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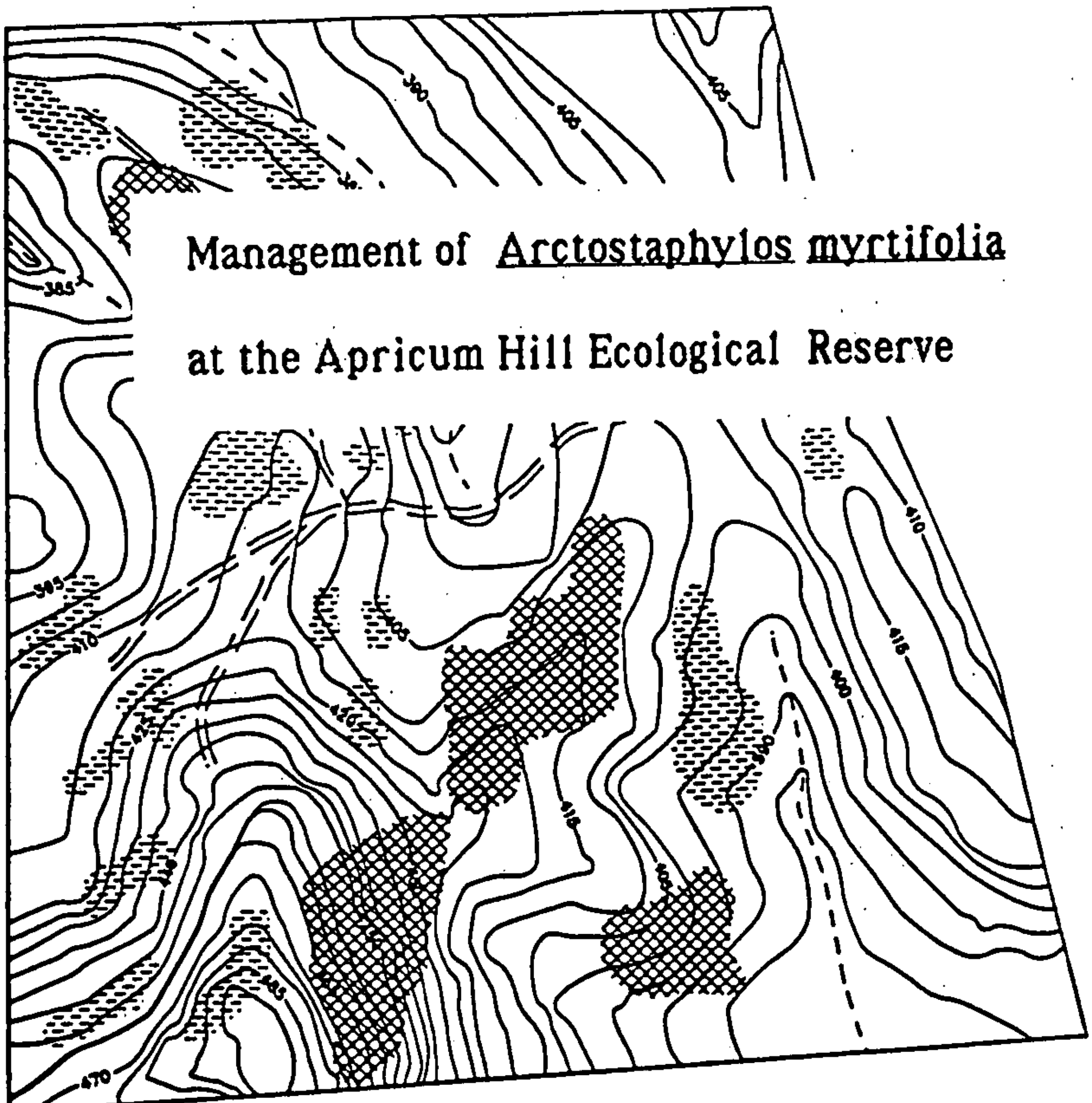
Management of <u>Arctostaphylos myrtifolia</u> at the Apricum Hill Ecological Reserve



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Management of *Arctostaphylos myrtifolia* Parry at the Apricum Hill Ecological Reserve

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Soils:

Results of the present study provide strong evidence that A. myrtifolia is an edaphic endemic and confirm earlier hypotheses concerning its peculiar edaphic relationships. A strong correlation exists between the distribution of A. myrtifolia and various edaphic factors which may exclude neighboring species. Low fertility and pH levels and high concentrations of aluminum were generally found to correspond with the occurrence of A. myrtifolia along an edaphic gradient. Regarding soils and erosion on the Apricum Hill Ecological Reserve no specific management is needed.

Fire and Regeneration:

The genus Arctostaphylos has been the subject of much research. Virtually all members of the genus possess specific mechanisms for recovery after fire. As an obligate seeder, A. myrtifolia is killed outright by fire and stand regeneration is dependent on seedling establishment. Any long-term management of the Reserve should consider the regeneration capabilities of A. myrtifolia especially with regard to fire. The establishment of a specific fire policy concerning both wild and prescribed fires on the Reserve is essential.

During the course of this study, A. myrtifolia was found to respond unlike other members of the genus studied to date. Seeds do not respond to stimulatory treatments normally successful in promoting germination in other chaparral species. Response after disturbance appears variable and unpredictable. In the field, good germination in response to fire has been observed and can been seen at several sites with documented fire histories. However, we do not currently recommend any prescribed burning of populations of A. myrtifolia on the Reserve until additional experiments can be conducted.

Fungal Pathogens:

We are very concerned about the sudden death of large stands of A. myrtifolia throughout its range. Little is known about the die-back except that it may be caused at least secondarily by a fungal pathogen. While the disease has not inflicted heavy losses on the Reserve, individual plants show symptoms of die-back and a policy needs to be established in the event that this threat should increase.

A prioritized summary of our recommendations for the management of A. myrtifolia and the Apricum Hill Ecological Reserve follows:

1. Until more is known about the reproductive capabilities of A. myrtifolia, stands on the Reserve should be left alone. No controlled burning of the Reserve is recommended at this time.

2. Private land owners should be found who are willing to allow the burning and monitoring of stands of A. myrtifolia on their land. More data on the reproduction of this species and its response to fire is essential if it is to be managed effectively.

3. Further research into the cause of the sudden dying off of entire stands of A. myrtifolia is needed. Sites exhibiting various stages of die back should be studied, manipulated and monitored in order to understand what steps can be taken to prevent its spread and to prevent the destruction of populations of A. myrtifolia at Apricum Hill.

4. Additional land should be purchased supporting separate populations of A. myrtifolia on a range of soil properties. The acquisition of several sites with numerous populations of A. myrtifolia will ensure the preservation of a large gene pool of this highly variable species as well as reduce the risk of losing the only protected populations to sudden die-off.

5. A fire management plan should be developed in the event of a wildfire. While no prescribed burning is currently recommended, periodic burning may need to be incorporated in a management plan the future. Prescribed burns should be conducted only in the late summer or early fall when conditions are dry. We recommend that fires be limited to less than 20 percent of the site at any one time. We also recommend enlarging the existing site as small reserves are difficult to manage with fire.

6. Studies should be initiated to determine what factors influence the germination of A. myrtifolia and how this species differs from others within the genus. Additional studies into the growth requirements and soil-plant interactions of A. myrtifolia should also be initiated.

7. A program of rubbish removal and site clean-up should be initiated for the Reserve.

ADDENDUM (January 10, 1989)

Regarding the above recommendations, certain studies have already been initiated since this report was first completed. We have been attempting to germinate seeds of Arctostaphylos myrtifolia in the laboratory using standard techniques. Seeds were subjected to stratification with heat and cold treatments, scarification by abrading seed coats, soaking in charate, gibberellic acid or pure water and in a variety of combinations. To date, no seedlings of A. myrtifolia have resulted. Seed bank studies and direct sowing of fresh seeds in soil have also failed to yield seedlings of this species. We are currently attempting to germinate (on filter paper) one year old seeds sifted from the soil but have had no success thus far.

Interestingly, seeds of A. viscida and Adenostoma fasciculatum collected from the Ione soils have exhibited much poorer rates of germination when compared to seeds collected from other parts of the state. We can offer no specific explanation for this other than race differences for plants occurring on soils derived from the Ione Formation.

We have begun conducting comparative growth studies using seeds of the dominant species collected from Ione and the same species collected off of the Ione soils. Seedlings grown in sand culture will be treated with various concentrations of aluminum. To date, only seedlings of Quercus wislizenii have been generated in sufficient quantity to initiate this study.

On November 7, 1988, the CDF conducted a prescribed burn on private land located on the west side of Buena Vista Rd. between Highway 88 and the Jackson Valley Rd. intersection. We installed permanent plots prior to the burn within stands supporting A. myrtifolia and A. viscida exhibiting various signs of die-back. We will be monitoring these plots closely and hope to gain valuble data on the regeneration of these stands. Another burn is planned for the property in June, 1989. Regarding these burns, contact Jim Smith of the Resources Agency, Dept. of Forestry and Fire Protection, Camino, CA (916) 644-2345.

Dave Adams, a forest pathologist for the CDF, has been investigating the cause of the die-back of A. myrtifolia and is attempting to identify the organisms involved. In addition, he has aerial color and infra-red photos of stands of A. myrtifolia. He can be reached at (916) 322-0126.

Bob Lehman of the BLM (Folsom office) has jurisdiction over a piece of land supporting A. myrtifolia along Buena Vista Rd. near Comanche Resevoir. He is interested in learning more about the management and protection of A. myrtifolia and is very willing to have research conducted on this site. He can be contacted at (916) 985-4475.

These agencies have demonstrated a great deal of interest and willingness in promoting research in maintaining and managing populations of A. myrtifolia. We urge that these agencies be contacted to pool resources and to avoid duplication of effort. This offers a unique opportunity to conduct scientific research geared towards practical application and the developing of realistic management policies concerning A. myrtifolia.

INTRODUCTION

The region around Ione in Amador County, California, consists of a unique landscape. Many rare and endangered plant species can be found situated on the Ione Formation, a geologic formation unusual in the continental United States. The land there has served many purposes since it was first settled in 1848. Farming, grazing and mining operations have irreversibly altered the landscape and with it, disrupted numerous plant and animal communities. This process continues today with the added pressures of increased land development and off-road vehicle use. We will never know how many plant species have already disappeared as a result of these activities.

The acquisition of Apricum Hill and its subsequent designation as one of the California Department of Fish and Game's Ecological Reserves has assured that at least one representative sample of this unique landscape will be preserved. The Reserve supports an especially large population of the state-listed rare and endangered Ione buckwheat (*Eriogonum apricum* var. *apricum*), several stands of Ione manzanita (*Arctostaphylos myrtifolia*), as well as several other species either restricted to or with disjunct populations in the Ione region.

Because *Arctostaphylos myrtifolia* is an obligate seeder, reproducing only by seed and lacking the ability to crown sprout, it depends entirely on seeds stored in the soil to regenerate after a disturbance. As is often the case with fire-adapted chaparral plant species, seedlings of *A. myrtifolia* are only found on sites disturbed by fire, clearing or road grading operations. Seedlings of *A. myrtifolia* are not known to occur within mature, undisturbed stands.

Arctostaphylos myrtifolia appears sensitive to habitat disturbance and therefore highly endangered. Elsewhere in the vicinity of Apricum Hill, entire stands of A. myrtifolia, for example, died quite suddenly in the early 1980's, perhaps due to pathogenic fungi. No regeneration of A. myrtifolia has been observed on these sites. Other threats to populations of this species are numerous and include those of human and non-human nature. Objectives of this study were to investigate the ecology and reproductive potential of A. myrtifolia, in the interest of preserving its habitat.

Effective management of "natural areas" has become a central issue in plant and animal conservation. The landscape associated with human populations is often modified in such a way that previously natural processes are eliminated or controlled. Managing the habitat of rare taxa requires an understanding of the biology of those species and their interactions within the community in which they exist.

I. INVENTORY AND TESTING RESULTS

A. General Remarks

The Apricum Hill Ecological Reserve supports a vegetation consisting predominantly of low-growing chaparral shrubs. Species diversity is relatively low with only 18 woody and suffrutescent plant species occurring on the site (Table 1). Vegetation includes one small grassland site; five stands of low shrubs (to five decimeters in height); several extensive stands of taller species (from three to four meters tall), which dominate the majority of the Reserve; and four stands of trees (to ten meters in height).

While chaparral communities do not usually support a very dense cryptogamic flora, that associated with the vegetation in the Ione region is both remarkably diverse and rich. Lichen species collected at Apricum Hill and a second site near the junction of Lambert and Carbondale Road have been listed (Tables 2 and 3). The fungal flora is equally remarkable, being rich in species not normally associated with chaparral vegetation (Table 4). One possibly undescribed species of <u>Leccinum</u> was found in large numbers on the Apricum Hill Reserve in the spring of 1987.

B. Species Present

The Ione region is well known for supporting many restricted or disjunct plant species (Howell, 1955; Gankin, 1963; Gankin and Major, 1964). The Apricum Hill Reserve supports many of these species. <u>Arctostaphylos</u> <u>myrtifolia</u> occurs in several small, isolated stands within the Reserve. These stands are relatively pure and occur on otherwise bare lateritic crusts. Also, due to

Table 1

List of Woody and Suffrutescent
Plant Species found
at Apricum Hill

Anacardiaceae
- Toxicodendron diversilobum (poison oak)

Cistaceae
- Helianthemum suffrutescens (rock rose)

Compositae
- Baccharis pilularis ssp. consanguinea (coyote brush)

Ericaceae
- Arctostaphylos myrtifolia (Ione manzanita)
- Arctostaphylos viscida (Whiteleaf manzanita)
- Arctostaphylos manzanita (Parry manzanita)

Fagaceae
- Quercus wislizenii (interior live oak)
- Quercus wislizenii var. frutescens (shrub live oak)
- Quercus douglasii (blue oak)

Hydrophyllaceae
- Eriodictyon californicum (Yerba santa)

Leguminosae
- Lotus scoparius (bird's foot treefoil)

Pinaceae
- Pinus sabiniana (gray pine, [formerly digger pine])

Rhamnaceae
- Ceanothus cuneatus (buck brush)
- Ceanothus tomentosus (California lilac)

Rosaceae
- Adenostoma fasciculatum (chamise)
- Heteromeles arbutifolia (toyon)
- Horkelia parryi (no common name)

Scrophulariacea
- Mimulus longiflorus (monkey flower)
- Mimulus viscidus (monkey flower)

Table 2

List of Lichen Species
found at Apricum Hill*

Cladonia chlorophaea

Cladonia ecmocyna

Cladonia rei

Cladonia cervicornis ssp. *vericillata*

Diploschistes scrüposus

Diploschistes scruposus var. *parasiticus*

*identification by Sam Hammer, Department of Biology, San Francisco State University

Table 3

List of Lichen Species
found at Lambert Road Site*

Cladonia gracilis ssp. *turbinata*

Diploschistes actinostomus

Ramalina farinacea

Xanthoparmelia cumberlandia

*identification by Sam Hammer, Department of Biology, San Francisco State University

Table 4

List of Fungi found at Apricum Hill*

Amanita aspera

Amanita constricta

Inocybe geophylla

Laccaria laccata

Leccinum sp. sp. nov.?

Omphalina ericetorum (Basidiomycetous lichen)

Russula fragilis

Russula spp.

*identification by Dr. Harry D. Thiers, Department of Biology, San Francisco State University its prostrate habit and rusty-green hue, A. myrtifolia creates a stark contrast to the much taller neighboring vegetation. Due to mining activities, land development and off-road vehicle use, the habitat of this manzanita is seriously threatened. Arctostaphylos myrtifolia is on the California Native Plant Society's (CNPS) List 1B of plants rare and endangered in California. Although locally common, A. myrtifolia has been deemed vulnerable to extinction due to its sensitivity to habitat disturbance and the limited number of sites on which it occurs.

Eriogonum apricum var. apricum, the Ione Buckwheat, is restricted entirely to barren outcrops of the Ione Formation. It occurs on extremely infertile eroded slopes supporting little else (Howell, 1955). This subspecies is limited to open eluviated sites in the vicinity of Apricum Hill. Eriogonum apricum var. apricum is listed as Endangered by the State of California and is also on the California Native Plant Society's (CNPS) List 1B of rare and endangered plants. Apricum Hill supports one of the larger populations of E. apricum var. apricum yet discovered.

Several other restricted or disjunct plant species can be found at Apricum Hill. While these are not found solely on the Reserve, their presence adds to its value and they are worthy of management consideration. Perhaps a dozen individuals of Helianthemum suffrutescens can be found near the western border of the Reserve. Helianthemum suffrutescens is on the CNPS List 1B. Horkelia parryi (Potentilla parryi) occurs in several moist, low-lying regions adjacent to Jackson Valley Road and the southern end of the grassland. At least three individuals of

Ceanothus tomentosus have been located within the boundaries of the Reserve. Additional individuals can be found in a stand consisting of large plants and seedlings occur just across the north fence, approximately 25 meters from the northwest corner on top of Apricum Hill, near a large, open soil pit.

Seedlings of *Mimulus viscidus* appeared in seed banks collected from two different regions of the Reserve but have not as yet been observed in the field. Dr. David Thompson of the Rancho Santa Ana Botanical Garden believes that there may be an undescribed subspecies of *Mimulus viscidus* in the vicinity of Apricum Hill (pers. comm.) and is currently investigating its taxonomy. Herbarium sheets of *M. viscidus* grown in soil collected from Apricum Hill in our study are on file at Rancho Santa Ana Botanic Garden.

C. Habitat Features

Vegetation at the Apricum Hill Reserve is dominated by low-growing sclerophyllous shrubs. The chaparral is composed of relatively few species and several stands are dominated by a single species. The distribution of some species appears to correspond with topography, probably due to its influence on soil formation, erosion, soil moisture, or other factors. Vegetation in ravines and low-lying areas is typically taller and more dense. Species diversity is often greater in ravines and at Apricum Hill the only tree species occur in such locations. Several species, most notably *Arctostaphylos myrtifolia* and *Eriogonum apricum* var. *apricum*, tend to occur in pure stands that are quite distinct from the surrounding vegetation. Both tend to occur on eroded sites with thin, barren, extremely infertile soils. Locations of all woody species as well as herbaceous species of restricted occurrence have been mapped (Appendices 10-16).

Table 5 lists the main woody species found on the Reserve, the percent frequency with which each was encountered and their relative frequencies. *Arctostaphylos viscida* is by far the most dominant species, found on over 93 percent of the Reserve; this species makes up about one-third of the vegetation. *Arctostaphylos myrtifolia* is the second most frequently encountered species making up nearly 19 percent of the vegetation occurring on the Reserve. *Adenostoma fasciculatum* comprises 16.5% of the vegetation followed by *Quercus wislizenii* var. *frutescens* (14%), and *Q. wislizenii* (12%). These five species comprise 94.6 percent of the Reserve. Methods used in obtaining frequency data

Table 5

Frequency and Relative Frequency of Woody Plant Species at Apricum Hill

Species	Percent Frequency	Relative Frequency
Arctostaphylos viscida	93.5	33.2
Arctostaphylos myrtifolia	53.2	18.9
Adenostoma fasciculatum	46.3	16.5
Quercus wislizenii var. *frutescens*	39.4	14.0
Quercus wislizenii	33.8	12.0
Pinus sabiniana	4.8	1.7
Arctostaphylos manzanita	4.3	1.5
Heteromeles arbutifolia	1.7	0.6
Baccharis pilularis ssp. *consanguinea*	1.7	0.6
Ceanothus tomentosus	0.9	0.3
Mimulus longiflorus	0.9	0.3
Ceanothus cuneatus	0.4	0.2
Quercus douglasii	0.4	0.2
		100

are described in Appendix 1.

