Conservation and Recovery of Ione Endemic Plants: Mapping the Ione Plant Community

Final Report

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EXECUTIVE SUMMARY

This study determines the distribution of *Arctostaphylos myrtifolia* (Ione manzanita) and the associated *Eriogonum apricum* var. *apricum* (Ione buckwheat) and *Eriogonum apricum* var. *prostratum* (Irish Hill Buckwheat) within Amador and Calaveras counties. The information is represented as GIS coverages that allow for further geographic analysis, revisions and updates. *Arctostaphylos myrtifolia* is federally listed as threatened and listed as endangered in California. *Eriogonum apricum* var. *apricum* (Ione buckwheat) and *Eriogonum apricum* var. *prostratum* (Irish Hill buckwheat) are both listed federally and by the State of California as endangered. Pinpointing the distribution of these endemic species provides information for more effective planning and habitat conservation for their future recovery and survival.

An accuracy assessment of the GIS map of vegetation was performed to estimate the correctness of the mapped vegetation classification. Fifty random plots were located and surveyed within the study area. Surveyed plots were compared with their location on the map and the vegetation class assigned on the map was compared to that determined by ground survey.

Thirty survey plots were taken within the *A. myrtifolia* community using a releve method to obtain a clearer, more quantitative description of the community. An estimate of cover, species composition and abundance were recorded for each plot.

Additionally, there has been a considerable amount of *A. myrtifolia* dieback noted in the past few years. This study provides a quantitative and spatial measurement of how much dieback currently exists and investigates the causal agents for the decline. The pathogens involved are identified and the potential methods of management appropriate to improve the health and survival of the Ione chaparral are suggested.

Project Area

Although there is exposed Ione Formation found in other parts of California besides western Amador County, no Ione plant community associates have been recorded in these areas. The study area focuses on western Amador County where known populations exist. Initially the area of interest was defined by what had been recorded in the California Natural Diversity Database (CNDDB). After preliminary field observations and viewing aerial photography, the area was extended beyond the CNDDB record because other populations were found that had not been previously recorded. Two populations that had been recorded in Calaveras County are also surveyed. The final project area includes all known populations of the *Arctostaphylos myrtifolia* and is buffered by one hundred meters in every direction totaling 9534 hectares (23,558.19 acres).

The mapped project area is approximately 19.5 miles long, extending from Highway 16, paralleling the Sacramento County line to the Calaveras County border. The town of Ione and Highway 88 bisect the center of the project area. In addition to this core area, the project also surveyed two disjunct areas in Calaveras County: Valley Springs Peak, just north of the town of Valley Springs, and a section northeast of the town of San Andreas.

Vegetation Mapping of the Target Species

The distribution of Ione Manzanita

A current set of aerial photography, IKONOS satellite imagery, and ancillary data, such as soil and geologic information, CNDDB data, digital ortho quadrangles (DOQQs), Digital Raster Grids (DRGs), previous surveys and field surveys, were used to delineate polygons of Ione manzanita. Each polygon is attributed with the following:

1. Area in hectares (acres)
2. The percentage of dead foliage
3. Ocular estimate of Ione manzanita percent coverage
4. Associated Vegetation Community Classification

The *Arctostaphylos myrtifolia* distribution map provides a description of the plant communities in the project area using the Sawyer & Keeler-Wolf (1995) classification at the series level. The project area was broken into seventeen different types, including ten vegetation series. Although the *Arctostaphylos myrtifolia* distribution map includes the surrounding vegetation, the focus was on *A. myrtifolia*. Four hundred and eighty-four hectares (1196 acres) of *A. myrtifolia* were mapped, revealing five major population sites and a few smaller populations in a disjunct distribution running in a distinct northwest to southeast vein across the landscape.

The distribution of Ione buckwheat and Irish Hill buckwheat

Eriogonum apricum is such a small plant that it was impossible to see remotely, even with high resolution, multispectral imagery. The populations were typically very small, covering less than 50 meters of ground. Because of this, a GIS point layer instead of a polygon layer was used to represent the *E. apricum* distribution. *E. apricum* populations were identified and their locations were determined using a GPS. GPS coordinates were recorded every time an area of *E. apricum* was located. The *E. apricum* GIS layer includes attributes that identify the variation of *E. apricum* found at that point. Notes are also included to describe the populations, such as recently burned, or health appearance.

Every effort was made to identify as many *E. apricum* populations as possible, but only populations that were identified or noted by previous researchers, property managers, or other individuals were recorded. It is probable that there are *E. apricum* populations that are not identified on the map, such as those existing on inaccessible private property or those overlooked. Because the *E.*

apricum GIS layer is a dynamic layer, when more plants are located and recorded those coordinates can be added to the layer.

The *E. apricum* distribution map revealed seven major population centers. Five were *E. apricum v. apricum* and the other two were *E. apricum v. prostratum*. A population of *E. apricum v. apricum* was found between two populations of *E. apricum v. prostratum*. This species variation distribution generates questions regarding gene flow and exchange, plant dispersal, and speciation mechanisms. Not all of the populations were directly associated with the *A. myrtifolia* or the Ione formation. The range of *E. apricum,* spanning 12 miles, has a smaller extent than *A. myrtifolia* which extends across a distance of 19.5 miles.

Assessing Accuracy

An accuracy assessment of the *A. myrtifolia* and adjoining vegetation map was performed in order to determine its utility and limitations. Since all of the polygons could not be field checked due to time and budget constraints, a random sample of 50 sites were selected. The sample selection was limited to public and accessible private property that was located and surveyed within the study area. The dominant vegetation observed at surveyed plots on the ground was compared to the mapped vegetation class of the polygon containing the mapped survey plot. No formal accuracy assessment was conducted for the *E. apricum* map. The accuracy of the Ione manzanita designated on the map was approximately 70 percent. For overall accuracy of the entire map was approximately 70 percent. Some of the misclassification on the map was due to segmentation error of the mapping program, majority rule used for classification, minimum area required for classification or to the exclusiveness of the community classification criteria. Twenty seven percent of the plots were determined to be mislabeled, that is classified as a community entirely different than that which appeared on the map. The additional error was from the ground surveyed assessment plots that noted sample plots contain additional species, not originally designated in the remotely sensed data.

Releve Plots of *Arctostaphylos myrtifolia* community

Until this study, the *Arctostaphylos myrtifolia* plant community had not been quantitatively described thoroughly. This study examined 30 releve plots following the CNPS protocol with the goal of acquiring a set of data that quantitatively describes the entire community.

From the releve plots, elevation ranged from 74 to 156 meters with an average elevation of 114m. Slope averaged 10.72 degrees and ranged from 0 to 50 degrees. Aspect varied. Average percent cover by *Arctostaphylos myrtifolia* was estimated at 87 percent. Other species present in the releves included *Arctostaphylos viscida, Arctostaphylos manzanita, Arctostaphylos xhelleri, Eriogonum apricum, Adenostoma fasiculatum, Eriodycton californicum, Quercus wislizenii, Pinus sabiniana, Baccharis pilularis,* and unidentified mosses, lichen and grass species. At least one other species was found on the Ione manzanita plots in 97 percent of the plots, although those associated species typically occurred in small percentages. Total species within a releve ranged from pure *A. myrtifolia* to four different species within the defined plot. An average of three associated species per plot was observed within the releve plots.

Adjacent alliances surrounding the *A. myrtifolia* releves included the whiteleaf manzanita, interior live oak, chamise, mixed scrub, foothill pine and common manzanita series.

In the releve plots, health of the stand was assessed in terms of estimated percentage live vegetation. Average live vegetation was 87 percent. Noted impacts that may be threatening the plant community were included in the releve data. Of the 30 plots surveyed 47 percent were found to have some impact of dieback from disease or fungus. Ten percent had evidence of previous fire; thirty percent had other impacts such as mining, or road building in the area. Only 13 percent had no impacts noted.

The Health of *Arctostaphylos myrtifolia* Populations

Mapping Stand Health

Using remotely sensed imagery and field checking, the health of *A. myrtifolia* populations was evaluated and mapped. The percent of dead *A. myrtifolia* versus live foliage was analyzed and included in the map. Thirty percent of *A. myrtifolia* was found to have less than half live foliage, meaning it is in poor health. It should be noted that a large portion of this figure may be due to a wildfire in 2002 that caused a considerable amount of dead foliage.

Determine the Pathogens and/or Agents involved in Ione Manzanita Dieback

An additional task of this study identifies and researches the pathogens associated with large events of dieback throughout the populations. Using a variety of plant disease diagnostic techniques, pathogens associated with plant decline were identified. At least two unidentified species of *Fusicoccum* have been found to affect the health of *A. myrtifolia* and *A. viscida* in the Ione area. *Fusicoccum sp*. may contribute to *A. myrtifolia* dieback and possibly even mortality. Symptoms associated with this pathogen tend to be found scattered throughout affected stands.

Most importantly, a second disease, *Phytophthora cinnamomi*, newly identified and documented in this study, was found to cause root and crown rot that typically lead to large mortality centers of *A. myrtifolia* and *A. viscida*. Infected plants desiccate rapidly at the onset of hot weather. *P. cinnamomi* was isolated from plants at two different locations and was also found in the soils collected from one of the two sites. Greenhouse tests confirmed pathogenicity of *P. cinnamomi* isolates to *A. myrtifolia*.

Phytophthora cinnamomi crown and root rot is a very serious crisis for *A. myrtifolia* and has the potential to eliminate entire populations of the manzanita. Because *P. cinnamomi* can persist in soils for undetermined amounts of time, infected areas may create long-term or permanent loss of habitat.

Recommendations

Based on the above research, the following management recommendations have been made.

Preserve Habitat**:** The most important step in conserving the Ione plant community is to preserve habitat. Because it is not known how interdependent these disjunct populations are, it will be necessary to preserve as many of them as possible until more is understood about these relationships. Critical habitat needs to be identified with special consideration to the health of the populations, particularly relative to disease potential. Over ninety-six percent of the *A. myrtifolia* exists on private land. Mining activities currently occupy a large portion of *A. myrtifolia* habitat. Partnerships with mining interests could be an excellent source for habitat reclamation and possible reestablishment of populations.

Contain *Phytophthora cinnamomi* Disease: Minimizing the impact of *Phytophthora cinnamomi* is vital to the conservation of *A. myrtifolia*. The recommended management strategies to accomplish this are to prevent the spread of the pathogen to uncontaminated stands, stop the spread in existing mortality centers, and rehabilitate areas that have been completely infested, if possible. Soil borne pathogens such as *Phytophthora cinnamomi* are spread by moving infested soils. Generally root infections occur during wet seasons when soils are saturated. Soil transportation through mechanisms such as vehicles, OHVs, walking through an infected area, mining and soil operations should be restricted in *A. myrtifolia* populations, particularly during wet seasons. Care needs to be taken not to introduce new infestation of *Phytophthora cinnamomi* from outside sources.

