		Chta/shrub		Chta/bamboo		Chfo/bamboo		Chfo/shrub	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.
Symplocos morrisonicola	S	75	7	33	3	--	--	64	5
Schefflera taiwaniana	S	35	4	44	5	--	--	29	1
Illicium tashuroi	T	35	11	--	--	--	--	36	22
Stauntonia hexophylla	S	40	1	--	--	--	--	79	1
Cleyera japonica	S	90	8	--	--	--	--	29	5
Ilex goshiensis	S	65	t	--	--	--	--	29	1
Ophiopogon scaber	H	45	2	--	--	--	--	36	1
Vittaria flexuosa	H	35	t	--	--	--	--	36	t

1/ see Appendix I for definitions of community names

Table 17. Constancy-cover (%) in U.S. *Chamaecyparis* communities (includes trees, T; shrubs, S; and herbs, H which have constancy greater than 24% in any community: cover values are rounded to whole numbers; t cover equals less than one half percent average cover in the community).

Taxon		Pinus Chla Quva Xete		Chla Lide		Chla Tshe Xete		Tshe Chla Rhma Gash		Tshe Chla Pomu Oxor		Abco Tshe Chla		Abco Chla herb		Abies Chla herb	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.
Abies magnifica	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	53	1
Pachistima myrsinites	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	1
Symphoricarpos mollis	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	t
Rubus lasiococcus	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	t
Pyrola secunda	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	67	1
Senecio bolanderi var. harfordii	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40	t
Calypso bulbosa	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40	t
Phlox adsurgens	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	33	t
Pedicularis racemosa	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	t
Stenanthium occidentale	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	t
Campanula scouleri	H	--	--	--	--	--	--	--	--	--	--	--	--	27	t	47	t
Lathyrus polyphyllus	H	--	--	--	--	--	--	--	--	--	--	--	--	27	t	27	t
Vaccinium membranaceum	S	--	--	--	--	--	--	--	--	--	--	--	--	40	1	53	2
Osmorhiza chilensis	H	--	--	--	--	--	--	--	--	--	--	--	--	33	t	47	1
Gaultheria ovatifolia	S	--	--	--	--	--	--	--	--	--	--	--	--	33	2	33	t
Clintonia uniflora	H	--	--	--	--	--	--	--	--	--	--	--	--	73	t	87	1
Viola glabella	H	--	--	--	--	--	--	--	--	--	--	--	--	60	1	60	t
Listera cordata	H	--	--	--	--	--	--	--	--	--	--	--	--	53	t	33	t
Achlys triphylla	H	--	--	--	--	--	--	--	--	--	--	--	--	47	2	67	3
Rubus parviflorus	S	--	--	--	--	--	--	--	--	--	--	--	--	40	t	--	--
Smilacina racemosa	H	--	--	--	--	--	--	--	--	--	--	--	--	27	t	--	--
Elymus glauca	H	--	--	--	--	--	--	--	--	--	--	--	--	27	2	--	--
Alnus rhombifolia	S	--	--	--	--	--	--	--	--	--	--	--	--	27	2	--	--

Community[1/] (spanning header over the community columns)

(continued on next page)

Table 17. (Continued)

Taxon		Pinus Chla Quva Xete		Chla Lide		Chla Tshe Xete		Tshe Chla Rhma Gash		Tshe Chla Pomu Oxor		Abco Tshe Chla		Abco Chla herb		Abies Chla herb	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.
Veratrum spp.	H	--	--	--	--	--	--	--	--	--	--	--	--	47	t	--	--
Senecio triangularis	H	--	--	--	--	--	--	--	--	--	--	--	--	40	t	--	--
Angelica arguta	H	--	--	--	--	--	--	--	--	--	--	--	--	33	t	--	--
Streptopus amplexifolius	H	--	--	--	--	--	--	--	--	--	--	--	--	33	1	--	--
Arenaria macrophylla	H	--	--	--	--	--	--	--	--	--	--	40	t	27	t	33	t
Pyrola asarifolia	H	--	--	--	--	--	--	--	--	--	--	50	t	33	t	27	t
Abies concolor	S	--	--	--	--	--	--	--	--	--	--	90	7	100	7	100	16
Thuja plicata	S	--	--	--	--	--	--	--	--	--	--	50	t	--	--	--	--
Castanopsis chrysophylla	T	--	--	--	--	--	--	--	--	--	--	40	2	--	--	--	--
Abies concolor	T	--	--	--	--	--	--	--	--	--	--	50	9	80	15	87	18
Thuja plicata	T	--	--	--	--	--	--	--	--	--	--	50	10	--	--	--	--
Asarum caudatum	H	--	--	--	--	--	--	--	--	--	--	30	t	--	--	--	--
Leucothoe davisiae	S	--	--	--	--	--	--	--	--	--	--	90	11	--	--	--	--
Corallorhiza maculata	H	--	--	--	--	--	--	--	--	--	--	50	t	--	--	--	--
Lysichiton americanum	H	--	--	--	--	--	--	--	--	--	--	40	2	--	--	--	--
Anemone deltoidea	H	--	--	--	--	--	--	--	--	46	t	--	--	47	t	60	1
Smilacina stellata	H	--	--	--	--	--	--	--	--	38	t	--	--	27	t	53	t
Adiantum pedatum	H	--	--	--	--	--	--	--	--	38	t	--	--	33	t	--	--
Alnus rubra	T	--	--	--	--	--	--	--	--	46	7	50	6	--	--	--	--
Arbutus menziesii	T	--	--	38	3	--	--	33	3	--	--	30	t	--	--	--	--
Acer circinatum	S	--	--	--	--	--	--	50	5	--	--	--	--	--	--	--	--
Corylus cornuta	S	--	--	--	--	--	--	33	2	--	--	--	--	--	--	--	--
Berberis aquifolium	S	--	--	--	--	--	--	33	1	--	--	--	--	--	--	--	--
Polypodium glycerrhiza	H	--	--	--	--	--	--	50	t	--	--	--	--	--	--	--	--
Montia sibirica	H	--	--	--	--	--	--	--	--	31	t	--	--	--	--	--	--
Nemophila parviflora	H	--	--	--	--	--	--	--	--	31	t	--	--	--	--	--	--
Tiarella unifoliata	H	--	--	--	--	--	--	33	t	54	t	40	1	40	t	60	t

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Table 17. (Continued)

Taxon		Community															
		Pinus Chla Quva Xete		Chla Lide		Chla Tshe Xete		Tshe Chla Rhma Gash		Tshe Chla Pomu Oxor		Abco Tshe Chla		Abco Chla herb		Abies Chla herb	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.
Adenocaulon bicolor	H	--	--	--	--	--	--	33	t	46	t	30	t	53	t	47	1
Athyrium filix-femina	H	--	--	--	--	--	--	33	1	--	--	--	--	27	t	33	t
Tiarella trifoliata	H	--	--	--	--	--	--	33	t	54	t	--	--	--	--	--	--
Blechnum spicant	H	--	--	--	--	--	--	33	2	38	t	--	--	--	--	--	--
Oxalis oregana	H	--	--	--	--	--	--	50	3	77	16	--	--	--	--	--	--
Acer macrophyllum	T	--	--	--	--	--	--	--	--	46	t	--	--	--	--	--	--
Abies grandis	T	--	--	--	--	--	--	33	2	31	3	--	--	--	--	--	--
Abies grandis	S	--	--	--	--	--	--	33	2	--	--	--	--	--	--	--	--
Coptis laciniata	H	--	--	--	--	25	1	--	--	--	--	--	--	--	--	--	--
Senecio bolanderi var. bolanderi	H	--	--	--	--	25	1	--	--	--	--	--	--	--	--	--	--
Listera caurina	H	--	--	--	--	25	t	--	--	--	--	--	--	--	--	--	--
Tsuga heterophylla	T	--	--	--	--	50	10	67	14	85	27	70	15	--	--	--	--
Tsuga heterophylla	S	--	--	--	--	83	7	67	19	92	30	100	5	--	--	--	--
Galium triflorum	H	--	--	--	--	25	t	83	1	77	1	--	--	33	t	53	t
Vaccinium ovatum	S	--	--	50	8	33	3	83	6	46	1	--	--	--	--	--	--
Gaultheria shallon	S	--	--	81	18	67	4	100	29	77	2	100	6	--	--	--	--
Syntheris reniformis	H	--	--	31	t	50	t	--	--	--	--	40	1	40	t	--	--
Castanopsis chrysophylla	S	--	--	56	4	--	--	--	--	--	--	--	--	--	--	80	2
Corallorhiza mertensiana	H	--	--	31	t	--	--	33	t	--	--	30	t	40	t	27	t
Quercus sadleriana	S	--	--	38	t	--	--	--	--	--	--	100	6	40	4	67	5
Lithocarpus densiflora	T	--	--	38	4	--	--	--	--	31	2	--	--	--	--	--	--
Linnaea borealis	H	--	--	50	1	25	1	--	--	31	t	80	3	67	2	80	3
Viola sempervirens	H	--	--	44	t	42	t	83	1	92	2	--	--	27	t	60	t
Disporum hookeri	H	--	--	44	t	67	t	67	t	77	t	30	t	60	1	60	1
Chimaphila umbellata	H	--	--	50	1	50	t	33	t	--	--	80	t	93	t	93	t
Chimaphila menziesii	H	--	--	50	t	67	t	50	t	--	--	80	t	93	t	93	t

(continued on next page)

Table 17. (Continued)

Taxon		Community															
		Pinus Chla Quva Xete		Chla Lide		Chla Tshe Xete		Tshe Chla Rhma Gash		Tshe Chla Pomu Oxor		Abco Tshe Chla		Abco Chla herb		Abies Chla herb	
		con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.
Vancouveria planipetala or V. hexandra	H	--	--	75	1	50	1	50	t	38	t	--	--	60	1	73	1
Taxus brevifolia	T	--	--	44	2	33	1	33	2	--	--	80	2	40	1	47	5
Pteridium aquilinum	H	--	--	38	t	--	--	33	t	77	t	60	t	67	1	53	t
Trillium ovatum	H	--	--	56	t	58	t	83	t	77	t	100	t	73	t	93	t
Polystichum munitum	H	--	--	81	2	75	2	100	14	100	35	90	1	53	t	40	t
Rubus ursinus or Rubus vitifolius	S	--	--	69	t	42	t	50	1	62	t	80	t	80	1	47	1
Berberis nervosa	S	--	--	69	2	75	t	83	8	92	2	80	2	60	2	100	3
Rhododendron macrophyllum	S	--	--	63	13	83	11	83	32	38	t	70	9	27	6	27	6
Chamaecyparis lawsoniana	T	82	20	100	56	100	53	100	52	100	53	100	56	100	51	100	44
Chamaecyparis lawsoniana	S	82	16	100	30	100	24	100	9	100	13	100	12	100	26	100	18
Pseudotsuga menziesii	S	82	8	94	2	100	t	100	1	100	2	90	t	87	1	100	7
Pseudotsuga menziesii	T	27	2	94	29	100	27	100	38	100	28	80	19	87	20	87	22
Vaccinium parvifolium	S	73	6	94	1	75	1	50	1	92	1	100	1	60	2	67	3
Lithocarpus densiflora	S	36	1	100	24	92	10	67	3	77	1	80	1	40	1	27	2
Trientalis latifolia	H	45	t	50	t	50	t	50	1	85	1	60	t	80	1	87	1
Goodyera oblongifolia	H	27	t	100	t	92	1	100	t	85	t	90	1	93	t	100	t
Whipplea modesta	H	36	1	44	t	50	t	50	1	62	t	40	t	40	t	--	--
Rosa gymnocarpa or sp.	S	45	t	63	t	58	t	33	1	--	--	60	t	93	2	73	1
Pinus lambertiana	T & S	36	4	31	3	42	1	--	--	--	--	50	1	40	4	40	3
Pinus monticola	T & S	64	9	25	4	25	3	--	--	--	--	--	--	47	5	--	--
Pyrola picta dentata	H	64	t	38	t	33	t	50	t	--	--	--	--	60	t	80	t
Pinus jeffreyi or P. ponderosa	T & S	91	5	--	--	--	--	--	--	--	--	--	--	27	t	--	--
Calocedrus decurrens	T & S	45	1	--	--	--	--	--	--	--	--	--	--	47	t	--	--
Quercus vaccinifolia	S	100	26	31	1	--	--	--	--	--	--	40	1	40	1	--	--

(continued on next page)

Table 17. (Continued)

Taxon	Community															
	Pinus Chla Quva Xete		Chla Lide		Chla Tshe Xete		Tshe Chla Rhma Gash		Tshe Chla Pomu Oxor		Abco Tshe Chla		Abco Chla herb		Abies Chla herb	
	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.	con.	cov.
Amelanchier pallida	S 73	1	25	t	--	--	--	--	--	--	--	--	40	t	--	--
Quercus chrysolepis	S 64	t	63	2	25	t	--	--	--	--	--	--	33	t	--	--
Anemone quinquefolia	H 36	t	25	t	--	--	--	--	--	--	--	--	67	t	--	--
Rhododendron occidentale	S 45	9	63	13	33	1	--	--	--	--	--	--	67	8	--	--
Iris innominata	H 91	t	31	t	67	t	--	--	--	--	--	--	47	t	--	--
Xerophyllum tenax	H 91	11	88	1	92	18	--	--	--	--	60	t	53	2	--	--
Erythronium oregonum	H 64	t	31	t	33	t	--	--	--	--	--	--	27	t	--	--
Galium ambiguum	H 82	1	31	t	50	t	--	--	--	--	--	--	--	--	--	--
Trillium rivale	H 91	t	38	t	42	t	--	--	--	--	--	--	27	t	--	--
Holodiscus discolor	S 27	t	--	--	--	--	33	t	--	--	--	--	27	7	--	--
Umbellularia californica	S 64	1	50	7	--	--	50	2	--	--	--	--	--	--	--	--
Ceanothus pumilus	S100	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex serratodens	H 55	1	31	t	--	--	--	--	--	--	--	--	--	--	--	--
Arctostaphylos nevadensis	S 73	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juniperus communis	S 64	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Berberis repens	S 45	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Festuca californica	H 82	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brodiaea elegans or B. bridgesii	H 82	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Viola cuneatus	H 73	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calochortus elegans	H 64	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Microseris nutans	H 73	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gentiana affinis	H 73	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Horkelia sericata	H 64	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Festuca rubra	H 64	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Senecio canus	H 55	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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Table 17. (Continued)

Taxon		Pinus Chla Quva Xete con.	Pinus Chla Quva Xete cov.	Chla Lide con.	Chla Lide cov.	Chla Tshe Xete con.	Chla Tshe Xete cov.	Tshe Chla Rhma Gash con.	Tshe Chla Rhma Gash cov.	Tshe Chla Pomu Oxor con.	Tshe Chla Pomu Oxor cov.	Abco Tshe Chla con.	Abco Tshe Chla cov.	Abco Chla herb con.	Abco Chla herb cov.	Abies Chla herb con.	Abies Chla herb cov.
		Community															
Onychium densum	H	45	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rhamnus californica	S	91	9	31	1	--	--	--	--	--	--	--	--	--	--	--	--
Antennaria suffrutescens	H	36	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Erigeron foliosus	H	64	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Castilleja miniata	H	27	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lomatium howellii	H	45	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sanguisorba microcephala	H	36	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sedum laxum	H	27	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ligustrum apiifolium	H	27	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perideridia sp.	H	55	t	--	--	--	--	--	--	--	--	--	--	--	--	--	--

1/ see Appendix I for definitions of community names

communities studied here. The species between Vaccinium ovatum and Umbellularia californica occur in all zones and most communities. There are no good indicator species within these, but their importance varies among communities and zones (e.g. large amounts of Gaultheria shallon and Lithocarpus densiflora are fairly indicative of low elevation Tsuga heterophylla Zone and Mixed Evergreen Zone communities, but by themselves, neither species is a good indicator). The remainder of the tabulated species (Table 17) are fairly good indicators of more mesic sites than are those of the last group discussed.

The value of indicator or character species varies and depends upon the point of view of the investigator. Species that are good indicators of one or more environmental characteristic may not have the same significance outside of the range of their association and with any set of other species. This means that indicators and character species discussed for my communities are of value only in defining Chamaecyparis communities. One needs to exercise some care in equating indicator species from different areas without substantiating environmental data from both areas. Many of my indicator or character species occupy similar habitats as those of Waring (1969), Minore (1972), Dyrness, Franklin, and Moir (1974), and Zobel et al. (1976) with regards to their occurrence along temperature, moisture and light gradients.

COMMUNITY DESCRIPTIONS

United States

Introduction

Within the United States I have defined eight major plant communities where C. lawsoniana is an important tree species. Those eight communities occur within three major vegetation zones of the Pacific Northwest as described by Franklin and Dyrness (1973). The zones are the Tsuga heterophylla, Mixed Evergreen, and Abies concolor Zones. In addition, there are other Chamaecyparis communities which are not extensive or were not sampled enough to describe in the same detail as major communities. These communities are covered as special habitats even though they often do occur within the three vegetation zones discussed.

Tsuga heterophylla Zone

The Tsuga heterophylla (Western hemlock) Zone occurs primarily in the northern portion of the study area but also includes the narrow coastal strip extending south into the northern redwood forests of California. This zone contains 38 plots with 13 in the Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana community, 6 plots in the Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon community, 12 plots in the Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax community, and 7 plots in coastal habitats of limited extent and all within the Picea sitchensis (Sitka spruce) Zone of Franklin and Dyrness (1973). This zone may be considered a variant of the Tsuga heterophylla Zone distinguished by Picea sitchensis, frequent summer fogs, and its proximity to the Pacific Ocean (Franklin and Dyrness, 1973).

Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana (Tshe-Chla/Pomu-Oxor) Community. This community has been sampled by 13 stands located north of Panther Ridge (Figure 1). Elevation of plots ranges from 300 to 800 m, but the community has been observed at slightly higher elevations. The most vigorous stands occur on lower terraces of the Coquille River Falls Research Natural Area at 450 to 500 m elevation. Most plots occur on benches of shallow relief, but some have been sampled on sideslopes with up to 35% slope (Table 18). Aspects of stands are primarily northern, and all stands sampled occur upon sedimentary parent material of the Galice, Umpqua, and Tyee Formations. Soils here are well developed, having horizons which differ markedly in texture and structure. Depth to the surface of the C horizon averages 66 cm, which is comparatively deep, and ranges from 40 to 117 cm. Shallow soils occur on sideslopes where accumulation is opposed by erosion. Deeper soils occur on benches and river terraces. Variation in the texture of soils between plots is small. Soils consist of gravelly, silt loam A horizons; gravelly cobbly, silty clay loam B horizons; and gravelly cobbly, silty clay loam C horizons of great depth.

The tree stratum, with an average of five species per plot, contains Pseudotsuga menziesii and Chamaecyparis lawsoniana in all old growth forests. Tsuga heterophylla is present in all but stand 37 (Table 19), on a river terrace near a stand with more than 50% cover of Tsuga. The average mature tree cover is 84% which is about average for Chamaecyparis communities studied. Immature conifer cover is 47%, the highest found for any community studied. This indicates the vigor of the understory trees within this community; other communities have higher sapling density but lower cover within this layer. Trees with maximal development here include Tsuga heterophylla and Alnus rubra. Abies grandis and Acer macrophyllum are about equally developed in this and the Tshe-Chla/Rhma-Gash communities.

I was unable to locate many young seral representatives of this community. However, stands 47 and 65 (Tables 18 and 19) represent post-fire seral associes of the community. Stand 47 is about 65 years old, and stand 65 is about 100 years old. Other stands in this community are over 350 years old.

There is good evidence that Tsuga heterophylla is the major climax species (Table 5); it is followed by C. lawsoniana in importance.

Table 18. Site characteristics of *Tsuga heterophylla*-*Chamaecyparis lawsoniana*/*Polystichum munitum*-*Oxalis oregana* community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
47	14	700	nne	10	70	40	sedimentary
29	13	460	n	17	350	46	sedimentary
64	8	700	sw	3	380	56	sedimentary
65	8	500	nw	20	100	117	sedimentary
28	13	600	wnw	7	400+	52	sedimentary
35	14	580	nnw	2	400+	42	sedimentary
37	14	300	nnw	2	400+	84	sedimentary
36	14	450	n	5	400+	74	sedimentary
31	14	460	nne	35	400+	94	sedimentary
33	14	520	nw	6	400+	57	sedimentary
34	14	490	nw	5	400+	73	sedimentary
42	14	820	wnw	10	400+	57	sedimentary

Table 19. Cover and constancy of species in the Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana community (cover given in whole percent except for t = trace less than .5%).

Layers and Species		Stands representing this community													% Const.	% Ave. Cover
		47	29	64	65	28	35	37	36	32	31	33	34	42		
Tree Layer																
Pseudotsuga menziesii	M[1]	60	20	30	40	5	20	20	20	30	15	30	30	40	100	28
Pseduotsuga menziesii	R	10	--	--	--	--	--	--	5	--	5	--	5	--	31	2
Chamaecyparis lawsoniana	M	65	50	70	60	50	60	30	35	50	60	55	75	30	100	53
Chamaecyparis lawsoniana	R	55	3	--	5	5	5	15	25	5	15	30	5	5	92	13
Tsuga heterophylla	M	15	10	70	50	--	30	--	30	30	10	30	20	50	85	27
Tsuga heterophylla	R	--	80	25	20	60	30	--	25	10	10	35	35	60	85	30
Abies grandis	M	--	--	--	--	20	t	15	--	--	--	--	--	--	31	3
Abies grandis	R	--	10	--	--	5	--	10	--	--	--	--	--	--	23	2
Alnus rubra	MR	--	--	--	--	15	5	15	40	t	20	--	--	--	46	7
Acer macrophyllum	MR	t	--	--	--	t	t	20	--	--	--	t	t	--	46	2
Lithocarpus densiflora	MR	--	--	--	--	--	t	5	--	t	15	--	--	--	31	2
Shrub Layer																
Rhododendron macrophyllum		1	t	t	t	1	--	--	--	--	--	--	--	--	38	t
Gaultheria shallon		1	t	--	8	t	8	--	t	--	2	4	3	t	77	2
Berberis nervosa		t	1	t	3	3	2	--	2	t	10	t	1	4	92	2
Vaccinium parvifolium		t	t	t	2	1	1	t	t	1	t	3	t	--	92	1
Rubus ursinus		t	t	--	t	t	t	--	t	--	--	1	4	--	62	t
Lithocarpus densiflora		t	4	--	--	2	3	t	t	t	--	2	6	t	77	1
Vaccinium ovatum		--	--	--	1	--	1	--	t	--	t	4	3	--	46	1
Herb Layer																
Goodyera oblongifolia		t	1	t	t	--	1	t	t	t	--	1	1	t	85	t
Chimaphila menziesii		t	t	--	--	--	t	--	--	--	--	--	--	t	31	t
Viola sempervirens		t	4	t	t	3	15	--	2	t	t	1	4	t	92	2
Whipplea modesta		t	--	t	--	t	1	--	t	t	--	t	t	--	62	t

(continued on next page)

Table 19. (Continued)

Layers and Species	Stands representing this community													% Const.	% Ave. Cover
	47	29	64	65	28	35	37	36	32	31	33	34	42		
Pteridium aquilinum	5	t	--	1	--	1	--	2	1	t	6	t	t	77	1
Polystichum munitum	t	6	t	71	54	33	55	61	75	58	16	27	1	100	42
Trientalis latifolia	--	t	t	t	t	3	t	1	t	t	4	1	--	85	1
Trillium ovatum	--	t	t	t	--	t	t	t	2	--	1	t	t	77	t
Hieracium albiflorum	--	t	t	--	--	1	t	--	t	t	t	t	--	62	t
Anemone deltoidea	--	--	t	t	--	t	--	t	--	--	t	t	--	46	t
Disporum hookeri	--	--	t	t	--	1	t	t	1	1	t	t	t	77	t
Galium triflorum	--	--	t	t	2	1	1	4	1	t	t	1	--	77	1
Smilacina stellata	--	--	t	--	--	t	t	--	--	--	t	t	--	38	t
Adiantum pedatum	--	--	--	t	2	--	--	t	2	t	--	--	--	38	t
Blechnum spicant	--	--	--	4	t	--	--	t	1	--	--	t	--	38	t
Oxalis oregana	--	--	--	12	30	13	23	31	34	57	7	4	t	77	16
Tiarella unifoliata	--	--	--	t	t	t	--	t	t	--	t	t	--	54	t
Adenocaulon bicolor	--	--	--	t	t	t	t	t	--	t	--	--	--	46	t
Vancouveria hexandra	--	--	--	t	1	t	--	--	t	--	--	t	--	38	t
Tiarella trifoliata	--	--	--	t	1	1	--	t	1	--	t	t	--	54	t
Montia sibirica	--	--	--	--	3	--	t	3	--	t	--	--	--	31	t
Nemophila parviflora	--	--	--	--	1	--	t	1	--	t	--	--	--	31	t
Linnaea borealis	--	--	--	--	--	t	--	t	--	--	t	t	--	31	t

1/ M and R under the tree layer refer to mature and immature (reproductive) classes.