D. Physical Features

The Apricum Hill Ecological Reserve covers 37.5 acres of relatively uneven terrain between 375 and 490 feet above sea level. A topographical map of the Reserve was submitted with this report.

Soils of the Ione region have been of great interest to geologists for nearly 100 years. Clays of the Ione Formation have long been exploited for their excellent ceramic qualities, as have its quartz sands due to their glassmaking properties. Pockets of lignite were also discovered in the Jackson-Carbondale Quadrangle and are still being mined off Buena Vista Road. The Ione Formation appears at the surface as eroded outcrops for 340 km along the Sierra Nevada foothills, ranging from the town of Oroville near Chico to Friant in the vicinity of Fresno. The soils of these outcrops are considered exhumed oxisols (Singer and Nkedi-Kizza, 1980) and are composed of kaolinitic clay minerals, quartz sands and indurated ironstone. The formation is rich in oxides of iron and aluminum and its minerals are in at least their second stage of weathering (Pask and Turner, 1952).

The Ione Formation is believed to have formed during the Eocene (38-54 million years before present) on or near the surface as highly mineralized quartz and clays. These minerals were deposited as sediments in deltas along the shore of a rapidly retreating inland sea (Pask and Turner, 1952). The highly weathered nature of these sediments indicates that they were formed in a tropical or subtropical climate. Such red, ferruginous lateritic soils as these are characteristic of tropical regions. Formation of these soils under tropical conditions is supported by the tropical and subtropical flora identified from fossils in Tertiary gravels of the Sierra (Allen, 1928).

After deposition, the Ione Formation was covered first by rhyolite tuffs erupted from the volcanic crests of the Sierra during the lower Miocene and washed into the deltas. Andesite tuffs were later deposited on top as volcanic ash (Pask and Turner, 1952). Continued uplifting of the Sierran block has resulted in the erosion of these over-lying layers. In the Ione and Buena Vista areas, particularly large sections of the Ione Formation have been exposed, creating a unique geological landscape.

E. Cultural Features

The area surrounding the Apricum Hill Reserve supports a more of less contiguous vegetation composed of chaparral and oak woodland with occasional pines interspersed. The eastern edge of the Reserve borders Jackson Valley Road and adjacent to the southwest corner is an open pit clay mine no longer in operation. The site is fenced off with barbed wire and may be accessed by a locked gate in the middle of the Reserve along Jackson Valley Road. Signs are posted on the fence identifying the site as an ecological reserve.

An east-west road has been cut roughly through the middle of the Reserve leading to what was presumably a test dig on the north side of Apricum Hill. Vegetation at this location has been damaged considerably by digging operations. Adjacent to the road cut is a large stand of Eriogonum apricum var. apricum which may have become established on soil dumped from the road cut. Elsewhere on the Reserve, tire ruts can be found through the vegetation but in these locations the chaparral is regenerating. Adjacent to Jackson Valley Road, vegetation on the Reserve has been severely disturbed by road grading activities. In several locations piles of asphalt, tin cans, bottles and rubbish have been dumped. There are no such dump sites within stands of Arctostaphylos myrtifolia. Several plant species occur on these disturbed sites that are not found elsewhere within the Reserve. These include Baccharis pilularis ssp. consanguinea, Eriodictyon californicum, and Mimulus (Diplacus) longiflorus. All are native to the region and frequently colonize disturbed soils.

II. SPECIES MANAGEMENT GOALS

A. Featured Species

Although several restricted species occur at the Apricum Hill Reserve, only Arctostaphylos myrtifolia is considered in the present study. Neighboring vegetation, soil type, climate, and how they affect the distribution, growth, and reproduction of A. myrtifolia are the primary concerns of this report. Still, the presence of any and all restricted plant species should be taken into consideration when decisions about management objectives of the Reserve are made.

B. Arctostaphylos myrtifolia

1. Background

1.1 Taxonomy

Arctostaphylos myrtifolia belongs to the section Schizococcus, one of the few distinct groups within the genus Arctostaphylos (Eastwood, 1937). Species belonging to this section differ from other members of the genus by producing fruits with a thin pericarp that readily splits into nutlets. Members of Schizococcus possess many characters that are thought to be primitive for the genus as a whole. Other species currently recognized as belonging to Schizococcus are: A. nummularia, found in the pygmy forest of Mendocino County; A. sensitiva, which occurs on Mt. Tamalpais and Bolinas Ridge in Marin County and the Santa Cruz Mountains; and A. nissenana, which is found near Placerville in El Dorado County. Arctostaphylos nissenana is on the CNPS List 4 (watch list) of plants susceptible to endangerment. All members of this section are narrow endemics, being restricted to poor, acidic or infertile soils and occurring in small, isolated stands on open sites.

1.2 Distribution

Arctostaphylos myrtifolia (Ericaceae) is limited to bare outcrops of the Ione Formation or its sediments with a few disjunct populations on similarly infertile soils near San Andreas in Calaveras County (Gankin, 1957; 1963; Gankin and Major, 1964). The Ione manzanita is limited in distribution; it exists only in relatively pure populations in Amador and Calaveras Counties at elevations between 60 and 580 meters with the largest populations occurring between 90 and 280 meters in elevation.

1.3 Population status

Vegetation of the Ione region occurs in distinct zones or patterns. Changes in species composition are often quite abrupt and transitions may be well-defined by obvious differences in the growth habits of adjacent species (Appendix 2). This abrupt transition in the vegetation is especially evident where A. myrtifolia is found. Arctostaphylos myrtifolia occurs on low hilltops and exposed sites in isolated populations separated by extensive stands of A. viscida. The interface between these two manzanitas is accentuated by their distinct morphologies. Arctostaphylos myrtifolia is a prostrate shrub reaching five decimeters in height with narrow, lanceolate, brownish leaves. Arctostaphylos viscida is a robust, profusely branching shrub reaching three to four meters in height and having much larger, rounded and glaucous leaves.

Stands of A. myrtifolia are mostly pure with only an occasional stunted individual of A. viscida or Q. wislizenii var. frutescens. Arctostaphylos myrtifolia may, in some locations, also occur in the understory of A. viscida. These are virtually always sparsely foliated, "leggy" individuals and may be much taller than those in pure stands. As one gets farther away from the A. myrtifolia/A. viscida transition zone a greater number of species may be found. In addition, the vegetation becomes taller and more dense. These dense stands, dominated by A. viscida, Adenostoma fasciculatum, and Quercus wislizenii var. frutescens, may be penetrated only with great difficulty. Where high amounts of organic matter have accumulated, soils may develop that are sufficiently deep to support individuals or stands of Pinus sabiniana, Quercus wislizenii and Q. douglasii. A thinning out of the chaparral normally occurs underneath stands of these trees.

Cover data was compiled for "pure" stands of A. myrtifolia, A. viscida, Quercus wislizenii var. frutescens, as well as for mixed stands at Apricum Hill (Appendix 9). Fifteen plots within each stand class were randomly selected. The number of live and dead individuals of each species were counted and the percent cover estimated. From these data relative cover and density per square meter for each species in each stand class were calculated (Table 6).

As shown, stands classified as A. myrtifolia have an absolute cover of 73.7% A. myrtifolia, and 25.7% bare ground with a few individuals of A. viscida and Q. wislizenii var. frutescens

Table 6

Comparative Coverage and Frequency Data for Major Plant Species in Four Distinct Vegetation Zones at Apricum Hill

vegetation zones	species				
	Arcto. myrtifolia	Arcto. viscida	Chamise	Quercus	bare ground
Arctostaphylos myrtifolia					
density/m^2 live	3.5	0.07	0	0.07	
density/m^2 dead	0.7	0	0	0	
% absolute cover	73.7	0.33	0	0.33	25.7
% relative cover	99.0	0.004	0	0.004	
Arctostaphylos viscida					
density/m^2 live	0.1	2.3	0	0.04	
density/m^2 dead	0.07	0.3	0	0	
% absolute cover	0.93	92.5	0	0.07	6.5
% relative cover	0.01	98.9	0	0.001	
mixed vegetation					
density/m^2 live	0	0.43	0.07	0.13	
density/m^2 dead	0	0.33	0.23	0	
% absolute cover	0	35.6	28.1	29.2	7.2
% relative cover	0	38.3	30.3	31.4	
Quercus wislizenii					
density/m^2 live	0	0.04	0.03	0.24	
density/m^2 dead	0	0.01	0.04	0.004	
% absolute cover	0	4.8	5.7	83.8	5.9
% relative cover	0	5.1	6.0	89.0	

making up the difference. In terms of relative plant cover, in these stands, A. myrtifolia composes 99% of all species present. In these plots, A. myrtifolia occurs at an average density of 3.5 live plants and 0.7 dead plants per square meter. Stands classified as A. viscida were estimated to have an absolute cover of 92.5% A. viscida, 6.5% bare ground and less than 1% A. myrtifolia. Relative cover is clearly dominated by A. viscida which represents 98.9% of all species in such stands. At these sites, A. viscida occurs at a density of 2.3 live and 0.3 dead individuals per square meter. It is interesting to note that live and dead individuals of A. myrtifolia occurred in these plots at equally low frequencies.

Absolute cover within mixed stands was estimated at 35.6% A. viscida, 29.2% Quercus, 28.1% Adenostoma fasciculatum and 7.2% bare ground. In mixed stands relative cover for A. viscida (38.3%), Quercus (31.4%), and Adenostoma (30.3%) is evenly divided between the three species present. However, A. viscida occurs in these stands with the greatest density for both live and dead plants. Quercus wislizenii var. frutescens is the second most dense species followed by Adenostoma fasciculatum.

Absolute cover of oak stands was estimated at 83.8% Quercus, 5.9% bare ground, 5.7% Adenostoma, and 4.8% A. viscida. Relative cover in oak stands shows approximately the same proportions with 89% of all species being Quercus, 6% Adenostoma and 5.1% A. viscida. Live individuals of Quercus were found to occur at a density of 0.24 plants per square meter and dead plants at an average of 0.004 plants per square meter. There was a slightly greater density for dead plants of Adenostoma than live with 0.04

and 0.03 plants per square meter respectively. All coverage and density data collected from permanent plots on the Apricum Hill Reserve are included in Appendices 21-24.

1.4 Limiting factors: soil zonation patterns

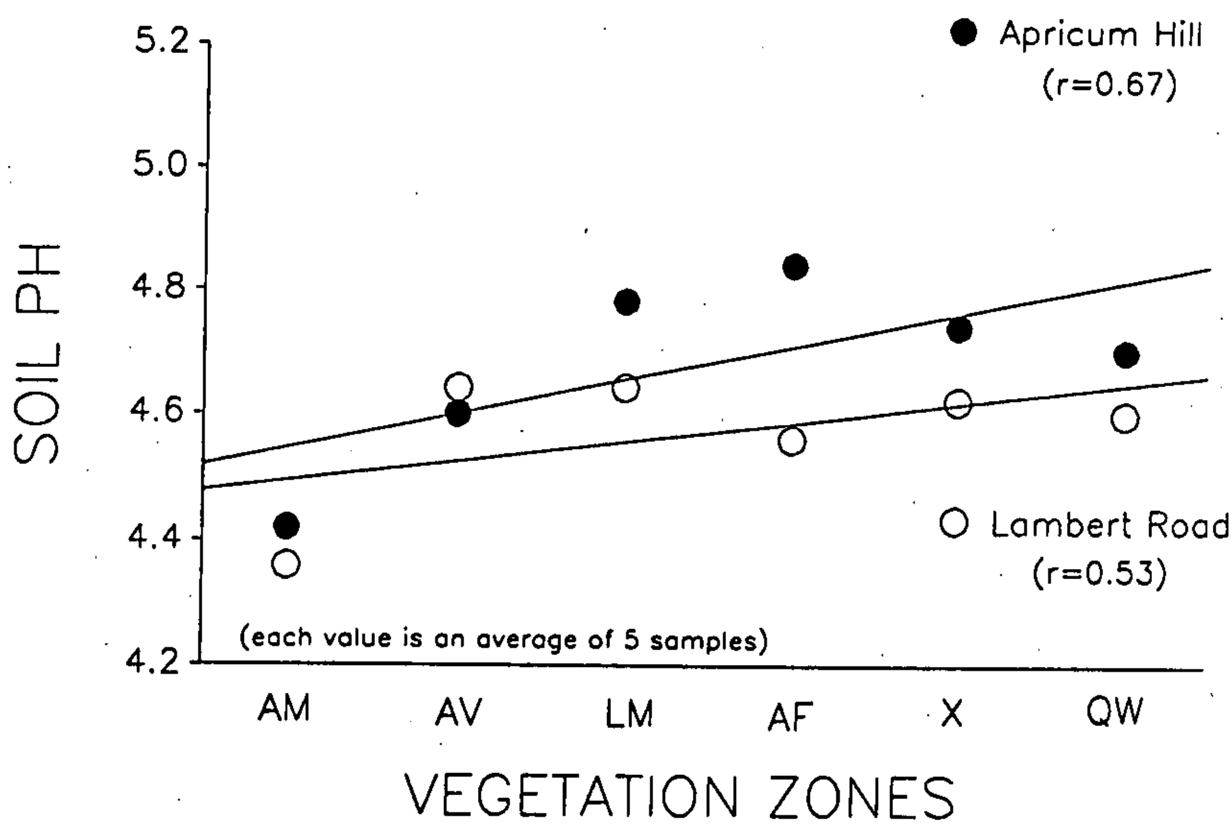
1.4.1 soil zones

Because A. myrtifolia and A. viscida occur in a variety of similar microclimates, that is, on slopes of all exposures and various degrees of steepness, above-ground environmental factors can be ruled out as a cause of the transition between them. Instead, edaphic features appear more likely responsible for the abrupt transition between these two manzanitas. Soils of the Ione Formation possess unique mineral properties (Gankin and Major, 1964; Singer and Nkedi-Kizza, 1980), which alone or in combination may exert a great influence on the distribution of plant species. Soils derived from the Ione Formation are composed primarily of kaolinitic clay minerals, quartz sands and plinthite, the latter of which hardens irreversibly into ironstone upon exposure at the surface.

Mineral composition within the root zone of these soils is highly variable, creating a mosaic of soils with possibly abrupt transitions in properties. Gankin and Major (1964) attributed the sharp transitions in vegetation to genetic differences between species in their ability to grow on soils of varying properties. They concluded that A. myrtifolia is better able to "tolerate" edaphic conditions found in the Ione soils than A. viscida, and can therefore exist on the "worst" or least developed soils which exclude most other species.

Where the Ione Formation is exposed and intact, that is, unaltered, soils are hard, rocky and barren. Concentrations of aluminum are high and pH is lower on such exposed soils (than, for example, in alluvial soils modified by additions of clays and organic matter). Soils of this type are most evident on slopes and hilltops and it is in such locations that one finds pure stands of *A. myrtifolia*. *Arctostaphylos viscida*, on the other hand, appears on somewhat deeper, more developed soils. Soils supporting this species exhibit a more neutral pH and lower concentrations of aluminum. This trend towards more moderate soil properties progresses as one continues into mixed stands and oak woodland. At these latter sites, the vegetation itself may exert a significant modifying influence on soil properties by depositing considerable amounts of organic matter which might mediate whatever effects the mineral soil has on plant growth.

In an attempt to correlate the observed vegetational gradient with changes in the edaphic environment, soil samples were taken (see Appendix 7). Gankin and Major (1964) suggested that aluminum in the soil is a likely cause of this gradient but made no measurements. Because pH is strongly correlated with the solubility of aluminum as well as nutrient availability, our research focused primarily on pH and the concentration of soluble aluminum. Figure 1 shows pH values for soils collected at the Apricum Hill Reserve and Lambert Road sites along this vegetational gradient. These values demonstrate a similar trend at both sites from highly acid soils underneath pure stands of *A. myrtifolia* to those of a slightly more neutral pH as one progresses into oak woodland.



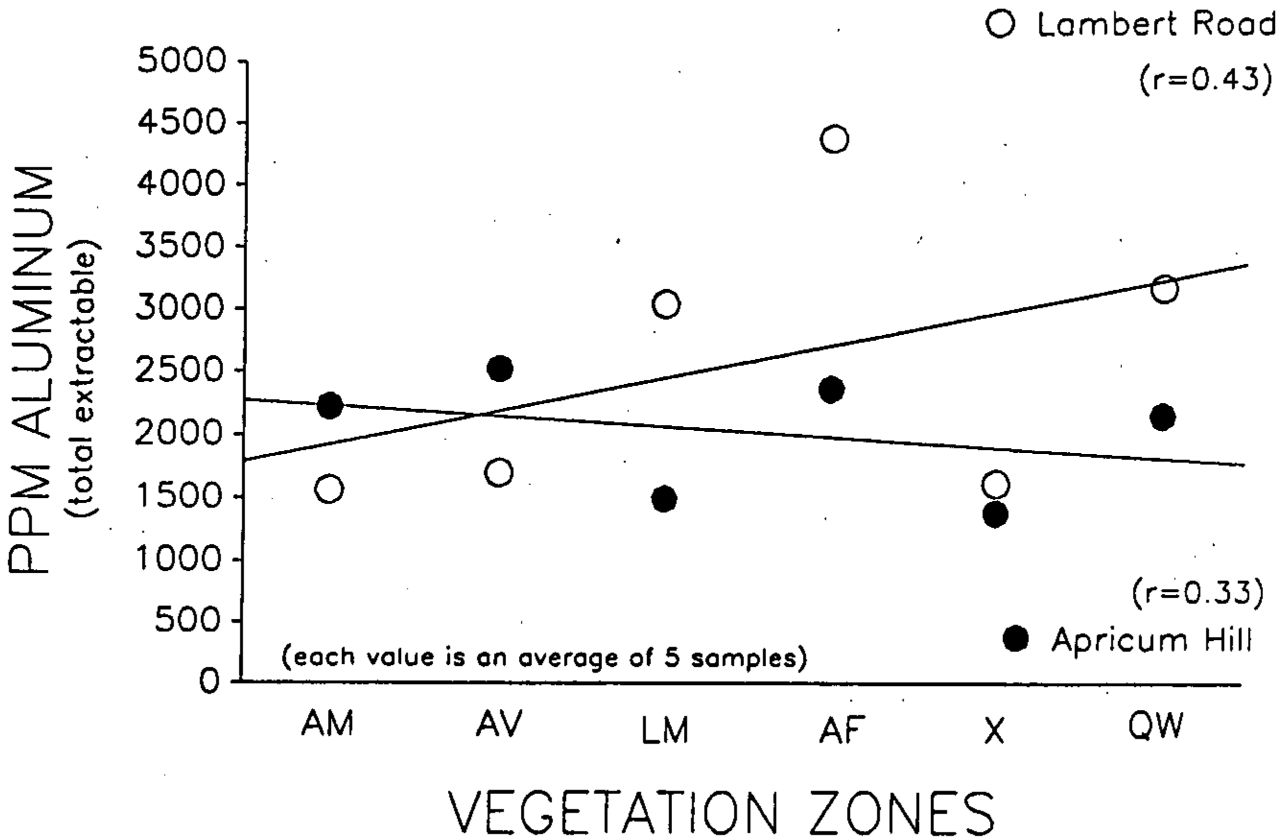
key to vegetation zones:
AM = pure _A_. _myrtifolia_ AV = first _A_. _viscida_
LM = zone where _A_. _myrtifolia_ disappears from understory
AF = first appearance of _Adenostoma_ _fasciculatum_
X = mixed vegetation QW = pure _Quercus_ _wislizenii_

Figure 1.