Involve Local Landowners and Citizens: Local citizens, landowners and local government need to be included in Ione plant community conservation. Currently, Amador County does not emphasize environmental support or planning, but local meetings, public awareness, and educational campaigns could assist in shifting attitudes towards a pride for this precious resource. Local involvement will facilitate a more holistic, adaptive approach to Ione plant community management.

Continue research**:** The current scientific literature involving the two species of concern in this research is brief and incomplete. Proper management of the Ione plant community will require a better understanding of its biology and a long term monitoring program such as the Inventory, Monitoring and Assessment Program (IMAP).

Additionally, understanding how both species of interest react to fire, restoration, or reclamation efforts may improve and increase options for their recovery.

CONCLUSION

Efforts towards mapping *Arctostaphylos myrtifolia* and *Eriogonum apricum* yielded excellent distribution maps that reveal vital statistics of the two species. A map of the associated vegetation has added information about the plant associations surrounding the Ione plant community. Health analysis mapping efforts support studies of the two pathogens that are causing large amounts of dieback throughout the *Arctostaphylos myrtifolia* stands.

An accuracy assessment found that *A. myrtifolia* populations were mostly correctly labeled. Although remote spectral analysis provided a good initial mapping effort, achieving appropriate accuracy was not possible without further supervision, hands on adjustment, and ground surveys. This was particularly evident in differentiating chamise from Ione manzanita. Although remotely sensed imagery allows for a faster evaluation, the necessity for on the ground evaluation continues to be crucial in mapping these rare populations. The study also provides the first extensive quantitative examination of the Ione manzanita plant community using thirty releve plots.

By researching this rare endemic plant community we are better able to understand its distribution and the characteristics of the community, and make recommendations for future studies and proper management. Immediate management, research, protection and continuous monitoring will play a crucial role in maintaining stable populations into the future.

INTRODUCTION

The Ione chaparral community is dominated by *Arctostaphylos myrtifolia*, (Ione manzanita) a low growing, evergreen native California shrub that is only found in small, disjunct populations in Amador and Calaveras counties. Its restricted range is largely attributed to specific environmental traits, the most obvious being the Ione Formation, a relict geologic formation. *Arctostaphylos myrtifolia* is listed as threatened under the Federal Endangered Species Act. The associated *Eriogonum apricum* (Ione buckwheat) is listed as endangered both federally and within the State of California. Little is known about the species' distribution and associated autecologies. Human pressures such as development, mining and recreation are threatening these already perilously small populations.

This study presents measurements of Ione manzanita and defines the distribution of the Ione chaparral community by creating GIS maps using remote sensing techniques and high resolution, multispectral imagery. During this study, over 9534 hectares (23,000 acres) were mapped. Of the area mapped, 484 hectares (1196 acres) were identified as *Arctostaphylos myrtifolia*. Seven major population sites of *Eriogonum apricum* were located.

Within this limited population of *Arctostaphylos myrtifolia* it was observed that individuals within the community appear to be diseased or dying. In addition to the distribution and description of the *Arctostaphylos myrtifolia* presented here, the pathogens causing this dieback are identified (through subcontract) and the distribution of the extent of *Arctostaphylos myrtifolia* health is mapped.

Purpose

The purpose of this study is to determine and map the distribution of *A. myrtifolia* and *E. apricum* using a Geographic Information System. The maps will offer a tool for conservation and management planning and a baseline of the existing *A. myrtifolia* and *E. apricum* populations. The study describes the Ione Manzanita plant community and classifies its associated plant types for mapping purposes to provide a better understanding of the Ione plant community and its environment. Area estimates based on remotely sensed data for *A. myrtifolia* and associated vegetation communities and point coverages for *E. apricum* populations are also provided. An accuracy assessment of the classified vegetation map is performed.

From field observations it appears that this community is being severely affected by pathogens that are causing extensive mortality. The pathogens that are affecting these stands are identified, described and the extent of its effect is mapped, with acreage quantified.

This project was designed under Section 6 of the Federal Endangered Species Act. Section 6 was developed to encourage species protection through State partnerships. The project is administered by California Department of Fish and Game.

***Arctostaphylos myrtifolia* Described**:
Arctostaphylos myrtifolia (Ione manzanita) is a low growing, evergreen native California shrub that is only found in a small section of the Sierra Nevada foothills, almost exclusively in western Amador and eastern Calaveras counties. *Arctostaphylos myrtifolia* is known to be found in communities that show very low diversity of plant species, with the exception of crytogamic flora (Parker and Wood 1988). The species has reddish bark, shiny, small green leaves and whitish pink flowers that bloom from January to February (Hickman 1996) (Figure 1).

Figure 1: *Arctostaphylos myrtifolia* (Photo: T. Meyer)

A. myrtifolia belongs to the small fruited manzanita subgroup known as *Micrococcus* (Hickman 1996). Other manzanita species that fall into this group are the coastal *Arctostaphylos nummularia* and *Arctostaphylos sensitivia,* and the foothill species *Arctostaphylos nissenana*. Eastwood separated these species into their own subgroup *Schizococcus,* because of many common phenotypic features, such as fruits with thin pericarps that split into nutlets. This subgroup was also recognized as having characteristics considered primitive relative to the rest of the members of the genus (Vasey pers com. 2000). But after further studies these species were eventually grouped back into the *Arctostaphylos* genus (Vasey pers.com. 2000). Recent DNA studies conducted by Vasey and Parker found that *A. myrtifolia* is not closely related to any of the other species in the *Micrococcus* subgroup, and described it as a relict species (Vasey pers. com. 2000). Another interesting aspect of the *A. myrtifolia* is that it has been observed hybridizing with the common *Arctostaphylos viscida*, creating a species called *A. xhelleri*, first described by Eastwood in 1945.

There have been minimal studies conducted on the biology of *Arctostaphylos myrtifolia*, but there are some educated speculations about its regeneration, dispersal and pollination mechanisms. *A. myrtifolia* was documented as producing 2913.7 seeds per square meter for the year of 1987 (Parker and Wood 1988). Although high in seed production, there has also been speculation that *A. myrtifolia* experiences high seed predation because the fruits mature and drop in spring during the time when predators are very active. Additionally, seeds tend to be very exposed once they drop because there is usually a dense crytogamic layer under the plants that tend to make the seeds easy to find (Parker and Wood 1988). Ants have been seen gathering plant seeds in the spring. It is possible that the ants act as a dispersal agent by dropping seeds (Hartwell 2001). There is also anecdotal evidence that birds are involved in pollination and dispersal (Myatt 1983). *A. myrtifolia* appears to be an obligate seeder; needing fire to propagate, thus it relies solely on seeds that have been stored in the soil for regeneration after disturbance (Parker pers com. 2003).

<u>*Arctostaphylos myrtifolia* Status:</u>
On May 26, 1999, the U.S. Department of Fish and Wildlife listed Ione manzanita (*Arctostaphylos myrtifolia*) as threatened according to the Federal Endangered Species Act (ESA) (Davis & Tarp 1999). Plants listed as threatened under the ESA generally receive the same protection as species listed as endangered although this protection is not required by law.

The California Native Plant Society (CNPS) maintains the California Native Plant Species List, a list of California's plants and their status. Their list provides specific information about California native plant species distribution and degree of rarity. The CNPS has listed *A. myrtifolia* in the 1B category under the California Native Plant Species List meaning that these plants are considered the highest level of rarity, are limited to such small populations that they are rarely reported, and their distributions are endemic to California (Smith 1987).

***Eriogonum apricum* Described**:

Eriogonum apricum (Ione buckwheat) is a perennial herbaceous plant that is endemic to the foothills of the Sierra Nevada. It belongs to the Polygonaceae family, commonly known as the Buckwheat family. Polygonaceae is one of the more frequently occurring plant families in California, yet this particular species is very rare. The Buckwheat family has 50 genera and over 1100 species that are distributed worldwide. The *Eriogonum* genera are normally found in dry, inhospitable environments, and tend to have woolly leaves and flowers without petals, generally making the 100 species found in California relatively easy to identify (Horn 1998)(Figure 2). There are two known variations of *E. apricum*. The first was described by Howell in 1955 as *E. apricum* var. *apricum* or Ione buckwheat (Hickman 1996). This variation has small, pinkish white flowers, erect stems and blooms from June through October. Myatt (1970) discovered another variation E*. apricum* var*. prostratum*. This variation is commonly known as Irish Hill buckwheat, after the location where it was found. It has white flowers with red " midribs" and tends to grow prostrate along the ground. It has smaller leaves than the var. *apricum* and blooms earlier in the season, around May (Hartwell 1999). The flowers and fruits of both of the variations are glabrous (Hickman 1993). Both of the variations grow from 8 to 20 centimeters in height and have round to oval leaves located basely on the stock (Davis & Tarp 1999). Recent preliminary results of Crawford (2000) suggest that the two species are not genetically varied enough to be considered two separate taxonomic variations. These findings have stirred up some controversy among the small group of experts who are aware of the plant. The two variations do look remarkably different, and bloom at different seasons. In this study the *E. apricum* variations are treated at the species level, assuming that the two variations prefer the same habitat.

Figure 2: *Eriogonum apricum* v. *apricum*

The total distribution of *E. apricum* is confined to a very small range. The only populations in the world are scattered across the western region of rural Amador County. This buckwheat is most likely to be found on bare patches of gravely ridges that are hot and dry and consist of a mosaic of red and/or white soils. The species is also found on disturbed areas such as road cuts and the edges of mining pits and quarries.

Most of the known Ione buckwheat populations are located along roadsides. One known population is located several miles north of the small town of Buena Vista on the Ione-Buena Vista Road at a site called the Yaeger location. Another location is on Irish Hill, which is one mile north of the town of Ione, and the other is called Manzanita Hill, which is a few hundred yards off of Highway 88 (Aparicio 1979). There are also two small publicly owned preserves where *E. apricum* exists. One is a 37 acre parcel managed by the California Department of Fish and Game called Apricum Hill Ecological Reserve, and the other is a 36 acre property managed by the Bureau of Land Management (BLM) called the Ione Manzanita Area of Critical Environmental Concern (ACEC) (Davis & Tarp 1999). Other than the roadside stands, populations that occurred on private lands have not been documented prior to this study.

Eriogonum apricum status:
Although the sites where the Ione plant communities reside are not very desirable for other plant communities, the Ione plant community continues to decrease to the extent that both variations of *E. apricum* are state and federally listed endangered species. The small population numbers and unique characteristics of *E. apricum* were brought to the attention of the U.S. Fish and Wildlife Service in 1973 when the Smithsonian Institute recommended it as an endangered species. California listed *Eriogonum apricum* var. *apricum* as endangered in 1981 and at the same time listed var. *prostratum* as threatened. Neither variation was actually listed as federally endangered until the summer of 1999 (Davis & Tarp 1999). A species listed as federally endangered is considered to be in immediate danger of becoming extinct because population numbers are extremely low. As a listed federally endangered species, federal agencies are required to take action in the conservation and management of the species by working with each other to perform research, develop programs that will optimize populations and acquire land for habitat (Smith 1987). Plant collecting on public lands is limited to permits only, but there are no regulations for private landowners. The CNPS lists *E. apricum* in the 1B category, the highest level of rarity. (Smith 1987).