Immature conifers in all stands average 30% cover for Tsuga and 13% for Chamaecyparis. Saplings range from one to ten meters tall and appear to be scattered in the stands, though occassional groups of saplings are found together on nurse logs or old stump bases. Conifer seedlings also have high density within this community (Table 5). Sixty-six percent of them are Tsuga, and 26% are C. lawsoniana. It appears that C. lawsoniana is seral to Tsuga heterophylla in this habitat type.

The shrub stratum is comparatively poorly developed, though species diversity is similar to that of the other Tsuga heterophylla Zone Chamaecyparis communities (Table 9). The shrub cover is much lower in the Tshe-Chla/Pomu-Oxor community than in most other communities studied; accumulative shrub cover is only 9%. This and the Chla-Tshe/Xete community are apparent exceptions to the normal shrubby nature of Chamaecyparis forest communities. The more important shrubs are Gaultheria shallon and Berberis nervosa in the low shrub layer and Lithocarpus densiflora in the tall shrub layer.

The herb stratum is the best developed of all my communities. The average accumulative cover is 60%, more than twice that of any other community (Table 9). Species diversity of this stratum is about normal for the Tsuga heterophylla Zone communities. Polystichum munitum and Oxalis oregana make up 85% of the cover (Table 19). Other herbs with maximal development and have a constancy greater than 25% in this community include Tiarella trifoliata, Blechnum spicant, Viola sempervirens, Pteridium aquilinum, and Montia sibirica. All have been cited by others as members of comparatively mesic habitats in the Pacific Northwest (Daubenmire, 1969; Franklin and Dyrness, 1973; Dyrness, Franklin, and Moir, 1974; Hawk and Zobel, 1974; and Zobel et al., 1976). Moss cover in this community averages 39% and is dominated by "moisture-loving" terrestrial species.

The Tshe-Chla/Pomu-Oxor community has been discussed by others as part of SAF cover type 231, Port Orford Cedar-Douglas Fir (Society of American Foresters, 1954); Type 2 Cedar-Hemlock Douglas Fir Forest (Kuchler, 1964); and as a Chamaecyparis variant of the Tsuga heterophylla Zone (Franklin and Dyrness, 1973). Franklin et al. (1972) includes a discussion of old growth forest communities containing Polystichum munitum as an understory dominant on moist benches or well-watered slopes. The sample descriptions of Franklin and Dyrness (1973) list the Polystichum munitum community as occupying the more mesic sites and occurring adjacent to or mixed with a more shrubby variant that occurs on better drained sites (discussed here as the Tshe-Chla/Rhma-Gash community).

Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon (Tshe-Chla/Rhma-Gash Community). Only six stands have been sampled in this type; all occur within a few km of Agness Pass on Panther Ridge (Figure 1). Five of them occur north of Panther Ridge while the sixth lies just south of the ridge. The best developed stands have been found between 650 and 750 m elevation in the Port-Orford Cedar-Research Natural Area. All stands occur on sedimentary soils of the Galice, Umpqua and Tyee Formations (Table 20). Typical soils contain four or more horizons with distinct colors, textures, or structures. The average depth to the surface of the C horizon is 73 cm. Texturally the soils range from silt-loam A horizons to gravelly, silt-loam or cobbly, silt-loam B horizons and very gravelly-cobbly, silty-clay-loam C horizons. They have a greater relative volume of gravels and cobbles than horizons in the Tshe-Chla/Pomu-Oxor community, and they are typically better drained.

The tree canopy cover of the Tshe-Chla/Rhma-Gash community is 84% while immature conifer cover is 33% (Table 9). Pseudotsuga menziesii and C. lawsoniana are present in all stands (Table 21), but Tsuga occurs in only four of the six plots. The two plots which lack Tsuga lie at the dry limits of the community type. There are Tsuga trees in the vicinity of each plot. A variety of other trees occur here (Table 21); however, none are found with any consistency within the community. Most mature trees are C. lawsoniana, followed by Tsuga and then Pseudotsuga in mature stands (Table 5).

Seedlings and saplings of all species have reduced density in this shrubby community compared to the Tshe-Chla/Pomu-Oxor community, and the total immature tree density is the lowest of all the major U.S. communities (Table 5). The only tree species which shows maximal development here is Abies grandis, though it is quite local in both distribution and density.

Table 20. Site characteristics of *Tsuga heterophylla*-*Chamaecyparis lawsoniana*/*Rhododendron macrophyllum*-*Gaultheria shallon* community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
45	15	650	s	29	230	40	sedimentary
27	13	600	nne	5	400+	75	sedimentary
62	8	220	wnw	11	145	60	sedimentary
63	8	700	s	35	360	90	sedimentary
30	13	450	ese	20	250	100	sedimentary
26	13	580	nw	2	400+	70	sedimentary

Table 21. Cover and constancy of species in the Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon community (cover given in whole percent except for t = trace less than .5%).

Layers and Species		Stands representing this community 45	27	62	63	30	26	% Const.	% Ave. Cover
Tree Layer									
Chamaecyparis lawsoniana	M[1]	75	45	55	40	50	45	100	52
Chamaecyparis lawsoniana	R	20	3	12	15	5	--	83	9
Pseudotsuga menziesii	M	5	35	30	70	40	50	100	38
Pseudotsuga menziesii	R	5	--	3	--	--	--	33	1
Tsuga heterophylla	M	--	20	--	40	15	10	67	14
Tsuga heterophylla	R	--	15	--	20	15	60	67	18
Abies grandis	M	t	13	--	--	--	--	33	2
Abies grandis	R	--	3	--	10	--	--	33	2
Taxus brevifolia	MR	--	--	t	--	10	--	33	2
Arbutus menziesii	M	--	--	15	--	--	t	33	3
Shrub Layer									
Gaultheria shallon		86	4	5	3	70	5	100	29
Lithocarpus densiflora		11	2	--	--	5	t	67	3
Vaccinium ovatum		4	3	11	--	3	14	83	6
Rubus ursinus		1	--	t	--	7	--	50	1
Rhododendron macrophyllum		6	63	--	58	16	46	83	32
Umbellularia californica		t	--	8	--	2	--	50	2
Berberis nervosa		--	11	7	17	7	7	67	8
Acer circinatum		--	--	t	21	7	--	50	5
Vaccinium parvifolium		--	--	t	t	3	--	50	1
Berberis aquifolium		--	--	t	--	4	--	33	1
Rosa gymnocarpa		--	--	t	--	3	--	33	1
Holodiscus discolor		--	--	t	--	3	--	33	1
Corylus cornuta		--	--	t	--	10	--	33	2

(continued on next page)

Table 21. (Continued)

Layers and Species	Stands representing this community						% Const.	% Ave. Cover
	45	27	62	63	30	26		
Herb Layer								
Blechnum spicant	14	--	--	--	t	--	33	2
Polystichum munitum	9	21	4	13	34	1	100	14
Galium triflorum	t	t	1	t	1	--	83	t
Disporum hookeri	t	--	t	t	1	--	67	t
Athyrium filix-femina	4	--	--	--	t	--	33	1
Trillium ovatum	t	--	t	t	1	t	83	t
Pteridium aquilinum	t	--	--	--	t	--	33	t
Goodyera oblongifolia	t	t	1	t	t	t	100	t
Vancouveria hexandra	t	--	t	--	2	--	50	t
Viola sempervirens	--	2	1	t	2	1	83	1
Trientalis latifolia	--	t	2	--	1	--	50	1
Pyrola picta	--	t	--	--	t	t	50	t
Corallorhiza mertensiana	--	t	--	t	--	--	33	t
Polypodium glycerhiza	--	t	t	--	t	--	50	t
Whipplea modesta	--	--	1	t	2	--	50	1
Chimaphila menziesii	--	--	t	t	--	t	50	t
Hieracium albiflorum	--	--	t	--	1	--	33	t
Adenocaulon bicolor	--	--	t	--	t	--	33	t
Oxalis oregana	--	--	--	6	13	t	50	3
Tiarella unifoliata	--	--	--	t	t	--	33	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

The shrub stratum is well developed with an average accumulative cover of 91% (Table 9). The structure and flora of the shrub layer are essentially the same as those of the shrub layer in the Chla/Lide and Abco-Tshe-Chla communities (Tables 9 and 17). Here the layer is dominated by the tall shrub Rhododendron macrophyllum and the low shrub Gaultheria shallon, which account for 62% of the total shrub cover; both exhibit their maximal development in this community. Other shrubs which show maximal development here include Berberis nervosa, Vaccinium ovatum, Berberis aquifolium, Corylus cornuta, and Acer circinatum.

The herb stratum is poorly developed, but does maintain fairly high cover values for Polystichum munitum. With such a dense shrub layer it is natural that the herb layer is poorly developed, specially when compared to the previous community. In patches, there is usually high local herb diversity; many species have greater than 25% constancy. Thus, despite the more xeric nature of the Tshe-Chla/Rhma-Gash community, it is still a very mesic community in comparison to other communities studied. The dominant herb is Polystichum munitum; several others are common in this community as well as within the Pomu-Oxor community (Table 21). Terrestrial bryophyte cover in this community averages 40%.

The Tshe-Chla/Rhma-Gash community has been discussed by Franklin and Dyrness (1973) and Franklin et al. (1972). These authors point out the similarity of the shrub community in mature stands with the earlier seral stages of the more mesic forest communities in the Port Orford Cedar and Coquille River Falls Research Natural Areas.

Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax (Chla-Tshe/Xete) Community. In my study area, the dense occurrence of Xerophyllum tenax is a good indicator of open habitats, medium in moisture balance, and with high probability of being on ultramafic soils.

This community has been sampled by 12 stands (Table 22) located within a few km of Agness Pass (Figure 1). They are mostly along upper slopes between Iron Mountain, Powers, and Agness, Oregon. The community is not extensive but rather occurs as large patches distributed in a matrix of non-Chamaecyparis communities, Chla/Lide, or the Tshe-Chla/Rhma-Gash communities. It generally occurs on more undulating terrain, similar in landform to the Tshe-Chla/Rhma-Gash community. Stands occupy a fairly

Table 22. Site characteristics of _Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax_ community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
100	16	810	w	15	350	54	ultramafic mix
46	16	820	wnw	13	290	95	ultramafic mix
39	15	900	ne	9	400+	85	ultramafic mix
41	15	600	e	23	290	67	ultramafic mix
99	16	790	wnw	35	330	18	ultramafic mix
101	16	780	ne	7	170	33	ultramafic mix
105	16	720	nw	33	400+	59	ultramafic
104	16	720	wnw	38	400+	47	ultramafic
106	16	640	se	39	180	32	ultramafic
98	16	850	w	32	325	15	ultramafic
102	16	920	sw	35	300+	40	ultramafic
103	16	980	sw	30	145	17	ultramafic

constant landform, however, occurring on convex sideslopes or gently rolling ridge positions between two drainages. The four stands which occur on concave landforms (Table 22) have little Xerophyllum tenax (Table 23, stands 100, 46, 41, and 104).

All stands in this community occur on ultramafic parent materials (peridotite, dunite, or serpentinite). The parent material on the two major ridges where this community was sampled contains a mixture of many types. Both ridges occur in major contact zones between granitic and ultramafic intrusives, and evidence of metamorphosis of sedimentary rocks exists here as well. Most ultramafic material excavated from soil pits here is serpentinite rather than peridotite, which is more common in the Pinus-Chla/Quva/Xete community. Depth of the soil to the surface of the C horizon averages 42 cm; the six stands (Table 22) on mixed ultramafic parent material, average 59 cm, and the five stands on ultramafic material average only 35 cm depth. The mixed parent material soils have silt-loam to silty-clay-loam B horizons; and gravelly-cobbly, sandy-loam to clay C horizons. Soils on pure ultramafic parent material include gravelly, silt-loam A horizons; gravelly-cobbly, silty-clay-loam B horizons; and gravelly-cobbly-stony, clay-loam C horizons.

The mature tree canopy cover is 85% and that of the immature conifers is 30% (Table 9). In the Pomu-Oxor and the Rhma-Gash communities the accumulative tree cover often reaches 150%, yet actual cover is nearly identical with that of the Chla-Tshe/Xete community (tree actual and accumulative cover here are often within 10% variation). The foliage of trees in the Chla-Tshe/Xete community is often noticeably thinner, allowing the passage of more light through the canopy. This decrease in crown vigor is another indication of the more xeric and ultramafic nature of the habitat type compared to the other communities of the Tsuga heterophylla Zone. Pseudotsuga and Chamaecyparis are always present in moderate to old growth stands. Tsuga is found in 83% of the stands (Table 23). Hardwoods found in this community are often too small to call trees. Whittaker (1960) has mentioned the lack of hardwood trees on serpentine soils. Many of the typical hardwood species are major components of the shrub layer here.

Chamaecyparis lawsoniana is listed in the community name prior to

Table 23. Cover and constancy of species in the <u>Chamaecyparis lawsoniana</u>-<u>Tsuga heterophylla</u>/<u>Xerophyllum tenax</u> community (cover given in whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community												% Const.	% Ave. Cover
		100	46	39	41	99	101	105	104	106	98	102	103		
<u>Tree Layer</u>															
Pseudotsuga menziesii	M[1]	15	30	15	20	10	45	35	35	15	15	65	25	100	27
Pseudotsuga menziesii	R	--	--	5	--	--	--	--	--	--	--	t	1	25	1
Chamaecyparis lawsoniana	M	65	70	30	45	65	60	45	55	70	70	35	30	100	53
Chamaecyparis lawsoniana	R	35	10	15	20	15	55	--	--	10	35	25	65	83	24
Tsuga heterophylla	M	--	10	10	35	--	--	40	20	--	--	t	--	50	10
Tsuga heterophylla	R	t	10	40	20	t	--	1	--	5	3	--	--	67	7
Pinus lambertiana	MR	--	t	--	--	5	--	--	--	--	1	t	t	42	1
Taxus brevifolia	MR	--	5	--	--	1	--	--	--	6	4	--	--	33	1
Pinus monticola	MR	--	t	35	--	--	--	t	--	--	--	--	--	25	3
<u>Shrub Layer</u>															
Lithocarpus densiflora		2	3	1	2	56	2	t	--	31	4	8	5	92	9
Rhododendron macrophyllum		5	5	30	73	5	14	t	t	t	5	--	--	83	11
Vaccinium parvifolium		t	2	5	t	1	--	--	--	t	t	2	t	75	1
Berberis nervosa		t	t	t	--	t	t	--	1	2	t	1	--	75	t
Gaultheria shallon		5	--	13	5	1	3	t	--	19	3	--	--	67	4
Rosa gymnocarpa		--	t	t	t	t	--	--	--	5	t	--	t	58	t
Rubus ursinus		--	t	t	--	t	--	--	--	1	t	--	--	42	t
Rhododendron occidentale		--	2	3	--	t	--	--	--	--	3	--	--	33	1
Vaccinium ovatum		--	--	--	9	--	--	11	1	15	--	--	--	33	3
Quercus chrysolepis		--	--	t	--	--	--	--	--	--	--	t	2	25	t
<u>Herb Layer</u>															
Xerophyllum tenax		--	1	25	1	46	7	34	2	29	25	25	20	92	18
Goodyera oblongifolia		1	t	1	1	t	1	t	t	1	1	1	--	92	1
Polystichum munitum		10	t	t	--	2	t	1	--	7	1	--	--	75	2
Chimaphila menziesii		--	t	t	t	--	--	t	t	t	--	1	t	67	t

(continued on next page)

Table 23. (Continued)

Layers and Species	Stands representing this community												%	%
	100	46	39	41	99	101	105	104	106	98	102	103	Const.	Ave. Cover
Disporum hookeri	--	1	t	--	--	t	t	--	t	t	t	t	67	t
Iris innominata	--	2	t	--	t	t	t	--	t	1	2	--	67	t
Trillium ovatum	t	t	t	--	1	--	t	t	--	t	--	--	58	t
Vancouveria hexandra	2	2	t	--	--	1	--	--	--	1	t	--	50	1
Trientalis latifolia	1	t	t	--	--	--	t	--	4	--	t	--	50	t
Synthyris reneformis	--	t	t	--	2	--	--	--	1	1	1	--	50	t
Chimaphila umbellata	--	t	t	--	--	--	t	--	t	--	1	--	50	t
Whipplea modesta	--	t	--	--	t	t	--	--	t	t	--	t	50	t
Galium ambiguum	--	--	--	--	t	t	--	--	1	t	t	t	50	t
Viola sempervirens	t	2	--	--	--	--	t	--	--	t	t	--	42	t
Trillium rivale	t	1	t	--	--	--	t	--	--	t	--	--	42	t
Erythronium oregonum	t	t	t	--	--	--	--	--	--	t	--	--	33	t
Pyrola picta dentata	--	--	t	--	--	--	t	t	--	--	--	t	33	t
Coptis laciniata	6	3	--	--	--	--	--	--	--	t	--	--	25	1
Galium triflorum	--	t	t	--	--	--	--	t	--	--	--	--	25	t
Listera caurina	--	1	--	--	2	--	--	--	--	4	--	--	25	1
Senecio bolanderi	--	1	--	--	--	1	--	--	--	--	t	--	25	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

Tsuga heterophylla for two reasons: (1) the reproductive size classes indicate a continued dominance of Chamaecyparis (Table 5); and (2) the constancy and apparent rate of growth of Chamaecyparis on this parent material are greater than for other species. Pseudotsuga occurs in all layers of trees. This habitat may not support a stand of dominant Tsuga because of the parent material as well as the secondary effects of reduced crown vigor which allows greater light intensities into the understory. No trees show maximal development in this community, though Chamaecyparis lawsoniana does nearly as well here in terms of importance as it does in the Chla/Lide community (Tables 5 and 8).

The shrub stratum is highly variable, being quite well developed in some areas and almost lacking in others. However, with an average accumulative cover of only 30%, the development of shrubs is far less than that in most other Chamaecyparis communities studied (Table 9). The dominant shrubs include Lithocarpus densiflora, Rhododendron macrophyllum, Gaultheria shallon, and Berberis nervosa (Table 23). Another common shrub is Rhododendron occidentale, which has often been cited as occurring on ultramafic soils. None of the common shrubs in this community show maximal development here.

In the herb stratum average plot diversity is relatively low compared to other communities, but the average cover is moderate (Table 9). This is primarily due to the dominant, Xerophyllum tenax, which occurs in most of the plots with high cover and density (Table 23). The species diversity within the herb stratum here may be indicative of the large variation in available microhabitats. Since the amount of shrub cover is so variable, and the community occurs on a variety of aspects, it is not surprising to find such variability in the herb layer. Polystichum munitum and Goodyera oblongifolia are often present with low cover. Herb species within this community are often cited as indicators of ultramafic parent materials; these include Iris innominata, Galium ambiguum, Trillium rivale, Erythronium oregonum and Pyrola picta var. dentata. These occur here with greater than 25% constancy. This community has more "rock-loving" terrestrial bryophytes; the average moss cover (45%) is the greatest encountered in any community studied.

Mixed Evergreen Zone

The Mixed Evergreen Zone occurs primarily in the central portions of the range of *Chamaecyparis lawsoniana*. It is bounded to the north and west by the lower elevation *Tsuga heterophylla* Zone and to the east and southeast by the high elevation *Abies concolor* Zone. This zone contains 28 study plots with 16 in the *Chamaecyparis lawsoniana*/*Lithocarpus densiflora* community, 11 plots in the *Pinus*-*Chamaecyparis lawsoniana*/*Quercus vaccinifolia*/*Xerophyllum tenax* community, and one plot in the *Pseudotsuga*-*Chamaecyparis*/foothill alluvial terrace community, a special habitat type discussed later.

Chamaecyparis lawsoniana/*Lithocarpus densiflora* (*Chla*/*Lide*) *Community*. This community is similar to the *Tshe*-*Chla*/*Rhma*-*Gash* community and the *Chla*-*Tshe*/*Xete* community (Tables 21, 23, and 25). The *Chla*/*Lide* community occurs on ultramafic substrates similar to the *Chla*-*Tshe*/*Xete* community, and where moisture characteristics are similar to those within the *Tshe*-*Chla*/*Rhma*-*Gash* community. This results in very shrubby stands which lack *Tsuga heterophylla*. The lack of *Tsuga* appears to be more of a climatic than an edaphic response since *Tsuga* is found in the *Chla*-*Tshe*/*Xete* community on similar serpentine soils. *Tsuga* is also found within the *Abco*-*Tshe*-*Chla* community on soils similar to those of the mixed soils within the *Chla*-*Tshe*/*Xete* community above. Stands with common *Tsuga heterophylla* are restricted to the coastal belt, and inland primarily north of the Rogue River drainage (Figure 1).