Comparison of Soil pH along a Vegetational Gradient at Apricum Hill and Lambert Road Sites

Soil pH exerts a profound influence on mineral solubility and the presence of a suppressed pH in soils underneath A. myrtifolia adds credence to the hypothesis that edaphic factors may restrict the dispersal of neighboring plant species onto such soils. However, aluminum concentrations were not found to be significantly higher beneath A. myrtifolia nor was there a strong correlation between aluminum and the observed vegetational gradient (Figure 2). Summaries of soils data from the Apricum Hill and Lambert Road sites are presented in Tables 7-8. All soils data are included in Appendices 17-18.

While the effects of aluminum on growth of chaparral species are not well understood, high concentrations of aluminum may damage the roots of some agricultural crops (Thompson and Troeh, 1978) and inhibit cell elongation and cell division in others (Treshow, 1970). In soils with a pH below 5.0, free aluminum may occur in concentrations high enough to be damaging to most cultivated crops (Marschner 1986) and aluminum ion concentration may be the most common cause of crop failure in acid soils (Russell, 1973). Aluminosilicate clays, like those found in soils of the Ione Formation, release free aluminum cations by isomorphic substitution in strongly acid environments. These cations may be hydrolized, adsorbed onto plant roots and absorbed into plant tissues. Due to the high concentration of aluminosilicates in the Ione soils and the acidifying effects of the lateritic parent material the vegetation associated with these soils may be subjected to unusually high amounts of this element. If, as Gankin and Major (1964) suggest, A. myrtifolia and A. viscida do in fact differ in their ability to avoid aluminum toxicity, for example,



key to vegetation zones:
AM = pure A. myrtifolia AV = first A. viscida
LM = zone where A. myrtifolia disappears from understory
AF = first appearance of Adenostoma fasciculatum
X = mixed vegetation QW = pure Quercus wislizenii

Figure 2.

Comparison of Soil Aluminum Concentrations along a Vegetational Gradient at Apricum Hill and Lambert Road Sites

Table 7

Summary of Soils Data along a Vegetation Gradient at Apricum Hill*

	zone					
	pure <u>A. myrt</u>	first <u>A. vis</u>	last <u>A. myrt</u>	first <u>chamise</u>	<u>mixed</u>	<u>oak</u>
pH	4.4	4.6	4.8	4.8	4.7	4.7
	(0.2)	(0.3)	(0.1)	(0.3)	(0.4)	(0.3)
% organic	3.22	2.6	3.1	3.7	3.8	7.4
matter	(0.6)	(0.7)	(0.5)	(0.3)	(1.0)	(1.7)
total N	4.1	3.8	4.8	2.7	3.2	9.2
	(2.6)	(1.7)	(2.9)	(1.4)	(1.6)	(3.1)
P_2O_5	2.4	3.3	5.3	5.1	2.8	3.6
	(0.73)	(0.6)	(0.9)	(1.2)	(0.6)	(0.73
K_2O	23	20	25	31	37	52
	(9.3)	(4.5)	(3.2)	(8)	(12.9)	(8.1)
Ca	87	58	55	155	194	48
	(43.2)	(42.4)	(32.4)	(63)	(88.5)	(11.7)
Mg	30.6	37.6	25.5	55.6	36.9	18.8
	(17.1)	(29.6)	(15.6)	(11.5)	(12.8)	(4.4)
SO_4	31.8	69.8	163	39.9	126	34.9
	(8.5)	(41.2)	(32.3)	(22.9)	(39.3)	(6.8)
Cl	3.6	2.3	2	2.7	8.8	6.9
	(1.6)	(1.7)	(1)	(1.3)	(2.1)	(3.2)
Na	2.9	3.1	3.6	1.3	7	4.1
	(1.2)	(2.0)	(2.3)	(0.68)	(2.9)	(2.1)
Mn	0.04	0.03	0.05	0.18	0.66	0.54
	(0.04)	(0.04)	(0.1)	(0.15)	(0.58)	(0.5)
Fe	1360	988	1838	3140	812	2500
	(120)	(363)	(452)	(1113)	(182)	(415)
Cu	0.26	0.41	0.18	0.22	0.71	0.45
	(0.09)	(0.17)	(0.06)	(0.1)	(0.61)	(0.26
Zn	0.57	0.5	0.63	1.41	0.04	4.54
	(0.29)	(0.17)	(0.15)	(0.44)	(0.01)	(4.85)
B	0.18	0.37	0.39	0.14	0.22	0.07
	(0.13)	(0.25)	(0.34)	(0.06)	(0.16)	(0.05)
Al	2220	2520	1496	2362	1380	2440
	(412)	(643)	(438)	(944)	(264)	(734)
sand	55	53.4	58.6	76.4	54.8	60.2
	(12.1)	(11.2)	(22.5)	(12.7)	(18.6)	(9.5)
silt	20.4	15.4	14.6	12.8	28.8	25
	(8.7)	(6.2)	(7.0)	(7)	(13)	(6.4)
clay	24.6	31.2	26.8	10.8	16.4	14.8
	(4.0)	(7.4)	21.67	(6.4)	(7.3)	(5.3)

*Each value is an average of five samples. Standard deviations are given in parentheses. Nutrient averages are ppm total extractable.

Table 8

Summary of Soils Data along a
Vegetational Gradient at Lambert Road Sites*

	zone					
	pure <u>A. myrt</u>	first <u>A. vis</u>	last <u>A. myrt</u>	first <u>chamise</u>	<u>mixed</u>	<u>oak</u>
pH	4.4 (0.4)	4.6 (0.2)	4.6 (0.08)	4.6 (0.08)	4.6 (0.1)	4.6 (0.2)
% organic matter	2.7 (0.5)	4.7 (1.6)	5.7 (3.2)	6.8 (2.4)	4.3 (1.5)	10.0 (3.0)
total N	7.5 (0.63)	8.2 (1.6)	5.3 (1.7)	3.4 (1.2)	9.5 (3.9)	3.1 (2.4)
P_2O_5	5.8 (0.4)	5.6 (0.2)	5.6 (0.2)	2.6 (1.5)	5.5 (0)	6.4 (6.9)
K_2O	25.5 (10.1)	29 (4.9)	30 (3.2)	35 (4.5)	31 (7.4)	37 (9.3)
Ca	192 (129.5)	67 (15.0)	89 (31.2)	104 (34.7)	54 (23.5)	91 (72.6)
Mg	35.4 (14.7)	33.2 (3.9)	47.7 (12.5)	21.9 (5.6)	31.7 (10.2)	29.1 (9.3)
SO_4	103 (76.3)	54.1 (7.1)	66 (22.2)	150 (25.5)	70 (11.0)	128 (19.7)
Cl	10.2 (3.4)	7.8 (2.0)	9.7 (1.5)	6.8 (2.8)	6.4 (2.4)	6 (2.6)
Na	13.5 (2)	12 (4)	16 (2)	3.7 (1.7)	17.5 (3.9)	4.5 (3.3)
Mn	0.1 (0.04)	0.05 (0)	0.09 (0.02)	0.33 (0.13)	0.1 (0.03)	0.97 (0.96
Fe	834 (357)	550 (198)	2500 (936)	2880 (643)	394 (56)	1848 (1770)
Cu	0.88 (0.27)	0.64 (0.08)	0.72 (0.16)	0.12 (0.04)	0.6 (0.13)	0.21 (0.18)
Zn	1.11 (0.36)	2.03 (0.78	4.2 (2.2)	0.04 (0.02)	1.48 (0.41)	0.09 (0.07)
B	0.53 (0.42)	0.2 (0)	0.28 (0.16)	0.28 (0.1)	1.36 (0.64)	0.28 (0.1)
Al	1560 (344)	1676 (629)	3040 (1695)	4380 (1083)	1616 (432)	3178 (2479)
sand	45.8 (9.7)	68.4 (5.3)	68.9 (13.4)	67 (5.5)	66 (11.8)	69.7 (3.1)
silt	20.6 (5.3)	20.4 (3)	19 (9.1)	23.2 (2.7)	15.6 (5.6)	18.6 (3.4)
clay	33.6 (8.4)	11.2 (4.3)	12.1 (4.5)	9.8 (4.7)	18.4 (8.7)	11.7 (2.2)

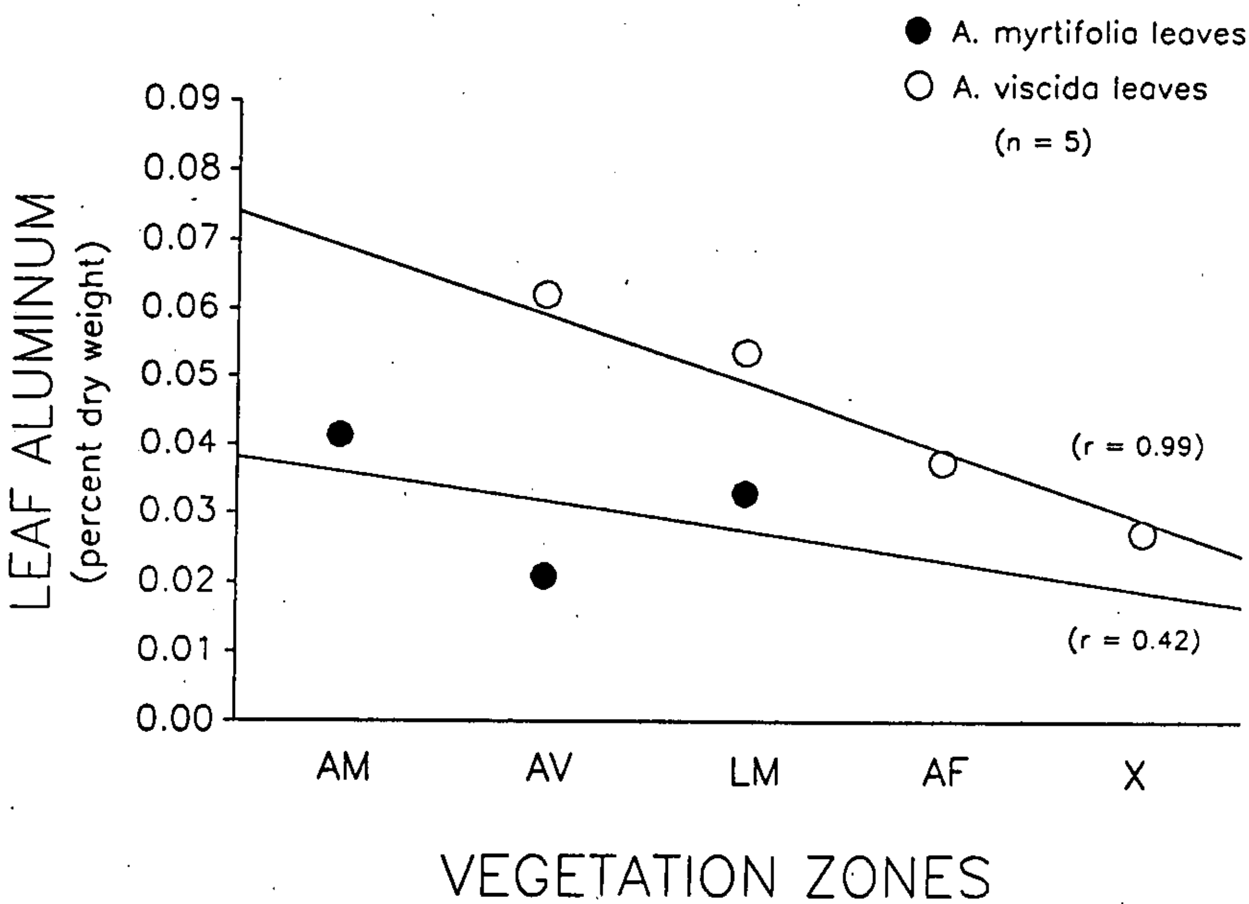
*Each value is an average of five samples.
Standard deviations are given in parentheses.
Nutrient averages are ppm total extractable.

we may expect the distribution of these two species to be affected by differing concentrations of aluminum in the soil.

1.4.2 leaf mineral content

Leaf mineral content was determined in an attempt to discover how A. myrtifolia and A. viscida react to their edaphic environment. Leaf samples were collected from all species adjacent to sites where soil samples had been taken (Appendix 8). Foliar analysis may offer insight into the respective abilities of these two manzanitas to cope with high concentrations of potentially toxic elements in the soil. In the case of aluminum, leaves of A. viscida were found to contain consistently higher levels of aluminum than leaves of adjacently occurring individuals of A. myrtifolia (Figure 3). Figure 3 also shows that leaf aluminum concentrations decrease along a gradient similar to that of soil samples. Leaf analysis data for Apricum Hill are summarized in Tables 9-10.

The lower levels of aluminum in leaves of A. myrtifolia may indicate an ability to exclude, to some degree, the uptake of aluminum by the roots. Such an exclusion mechanism could limit the damaging effects of potentially toxic minerals to plant tissues. Similarly, because A. viscida exhibits higher levels of aluminum in its leaves it may lack this mechanism for limiting the uptake of aluminum making it, in effect, more susceptible to aluminum toxicity. In addition, foliar concentrations of aluminum within species were observed to decrease along a vegetational gradient at a rate which closely corresponds to that of soil samples. In other words, concentrations of aluminum in



key to vegetation zones:
AM = pure _A. myrtifolia_ AV = first _A. viscida_
LM = zone where _A. myrtifolia_ disappears from understory
AF = first appearance of _Adenostoma fasciculatum_
X = mixed vegetation QW = pure _Quercus wislizenii_

Figure 3.

Comparison of Leaf Aluminum Concentrations along a Vegetational Gradient between _Arctostaphylos myrtifolia_ and _A. viscida_ at Apricum Hill

Table 9

Summary of Leaf Analysis Data for *Arctostaphylos myrtifolia* from Three Vegetation Zones at Apricum Hill*

	zone		
	pure *A. myrt*	first *A. vis*	last *A. myrt*
N	0.46 (0.08)	0.68 (0.066)	0.54 (0.057)
P	0.02 (0.008)	0.014 (0.007)	0.026 (0.008)
K	0.13 (0.022)	0.23 (0.052)	0.21 (0.05)
Ca	0.52 (0.092)	0.42 (0.18)	0.42 (0.11)
Mg	0.13 (0.032)	0.16 (0.044)	0.21 (0.07)
Fe	0.02 (0.007)	0.014 (0.009)	0.02 (0.007)
Mn	0.005 (0.002)	0.003 (0.001)	0.004 (0.003)
Al	0.041 (0.01)	0.021 (0.014)	0.033 (0.012)

*Each value is an average of five samples. Standard deviations are given in parentheses. Values given as percent dry weight of leaf tissue.

Table 10

Summary of Leaf Analysis Data for *Arctostaphylos viscida* from Five Vegetation Zones at Apricum Hill*

	zone			
	first *A. vis*	last *A. myrt*	first *chamise*	*mixed*
N	0.7 (0.13)	0.79 (0.12)	0.63 (0.10)	0.8 (0.1)
P	0.03 (0.017)	0.04 (0.02)	0.05 (0.02)	0.022 (0.01)
K	0.27 (0.08)	0.61 (0.09)	0.27 (0.037)	0.24 (0.02)
Ca	0.49 (0.14)	0.54 (0.18)	0.60 (0.30)	0.56 (0.24)
Mg	0.24 (0.06)	0.24 (0.034)	0.25 (0.041)	0.19 (0.046)
Fe	0.029 (0.012)	0.02 (0.005)	0.02 (0.009)	0.017 (0.018)
Mn	0.003 (0.003)	0.003 (0.001)	0.003 (0.002)	0.002 (0.001)
Al	0.06 (0.019)	0.05 (0.024)	0.04 (0.02)	0.027 (0.026)

*Each value is an average of five samples. Standard deviations are given in parentheses. Values given as percent dry weight of leaf tissue.

the soil are highest underneath pure stands of A. myrtifolia and decrease progressively along the vegetational gradient described in Appendix 2, as do intraspecific foliar concentrations. Further study is required to determine if these generalizations are true and that A. myrtifolia actually possesses a greater ability to limit the uptake of aluminum than A. viscida. Figure 4 compares soil and leaf concentration gradients for both species of Arctostaphylos. Results from foliar analyses are included in Appendices 19-20.

1.5 Recovery potential for degraded or damaged populations

1.5.1 general remarks

Of prime consideration in the undertaking of this study at the Apricum Hill Reserve was evaluation of the growth requirements, reproductive capabilities and management needs of A. myrtifolia and Eriogonum apricum var. apricum. These two taxa are the most seriously endangered plants found on the Reserve and understanding their growth and reproductive habits is essential if the goals of the Reserve are to be realized. The main focus of the current report is on those factors influencing A. myrtifolia. A separate ecological evaluation of Eriogonum apricum var. apricum has been submitted by Dr. Rodney Myatt of San Jose State University.

Several field and greenhouse experiments were conducted to evaluate the reproductive capacity of A. myrtifolia. Because both A. myrtifolia and A. viscida are obligate seeders and do not possess the ability to resprout from lignotubers as do some manzanita species, they rely entirely on seeds stored in the soil

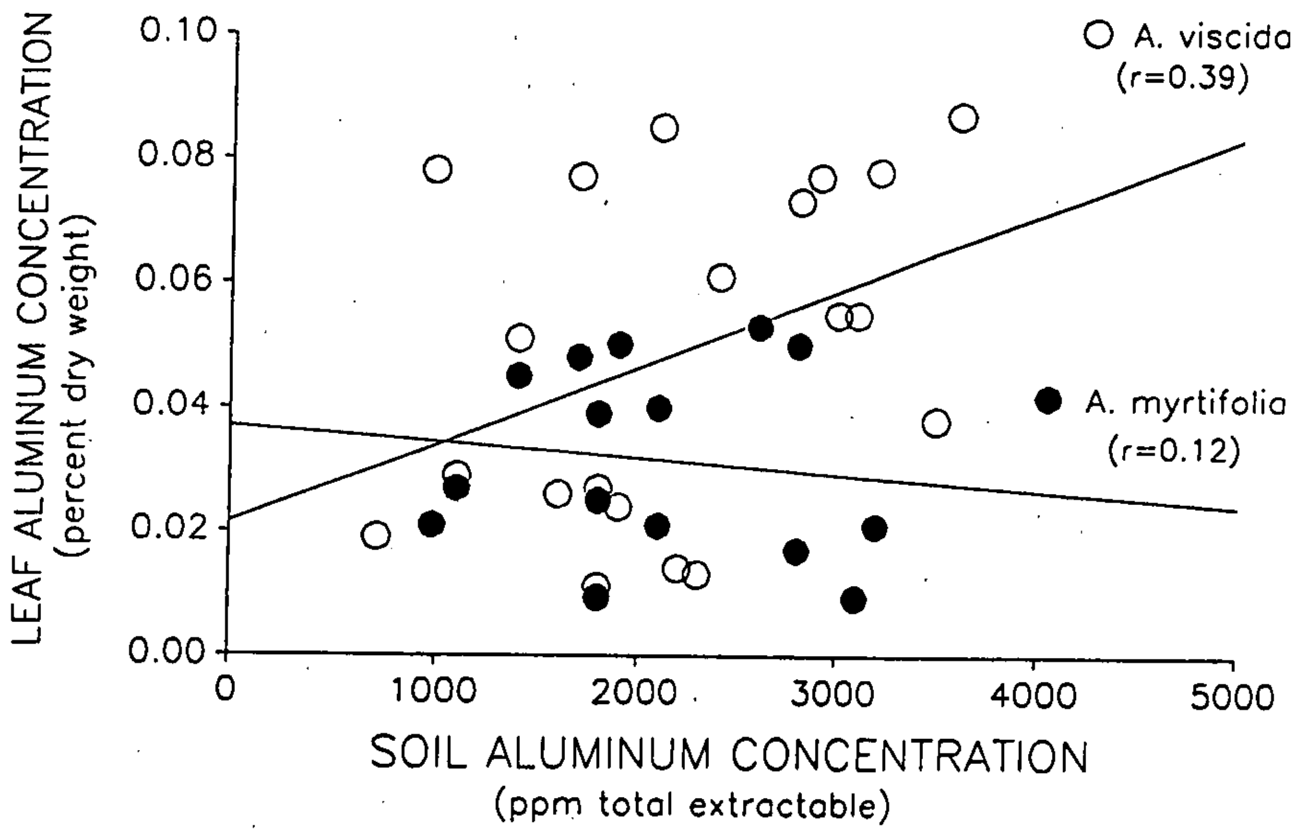


Figure 4.