The Current Ione Plant Community Habitat:

Ione Formation

Most of the published literature on the distribution of the Ione chaparral community suggests that its small range is directly related to the clay soils of the Ione Formation (Aparicio 1978, Davis & Tarp 1999, Ornduff 1974). Generally the soils appear as white or red clay and are composed of a combination of kaolinitic or white clay minerals, quartz, sand, lignite and ironstone (Gankin & Major 1964). The soils have many characteristics that are incompatible with most vegetation, such as extreme acidity, low macronutrients such as calcium, nitrogen, and magnesium with high amounts of other elements that most plants find toxic, such as aluminum.

The Ione Formation first began to form during the Eocene Epoch, 65 to 40 million years ago, during a time when the Ione region was submerged under an inland sea (Singer 1987). The inland sea and climate of the time played a significant role in influencing the characteristics of the Ione Formation parent material. During the Eocene Epoch the inland sea began receding. This was a time when the climate was hot and moist, resembling a tropical climate. This parent material was formed over millions of years of exposure to these tropical conditions.

Approximately 20 to 30 million years ago the Sierra Nevada mountain range began eroding and covered much of the now weathered Ione Formation with sediments of granitic quartzrose and clay (Singer 1978). What is now left of this sediment, that still obscures most of the Ione Formation, is known as hardpan. The rich sediment of the Sierra Nevada eroded material preserved the Formation for many years until further erosion eventually began exposing regions of the Formation. The raised areas of the Formation were more likely to be exposed. This complex series of layering and erosion created these unique, highly variable soils that most closely resemble tropical soils. The Ione Formation's closest relatives are found in Hawaii and Puerto Rico (Singer 1978).

This edaphic factor is an important influence on the Ione plant community. Edaphic qualities can be driven by climate and the methods in which the soils were formed. The Ione Formation has been transformed by heavy leaching and layering that has resulted in a particularly high concentration of some minerals and metals and a deficiency of others (Figure 3). This unique composition of minerals and metals has a significant effect on the floristic community in western Amador County. It is likely that the high ferric iron and acidic levels of the Ione Formation has caused mutations within the Ione chaparral community. According to Mason (1946) species that are found on soils with high metal concentrations such as serpentine are good examples of species with " taxonomic peculiarities" . Soils such as these have a very high " selective value" on the vegetation, and may even induce mutations and changes in the chromosomes.

Figure 3: Exposed Ione Formation (Photo: T. Meyer)

Past and Present Distribution

Presently, there appears to be a direct correlation between the exposed Ione Formation and *A. myrtifolia* distribution. There is little understanding of this relationship, but the most commonly accepted theory is that while *A. myrtifolia* lacks the ability to compete with other vegetation, it continues to persist on the Ione Formation where the environment is inhospitable for most other vegetation (Stebbins 1965). Previous studies have also shown that *A. myrtifolia* takes up aluminum more quickly than *Arctostaphylos viscida* (whiteleaf manzanita), another common manzanita in the area, which could potentially be a competitive advantage for *A. myrtifolia* to withstand living on the aluminum concentrated Ione Formation (Parker and Wood 1988).

Throughout time, erosion and natural processes have covered most of the Ione Formation with other soils, leaving only patches of the exposed clay across the landscape. The pattern of *A. myrtifolia* distribution reveals where these islands of exposed clay currently exist. According to Aparicio (1979) *A. myrtifolia* and *E. apricum* actually grow where the harsh soils are directly exposed along ridges (Figure 4). *A. myrtifolia's* patchy distribution could potentially have implications for the future of the plant with respect to genetic flow, habitat suitability, dispersal and pollination.

The known exposed areas of the Ione Formation span a little more than 200 miles along the Sierra Nevada foothills (Allen 1929). The range of the exposed Ione Formation is much larger than the range of *A. myrtifolia*, yet there is little explanation for this limited distribution. Gankin and Major (1964) suggest that Amador and Calaveras counties have a slightly milder climate than the rest of the Sierra foothills because it is directly east of the San Francisco Bay. Thus maritime air flow is channeled through the Central Valley to the area. This leads to less extreme annual temperatures, up to 3-4 degrees Fahrenheit less than other foothill communities. This is a potential factor for the presence of *A. myrtifolia* in this limited locality.

Figure 4: Ione manzanita plant community. *Arctostaphylos myrtifolia* is the darker low growing shrub. *Arctostaphylos viscida* is the taller grey-green shrub in the foreground.

<u>Associated Plant Community</u>
The soil types in this region are well represented by the vegetation, with vegetation changing drastically at the soil transition lines. The non-clay soils support a tall *Arctostaphylos viscida, Quercus wislizenii* (Interior live oak) or mixed chaparral community. When crossing the soil transition line into Ione Formation the chaparral becomes dominated by the small and stunted *A. myrtifolia*. All of the species found on these Ione soils are considered nonclimax species and have a geographically disjunct distribution (Gankin 1964). Plants that are more commonly known to be in the Sierra Nevada chaparral foothill

community grow directly adjacent to the Ione flora, these include *Arctostaphylos viscida* (whiteleaf manzanita), *Quercus wislizenii* (interior live oak), *Adenostema fasciculatum* (chamise), and *Arctostaphylos manzanita* (common manzanita), but *A. myrtifolia* commonly is thought to grow in pure stands (Gankin and Major 1964). Generally, when the other common shrub types are found growing with *A. myrtifolia,* they are stunted.

Fire is very important in most chaparral communities and there is speculation that it is also an important factor for the Ione chaparral community. *A. myrtifolia* appears to be an obligate seeder, needing fire to initiate germination. It can also be killed by fire and does not stump sprout, like some other *Arctostaphylos* species. *A. myrtifolia* and *E. apricum* need clear, sunny, open hillsides to regenerate; a condition that fire would naturally generate. Fire suppression by humans has probably been a factor in inhibiting the plant community's regeneration. There has been speculation that taller shrub communities become established in more fertile soils surrounding the Ione formation and gradually shade out the *A. myrtifolia*. Normal fire cycles may potentially alleviate this edge effect. There has been little to no research on this aspect of *A. myrtifolia* autecology.

A theory derived from examining plants growing on serpentine soils suggests that the Ione plant community exists not because it requires something specific from the soils, but because there is little competition in these environments, and that is the reason why it is not extinct (Stebbins and Major 1965). This passiveness may be carried over from earlier times when the populations encompassed larger habitats. Large geological events, such as Pleistocene glaciation, could have restricted its population and limited it to small, unique niches. Thus it has become specialized, losing much of its genetic variability (Stebbins and Major 1965). *E. apricum* is probably also a paleoendemic or relict endemic and could theoretically follow this same ancient event theory. Paleoendemics are generally systematically isolated, show little variability, are ecological specialists and may be more susceptible to extinction (Stebbins and Major 1965). Both A*. myrtifolia* and *E. apricum* display these characteristics. Careful study and monitoring of these populations will provide more information to help prevent their extinction.

Impacts to the Ione Plant Community

Many of the activities in western Amador County have heavily impacted the Ione plant community. Because this community occupies soils that are economically desirable, its habitat has become a major focus for the mining industry. In addition to the older quarries and large moonscapes created by hydraulic mining during the gold rush, extensive mining operations persist throughout the region and threaten the Ione plant habitat. The clay component of these soils has high economic value and has been actively mined since the 1860s (Davis & Tarp 1999). Their low sodium, potash, calcium and magnesium content make them an excellent, source for ceramic materials (Allen 1929). The silicon component is a desirable material for making glassware largely because it has low iron content (Gankin 1964). The clay is also mined for fire clay, the lignite is low-grade coal harvested for making a specialized wax (Davis & Tarp 1999). The local soils are also mined for gravel, cement and sand. A common method of mining for these materials is strip mining, involving moving large amounts of soil. This clearly conflicts with any flora and fauna that is dependent on the specific habitat of the Ione Formation. Active mining companies own most of the private lands where the chaparral exists.

Other threats and causes of habitat fragmentation to the Ione plant community are increases in residential and commercial development and off road recreation (Davis & Tarp 1999). Years of fire suppression as noted earlier may also adversely affect this fire dependent community.

In addition to the variety of human-induced pressures on its habitat, Ione manzanita is currently experiencing a biological dieback from the pathogen *Phytophthora cinnamomi* (Swiecki and Bernhardt 2003). This is discussed in Appendix B of this report.

By mapping populations of *A. myrtifolia* and *E. apricum* one can get a better idea of the limited extent of their distribution. The combination of remotely sensed imagery and analysis, along with on the ground surveys, provides a clearer and more extensive picture than one method can do alone. This report addresses the methods used to map the distribution of these species and their associated communities and the results of those efforts. Secondly, a pathological examination of the potential causes of increased dieback and decreased plant health of these *A. myrtifolia* communities is provided.

METHODS

Remotely sensed imagery and analysis, along with a combination of GIS and field checking were selected as methods to complete this project and provide the maps and data included.

Remote sensing was chosen for the following reasons: the imagery can be spatially referenced and orthorectified; the imagery is digital so it is stored on a computer; the digital data are easy to copy and share; the data displayed on computers can be varied based on detail required for analysis; the imagery can be manipulated and used to perform a variety of processes such as segmentation, change detection, classifications, etc.; the imagery can be printed like aerial photography if necessary and automated processes can be run on digital imagery, producing more accurate data very quickly.

GIS provides an easy and accessible way to view, analyze and update the data. Field checking was found to be a necessary step and allows for on the fly corrections of confused, misinterpreted or mislabeled area data.

Arctostaphylos myrtifolia Mapping Methods

Project Area

The first step in mapping *Arctostaphylos myrtifolia* was to define the project area. Although there is exposed Ione Formation found in other parts of California besides western Amador County, from as far north as Oroville in northern California, south to Friant in southern California, no Ione plant community associates have been recorded in these areas. Because of limited resources, this study focuses on western Amador County where known populations exist. Initially the area of interest was defined by what had been recorded in the California Natural Diversity Database (CNDDB). After preliminary field observations and viewing aerial photography, the area was extended beyond the CNDDB record because other populations were found that had not been previously recorded. Two populations that had been recorded in Calaveras County were also surveyed for the study. The final project area includes all known populations of the Ione manzanita, buffered by one hundred meters in every direction. A total of 9,534 hectares (23,558.19 acres) were surveyed.

The mapped project area is approximately 19.5 miles long, extending from Highway 16, paralleling the Sacramento County line south to the Calaveras County border, between the Pardee Reservoir and the Camanche Reservoir. The town of Ione and Highway 88 bisect the center of the project area (Map 1). In addition to this core mapped area, the project area also includes two disjunct areas in Calaveras County: Valley Springs Peak just north of the town of Valley Springs, and a section northeast of the town of San Andreas. The most southern stand of *A. myrtifolia* historically recorded is the Valley Springs Peak population.