The *Chla*/*Lide* community has been sampled by 16 plots (Table 24) located over most of the latitudinal range of *Chamaecyparis lawsoniana*, including Agness Pass, Pine Point, Red Mountain, and the Orleans-Blue Lake study areas (Figure 1). It is probably the most common *Chamaecyparis* community and occurs over most of the more mesic portions of the Mixed Evergreen Zone of Franklin and Dyrness (1973). This community has a broader distribution than the other communities already discussed. In the north it occurs between 400 and 850 meters elevation, and in the south, between 580 and 910 meters (Table 24). It is common on benches, along perennial stream drainages, and on gently rolling areas that have seeps or standing water. The parent material of the northern plots and

Table 24. Site characteristics of Chamaecyparis lawsoniana/Lithocarpus densiflora community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
15	19	480	wnw	5	100	50	ultramafic mix
38	15	850	w	3	110	76	ultramafic
43	16	420	nnw	27	160	80	ultramafic
14	19	620	wnw	8	180	85	ultramafic
12	19	620	n	10	230	25	ultramafic
50	46	560	nw	90	325	70	ultramafic mix
44	16	620	sw	63	270	90	ultramafic mix
75	36	580	e	7	260	72	ultramafic
51	39	830	n	12	370	45	granitic+unknown
83	39	910	ne	14	400+	60	unknown
84	39	790	n	25	350	28	granitic+unknown
82	39	900	n	5	270	55	unknown
53	39	810	nw	5	290	84	ultramafic mix
52	39	900	e	3	350	77	ultramafic mix
19	19	830	nw	12	215	105	ultramafic
85	39	960	e	0	350	83	ultramafic

Table 25. Cover and constancy of species in the Chamaecyparis lawsoniana/Lithocarpus densiflora community (cover given in whole percent except for t = trace less than .5%).

Layers and Species		Stands representing this community																% Const.	% Ave. Cover
		15	19	38	85	43	14	12	50	44	75	51	83	84	82	53	52		
Tree Layer																			
Chamaecyparis lawsoniana	M[1/]	40	60	40	40	30	40	65	45	60	60	80	55	65	55	70	95	100	56
Chamaecyparis lawsoniana	R	30	25	25	13	20	70	30	10	2	40	65	10	25	35	35	70	100	32
Pseudotsuga menziesii	M	5	35	25	50	25	45	--	10	45	20	15	55	45	45	25	20	94	29
Pseudotsuga menziesii	R	--	5	10	3	--	--	--	2	2	1	5	--	--	--	--	5	50	2
Taxus brevifolia	MR	15	--	t	--	--	--	--	2	--	t	5	3	--	--	--	t	44	2
Pinus lambertiana	MR	--	--	--	12	--	--	15	1	--	15	1	--	--	--	--	--	31	3
Pinus monticola	MR	t	5	50	--	--	--	--	--	10	--	--	--	--	--	--	--	25	4
Lithocarpus densiflora	M	10	--	--	--	20	t	t	15	10	--	--	--	--	--	--	--	38	3
Shrub Layer																			
Lithocarpus densiflora		34	3	25	25	36	10	35	74	90	25	5	4	5	1	10	1	100	24
Gaultheria shallon		25	--	40	--	10	16	15	--	49	18	49	1	25	27	7	t	81	18
Vaccinium parvifolium		t	t	2	1	1	t	5	1	t	6	t	t	t	1	--	t	94	1
Rhododendron macrophyllum		34	--	48	--	--	5	--	--	33	--	14	34	12	23	12	t	63	13
Berberis nervosa		--	--	1	t	--	--	t	--	10	t	t	t	6	1	4	8	69	2
Rubus ursinus		--	--	--	t	t	t	1	3	t	t	t	t	--	t	--	t	69	t
Rhododendron occidentale		20	--	8	t	15	31	17	44	--	57	21	--	--	--	--	t	63	13
Castanopsis chrysophylla		--	--	t	--	--	--	--	--	28	9	1	t	10	14	t	t	56	4
Rosa gymnocarpa		t	t	t	1	--	t	t	t	t	t	--	--	--	--	--	t	63	t
Quercus chrysolepis		2	t	t	13	--	t	22	t	--	1	--	--	--	--	t	t	63	2
Vaccinium ovatum		19	--	--	--	11	8	24	--	6	55	--	--	2	1	--	--	50	8
Umbellularia californica		2	23	--	--	74	--	8	9	t	t	t	--	--	--	--	--	50	7
Quercus sadleriana		--	--	1	--	--	--	--	--	--	--	1	t	--	t	t	t	38	t
Arbutus menziesii		--	--	15	15	t	15	--	10	--	t	--	--	--	--	--	--	38	3
Quercus vaccinifolia		t	--	9	10	--	--	--	--	--	t	--	--	--	--	--	2	31	1
Rhamnus californica		--	--	t	t	12	--	3	--	--	2	--	--	--	--	--	--	31	1
Amelanchier pallida		--	--	t	t	--	6	--	--	t	--	--	--	--	--	--	--	25	t

(continued on next page)

Table 25. (Continued)

Layers and Species	Stands representing this community																%	%
	15	19	38	85	43	14	12	50	44	75	51	83	84	82	53	52	Const.	Ave. Cover
<u>Herb Layer</u>																		
Goodyera oblongifolia	t	t	t	t	t	t	1	t	t	1	1	1	t	t	t	1	100	t
Polystichum munitum	t	--	t	--	4	1	1	13	1	3	t	t	t	--	t	t	81	1
Xerophyllum tenax	4	2	6	3	1	1	t	--	--	t	t	t	t	t	t	2	88	1
Vancouveria planipetala	t	--	1	2	--	--	--	6	1	t	2	2	1	t	t	t	75	1
Trillium ovatum	--	--	t	--	--	--	--	t	t	--	t	t	t	t	t	t	56	t
Linnaea borealis	--	--	6	--	t	--	--	5	t	--	--	2	--	1	t	t	50	1
Chimaphila menziesii	--	--	t	--	--	--	--	t	--	t	--	t	t	t	4	t	50	t
Viola sempervirens	t	--	t	--	t	--	--	--	t	t	--	t	--	1	--	--	43	t
Trientalis latifolia	--	--	t	t	t	1	--	1	t	--	--	--	--	--	t	1	50	t
Chimaphila umbellata	--	--	1	1	--	--	--	--	3	t	--	5	1	6	--	t	50	1
Whipplea modesta	--	--	t	--	t	--	--	3	t	--	--	t	2	--	t	--	44	t
Disporum hookeri	--	--	t	--	t	--	--	t	t	t	--	t	--	--	--	t	44	t
Pteridium aquilinum	t	--	--	--	--	--	--	2	2	t	--	--	--	--	t	t	38	t
Trillium rivale	t	t	t	--	t	t	--	--	t	--	--	--	--	--	--	--	38	t
Pyrola picta dentata	--	t	t	--	--	--	--	--	--	--	--	t	--	t	t	t	38	t
Anemone quinquefolia	t	--	1	--	--	1	t	--	--	--	--	--	--	--	--	--	25	t
Galium ambiguum	1	--	t	1	--	t	--	--	--	--	--	--	--	--	--	1	31	t
Iris innominata	t	--	t	1	--	--	t	t	--	--	--	--	--	--	--	--	31	t
Syntheris reneformis	t	t	t	--	--	t	--	--	--	--	--	--	--	--	--	t	31	t
Erythronium oregonum	t	t	t	--	--	t	--	--	t	--	--	--	--	--	--	--	31	t
Corallorhiza mentensiana	--	t	--	--	--	--	--	--	--	--	t	t	--	t	--	t	31	t
Carex sp.	--	t	7	1	--	--	--	--	--	t	--	7	--	--	--	--	31	1

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

some southern plots includes a mixed colluvium of ultramafic and other parent materials (often gabbro) or upon a mixed colluvium of different ultramafic types. Some southern stands occur where there has been considerable intergradation of granodioritic, ultramafic, and metavolcanic parent materials (Blue Lake study area, Figure 1). Soils within this community characteristically have many coarse fragments in all horizons. The texture ranges from gravelly-cobbly, silt-loams to loam in the shallow A horizons; gravelly-cobbly-stony, silt-loam to clay-loam B horizons (which are comparatively deep and often multi-layered); to gravelly-cobbly-stony, silty-clay-loam to clay-loam C horizons. The average depth to the surface of the C horizon is 64 cm (Table 24).

The tree canopy cover here is 80%, and the immature conifer cover is 37% (Table 9). Chamaecyparis is the only tree found in all of the sampled stands, although Pseudotsuga is missing in the tree layer of only one plot and does occur nearby. Taxus brevifolia and Lithocarpus densiflora as well as Pinus species are also common (Table 25). Pinus species are more common here than in any of the other communities described above. Pinus attenuata, Arbutus menziesii, Umbellularia californica, Quercus chrysolepis, and Castanopsis chrysophylla are also occassionaly found in the tree layer. Trees that show maximal development in the Chla/Lide community are Lithocarpus densiflora and Arbutus menziesii. Scattered seedlings and saplings of Pinus lambertiana, Pinus monticola, and Pinus attenuata attest to the semi-xeric, open nature of the community. The well developed reproductive tree layer is dominated by Chamaecyparis lawsoniana (Table 5).

The accumulative shrub cover is 97%, the strongest development of this stratum among the C. lawsoniana communities (Table 9). The reason for the high cover is the abundance of hardwoods (Lithocarpus and Castanopsis) that are too small to fit tree categories. The shrub stratum is the most developed stratum within this community. There are 17 species with constancy greater than 25% (Table 25). Lithocarpus is the dominant shrub. Other minor dominants include Vaccinium ovatum, Gaultheria shallon, and Umbellularia californica. Lithocarpus is usually a tall shrub or small tree, but it may also be a low sprawling shrub, like many hardwoods in this region (Whittaker, 1960; Emmingham, 1973). As a shrub, Lithocarpus shows its maximal development in this community; other shrubs include Quercus chrysolepis, Rhododendron occidentale , and Castanopsis chrysophylla.

Herbs have an average cover of only 8%, the lowest of any community studied (Table 9). They also have less than the average diversity. The layer contains an average moss cover of only 19%; about half that in the communities discussed above. Here the "rock-loving" forms of terrestrial bryophytes are relatively important. Although there are 21 herb species with greater than 25% constancy, only 12 have constancies greater than 50%, and only six species have an average cover of greater than trace amounts. The more common species include Polystichum munitum and Xerophyllum tenax (Table 25). Ultramafic indicators among the herbs are common (Table 17).

This community is commonly found near the Tshe-Chla/Rhma-Gash and Chla-Tshe/Xete communities of the Tsuga heterophylla Zone, at both the northern and the southwestern ends of the study area (Agness Pass and Blue Lake study areas respectively of Figure 1). In more xeric areas it occurs as strip communities along perennial streams or well protected benches with common seeps; the Pinus-Chla/Quva/Xete community or old burns with nearly solid stands of Pinus attenuata and sclerophyllous shrubs occupy the drier topography. The Chla/Lide community appears to be a topoedaphic climax which develops in areas with frequent incomplete burns and within mesic portions of the Pseudotsuga-sclerophyll vegetation type described by Whittaker (1960).

Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax (Pinus-Chla/Quva/Xete) Community. This community has been sampled by 11 stands (Table 26) located over much of the range of Chamaecyparis lawsoniana. The 11 sites range from 360 to 1360 m elevation, occupying the greatest elevational range of any community in this study. It has been recorded near Rabbit Lake (1390 m) and El Capitan Mountain near Youngs Valley study area (Figure 1) at nearly 1500 m elevation. The community has not been divided into high and low elevation forms because of the continuity it shows within the range of elevations found and also because few of the higher elevation plots were measured. The species continuity over so great an elevational change indicates that the

Table 26. Site characteristics of <u>Pinus</u>-<u>Chamaecyparis lawsoniana</u>/<u>Quercus vaccinifolia</u>/<u>Xerophyllum tenax</u> community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
				Shrub Matrix Phase			
17	19	820	ssw	3	110	95	ultramafic
16	19	580	nne	45	150	40	ultramafic
11	19	580	nnw	11	60	50	ultramafic
87	38	1360	ene	3	142	42	ultramafic
108	23	1240	sw	15	400+	15	ultramafic
76	36	1120	ne	10	230	12	ultramafic
				Herb Matrix Phase			
18	19	830	ssw	25	160	20	ultramafic
13	19	590	nne	27	60	19	ultramafic
40	15	900	wsw	45	180	16	ultramafic
60	24	360	wnw	15	300	16	ultramafic
59	24	500	n	59	100	25	ultramafic

vegetation is responding primarily to some edaphic factor, rather than to those factors correlated with elevation. Climatic conditions are superimposed over the apparent controlling force, ultramafic soils. The distribution of Abies concolor and Pinus jeffreyi reflect the secondary, but important, influence of temperature and moisture within this community; Pinus jeffreyi is in dry areas while Abies concolor is in cool areas. Both of these species are found here with Chamaecyparis lawsoniana. Stand 18 (Table 27), located five meters upslope from plot 17, was measured to show the rapid contrast in vegetation as well as to establish a comparative basis for moisture stress measurements.

This community has been separated into shrub and herb matrix phases (after Whittaker, 1960). Although the two may be found quite close together, they often occupy noticeably different microhabitats. The shrub phase occurs on benches and drainages with slopes averaging about 15% while the herb phase occurs on midslopes with an average slope of 34%.

All of the plots in this community occur on weakly weathered peridotite or serpentinite, with the peridotite more common. Soil texture varies greatly from gravelly to stony loam or clay textures within the shallow A horizon; gravelly-cobbly-stony, silty-clay-loam B horizons; and gravelly-cobbly-stony, silty-clay to clay C horizons. The major exception is in the C horizons; in many plots it was a mass of extremely weathered, "mushy" serpentinite. There was standing water in some soil pits even in late summer months. The depth of soil to the surface of the C horizon averages 32 cm (42 cm in the shrub matrix phase and 19 cm in the herb matrix phase, Table 26).

The actual mature canopy cover here is only 39% and that of the immature conifers is 34%. The immature cover is near average, but the mature tree cover is the lowest of any community observed (Table 9). Due to the patchiness of the shrub and herb matrix phases there was no attempt to sample them separately. My plots are separated in Tables 26 and 27 according to the phases they appear to represent. The vegetation data as well as the site characteristics support the separation. Mature stands of this community maintain the highest density of Pseudotsuga menziesii saplings found (Table 5). However, C. lawsoniana density is second-to-

Table 27. Cover and constancy of species in the Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax community (cover given in whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community											% Const.	% Ave. Cover
		Herb matrix phase					Shrub matrix phase							
		18	13	40	60	59	17	16	11	87	108	76		
Tree Layer														
Chamaecyparis lawsoniana	M[1/]	--	5	15	20	45	60	--	20	15	20	25	82	20
Chamaecyparis lawsoniana	R	--	15	35	10	25	45	3	20	15	5	10	91	17
Pseudotsuga menziesii	M	--	--	--	5	5	--	--	--	--	10	--	27	2
Pseudotsuga menziesii	R	--	7	10	5	5	7	30	10	t	10	--	82	8
Pinus jeffreyi	MR	17	27	35	10	5	40	30	27	30	11	--	91	21
Pinus monticola	MR	--	t	15	--	--	--	20	10	10	9	35	64	9
Calocedrus decurrens	MR	--	--	--	t	5	--	t	--	6	5	--	45	1
Pinus lambertiana	MR	--	--	--	--	30	--	--	t	14	--	t	36	4
Shrub Layer														
Quercus vaccinifolia		22	36	28	t	6	32	66	9	27	39	21	100	26
Rhamnus californica		t	18	6	1	4	1	20	23	8	--	4	91	8
Ceanothus pumilus		6	3	23	t	t	3	4	2	8	9	5	100	6
Quercus chrysolepis		--	t	t	1	t	--	t	--	--	t	t	64	t
Vaccinium parvifolium		--	6	3	5	--	--	11	1	17	2	15	73	5
Amelanchier pallida		--	1	--	1	1	--	5	t	t	2	2	73	1
Umbellularia californica		2	t	--	1	2	2	--	t	--	--	t	64	1
Arctostaphylos nevadensis		11	9	t	--	--	5	13	5	1	8	--	73	5
Juniperus communis		2	2	--	--	--	2	5	3	1	--	t	54	1
Rosa gymnocarpa		--	--	t	--	--	--	1	t	--	t	t	45	t
Lithocarpus densiflora		--	t	--	--	3	--	1	--	--	--	5	36	1
Berberis repens		--	t	t	--	--	--	--	--	t	3	1	45	t
Rhododendron occidentale		--	--	--	32	24	--	--	4	--	14	28	45	9
Holodiscus discolor		--	--	--	--	--	--	--	--	t	t	t	27	t
Herb Layer														
Xerophyllum tenax		3	4	t	--	20	4	22	10	47	2	23	91	11

(continued on next page)

Table 27. (Continued)

Layers and Species	Stands representing this community											% Const.	% Ave. Cover
	Herb matrix phase					Shrub matrix phase							
	18	13	40	60	59	17	16	11	87	108	76		
Iris innominata	t	t	1	t	1	1	t	t	--	t	t	91	t
Galium ambiguum	2	1	1	t	t	t	3	t	--	t	--	82	1
Trillium rivale	t	t	t	t	t	--	t	t	t	t	t	91	t
Festuca californica	6	8	t	1	t	12	4	8	t	--	--	82	3
Brodiaea spp.	t	t	t	1	t	t	1	t	t	--	--	82	t
Viola cuneatus	t	t	2	1	--	t	t	t	t	--	--	73	t
Calochortus elegans	t	--	--	t	--	t	t	t	t	t	--	64	t
Microseris nutans	3	2	t	t	--	t	t	1	t	--	--	73	1
Gentiana affinis	--	t	--	--	--	t	1	1	5	t	t	73	1
Pyrola picta dentata	--	t	t	--	1	t	--	--	t	t	t	64	t
Erythronium oregonum	--	t	t	2	1	--	t	t	--	--	t	64	t
Horkelia sericata	t	6	--	t	t	t	t	1	--	--	--	64	1
Festuca rubra	4	5	--	7	3	t	--	1	--	--	1	64	2
Senecio canus	1	t	t	t	--	--	t	t	--	--	--	55	t
Trientalis latifolia	--	1	t	--	t	--	t	t	--	--	--	45	t
Onychium densum	t	--	2	2	t	t	--	--	--	--	--	45	t
Goodyera oblongifolia	--	--	t	--	--	--	--	--	--	t	t	27	t
Whipplea modesta	--	--	t	--	1	--	5	t	--	--	--	36	1
Anemone quinquefolia	--	--	t	--	--	--	1	--	t	--	t	36	t
Carex serratodens	t	1	4	t	--	--	--	5	--	--	--	55	1
Antennaria suffrutescens	t	t	--	--	--	t	t	--	--	--	--	36	t
Erigeron foliosus	t	--	t	t	--	t	t	--	--	t	--	64	t
Castilleja miniata	t	--	1	t	--	--	--	--	--	--	--	27	t
Lomatium howellii	--	t	--	t	t	--	t	t	--	--	--	45	t
Sanguisorba microcephala	--	t	--	t	t	t	--	--	--	--	--	36	t
Sedum laxum	--	t	--	t	t	--	--	--	--	--	--	27	t
Ligustrum apiifolium	--	t	--	--	--	--	t	t	--	--	--	27	t
Perideridia sp.	t	t	t	t	t	--	--	t	--	--	--	55	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

lowest here. Trees which are maximally developed here include immature Pseudotsuga, mature Pinus lambertiana, P. monticola, P. jeffreyi, P. ponderosa, and Calocedrus decurrens.

The shrub layer typically has about 67% accumulative cover (Table 9). There can be quite high accumulative cover of shrubs even within the herb phase (Table 27). This is mainly due to overlap of shrubs that is not apparent in an accumulative cover value. The shrub layer is dominated by Quercus vaccinifolia and Rhamnus californica along with several other locally important species (Table 27). Optimally developed shrubs in this community include Quercus vaccinifolia, Vaccinium parvifolium, Amelanchier pallida, Ceanothus pumilus, Arctostaphylos nevadensis, Juniperus communis, Berberis repens, and Rhamnus californica.

The herb layer of this community averages 25% cover (Table 9). It is usually patchy, rather than diffuse, over the areas not occupied by shrubs. Indicators of ultramafic soils are numerous and abundant (Table 17). Mosses are unimportant here (Table 9) and usually include many small, "rock-loving" terrestrial bryophytes. The layer is dominated by Xerophyllum tenax which is most abundant within the shrub matrix phase.

Adjacent to the Pinus-Chla/Quva/Xete community, Pinus jeffreyi and sclerophyllous shrubs or grassy areas with few trees or shrubs dominate the xeric sites. The fire sere dominated by Pinus attenuata may also be found over most of the range of this community. In more mesic adjacent areas the Chla/Lide community is common. Due to the wide range of elevations where this community is found, however, it is possible to find almost any of the Chamaecyparis lawsoniana communities adjacent to it.

Most of the stands in this community are on either pure serpentinite or peridotite, and can be compared almost directly with those of Whittaker (1960). He states that the two phase character includes fairly closed shrub patches alternating with completely open, shrubless areas. In Whittaker's and my studies the shrub matrix phase is found predominantly on the more mesic sites and decreases towards the more xeric sites.

Abies concolor (White Fir) Zone

The Abies concolor Zone contains 40 plots with 10 in the Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community, 15 in the Abies concolor-Chamaecyparis lawsoniana/herb community, and 15 in the Abies-Chamaecyparis lawsoniana/herb community. The Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community is transitional between the Tsuga heterophylla and the Abies concolor Zones of Franklin and Dyrness (1973). It occurs in the northeastern part of the range of C. lawsoniana at middle elevations and upon a variety of soil types. The other two communities are edaphic variants of one another: the Abies concolor-Chamaecyparis lawsoniana/herb community occurs on a mixture of parent materials including ultramafics, basic intrusives (gabbro), and a mixed colluvium of gabbro, peridotite and serpentinite; while the Abies-Chamaecyparis lawsoniana/herb community occurs mostly on granodiorite. The first of these occurs over much of the southern and inland portions of the range at high elevations, while the latter community is more restricted to northern, high elevation sites.

Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana (Abco-Tshe-Chla) Community. This community has been sampled by 10 plots located along tributaries of Silver Creek (Galice study area, Figure 1). It was observed along the western and northwestern aspects of one major mountain ridge (Chrome Ridge), thus over a limited range of elevations and aspects (Table 28). The community occurs within a complex geologic region, including soils derived from quartz diorite, metavolcanics, mixed gneiss, schists, and gabbro, all of which are complexly intruded with peridotite and serpentinite (Wells and Walker, 1953). My data indicate the predominance of coarse-grained granitic to gabbroic rocks, which in some cases are mixed with ultramafics. The soils here are noticeably shallow with an average depth to the surface of the C horizon of 43 cm (Table 28). They are typically colluvium or mixed colluvium and alluvium. There are many coarse fragments within most horizons. A horizons are gravelly-cobbly, silt-loams with moderate to weak structure. These overlie B1 or more commonly B3 horizons of moderate depth and structure and gravelly-cobbly stony, silty-clay-loam textures. The C horizons are very gravelly-cobbly-stony, sandy or silty-clay-loams (or a sandy gravel in alluviated areas). In the five plots with the least slope angle there was standing water in the late summer of 1975.