Comparison of Leaf:Soil Aluminum Concentration Ratios between <u>Arctostaphylos myrtifolia</u> and <u>A. viscida</u>

for regeneration after disturbance. Seed production, predation, viability and longevity are important factors affecting the reproductive potential of both species.

1.5.2 seed production

Overall seed production was estimated for A. myrtifolia by the random placement of seed collection trays throughout the Reserve (Appendix 3). One half (n=30) of the trays were designed to exclude all possible seed predators in order to provide data on actual seed production. From the data in Table 11 seed production per square meter can be calculated. Arctostaphylos myrtifolia produced an average of 2913.7 seeds per square meter in 1987. Field observations confirmed that fruit production for this period was indeed heavy. It should be noted, however, that these data represent only a very short period in the life of this plant community and that seed production is certainly subject to large fluctuations (Keeley, 1977; 1987).

1.5.3 seed predation

Predation of seeds is known to account for substantial losses in chaparral communities (Keeley and Hayes, 1976; Kelly and Parker, in review; Parker and Kelly, in press). Birds, ants, wood rats and other rodents, and even coyotes are active foragers of chaparral seeds. Because fruits of A. myrtifolia mature and drop before the onset of high summer temperatures they may be especially subject to removal by predators that go underground during those months. In addition, due to the extraordinarily dense cover of cryptogams beneath A. myrtifolia, seeds may lie exposed on the surface instead of falling into cracks in the

Table 11

Seed Collection Data for
Arctostaphylos myrtifolia
at Apricum Hill*

	open trays	exclosure trays
average # seeds/tray*	130.3	188.0
average # seeds/m^2	2019.2	2913.7

*Figures include seeds found singly and those in unbroken fruits fruits. The average number of seeds per fruit was determined to be 4.23 (n=100).

earth, making them easier to find. Unlike fruits of A. viscida which remain intact after dropping, those of A. myrtifolia split readily into tiny nutlets. This feature may render seeds more susceptible to predation by ants which are unable to manage large, entire fruits. At Apricum Hill, ants are extremely active collectors of seeds of all types and may contribute to the loss of as many as 31% of all seeds produced by A. myrtifolia.

Of the seed collection trays placed in the field, one half was designed to exclude all predators. The other half was designed to exclude ants only, thereby permitting predation by vertebrates. By the end of the study an average of 130.27 seeds were recovered from each tray open to predation compared with 188 seeds per screened tray (Figure 5). A net average of 2019.2 seeds per square meter were remaining after predation losses. Based on total seed production values obtained from exclosure trays, as many as 900 seeds per square meter (31% of all seed produced) may have been lost to predation.

1.5.4 seed viability

In addition to seed production, seed viability was also estimated. Fresh seeds of A. myrtifolia and A. viscida as well as one year-old seeds of A. viscida were tested for percent viability (Appendix 4). Due to the splitting nature of A. myrtifolia fruits and the minute size of its seeds, no one year old seeds could be obtained. Viability tests for both species indicate that an adequate percentage of seeds produced are viable (Table 12). However, viability is significantly higher for seeds of A. viscida than A. myrtifolia. Seeds of A. myrtifolia and A.

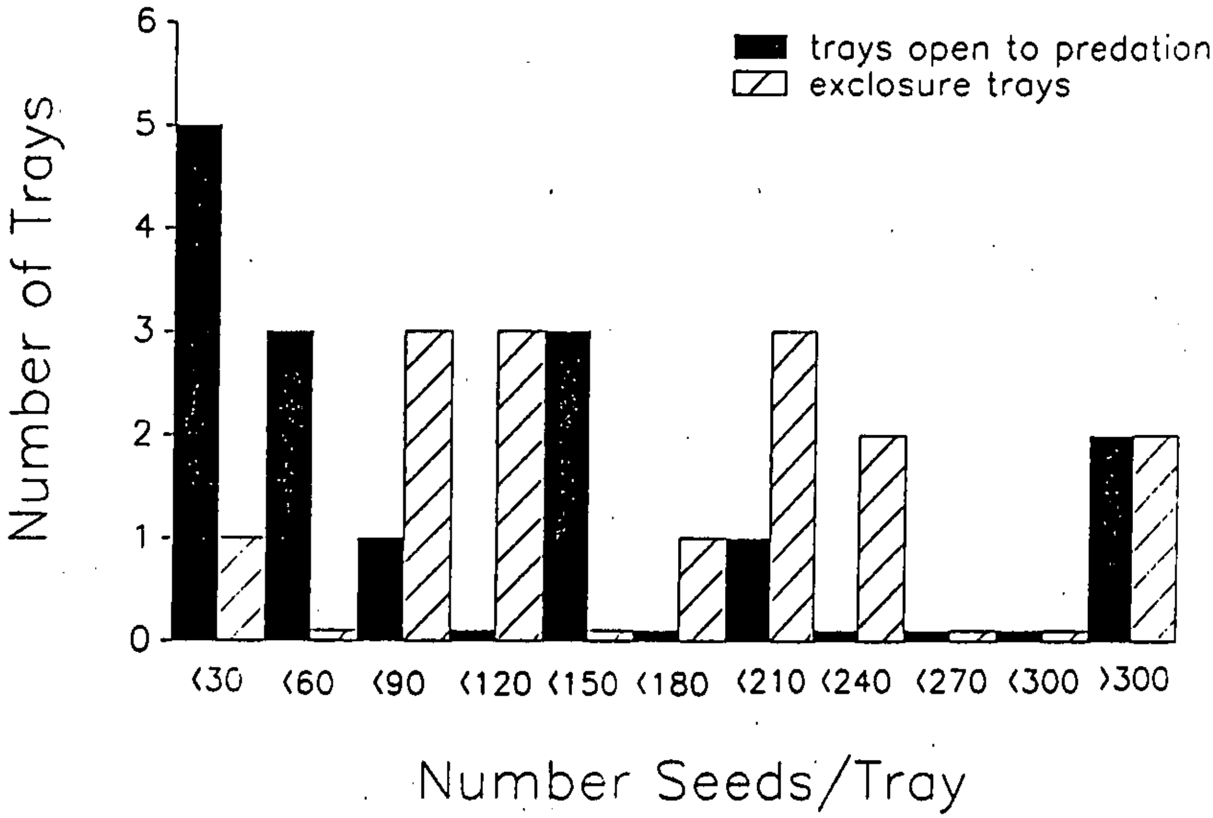


Figure 5.

Comparison of the Number of Seeds Recovered per Tray between Trays Subjected to and Protected from Predation

viscida collected immediately after fruit maturation were found to have viabilities of 51.4% (n=70) and 84.2% (n=38) respectively. Seeds of *A. viscida* collected in the soil prior to maturation of the current year's crop were assumed to have been produced the previous year. Viability of these one year-old seeds was estimated at 76.3% (n=38). No data on seed longevity is available.

Table 12

Percent Seed Viability for *Arctostaphylos myrtifolia* and *A. viscida*

	A. myrtifolia	*A. viscida*
fresh seed	0.514 (n=70)	0.842 (n=38)
1 year old seed	-- --	0.763 (n=38)

1.5.5 seed banks

An effective method of determining the potential for recovery of a plant community after fire is by performing seed bank experiments. Soil is collected from the field, subjected to treatments mimicking the effects of fire and placed in flats in a greenhouse. By observing the numbers and species of seedlings that develop from seeds stored in the soil we can estimate how well a plant community might recover after a fire.

Seed bank experiments were run with soil samples collected at the Apricum Hill Reserve (Appendix 5). A primary concern of this study was the determination of how readily *A. myrtifolia* could be expected to respond in the event of a fire. While numerous woody and herbaceous species responded vigorously to the seed bank treatment, *A. myrtifolia* showed a disappointingly poor response. Forty five soil samples were collected, 15 from each of the three distinct vegetation zones where *A. myrtifolia* occurs. Of these, only seven samples produced any *Arctostaphylos* seedlings during the nine months that the test was conducted. Although none of these seedlings survived to flowering permitting positive determination to species, preliminary observations of leaf and stem morphology lead us to the conclusion that no seedlings of *A. myrtifolia* resulted from the treatment. Only *A. viscida* demonstrated any response. In addition, virtually all *Arctostaphylos* seedlings germinated in flats containing soil collected from stands of *A. viscida*. No *Arctostaphylos* seedlings were observed in seed banks collected from transition zones dominated by *A. myrtifolia* and *A. viscida* and only one seedling appeared in soils collected from pure *A. myrtifolia* stands.

Data from seed banks indicate that response of woody and herbaceous plant species after fire is far greater within stands of *A. viscida* than *A. myrtifolia* (Table 13). The total number of individuals and the total number of species to germinate were lowest in seed banks collected from stands of *A. myrtifolia*. The number of species of seeds stored in these soils is expected to be low due to the low species diversity in these stands. Given these results, revegetation of stands of *A. myrtifolia* after fire may be slow. Field observations indicate that sites supporting *A. viscida* appear to respond somewhat faster and more completely after disturbance.

Table 13

Seed Bank Data for Three Vegetation Zones at Apricum Hill

species	zone		
	A. myrt	trans	A. viscida
Arctostaphylos spp.	1	0	13
Mimulus viscidus	1	3	62
Eriodictyon californicum	0	11	37
Capsella bursa-pastoris	0	0	1
Gnaphalium luteo-album	1	5	3
Ceanothus spp.	0	1	0
Crassula erecta	0	6	5
Adenostoma fasciculatum	0	0	3
Leguminosae	0	3	37
Compositae	0	0	4
monocot	11	18	19
unidentified (3 spp.)	1	2	19
total # individuals	15	49	203
total # of species	5	8	12
avg # plants/sample	1	3.3	13.5

III. Area Management Objectives

A. Description of Area

The Apricum Hill Ecological Reserve is located in southwestern Amador County about three miles south of the town of Ione. The Reserve is on the west side of Jackson Valley Rd. approximately one mile south of Highway 88. The legal description of the site is the Northwest quarter of the Southwest quarter of Section 5, Township 5 North, Range 10 East, Mt. Diablo Base and Meridian. The Reserve covers 37.5 acres of relatively uneven terrain between 375 and 490 feet above sea level.

Climate in the Ione region is typified by long periods of hot, dry weather in summer and cool, wet winters. Summer temperatures may exceed 40°C but on the whole are mediated by marine air that flows up the Delta from San Francisco Bay (Gankin and Major, 1964). Rainfall is concentrated primarily in the winter months and frosts are infrequent. The mean annual temperature is 16°C and the mean annual precipitation is approximately 51 cm (Singer and Nkedi-Kizza, 1980).

B. Species Management Recommendations

1. General remarks

Arctostaphylos myrtifolia is a prostrate manzanita occurring on lateritic outcrops of the Ione Formation or its sediments. *Arctostaphylos myrtifolia* is an obligate seeder, lacking the ability to resprout from the base, and is killed outright by fire. Regeneration after fire is entirely dependent on the germination of seeds stored in the soil or dispersed to the site. Although branches of *A. myrtifolia* may layer, enabling a particular genome to exist for many decades, individuals are not thought to live much longer than 50 years (Gankin and Major, 1964). Arctostaphylos myrtifolia thrives on otherwise barren soils and appears to have the ability to tolerate edaphic conditions that exclude neighboring species. While A. myrtifolia can be found in the understory of A. viscida, it does not appear to grow as vigorously under such conditions as on open sites.

2. Protection objectives

Although its exact growth requirements have not been determined, A. myrtifolia appears to be very sensitive to habitat alteration and its regenerative potential appears to be low. Mature individuals in well established, undisturbed stands have been seen to senesce, suggesting the poor ability of this species to persist even in natural habitats. Steve Edwards at Tilden Park at the University of California at Berkeley reports that specimens cultivated for many years have died suddenly for no apparent reason (pers. comm.). Roman Gankin has also attempted to cultivate A. myrtifolia with very little success. He feels that this species is perhaps the most difficult Arctostaphylos to raise in "captivity" (pers. comm.).

Soil-plant interactions appear to play a significant role in the distribution of A. myrtifolia and A. viscida. The high concentration of aluminum in some soils may be a major factor restricting the occurrence of neighboring chaparral species. We have demonstrated a correlation between soil properties and plant growth. Further understanding of the relationship between soil environment and the physiology of these species is a key aspect in their effective management.

Another factor that may affect the protection of A. myrtifolia is the sudden and virtually complete die-off of entire stands, observed in the past at several locations in the Ione region. The cause of this die-off is puzzling and may pose a significant long-term threat to the existence of the species. The concentric pattern that characterizes the die-off suggests the mycelial growth of a soil fungal pathogen. The identity of this pathogen, how its growth is triggered, and how it can be controlled are important questions that need to be answered. Further understanding about the growth requirements of A. myrtifolia, how it responds to various soil conditions, the effects of competition for space by other plant species and the effects of possible pathogens is needed before specific management plans can be prescribed.

3. Manipulation objectives

3.1 Effects of burning on moist soil

Viability of seeds of chaparral species stored in the soil can be significantly reduced by the burning of vegetation while the soil is moist (Parker, 1987). Moist soil conducts heat far more effectively than dry soil and may greatly reduce the number of seeds capable of germinating. To demonstrate this experimentally, a heat/moisture test was designed (Appendix 6).

Two treatments were set up using soil collected from the same source. One sample, in an air-dry condition (ca. 4.8% moisture content), was heated in a soil oven while the other was heated after its soil moisture content had been raised to 30 percent. Soil samples were then placed in flats in a greenhouse. As seedlings germinated, they were identified and counted for each treatment for a period of five months. Both the number of individuals and the number of species to germinate were significantly lower for the treatment heated at a 30 percent moisture content than the air-dry treatment (Figure 6). The contrast in response between the two treatments was substantial and confirms the hypothesis that controlled burning of chaparral during dry months will result in far better regeneration of chaparral species than during winter or spring months when the soil moisture content is high. However, no seedlings of A. myrtifolia resulted from this treatment.

3.2 General comments on manipulation

Species in the genus Arctostaphylos, like most chaparral species in general, are fire-adapted in some way. Seeds of many chaparral species are stimulated to germinate by fire. Exposure to a combination of heat and by-products of hemicellulose, a compound contained in cell walls whose heat by-products are released into the soil by the leaching of partially burned wood, has been shown to significantly increase the germination of some chaparral species (Keeley and Pizzorno, 1986). While seeds of many woody species can be stimulated to germinate artificially by heating and the application of finely ground charred wood (Keeley, 1987; Parker, 1987), we have been unable to successfully germinate seeds of A. myrtifolia, even though seed viability is moderately high.

Although germination experiments failed, A. myrtifolia is

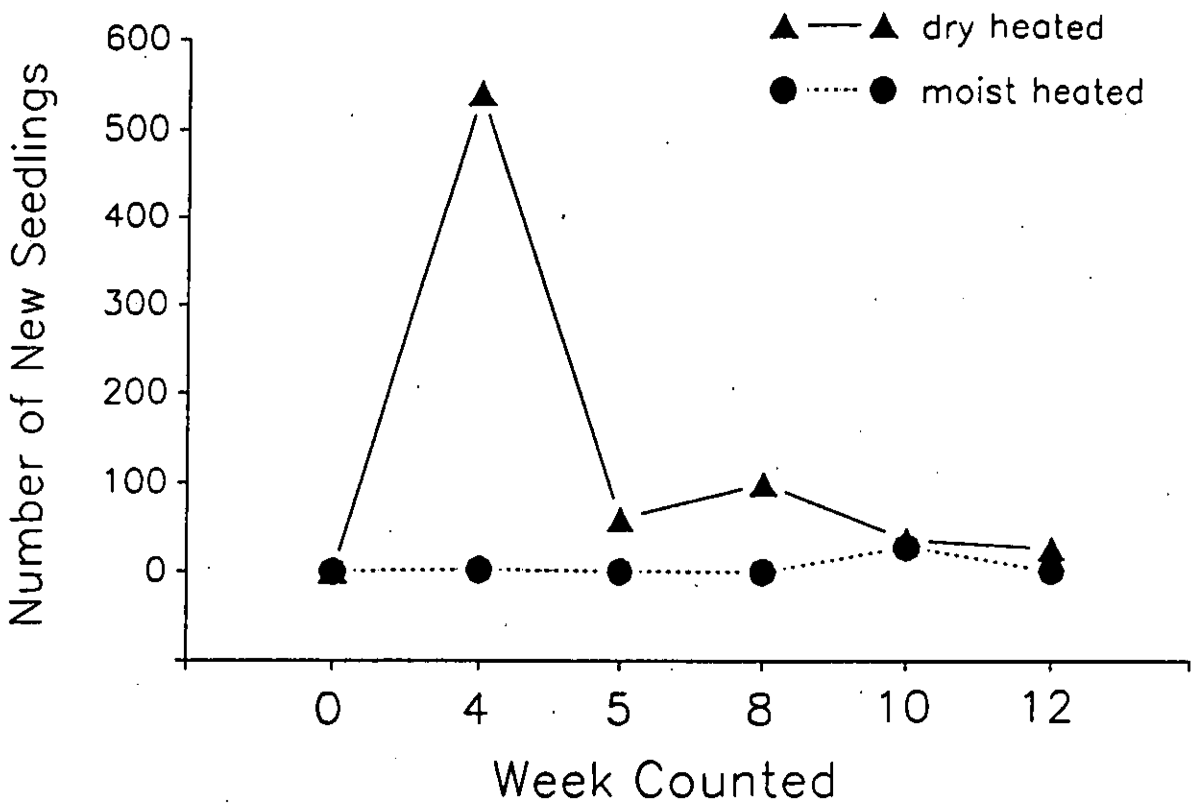


Figure 6.

Comparison of Germination between Seed Banks Heated in Air-dry and Moist (30%) Conditions

not necessarily reproductively inferior. Rather, we merely have yet to discover the exact combination of treatments required to artificially stimulate germination in this species. However, caution is suggested in the management of this plant and its habitat. Observations in the field support this need for caution. While seedlings of A. myrtifolia can be found at some burn sites and road cuts, its response appears irregular and unpredictable. The presence of seedlings at the site of road cuts is curious and the stimulatory effect on seeds is not known.

Despite the somewhat discouraging results from seed bank experiments concerning the response of A. myrtifolia after fire, the potential for a good response still exists. The reasonably high seed viability, high seed production and continued success of A. myrtifolia as a species indicate that its potential for reproduction must be high. Although A. myrtifolia occurs in somewhat isolated stands, they remain well within the range of pollinating agents. The combining of genetic material between these adjacent but separate populations is believed to have preserved a high degree of genetic heterozygosity (Gankin, pers. comm.). Even though the geographic range of A. myrtifolia is highly restricted, this does not mean that the species lacks the ability to maintain its populations if left undisturbed.