Image Processing

Once the project area was defined, the area within Amador County was flown by the California Department of Forestry (CDF) Airborne Infra-Red Imagery System (AIRIS) program. During the time of the project the AIRIS program was still in the developmental stage, and thus the imagery produced for this project was completed as a pilot program[1].

The Ione flight mission was prematurely aborted a number of times because of equipment failure or cloud cover before a complete set of imagery was acquired. The final photography was taken on September 17, October 17 and October 22, 2002. The final imagery was taken as one meter per pixel resolution, with four

[1] The AIRIS program was being organized with the intention of being able to deliver high resolution, multispectral imagery of active fires to ground crews as a resource to help combat the fires. Since the project's imagery has been delivered, the AIRIS program was terminated due to lack of budget and technical expertise.

different cameras resulting in a multispectral product containing the following four bands: blue, green, red and near infrared. During the imagery post processing, CDF co-registered each band by matching each by similar points. This process was done for each individual scene. Then the imagery was spatially referenced using DIME software on a UNIX platform at one-meter resolution to USGS Digital Ortho Quarter Quads (DOQQ). The final output that CDF delivered was over 200 co-registered .lan files[2]

Poor georeferencing had occurred during the CDF preprocessing, and the imagery had not been orthorectified so scenes did not overlap properly for mosaicking[3]. In addition to the poor geographic quality of the delivered imagery, it was delivered in the wrong projection. To correct these issues, each scene was georeferenced in ArcGIS using USGS Digital Ortho Quarter Quads (DOQQs) as reference data. The DOQQs are in UTM 10 NAD83 so during the georeferencing process the AIRIS images were reprojected to UTM 10 NAD83 projection. After georectification, the scenes were mosaicked using ERDAS Imagine's processing tool. Because the images were never orthorectified, some areas of overlap around the edges of the scenes are blurred due to poor registration. Although this effect is visually displeasing, it did not seem to influence the segmentation or classification processes. A total of ninety-one AIRIS images were included for the project using the above technique.

Because different areas of the imagery had been flown at different times, not all of the pixel values of the scenes were compatible. This could be due to different conditions during the flight, such as clouds or haze, or the cameras may have been on different settings during different flight days. The scenes that had incompatible values had to be processed separately. The project was mosaicked into four different sections to maintain consistent pixel values throughout the scenes.

The most difficult issue to overcome with the AIRIS imagery was that many of the scenes throughout the northern part of the project either did not properly overlap or there were missing data between scenes. Some scenes were never delivered at all, creating large data gaps. These problems were impossible to fix, and unacceptable for image processing. To compensate for this issue two archive scenes of IKONOS data were acquired for the project area that extends north of the town of Ione (Figure 5).

The IKONOS imagery was taken on July 22nd, 2001. This imagery is 11 bit data, consisting of a near infrared band, red band and green band. The IKONOS

[2] A .lan file is the native image format file for ERDAS Imagine 7.X.
[3] Mosaicking is a process that combines several adjacent and overlapping images to create one large continuous file.

is a composite image created from four meter color imagery and 1 meter panchromatic imagery making a one meter multispectral bundle.

Although there were two different types of imagery used for the project, collected from two different platforms, the same methods were used to process each. Most of the characteristics of the imagery, such as resolution, spectral information and date acquisitions were similar.

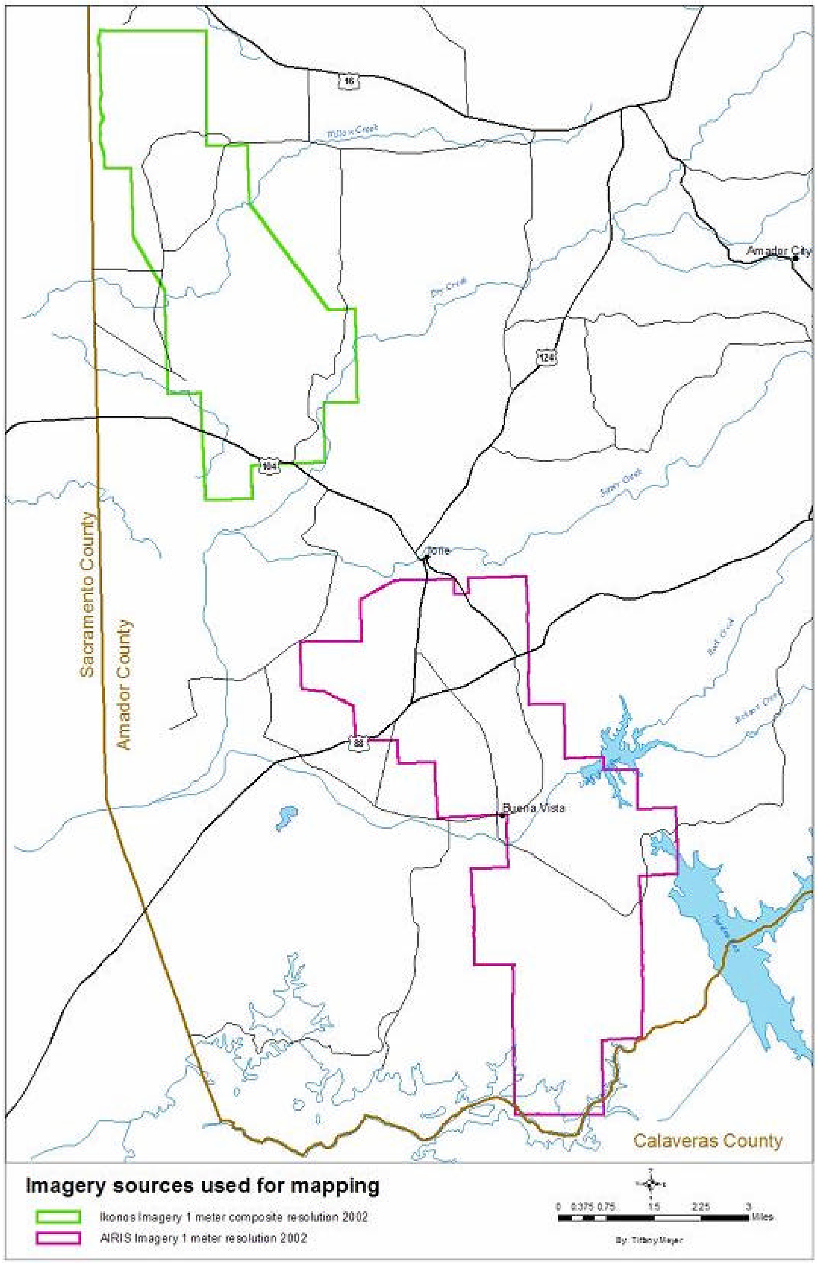

Figure 5: IKONOS and AIRIS imagery sources were used to complete the mapping area.

Segmentation

Segments are polygon coverages in a GIS that depict unique areas of vegetation on the map. Accurate segments are one of the most critical components to a GIS vegetation map. Poor segment quality can lead to inaccurate or missed vegetation labels. A digitally automated segmentation program called SKOGIS was used for segmenting each of the Ione imagery scenes (Bunselmeier 2002)[4]. This segmentation program was developed by the Remote Sensing Lab at the Swedish University of Agricultural Science in Umeå, Sweden as a forestry planning tool. The program uses algorithms to separate pixels into spectrally similar polygons. Using an automated program such as SKOGIS to create segments is not only faster than hand drawing the polygons, but the computer can detect differences between pixel values that the human eye would never see. This creates a more accurate and thorough product than heads-up digitizing. The output is of much higher quality and detail (Figure 6).

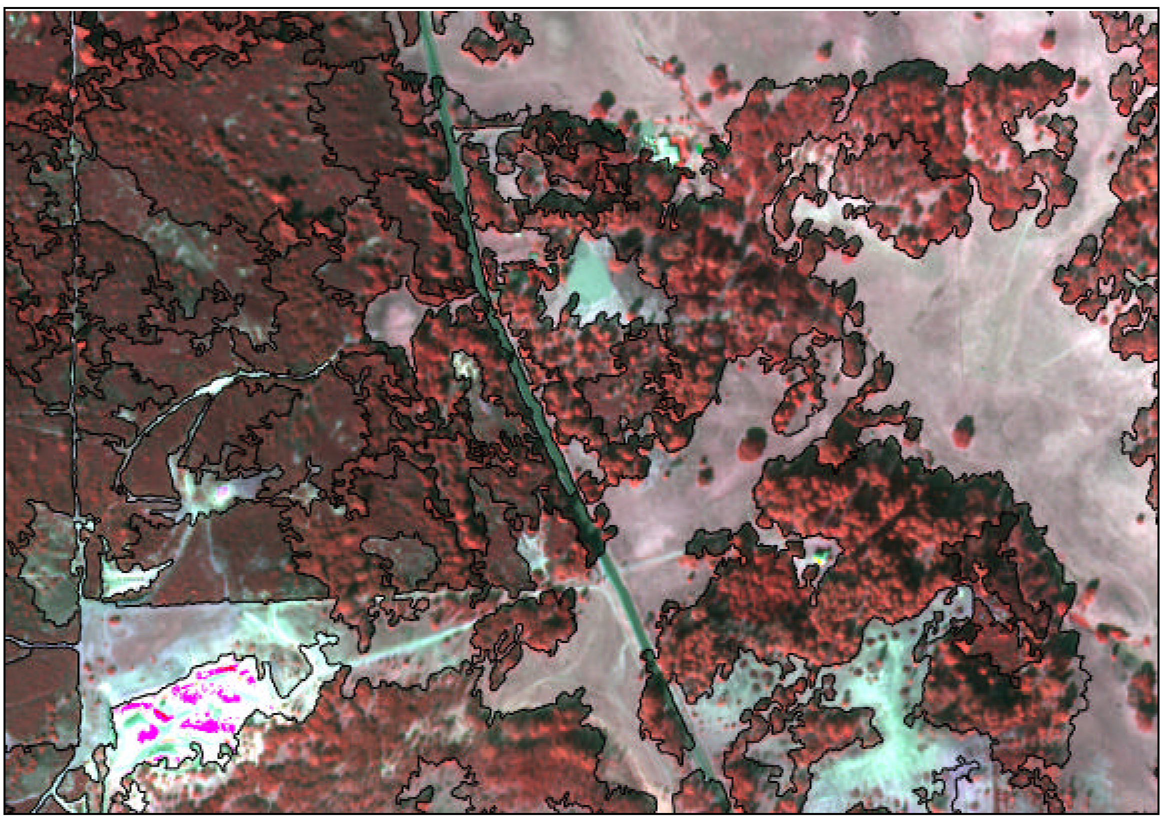

Figure 6: Example of automated segmentation at Apricum Hill Preserve, DFG.

[4] There are a variety of commercial segmentation programs available but they are more costly than this project allowed, so a program was downloaded from the internet.