Table 28. Site characteristics of _Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana_ community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
94	23	1100	wnw	30	350	40	granitic mix
107	23	1260	wnw	10	400+	57	granitic mix
92	23	930	w	33	315	40	granitic mix
93	23	910	sse	3	370	42	granitic and metavolcanic
96	23	940	wsw	20	360	35	granatic mix metavolcanic
95	23	1120	wnw	33	370	37	granitic mix
90	23	940	nnw	43	360	23	granitic mix
89	23	940	ssw	10	340	40	ultramafic granitic
91	23	920	w	4	260	70	ultramafic granitic
80	23	920	wsw	2	250	50	ultramafic granitic

Tree cover averages 86% and is therefore more like the low elevation Tsuga heterophylla Zone communities (Table 9). The stands that I measured are almost all within narrow draws where regional tree densities are maximal. Adjacent stands are much more open, ranging from 40 to 70% canopy cover. Cover of immature conifers here is 30%. The community has a low sapling density, higher than average seedling density, and high tree density (Table 5). Chamaecyparis lawsoniana is the densest tree, followed by Tsuga heterophylla and Abies concolor. Dominance of the tree layer reflects the sequential invasion by these three species following the initial pioneer stand of Pseudotsuga menziesii and Chamaecyparis lawsoniana. This is the only community outside the Tsuga heterophylla Zone with great amounts of Thuja plicata, and it is the only community where Thuja is reproducing well (Table 29). This community is intermediate in elevation and climate, a typical site for dominance or co-dominance by Thuja plicata within the Central Western Cascades of Oregon (Franklin and Dyrness, 1973; Dyrness, Franklin and Moir, 1974). Trees with maximal development in this community include Castanopsis chrysophylla, Alnus rubra, and Thuja plicata.

The accumulative cover of the shrub stratum is 50%. The stratum is either diffuse and continuous over large areas, or is lacking all together in younger stands with dense trees. In these younger plots there are occassional shrubby openings. The shrub layer in this community is the most dense and best developed of any in the Abies concolor Zone (Table 9). Quercus sadleriana, Gaultheria shallon and Vaccinium parvifolium are in all plots. Leucothoe davisiae is found on 9 out of 10 plots and has the highest average cover of any shrub in the community (Table 29). Leucothoe and Gaultheria shallon usually occur in low streamside mats. Away from the stream are scattered the taller Vaccinium parvifolium and Quercus sadleriana. The latter species share a layer with the immature conifers and the hardwood Lithocarpus densiflora. The dominant tall shrub is Rhododendron macrophyllum. Quercus sadleriana and Leucothoe are the only shrubs maximally developed in this community.

The herb layer has an average cover of only 16%. This is the second-to-lowest herb cover of any community (Table 9). There are no dominant herbs. Linnaea borealis, Arenaria macrophylla, Synthyris

Table 29. Cover and constancy of species in the Abies concolor-Tsuga heterophylla Chamaecyparis lawsoniana community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community										% Const.	% Ave. Cover
		94	107	92	93	96	95	90	89	91	80		
Tree Layer													
Chamaecyparis lawsoniana	M[1/]	80	65	65	45	45	30	60	55	45	50	100	56
Chamaecyparis lawsoniana	R	3	7	17	18	15	5	5	5	10	30	100	12
Tsuga heterophylla	M	15	35	35	30	15	5	--	--	15	--	70	15
Tsuga heterophylla	R	10	3	10	10	7	5	t	t	5	3	100	5
Abies concolor	M	--	5	--	30	30	--	--	15	5	--	50	9
Abies concolor	R	3	3	5	15	10	5	7	6	15	--	90	7
Pseudotsuga menziesii	M	25	--	15	5	30	35	25	15	30	--	80	19
Pseudotsuga menziesii	R	--	--	--	--	--	--	--	--	--	t	10	t
Taxus brevifolia	MR	--	2	t	1	t	--	5	10	t	t	80	2
Alnus rubra	M	--	--	--	20	--	--	t	3	40	1	50	6
Pinus lambertiana	MR	--	--	--	--	t	5	t	t	t	--	50	1
Thuja plicata	MR	--	--	--	--	t	--	t	1	5	90	50	10
Castanopsis chrysophylla	M	--	--	t	--	--	9	--	4	3	--	40	2
Arbutus menziesii	M	--	--	t	--	--	--	t	t	--	--	30	t
Shrub Layer													
Gaultheria shallon		t	6	11	3	21	5	1	9	4	t	100	6
Quercus sadleriana		t	1	t	10	15	8	1	21	8	t	100	6
Vaccinium parvifolium		t	t	1	2	1	2	3	1	2	t	100	1
Leucothoe davisiae		3	52	--	10	5	2	t	4	4	34	90	14
Berberis nervosa		1	--	t	2	1	4	2	1	4	--	80	2
Rubus ursinus		--	t	t	1	t	--	t	t	1	t	80	t
Lithocarpus densiflora		--	--	2	2	1	2	1	t	3	t	80	1
Rhododendron macrophyllum		12	25	1	--	t	40	--	t	10	--	70	9
Rosa gymnocarpa		--	t	--	t	t	t	--	t	t	--	60	t
Quercus vaccinifolia		--	--	--	t	--	4	4	t	--	--	40	1

(continued on next page)

Table 29. (Continued)

Layers and Species	Stands representing this community										%	%
	94	107	92	93	96	95	90	89	91	80	Const.	Ave. Cover
Herb Layer												
Trillium ovatum	t	t	t	t	t	t	t	t	t	t	100	t
Goodyera oblongifolia	t	--	t	t	2	2	t	t	1	t	90	1
Polystichum munitum	t	--	6	t	t	t	2	t	2	t	90	1
Chimaphila umbellata	t	--	t	t	t	1	t	t	t	--	80	t
Chimaphila menziesii	--	t	t	t	t	t	t	t	t	--	80	t
Linnaea borealis	--	t	t	6	6	1	7	2	3	--	80	3
Xerophyllum tenax	t	--	t	t	1	3	t	--	--	--	60	t
Trientalis latifolia	--	t	--	t	2	t	1	1	--	--	60	t
Pteridium aquilinum	--	t	t	t	2	--	--	1	--	t	60	t
Pyrola asarifolia	--	1	t	--	t	t	--	--	--	t	50	t
Corallorhiza maculata	--	--	t	--	t	t	t	--	t	--	50	t
Tiarella unifoliata	--	1	1	1	--	--	--	--	--	4	40	1
Whipplea modesta	--	--	t	t	--	6	5	--	--	--	40	1
Arenaria macrophylla	--	--	t	--	t	--	t	--	--	t	40	t
Syntheris reniformis	--	--	t	t	3	--	4	--	--	--	40	1
Lysitchitum americana	--	--	--	--	t	--	--	t	t	22	40	2
Corallorhiza mertensiana	t	--	--	--	--	t	t	--	--	--	30	t
Adenocaulon bicolor	--	--	--	t	--	--	t	--	--	t	30	t
Asarum caudatum	--	--	--	--	2	--	--	--	1	t	30	t
Disporum hookeri	--	--	--	--	--	--	t	t	--	t	30	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

reneformis, Pyrola asarifolia, Corallorhiza mertensiana, and C. maculata show maximal development here (Table 29).

Stands here are different from any described in the literature. This unique area of Oregon has the following features: (1) it is intermediate in elevation between the Tsuga heterophylla and Abies concolor Zones; (2) the mixture of soil types spans the variety found in most other major Chamaecyparis lawsoniana communities; (3) it is effectively separated from the other Chamaecyparis forests by the interior valleys around the Rogue and Illinois Rivers; and (4) the area is one of few locations where Tsuga heterophylla extends inland from the Coast Range towards the Cascades in southern Oregon in a situation where Abies concolor is also present (Little, 1971). This area is within an extension and combination of the Mixed Evergreen and Mixed Conifer Zones of Franklin and Dyrness (1973). The floristic unit in this community fits most closely Whittaker's (1960) middle elevation gabbro communities. However, since my sites were chosen for the presence of Chamaecyparis lawsoniana, they have much higher tree density and vigor than those of Whittaker. In this area, where large areas of serpentine or peridotite are exposed, the common plant community is the Pinus-Chla/Quva/Xete community. The Abco-Tshe-Chla community has the appearance of the Tshe-Chla/Rhma-Gash community with the addition of Abies concolor. Adjacent, more xeric forests are of the Pseudotsuga-sclerophyll type described by Whittaker (1960).

Abies concolor-Chamaecyparis lawsoniana/herb (Abco-Chla/herb) Community. This community was sampled by 15 stands over much of the range of C. lawsoniana, including Game Lake, Galice, Rabbit Lake, Page Mountain, Laird Meadow, Dillon Mountain, Ramshorn Creek, Bear Creek, Castle Lake, and Willow Creek (Figure 1). Elevation averages 1256 m (Table 30) and ranges from 900 to 1540 m. The predominant parent material occupied by this community is at least partially ultramafic (Table 30). Soils are shallow, averaging 46 cm to the surface of the C horizon. Profiles are well developed except in more recent alluvium. They are typically composed of a shallow and gravelly cobbly silt loam A horizon; gravelly cobbly, silt loam to clay loam B horizon; and very gravelly cobbly, sandy loam to clay loam C horizon. The great textural variety here is similar

Table 30. Site characteristics of Abies concolor-Chamaecyparis lawsoniana/herb community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
81	41	1240	nw	62	255	63	ultramafic
56	42	1080	nw	13	340	70	ultramafic mix
57	43	1540	nw	7	300+	49	basic intrusive
58	43	1520	nnw	9	300+	56	basic intrusive
23	21	1280	w	15	140	27	ultramafic mix
20	21	1280	nnw	15	180	36	ultramafic mix
21	21	1280	ne	11	170	37	ultramafic mix
22	21	1270	nw	3	75	65	ultramafic mix
88	45	1140	n	3	400+	40	ultramafic mix
86	38	1130	nne	5	185	43	ultramafic
72	29	1250	n	45	300+	35	ultramafic mix
61	30	1280	n	60	185	66	metavolcanic
55	42	900	w	3	350	40	ultramafic mix
97	33	1415	ne	7	400+	30	ultramafic mix
79	23	1240	n	20	310	46	ultramafic

to that in many other communities. All soils were wet to moist in all horizons in late summer of 1974 and 1975.

Within mature stands, the tree density of this community is the highest of any community studied (Table 5). The dominant is Chamaecyparis lawsoniana. Chamaecyparis here has three times the density attained in the Abies-Chla/herb community of different parent materials. Abies concolor and Pseudotsuga menziesii are both less dense within the Abco-Chla/herb community than in the Abies-Chla/herb community. Saplings within the Abco-Chla/herb community are dominated by Chamaecyparis lawsoniana (Table 5), but many of them are old and suppressed. The many Abies concolor saplings show greater vigor than Chamaecyparis. In terms of cover, density and constancy, Chamaecyparis lawsoniana does as well or better in this community as in either the Chla-Tshe/Xete or the Chla/Lide communities which occur on similar parent materials but within the Tsuga heterophylla and Mixed Evergreen Zones, respectively.

The accumulative shrub cover is less than within most Tsuga heterophylla Zone communities or those of the Mixed Evergreen Zone (Table 9). The only dominant shrub is Rhododendron occidentale ; it is dominant only where the parent material is largely ultramafic. Local dominance by combinations of shrubs is the general situation. Gaultheria ovatifolia, Rubus parviflorus, Alnus rhombifolia, Rubus ursinus, and Rosa gymnocarpa show their maximal development here.

The herb layer, with 20% cover, is about average (Table 9) but includes much variation in species composition from stand to stand (Table 31). Much local variation is accounted for by the variation in parent materials, moisture, and the geographical distribution of the herbaceous species. The herb layer has few species with high but many species with moderate constancy. No herbs are dominant, but Xerophyllum tenax occurs in half of the plots with moderate cover (Table 31). Linnaea borealis and Achlys triphylla are also fairly common. Several herbs are present only in this community (Table 17). Moss cover in this community ranges from 0 to 5%.

Whittaker (1960) described a high elevation forest with mixtures of Picea breweriana, Abies concolor, Pinus monticola, Pseudotsuga menziesii, Calocedrus decurrens and Chamaecyparis lawsoniana on more mesic sites,

Table 31. Cover and constancy of species in the Abies concolor-Chamaecyparis lawsoniana/herb community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community															%	%
		81	56	57	58	23	20	21	22	88	86	72	61	55	97	79	Const.	Ave. Cover
Tree Layer																		
Chamaecyparis lawsoniana	M[1]/	65	40	70	90	50	30	60	10	75	45	45	60	30	70	30	100	51
Chamaecyparis lawsoniana	R	--	30	70	10	20	12	15	15	60	30	15	15	8	70	15	93	26
Abies concolor	M	--	40	10	20	15	40	5	15	--	20	10	5	20	--	30	80	15
Abies concolor	R	1	40	3	t	15	3	10	10	t	5	10	5	2	t	--	93	7
Pseudotsuga menziesii	M	15	10	--	--	20	40	40	50	20	15	20	15	30	20	10	87	20
Pseudotsuga menziesii	R	3	5	--	--	--	--	--	5	1	--	t	2	t	5	--	53	1
Calocedrus decurrens	MR	15	--	--	--	--	--	t	t	t	10	--	--	--	10	20	47	4
Pinus monticola	MR	--	--	31	30	10	t	t	5	--	--	t	--	--	--	--	47	5
Pinus lambertiana	MR	17	--	5	t	--	--	--	--	5	20	15	--	--	--	--	40	4
Taxus brevifolia	MR	2	t	--	--	--	--	--	--	t	--	--	15	t	5	--	40	1
Pinus jeffreyi or P. ponderosa	MR	--	--	--	--	--	--	t	3	20	t	--	--	--	--	--	27	2
Shrub Layer																		
Rosa gymnocarpa		t	1	t	t	10	5	2	1	2	1	--	t	1	t	t	93	2
Rubus ursinus		--	t	t	--	1	t	t	2	1	3	--	t	1	t	t	80	1
Rhododendron occidentale		--	27	t	3	5	10	15	3	--	17	--	28	--	10	--	67	8
Vaccinium parvifolium		1	--	--	--	16	2	t	2	1	1	--	t	t	--	--	60	2
Berberis nervosa		1	--	--	--	4	10	2	1	--	t	1	2	8	--	--	60	2
Lithocarpus densiflora		12	t	t	--	--	--	--	1	1	--	--	--	--	t	--	40	1
Quercus vaccinifolia		1	1	--	--	--	--	--	2	8	7	--	t	--	--	--	40	1
Quercus sadleriana		--	--	--	--	16	11	1	8	--	t	26	--	--	--	--	40	4
Amelanchier pallida		t	t	--	--	t	--	--	1	t	--	--	--	--	t	--	40	t
Rubus parviflorus		--	t	t	t	--	--	--	--	--	t	--	--	1	--	t	40	t
Vaccinium membranaceum		--	--	6	1	1	2	--	1	--	--	--	2	--	--	--	40	1
Quercus chrysolepis		1	t	--	--	--	t	--	--	--	t	--	t	--	--	--	33	t
Gaultheria ovatifolia		--	--	t	t	--	t	--	--	--	t	29	--	--	--	--	33	2

(continued on next page)

Table 31. (Continued)

Layers and Species	Stands representing this community															% Const.	% Ave. Cover
	81	56	57	58	23	20	21	22	88	86	72	61	55	97	79		
Alnus rhombifolia	--	13	3	t	--	--	--	--	--	--	--	14	--	--	--	27	2
Rhododendron macrophyllum	--	--	--	--	4	t	--	--	--	--	82	1	--	--	--	27	6
Holodiscus discolor	--	--	--	--	t	--	--	t	t	1	--	--	--	--	--	27	t
<u>Herb Layer</u>																	
Goodyera oblongifolia	t	t	--	t	t	t	t	t	1	t	t	t	t	t	t	93	t
Chimaphila menziesii	t	1	--	t	t	t	t	t	1	t	1	t	t	t	t	93	t
Trientalis latifolia	5	--	--	--	t	2	1	t	t	1	t	3	3	t	1	80	1
Clintonia uniflora	t	--	t	t	--	1	t	t	t	2	--	t	1	--	t	73	t
Trillium ovatum	t	--	--	--	1	1	t	t	t	1	t	t	t	--	t	73	t
Chimaphila umbellata	--	t	--	t	t	2	1	t	--	1	7	1	t	--	t	73	1
Pteridium aquilinum	t	2	3	t	7	t	t	t	--	t	--	--	--	t	--	67	1
Linnaea borealis	--	t	4	t	1	3	--	--	t	10	t	3	2	--	--	67	2
Anemone quinquefolia	--	--	t	t	t	t	t	t	--	1	--	t	t	--	t	67	t
Disporum hookeri	1	1	--	--	--	1	1	--	t	1	--	t	2	--	1	60	1
Pyrola picta	t	t	--	--	1	1	t	t	--	t	1	--	t	--	--	60	t
Viola glabella	--	--	3	t	t	--	1	1	--	t	--	1	t	--	t	60	t
Polystichum munitum	4	--	--	--	t	--	t	t	t	--	--	t	2	t	--	53	t
Adenocaulon bicolor	t	1	--	--	--	t	2	--	--	1	--	t	t	--	t	53	t
Xerophyllum tenax	t	--	--	--	2	2	1	8	2	--	11	2	--	--	--	53	2
Listera cordata	--	--	1	t	t	t	t	t	--	--	--	t	t	--	--	53	t
Vancouveria planipetala	3	--	--	--	2	1	1	1	t	t	--	1	2	--	--	60	1
Iris innominata	1	--	--	--	t	--	t	t	1	t	t	--	--	--	--	47	t
Achlys triphylla	t	--	--	--	--	4	t	--	t	--	--	2	18	-	2	47	2
Veratrum spp.	--	t	t	--	--	t	t	--	t	--	t	2	--	--	--	47	t
Anemone deltoidea	--	--	--	--	1	2	t	t	--	--	--	t	1	--	2	47	t
Hieracium albiflorum	t	--	--	--	--	t	t	--	t	--	--	t	t	--	--	40	t
Corallorhiza mertensiana	t	--	--	--	t	t	t	--	--	--	--	t	t	--	--	40	t
Senecio triangularis	--	t	t	t	t	--	1	--	--	--	--	3	--	--	--	40	t
Whipplea modesta	--	--	--	--	t	--	t	t	1	t	--	--	1	--	--	40	t

(continued on next page)

Table 31. (Continued)

Layers and Species	Stands representing this community															%	%
	81	56	57	58	23	20	21	22	88	86	72	61	55	97	79	Const.	Ave. Cover
Syntheris reneformis	--	--	--	--	t	1	t	t	--	--	--	t	t	--	--	40	t
Tiarella unifoliata	--	--	--	--	t	1	2	--	--	--	--	t	1	--	1	40	t
Galium triflorum	t	--	--	--	--	--	t	--	--	--	--	t	1	--	t	33	t
Angelica arguta	--	t	--	--	--	--	--	--	t	t	--	t	--	t	--	33	t
Adiantum pedatum	--	t	--	--	t	--	t	t	--	--	--	11	--	--	--	33	t
Pyrola asarifolia	--	--	1	t	--	1	--	--	--	--	2	5	--	--	--	33	1
Streptopus amplexicaulis	--	--	11	5	t	--	t	--	--	--	--	2	--	--	--	33	1
Osmorhiza chilensis	--	--	--	--	--	t	t	--	--	--	--	t	1	--	1	33	t
Erythronium oregonum	1	--	--	--	2	--	t	1	--	--	--	--	--	--	--	27	t
Smilacina racemosa	1	--	--	--	--	t	--	--	t	--	--	--	t	--	--	27	t
Arenaria macrophylla	t	--	--	--	t	--	--	t	--	t	--	--	--	--	--	27	t
Smilacina stellata	--	t	--	--	--	--	t	--	--	--	--	t	2	--	--	27	t
Trillium rivale	--	t	--	--	t	--	t	t	--	--	--	--	--	--	--	27	t
Athyrium filix-femina	--	--	2	t	--	--	1	--	--	--	--	t	--	--	--	27	t
Lathyrus polyphyllus	--	--	t	--	t	--	--	--	--	--	--	t	t	--	--	27	t
Viola sempervirens	--	--	--	--	--	1	t	--	--	--	t	--	t	--	--	27	t
Campanula scouleri	--	--	--	--	--	t	t	--	--	t	--	--	t	--	--	27	t
Elymus glauca	--	--	--	--	--	--	1	1	--	--	--	--	t	t	--	27	t
Lomatium triternatum	--	--	--	--	--	t	--	t	--	--	--	--	--	t	--	27	t
Ligusticum apiifolium	--	--	t	--	--	t	t	t	--	--	--	--	--	--	--	27	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

occurring near 1500 m elevation upon serpentine soils. In his discussions he refers to it as Chamaecyparis-Pinus monticola-Pseudotsuga forest which intergrades with forests having greater Abies concolor dominance at 1200 m elevation and above. A similar forest type is cited by Sawyer and Thornburgh (1969) within the proposed Bear Basin Butte Natural Area in northern California. In areas adjacent to the Abco-Chla/herb community, the Pinus-Chla/Quva/Xete community occurs on xeric sites with serpentine or peridotite parent material. Across ecotones to extremely dry and exposed sites the vegetation changes rapidly to almost pure, open stands of Calocedrus decurrens with sclerophyllous shrubs. On adjacent forests on non-ultramafic parent materials the Abies-Chla/herb community is common.

Abies-Chamaecyparis lawsoniana/herb (Abies-Chla/herb) Community. Fifteen stands were sampled in this community (Table 32) mostly near Grayback Mountain to the east and northeast of Oregon Caves (Figure 1). Also included in this community are stands near Rabbit Lake, Youngs Valley, and the Sutcliffe Creek study areas (Figure 1). This community occupies less latitudinal range and, with an average elevation of 1280 m, averages only 30 m higher than the Abco/Chla/herb. However, the elevational range within the Abies-Chla/herb community is less than that in the Abco-Chla/herb community and the latitude is for most part farther north. Eleven of the plots are located on pre-Tertiary granitic intrusive rocks (Table 32) while the remainder are on metasedimentary or volcanic rocks. Soils are moist, well drained, and contain considerable coarse fragments. Most are deep, moderately developed, colluvial soils. The average depth to the surface of the C horizon is 60 cm. Profiles consist of gravelly cobbly, sandy loam A horizons; thick, very gravelly cobbly, sandy loam B horizons; and very cobbly gravelly, sandy loam C horizons. These are the coarsest textured soils found in any major Chamaecyparis community.