For these reasons, we recommend that, at least for the time being, the stands of A. myrtifolia on the Apricum Hill Reserve be left alone and carefully monitored. We feel confident that A. myrtifolia will respond to fire similarly to other manzanita species that have been studied and that once burned, provided no exotic species invade and dominate the site first, these stands will regenerate. However, due to the lack of concrete evidence in support of this belief, we recommend that no prescribed burning of the vegetation at Apricum Hill occur at this time. On the other hand, a controlled burn of the vegetation at some off-site location is recommended and even encouraged. Permission should be sought to perform a test burn of A. myrtifolia on private land in order to observe its response to fire. How well A. myrtifolia regenerates at other sites will give us an idea of what to expect if a burn is prescribed for the Apricum Hill Reserve.

C. Site Management Recommendations

Management of the Apricum Hill Reserve on the whole should be based on guidelines similar to those affecting endangered species on the Reserve. Any activity that would risk destroying the stands of A. myrtifolia or Eriogonum apricum var. apricum should be carefully considered. A controlled burn of the entire site is therefore not recommended. If an accidental fire should pass through the site, reproduction data on A. myrtifolia, A. viscida, mixed vegetation and oak woodland can be obtained from permanent plots in place on the Reserve (Appendix 9).

Erosion is not seen as a problem at the Reserve, even though water run-off has cut small ravines in several locations. On the whole, erosion is slight and viewed as an acceptable natural alteration of the habitat. Also, because Eriogonum apricum var. apricum appears capable of invading and becoming established on eroded sites no erosion control is recommended. There also appears to be no need for disking or the selective removal of exotic plant species.

D. Summary and Specific Recommendations

1. General remarks

Because Apricum Hill is dominated by chaparral containing the rare, endemic species, *Arctostaphylos myrtifolia*, we combine our following species and site recommendations. The Reserve seems currently stable, but a number of unpredictable threats exist. Consequently, we recommend two separate approaches to the management of *A. myrtifolia* and the Apricum Hill Reserve. While a chaparral species and a member of a large and well-known genus, this particular species behaves uniquely in a number of ways, the basis for which is not clear. Thus, one approach in learning how to manage *A. myrtifolia* requires an increased understanding of its biology. Secondly, threats to the Reserve may require large scale management intervention to prevent site degradation, or, failing that, to restore the site. Preparation for these threats will involve experimentation using field manipulation. Our specific recommendations follow:

2. Further Studies on factors influencing germination in *Arctostaphylos myrtifolia*

We recommend that studies be initiated to determine how germination of *A. myrtifolia* differs from other species within the genus. The restoration of stands of *A. myrtifolia* is dependent upon fire and the subsequent germination of seeds stored in the soil or dispersed to the site. Seed banks are essentially the sole source of seeds for the regeneration of populations after fire. Still, efforts to germinate seeds with techniques successful on other _Arctostaphylos_ species have proved ineffective. Any restoration or enhancement efforts will require this ability.

3. Research into the soil relationships of Arctostaphylos myrtifolia

The effects of pH, aluminum concentrations, calcium/magnesium ratios, and the availability of micro- and macronutrients on _A. myrtifolia_ will assist us in understanding its distribution patterns. Also, an important management consideration is whether or not _A. myrtifolia_ and _A. viscida_ differ significantly in their responses to edaphic conditions, especially to the concentration of aluminum in the soil. Does _A. myrtifolia_, for example, possess a greater ability to prevent potentially toxic concentrations of aluminum from being taken up by its roots than _A. viscida_? Or is _A. viscida_, in fact, capable of invading onto sites supporting pure stands of _A. myrtifolia_ and is it merely a question of time before the larger, more robust _A. viscida_ crowds out the last stand of _A. myrtifolia_? Comparative growth studies of these two species in a variety of controlled soil conditions would provide insight into these questions. These studies are dependent upon reasonably successful germination studies.

4. Studies into stand die-off

More must be learned about the unusual sudden die-off witnessed within entire stands of _A. myrtifolia_. Is this really caused by a fungal pathogen? How does it affect recovery? Can it happen at Apricum Hill and can it be prevented? If stands killed by this die-off are burned or otherwise manipulated, can we stimulate revegetation of A. myrtifolia or are seeds also affected by this blight? A site located on the north side of Highway 88 between Buena Vista and Jackson Valley Roads shows all the signs of sudden die-off and would provide an excellent starting point for such an investigation. Permission should be sought to establish permanent plots on this site, to analyze soils and to do a controlled burn or other manipulation to observe what plant species result.

5. Studies into fire response and prescribed burning

Due to the presence of only small populations of A. myrtifolia on the Apricum Hill Reserve, we consider it unwise to risk losing any of them to a prescribed burn. If a controlled burn were desired as an experiment, only one stand or portion thereof should be burned to minimize the risk to the entire Reserve. In such a case, we feel that the best site for such a burn would be the stand of A. myrtifolia on the eastern slope of Apricum Hill. Cover is low, sparse, and a fire could be easily managed. There is also less chance that other species, notably A. viscida, would invade an uphill site restricting the return of A. myrtifolia. Permanent plots have been installed within this stand and will yield reproduction data if burned.

A detailed map of the locations of all permanent plots has been included with this report. A description of permanent plots is included in Appendix 9. (Complete coverage and frequency data obtained from permanent plots are included in Appendices 21-24.)

An alternative to burning one of the few stands of A. myrtifolia on the Apricum Hill Reserve is to conduct a controlled burn on private land, if a land owner were willing to permit a controlled burn on his or her property. Permanent plots would need to be established prior to burning and the number of species, number of individuals and percent coverage calculated for each species within each plot. Further, we recommend that any controlled burns be conducted in the late summer or early fall. Ideally, a burn site should be left undisturbed for many years and the developing vegetation then compared with data obtained prior to burning. The results would suggest whether or not controlled burns could be successfully used in regenerating senescent populations.

In addition, a quantitative investigation of earlier burns at other locations would be of management interest. We are especially interested to learn how different vegetation zones will recover after fire and if species diversity and density are altered. A location along Carbondale Road which burned a few years ago is one example of a possible study site.

6. Land acquisition

After carefully surveying the vegetation at Apricum Hill and several other locations around Ione, we recommend that other properties be purchased for the preservation of current habitats of *Arctostaphylos myrtifolia* and *Eriogonum apricum* var. *apricum*. While the Apricum Hill Reserve has several sites supporting extensive populations of *E. apricum* var. *apricum*, even larger populations have been discovered near Highway 88. These sites also have a high erosion potential and thereby the potential for opening up large areas to invasion by this species is also high.

Regarding A. myrtifolia, sites near the junction of Lambert Road and Carbondale Road about five miles north of Ione appear to support larger and more vigorous populations and are less disturbed. Transitions in the vegetation are also more distinct there than at Apricum Hill and seem to better represent the vegetational gradients identified in this study. Also, a very characteristic stand of A. myrtifolia exists due west of Apricum Hill on the north side of Buena Vista Road. This population is quite extensive and would be very conducive to research on the reproductive capabilities of A. myrtifolia.

Because the soils of the Ione Formation are thought to consist of a mosaic of edaphic characteristics, the edaphic environments beneath separate populations of A. myrtifolia may vary greatly. Arctostaphylos myrtifolia has been suggested to exhibit a high degree of heterogeneity and isolated stands may therefore possess differing adaptations to their unique soil conditions. We therefore recommend that soils of competing prospective sites be surveyed by a soils scientist or geologist prior to acquisition. If other sites are to be purchased, a range of soil qualities would be of great interest in the protection of the genetic diversity of A. myrtifolia. The conservation of the genetic heterogeneity of A. myrtifolia may be a critical factor in the long-term preservation of this species.

The acquisition of additional sites is also urged given the disturbing evidence of the susceptibility of mature stands of A. myrtifolia to suddenly dying off. If such a blight were to occur at the Apricum Hill Reserve, given our current lack of understanding about this phenomenon, entire stands of A. myrtifolia could be lost. Therefore, we strongly recommend purchase of multiple sites as a management strategy for protection against the sudden loss of one or more populations.

7. Additional recommendations

A program of rubbish removal should be considered for the Reserve. There are perhaps a dozen small rubbish heaps on the site, mostly along the northern border of the meadow and adjacent to the east fence. South of the main service road near the main gate is a pile of asphalt and road building materials. Numerous manzanitas have died near this dump, perhaps as the result of chemicals leached out of these materials, and its removal might also be considered.

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Appendix 1

Species Inventory Methodology

Species Dominance:

Data for compiling a list of species on the Apricum Hill Reserve, determining their relative dominance and completing an accurate survey of the site were obtained by walking line transects throughout the Reserve. Parallel transects were spaced approximately 30 meters apart. All species occurring within a five meter radius were recorded at sites located at 30-meter intervals along each transect. The presence of all species observed within the Reserve were also recorded. A total of 650 sites along 28 transects were sampled. Relative frequencies for each species were calculated by dividing the number of times each was encountered by the total number of sites sampled. Locations of infrequently occurring species were noted as were major zones of individual species and transition zones between vegetation types.

Woody Species List:

All species observed during the walking of transects were recorded. A detailed survey of the property led to the discovery of additional species occurring within the Reserve.

Site Survey:

While relative frequencies provide an indication of the percentage of the total land area occupied by each species, a detailed survey of the Reserve and vegetation mapping provide a more accurate picture of actual distribution. Species maps (see Appendices 10-16) were drawn up based on aerial photographs, field observations and data collected from walking transects. Location of large trees and less common suffrutescent shrubs is also indicated.

Appendix 2

Vegetational Zonation

The vegetation on the Apricum Hill Reserve was initially divided into six zones based on the presence or absence of particular species or species combinations. Zones were defined in order to accurately describe observable transitions within the chaparral. It was determined that as one walks down slope the following zones could be easily recognizable: 1) stands composed more or less exclusively of Arctostaphylos myrtifolia; 2) zones where Arctostaphylos viscida first appears; 3) zones where A. myrtifolia drops out of the understory; 4) zones where Adenostoma fasciculatum first appears within stands of A. viscida; 5) mixed zones composed of A. viscida, Adenostoma fasciculatum and Quercus wislizenii var. frutescens; and 6) stands of pure Quercus wislizenii and Q. w. var. frutescens. This gradient can be found where ever Arctostaphylos myrtifolia forms pure stands.

At Apricum Hill five independent stands of Arctostaphylos myrtifolia were identified. These stands were used as the starting point for all random transects which were utilized for the collection of soil and leaf samples, the placement of seed collection trays and of permanent plots.

Appendix 3

Seed Production and Predation Determination

In an attempt to determine relative seed production capabilities for the two species of Arctostaphylos, seed collection trays were placed within pure stands of both species. Because of the prostrate nature of A. myrtifolia it was necessary that the trays be quite shallow. Plastic greenhouse half-flats (10" x 10" x 2") were used. To limit seed predation solely to rodents and birds, it was necessary to exclude ants. Drainage holes in the flats were sealed with acrylic caulking and the inner sides were coated with Tanglefoot, a sticky, non-toxic compound that creates a physical barrier to ants. In addition, to exclude all seed predators as a control, one half of all flats were fitted with 1/4 in. hardware cloth. It was assumed that the screen would permit the fruits of both species to pass. This, however, proved not to be the case for fruits of A. viscida and neither seed production nor seed predation data was obtained for this species.

Six seed trays were randomly placed within each of the five stands of A. myrtifolia and five adjacent stands of A. viscida. A total of 30 trays for each species was used. Random placement involved dividing each stand by a single line. Using a random numbers table, points along this line were selected. A perpendicular transect was laid out and points at five or ten meter intervals, depending on the size of the stand, were marked. Perpendicular transects were laid out over each point and a second point was randomly selected. Seed trays were placed underneath plants intersected by the line. Trays were held in place by metal pins pounded into the ground.

Seed trays were placed mid-March, 1987, before fruits had matured. Those trays placed underneath A. myrtifolia were retrieved in July once fruit drop was complete. Numbers of whole fruits, individual seeds, and aborted fruits were counted and recorded. The number of seeds recovered from flats with exclosure screens was compared to flats left open to predation. The average number of seeds per fruit and average seed weight were also calculated.

Appendix 4

Seed Viability Tests

Fresh seeds of A. myrtifolia (n=70) and A. viscida (n=38) were tested for average percent viability using 0.5% tetrazoleum. Seeds were selected randomly, cut in half, and both halves were placed in one depression of porcelain spot trays. Depressions were filled with 0.5% tetrazoleum solution and placed in the dark. Initially, seeds were checked every few hours for evidence of respiration. It was necessary, however, to leave seeds in the solution for up to 40 hours before respiration could be observed. The total number of seeds reacting positively was divided by the total number of seeds tested. The same procedure was repeated for one year old A. viscida seeds sifted out of mass soil collections made before the current year's fruits had matured.

Appendix 5

Seed Banks

Mass soil collections were made (n=15) within each of three zones described as pure A. myrtifolia, pure A. viscida and a transition between the two. Three of the six seed trays placed within pure stands of both species were chosen as locations for the collection of soil. Selections were based on the flip of a coin. Mass collections from transition zones were randomly taken from the perimeter of each of the five pure stands of A. myrtifolia. In order for a site to be selected as a transition zone, both species of Arctostaphylos needed to be present. Metal frames (20cm x 20cm) were laid out and samples were 5-10 cm deep were collected.

Mass collections were made in April, 1987. Labeled samples were air dried for two weeks and heated in thin layers in a soil oven to 100 C for 30 minutes. Soil samples were mixed with approximately 15% Perlite and spread into 10 in. x 10 in. half-flats over a 1 cm layer of washed river sand. It was believed that the Perlite might increase germination by improving porosity of these heavy clay soils. Due to the large amount of soil some samples were divided among two or three flats to limit the thickness of any given sample to three centimeters. Flats were placed on benches in an unheated greenhouse in early June, 1987.

In conjunction with the heat treatment of soil collections, a charrate powder made from finely ground, charred plant stems was applied to the surface of all seed banks. Stems of Adenostoma fasciculatum of less than pencil thickness were collected from Bolinas Ridge, Marin County. Material was charred with a propane torch and snuffed out before turning to ash. Charred material was ground using a Wiley mill fitted with a #20 screen. Charrate was sprinkled evenly over the surface of each soil sample at the rate of 0.04 grams per 50 cc of soil (Keeley, 1984). In order to stimulate the germination of any remaining seeds a second treatment was applied after two months.

As seedlings began to appear they were carefully described and numbers were assigned to those species not immediately identifiable. Each new seedling was assigned an ID number and the flat sample number in which it had germinated was recorded. As seedlings became identifiable, even those individuals that had died before reaching maturity could be identified by their ID number. New seedlings were counted every two weeks for six months. The total number of individuals of each species found in each sample was determined and number of seeds of each species per square meter calculated.

Appendix 6

Heat/Moisture Germination Experiment

A mass soil collection from beneath individuals of _A. myrtifolia_ was made. Collection included the O and A horizons in order to include as many seeds as possible. Soil was sifted with a 2 mm screen. To determine the percent moisture in air dry soil five small tins were pre-weighed, filled with soil then weighed again. Tins were then placed in an oven and heated at 80°C for two days. Tins and soil were again weighed, weights of the tins subtracted and the weight of oven-dried samples obtained. The average percent moisture of air-dried soil was calculated at

4.8 percent.

Two 15 pound soil samples were weighed out. To one sample, enough water was added to raised its moisture content to 30 percent. The two samples were heated separately in thin layers to 100°C for 30 minutes in a soil oven. Soils from each treatment were placed into 13 half-flats over a 1 cm layer of sand. Powdered charred material was applied evenly over the surface of each flat at the rate of 0.04 grams per 50 cc of soil. Flats were placed on greenhouse benches and watered. For four months all seedlings were counted and identified. Treatments were compared by species and numbers of individuals germinated.

Appendix 7

Soil Samples

Soil samples (n=5) were collected from each of the six vegetation zones described above. Sampling sites were randomly selected. Within stands of _A. myrtifolia_ and _A. viscida_ sampling sites were chosen based on the same criteria used in placement of seed trays. One soil sample was collected from each of the five stands designated as pure _A. myrtifolia_ and adjacent stands of _A. viscida_. Locations to be sampled from zones designated as last _A. myrtifolia_, first _Adenostoma fasciculatum_, mixed, and pure _Quercus_ were determined by walking transects through vegetation exhibiting these transitions. Samples were collected based solely on how well a site fit the description of the zone to be sampled. If a zone wasn't present along a given transect no sample could be taken. A matching set of soil samples was collected from another site near the intersection of

Lambert Road and Carbondale Road to the north of Ione.

In collecting soil samples, surface litter was brushed away and 10 cm x 10 cm squares were exhumed to a depth of 10 cm. Within stands of _A_. _myrtifolia_, the soil was usually too hard and shallow to obtain a sample 10 cm deep. In such places, samples were taken only to 5 cm. Samples were placed in labeled plastic bags and stored unsealed until analyzed. For analysis, 100 gram sub-samples were taken from each thoroughly mixed, air dried sample. Samples were analyzed for pH, percent organic matter, total available N, P, K, Ca, Mg, sulfate, Cl, Na, Mn, Fe, Cu, Zn, B, and Al.

Appendix 8

Leaf Samples

Leaf samples (n=5) were collected for each species associated with each zone. Leaves were collected from plants adjacent to each site from which a soil sample was taken. Sub-terminal leaves were stripped away by hand making sure to keep petioles intact. Neither new leaves nor older leaves on a stem were used. Leaves were placed in labeled plastic bags and stored unsealed. For analysis, sub-samples consisting of 20-30 leaves were taken randomly from each sample. Corresponding leaf samples were also collected adjacent to soil sample sites from the Lambert Road location. Samples were analyzed for total N, P, K, Ca, Mg, Fe, Mn, and Al.

Appendix 9

Permanent Plots

At the Apricum Hill Reserve 60 permanent plots have been installed and mapped. While the collection of soil and leaf samples was based on the presence of six distinctive vegetation zones only four were determined to be functional for the purpose of placing permanent plots. Fifteen 1m x 2m plots each were placed in zones described as pure A. myrtifolia, pure A. viscida, and mixed. Fifteen and 3m x 5m plots were placed on sites described as pure Quercus.

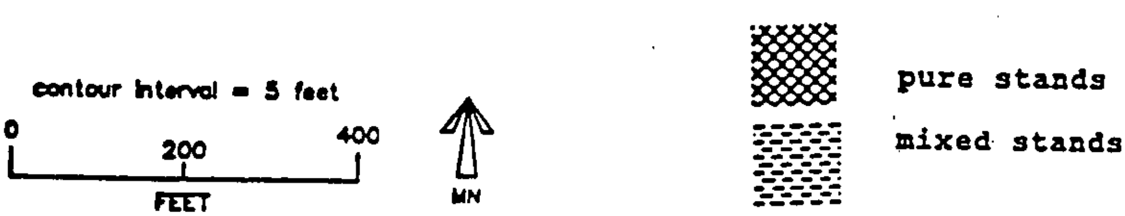
Plots were placed randomly within zones that met the required characteristics. A transect was laid out through each stand and random numbers were utilized to determine at what point along each transect a plot was to be placed. Each point selected was arbitrarily designated as the northeast corner of the plot. All plots are oriented in a north-south fashion. Plots were marked with 3/8in. x 10in. reinforcing steel rods hammered into the ground. To facilitate relocation, the ends of the stakes were sprayed with fluorescent red paint. In addition, red flagging tape was tied to the northeast stake of each plot. Flagging tape was tied to all stakes of plots in especially thick brush and was also tied onto branches adjacent to trails indicating the beginning of transects. Once the plots were in place, numbers of individuals of each species were counted and their cover was estimated. The sum of this data was used to determine relative cover and density per square meter for each species.