Some of the drawbacks of using this segmentation program versus a commercial product is that it would only run on a Windows NT platform or older, and was limited by file size. The CDF AIRIS and IKONOS images are very large because of the resolution (of the four final images for the project area, the smallest is 38 megabites). Because of the issue of large files, the project area was broken up into eleven regions for segmentation processing. Effort was taken to subset the imagery into the eleven regions using natural lines throughout the landscape such as roads and water courses, although remnant lines throughout continuous vegetation types may be seen in some areas. The segmentation output was eleven .lan files that were converted to GIS shapefiles. Once the segmentation was completed the shapefiles were merged into one continuous map.

The segmentation program often produces polygons that are as small as a few pixels. These polygons are generally too small for any type of analysis, and are generally considered noise. Because of this, polygons with an area of 500 square meters or less were merged within the nearest larger polygon. The segmented output polygons appeared to have one meter stair steps, since they were processed from one meter imagery, and the coverage was treated with a generalization process to smooth the corners, providing a more natural appearance. The final result was a GIS shapefile consisting of nearly 35,000 unlabeled polygons that outline different natural features throughout the landscape.

Vegetation labels

Once the entire project area had been properly segmented a process of labeling the segments began. The Sawyer & Keeler-Wolf (1995) classification was used at the series level. The classification is designed to emphasize plant and animal species as part of an ecosystem. The vegetation series is generally defined by dominance because the objective of the classification is to arrange California's vegetation types into a uniform hierarchical structure. The Ione Manzanita Series has a variety of associations such as *Arctostaphylos viscida* (whiteleaf manzanita), *Quercus wislizenii* (interior live oak) or *Eriodictyon californicum* (yerba santa), but *Arctostaphylos myrtifolia* is clearly the most dominant species. This classification is also based on vegetation that currently exists, rather than potential habitat as some other classifications are based.

Map labeling was performed by running an unsupervised classification using the nearest-neighbor algorithm in ERDAS Imagine. All four bands were used to generate between 50 and 100 classes for each of the four images within the project area. This method is an iterative process that forms clusters based on a spectral distance formula. Each class within each of the classification types was given a label. About one third of the classes fell into incorrect vegetation types, and were labeled as " confused" , rendering them insignificant to the map. These areas then underwent rigorous hand editing and field observations for accurate labeling. The classified images were regionalized into the segments with a majority rule[5]. The unsupervised classifications identified water, grassland and some hardwoods very well, but shrub and other hardwood types tended to be less discriminating and harder to separate into their own types using only the unsupervised classification.

Once an initial base map was established with the unsupervised classification, a more detailed hand labeling process began. The map was systematically edited using the imagery, and labels were edited to more accurately identify vegetation types in the imagery.

Areas that were known to have *A. myrtifolia* were given the most attention, although surrounding vegetation types were also labeled. *Adenostoma fasciculatum* (chamise) and *A. myrtifolia* look very similar on the imagery, sometimes causing a problem for aerial photography interpretation. Areas that were particularly hard to distinguish on the imagery were flagged for field reconnaissance, these included areas of shrub that could either be *Adenostoma fasciculatum* or *Arctostaphylos myrtifolia.*

The last and most important step of the vegetation map labeling occurred in the field. This step was so important to the process because *A. myrtifolia* was found to be so spectrally similar to *A. fasciculatum* that the only true way to distinguish the shrub types was by observing the stands on the ground. For this reason extensive field observations were conducted. Two field verification methods were predominantly used throughout the study. The preliminary draft vegetation map was overlaid and printed on 7.5 minute USGS quad maps and taken to the field to compare the remotely sensed data to true or ground information. Errors that had been found in the field were brought back to the office and corrected in the map using the imagery as a backdrop for aerial interpretation. This method works well to confirm patterns throughout the landscape and larger stands of the same types (Congalton & Green 1999). But this method was not ideal for verifying smaller stands of unique vegetation because the USGS 7.5 minute quad base maps are at a scale of 1:24,000 which is coarse enough to miss a large number of landmarks on the ground.

The second iteration of field work is designed to capture more detail. This method consists of using Global Position System (GPS) to identify stands of *A. myrtifolia* in the field and then processing the data to confirm known locations of *A. myrtifolia* on the map. This method is much more accurate than the first but is very time consuming and limited to lands that are legally accessible. The two mentioned methods were also used in tandem in that once *A. myrtifolia* stands were confirmed with GPS points they were used as training sites to help photo

[5] Each polygon was labeled with the classes that had the most of the same type of pixels, so if a polygon contained 30 pixels, and 20 of them had been labeled as *Arctostaphylos myrtifolia* and 10 had been labeled as grass, then that polygon would get a label of *Arctostaphylos myrtifolia*.

interpret areas that were inaccessible. Because the extensive size of the study area it was not only impossible, but also impractical to visit all potential *A. myrtifolia* stands. None-the-less significant effort was put towards field verification of the map and permission was obtained to access a variety of private lands.

Calaveras County Mapping Effort
The California Natural Diversity Database noted *A. myrtifolia* in two different locations in Calaveras County. The study set out to examine and map those sites. The furthest eastern documented population was thought to be approximately six miles northeast of the town of San Andreas (Gankin and Major 1956). AIRIS imagery existed for this site, but *A. myrtifolia* was not distinguishable on the imagery. Two separate field visits were made to this part of the project area. Sites were checked based on the descriptions in the CNDDB and no *A. myrtifolia* stands were found. The landscape in this area is very different than the Ione area. There is no Ione Formation present, the topography is steep and ridges extend to 625 meters elevation creating distinct aspects. The vegetation is denser, consisting of *Pinus ponderosa*, *Quercus wislizenii*, *Adenostoma fasiculatum* and mixed shrub. The *A. myrtifolia* that was observed in this area in 1956 was described as being taller and having a structure more similar to *Arctostaphylos viscida* than its Ione counterpart (Gankin & Major, 1964). This most eastern recorded population and the surrounding vegetation near San Andreas were not mapped because extensive field observations and imagery analysis revealed no *A. myrtifolia* present in the area. Although the survey was extensive, further investigation would be necessary to conclusively say that the population is no longer present.

The second Calaveras site examined is located on the northern side of Valley Springs Peak. Because multispectral imagery did not exist for this site, a one meter resolution 1993 USGS DOQQ was processed to create segmentation for this stand to maintain polygon structure consistency. Polygons of *A. myrtifolia* were identified through photo-interpretation using the DOQQs and were field verified. This stand of *A. myrtifolia* is the most southern population of the species known and mapped. The surrounding vegetation was not mapped for this area because of the lack of multispectral imagery. The mapping of the *A. myrtifolia* in this area is thought to be fairly complete.

Releve Plots

In order to provide a quantitative description of the *A. myrtifolia* community, 30 plots were chosen and releves were performed. Releves are commonly used to provide data on percent cover, species composition, percent live vegetation and environmental variables of a particular plant population or community of interest (Figure 7). Releve sites were chosen to be representative of the *A. myrtifolia* community in the study area.

Although CNPS recommends 400m plots for shrub types, once in the field it was decided that most Ione manzanita stands were too small to accommodate this size and maintain homogeneity, and structural and compositional integrity within the stands. Plot size was reduced to 200m to best represent the stands, as it was important that all plots were the same size. All decisions made to justify plot size and locations are supported in the CNPS releve protocol Oct 20, 2000 (revised 7/08/02).

Figure 7. Recording data from a releve plot. (Photo B. Holzman)

Accuracy assessment

Since all of the polygons could not be field checked due to time and budget constraints, a random sample of 50 plots was selected. Plots were chosen using a random sampling extension in ArcView 3.2 called "Animal Movement SA" version 2.04 beta. The software randomly chooses polygon centroids. In order to prevent plots on borders or edges of vegetation types, polygons were buffered. Sites were randomly stratified by vegetation type and landownership. Public lands and known accessible private properties were more heavily populated with sample points. More plots were chosen within polygons classified as *A. myrtifolia* than within those classified as the other vegetation types in order to focus the assessment on the target species. X, Y coordinates were assigned to each plot using Xtools (another ArcView extension) and projected into UTM coordinates.

Sites were thrown out due to their inaccessibility on the ground (thick brush impeded travel) or because the plot sampled on the ground placed us too near or on the edge of a polygon. Additional sites were selected to reach the 50 site goal.

Each randomly selected set of coordinates were located and the vegetation series in the area surrounding the point was identified. The vegetation series was recorded and compared to the mapped identified series to determine the percentage of correctly mapped locations.

A. myrtifolia Health Assessment

A component of the mapping project included evaluating the current health of the *Arctostaphylos myrtifolia* by assessing and mapping the percent of dead shrubs within each stand. This process was accomplished by using a Normalized Difference Vegetation Index (NDVI) generated from the AIRIS and IKONOS imagery. An NDVI is a proportional measurement so it normalizes anomalies like changing illumination conditions due to slope differences (Kiefer and Lillesand 2002). The NDVI relates the infrared reflectance of green vegetation to the absorption in the nonvisible red band so that high values indicate more vegetated areas. The NDVI is the computation:

$$NDVI = IR – R/IR + R$$

where IR represents the infrared digital values and R represents the red digital values. The NDVI is commonly used to detect vegetation related trends such as seasonal dynamics, tropical forest harvest, leaf area indices, photosynthetically active radiation, biomass estimates, and percent ground cover estimates (Kiefer and Lillesand 2002).

The NDVI does not distinguish between dead plant material and bare ground, so the classification combines these factors. Often bare ground is caused by severe dieback, so it often represents poor health, but a stand that is growing in a naturally sparse pattern could potentially fall into the same NDVI class as a stand that is actually dying from disease. Despite this lack of discrepancy in the NDVI classification, this method was found to be the most accurate, inclusive method for assessing the plant community health short of intensive ground surveys. This method allows for condition assessment for all of the *Arctostaphylos myrtifolia* stands whether accessible on the ground or not, whereas field assessment is only accountable for accessible areas.

An NDVI was calculated from the near infrared and red bands of imagery in ERDAS Imagine 8.6, producing an eight bit image with 255 relative values. The image values were sliced into four classes that were derived from ocular estimations using the imagery.

The classes were broken into the following ranges of relative living vegetation:

1: < 25% live vegetation
2: 26 -50% live vegetation
3: 51 – 75% live vegetation
4: > 75% live vegetation

These values were regionalized into the *A. myrtifolia* GIS map layer, using a zonal majority function, where all areas of *Arctostaphylos myrtifolia* existed. The values were then checked in the field for accuracy; a positive relationship was established between the NDVI values and living vegetation. Additional ground truthing can provide a more quantitative assessment if necessary.