The average mature canopy cover in this community is 75%. Pseudotsuga, Chamaecyparis, and Abies concolor are in all mature stands, with high cover values (Table 33). Pseudotsuga is usually large in mature stands, but is most dominant here as a pioneer species in post-fire secondary succession. Chamaecyparis lawsoniana is also present as large, fire-scarred, individuals, but it also occurs in multiple size classes. Abies concolor is similar to Chamaecyparis except for the lack of large,

Table 32. Site characteristics of Abies-Chamaecyparis lawsoniana/herb community plots.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
48	32	1200	ese	34	280	25	schist
54	38	1200	nw	0	300	51	schist
49	32	1140	ese	3	150	55	schist
73	33	1040	sw	7	280	84	granitic volcanic
71	29	1340	n	35	390	80	metavolcanic
1	28	1380	nnw	45	210	60	granitics
3	28	1280	wnw	29	400+	63	granitics
4	28	1240	ne	7	60	70	granitics
8	28	1400	nnw	27	230	30	granitics
5	28	1260	se	13	80	45	granitics
9	28	1200	nnw	37	240	69	granitics
10	28	1140	wnw	15	290	75	granitics
2	28	1450	nnw	40	350	50	granitics
6	28	1420	nw	10	400+	62	granitics
7	28	1420	nnw	45	400+	78	granitics

Table 33. Cover and constancy of species in the Abies-Chamaecyparis lawsoniana/herb community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community															% Const.	% Ave. Cover
		48	54	49	73	71	1	3	4	8	5	9	10	2	6	7		
Tree Layer																		
Pseudotsuga menziesii	M[1/]	2	35	20	30	30	--	10	45	--	60	10	30	20	10	30	87	22
Pseudotsuga menziesii	R	5	10	--	10	t	t	5	15	t	10	5	35	3	--	--	80	6
Abies concolor	M	35	--	45	--	10	25	20	30	10	--	15	15	30	15	20	87	18
Abies concolor	R	20	3	20	30	3	5	15	30	15	10	30	20	10	25	5	100	17
Chamaecyparis lawsoniana	M	55	45	30	20	60	50	70	30	60	20	30	45	25	80	35	100	44
Chamaecyparis lawsoniana	R	5	20	40	5	15	25	15	35	15	35	--	--	30	5	30	87	18
Abies magnifica	MR	t	--	t	10	t	--	--	--	30	5	--	5	20	--	--	53	5
Taxus brevifolia	MR	--	--	10	t	50	t	15	5	t	--	--	--	--	--	--	47	5
Pinus lambertiana	MR	t	22	--	2	--	--	--	--	--	20	5	t	--	--	--	40	3
Shrub Layer																		
Berberis nervosa		1	2	1	t	3	7	1	2	13	t	3	2	5	t	10	100	3
Castanopsis chrysophylla		2	t	t	4	1	t	4	4	--	1	7	4	--	t	--	80	2
Rosa gymnocarpa		t	1	1	--	2	t	t	--	2	--	--	4	t	1	t	73	1
Quercus sadleriana		1	t	1	6	--	--	16	12	4	1	27	3	--	--	--	67	5
Vaccinium parvifolium		--	4	--	1	3	t	8	6	--	2	11	11	t	--	--	67	3
Pachystima myrsinites		--	--	t	1	1	--	1	t	t	t	3	1	--	--	--	60	t
Vaccinium membranaceum		--	--	--	--	--	1	3	t	14	--	4	t	1	--	t	53	2
Rubus ursinus		1	1	1	--	1	--	t	--	--	--	--	3	--	t	--	47	t
Gaultheria ovatifolia		t	--	--	--	--	--	t	1	--	1	--	3	--	--	--	33	t
Lithocarpus densiflora		--	15	--	10	--	t	--	--	--	--	--	--	t	--	--	27	2
Rhododendron macrophyllum		--	--	--	--	--	t	--	--	--	15	58	18	--	--	--	27	6
Symphoricarpos mollis		--	--	--	--	--	--	t	--	--	--	--	--	t	t	1	27	t
Rubus lasiococcus		--	--	--	--	--	--	1	--	t	--	--	--	1	--	t	27	t
Herb Layer																		
Goodyera oblongifolia		t	t	t	t	1	t	1	t	t	t	1	t	1	t	t	100	t

(continued on next page)

Table 33. (Continued)

Layers and Species	Stands representing this community															%	%
	48	54	49	73	71	1	3	4	8	5	9	10	2	6	7	Const.	Ave. Cover
Chimaphila umbellata	3	t	1	1	2	1	4	1	4	t	3	2	t	--	4	93	2
Chimaphila menziesii	t	t	t	t	t	t	t	t	t	t	t	t	1	--	t	93	t
Trillium ovatum	t	t	1	--	t	t	1	t	1	t	t	t	1	2	1	93	t
Trientalis latifolia	3	1	1	t	1	t	1	t	2	--	--	t	1	5	t	87	1
Clintonia uniflora	2	2	1	--	1	1	1	t	2	t	--	t	1	5	1	87	1
Linnaea borealis	6	8	3	8	7	1	4	1	--	1	--	5	3	--	1	80	3
Pyrola picta	1	t	t	t	t	t	t	t	t	t	--	--	t	--	t	80	t
Pyrola secunda	1	--	--	--	2	t	1	t	2	t	t	--	8	--	t	67	1
Achlys triphylla	5	--	1	--	10	5	1	--	1	--	--	t	2	10	16	67	3
Vancouveria hexandra	3	1	3	--	1	2	t	--	1	--	--	t	t	3	2	73	1
Disporum hookeri	3	1	1	--	1	t	t	--	1	--	--	--	--	3	t	60	1
Anemone deltoidea	1	--	1	--	1	t	t	--	2	--	--	--	t	3	t	60	1
Viola glabella	t	--	1	--	t	t	t	--	t	--	--	--	t	2	t	60	t
Tiarella unifoliata	--	--	t	--	4	2	t	--	1	--	--	1	6	4	2	60	1
Viola sempervirens	--	--	--	t	--	1	2	t	t	t	--	1	1	--	1	60	t
Hieracium albiflorum	1	--	--	--	1	t	t	--	t	--	--	--	t	1	t	53	t
Galium triflorum	t	--	t	--	--	t	t	--	t	--	--	--	t	1	t	53	t
Pteridium aquilinum	1	t	1	--	t	t	--	--	t	--	--	1	--	t	--	53	t
Smilacina stellata	--	t	1	--	--	1	1	--	t	--	--	--	t	1	t	53	t
Osmorhiza chilensis	t	--	t	--	t	t	--	--	t	--	--	--	--	3	t	47	t
Adenocaulon bicolor	--	--	--	--	1	1	--	--	t	--	--	t	t	5	1	47	1
Polystichum munitum	--	t	--	--	t	1	--	--	--	--	--	t	1	--	t	40	t
Senecio integerrimus	--	--	--	--	t	t	t	--	--	--	--	t	t	--	t	40	t
Calypso bulbosa	--	--	--	--	--	t	--	--	t	--	--	t	t	t	t	40	t
Listera cordata	t	--	--	--	--	--	t	--	--	t	--	t	t	--	--	33	t
Athyrium filix-femina	1	--	t	--	--	t	--	--	--	--	--	t	t	--	--	33	t
Arenaria macrophylla	--	t	--	--	1	--	--	--	t	--	--	--	--	1	t	33	t
Phlox adsurgens	--	--	--	--	1	--	--	t	t	--	--	--	1	--	t	33	t
Campanula scouleri	t	--	--	--	2	t	--	--	t	--	--	--	1	1	1	47	t
Corallorhiza mertensiana	t	t	t	--	t	--	--	--	--	--	--	--	--	--	--	27	t

(continued on next page)

Table 33. (Continued)

Layers and Species	Stands representing this community															% Const.	% Ave. Cover
	48	54	49	73	71	1	3	4	8	5	9	10	2	6	7		
Pedicularis racemosa	--	--	--	--	t	--	--	--	t	--	--	t	--	t	--	27	t
Lathyrus polyphyllus	--	--	--	--	t	t	--	--	--	--	--	4	--	1	--	27	t
Pyrola asarifolia	--	--	--	--	--	--	t	t	--	t	--	t	--	--	--	27	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

fire-scarred individuals. Abies concolor appears to follow Chamaecyparis in ecesis in this community (Table 5). Abies magnifica, Abies concolor, and Taxus brevifolia show their maximum development here, and Tsuga mertensiana was recorded in one stand. Other tree species present here which are rare or absent in other communities are Picea breweriana and Chamaecyparis nootkatensis.

The shrub stratum averages 38% cover (Table 9) but is quite variable. The younger stands are dense while more mature stands have diffuse shrub layers only in major canopy openings. In early seral stands tall shrubs comprise single strata which virtually fill the gap between the older trees and conifer regeneration. The shrub layer often appears as scattered clusters of shrubs in more mature areas. Pachistima myrsinites, Vaccinium membranaceum, Symphoricarpos mollis, and Rubus lasiococcus show maximal development here. There are no major dominants of the shrub layer here (Table 33).

The herb layer is diverse. Young stands have little herb cover in openings left by woody species, whereas mature stands have large patches of herbs. There are 17 species of herbs that show their maximal development here (Table 17). Dominance in the herb layer is only local (Table 33), and the important species include Achlys triphylla, Linnaea borealis, Trillium ovatum, Clintonia uniflora, and Chimaphila umbellata. The Abies-Chla/herb community has about the same number of species as the Abco-Chla/herb community, but many show a higher fidelity or constancy within the Abies-Chla/herb community (Table 17). Again, as in the Abco-Chla/herb community, terrestrial bryophytes are virtually lacking in the Abies-Chla/herb community.

Granodiorite and ultramafic rocks often occur together at higher elevations of the study area; in such areas the Abies-Chla/herb community and the Abco-Chla/herb community are often found in close proximity. Adjacent mesic sites are typically occupied by purer stands of Abies concolor, Abies magnifica, or both. Adjacent plant communities on more xeric habitat types typically include Pseudotsuga menziesii and Calocedrus decurrens with increased relative importance. All Abies magnifica found during this study is probably variety shastensis.

Special Habitats Within the United States

Introduction

One of the objectives of this study is to identify and describe the variation in habitat occupied by *C. lawsoniana*. Thus, I sampled representative plots in special habitats throughout the range of the species. Most communities described here are limited in extent or maturity and exemplify the unusual tolerance of at least some *C. lawsoniana* populations. Some communities have wide enough distribution to be considered major communities; however, disturbance, lack of mature stands, or time limitations prevented adequate data collection. Since most special habitats have distinctive parent materials on which they occur, as well as different vegetational characters, the names given the communities include both edaphic and floral components.

Communities within special habitats are in all zones I describe. The *Tsuga heterophylla* Zone contains the *C. lawsoniana*-*Picea sitchensis*/sand dune, *C. lawsoniana*-*Picea sitchensis*/Blacklock soil, *Picea sitchensis*-*C. lawsoniana*/Eocene sandstone, and the *Sequoia sempervirens*-*C. lawsoniana*/alluvial terrace communities. The Mixed Evergreen Zone includes the *Pseudotsuga menziesii*-*C. lawsoniana*/foothill terrace community. A final special habitat community, the *Chamaecyparis lawsoniana*/ultramafic meadow community, is azonal and spans the *Tsuga heterophylla*, Mixed Evergreen and *Abies concolor* Zones. All communities in the special habitats as well as the major communities discussed above occur on mesic to hydric microhabitats that maintain a high moisture content because of increased local groundwater, fog drip, perennial streams and seeps, or because the climate decreases the demand for moisture by plants.

Communities within the special habitats will be discussed in the same order as the zones have been discussed above. Within the *Tsuga heterophylla* Zone, communities are discussed in accordance with their latitudinal distribution; no importance is placed on the order of appearance in discussion.

Tsuga heterophylla Zone

Chamaecyparis lawsoniana-Picea sitchensis/sand dune (Chla-Pisi/dune) Community. This community has been observed between Coos Bay and Saunders Lake, Oregon (Figure 1). Chamaecyparis lawsoniana, Pseudotsuga menziesii, and Pinus contorta are the dominant trees. Plot 69 is on top of a sand dune (Table 34), and from the exposed Chamaecyparis roots, the species appears to be a dune stabilizing species. Plot 68 is in a deflation plain with a shallow water table. The stands are only about 40 years old, and trees are shorter here than trees of the same age and species in other communities. No seedlings or saplings were found in either plot, though the older trees are producing cones. In the dune plot, trees are sparse and clustered while those in the deflation plain have a continuous canopy and are entangled with tall, spindly Rhododendron macrophyllum. It appears that reproduction by layering may be responsible for some of the clustering of trees on sand dunes.

The shrub layer in plot 69 occurs under the tree canopy with low cover values (Table 35). Herbs are patchy and tend to occur in the open. Dominant herbs are grasses (Table 35). Many forbs occur near the shrubs. Plot 68 has a well developed shrub layer dominated by Rhododendron macrophyllum and Myrica californica. Vaccinium ovatum is a small shrub here as well. Depth of soils in these plots is undetermined; structure is lacking; and texture is primarily coarse sand, with more organic inclusions common in the deflation plain.

The forest in the deflation plain will probably develop into a mature forest in 90 to 125 years. Older sites in the area are dominated by Tsuga, Thuja, and Picea, with scattered Chamaecyparis. Trees form a nearly continuous canopy with major openings common. The tree layer overlies a well developed shrub layer of Vaccinium ovatum, Gaultheria shallon, and Rhododendron macrophyllum. No stands older than 40-50 years were studied in the sand dunes.

Chamaecyparis lawsoniana-Picea sitchensis/Blacklock soil (Chla-Pisi/Blacklock) Community. This community occurs on the Blacklock Soil Series (described by Jenny et al., 1969), which contains an ironpan. This community is quite similar to the Pisi-Chla/Eocene sandstone community in species composition. However, they differ greatly in the relative importance of the species. Trees on Blacklock soil have much

Table 34. Site characteristics of special habitat communities within the *Tsuga heterophylla* Zone.

Plot Number	Location Figure 1	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material	Community[1]
69	1	30	all	0-50	35	nd[2]	unstable sand	Chla-Pisi/dune
68	2	10	all	0	40	40	stable sand	Chla-Pisi/dune
70	3	140	ne	0-5	100	70	sandstone ironpan	Chla-Pisi/Blacklock
66	4	70	wsw	10	65	54	Eocene sandstone	Pisi-Chla/sandstone
67	4	70	ssw	10	65	61	Eocene sandstone	Pisi-Chla/sandstone
74	35	220	nne	5-7	350	75	recent alluvium	Sese-Chla/terrace
77	35	100	nnw	0	700+	nd	recent alluvium	Sese-Chla/terrace

1/ see Appendix I for definition of community names
2/ = no data available

Table 35. Cover of species in the special habitat plots within the coastal Tsuga heterophylla Zone (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing communities in this zone[1]						
		69	68	70	66	67	74	77
Tree Layer								
Pinus contorta	M[2]	20	30	--	--	--	--	--
Pinus contorta	R	15	--	--	--	--	--	--
Pseudotsuga menziesii	M	15	40	--	35	20	20	15
Pseudotsuga menziesii	R	15	10	--	--	--	1	--
Chamaecyparis lawsoniana	M	30	40	65	80	99	20	50
Chamaecyparis lawsoniana	R	10	--	60	--	--	15	t
Tsuga heterophylla	M	--	60	--	--	30	--	20
Tsuga heterophylla	R	--	30	35	--	--	--	20
Picea sitchensis	M	--	--	--	35	20	--	--
Picea sitchensis	R	--	t	10	--	--	--	--
Sequoia sempervirens	M	--	--	--	--	--	30	60
Sequoia sempervirens	R	--	--	--	--	--	10	20
Acer macrophyllum	M	--	--	--	--	--	10	20
Lithocarpus densiflora	M	--	--	--	--	--	15	--
Umbellularia californica	M	--	--	--	--	--	10	--
Thuja plicata	MR	--	--	--	--	--	--	t
Shrub Layer								
Arctostaphylos columbiana		t	--	--	--	--	--	--
Myrica californica		t	40	21	--	--	--	--
Gaultheria shallon		t	t	33	--	--	t	t
Rubus parviflorus		t	--	--	--	--	--	t
Rhamnus purshiana		--	t	--	t	t	--	--
Vaccinium ovatum		2	25	60	9	t	77	21
Rhododendron macrophyllum		--	80	9	--	--	--	--
Vaccinium parvifolium		--	--	t	--	--	--	--
Ledum glandulosum		--	--	3	--	--	--	--
Berberis nervosa		--	--	--	t	t	t	--

(continued on next page)

Table 35. (Continued)

Layers and Species	Stands representing communities in this zone						
	69	68	70	66	67	74	77
Alnus rubra	--	--	--	t	--	43	--
Quercus chrysolepis	--	--	--	--	--	t	--
Rhododendron occidentale	--	--	--	--	--	4	--
Umbellularia californica	--	--	--	--	--	53	8
Lithocarpus densiflora	--	--	--	--	--	13	20
Rubus spectabilis	--	--	--	--	--	2	--
Corylus cornuta	--	--	--	--	--	t	5
Euonymus occidentalis	--	--	--	--	--	t	--
<u>Herb Layer</u>							
Lupinus littoralis	3	--	--	--	--	--	--
Fragaria chiloensis	2	--	--	--	--	--	--
Anaphalis margaritacea	3	--	--	--	--	--	--
Ammophila arenaria	4	--	--	--	--	--	--
Hieracium albiflorum	1	--	--	--	--	--	--
Aira praecox	2	--	--	--	--	--	--
Aira caryophyllea	4	--	--	--	--	--	--
Festuca rubra	3	--	--	--	--	--	--
Pteridium aquilinum	--	--	14	t	t	3	--
Maianthemum dilatatum	--	--	t	--	--	--	--
Polypodium vulgare	--	--	t	--	--	--	--
Blechnum spicant	--	--	t	--	--	t	--
Polystichum munitum	--	--	--	2	t	2	24
Corallorhiza mertensiana	--	--	--	t	--	--	--
Chimaphila menziesii	--	--	--	t	t	--	--
Montia perfoliata	--	--	--	--	t	--	--
Carex obnupta	--	--	--	--	--	t	--
Trientalis latifolia	--	--	--	--	--	--	t
Oxalis oregana	--	--	--	--	--	--	19
Petasites frigidus	--	--	--	--	--	--	t
Asarum caudatum	--	--	--	--	--	--	5

(continued on next page)

Table 35. (Continued)

Layers and Species	Stands representing communities in this zone						
	69	68	70	66	67	74	77
Galium triflorum	--	--	--	--	--	--	t
Angelica arguta	--	--	--	--	--	--	t
Stachys palustris	--	--	--	--	--	--	t
Adiantum pedatum	--	--	--	--	--	--	t
Vancouveria hexandra	--	--	--	--	--	--	t
Disporum hookeri	--	--	--	--	--	--	t
Athyrium filix-femina	--	--	--	--	--	--	t

1/ Plots 68-69 are in the Chla-Pisi/dune community
Plot 70 is in the Chla-Pisi/Blacklock community
Plots 66-67 are in the Pisi-Chla/sandstone community
Plots 74-77 are in the Sese-Chla/terrace community
See Appendix I for defintion of community names

2/ M and R in the tree layer refer to mature and immature (reproductive) size classes less dense foliage and are shorter and smaller in diameter than are trees of similar age on adjacent soils. Chamaecyparis lawsoniana is the dominant tree species here. The densest tree canopy approaches 60% cover, but the average cover is much less. Saplings of Chamaecyparis, Tsuga, Picea, and Pseudotsuga have an accumulative cover of nearly 100%, but their actual cover is only 65%. There are many dead and dying saplings. In plot 70 Chamaecyparis dominates the reproduction. This forest is about 100 years old and is disturbed by man. Notes taken from adjacent areas suggest that the type may have a tree density at maturity of only about 150-200 trees per hectare.

The shrub layer is well developed. In fairly undisturbed sites the shrub layer is broken only by occassional tree boles and very small openings. Accumulative cover of the shrubs approaches 200%, and actual cover is near 90% (Table 35). Scattered herbs grow beneath the shrubs and in the edges of small openings in the shrub layer. The most common herb is Maianthemum dilatatum, and there are several common fern species (Table 35). Mosses and lichens are common in the openings.

The Chla-Pisi/dunes and Chla-Pisi/Blacklock communities are edaphically specialized communities which have probably always had limited extent. They both draw their major species from a more widespread floristic unit of the north coastal range of Chamaecyparis lawsoniana, the Pisi-Chla/Eocene sandstone community.

Picea sitchensis-Chamaecyparis lawsoniana/Eocene Sandstone (Pisi-Chla/sandstone) Community. This community on non-indurated Eocene sandstone soils has higher tree density and vigor than the Blacklock soil community. Two stands have been sampled within 65 year old, post-logging, natural regeneration. They occur within the Coos County Forest, south of Coos Bay, Oregon (Figure 1). Field notes were made in other slightly older stands.

The young forests contain large amounts of Chamaecyparis and Picea sitchensis with scattered Pseudotsuga and Tsuga in the overstory. Seedlings and saplings are absent in most stands. The canopy cover of both plots is 100%. Plot 66 is on a gentle footslope, while plot 67 is located across the top of a gentle ridge; both occur on nearly the same aspect and at the same elevation (Table 34). The landform positions appear to make a large difference in the forest structure. The footslope stand has deep soils with fine textures, while the ridge soil (also deep) is coarser and better drained. Density of the trees on the footslope plot is nearly three times greater than that on the ridge position. Furthermore, the stands, though of equal age, are reacting differently to the different edaphic factors. In the footslope plot, tree mortality has been small so the forest floor is still fairly passable. However, in the ridge plot the less competitive individuals have been dying and losing branches for a number of years resulting in dense, coarse litter.

Subordinate strata in these stands are virtually lacking except beneath holes in the canopy. Shrubs include Berberis nervosa and Vaccinium ovatum. Herbs include Polystichum munitum and Chimaphila umbellata. In older forests of the type the tree layer is open enough to support more understory plants. The tree composition in stands 135-150 years old is similar to that of younger stands, but density is reduced. In mesic areas, the older forests are similar to the Tshe-Chla/Pomu-Oxor community. However, here Picea sitchensis is a dominant tree. The diagnostic understory species of both the latter communities are present in greater amounts in the coastal community. A shrubby variant of the Pisi-Chla/sandstone community occurs on wet sideslopes and is quite similar to the Tshe-Chla/Rhma-Gash community. Again the major differences are in the abundance of dominant species of each stratum. In the Pisi-Chla/sandstone community Vaccinium ovatum is more important than Rhododendron. Within the more mature stands Gaultheria shallon is important in both the coastal and the inland communities, but it is generally taller, denser and more robust in general within the coastal community. No stands greater than 135-150 years old were observed in this type; they have probably all been logged. However, similar climatic and edaphic conditions to those within the Pisi-Chla/sandstone community occur over most of the north coastal range of Chamaecyparis lawsoniana, from the northern limits to a point near Port Orford, Oregon. South of this point, little or no Chamaecyparis lawsoniana was found or reported. The species then reappears to the south, within the range of Sequoia sempervirens.

There are few detailed accounts of the structure of the primeval coastal vegetation. However, there are numerous general accounts in the literature concerning the "grandeur" of the Chamaecyparis forests. Shelford (1926) states that the forests of old dunes are the "ordinary" conifer forests of the region. He was referring to the Pseudotsuga-Tsuga-Picea-Thuja-Chamaecyparis forests near Marshfield and Coos Bay, Oregon. The trees occurred over a dense layer of Myrica californica and Gaultheria shallon. Dion (1938) gives an account of the size and form of Chamaecyparis in this same region and mentions the large areas of the magnificent forest that were removed by the fire in 1936 and have since been replaced mainly by brushfields north of Port Orford, Oregon. Dion also mentions that early logging began in the best of the virgin forests along the river terraces and lower ridges near the ocean. Kerber (1974) discusses his role in the logging of majestic Chamaecyparis forests between 1937 and 1944, giving some idea of the extent of this forest type. Weidemann, Dennis, and Smith (1969) discuss the early successional development of communities on the dunes and deflation plains that describe the general situation at my plots 68 and 69 well.