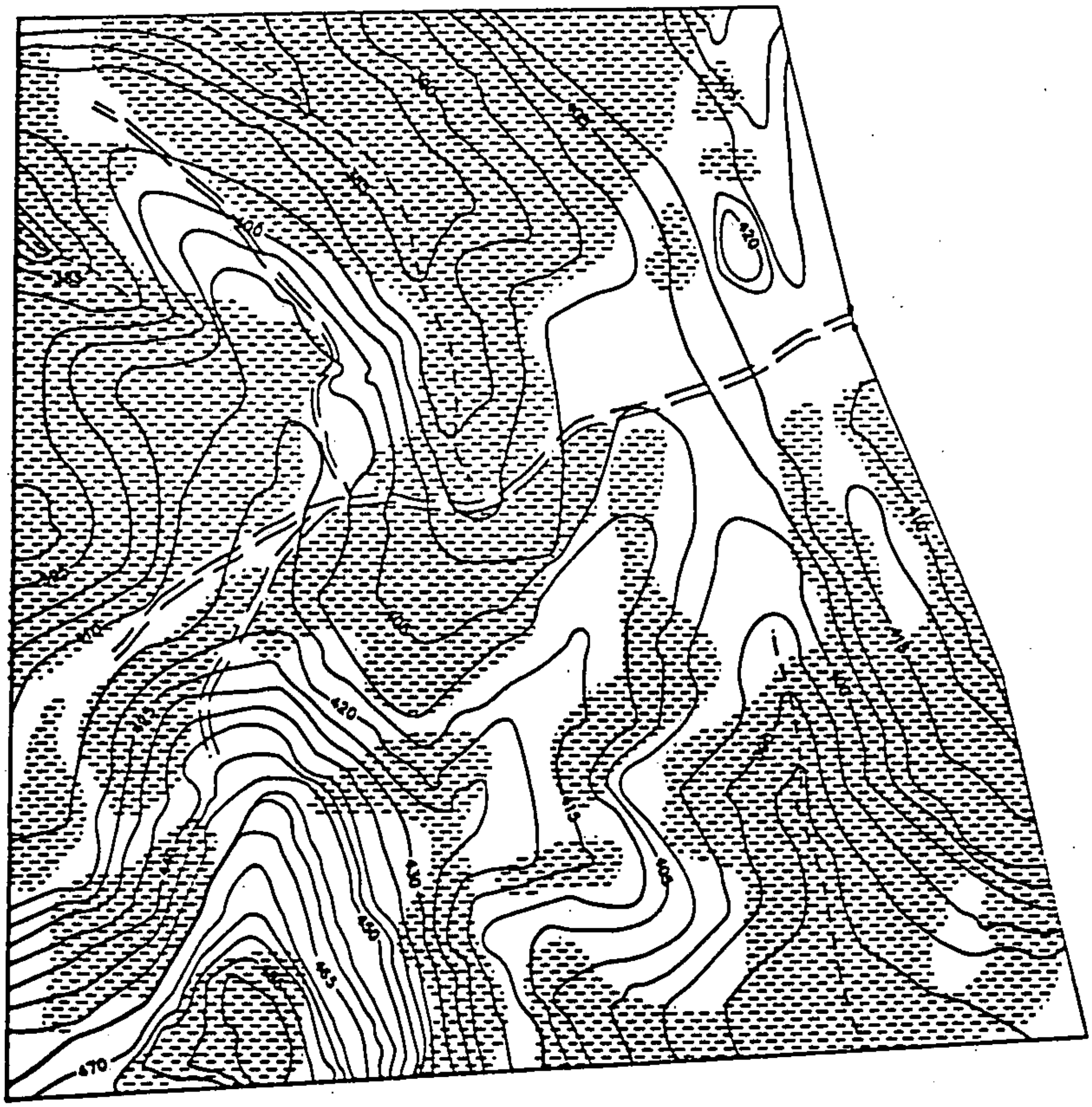
List of Maps

Distribution of Woody Species on the Apricum Hill Reserve

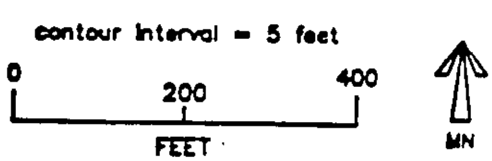
Appendix no.

Distribution of <u>Arctostaphylos</u> <u>myrtifolia</u> Parry
at the Apricum Hill Ecological Reserve

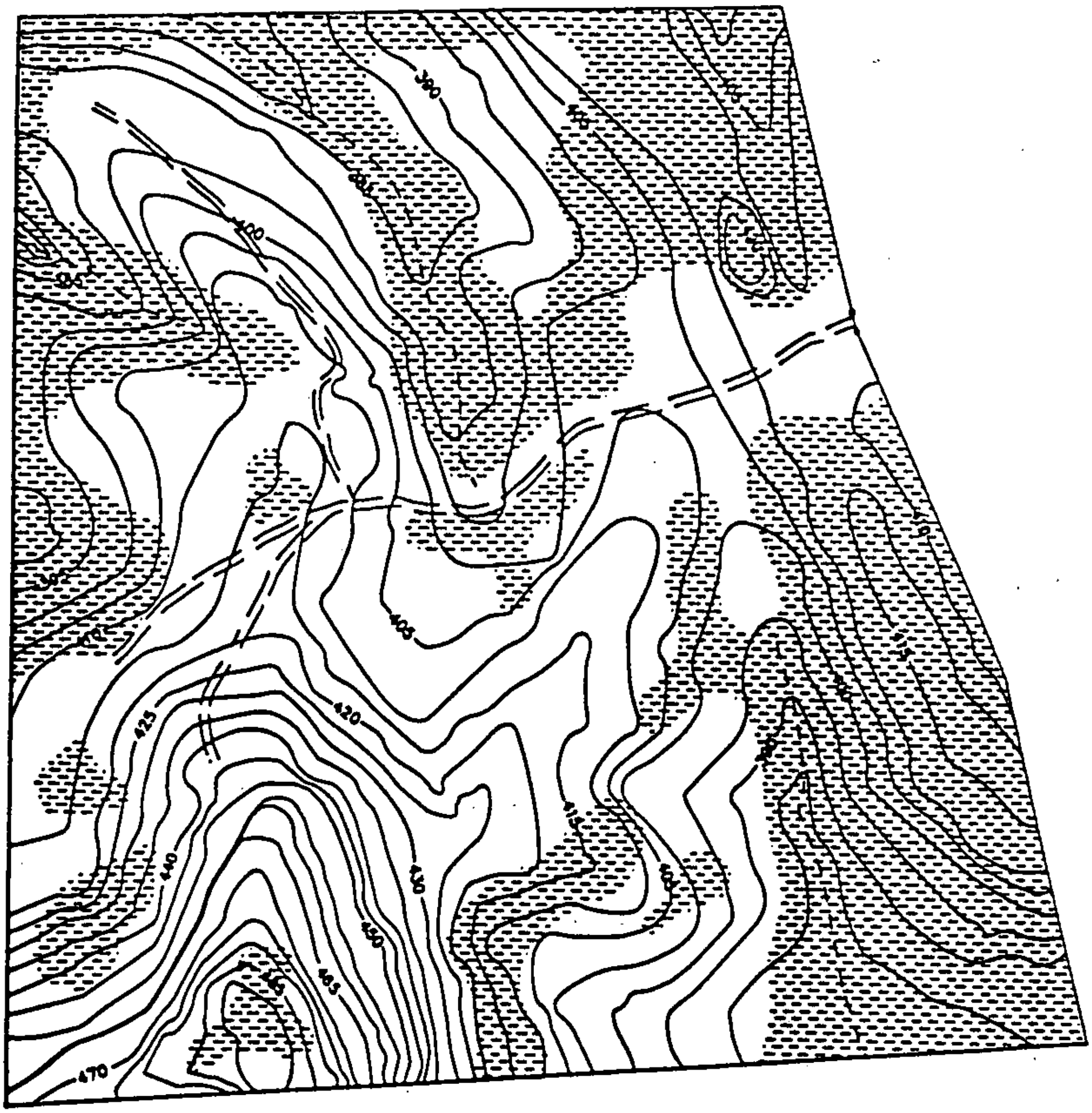




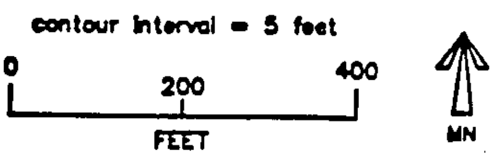
Distribution of Arctostaphylos viscida Parry
at the Apricum Hill Ecological Reserve



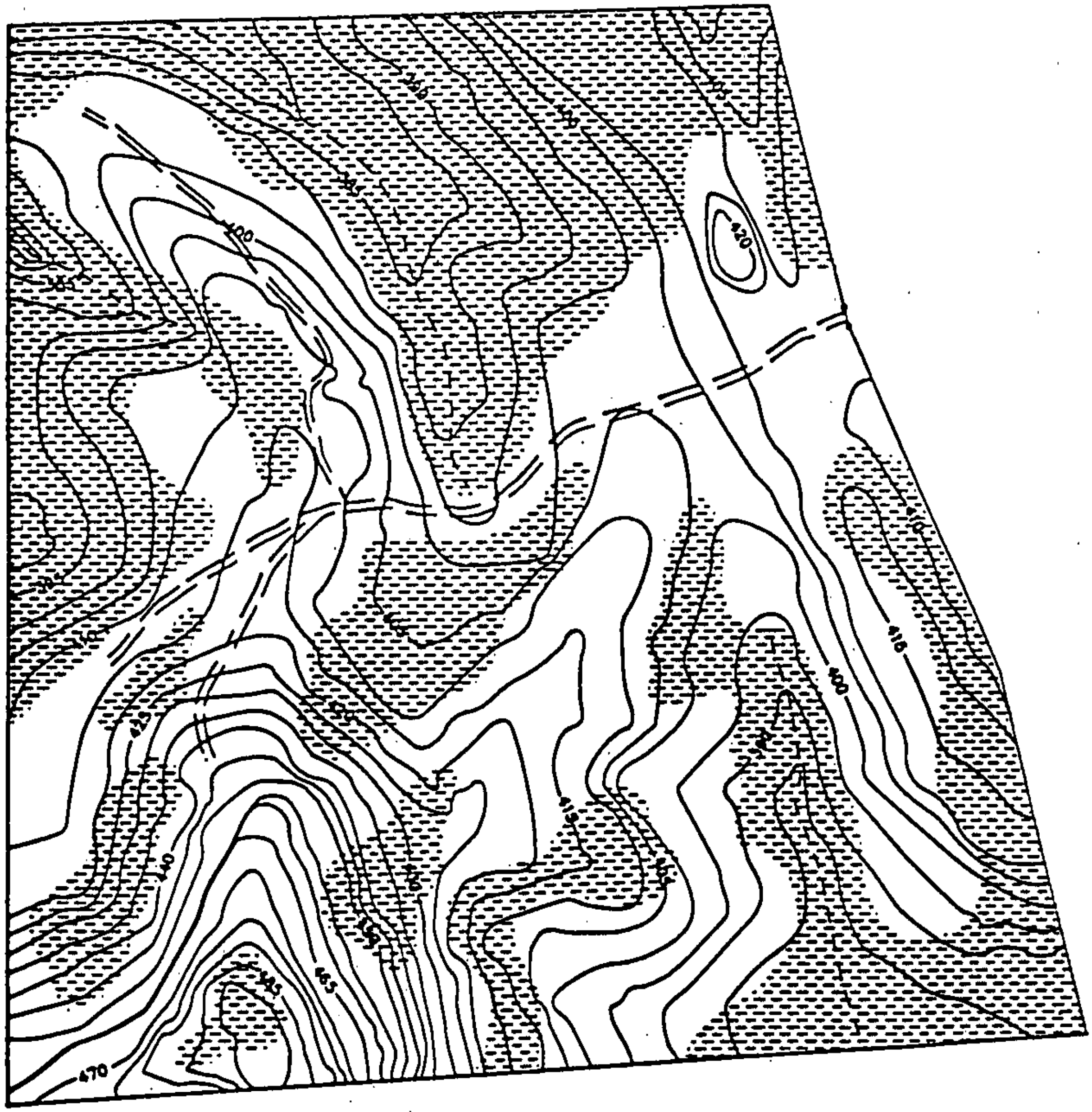
Appendix 12



Distribution of Adenostoma fasciculatum H. & A.
at the Apricum Hill Ecological Reserve



Appendix 13



Distribution of Quercus wislizenii var. frutescens Engelm. at the Apricum Hill Ecological Reserve

contour interval = 5 feet

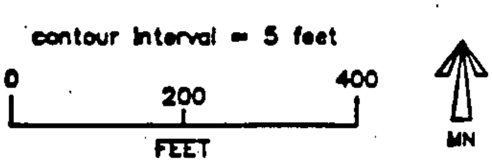
0 200 400

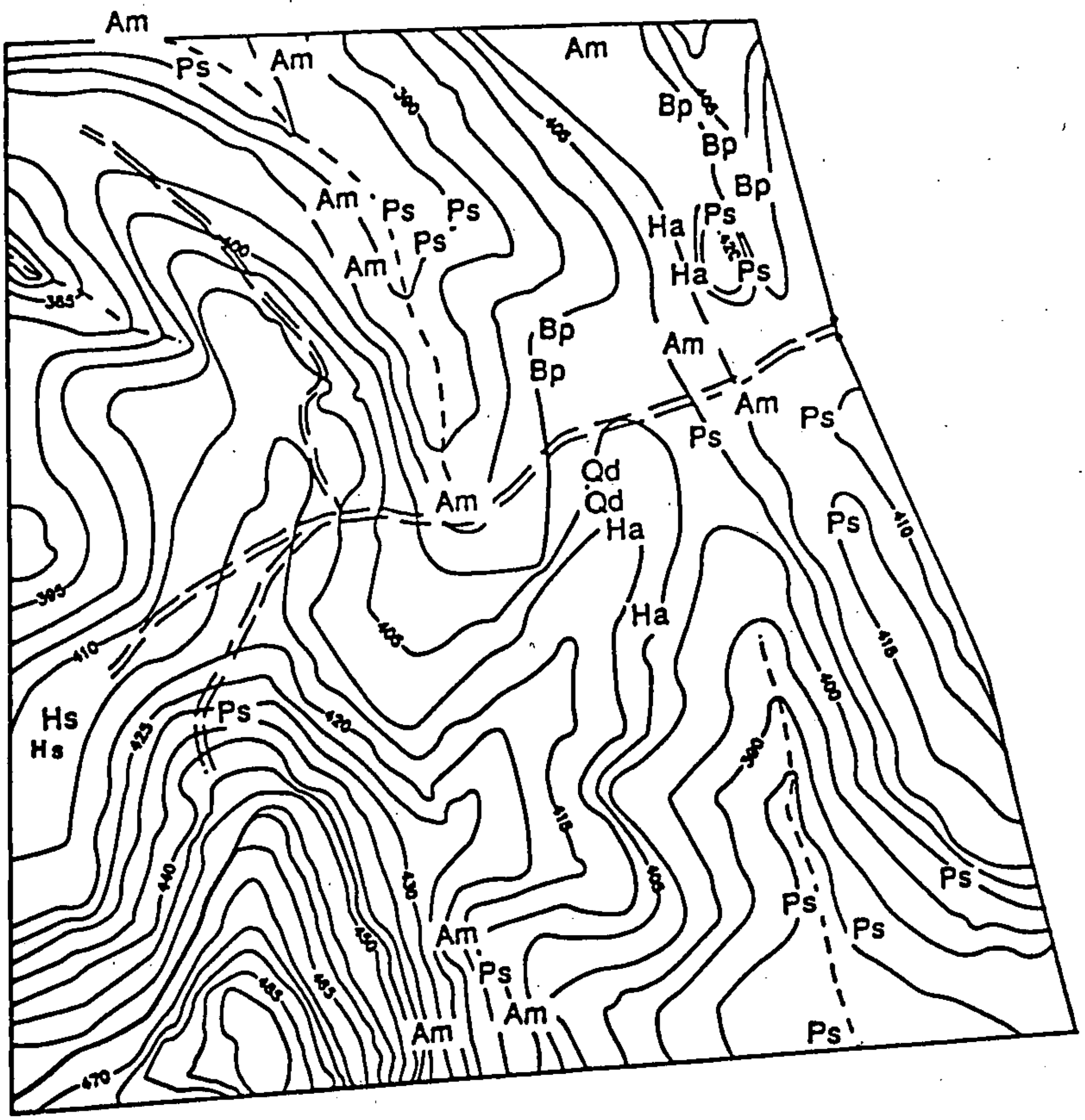
FEET

MN

Appendix 14

Distribution of <u>Quercus</u> <u>wislizenii</u> A. DC.