Identifying pathogens causing A. myrtifolia dieback

An additional component of this project included an effort to identify the cause of extensive dieback throughout the A. myrtifolia populations. Through subcontract, Swiecki and Bernhardt conducted a series of tests to determine that g. *Fusicoccum* was indeed the pathogen present throughout A. myrtifolia populations. Isolates gathered from stem lesions on plants near Lambert Road and at the Department of Fish and Game Apricum Hill Preserve were grown on a potato-dextrose agar (PDA) sterile growth media that favors g. Fusicoccum. The isolates showed growth, confirming that they were *Fusicoccum* sp. A second isolation experiment was conducted on a set of *Arctostaphylos viscida* plants by inoculating *A. viscida* seedlings with *Fusicoccum* from different sources harvested throughout the Ione area and supplied by California Department of Food and Agriculture (Swiecki and Bernhardt 2003). The seedlings were obtained from Corn Flower Farms Nursery in Elk Grove, California. *A. viscida* plants were used for these inoculations instead of *A. myrtifolia* because of availability. *A. myrtifolia* is extremely hard to propagate domestically, so seedlings are not available in nurseries. Inoculated plants developed cankers, necrotic reactions, stem girdling, and fruiting bodies on the stems. The results of the inoculation study lead Swiecki and Bernhardt (2003) to believe that *Arctostaphylos* in the Ione area is indeed susceptible to *Fusicoccum sp*.

Swiecki and Bernhardt conducted a series of tests to determine whether additional disease vectors may be present. A soil baiting test was completed by collecting soil samples from beneath infected *A. myrtifolia* plants. Green pears were exposed to the soil and the exposed pears consequently developed brown lesions and oomycetes that formed mycelia and hyphal swelling indicating the presence of *Phytophthora cinnamomi.*

Plant materials showing root rot symptoms were collected throughout six areas of the Ione region. The pathogen suspected of being *Phytophthora* was isolated from the plant samples on PARP and hymexazol PDA media that is favored by *Phytophthora*. There were no obvious sporangia cultures from the initial isolation studies so further trials were conducted on V8 juice agar. The second iteration of treatments produced isolates that were identified as the *Phytophthora* species. Swiecki and Bernhardt (2003) observed that the isolated *Phytophthora* showed characteristics of the species *cinnamomi*. Dr. Matteo Garbelotto of the Forest Pathology and Mycology Department of Environmental Science, Policy and Management, Ecosystem Science Division at UC Berkeley, used molecular and DNA testing methods to confirm the species.

Eriogonum apricum **Mapping Methods**

Eriogonum apricum is such a small plant that it was impossible to see remotely, even with high resolution, multispectral imagery. The populations are also very small, sometimes covering less than 50 meters of ground. Because of this, a GIS point layer instead of a polygon layer was used to best represent the *E. apricum* distribution. The most accurate method for recording where the *E. apricum* populations existed was to actually identify every population that could be found and take the GPS position of these locations. Originally, area of *E. apricum* was going to be estimated, but after extensive field assessment and discussions it was decided that any type of acreage estimation would only be misleading. *E. apricum* tends to be sparse, intermittent and inconsistent, and there is no way to collect the data remotely. Thus field data collection was considered unreasonable.

A Garmin GPS 76 unit was used to record the *E. apricum* populations. This unit has an accuracy of less than three meters when it is receiving the Wide Area Augmentation System (WAAS) (Garmin 2003). Areas where known *E. apricum* was present (based on NDDDB, other researchers and land managers) were examined. Also areas within the *A. myrtifolia* stands and other accessible areas where soil conditions (i.e. Ione Formation) indicated the potential for *E. apricum* were examined. A GPS position was taken at every place *E. apricum* was located (Figure 8). If an area had a high density of plants, many points were recorded, but if the area had a sparse number of plants, one point was taken. A point on the map does not represent a specific number of plants but rather is designed to give the map user a qualitative idea of the number of plants in an area. The GIS layer also includes an attribute that identifies which variation of *E. apricum* was found at that point. Notes are also included to describe some of the populations, such as recently burned, or health appearance.

As mentioned above, it is important to note that the only *E. apricum* populations that were identified were those known from previous researchers, observations from agency personnel or land managers, and those encountered during the project. It is probable that there are *E. apricum* populations that are not identified on the map, such as those existing on inaccessible private property. Because the *E. apricum* GIS layer is a dynamic layer, when more plants are located and recorded, those points can be added to the layer.

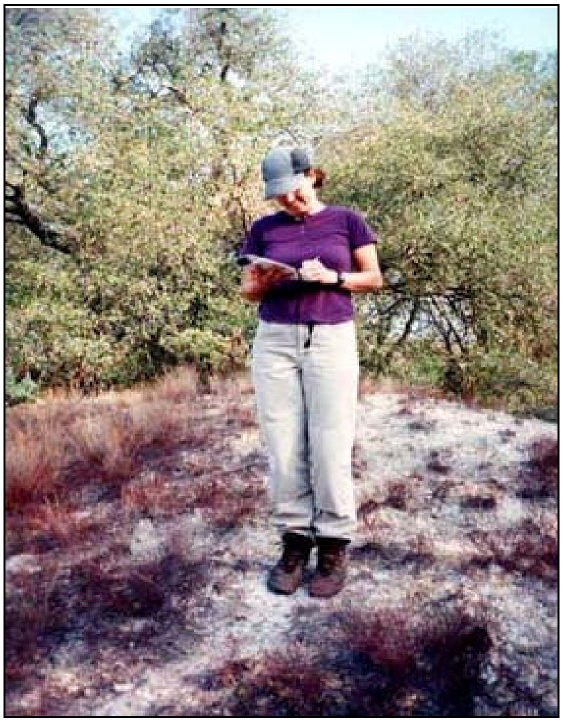

Figure 8: Data collection for *E. apricum*
(Photo: B. Holzman)

RESULTS

The project area consisted of 9,534 hectares (23,558 acres) located in western Amador County and a small part of eastern Calaveras County at the base of the foothills of the Sierra Nevada where the hills begin to rise out of the Central Valley. The average rainfall is 559 millimeters (22 inches) per year. The vegetation predominantly consists of drought tolerant oak woodlands, annual grasslands and chaparral. Three perennial creeks run through the project area: Willow Creek, Dry Creek, and Jackson Creek. The Mokelumne River defines part of the southern boundary of the project area for the vegetation mapping, with the exception of the *A. myrtifolia* that was mapped on the Valley Springs Peak south of the river in Calaveras County **(Appendix A- Map 1)**.

The project area was divided into two sections split by the town of Ione. Throughout these two sections a total of 34,990 segments (polygons) were created from the imagery and mapped. After the mapping process was completed, the line work was dissolved based on vegetation types resulting in 5990 mapped polygons.

Arctostaphylos myrtifolia Distribution (Appendix A- Map 2)

The **Ione Manzanita Series** (ionmanzanita) is dominated by *A. myrtifolia*. It may have other shrub components included such as *Adenostoma fasciculatum* (chamise), *Quercus wislizenii* (interior live oak), *Heteromeles arbutifolia* (toyon), *Arctostaphylos viscida* (whiteleaf manzanita), *Ceanothus tomentosus* (woolly leaf ceanothus), *Eriodictyon californicum* (yerba santa) and *Lotus scoparia* (deer weed) (Figure 9). There are also three rare species that are known to be present within this series including *Horkelia parryi* (Parry's horkelia), *E. apricum* (Ione buckwheat), and *Helianthemum suffrutescens* (Bisbee Peak rush-rose)(Sawyer and Keeler-Wolf 1995).

The total area of *Arctostaphylos myrtifolia* detected in the study is 484 hectares (1,196 acres). Out of the 34,990 polygons mapped, 1,220 were mapped as *A. myrtifolia*. The *Arctostaphylos myrtifolia* distribution runs across the western edge of Amador County from northwest to southeast, extending into northern Calaveras County, covering a span of approximately 31 kilometers (19.5 miles). The Ione manzanita was distributed across the project area in 10 distinct disjunct populations in addition to a few scattered, small populations (**Appendix A- Map 2**). Approximately 250 hectares (617 acres) were mapped in four populations north of the city of Ione, while 234 hectares (579 acres) were mapped throughout six populations south of Ione. Out of the 484 hectares (1,196 acres), a little over five percent occurs on public land and the remaining 94 percent is on private land.

Figure 9. *A. myrtifolia* community interspersed between *A. viscida* and *Quercus wislizenii* communities. Arrows designates *A. myrtifolia*. (Photo: B. Holzman)

Associated Plant Communities (Appendix A- Map 3)
Along with the Ione manzanita dominated community, the plant communities or series adjacent to *A. myrtifolia* series were also mapped. Plant community series were based on Sawyer & Keeler-Wolf (1995) and are described below. These are quantified in terms of coverage (Table 1).

The **California Annual Grasslands Series** (calanngra) is the most dominant community in the study area. This series is composed mostly of alien species such as *Bromus* sp., *Avena* sp., *Lolium* sp., *Erodium* sp. and a few native species. There were 3031 hectares (7489 acres) mapped, comprising 32 percent of the project area.

The **Interior Live Oak Scrub Series** (intlivoakscr) is the most abundant shrub type within the project area and the second most common type overall in the study area. This series is found near drainages and occurs as open woodlands. This series is dominated by *Quercus wislizenii* (interior live oak) but may also *contain Adenostoma fasciculatum* (chamise*), Arctostaphylos viscida* (whiteleaf manzanita*), Ceanothus tomentosus* (ceanothus) and *Heteromeles arbutifolia* (toyon). *Quercus douglasii* (blue oak) is often present in open woodland stands, and *Pinus sabiniana* (foothill pine) may be present in sparse amounts. There were 1540 hectares (3805 acres) mapped comprising 16 percent of the study area.

The **Chamise Series** (chamise) is where *Adenostoma fasciculatum* is often intermixed at the edges of the Ione manzanita stands, transitioning into pure *A. fasciculatum*. These stands have over 60% cover of pure *A. fasciculatum*. There were 793 hectares (1960 acres) mapped comprising eight percent of the project area. Spectrally this species was found to be very similar to *A. myrtifolia*.

The **Blue Oak Series** (bluoak) and **Valley Oak Series** (valoak) generally occur on the outer edge of the project area in open woodlands. The understory of these oak woodlands is usually native and nonnative annual grasslands, although the Blue Oak Series can have a shrub understory component, including *Quercus wislizenii*. *Pinus sabiniana* also may be present in both of these two oak series. There were 1220 hectares (3014 acres) of these two oak types mapped that comprised 14 percent of the project area.

The **Whiteleaf Manzanita Series** (whitleafmanzanita) is dominated by *Arctostaphylos viscida* (whiteleaf manzanita), containing at least 60% of the specific shrub. Other components can include *Arctostaphylos myrtifolia* (Ione manzanita)*, Adenostoma fasciculatum* (chamise)*, Quercus wislizenii* (interior live oak) or *Quercus berberidifolia (scrub oak).* There were 458 hectares (1,132 acres) of Whiteleaf Manzanita Series mapped, comprising five percent of the project area.