Sequoia sempervirens-Chamaecyparis lawsoniana/Alluvial terrace (Sese-Chla/terrace) Community. From the vicinity of Crescent City to Eureka, California the redwood forests occur. Within these forests, Chamaecyparis appears to be rare upon the uplands but locally common in the forest along major rivers such as the Smith River as it flows through Jedediah Smith Redwood State Park. Chamaecyparis lawsoniana is generally restricted to the forest edge near the river with individual trees rarely found deeper within the groves of redwood. Two plots were measured in the redwood forests. Plot 74 is a 100-135 year old stand of Sequoia sempervirens and Chamaecyparis lawsoniana occurring under widely scattered, fire-scarred Pseudotsuga menziesii (350 years old). Plot 77 is near Stout Grove in the Jedediah Smith Redwood State Park, in forest over 700 years old (Table 34).

The tree layer of the younger plot has nearly continuous cover; most of the Sequoia and Chamaecyparis are equal aged and appear to have entered the community simultaneously after fire. They overlie a well developed hardwood tree layer (Table 35). The understory includes dense shrubs on well-drained hummocks and a thick herb layer on areas with standing water or in slight depressions. The shrub layer is dominated by Vaccinium ovatum (Table 35). The herb layer, where it is found, is dominated by a mixture of ferns.

Seedlings and saplings of Chamaecyparis and Tsuga heterophylla are common as well as a few of Sequoia. The tree layer of the older forests is similar except for the superior height of Sequoia. Chamaecyparis appears dwarfed in the old stand. The shrub layer in older stands is only dense along the forest edge and decreases in density and cover away from the river. Herbs, on the other hand, tend to increase in cover and density as well as diversity further into the groves. Important shrubs include Vaccinium ovatum, and Lithocarpus densiflora. Herbs are dominated by Polystichum munitum and Oxalis oregana (Table 35).

The soils of the alluvial terraces where this community was sampled include a variety of parent materials. In general they are fine textured but contain many coarse fragments in most horizons.

Mixed Evergreen Zone

Chamaecyparis lawsoniana-Pseudotsuga menziesii/Foothill Alluvial Terrace (Chla-Psme/terrace) Community. This community is common and widespread along streams at lower elevations in the transition from the mountains to the interior valleys of Oregon and Northern California. The community is typical of the Mixed Evergreen Zone. In many cases it appears to be transitional to the open oak woodlands of the Interior Valley Zone (Franklin and Dyrness, 1973). The community location between the mountains and valleys results in stands of high species diversity. The main variations in this community appear related to moisture relations of the individual stands. The importance of parent material type is reduced since nearly all examples found occur on mixed alluvium including virtually all rock types found in this study. At higher elevations, fewer alluvial terraces are formed, and the heterogeneity of the parent material is reduced. Here the terrace community appears more like communities previously listed for the Zone.

Lower elevation terraces range from very moist, poorly drained on fine texture alluvial deposits to those on coarse textured, well-drained soils. The wet type was sampled at Cedar Rustic Campground (Figure 1). It is about 150 years old. The tree layer is open (75% cover) and composed of Chamaecyparis, Pseudotsuga, Acer macrophyllum, and Alnus rubra. These trees are of moderate height and have a well developed layer of smaller hardwoods beneath them (Table 36). Reproduction of Pseudotsuga and Chamaecyparis is dense, with abundant hardwoods of nearly tree size.

The shrub layer dominants are mainly broadleaf deciduous species such as Acer macrophyllum, Alnus rubra, Cornus nuttallii, and Corylus cornuta (Table 36). The accumulative shrub cover here is over 100% while actual cover ranges between 60 and 95%. The herb layer on mesic sites resembles that of other mesic coastal communities discussed, being dominated by Polystichum munitum and Oxalis oregana.

A drier terrace community approximately 600 years old (located near and within the Grayback Campground near Cave Junction, Oregon of Figure 1) is compositionally quite similar to the stand described immediately above. However, the stand differs greatly in structure and the relative importance of the species that are shared. The tree layer here is of low density and is composed of old growth Pseudotsuga and Chamaecyparis with occassional large Lithocarpus densiflora whose crowns approach those of the conifers. A lower layer of scattered hardwoods is joined by relatively few immature conifers (Pseudotsuga, Chamaecyparis, Abies grandis, and Taxus brevifolia).

In untrailed areas the shrub layer has 24 species and is dominated by hardwood deciduous species. It is a fairly continuous layer, two to five meters tall. The herb layer is restricted to openings and no species are particularly abundant. In mesic pockets, Linnaea borealis may form mats.

In both areas reproduction includes large amounts of Pseudotsuga menziesii, indicating at least a small role for this species in the climax community. More mature stands in either area appear more mesic in the understory; the tree canopy becomes denser, importance of shrubs decreases, and that of the remaining herbs increases. In these mature areas Polystichum munitum is again found along with Viola sempervirens, Viola

Table 36. Species cover (%) for plots 78 and 25 of the *Pseudotsuga menziesii-Chamaecyparis lawsoniana*/foothill alluvial terrace and the *Chamaecyparis lawsoniana*/ultramafic meadow communities respectively.

Plot Number	78		25		
Tree Layer					
Pseudotsuga menziesii	R[1]	40	Pseudotsuga menziesii	R	2
Chamaecyparis lawsoniana	M	50	Chamaecyparis lawsoniana	M	25
Chamaecyparis lawsoniana	R	10	Chamaecyparis lawsoniana	R	10
Acer macrophyllum	M	10	Pinus attenuata	M	15
Alnus rubra	M	30			
Lithocarpus densiflora	M	15			
Umbellularia californica	M	15			
Shrub Layer					
Lithocarpus densiflora		51	Rhododendron occidentale		10
Umbellularia californica		33	Ledum glandulosum		10
Gaultheria shallon		8	Quercus vaccinifolia		t[2]
Vaccinium ovatum		31			
Berberis nervosa		5			
Rubus ursinus		2			
Castanopsis chrysophylla		t			
Cornus nuttallii		3			
Acer macrophyllum		20			
Alnus rubra		30			
Corylus cornuta		4			
Herb Layer					
Oxalis oregana		8	Carex spp.		40
Polystichum munitum		28	Rudbeckia californica		30
Trientalis latifolia		t	Juncus spp.		20
Pteridium aquilinum		6	unidentified grasses		15
Actaea rubra		2	Darlingtonia californica		15
Galium triflorum		1	Tofieldia glutinosa		10
Athyrium filix-femina		t	Habenaria sparsiflora		6
Trillium ovatum		t	Narthecium californicum		3
Goodyera oblongifolia		t	Sisyrinchium angustifolium		2
Asarum caudatum		t	Habenaria unalascensis		2
Viola sempervirens		t	Cypripedium californicum		2
Whipplea modesta		t	Trillium rivale		1
Vancouveria planipetala		t	Lilium pardalinum		1
Festuca californica		t	Castilleja spp.		3
			Iris innominata		1
			Polygonum bistortoides		t

1/ R = reproductive sizes, M = mature sizes

2/ cover is given in nearest whole percent unless less than .5% which is given a t (trace) glabella, Clintonia uniflora, and Chimaphila umbellata.

Azonal Community

Chamaecyparis lawsoniana/Ultramafic Meadow Community. This community has been studied at two locations where it occupies several hectares each. The type occurs throughout the range of C. lawsoniana along streamsides, on ultramafic parent material, and usually in exposed sites. The two areas studied are the Hunter Creek Bog near Pine Point (Figure 1) and Snow Camp Meadow (Table 36) farther inland on the same road system. Both areas are wide bowl shaped valleys with meadows, meandering drainage, and extensive standing water. These wetlands are surrounded by forest communities; the Pinus-Chla/Quva-Xete and Chla/Lide communities at mid to low elevations and the Abco-Chla/herb community at higher elevations. Another common adjacent community is pure Pinus attenuata, on areas burned relatively recently and probably repeatedly. The Chamaecyparis lawsoniana/ultramafic meadow community is an open community (usually even more so than the Pinus-Chla/Quva/Xete community) having only occassional old trees of Chamaecyparis lawsoniana present; other tree species are mostly lacking. The hummocky, better drained areas of the habitat type may include Pseudotsuga menziesii, Pinus contorta, Pinus attenuata, and Pinus monticola.

The shrub layer is typically very poorly developed in the wetter areas. However, on the better drained areas there occur thickets with up to 21 species recorded. Over 50 herbs have been identified and the herb layer is typically the most developed layer of the community. There are no clear dominants (Table 36).

Soils of this community are shallow, fine textured, high in organic matter, and extremely wet. In many areas within the meadows the ground moves when one walks, as many sphagnum bogs do. There is a noticeable invasion of this community by several shrubs and trees. However, the transition from xeric to wet soils is usually so short that the ecotone between this and other communities remains definite. Fire in much of the surrounding area has probably also been important in maintaining the meadow community. One plot within this community was sampled at

Snow Camp Meadow (Table 36); the resulting destruction of the biota terminated further quantitative sampling in the type. The community, in more restricted streamside stands, has also been mentioned in the Colliers Bar and Deer Creek areas of the lower Illinois River by Emmingham (1973). I have recorded the community at Iron Mountain and Panther Ridge, the Port Orford Cedar Research Natural Area, Hunter Creek Bog, Snow Camp Meadow, Game Lake, Kerby, Page Mountain, Castle Lake, Onion Mountain, and Laird Meadow study areas (Figure 1).

Taiwan

Warm Temperate Montane Conifer Zone

Sixty-one plots were studied at 11 sites in Taiwan (Figure 4); 28 are *Chamaecyparis formosensis* stands; 29 are *Chamaecyparis taiwanensis* stands; and the remaining four stands include both species. A major distinction within forests dominated by one species became obvious early in the study: (1) those forests with alpine bamboo (*Pleioblastus niitakayamensis*) and (2) those without it. Liu (1968) had already reported three major associations including; (1) *Chamaecyparis taiwanensis* association, (2) *Chamaecyparis formosensis* association, and (3) mixed *Chamaecyparis* association. His associations are defined the same as my communities and are thus equivalent to the habitat type (V.T. Liu, pers. comm.). Liu (1968) also recognized many seral communities after fire which included the alpine bamboo. Due to the dominance of alpine bamboo in many forests, even old ones, I have used its presence to subdivide the *Chamaecyparis taiwanensis* and *C. formosensis* associations of Liu. In the areas without bamboo there was usually an outstanding variety of other shrub species with no constant dominants. Of the 29 *C. taiwanensis* stands, 20 are the non-bamboo type and named the *Chamaecyparis taiwanensis*/shrub community; and nine stands are of the bamboo type and are named *Chamaecyparis taiwanensis*/bamboo community. Of the 28 *Chamaecyparis formosensis* stands 14 are of the bamboo type named the *Chamaecyparis formosensis*/bamboo community; and 14 are of the shrub type named the *Chamaecyparis formosensis*/shrub community (Table 16). All four of the mixed Chamaecyparis stands were within the bamboo type. This community is not described in detail here since my data are not sufficient.

These four communities are the main Chamaecyparis communities in Taiwan. They are admittedly rather broad, and in some cases, a given community may contain several seral representatives of the sequence. In this discussion reference will often be made to floristic peculiarities which may be common to certain stages of given associations.

Chamaecyparis taiwanensis/shrub (Chta/shrub) Community. Twenty plots have been sampled within this community (Table 37) and are located at Yuan Yang Lake, Ta Hsueh Shan, An Ma Shan, and Ren Lwun study areas (Figure 4). Stands of this community are found on eastern to southern aspects of upper topographic positions (Table 37). Soils within this community are partially to well drained, shallow, and moderately stony. They are dry podzols. In some areas the soils are deeper and finer textured forest brown soils. Surface soils are commonly silty or silt loam A horizons over silty clay, clay loam, or loam B horizons, and deep massive C horizons of colluvial origins.

The actual mature tree cover averages 86% and is dominated by Chamaecyparis taiwanensis and Tsuga chinensis (Table 6). These overlie a secondary tree stratum composed of hardwoods and dominated by Illicium tashuroi, Trochodendron aralioides, Cyclobalanopsis morii, and Cleyera japonica (Table 38). The immature conifer layer of the Chta/shrub community is the best developed of all Taiwan Chamaecyparis communities studied. Saplings and seedlings are dominated in both cover and density by Chamaecyparis taiwanensis; it is followed in importance by Tsuga chinensis. No other conifers are important within most mature stands.

The shrub stratum of the Chta/shrub community is well developed (Table 9), with 66% actual cover and 122% accumulative cover. The community contains 100 known shrub species, but the average per plot is only 27 species. Shrub diversity is thus over twice that of any Chamaecyparis lawsoniana community. Most shrub cover, however, is contributed by relatively few species. Fifteen species occur with at least 50% constancy (Table 38). Dominance of the layer is only local. Later seral stands usually have high constancy and cover of Cleyera japonica, Neolitsea acuminatissima, Barthea formosana, Illicium tashuroi, Rhododendron morii,

Table 37. Site characteristics of Chamaecyparis taiwanensis/shrub community plots.

Plot Number	Location Figure 4	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
18	5	1600	e	7	10	35	sedimentary
19	5	1640	ssw	35	10	35	sedimentary
20	5	1620	ssw	45	10	35	sedimentary
39	7	2450	e	40	40	50	schist
30	4	2200	e	50	200	35	sedimentary
31	4	2200	e	30	200	23	sedimentary
16	5	1680	ssw	20	250	35	sedimentary
13	5	1700	sse	25	350	35	sedimentary
14	5	1730	sse	15	400	35	sedimentary
1	1	2360	ne	57	900	72	sedimentary
2	1	2350	ne	35	900	80	sedimentary
15	5	1650	nnw	5	600	35	sedimentary
12	4	2200	sse	45	600	40	granitics
50	4	2050	se	65	500	34	granitics
44	4	2170	sw	45	500	48	granitics
45	4	2170	wsw	70	500	45	granitics
46	4	2270	wsw	50	500	23	granitics
47	4	2150	nw	10	600	45	granitics
48	4	2150	sw	10	700	40	granitics
49	4	2200	sw	40	700	45	granitics

Table 38. Cover and constancy of species in the Chamaecyparis taiwanensis/shrub community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community																				% Const.	% Ave. Cover
		18	19	20	39	30	31	16	13	14	1	2	15	12	50	44	45	46	47	48	49		
Tree Layer																							
Chamaecyparis taiwanensis	M[1/]	--	5	--	--	55	20	70	90	80	40	55	80	65	30	65	60	70	55	60	45	85	47
Chamaecyparis taiwanensis	R	30	45	25	1	60	15	10	17	10	15	15	15	15	10	--	25	15	3	10	5	95	17
Tsuga chinensis	M	--	--	--	--	10	--	30	25	40	25	40	--	25	65	t	45	35	30	35	65	70	24
Tsuga chinensis	R	--	--	--	t	10	2	2	3	1	--	1	3	5	10	t	5	1	5	15	10	80	4
Illicium tashuroi	M	--	--	--	--	--	--	--	--	--	--	--	41	25	--	20	5	--	75	35	10	35	11
Cleyera japonica	M	--	--	--	--	7	10	--	--	--	--	--	--	--	--	--	35	45	15	15	10	35	6
Trochodendron aralioides	M	--	--	20	--	15	10	--	--	--	25	--	--	--	--	--	--	--	--	10	10	30	5
Pinus taiwanensis	M	--	--	--	45	50	40	--	--	--	--	--	--	--	25	30	20	--	--	--	--	30	11
Cyclobalanopsis morii	M	--	--	--	--	--	--	--	--	--	35	--	--	15	--	30	--	--	--	35	30	25	10
Lithocarpus amygdalifolius	M	--	--	--	--	--	--	--	--	--	--	--	--	20	30	--	--	10	15	--	60	25	7
Shrub Layer																							
Cleyera japonica		--	10	7	--	25	7	4	11	3	1	5	3	11	24	t	7	16	1	4	11	90	8
Neolitsea acuminatissima		7	3	3	--	2	--	2	11	3	10	10	9	33	t	3	22	14	2	12	35	90	9
Smilax arisenensis		2	2	2	--	1	--	1	1	t	1	1	1	5	2	2	1	2	3	3	1	90	2
Viburnum taiwanianum		3	19	20	--	t	1	3	1	t	--	1	1	15	5	3	2	t	2	3	t	90	4
Dendropanax pellucipunctata		5	5	5	1	2	--	31	13	6	t	t	14	--	1	t	--	1	1	t	t	85	4
Symplocos morrisonicola		3	7	4	--	--	--	18	8	7	21	37	--	3	--	7	1	t	1	5	6	75	7
Barthea formosana		t	--	2	--	--	--	--	9	1	20	16	--	26	1	12	30	40	21	23	32	70	12
Illicium tashuroi		15	1	--	--	--	--	3	14	12	--	--	--	10	11	30	9	27	22	17	32	65	10
Ilex hanceana		2	--	--	--	--	2	--	1	1	1	t	t	2	1	t	2	--	--	1	5	65	1
Eurya glaberrima		10	15	5	--	--	1	2	t	1	--	t	1	--	3	t	5	--	--	--	--	60	2
Eurya leptophylla		40	35	30	2	2	t	1	5	7	--	--	2	--	--	--	--	t	--	--	--	55	6
Hydrangea integra		12	15	5	--	--	--	--	4	7	t	--	7	--	--	5	--	--	6	9	--	50	4
Trochodendron araliodes		7	--	5	--	3	3	--	--	--	1	--	8	2	--	--	--	t	2	14	--	50	2
Ternstroemia gymnanthera		--	3	3	--	2	--	9	3	6	--	t	--	--	--	--	--	t	--	t	1	50	1
Rhododendron morii		--	--	5	--	--	--	3	--	--	--	--	--	20	12	37	6	47	16	10	--	45	8

(continued on next page)

Table 38. (Continued)

Layers and Species	18	19	20	39	30	31	16	13	14	1	2	15	12	50	44	45	46	47	48	49	% Const.	% Ave. Cover
	Stands representing this community																					
Elaeocarpus japonicus	3	3	1	--	--	--	3	3	1	--	--	--	5	--	--	--	--	--	3	4	45	1
Actinodaphne mushaensis	7	--	15	--	--	--	--	--	--	t	--	t	--	--	2	--	1	t	--	7	40	2
Stauntonia hexophylla	5	5	7	--	1	--	--	2	1	--	--	1	--	--	3	--	--	--	--	--	40	1
Ardisia crenata	--	3	13	--	--	--	--	2	1	--	--	--	--	--	1	--	t	1	2	--	40	1
Eurya acuminata	--	--	--	--	2	t	--	--	--	7	3	--	1	--	15	--	2	--	--	2	40	2
Symplocos stellaris	--	--	--	--	--	--	--	--	--	t	t	--	--	2	t	1	--	1	3	4	40	1
Schefflera taiwaniana	7	7	2	--	--	--	15	5	1	--	--	43	--	--	--	--	--	--	--	--	35	4
Damnacanthus angustifolius	--	--	--	--	t	--	t	1	1	--	--	t	--	--	--	--	--	t	1	--	35	t
Viburnum integrifolium	13	8	13	--	--	--	--	1	t	--	--	t	1	--	--	--	--	--	--	--	35	2
Lithocarpus amygdalifolius	--	--	--	--	1	--	--	--	--	--	t	--	8	1	14	4	t	--	--	--	35	1
Symplocos heishanensis	--	--	--	--	2	--	--	1	--	--	--	--	12	--	5	1	6	--	--	3	35	2
Skimmia arisenensis	10	35	5	--	--	--	5	16	11	--	--	t	--	--	--	--	--	--	--	--	35	4
Miscanthus transmorrisonensis	25	15	t	100	3	30	t	--	--	--	--	--	--	--	--	--	--	--	--	--	35	9
Hugeria lasiostemon	2	1	7	--	--	--	1	--	1	--	--	2	--	3	--	--	--	--	--	--	35	1
Microtropis fokiensis	--	--	--	--	3	--	2	--	--	t	t	--	--	--	--	--	--	t	--	1	30	t
Rhododendron formosanum	--	2	--	--	10	63	--	1	--	--	--	t	--	--	--	31	--	--	--	--	30	5
Castanopsis carlesii	--	--	--	--	--	--	--	--	--	1	--	--	--	16	1	14	t	--	--	4	30	2
Lonicera acuminata	3	11	5	--	--	--	--	--	1	--	--	2	--	--	--	t	--	--	--	--	30	1
Damnacanthus indicus	--	--	--	--	--	--	--	2	--	--	t	--	3	1	10	--	--	--	--	--	25	1
Cyclobalanopsis morii	--	--	--	--	--	--	--	--	--	--	t	--	t	1	1	--	--	--	1	--	25	t
Smilax raindaiensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	t	1	3	--	1	5	25	1
Berberis alpicola	7	5	--	--	--	--	--	2	1	--	--	3	--	--	--	--	--	--	--	--	25	1
Ilex sugeroki	--	3	5	--	--	--	4	--	1	--	--	1	--	--	--	--	--	--	--	--	25	1
Stransvaesis niitakayamensis	3	3	7	5	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	25	1
Herb Layer																						
Monachosorum henryi	--	5	4	--	t	--	1	4	1	1	--	2	--	--	6	--	--	2	5	t	60	2
Sarcopyramis delicata	--	3	2	--	--	--	t	1	1	t	t	1	--	--	--	--	t	2	t	t	60	1
Hymenophyllum polyanthos	12	17	4	--	--	--	34	39	21	t	--	8	--	--	--	--	--	3	8	1	55	7
Plagiogyria formosana	7	13	22	--	--	--	9	7	27	21	9	35	--	--	--	--	--	3	--	--	50	8

(continued on next page)

Table 38. (Continued)

Layers and Species	Stands representing this community																				% Const.	% Ave. Cover
	18	19	20	39	30	31	16	13	14	1	2	15	12	50	44	45	46	47	48	49		
Goodyera velutina	--	--	--	--	--	1	--	t	t	t	t	--	t	t	t	--	t	--	t	--	50	t
Ophiopogon scaber	1	17	7	--	--	--	4	1	1	--	--	1	t	--	3	--	--	--	--	--	45	2
Hicriopteris glauca	30	20	13	15	1	--	1	5	--	--	t	--	--	--	--	--	--	--	--	--	40	4
Plagiogyria dunnii	--	--	--	--	1	--	--	--	--	--	--	--	t	--	2	5	4	4	3	14	40	2
Ainsliaea morrisonicola	--	--	--	--	--	--	t	--	2	--	--	1	3	t	--	--	--	3	2	--	35	1
Vittaria flexuosa	--	--	--	--	--	--	--	t	t	t	--	--	--	--	t	t	--	t	t	--	35	t
Oxalis griffithii	--	2	4	--	--	--	--	1	t	1	--	t	--	--	--	--	--	--	--	--	30	t
Araiostegia perdurans	--	4	2	--	--	t	1	t	--	--	--	--	t	--	--	--	--	--	--	--	30	t
Pellionia trilobulata	--	3	3	--	--	--	7	--	1	--	--	1	--	--	--	--	--	--	--	--	25	1
Dryopteris sp.	--	--	--	--	t	--	--	1	t	--	--	--	t	--	t	--	--	--	--	--	25	t
Asplenium normale	--	--	--	--	--	--	--	t	--	--	--	--	--	--	1	--	--	t	1	t	25	t
Lepisorus oligolepidus	--	--	--	--	--	--	--	--	--	--	--	--	t	t	--	--	t	t	--	t	25	t
Acrophorus stipellatus	--	--	--	--	--	--	--	--	--	--	--	--	--	t	t	--	--	3	8	1	25	1

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

Symplocos morrisonicola, and Eurya leptophylla. Many other species occur with 1 to 5% cover in 35 to 50% of the plots. Younger seral stands include high cover and constancy of such species as Miscanthus transmorrisonensis, Litsea cubeba, Rhododendron formosana, Skimmia arisenensis, Gaultheria cumingiana, and Ardisia japonica. Nearly 30 shrubs show their best development within this community (Table 38).