Distribution of Miscellaneous Species at the Apricum Hill Ecological Reserve

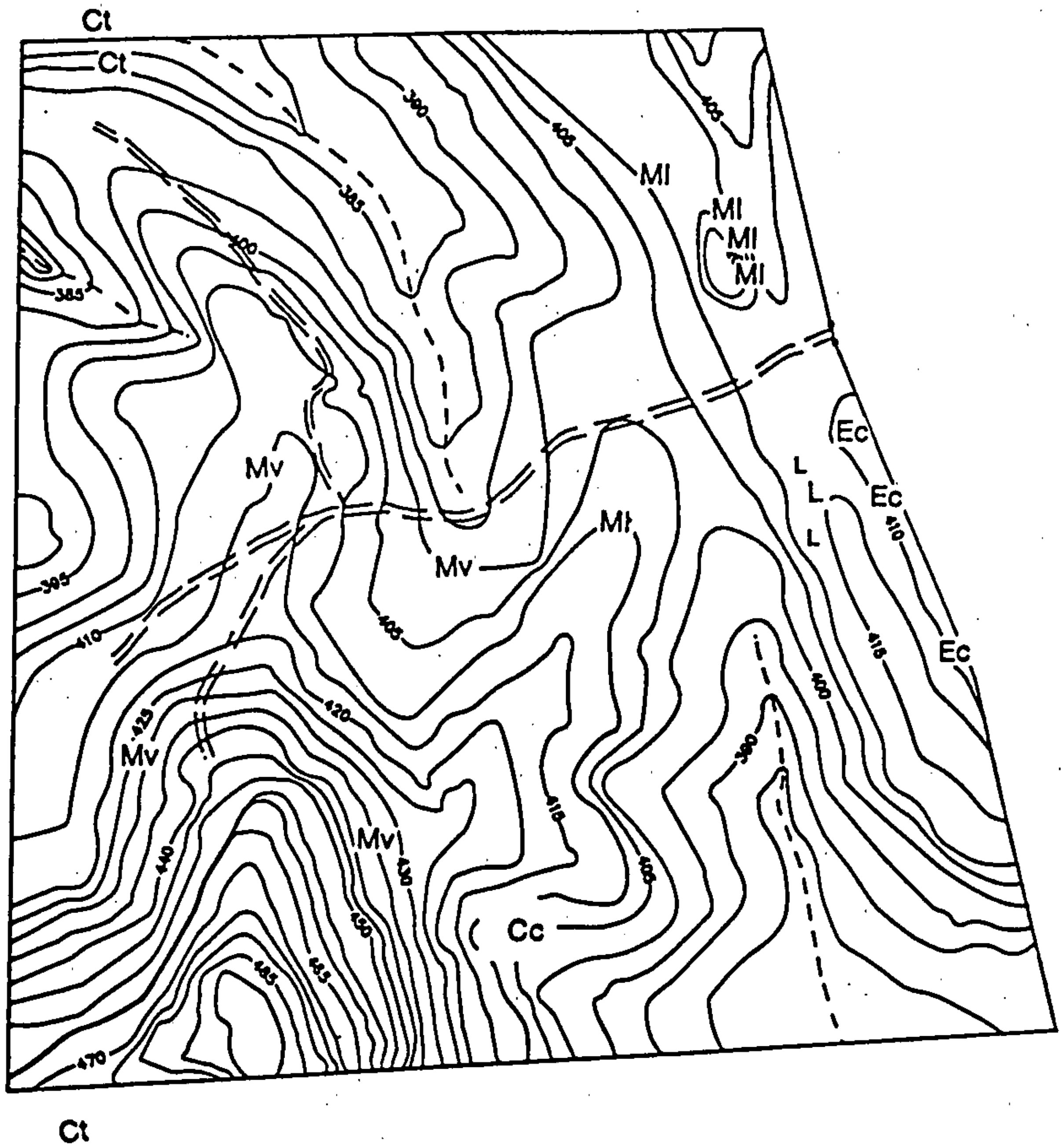
contour interval = 5 feet

0 200 400
FEET

MN

Am - *Arctostaphylos manzanita*
Bp - *Baccharis pilularis* ssp. *consanguinea*
Hs - *Helianthemum suffrutescens*
Ha - *Heteromeles arbutifolia*
Ps - *Pinus sabiniana*
Qd - *Quercus douglasii*

Appendix 16



Distribution of Miscellaneous Species at the Apricum Hill Ecological Reserve

contour interval = 5 feet

0 200 400
FEET

MN

Cc - <u>Ceanothus cuneatus</u>
Ct - <u>Ceanothus tomentosus</u>
Ec - <u>Eriodictyon californicum</u>
L - <u>Lotus scoparius</u>
Ml - <u>Mimulus longiflorus</u>
Mv - <u>Mimulus viscidus</u>

Appendix 17

Soils Data from Apricum Hill
Collected June, 1987

total extractable (ppm)
Eriogonum apricum var. *apricum* zones

	plot # 1	2	3	4	5	avg	std dev
pH	3.9	3.5	4.1	3.5	3.6	3.72	0.24
% organic matter	1.3	0	1	0.5	0	0.56	0.52
total N	3.5	8	9	1.5	6.5	5.7	2.8
total P_2O_5	1.5	0.5	1.5	1.5	7.5	2.5	2.53
total K_2O	10	11	7.5	6	5.5	8	2.17
total Ca	105	305	55	195	275	187	95.79
total Mg	46	55	7	60	33	40.2	18.97
total SO_4	185	265	60	205	360	215	98.54
total Cl	16	19	2	4	1.5	8.5	7.46
total Na	11	10	5.5	5	12.5	8.8	3.01
total Mn	0	0	0	0	0	0	0
total Fe	-	-	-	-	-	-	-
total Cu	0.36	0.18	0.32	0.24	0.12	0.24	0.09
total Zn	0.44	0.32	0.2	0.18	0.4	0.31	0.1
total B	0.08	0.12	0.02	0.02	0.02	0.05	0.04
total Al	-	-	-	-	-	-	-
% sand	62	36	54	42	62	51.2	10.55
% silt	14	14	12	10	10	12	1.79
% clay	24	50	34	48	28	36.8	10.48

pure *Arctostaphylos myrtifolia* zones

	1	2	3	4	5	avg	std dev
pH	4.4	4.6	4.6	4.3	4.2	4.42	0.16
% organic matter	3.1	4.4	3.2	2.7	2.7	3.22	0.62
total N	2.5	2.5	1.5	5.5	8.5	4.1	2.58
total P_2O_5	1.5	3	3	1.5	3	2.4	0.73
total K_2O	25	40	20	15	15	23	9.27
total Ca	35	140	75	50	135	87	43.2
total Mg	17	39	23.5	13.5	60	30.6	17.1
total SO_4	26.5	29.5	26	48.5	28.5	31.8	8.45
total Cl	5	6	2.5	2.5	2	3.6	1.59
total Na	5	2.5	2.5	1.5	3	2.9	1.16
total Mn	0.1	0.05	0.05	0	0	0.04	0.04
total Fe	1300	1500	1500	1200	1300	1360	120
total Cu	0.38	0.34	0.2	0.12	0.24	0.26	0.09
total Zn	1.1	0.6	0.48	0.38	0.28	0.57	0.29
total B	0.4	0.02	0.08	0.2	0.2	0.18	0.13
total Al	2800	2600	2100	1800	1800	2220	412
% sand	41	57	67	69	41	55	12.13
% silt	33	18	11	12	28	20.4	8.73
% clay	26	25	22	19	31	24.6	4.03

first *Arctostaphylos viscida* zones

	plot # 1	2	3	4	5	avg	std dev
pH	4.8	4.6	4.0	4.9	4.7	4.6	0.32
% organic matter	2.1	3.5	3.3	1.6	2.6	2.62	0.71
total N	6.5	2.5	2.5	2.5	5	3.8	1.7
total P_2O_5	3	3	4.5	3	3	3.3	0.6
total K_2O	25	25	20	15	15	20	4.47
total Ca	70	35	15	35	135	58	42.38
total Mg	50	17	9	22	90	37.6	29.61
total SO_4	50	48	65	36	150	69.8	41.15
total Cl	0.5	1.5	5	3.5	1	2.3	1.69
total Na	1	1.5	6	5	2	3.1	2.01
total Mn	0.1	0	0	0	0.05	0.03	0.04
total Fe	1620	880	1100	800	540	988	363
total Cu	0.28	0.24	0.7	0.36	0.48	0.41	0.17
total Zn	0.7	0.36	0.55	0.24	0.65	0.5	0.17
total B	0.44	0.28	0.32	0.02	0.8	0.37	0.25
total Al	3200	2800	1800	3100	1700	2520	643
% sand	36	63.4	67.4	50	50	53.36	11.15
% silt	24	10.6	10.6	10	22	15.44	6.21
% clay	40	26	22	40	28	31.2	7.44

last *Arctostaphylos myrtifolia* zones

	plot # 1	2	3	4	5	avg	std dev
pH	4.8	4.8	4.6	4.9	4.8	4.78	0.1
% organic matter	2.4	3.7	3.4	2.9	2.9	3.06	0.45
total N	3.5	4.5	2.5	10.5	3	4.8	2.93
total P_2O_5	4.5	5	4.5	7	5.5	5.3	0.93
total K_2O	20	30	25	25	25	25	3.16
total Ca	55	50	20	115	35	55	32.4
total Mg	42.5	19.5	8.5	45.5	11.5	25.5	15.56
total SO_4	155	160	225	140	135	163	32.34
total Cl	2	1.5	0.5	2.5	3.5	2	1
total Na	1	4	1.5	7.5	4	3.6	2.31
total Mn	0	0	0	0.25	0	0.05	0.1
total Fe	1820	2700	1400	1670	1600	1838	452
total Cu	0.28	0.18	0.12	0.12	0.18	0.18	0.06
total Zn	0.46	0.9	0.7	0.55	0.55	0.63	0.15
total B	0.2	0.02	1	0.48	0.24	0.39	0.34
total Al	1900	1400	980	2100	1100	1496	438
% sand	58	74	19.4	55.4	86	58.56	22.52
% silt	28	12	14.6	10.6	8	14.64	7.01
% clay	14	14	66	34	6	26.8	21.67

first *Adenostoma fasciculatum* zones

	plot #						std
	1	2	3	4	5	avg	dev
pH	4.4	4.8	4.7	5.1	5.2	4.84	0.29
% organic matter	4.0	4.0	3.5	3.2	3.8	3.7	0.31
total N	5	3	1.5	3	1	2.7	1.4
total P_2O_5	3	6	4.5	6	6	5.1	1.2
total K_2O	40	40	30	25	20	31	8
total Ca	135	45	220	210	165	155	63.01
total Mg	60	33	65	60	60	55.6	11.46
total SO_4	26.5	85	31	34	23	39.9	22.86
total Cl	3	3.5	4.5	1.5	1	2.7	1.29
total Na	2.5	1	1	1.5	0.5	1.3	0.68
total Mn	0	0	0.35	0.3	0.25	0.18	0.15
total Fe	2000	3800	1600	4000	4300	3140	1113
total Cu	0.14	0.42	0.18	0.18	0.16	0.22	0.1
total Zn	0.6	1.9	1.6	1.55	1.4	1.41	0.44
total B	0.12	0.08	0.08	0.2	0.24	0.14	0.06
total Al	2400	3500	710	2200	3000	2362	944
% sand	76	74	70	62	100	76.4	12.74
% silt	12	14	20	18	0	12.8	7
% clay	12	12	10	20	0	10.8	6.4

mixed vegetation zones

	plot #						std
	1	2	3	4	5	avg	dev
pH	4.8	4.3	4.4	4.9	5.3	4.74	0.36
% organic matter	5.1	4.6	4.1	2.6	2.6	3.8	1.03
total N	3.5	5.5	3.5	0.5	3	3.2	1.6
total P_2O_5	2.5	3.5	2.5	2	3.5	2.8	0.6
total K_2O	25	55	50	30	25	37	12.88
total Ca	100	110	200	215	345	194	88.51
total Mg	21.5	30	55	29	49	36.9	12.82
total SO_4	140	135	175	55	125	126	39.29
total Cl	9	10	12	7	6	8.8	2.14
total Na	10	7.5	2.5	10	5	7	2.92
total Mn	1.8	0.3	0.45	0.25	0.5	0.66	0.58
total Fe	580	600	950	980	950	812	182
total Cu	1.8	0.9	0.55	0.18	0.14	0.71	0.61
total Zn	0.02	0.04	0.04	0.06	0.04	0.04	0.01
total B	0.4	0.2	0.05	0.05	0.4	0.22	0.16
total Al	1800	1300	1000	1300	1500	1380	264
% sand	43.4	28	76	51.4	75.4	54.84	18.62
% silt	34.6	44	12	38.6	14.6	28.76	13
% clay	22	28	12	10	10	16.4	7.31

pure *Quercus wislizenii* zones

	plot# 1	2	3	4	5	avg	std dev
pH	4.7	4.6	4.2	4.9	5.1	4.7	0.3
% organic matter	8.2	9.5	8.5	6.0	4.8	7.4	1.73
total N	11.5	5.5	5.5	12.5	11	9.2	3.06
total P_2O_5	4.5	3	4.5	3	3	3.6	0.73
total K_2O	50	55	65	50	40	52	8.12
total Ca	50	60	30	40	60	48	11.66
total Mg	20	18	13.5	16	26.5	18.8	4.41
total SO_4	40	41	39.5	30.5	23.5	34.9	6.84
total Cl	11	8	9	2.5	4	6.9	3.17
total Na	7.5	5	4	2	2	4.1	2.06
total Mn	0	1.4	0.2	0.75	0.35	0.54	0.5
total Fe	2100	2500	3100	2800	2000	2500	112.4
total Cu	0.22	0.4	0.38	0.95	0.32	0.45	0.26
total Zn	0.4	2.8	14	3.65	1.85	4.54	4.85
total B	0.16	0.02	0.08	0.04	0.04	0.07	0.05
total Al	2900	1800	2300	3600	1600	2440	734
% sand	54	45.4	62	67.4	72	60.16	9.5
% silt	30	30.6	30	18.6	16	25.04	6.38
% clay	16	24	8	14	12	14.8	5.31

Appendix 18

Soils Data from Lambert Road
Collected June, 1987

total extractable ppm
pure *Arctostaphylos myrtifolia* zones

	plot # 1	2	3	4	5	avg	std dev
pH	4.7	4.4	4.4	3.6	4.7	4.36	0.4
% organic matter	3.1	3.3	2.7	1.8	2.8	2.74	0.52
total N	7.5	7.5	6.5	7.5	8.5	7.5	0.63
total P_2O_5	6.5	5.5	6	5.5	5.5	5.8	0.4
total K_2O	45	25	20	17.5	20	25.5	10.05
total Ca	445	150	125	80	160	192	129.48
total Mg	34	25	60	17	41	35.4	14.73
total SO_4	70	75	55	255	60	103	76.33
total Cl	11	6	16	10	8	10.2	3.37
total Na	15	15	12.5	15	10	13.5	2
total Mn	0.15	0.05	0.1	0.15	0.05	0.1	0.04
total Fe	1500	890	600	680	500	834	357
total Cu	1	1.2	0.8	0.4	1	0.88	0.27
total Zn	1.55	1.25	1.1	0.46	1.2	1.11	0.36
total B	0.05	0.2	0.4	1.2	0.8	0.53	0.42
total Al	1600	1400	2000	1800	1000	1560	344
% sand	43	58	50	29	49	45.8	9.66
% silt	30	14	18	21	20	20.6	5.28
% clay	27	28	32	50	31	33.6	8.4

first *Arctostaphylos viscida* zones

	1	2	3	4	5	avg	std dev
pH	4.7	4.5	4.9	4.4	4.7	4.64	0.17
% organic matter	3.3	7.8	4.2	3.9	4.5	4.74	1.58
total N	8	8.5	11	7	6.5	8.2	1.57
total P_2O_5	5.5	5.5	5.5	5.5	6	5.6	0.2
total K_2O	30	30	35	20	30	29	4.9
total Ca	75	65	60	45	90	67	15.03
total Mg	32.5	29.5	37.5	28.5	38	33.2	3.94
total SO_4	47	48.5	65	60	50	54.1	7.1
total Cl	5	8	10	6	10	7.8	2.04
total Na	10	10	20	10	10	12	4
total Mn	0.05	0.05	0.05	0.05	0.05	0.05	0
total Fe	900	400	340	610	500	550	198
total Cu	0.6	0.6	0.6	0.8	0.6	0.64	0.08
total Zn	1.1	3.2	2.4	1.25	2.2	2.03	0.78
total B	0.2	0.2	0.2	0.2	0.2	0.2	0
total Al	2700	1100	980	2000	1600	1676	629
% sand	77	72	66	63	64	68.4	5.31
% silt	18	18	21	19	26	20.4	3.01
% clay	5	10	13	18	10	11.2	4.26

last *Arctostaphylos myrtifolia* zones

	plot # 1	2	3	4	5	avg	std dev
pH	4.7	4.5	4.6	4.7	4.7	4.64	0.08
% organic matter	9.2	3.6	3.5	10.0	2.4	5.74	3.19
total N	7.5	6	4.5	6	2.5	5.3	1.69
total P_2O_5	5.5	6	5.5	5.5	5.5	5.6	0.2
total K_2O	35	30	30	30	25	30	3.16
total Ca	135	75	100	40	95	89	31.21
total Mg	60	50	60	27	41.5	47.7	12.45
total SO_4	55	60	50	110	55	66	22.23
total Cl	9.5	7.5	12	9	10.5	9.7	1.5
total Na	15	15	15	15	20	16	2
total Mn	0.1	0.1	0.1	0.05	0.1	0.09	0.02
total Fe	2300	1600	2300	4300	2000	2500	936
total Cu	0.6	0.6	0.6	1	0.8	0.72	0.16
total Zn	6	2.6	3.2	1.65	7.5	4.19	2.2
total B	0.2	0.6	0.2	0.2	0.2	0.28	0.16
total Al	3400	1600	2700	6100	1400	3040	1695
% sand	51.4	76	80	54	83	68.88	13.42
% silt	30	13	13	30	9	19	9.1
% clay	18.6	11	7	16	8	12.12	4.51

first *Adenostoma fasciculatum* zones

	plot # 1	2	3	4	5	avg	std dev
pH	4.6	4.6	4.4	4.6	4.6	4.56	0.08
% organic matter	8.8	3.7	4.0	9.0	8.3	6.76	2.39
total N	3	3	5	4.5	1.5	3.4	1.24
total P_2O_5	5.5	2.5	2	1.5	1.5	2.6	1.5
total K_2O	40	40	35	30	30	35	4.47
total Ca	105	60	85	165	105	104	34.7
total Mg	22.5	24.5	29.5	12.5	20.5	21.9	5.57
total SO_4	175	185	120	130	140	150	25.5
total Cl	7	6	4	5	12	6.8	2.79
total Na	5	5	5	2.5	1	3.7	1.66
total Mn	0.55	0.2	0.4	0.2	0.3	0.33	0.13
total Fe	3500	2200	2400	3800	2500	2880	643
total Cu	0.16	0.08	0.1	0.08	0.18	0.12	0.04
total Zn	0.02	0.04	0.02	0.08	0.04	0.04	0.02
total B	0.2	0.2	0.4	0.2	0.4	0.28	0.1
total Al	5400	3300	3100	5800	4300	4380	1083
% sand	71	73	67	57	67	67	5.5
% silt	20	20	26	24	26	23.2	2.7
% clay	9	7	7	19	7	9.8	4.6

mixed vegetation zones

	plot# 1	2	3	4	5	avg	std dev
pH	4.8	4.6	4.5	4.6	4.6	4.62	0.1
% organic matter	3.9	5.5	1.8	6.3	3.9	4.28	1.55
total N	6	5.5	14	14.5	7.5	9.5	3.94
total P_2O_5	5.5	5.5	5.5	5.5	5.5	5.5	0
total K_2O	25	25	30	45	30	31	7.35
total Ca	50	40	45	100	35	54	23.54
total Mg	35	25.5	21.5	50	26.5	31.7	10.15
total SO_4	70	60	90	70	60	70	10.95
total Cl	11	5.5	6	5.5	4	6.4	2.4
total Na	17.5	15	15	25	15	17.5	3.87
total Mn	0.15	0.05	0.1	0.1	0.1	0.1	0.03
total Fe	380	380	380	330	500	394	56
total Cu	0.6	0.6	0.6	0.8	0.4	0.6	0.13
total Zn	0.9	1.3	1.3	2	1.9	1.48	0.41
total B	0.2	1.6	1.2	1.8	2	1.36	0.64
total Al	2100	2100	1500	1400	980	1616	432
% sand	65	70	61	49	85	66	11.76
% silt	22	12	20	17	7	15.6	5.46
% clay	13	18	19	34	8	18.4	8.73

pure *Quercus wislizenii* zones

	plot# 1	2	3	4	5	avg	std dev
pH	4.5	4.6	4.3	4.7	4.9	4.6	0.2
% organic matter	12.0	11.0	11.0	12.0	4.1	10.02	2.99
total N	7.5	3.5	1	2	1.5	3.1	2.35
total P_2O_5	20	3	2.5	2	4.5	6.4	6.85
total K_2O	50	30	25	45	35	37	9.27
total Ca	230	40	35	55	95	91	72.62
total Mg	46	18	26	29.5	26	29.1	9.25
total SO_4	135	145	110	100	150	128	19.65
total Cl	6	2.5	10.5	5	6	6	2.59
total Na	10	5	5	0	2.5	4.5	3.32
total Mn	2.85	0.35	0.9	0.35	0.4	0.97	0.96
total Fe	430	530	480	3000	4800	1848	1770
total Cu	0.06	0.08	0.55	0.24	0.1	0.21	0.18
total Zn	0.16	0.06	0.18	0.02	0.02	0.09	0.07
total B	0.4	0.2	0.4	0.2	0.2	0.28	0.1
total Al	1600	1400	890	7400	4600	3178	2479
% sand	69	71	71.4	64	73	69.68	3.11
% silt	16	20	19	24	14	18.6	3.44
% clay	15	9	9.6	12	13	11.72	2.21