An additional series not noted in Sawyer and Keeler-Wolf (1995), but evident in this study was what we have called the mix scrub series. The **Mix Scrub Series** (mixscr) is a very common type in the study area. It is composed of similar associations as the Interior Live Oak Series such as *Quercus wislizenii* (interior live oak), *Adenostoma fasciculatum* (chamise), *Arctostaphylos viscida* (whiteleaf manzanita), and *Ceanothus tomentosus* (woolyleaf ceanothus), but is not dominated by any one species, rather the different shrub types are found in near equal amounts. There may also be *Lotus scoparia* (deer weed), *Heteromeles arbutifolia* (toyon) and *Eriodictyon californicum* (yerba santa) present in large amounts. There were 582 hectares (1439 acres) of the mixscr mapped, making up 6.38 percent of the project area.

Additional series types that occurred in limited extents include the following:
The **Coyote Bush Series** (coybrush) occurred in very small amounts in the project area (less than 0.5%) in wet draws only. It predominantly consists of *Baccharis* sp., annual grasses and sedges. The **Mixed Willow Series** (mixwillow) was only seen in a few riparian areas throughout the project area and consisted of at least three willow species as well as California sycamore and cottonwood. Coyote brush and mixed willow were the only soft shrub series mapped in the project area; totaling 65 hectares (159 acres) combined comprising 0.68 percent of the project area.

The **Foothill Pine Series** (foopine) is the only vegetation type in this area that has a native conifer as a component, *Pinus sabiniana*. Generally, foothill pines are very sparse, and in some areas, they are present in such low density that they may be mapped within another vegetation type, because the pine canopy is too sparse for mapping. The foothill pine is usually seen with *Quercus wislizenii* or *Quercus douglasii* understory in this area. There were 223 hectares (551 acres) mapped making up about 2 percent of the project area.

The remaining vegetation layers are more similar to land use descriptions than vegetation descriptions. Lakes are labeled as water, irrigated fields and crops are labeled as agriculture, and buildings and pavement are included in the urban designation. The nonnative conifer label includes all ornamental conifers that have been planted instead of naturally occurring. Wet meadows, barren land and Ione clay are also broken into their own classes. These types encompass the remaining 608 hectares (2804.50 acres) of the project area, about 12 percent.

From the map (Appendix A- Map 3), it appears that *A. myrtifolia* populations are closely aligned with chamise and interior live oak scrub series in the northern populations and mixed scrub, whiteleaf manzanita and interior live oak scrub series in the southern populations. Further spatial analysis may provide a clearer view of these relationships. This type of spatial analysis was not included in the currently funded project.

Table 1: Classification Results of Vegetation Composition Analyses

Sawyer Keeler-Wolf Series	Total Hectares	Total Acres	Percent of Project
Barren	251	619	3
Ione clay	395	977	4
Agriculture	96	238	1
Blue Oak	1212	2995	13
California Annual Grass	3031	7489	32
Chamise	793	1960	8
Coyote Bush	45	110	<1
Foothill Pine	223	551	2
Interior Live Oak Scrub	1540	3805	16
Ione Manzanita	484	1196	5
Mix Scrub	582	1439	6
Mix Willow	20	49	<1
Nonnative Conifer	1	2	<1
Urban	100	248	1
Valley Oak	8	19	<1
Water	223	552	2
Wet Meadow	72	179	<1
Whiteleaf Manzanita	458	1132	5
Total	**9534**	**23,558**	**100**

Mapping Accuracy (Appendix A- Map 4)

As noted in the methodology, during the mapping process many areas were ground surveyed to verify specific vegetation labeling. The Ione manzanita series was preferentially targeted to assure accuracy of that vegetation type in particular.

In addition to the mapping reconnaissance, and in order to assess the total accuracy of the map, an independent assessment was performed. From this accuracy assessment, from zero to 100 percent of the labeled series were found to be accurately labeled. Because some of the series were only represent by two or less plats they were not included in assessing the total accuracy. The range of those plots included in the total accuracy assessment was 63-75 percent (Table 2).

In the assessment, 50 plots were randomly selected and located. Upon further review, two plots were not included in the final assessment analysis due to there proximity to the edge of the vegetation type. Of the 48 randomly selected plot locations 19 plots were labeled as Ione manzanita, eleven of these plots were identified in the field as pure *A. myrtifolia* stands, while two had an *A. myrtifolia* component but included other species as codominants and were labeled in the field as mixed scrub. Six of the 19 plots were determined to be mislabeled upon ground assessment. Of these, two were *A. fasiculatum* plots, one was dominated by *Q. wislizenii,* one was grassland and two were dominated by mixed shrub with no *A. myrtifolia* component. Upon reviewing the digital imagery it was clear that the grassland plot was mislabeled representing a gross error. The other five plots were unsuccessfully detected in the classification process.

Eight Chamise series plots were examined. Five of the eight plots were found to be correctly labeled. Of the three noted as incorrect on ground survey, one was found to be grassland, one was primarily whiteleaf manzanita series and the third was classified as Mixed scrub with *A. fasiculatum* present, but not dominant.

Seven Whiteleaf manzanita plots were also examined and five were found to be correctly labeled. The two incorrectly labeled, were dominated by *Q. wislizenii*, and thus classified in the field in that series.

Four plots labeled as Interior Live Oak Scrub were among those randomly chosen. Of these plots, three of the four were found to be correctly labeled. The fourth was classified in the field as Mixed scrub due to shared dominance of *Q. wislizenii* with *A. viscida* and *A. fasiculatum.*

Of the four Mixed scrub plots randomly selected for plot assessment, three of the four plots were correctly labeled; the fourth was classified as Whiteleaf manzanita type in the field.

<u>Plots not include in the total accuracy percentages</u>
Only two grass plots were in the randomly selected assessment survey and both were found to be correctly classified. Two foothill pine plots were also assessed. In the field, the *Q. wislizenii* component was judged dominant and both were classified as Interior live oak scrub. Although foothill pine was a component of the plot, interior live oak tended to be present causing the plots to be classified as interior live oak in the field.

One Blue oak and one barren plot were among the selected random plots. Both plots were judged to be correctly labeled.

Because *A. myrtifolia* was the main species of concern in the assessment process those plots that contained *A. myrtifolia* were carefully examined. Although two of the 19 sites were classified in the field as Mixed Scrub, there was a clear *A. myrtifolia* component and so these plots were not considered in error in the mapping and labeling process. Thus, the accuracy of the Ione manzanita plots was assessed at 70 percent, with that qualification. Mislabeling was attributed to errors of omission and commission including misidentification, classification algorithm and generalizations made in the mapping process with the majority rule for classifying polygons or minimum classification area, as well as an occasional gross error.

Vegetation Type	n	Correctly labeled	Mislabeled	Correctly classified (%)
Ione manzanita	19	13	6	69
Chamise	8	5	3	63
Whiteleaf manzanita	7	5	2	71
Interior live oak	4	3	1	75
Mixed scrub	4	3	1	75
Total*	42	29	13	70

Table 2: Accuracy Assessment results. (Series with two or less plots assessed are not included in the calculated total accuracy due to insignificance of sample size).

Releve Plots (Appendix A- Map 5)
Thirty plots were evaluated to provide a quantitative description of the Ione Manzanita community. Releve protocol from CNPS was followed. The locations of the releve plots were selected to be representative of the Ione manzanita communities in the study area and are identified on **Map 5-Appendix A**. General descriptive statistics are provided for an overall look at the target community. Elevation ranged from 74 to 156 meters with and average elevation of 114m ($\pm$22.6). Slope averaged 10.72 degrees ($\pm$12.82) and ranged from zero to 50 degrees. Aspect varied (Table 3).

Average percent cover by *Arctostaphylos myrtifolia* was estimated at 87 (+21.25), and ranged from 22 to 96 percent on the releve plots. Other species present in the releves included *Arctostaphylos viscida, Arctostaphylos manzanita, Arctostaphylos xhelleri, Eriogonum apricum, Adenostoma fasiculatum, Eriodycton californicum, Quercus wislizenii, Pinus sabiniana, Baccharis pilularis,* and unidentified mosses, lichen and grass species. In 97 percent (29/30) of the releve plots at least one other species was found with Ione manzanita, although those associated species typically occurred in small percentages (averaging 12 to <1 percent). Total species within a releve ranged from pure *A. myrtifolia* to four different species within the area with an average of three associated species found on a releve. Total percent coverage of other species averaged 16 percent (+16.99) and ranged from zero to 60 percent. Those species occurring on Ione manzanita plots with an average cover of greater than one percent were *A. viscida, Adenostoma fasiculatum, Quercus wislizenii* and *Pinus sabiniana*. (**Selected releve data are presented in Appendix C**)

Adjacent alliances surrounding the *A. myrtifolia* releves included whiteleaf manzanita, interior live oak, chamise, mixed scrub, foothill pine and common manzanita series.

Health of the stand was assessed in terms of percentage live vegetation on the releve plots. Average live vegetation was 87 percent (+16) with a range of 99 to 26 percent live vegetation recorded. Potential impacts that may threaten the plant community were also noted. Of the 30 plots surveyed, 47 percent were found to have some impact of dieback from disease or fungus. Ten percent had evidence of previous fire; thirty percent had other impacts such as mining, or road building in the area. Only 13 percent had no impacts noted.

Table 3: Summary Data derived from Releve Plots

Variables	Mean	Standard Deviation	Minimum	Maximum	n
Aspect (°)	176	96.36	2	360	27
Slope (°)	10.72	12.82	0	50	26
Elevation (m)	114.23	22.60	74.27	155.63	29
ARMY Health (%live)	87	16.32	26	99	26
ARMY Cover (%)	87	21.25	22	96	30
Other Sp. Present (#)	3	1.12	0	4	30
Other Sp. Cover (%)	16	16.94	0	60	30
Bare Ground (%)	21	20.64	0	72	30

Arctostaphylos myrtifolia **Health (Appendix A- Map 6)**

From field observations it appeared that much of the *Arctostaphylos myrtifolia* was stressed or dying due to an unknown pathogen. During this study the percent of total vegetation cover of *A. myrtifolia,* using the NDVI procedure noted above, was mapped to identify areas of stress or potential pathogen outbreak. The map revealed that 23.5 percent of the *A. myrtifolia* showed a high rate of dieback or sparse growth. Populations that fell into this range should be considered as a population of concern and may be distressed by disease, fire or human impact, such as herbicide application or other. These areas should be reexamined on the ground to confirm reason for dieback. Approximately 31 percent was classified healthy, although a small amount of natural dieback exists within these stands. The remaining 45.5 percent showed robust growth and no dieback (Table 4) **(Appendix A - Map 6**).

Upon field observation it was noted that a combination of fires in 2001 and 2002 burned over 800 hectares of land in the northern part of the project area. A considerable amount of *A. myrtifolia* burned during these events (Figure 10a & 10b). The burned plants were noted on the map within the less than 50% live vegetation classes. Upon visiting some of the burned plots, *A. myrtifolia* seedlings were present under former shrubs. No specific data relating to the fire or regeneration after fire was recorded for this study.