The herb stratum averages 28% cover, higher than all except the Tshe-Chla/Pomu-Oxor community in the Pacific Northwest (Table 9). There are 69 herb species in the community, and many of them with high cover and constancy (Table 38). Herb stratum dominance is also only expressed locally. Wetter sites support Hymenophyllum polyanthos, Sarcopyramis delicata, and Plagiogyria formosana while drier sites support Plagiogyria dunnii with much lower cover. Many species represent certain seral stages; thus their actual cover values within their own seral stage are higher than those shown in the tables. The average moss cover within this community is 29%.

Chamaecyparis taiwanensis/Plieoblastus niitakayamensis (Chta/bamboo) Community. This community has been sampled by 9 plots (Table 39) located at the Ta Hsueh Shan, Tai Ping Shan, Yuan Yang Lake, Ren Lwun, Wang Hsiang, and Tan Ta study areas (Figure 4). Most of the stands sampled in this type are of old growth forest, at high elevations and on a variety of aspects (Table 39). Soils within this community are generally poorly developed, shallow, and fine textured. They have impeded drainage compared to those of the Chta/shrub community. They may have large or small amounts of coarse fragments present. This may result from a thicker litter layer, more organic matter in surface horizons, and reduced channelling of free water in surface soils that have fewer rooted plants to break the strongly structured surface horizons. There is usually little evidence of podzolization here. Differences between horizons in the soils of the Chta/bamboo community are not as marked as in those of the Chta/shrub community.

The crown cover of the Chta/bamboo community is 82%; accumulative cover is 157%. The actual tree cover is about equal to that of the Chta/shrub community (Table 9), but the accumulative cover is much less in the Chta/bamboo community. The major tree species again include

Table 39. Site characteristics of <u>Chamaecyparis taiwanensis</u>/bamboo community plots.

Plot Number	Location Figure 4	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
38	7	2430	ene	50	70	45	schist
43	8	2500	sw	65	400	35	schist
3	1	2580	nne	25	900	50	sedimentary
4	1	2600	ene	60	900	48	sedimentary
10	3	2150	s	20	600	45	sedimentary
11	3	2150	se	20	400	49	sedimentary
17	5	1580	none	3	700	35	sedimentary
42	8	2400	nw	45	900	35	schist
54	10	2250	nw	18	700	60	schist

Chamaecyparis taiwanensis and Tsuga chinensis with 61% and 14% average cover respectively (Table 40). There is a greater relative importance of Chamaecyparis taiwanensis here than in the shrub community, but the total tree density here is the lowest of all of the Taiwan communities, is lower than all but one of the Chamaecyparis lawsoniana communities, and is considerably lower than in the Chta/shrub community (Tables 5 & 6). Plots always contain Chamaecyparis taiwanensis and Tsuga chinensis in addition to some other less important species. Important immature conifers are also Chamaecyparis taiwanensis and Tsuga chinensis, with 8% and 2% average cover respectively. Chamaecyparis taiwanensis is the only tree species which shows its optimum development within this community.

The shrub stratum of the Chta/bamboo community is quite different from the Chta/shrub community. Alpine bamboo (Pleioblastus niitakayamensis) occurs in every plot and has an average cover of 89%. Diversity is also less here than in the shrub community with only 80 species (Table 9). Only the alpine bamboo can be considered a dominant shrub species. Other locally important species include Neolitsea acuminatiassima, Dendropanax pellucipunctata, Schefflera taiwaniana, Eurya acuminata, and others (Table 40). The actual shrub cover is 99% and the accumulative cover is 159%, both much higher than those of the shrub community (Table 9). While alpine bamboo is well developed, other species common to both of the Chamaecyparis taiwanensis communities are greatly reduced in cover, importance, or constancy within the bamboo community. Smilax raindaiensis, Microtropis fokiensis, Pleioblastus niitakayamensis, Schefflera taiwaniana, and Rhododendron ellipticum show their optimum development within the Chta/bamboo community.

The herb stratum, with an average cover of 15%, is greatly reduced as a result of the alpine bamboo. Plagiogyria formosana and Monachosorum henryi are the only dominants (Table 40). The average moss cover in this community is 23%.

Chamaecyparis taiwanensis-Chamaecyparis formosensis/Pleioblastus niitakayamensis (Chta-Chfo/bamboo) Community. The Chta-Chfo/bamboo community is a transitional forest community common in the Tan Ta, Ren Lwun, Wang Hsiang, and Hua Lien study areas (Figure 4). Since only three usable

Table 40. Cover and constancy of species in the Chamaecyparis taiwanensis/bamboo community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community									% Const.	% Ave. Cover
		38	43	3	4	10	11	17	42	54		
Tree Layer												
Chamaecyparis taiwanensis	M[1/]	75	65	65	85	45	50	65	60	40	100	61
Chamaecyparis taiwanensis	R	20	--	15	5	10	5	3	--	15	78	8
Tsuga chinensis	M	15	--	--	5	15	55	--	25	10	67	14
Tsuga chinensis	R	5	--	--	--	--	--	--	--	10	22	2
Cyclobalanopsis morii	M	15	45	25	--	--	--	--	--	--	33	9
Shrub Layer												
Pleioblastus niitakayamensis		80	75	75	100	100	100	75	100	100	100	89
Neolitsea acuminatissima		4	--	t	15	15	--	6	5	6	78	6
Microtropis fokiensis		2	1	9	3	t	--	--	1	1	78	t
Dendropanax pellucipunctata		4	13	6	5	--	--	8	--	--	56	4
Viburnum taiwanianum		--	t	6	--	--	--	t	t	2	56	1
Schefflera taiwaniana		24	16	--	--	--	--	--	2	3	44	5
Eurya acuminata		16	20	6	3	--	--	--	--	--	44	4
Smilax raindaiensis		1	3	1	2	--	--	--	--	--	44	1
Eurya glaberrima		10	--	--	--	t	--	--	1	t	44	1
Rhododendron morii		--	--	--	--	30	20	--	8	14	44	8
Smilax arisenensis		1	--	2	--	--	--	3	--	--	33	1
Illicium tashuroi		4	--	--	--	--	--	--	10	4	33	2
Hydrangea integra		1	--	--	--	t	--	1	--	--	33	t
Symplocos morrisonicola		4	14	8	--	--	--	--	--	--	33	3
Cyclobalanopsis morii		32	2	1	--	--	--	--	--	--	33	4
Symplocos stellaris		5	2	--	--	--	--	t	--	--	33	1
Rhododendron ellipticum		10	11	15	--	--	--	--	--	--	33	4
Herb Layer												
Plagiogyria formosana		3	21	3	--	t	t	20	3	15	89	7

(continued on next page)

Table 40. (Continued)

Layers and Species	Stands representing this community									%	%
	38	43	3	4	10	11	17	42	54	Const.	Ave. Cover
Monachosorum henryi	2	6	--	4	2	t	9	--	--	67	4
Goodyera velutina	--	t	t	--	--	--	t	t	--	44	t
Pellionia trilobulata	--	--	--	--	1	--	--	1	4	33	1
Plagiogyria euphlebia	3	--	--	1	--	--	1	--	--	33	1
Asplenium normale	t	t	--	2	--	--	--	--	--	33	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

stands were sampled within this community, it will not be discussed here. However, most parameters are intermediate between those of the Chta/bamboo and Chfo/bamboo communities. Most of these stands more closely resemble the Chta/bamboo community since all of the stands sampled were in areas dominated primarily by Chamaecyparis taiwanensis.

Chamaecyparis formosensis/Pleioblastus niitakayamensis (Chfo/bamboo) Community. There were 14 stands sampled within the Chfo/bamboo community (Table 41), located at the Hua Lien, Ren Lwun, Wang Hsiang, and Taitung study areas (Figure 4). They occur on moderate to high elevation west to north aspects, and all but three stands are 400 years old or more (Table 41). Soils within the Chfo/bamboo community are about a meter deep, and about half of them show marked podzolization. They have silt loam surface horizons which overlie clay loam and clay subsoils, are well drained but moist, and are typically classed as wet podzols. Other soils show less podzolization or are developing slowly between boulders in old talus fields; their profiles are difficult or impossible to study without massive excavations.

The mature tree cover within the Chfo/bamboo community averages 90% actual and 176% accumulative. However, tree density is predominantly hardwood species rather than conifers (Table 6). Chamaecyparis formosensis is the most constant species in the tree stratum with an average cover of 42% (Table 42). Tsuga chinensis occurs in only a third of the plots. Other locally important trees include Picea morrisonicola, Taiwania cryptomerioides, Trochodendron aralioides, Castanopsis stellatospina, and Cyclobalanopsis morii. Pinus taiwanensis and P. armandii are also important in early seral stages. Tree regeneration in this community is extremely reduced (Table 6) with only two stands containing seedlings or saplings of Chamaecyparis formosensis. Most of the conifer regeneration here is of Pinus within the early seral stands. Large Taiwania cryptomerioides and Castanopsis stellatospina are the only trees showing their optimum development within this community.

The shrub layer of the Chfo/bamboo community is again dominated by alpine bamboo (Table 42). Shrub diversity is nearly equivalent to the Chta/bamboo community with 80 species. The actual shrub cover is 92% and the accumulative cover is 143%. Alpine bamboo occurs in all

Table 41. Site characteristics of *Chamaecyparis formosensis*/bamboo community plots.

Plot Number	Location Figure 4	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
61	11	2120	w	10	800	35	limestone
60	11	2350	sw	5	800	40	limestone
58	11	2320	sw	30	600	30	limestone
41	8	2550	nw	55	500	35	schist
40	8	2400	nnw	45	600	50	schist
28	6	1900	w	30	600	nd[1]	schist
27	6	1870	w	30	800	nd	schist
25	6	1840	w	10	600	nd	schist
24	6	1860	w	60	900	nd	schist
34	7	2300	wnw	30	400	50	schist
26	6	1800	w	60	700	nd	schist
57	11	2320	w	15	17	65	limestone
56	11	2400	wsw	45	17	45	limestone
55	11	2350	wsw	5	17	60	limestone

1/ nd = no data available

Table 42. Cover and constancy of species in the <u>Chamaecyparis formosensis</u>/bamboo community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community														%	%
		61	60	58	41	40	28	27	25	24	34	26	57	56	55	Const.	Ave. Cover
Tree Layer																	
Chamaecyparis formosensis	M[1/]	45	75	55	35	40	75	65	55	45	50	50	--	--	--	79	42
Chamaecyparis formosensis	R	--	--	--	--	--	--	--	--	--	10	--	15	14	9	29	3
Trochodendron aralioides	M	--	--	--	25	--	60	30	15	40	25	40	--	--	--	50	17
Tsuga chinensis	M	35	25	60	85	55	--	--	--	--	--	--	--	--	--	36	19
Tsuga chinensis	R	2	2	2	--	--	--	--	--	--	--	--	--	--	--	21	t
Castanopsis stellatospina	M	--	--	--	--	--	30	70	60	45	--	45	--	--	--	36	18
Cyclobalanopsis morii	M	70	30	15	--	--	--	--	--	--	30	--	--	--	--	29	10
Taiwania cryptomeriodes	MR	25	15	7	--	--	--	--	--	--	--	--	5	--	--	29	4
Shrub Layer																	
Pleioblastus niitakayamensis		95	90	65	100	85	85	49	62	29	85	17	5	55	45	100	62
Smilax arisenensis		t	t	t	--	--	--	1	2	3	2	1	t	--	--	64	1
Neolitsea acuminatissima		6	17	10	--	5	t	2	--	7	t	3	--	--	--	64	4
Dendropanax pellucipunctata		22	7	--	--	15	t	4	1	2	19	3	--	--	--	64	5
Ardisia crenata		2	t	1	--	--	t	t	1	t	1	t	--	--	--	64	t
Trochodendron aralioides		--	--	--	t	--	9	24	3	5	2	20	--	--	--	50	5
Damnacanthus indicus		1	--	t	--	--	5	1	--	3	1	3	--	--	--	50	1
Cyclobalanopsis morii		6	10	30	--	--	1	5	--	6	t	--	--	--	--	50	4
Microtropis fokiensis		--	t	--	--	1	t	--	--	t	4	1	--	--	--	43	t
Pieris taiwanensis		--	1	1	--	--	--	--	--	--	--	--	2	15	2	36	2
Eurya crenatifolia		--	--	--	--	--	11	1	1	8	--	2	--	--	--	36	2
Castanopsis stellatospina		--	--	--	--	--	1	21	35	20	--	7	--	--	--	36	6
Eurya leptophylla		--	--	4	1	t	--	--	--	--	--	--	--	t	--	29	t
Actinodaphne mushaensis		--	--	--	--	--	4	4	3	1	--	--	--	--	--	29	1
Persea thunbergii		--	--	--	--	--	--	8	7	6	--	32	--	--	--	29	4
Eurya acuminata		--	2	--	7	27	--	--	--	--	4	--	--	--	--	29	3
Viburnum taiwanianum		--	--	--	1	t	--	--	1	2	--	--	--	--	--	29	t

(continued on next page)

Table 42. (Continued)

Layers and Species	Stands representing this community														% Const.	% Ave. Cover
	61	60	58	41	40	28	27	25	24	34	26	57	56	55		
Lonicera acuminata	--	--	--	--	--	--	t	--	--	--	--	3	10	1	29	1
Schizophragma integrifolia	--	--	--	--	--	--	1	3	2	--	1	--	--	--	29	1
Actinodaphne morrisonensis	--	--	--	--	--	5	2	t	--	--	3	--	--	--	29	1
Hedera rhombea	--	--	--	--	--	1	t	--	1	--	t	--	--	--	29	t
Hydrangea angustipetala	--	--	--	--	--	t	1	--	2	--	1	--	--	--	29	t
Miscanthus transmorrisonensis	--	--	--	--	--	--	--	--	--	--	--	65	85	75	21	16
Herb Layer																
Plagiogyria formosana	1	3	1	2	1	27	33	13	30	4	2	--	--	--	79	8
Sarcopyramis delicata	t	1	t	--	--	1	3	5	1	t	4	--	--	t	71	1
Monachosorum henryi	--	t	--	1	1	5	1	13	1	5	13	--	--	--	64	3
Hymenophyllum polyanthos	t	2	t	--	--	t	t	1	t	--	t	--	--	--	57	t
Plagiogyria euphlebia	t	t	t	t	--	--	--	--	--	2	t	--	--	--	43	t
Oxalis griffithii	--	t	1	--	--	--	1	--	t	--	t	--	--	--	36	t
Goodyera velutina	--	t	t	t	t	--	--	--	1	--	--	--	--	--	36	t
Pellionia trilobulata	--	--	--	--	--	4	7	1	t	--	t	--	--	--	36	1
Microsorium buergerianum	--	--	--	--	--	t	t	1	t	--	t	--	--	--	36	t
Hymenophyllum badium	--	--	--	--	--	1	4	2	t	--	1	--	--	--	36	1
Pilea sp.	--	--	--	--	--	t	t	1	t	--	1	--	--	--	36	t
Monachosorum sp.	--	--	--	--	--	t	6	8	4	--	5	--	--	--	36	2
Asarum blumei	--	--	--	--	--	--	t	t	t	--	t	--	--	--	29	t
Pellionia scabra	--	--	--	--	--	1	--	t	t	--	1	--	--	--	29	t
Ophiorrhiza japonica	--	--	--	--	--	--	t	2	t	--	5	--	--	--	29	1
Dryopteris sp.	--	--	--	--	t	--	1	t	--	--	t	--	--	--	29	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

stands, but its average cover value is only 62% compared to 89% in the Chta/bamboo community. Most of the alpine bamboo in this community appears to be shorter and less vigorous than that in the Chta/bamboo community. Other important shrub species in late seral stages include young hardwood trees of several species (Table 42). In young seral stages, Gaultheria cumingiana, Lonicera acuminata, Miscanthus transmorrisonensis, Pinus armandii, and Pieris taiwanensis are important. There were only seven shrub species which showed their optimum development within this community (Table 16).

The herb stratum of the Chfo/bamboo community reflects its close proximity to the Warm Temperate Montane Rain Forests with higher diversity. The average herb cover here is only 30%. Plagiogyria formosana, Monachosorum henryi and Sarcopyramis delicata are the dominant herbs, additional cover is mostly from ferns (Table 42). Moss cover is 22%.

Chamaecyparis formosensis/shrub (Chfo/shrub) Community. This community has been sampled by 14 stands (Table 43) located at the Ho Ping Shan, Hua Lien, Ren Lwun, Liu Kuei, and Taitung study areas (Figure 4). They are located on midelevation westerly aspects and all are over 300 years old (Table 43). Soils within this community are typically moist and moderately well drained. They range from shallow and fine textured to deep and stony. They all are partially to well podzolized. Texturally and structurally they are not unlike the soils of other Chamaecyparis communities in Taiwan. They are typically granular loams to silt-loams overlying loams or clays.

The mature tree cover here is 92%, and the accumulative cover is 190%. Chamaecyparis formosensis occurs in all plots and its average cover is 58% (Table 44). No other conifers are important at most lower elevation sites. Some higher elevation locations, or middle elevation stands in central Taiwan, contain mixed conifers with Chamaecyparis formosensis among them. Other important tree species include Trochodendron aralioides, Illicium tashuroi, Cyclobalanopsis morii, Castanopsis stellatospina, and Daphniphyllum membranaceum. The relative importance of conifers in this community is lower than in any other community studied (Tables 6 & 5). Along with the slight increase in canopy cover within

Table 43. Site characteristics of *Chamaecyparis formosensis*/shrub community plots.

Plot Number	Location Figure 4	Elevation (meters)	Aspect	Slope (%)	Approximate Age (Years)	Depth to C Horizon (cm)	Predominant Parent Material
5	2	1850	w	30	700	50	limestone
6	2	1900	sw	50	700	70	limestone
7	2	1880	wsw	50	900	65	limestone
8	2	1750	w	60	900	70	limestone
9	2	1750	w	50	600	85	limestone
21	6	1840	nnw	35	500	nd1/	schist
22	6	1800	nnw	7	500	nd	schist
23	6	1820	nnw	35	300	nd	schist
29	6	1600	w	25	600	nd	schist
33	7	2350	wsw	40	700	36	schist
51	9	2350	w	5	900	35	schist
52	9	2350	w	60	700	24	schist
59	11	2350	w	40	900	50	limestone
32	7	2300	wsw	50	300	43	schist

1/ nd = no data available

Table 44. Cover and constancy of species in the Chamaecyparis formosensis/shrub community (cover given as whole percent except t = trace less than .5%).

Layers and Species		Stands representing this community														%	%
		5	6	7	8	9	21	22	23	29	33	51	52	59	32	Const.	Ave. Cover
Tree Layer																	
Chamaecyparis formosensis	M1/	65	50	75	50	60	t	30	30	45	80	80	80	75	65	100	58
Trochodendron aralioides	M	40	--	10	--	50	50	65	35	50	50	--	--	--	--	57	25
Cyclobalanopsis morii	M	--	40	15	65	25	--	--	--	--	35	30	--	20	20	57	18
Illicium tashuroi	M	--	--	--	--	--	--	--	--	--	35	70	90	50	70	36	23
Castanopsis stellatospina	M	--	--	--	--	--	30	40	75	55	--	--	--	--	--	29	14
Daphniphyllum membranaceum	M	20	--	--	--	--	--	--	--	--	--	--	30	25	15	29	6
Shrub Layer																	
Neolitsea acuminatissima		5	11	31	16	3	--	t	--	1	1	3	8	8	2	86	6
Symplocos arisenensis		4	--	3	10	1	--	1	1	1	t	1	t	--	1	79	2
Smilax arisenensis		1	1	1	1	1	t	t	3	4	--	t	--	1	--	79	1
Stauntonia hexophylla		2	--	1	4	2	1	1	t	--	2	2	t	--	t	79	1
Damnacanthus indicus		10	10	9	13	5	1	1	--	3	2	3	--	--	2	79	4
Hydrangea integra		1	1	1	t	--	t	--	1	2	--	1	--	1	t	71	1
Persea thunbergii		--	15	--	--	--	19	18	6	1	1	1	19	t	5	71	7
Symplocos morrisonicola		3	--	t	29	1	--	--	2	--	5	8	--	1	20	64	5
Cyclobalanopsis morii		--	20	t	1	t	--	--	--	--	1	4	t	2	2	64	2
Eurya leptophylla		--	13	2	2	--	--	t	9	2	--	--	--	1	1	57	2
Eurya acuminata		24	5	45	8	11	--	--	--	--	15	5	--	--	2	57	8
Hedera rhombea		--	1	t	t	--	t	--	1	t	--	--	t	t	--	57	t
Hydrangea angustipetala		2	t	14	--	--	8	21	17	16	--	--	--	--	--	50	6
Rubus kawakamii		1	t	3	1	t	--	--	2	--	--	--	--	--	1	50	t
Illicium tashuroi		--	--	--	--	2	--	--	--	--	1	9	18	52	18	43	7
Trochodendron aralioides		--	--	3	--	1	8	17	4	4	--	--	--	--	--	43	3
Ardisia crenata		--	t	--	--	1	1	1	t	1	--	--	--	--	--	43	t
Daphniphyllum membranaceum		2	2	--	--	--	--	--	--	--	--	--	1	10	1	36	1
Viburnum taiwanianum		--	--	1	t	t	--	1	--	--	1	--	--	--	--	36	t

(continued on next page)

Table 44. (Continued)

Layers and Species	Stands representing this community														% Const.	% Ave. Cover
	5	6	7	8	9	21	22	23	29	33	51	52	59	32		
Actinodaphne morrisonensis	--	--	--	--	--	--	--	--	2	t	--	2	t	2	36	t
Actinodaphne mushaensis	--	--	--	--	--	--	1	--	1	--	--	t	--	t	29	t
Schefflera taiwaniana	7	--	5	t	2	--	--	--	--	--	--	--	--	--	29	1
Dendropanax pellucipunctata	--	--	--	--	4	--	2	1	1	--	--	--	--	--	29	1
Cleyera japonica	--	--	--	--	5	--	--	--	--	39	20	--	--	11	29	5
Ilex hanceana	1	--	--	--	--	--	--	--	--	1	4	--	--	2	29	1
Schizophragma integrifolia	--	--	--	--	--	--	--	2	1	t	--	--	t	--	29	t
Cinnamomum japonicum	--	--	--	--	22	--	--	--	--	--	--	7	11	t	29	3
Osmanthus lanceolatus	6	--	--	--	5	--	--	--	--	--	--	--	3	t	29	1
Litsea acutovena	--	--	--	--	--	--	--	--	--	2	1	t	--	1	29	t
Castanopsis stellatospina	--	--	--	--	--	11	28	32	3	--	--	--	--	--	29	5
Rubus shinkoensis	--	--	--	--	--	t	--	3	1	--	--	--	4	--	29	1
<u>Herb Layer</u>																
Plagiogyria formosana	--	--	21	6	2	4	14	14	14	20	51	60	35	33	86	20
Pellionia trilobulata	--	1	2	3	--	--	2	t	t	t	t	t	t	t	79	1
Sarcopyramis delicata	--	4	t	t	--	9	1	1	2	t	--	t	--	--	64	1
Monachosorum henryi	1	--	9	2	2	7	13	16	7	--	--	--	--	--	57	4
Pellionia scabra	--	--	t	--	--	1	1	2	2	t	--	1	--	t	57	1
Microsorium buergerianum	--	--	t	4	--	t	--	t	1	--	--	t	t	t	57	t
Oxalis griffithii	--	t	t	1	--	--	--	t	t	--	--	t	t	--	50	t
Ophiorrhiza japonica	--	--	t	--	--	t	2	t	t	--	--	1	3	--	50	t
Goodyera velutina	--	--	--	--	--	t	--	t	t	--	t	--	t	t	43	t
Plagiogyria euphlebia	t	--	2	--	1	--	--	--	--	2	--	t	--	t	43	t
Ophiopogon scaber	t	t	4	4	--	--	1	--	--	--	--	--	--	--	36	1
Vittaria flexuosa	--	--	--	--	--	--	--	t	--	t	t	--	t	t	36	t
Hymenophyllum badium	--	--	--	--	--	3	2	5	t	--	--	--	--	--	29	1
Pilea sp.	--	--	--	--	--	1	2	2	t	--	--	--	--	--	29	t

1/ M and R under the tree layer refer to mature and immature (reproductive) size classes.

this community, there is greater herb and less shrub cover (Table 9). Chamaecyparis formosensis, Daphniphyllum membranaceum, Cyclobalanopsis morii, Trochodendron aralioides, and Illicium tashuroi show their best development as trees within this community.