Appendix 19

Leaf Analysis Data from Apricum Hill
Collected June, 1987

in percent dry weight

A. myrtifolia leaves from pure A. myrtifolia zones

	plot#						std
	1	2	3	4	5	avg	dev
N	0.6	0.47	0.37	0.39	0.47	0.46	0.081
P	0.018	0.025	0.02	0.002	0.02	0.017	0.008
K	0.16	0.16	0.11	0.13	0.11	0.134	0.022
Ca	0.47	0.67	0.39	0.53	0.52	0.516	0.092
Mg	0.073	0.15	0.13	0.17	0.13	0.131	0.032
Fe	0.016	0.03	0.02	0.03	0.013	0.022	0.007
Mn	0.003	0.003	0.005	0.008	0.008	0.005	0.002
Al	0.05	0.053	0.04	0.04	0.013	0.041	0.016

A. myrtifolia leaves from first A. viscida zones

	plot #						std
	1	2	3	4	5	avg	dev
N	0.71	0.75	0.61	0.75	0.6	0.684	0.066
P	0.011	0.009	0.005	0.02	0.025	0.014	0.007
K	0.3	0.25	0.15	0.25	0.19	0.228	0.052
Ca	0.45	0.73	0.35	0.36	0.19	0.416	0.178
Mg	0.093	0.21	0.19	0.12	0.17	0.157	0.044
Fe	0.011	0.013	0.007	0.008	0.031	0.014	0.009
Mn	0.005	0.003	0.002	0.003	0.003	0.003	0.001
Al	0.021	0.017	0.009	0.009	0.048	0.021	0.014

A. myrtifolia leaves from last A. myrtifolia zones

	plot #						std
	1	2	3	4	5	avg	dev
N	0.58	0.5	0.47	0.63	0.54	0.544	0.057
P	0.036	0.016	0.027	0.032	0.018	0.026	0.008
K	0.23	0.23	0.11	0.22	0.25	0.208	0.05
Ca	0.32	0.45	0.59	0.47	0.28	0.422	0.111
Mg	0.1	0.22	0.24	0.31	0.17	0.208	0.07
Fe	0.025	0.028	0.013	0.01	0.021	0.019	0.007
Mn	0.002	0.005	0.003	0.01	0.002	0.004	0.003
Al	0.05	0.045	0.021	0.021	0.027	0.033	0.012

A. *viscida* leaves from first A. *viscida* zones

	plot# 1	2	3	4	5	avg	std dev
N	0.54	0.73	0.65	0.93	0.65	0.7	0.13
P	0.015	0.059	0.011	0.034	0.029	0.03	0.017
K	0.35	0.36	0.15	0.25	0.25	0.272	0.077
Ca	0.73	0.5	0.52	0.32	0.37	0.488	0.143
Mg	0.24	0.19	0.31	0.15	0.29	0.236	0.06
Fe	0.035	0.033	0.017	0.012	0.046	0.029	0.012
Mn	0.003	0.002	0.009	0.001	0.002	0.003	0.003
Al	0.078	0.073	0.027	0.055	0.077	0.062	0.019

A. *viscida* leaves from last A. *myrtifolia* zones

	plot# 1	2	3	4	5	avg	std dev
N	0.82	0.63	0.71	0.97	0.82	0.79	0.115
P	0.029	0.019	0.04	0.076	0.041	0.041	0.019
K	0.5	0.53	0.72	0.7	0.62	0.614	0.088
Ca	0.8	0.31	0.67	0.55	0.39	0.544	0.179
Mg	0.27	0.21	0.2	0.29	0.25	0.244	0.034
Fe	0.012	0.021	0.025	0.027	0.019	0.021	0.005
Mn	0.003	0.002	0.003	0.002	0.003	0.003	0.001
Al	0.024	0.051	0.078	0.085	0.029	0.053	0.025

A. *viscida* leaves from first *Adenostoma* zones

	plot# 1	2	3	4	5	avg	std dev
N	0.54	0.73	0.75	0.49	0.62	0.626	0.102
P	0.05	0.029	0.039	0.039	0.086	0.049	0.02
K	0.26	0.22	0.33	0.25	0.29	0.27	0.037
Ca	0.37	0.19	1.0	0.87	0.59	0.604	0.301
Mg	0.17	0.27	0.26	0.25	0.29	0.248	0.041
Fe	0.035	0.023	0.012	0.011	0.022	0.021	0.009
Mn	0.001	0.001	0.008	0.002	0.001	0.003	0.002
Al	0.061	0.038	0.019	0.014	0.055	0.037	0.019

A. viscida leaves from mixed vegetation zones

	plot # 1	2	3	4	5	avg	std dev
N	0.93	0.88	0.67	0.82	0.71	0.802	0.099
P	0.039	0.02	0.006	0.029	0.018	0.022	0.011
K	0.28	0.25	0.23	0.23	0.23	0.244	0.02
Ca	0.73	0.73	0.8	0.3	0.25	0.562	0.236
Mg	0.11	0.23	0.24	0.2	0.19	0.194	0.046
Fe	0.052	0.007	0.01	0.005	0.01	0.017	0.018
Mn	0.003	0.001	0.001	0.001	0.001	0.001	0.001
Al	0.077	0.011	0.013	0.009	0.026	0.027	0.026

Adenostoma leaves from first *Adenostoma* zones

	plot # 1	2	3	4	5	avg	std dev
N	0.93	1.1	0.78	0.85	0.85	0.902	0.11
P	0.07	0.023	0.082	0.12	0.13	0.085	0.038
K	0.28	0.25	0.31	0.26	0.25	0.27	0.023
Ca	0.43	0.25	0.47	0.41	0.4	0.392	0.075
Mg	0.15	0.5	0.25	0.23	0.18	0.262	0.124
Fe	0.011	0.015	0.01	0.012	0.028	0.015	0.007
Mn	0.014	0.01	0.019	0.009	0.01	0.012	0.004
Al	0.013	0.021	0.021	0.031	0.03	0.023	0.007

Quercus leaves from mixed vegetation zones

	plot # 1	2	3	4	5	avg	std dev
N	4.9	1.8	1.3	1.3	1.2	2.1	1.416
P	0.028	0.031	0.043	0.039	0.039	0.036	0.006
K	0.53	0.5	0.53	0.46	0.43	0.49	0.039
Ca	0.39	0.32	0.38	0.33	0.34	0.352	0.028
Mg	0.2	0.15	0.22	0.19	0.21	0.194	0.024
Fe	0.031	0.007	0.014	0.008	0.006	0.013	0.009
Mn	0.088	0.038	0.02	0.018	0.011	0.035	0.028
Al	0.039	0.011	0.02	0.015	0.013	0.02	0.01

Quercus leaves from pure *Quercus* zones

	plot # 1	2	3	4	5	avg	std dev
N	2.5	3.9	1.0	1.2	1.0	1.92	1.137
P	0.041	0.019	0.033	0.043	0.037	0.035	0.009
K	0.6	0.48	0.59	0.53	0.6	0.56	0.048
Ca	0.45	0.21	0.29	0.35	0.41	0.342	0.085
Mg	0.17	0.13	0.2	0.23	0.27	0.2	0.048
Fe	0.011	0.01	0.012	0.024	0.015	0.014	0.005
Mn	0.045	0.038	0.037	0.027	0.024	0.034	0.008
Al	0.037	0.023	0.053	0.034	0.005	0.03	0.016

Appendix 20

Leaf Analysis Data from Lambert Rd.
Collected June, 1987

in percent dry weight

A. myrtifolia leaves from pure *A. myrtifolia* zones

	plot # 1	2	3	4	5	avg	std dev
N	0.61	0.7	0.73	0.67	0.75	0.692	0.049
P	0.011	0.016	0.018	0.013	0.019	0.015	0.003
K	0.28	0.38	0.4	0.43	0.41	0.38	0.053
Ca	0.22	0.34	0.45	0.28	0.14	0.286	0.105
Mg	0.075	0.075	0.084	0.053	0.054	0.068	0.012
Fe	0.085	0.04	0.083	0.045	0.29	0.109	0.093
Mn	0.003	0.006	0.007	0.003	0.005	0.005	0.001
Al	0.056	0.033	0.072	0.046	0.084	0.058	0.018

A. myrtifolia leaves from last *A. myrtifolia* zones

	plot # 1	2	3	4	5	avg	std dev
N	0.58	0.7	0.54	0.68	0.63	0.626	0.06
P	0.019	0.19	0.014	0.026	0.022	0.02	0.004
K	0.41	0.5	0.43	0.55	0.58	0.494	0.066
Ca	0.3	0.11	0.19	0.11	0.075	0.157	0.081
Mg	0.058	0.064	0.049	0.057	0.069	0.059	0.007
Fe	0.041	0.18	0.044	0.21	0.077	0.11	0.071
Mn	0.002	0.003	0.005	0.003	0.002	0.003	0.001
Al	0.034	0.072	0.036	0.071	0.063	0.055	0.017

A. viscida leaves from first *A. viscida* zones

	plot # 1	2	3	4	5	avg	std dev
N	0.64	0.98	0.77	0.73	0.66	0.756	0.121
P	0.046	0.051	0.038	0.045	0.049	0.046	0.004
K	0.38	0.55	0.45	0.5	0.45	0.466	0.057
Ca	0.71	0.71	1.1	0.61	0.39	0.704	0.23
Mg	0.27	0.26	0.28	0.28	0.21	0.26	0.026
Fe	0.067	0.042	0.015	0.035	0.051	0.042	0.017
Mn	0.002	0.003	0.005	0.002	0.001	0.003	0.001
Al	0.046	0.043	0.029	0.063	0.044	0.045	0.011

<u>Adenostoma</u> leaves from first <u>Adenostoma</u> zones

	plot # 1	2	3	4	5	avg	std dev
N	0.76	0.84	0.84	0.82	0.61	0.774	0.087
P	0.031	0.052	0.05	0.06	0.02	0.043	0.015
K	0.67	0.8	0.43	0.53	0.42	0.57	0.146
Ca	0.34	0.25	0.26	0.37	0.26	0.296	0.049
Mg	0.23	0.24	0.29	0.25	0.23	0.248	0.022
Fe	0.019	0.03	0.024	0.017	0.021	0.022	0.005
Mn	0.035	0.014	0.03	0.023	0.02	0.024	0.007
Al	0.035	0.031	0.027	0.032	0.023	0.03	0.004

<u>Adenostoma</u> leaves from mixed vegetation zones

	plot # 1	2	3	4	5	avg	std dev
N	1.2	1.1	0.97	0.79	1.1	1.032	0.141
P	0.051	0.034	0.052	0.012	0.064	0.043	0.018
K	0.55	0.47	0.53	0.4	0.67	0.524	0.09
Ca	0.43	0.41	0.61	0.59	0.42	0.492	0.089
Mg	0.26	0.31	0.41	0.45	0.27	0.34	0.076
Fe	0.027	0.009	0.013	0.017	0.016	0.016	0.006
Mn	0.031	0.032	0.022	0.022	0.014	0.024	0.007
Al	0.055	0.015	0.021	0.017	0.021	0.026	0.015

<u>Quercus</u> leaves from mixed vegetation zones

	plot # 1	2	3	4	5	avg	std dev
N	1.0	1.4	1.2	1.2	0.85	1.13	0.189
P	0.02	0.023	0.021	0.02	0.019	0.021	0.001
K	0.35	0.38	0.4	0.55	0.5	0.436	0.076
Ca	0.2	0.14	0.32	0.27	0.22	0.23	0.061
Mg	0.057	0.089	0.067	0.067	0.069	0.07	0.01
Fe	0.11	0.065	0.038	0.035	0.03	0.056	0.03
Mn	0.041	0.013	0.042	0.025	0.022	0.029	0.011
Al	0.068	0.053	0.036	0.044	0.026	0.045	0.014

<u>*Quercus*</u> leaves from pure <u>*Quercus*</u> zones

	plot #						std
	1	2	3	4	5	avg	dev
N	1.3	1.2	0.98	1.5	1.3	1.256	0.169
P	0.046	0.041	0.042	0.032	0.04	0.04	0.005
K	0.61	0.5	0.44	0.48	0.43	0.492	0.064
Ca	0.36	0.37	0.27	0.35	0.28	0.326	0.042
Mg	0.21	0.2	0.21	0.19	0.18	0.198	0.012
Fe	0.01	0.052	0.021	0.042	0.062	0.037	0.019
Mn	0.027	0.034	0.033	0.022	0.032	0.03	0.004
Al	0.021	0.039	0.03	0.019	0.063	0.034	0.016

Appendix 21

Coverage Data for *Arctostaphylos myrtifolia* Zones from Permanent Plots at Apricum Hill

plot #	# live A.myrt	# dead A.myrt	% cover A.myrt	# live A.visc	# dead A.visc	% cover A.visc	# live Chamise
1	5	0	65	0	0	0	0
2	4	3	82	0	0	0	0
3	7	3	70	2	0	.5	0
4	13	0	80	0	0	0	0
5	16	2	80	0	0	0	0
6	14	4	85	0	0	0	0
7	7	1	65	0	0	0	0
8	5	3	50	0	0	0	0
9	5	2	82	0	0	0	0
10	4	2	95	0	0	0	0
11	4	0	50	0	0	0	0
12	9	0	88	0	0	0	0
13	5	0	90	0	0	0	0
14	1	0	40	0	0	0	0
15	5	1	85	0	0	0	0
avg	6.9	1.4	73.8	0.13	0	0.33	0
sum	104	21		2	0		0
rel. cover			0.99			0.004	
density/m^2	3.5	0.7		0.07	0		0
freq/plot	1	0.6		0.07	0		0

plot #	# dead Chamise	% cover Chamise	# live Oak	# dead Oak	% cover Oak	% bare ground	total cover
1	0	0	1	0	2	33	
2	0	0	0	0	0	18	
3	0	0	1	0	3	25	
4	0	0	0	0	0	20	
5	0	0	0	0	0	20	
6	0	0	0	0	0	15	
7	0	0	0	0	0	35	
8	0	0	0	0	0	50	
9	0	0	0	0	0	18	
10	0	0	0	0	0	5	
11	0	0	0	0	0	50	
12	0	0	0	0	0	12	
13	0	0	0	0	0	10	
14	0	0	0	0	0	60	
15	0	0	0	0	0	15	
avg	0	0	0.13	0	0.33	25.7	74.5
sum	0		2	0			
rel. cover		0			0.004		
density/m^2	0		0.07	0			
freq/plot	0		0.13	0			

Appendix 22

Coverage Data for
Arctostaphylos viscida Zones
from Permanent Plots at Apricum Hill

plot #	# live A.myrt	# dead A.myrt	% cover A.myrt	# live A.visc	# dead A.visc	% cover A.visc	# live Chamise
1	1	0	5	9	0	95	0
2	0	1	0	2	0	98	0
3	0	0	0	5	0	100	0
4	0	0	0	3	0	97	0
5	0	0	0	2	0	100	0
6	0	0	5	3	0	89	0
7	0	0	0	10	2	80	0
8	2	0	3	10	0	85	0
9	0	0	0	9	4	95	0
10	0	0	0	4	0	100	0
11	0	1	0	1	0	87	0
12	0	0	0	3	0	97	0
13	0	0	0	1	1	88	0
14	0	0	0	3	1	85	0
avg	0.2	0.14	0.93	4.64	0.57	92.57	0
sum	3.0	2		65	8.0		0
rel. cover			0.01			1.0	
density/m^2	0.1	0.07		2.32	0.29		0
freq/plot	0.13	0.13		1.0	0.27		0

plot #	# dead Chamise	% cover Chamise	# live Oak	# dead Oak	% cover Oak	% bare ground	total cover
1	0	0	0	0	0	0	
2	0	0	1	0	1	2	
3	0	0	0	0	0	0	
4	0	0	0	0	0	3	
5	0	0	0	0	0	0	
6	0	0	0	0	0	6	
7	0	0	0	0	0	20	
8	0	0	0	0	0	12	
9	0	0	0	0	0	5	
10	0	0	0	0	0	0	
11	0	0	0	0	0	13	
12	0	0	0	0	0	3	
13	0	0	0	0	0	12	
14	0	0	0	0	0	15	
avg	0	0	0.07	0	0.07	6.5	93.6
sum	0		1.0	0			
rel. cover		0			0.001		
density/m^2	0		0.04	0			
freq/plot	0		0.07	0			

Appendix 23

Coverage Data for Mixed Vegetation Zones from Permanent Plots at Apricum Hill

plot #	# live A.myrt	# dead A.myrt	% cover A.myrt	# live A.visc	# dead A.visc	% cover A.visc	# live Chamise
1	0	0	0	3	0	80	2
2	0	0	0	0	1	0	3
3	0	0	0	4	0	75	2
4	0	0	0	0	0	25	1
5	0	0	0	1	0	50	1
6	0	0	0	0	0	0	0
7	0	0	0	1	0	45	0
8	0	0	0	1	0	70	0
9	0	0	0	0	0	60	0
10	0	0	0	3	0	45	2
11	0	0	0	0	0	3	0
12	0	0	0	0	0	0	6
13	0	0	0	0	0	0	1
14	0	0	0	0	0	2	2
15	0	0	0	0	0	80	0
avg	0	0	0	0.87	0.07	35.7	1.33
sum	0	0		13.0	1.0		20.0
rel. cover			0			0.38	
density/m^2	0	0		0.43	0.33		0.67
freq/plot	0	0		0.4	0.07		0.6

plot #	# dead Chamise	% cover Chamise	# live Oak	# dead Oak	% cover Oak	% bare ground	total cover
1	0	5	0	0	0	10	
2	2	30	0	0	70	0	
3	0	30	0	0	0	0	
4	0	60	0	0	0	15	
5	1	40	0	0	10	0	
6	1	20	1	0	75	5	
7	0	0	1	0	50	5	
8	0	0	0	0	25	10	
9	0	0	0	0	25	15	
10	0	40	0	0	0	15	
11	0	0	2	0	94	3	
12	0	40	0	0	60	0	
13	0	80	0	0	0	20	
14	1	68	0	0	30	0	
15	2	10	0	0	0	10	
avg	0.47	28.2	0.27	0	29.3	7.2	93.1
sum	7.0		4.0	0			
rel. cover		0.3			0.31		
density/m^2	0.23		0.13	0			
freq/plot	0.33		0.2	0			

Appendix 24

Coverage Data for
<u>Quercus wislizenii</u> Zones
from Permanent Plots at Apricum Hill

plot #	# live A.myrt	# dead A.myrt	% cover A.myrt	# live A.visc	# dead A.visc	% cover A.visc	# live Chamise
1	0	0	0	1	0	0	2
2	0	0	0	3	0	5	0
3	0	0	0	1	0	10	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	2	3	40	0
7	0	0	0	0	0	0	4
8	0	0	0	1	0	10	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	1	0	9	0
15	0	0	0	0	0	1	0
avg	0	0	0	0.6	0.2	5.0	0.4
sum	0	0		9.0	3.0		6.0
rel. cover			0			0.05	
density/m^2	0	0		0.04	0.01		0.03
freq/plot	0	0		0.4	0.07		0.13

plot #	# dead Chamise	% cover Chamise	# live Oak	# dead Oak	% cover Oak	% bare ground	total cover
1	2	2	5	0	100	0	
2	0	0	10	0	97	0	
3	0	0	3	0	100	0	
4	0	10	1	0	100	0	
5	0	0	2	1	65	35	
6	4	0	1	0	55	10	
7	2	50	1	0	60	0	
8	1	20	2	0	75	0	
9	0	0	0	0	85	15	
10	0	5	7	0	70	25	
11	0	0	1	0	100	0	
12	1	0	1	0	100	0	
13	0	0	4	0	96	4	
14	0	0	2	0	100	0	
15	0	1	14	0	100	0	
avg	0.67	5.87	3.6	0.07	86.87	5.93	97.7
sum	10.0		54.0	1.0			
rel. cover		0.06			0.89		
density/m^2	0.04		0.24	0.004			
freq/plot	0.33		0.93	0.07			