The shrub stratum of the Chfo/shrub community has the highest species diversity of any community, with 110 species (Table 9). Once again dominance is expressed only locally (Table 44). The most important local dominants include Neolitsea acuminatissima, Damnacanthos indicus, Symplocos morrisonicola, Eurya acuminata, Hydrangea angustipetala, Cleyera japonica, and Castanopsis stellatospina.

The herb layer of the Chfo/shrub community also shows the greatest diversity, with 93 species present. However, the average stand contains only 16 species, which is fewer than in most Chamaecyparis lawsoniana communities (Table 9). Plagiogyria formosana and Monachosorum henryi are again the major dominants of the herb layer, as in other Taiwan communities. The average herb layer cover within stands of this community is 32%, which is comparatively high for all communities studied (Table 9). The two dominants listed account for 75% of the cover of this layer. Other common herbs here include Pellionia trilobulata, Sarcopyramis delicata, Pellionia scabra, and Carex spp. (Table 44).

SUMMARY AND CONCLUSIONS

A study of the temperate *Chamaecyparis* forests of Taiwan and the Pacific Northwest has been completed in order to learn more about the vegetation and soils in forests including the genus. The specific objectives of the study are: (1) quantitative analysis and description of *Chamaecyparis taiwanensis*, *C. formosensis*, and *C. lawsoniana* forests, including community structure and composition as well as their successional and environmental relationships; and (2) comparison of the temperate *Chamaecyparis* forests with emphasis on structural and successional similarities of the forests studied.

The study area includes the upland areas of Taiwan, southwestern Oregon, and northwestern California. The geology and parent materials included in both of these areas are remarkably similar in age and diversity of types. Both areas have a preponderance of multi-aged sedimentary formations with pre-Tertiary intrusions common. Taiwan's sedimentary deposits have mostly been metamorphosed into fine grained schists while granitics and limestone outcrops are common in some areas. In the range of *Chamaecyparis lawsoniana* the geology is extremely complex. It consists primarily of a matrix of sedimentary formations intruded with pre-Tertiary granitic and ultramafic formations. Soils of most Taiwan plots are podzolized or undeveloped. Soils in the Pacific Northwest *Chamaecyparis* communities are fairly young and undeveloped, with slight podzolization common at high elevations.

Climatic conditions in Taiwan and the Pacific Northwest differ greatly in that Taiwan forests endure no long dry periods and receive 2500 to 4000 + mm rainfall annually. *Chamaecyparis lawsoniana* forests, however, sustain a long summer dry period and receive 1000 to 3000 mm rainfall annually. The climate of both areas is under the strong influence of the Pacific Ocean. Taiwan forests maintain high relative humidity the year round, moderate annual temperatures, and receive little or no snow. Pacific Northwest *Chamaecyparis* forests have greater diurnal and annual temperature and humidity fluctuations and upper elevation communities may receive considerable snowfall each year.

One-hundred-sixty-nine plots have been sampled (61 in Taiwan and 108 in the Pacific Northwest). Cover data were taken on trees, shrubs, herbs and terrestrial bryophytes within Chamaecyparis communities. Stand samples were of the size described by Daubenmire (1968). Vegetation data were analyzed by manual-visual table sorting methods of Braun-Blanquet as described by Mueller-Dombois and Ellenberg (1974). The final communities derived were further checked by a simple modification of the community coefficient method of Jaccard (1912). Soil analysis consisted of the standard field soil description (USDA, 1960) followed by manual-visual table sorting of pertinent data.

Four communities in Taiwan and eight communities in the Pacific Northwest have been identified and described as major communities:

Taiwan (all in the Warm Temperate Montane Conifer Forest Zone)

(1) Chamaecyparis taiwanensis/shrub

(2) Chamaecyparis taiwanensis/bamboo

(3) Chamaecyparis formosensis/bamboo

(4) Chamaecyparis formosensis/shrub

Pacific Northwest

Mixed Evergreen Zone

(1) Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax

(2) Chamaecyparis lawsoniana/Lithocarpus densiflora

Tsuga heterophylla Zone

(1) Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax

(2) Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon

(3) Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana

Abies concolor Zone

(1) Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana

(2) Abies concolor-Chamaecyparis lawsoniana/herb

(3) Abies-Chamaecyparis lawsoniana/herb

Chamaecyparis formosensis forests were fairly restricted to north and northwestern aspects, while C. taiwanensis forests were less restricted. Chamaecyparis lawsoniana also showed some restriction to the north and northwestern aspects except at higher elevations. Chamaecyparis taiwanensis communities generally occur 200 to 500 m higher than the highest local populations of C. formosensis, while C. formosensis communities are commonly found 200 to 300 m lower than the lowest local populations of C. taiwanensis. In the Pacific Northwest, communities of the Tsuga heterophylla Zone occur from sea level to about 800 m elevation, Mixed Evergreen Zone communities between 500 and 1000 m (except for high elevation plots of the Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax community), and the Abies concolor Zone communities between 1000 and 1500 m elevation (Figure 27). There appear to be only minor differences in the elevations of the communities within a given zone. Landforms of Taiwan communities include mostly sideslope positions. Chamaecyparis taiwanensis occupies mostly topslopes while C. formosensis occupies midslopes. Chamaecyparis formosensis is typically located in areas with impeded drainage, while C. taiwanensis occurs on better drained areas. The summer dry period of the Pacific Northwest causes greater occurrence of Chamaecyparis forests along drainages, with the exception of the Tsuga heterophylla Zone communities which occur in the most mesic climate in the range. Some high elevation stands also show less dependence upon perennial seepage.

Most Taiwan communities are on metasedimentary parent materials, but granitic and limestone types are both common. Soils on metasedimentary parent materials, with slightly podzolized, dry horizons are common in C. taiwanensis communities along with local granitic intrusions. Chamaecyparis formosensis forests occur primarily upon sedimentary or limestone parent materials. In Taiwan, however, soil types do not appear to be a major factor in determining the distribution of Chamaecyparis communities. Chamaecyparis lawsoniana communities occur on parent materials including sedimentary, metasedimentary, metavolcanic, granodioritic, ultramafic, recent alluvium, and sand dunes. As seen in Figure 27, parent materials appear to play a major role in the distribution of Chamaecyparis communities. Other environmental factors appear to segregate the vegetation

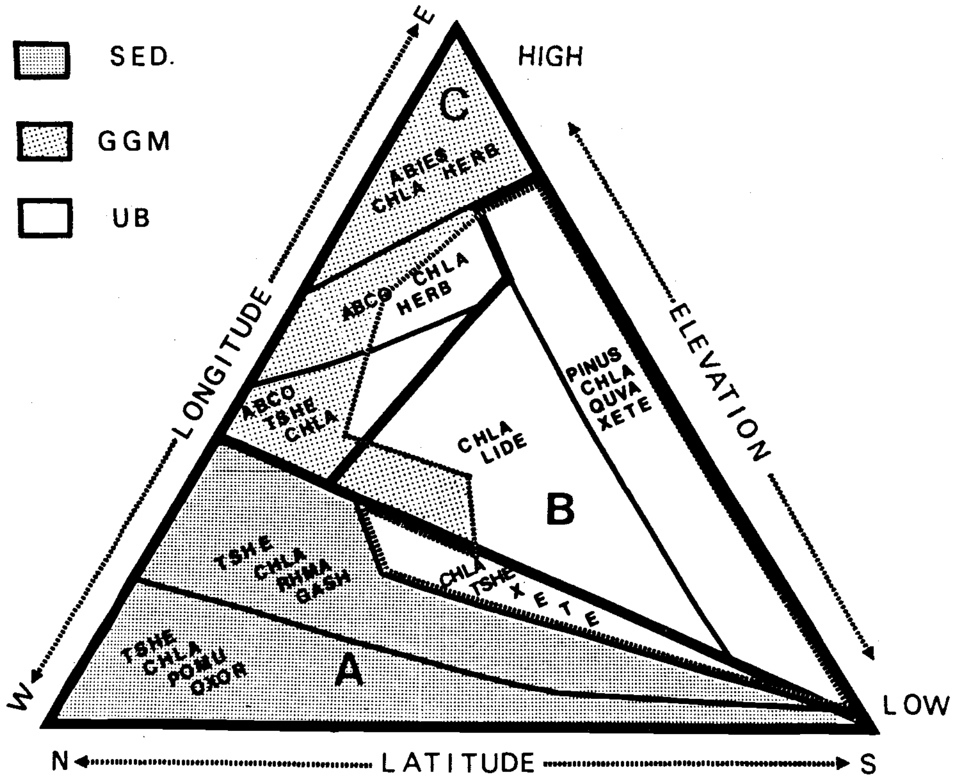

Figure 27. Diagramatic distribution of Chamaecyparis lawsoniana communities (within Zones A =Tsuga heterophylla Zone, B= Mixed Evergreen Zone, and C= Abies concolor Zone) with respect to latitude, elevation, and predominant parent material types (SED = sedimentary, GGM = granitic, gabbroic or metasedimentary, and UB = ultramafic or basic intrusive parent material).

zones well, but it is the parent materials which sharply separate many of the communities.

The relationships of Chamaecyparis lawsoniana communities to several environmental factors are portrayed diagramatically in Figure 27. Here are found three zones defined by elevation and the effects of changes in latitude and longitude. The diagram shows northern coastal Tsuga heterophylla Zone communities which extend to a narrow point in the south (redwood forests). This zone is adjacent to a mid-elevation, mid-latitude Mixed Evergreen Zone as well as to the transitional Abco-Tshe-Chla community of the northeastern high elevation Abies concolor Zone. The diagram places communities adjacent to those they would be expected to occur with naturally in the field while maintaining the natural variation in elevation and parent material types. At the same time it also reveals the close relationships of those communities which occur on one parent material type in different zones. In natural conditions there are also other non-Chamaecyparis forest communities which would fill some of the two dimensional space shown in Figure 27. Such communities, being vegetationally separated from Chamaecyparis forests, would likely be separated on other environmental characteristics that would create a pyramidal diagram in the third dimension.

Chamaecyparis forests of Taiwan and the Pacific Northwest are well stratified, shrubby communities. Hardwood tree species are more important in Taiwan with the most hardwoods in low elevation Chamaecyparis formosensis forests. As a product of the sampling methods, tree density data for most communities show Chamaecyparis to be the dominant tree species. Basal area is predominantly that of conifer species even in stands where hardwoods greatly outnumber the conifers. The total stand basal area is positively correlated with Chamaecyparis density. The density of trees in Taiwan Chamaecyparis forest communities does not vary considerably among communities, except for immature conifers. Chamaecyparis taiwanensis communities all include some immature Chamaecyparis and Tsuga, but Chamaecyparis formosensis communities rarely include reproduction. Tree density of all age classes and all species in Chamaecyparis lawsoniana communities varies considerably among communities.

Highest densities of Chamaecyparis lawsoniana occur upon substrates including ultramafic parent materials. This is probably the result of better adaptation by Chamaecyparis for the ultramafic conditions and the decreased success of competing species there. Total basal area of Chamaecyparis is also greater on ultramafics. Height of trees was only measured in the United States. Chamaecyparis lawsoniana is tallest on non-ultramafic soils. However, estimated volume of Chamaecyparis lawsoniana is greatest in the communities on substrates which are at least partially derived from ultramafic parent materials.

The Taiwan communities are much more diverse than are Pacific Northwest communities, containing twice as many tree species as American communities, although the average number of species per plot for both areas is the same. The amount of variation among communities in shrub diversity is greater in both Taiwan and the Pacific Northwest. Taiwan communities contain three to four times the shrub diversity found in any Pacific Northwest community. In Taiwan, the shrub communities are much more diverse than are the bamboo communities, the result of strong influence of alpine bamboo. The lower elevation Chamaecyparis formosensis/ shrub community just above the species-rich montane rain-forests contains the greatest shrub diversity. There is considerable variation in the shrub diversity of Pacific Northwest Chamaecyparis communities. However, high elevation communities usually have greater diversity. Herb layer diversity in Taiwan is not as markedly greater than that of the Pacific Northwest as for the shrub layer. Again, the diversity within the shrub communities of Taiwan is greater than that of the bamboo communities. Within the Pacific Northwest communities the herb diversity is again the highest in the high elevation communities of the Abies concolor Zone. The herb diversity of the remaining Chamaecyparis lawsoniana communities does not vary markedly.

Depth of the forest floor (litter and humus combined) differs greatly; Pacific Northwest communities have very thin layers (0 to 4 cm) while Taiwan communities have litter layers ranging from 5 to 43 cm thick. In Taiwan, the bamboo communities always have a thicker litter layer than the related shrub community. This is primarily the result of the great litter fall from alpine bamboo. Lower elevations or more southern latitudes have less litter accumulation, due to more rapid decay with warmer temperatures at lower elevations and the combination of higher temperature and summer rains in the south. Since Chamaecyparis formosensis occurs more in southern locations and at lower elevations, its communities typically have thinner litter layers than do the C. taiwanensis communities.

Chamaecyparis reproduction within my communities is correlated with different environmental conditions in the two major study areas. In Taiwan, Chamaecyparis taiwanensis saplings are commonly found close to the major canopy openings, on nurse logs or root balls of downed trees. Chamaecyparis formosensis saplings were not found in most closed forests; it appears less shade tolerant or less competitive than C. taiwanensis. When it is found, it is usually in the forest canopy openings and on disturbed microsites (as if both were necessary for the survival of the germinants). Both species reproduce well on trails, roadsides, and upon landslides in Taiwan's unstable uplands. Chamaecyparis lawsoniana appears to be well adapted to a wide variety of sites, growing with moderate density in burns, clearcuts, and shaded forests. Its success, however, appears to be greatly affected by the presence of strong competitors. My density data indicate that Chamaecyparis lawsoniana is more successful within communities whose parent material is at least partially derived from ultramafic rocks, where competition is somewhat reduced.

There appear to be major differences in the ecologic role of the Chamaecyparis species studied here. All three species, however, can function either as subclimax or climax species depending on the environmental and biological factors which become limiting. Chamaecyparis lawsoniana appears to be the most shade tolerant and the most likely to occur in the final climax forest, at the same time its tolerance is wide enough that it survives and thrives on open sites as well. Chamaecyparis taiwanensis appears to be more shade tolerant than C. formosensis, but again, the difference may be due to competition differences, availability of mineral soils, or the effect of mechanical stresses on the large forest trees in upper and lower elevation stands. Size class distribution diagrams indicate that C. lawsoniana and C. taiwanensis are abundant in multi-age stands and thus capable of maintaining themselves in the communities for future generations. Since immature C. formosensis are rare in closed forests, some other means of maintaining the species in late seral to climax stands must be necessary. I have suggested that both Taiwan Chamaecyparis species continue to occur in the forests because they aggressively colonize disturbed areas and are capable of ages in excess of 2000 years, thus surviving through several generations of their competitors.

Chamaecyparis lawsoniana occupies a wide variety of topoedaphic climax situations. On sedimentary parent materials in the north and along a coastal strip, it is co-climax with Tsuga heterophylla in a mesic climatic habitat type. Inland, south, and at higher elevations and upon a great diversity of parent materials, Chamaecyparis lawsoniana occurs in sub-mesic to mesic communities as a climax species essentially alone in the tree layer or as a co-climax with Abies concolor at higher elevations (Figure 27).

Fire has been a major feature of all Chamaecyparis forests studied. Taiwan Chamaecyparis species have very thin bark as compared to that of Chamaecyparis lawsoniana, and they are much more fire susceptible than is C. lawsoniana. This difference in anatomy is also congruous with their different successional status.

Constancy coefficients between Chamaecyparis communities in Taiwan indicate that adjacent communities in the table are nearly equally similar (Table 16). High species diversity and lack of widespread dominants in all communities yields high similarity, and the communities described here are highly abstract. There is much more variation in the amount of similarity between the eight Chamaecyparis lawsoniana communities. Similarity is usually higher between communities on similar parent materials than between communities on different parent materials within the same vegetation zone.

A floristic comparison between the two study areas shows 273 species of vascular plants in C. lawsoniana forests and 267 species in Taiwan Chamaecyparis forests. There are 60 plant families in the U.S. and 71 in Taiwan Chamaecyparis forests. Thirty-three families are common to both areas. There are also 33 genera common to both areas, and Ericaceae and Liliaceae are among the most important families of both areas. Rubus and Vaccinium are the most common genera of both areas.

The Chamaecyparis species that I have studied are economically important, with the potential for production under sustained yield programs given the proper emphasis on problem research. Each species has its own set of problems in management, including heart rot of Taiwan species, root rot of C. lawsoniana, regeneration shortages in Taiwan, and poor harvesting techniques in both areas, to cite only a few.

The species are already economically important, and there is a ready market for the product. Research has yielded little relief of the fungal problems mentioned above, but there still appears to be some hope that resistant strains of the trees can be found or developed. Until such a time, it would seem wise to manage the few remaining stands as if we intended to maintain the species as an economically important entity. Large tracts of C. lawsoniana have already been placed into Research Natural Areas, but parts of these are being rapidly invaded by root rot. The pattern of root rot invasion in most cases however, appears to be through introduction of spores from equipment on forest roads. Thus management techniques need to reduce innoculum through this route.

The species studied seem to be rapid colonizers of disturbed areas, but often they are not strong competitors. Thus some steps will have to be taken in the area of bamboo or shrub abatement in Taiwan. In the United States C. lawsoniana forests it would seem logical to utilize landforms and parent material types to their best advantage in artificial regeneration. In the case of C. lawsoniana, with the constant threat of root rot, it is obvious that such steps now would only be economically feasible in areas physiographically protected from obvious routes of contamination by spores. Further studies need to be made in Taiwan to determine the proper habitat needs of Chamaecyparis regeneration or for artificial plantations.

The decrease in supply will ultimately control the management of the genus in both Taiwan and the U.S. I do not feel that any of the species is in immediate danger of extinction since there are large stands that will remain economically inaccessible for many decades.

This inaccessibility has already slowed the tide of harvest in Taiwan. It will also help in maintaining a constant supply of stock in the U.S. since root rot may take a long time to reach roadless areas.

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APPENDIX

APPENDIX I

DEFINITIONS OF ZONE AND COMMUNITY SHORT NAMES USED IN THIS THESIS

Zones

1. Abco Zone = Abies concolor Zone
2. Tshe Zone = Tsuga heterophylla Zone
3. Pisi Zone = Picea sitchensis Zone

Communities

1. Pinus-Chla/Quva/Xete community = Pinus-Chamaecyparis lawsoniana/Quercus vaccinifolia/Xerophyllum tenax community
2. Chla/Lide community = Chamaecyparis lawsoniana/Lithocarpus densiflora community
3. Chla-Tshe/Xete community = Chamaecyparis lawsoniana-Tsuga heterophylla/Xerophyllum tenax community
4. Tshe-Chla/Rhma-Gash community = Tsuga heterophylla-Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon community
5. Tshe-Chla/Pomu-Oxor community = Tsuga heterophylla-Chamaecyparis lawsoniana/Polystichum munitum-Oxalis oregana community
6. Abco-Tshe-Chla community = Abies concolor-Tsuga heterophylla-Chamaecyparis lawsoniana community
7. Abco-Chla/herb community = Abies concolor-Chamaecyparis lawsoniana/herb community
8. Abies-Chla/herb community = Abies-Chamaecyparis lawsoniana/herb community
9. Chla-Pisi/dune community = Chamaecyparis lawsoniana-Picea sitchensis/sand dune community
10. Chla-Pisi/Blacklock community = Chamaecyparis lawsoniana-Picea sitchensis/Blacklock soil community
11. Pisi-Chla/sandstone community = Picea sitchensis-Chamaecyparis lawsoniana/Eocene sandstone community
12. Sese-Chla/terrace community = Sequoia sempervirens-Chamaecyparis lawsoniana/alluvial terrace community
13. Chla-Psme/terrace community = Chamaecyparis lawsoniana-Pseudotsuga menziesii/foothill alluvial terrace community
14. Chla/ultramafic meadow community = Chamaecyparis lawsoniana/ultramafic meadow community
15. Chta/shrub community = Chamaecyparis taiwanensis/shrub community

(continued on next page)

16. Chta/bamboo community = Chamaecyparis taiwanensis/Pleioblastus niitakayamensis community
17. Chfo/bamboo community = Chamaecyparis formosensis/Pleioblastus niitakayamensis community
18. Chfo/shrub community = Chamaecyparis formosensis/shrub community
19. Chta-Chfo/bamboo community = mixed Chamaecyparis taiwanensis-Chamaecyparis formosensis/Pleioblastus niitakayamensis community