Table 4: *A. myrtifolia* Foliage Analysis

Live Vegetation	Total Hectares	Total Acres	Total %
0 – 25%	113.91	281.48	23.53
26 - 50%	32.22	79.61	6.66
51 – 75%	117.62	290.65	24.30
76 – 100%	220.29	544.36	45.51

Figure 10a: *A. myrtifolia* after wildfire. (Photo: T. Meyer)

Figure 10b: *A. myrtifolia* seedling after fire. (Photo: B. Holzman)

Pathogen studies (Appendix B)

Phytosphere Research was subcontracted to identify the pathogen or pathogens that were affecting *Arctostaphylos myrtifolia*. Swiecki and Bernhardt determined that at least two different diseases were affecting the health of *Arctostaphylos myrtifolia* and *A. viscida* (see Appendix B for their complete report). A branch canker of the species *Fusicoccum* was identified. Dieback due to this species appeared scattered among both *Arctostaphylos* populations. Secondly, *Phytophthora cinnamomi* (a water mold) causing crown and root rot was isolated from the two species. Additional greenhouse work demonstrated pathogenicity of *P. cinnamomi* (**Appendix B**). This infestation was considered very serious with a potential for significant and possible complete loss of the *A. myrtifolia* species if not held in check.

The following pathogen information was directly extracted from studies conducted by Swiecki and Bernhardt (**Appendix B**) unless otherwise referenced. A series of field and lab tests carried out revealed that two independent pathogens are causing dieback symptoms throughout the *A. myrtifolia* populations (Swiecki and Bernhardt 2003).

Fusicoccum aesculi

The US Department of Agriculture tested for the branch canker *Fusicoccum aesculi* in *A. myrtifolia* and found it to be present. The pathogen is an ascomycete from the *Botryosphaeria* genus called *Fusicoccum aesculi*. *Fusicoccum* is a branch disease that causes " elongated and sunken" stem cankers, including black, round fruiting bodies. Swiecki and Bernhardt (2003) noted that the *Fusicoccum* does not generally cause large amounts of mortality throughout *A. myrtifolia* stands, but the stem cankers are capable of girdling the stems, which, in turn, restricts water movement through the stem, promoting desiccation, and leading potentially to the entire stem dying. In extreme cases, the infliction can progress throughout the entire plant, eventually killing it. The stems are prone to disease-related desiccation during the summer season when temperatures are high and water availability is low. These symptoms are observed on *Arctostaphylos viscida* throughout the Ione area. The *Fusicoccum* spores are dispersed by water, and most likely to spread during the rainy season.

Phytophthora cinnamomi
The second and more harmful pathogen, identified by Swiecki and Bernhardt (2003), is an aggressive microbe called *Phytophthora cinnamomi.* The pathogen is in the oomycetes subgroup belonging to the Chromista Kingdom that includes diatoms and brown algae. The *Phytophthora genus* is responsible for destroying agricultural crops, native plants and forests throughout the entire world. It is the cause of Port Orford cedar root disease in Northern California and the sudden oak death blight responsible for large diebacks of a variety of oak species throughout Northern California's coastal oak populations.

Phytophthora cinnamomi is a disease capable of infecting all age classes of a species. It functions by decaying roots and the root crowns, which destroys water-conducting tissues in the roots, causing desiccation. Although the disease is commonly identified as a root disease, it also has been observed affecting leaves and stems and thus, can be confused with *Fusicoccum.* Moreover, like *Fusicoccum, Phytophthora cinnamomi* disperses in water. Sporangia release zoospores in warm (18 – 30 C?), moist to wet condition; so new infection is most likely to occur during spring rains.

Phytophthora cinnamomi has been especially devastating in Australia where it has up to 2000 host species and has eradicated thousands of hectares of native forest, pushing many of Australia's rare plants to the point of extinction.

Phytophthora cinnamomi was observed in the Ione *A. myrtifolia* populations as showing dark brown discoloration on root crowns and taproots and fine root decay. These symptoms were observed in large mortality centers that affected all of the *A. myrtifolia* and *A. viscida* in the vicinity, but the evergreen oaks present in these mortality centers, such as *Quercus wislizenii* and *Quercus berberidifolia*, did not show symptoms. This infestation is considered very serious with a potential for significant and possible complete loss of the *A. myrtifolia* species if not held in check (Swiecki and Bernhardt 2003- Appendix B).

Eriogonum apricum **Distribution (Appendix A- Map 7)**

Seven distinct *Eriogonum apricum* population centers are identified in the study area. Five of these are the *Eriogonum apricum* var*. apricum* and two are *Eriogonum apricum* var*. prostratum*. As noted earlier, area could not be calculated for the *E. apricum* populations for two reasons. First, *E. apricum* is such a small plant that it is impossible to map remotely, thus polygons of *E. apricum* could not be captured. Therefore, no discrete polygons were available from which to calculate area. Secondly, populations are so varied and scattered that the clusters of individuals are not distinct. Some stands consist of a few individuals, while other stands consist of hundreds of individuals. Hence drawing polygons would be too arbitrary to give a true sense of area and abundance. In order to represent the *E. apricum* distribution, each group of individuals was recorded as a series of points.

Although *E. apricum* is found in the same general northwest to southeast distribution pattern as the *Arctostaphylos myrtifolia,* not all *E. apricum* are directly associated with the manzanita (Figure 11). The most obvious example of this is the most northern location. The most northern population of *E. apricum* is located on Valley Springs Formation instead of the Ione Formation (Sanders, pers comm. 2002). The Valley Springs Formation is made up of masses of kaolinitic altered rhyolite tuffs and gravel that covered the Western Sierra Nevada during the Late Pliocene (Gankin and Major 1964). It originated from Andesitic volcanic agglomerates and mudflows of the Mehrten Formation (USDA Forest Service, 2004).

This location of *Eriogonum apricum* var*. apricum* is intriguing because it is separated from the remaining four populations of that variation by the main population of *Eriogonum apricum* var. *prostratum*. The *Eriogonum apricum* distribution only extends 11.5 miles in contrast to the19.5 mile extent of *Arctostaphylos myrtifolia*. *Eriogonum apricum* distribution extends approximately half a mile northwest from the most northern extent of the manzanita, and stops approximately eight miles north of the further most southern manzanita population (**Appendix A-Map 7)**.

Figure 11: *E. apricum* in Valley Springs Formation (Photo: I. Signer)

DISCUSSION

A. myrtifolia was identified in two disjunct populations in Amador County and one limited population in Calaveras County. Total area of *A. myrtifolia* was determined to be 484 hectares. Its distribution was closely aligned with the Ione Geologic Formation.

Over nine thousand hectares of additional adjoining vegetation series and land use types were also mapped. In examining the mapped distribution *A. myrtifolia* appeared to be located in close proximity to chamise and interior live oak types in the north and whiteleaf manzanita, interior live oak, and mixed chaparral series in the south.

The methodology undertaken to map *A. myrtifolia* and adjoining communities used a combination of processes including remote sensing, GIS and ground surveys. Significant difficulties were encountered with obtaining imagery and additional sources were investigated. The segmentation process was accomplished with low budget software but appeared to present few problems once initial processing was completed.

Labeling of vegetation series was based on Sawyer and Keeler-Wolf (1995) and was found to be useful, but incomplete. An additional series called Mixed Scrub was added to more accurately reflect the plant community. Once the series were identified, the labeling process was fairly accurate. Additional on the ground surveys allowed for modification of the map. *A. myrtifolia* stands were specifically targeted in initial ground truthing to differentiate *A. myrtifolia* from *Adenostoma fasiculatum* that proved difficult remotely.

The accuracy assessment of the map produced varied results with approximately 70 percent of the Ione manzanita plots correctly classified. Mislabeling did occur. Some of the labeling errors were evident when reviewing the mapped and ground surveyed plots; others were due to the segmentation generalizations that limited the ability to capture patchiness. This allowed larger polygons that contained primarily uniform vegetation with small patches of a particular vegetation to be classified as the larger vegetation type, missing the small patches of other vegetation. This was most probably due to the decision to combine areas smaller than 500 meters^2 or the majority rule used in the polygon classification.

In the accuracy assessment no additional plots were found to be Ione manzanita, thus we feel that we accurately accounted for the Ione manzanita populations present in Amador County. However, because of the 500m^2 minimum mapping area requirement and the primary use of remotely sensed data for analysis, small patches of Ione manzanita within larger vegetation series may have been missed.

Because multispectral imagery was not available for Calaveras County, the mapped areas only included Ione manzanita populations verified by ground truthing. Other areas of Ione manzanita may exist and could be useful to examine in a future study. Because only Ione manzanita populations noted remotely and verified by ground surveys were included, the accuracy assessment did not include the Calaveras County populations. Although the Ione manzanita population noted in an earlier study (Gankin pers comm.), near San Andreas, was not found, additional work would be needed to rule out this previously reported population.

Releve plots revealed that Ione manzanita communities are similar throughout the study. They primarily occur as single species stands although a few were interspersed among whiteleaf manzanita and chamise populations. Although percentage cover was found to vary, plots tended to be dominated by Ione manzanita with high coverage estimates.

Ione buckwheat proved impossible to capture remotely, so all populations mapped had to be identified and geolocated in the field. The locations mapped are limited and were dependent on previous researchers, land managers information on population locations, as well as those encountered in the field on map reconnaissance, or those targeted for investigation due to geologic formation. Because of the diminutive nature of the plant, area estimates were also deemed impossible to accurately estimate.

The pathogens g. *Fusicocum* and *P. cinnamomi* were identified as threats to this limited population of Ione manzanita. *P. cinnamomi* appears to be a greater threat as the consequences of infection are typically fatal. Preliminary analysis indicated that the population of Ione manzanita was indeed susceptible to infection and steps are needed to protect the populations from further decline.

Identifying the distribution of Ione manzanita and Ione buckwheat as well as describing the community and potential for pathogenic invasions provide a base for future studies on this unique community. The following recommendations are provided to accompany the results of this study and inform future management efforts.

The Ione plant community has an extremely limited geographic range and a limited number of individuals, making it particularly susceptible to population reduction. Currently there is a 37-acre DFG preserve, with about one third containing *Arctostaphylos myrtifolia* and a very small population of *E. apricum*. The Bureau of Land Management manages two separate 20-acre parcels, that each contains a very small amount of *A. myrtifolia* and a very small amount of *E. apricum*. A portion of the DFG managed populations are already heavily infected by the pathogen *Phytophthora cinnamomi*. The total amount of *A. myrtifolia* on these properties is so small that it does not appear that there is enough to sustain the species. With respect to these faltering populations, a discussion of strategies for the conservation and recovery of the Ione plant community species is appropriate. Four main recommendations of management strategies follow.

Recommendations

1. Preserve land

The single most important action towards conserving the Ione plant community is to acquire or preserve critical habitat. This goal presents many obstacles, the most obvious being funding. Prioritizing the most critical habitat is also an important factor. Determining the most critical habitat for the Ione plant community is going to be particularly challenging because both Ione manzanita and Ione buckwheat have such disjunct populations. These fragmented populations raise unanswered questions such as whether the different patches are genetically interdependent and whether connectivity is needed between the patches for sustainability. When assessing critical habitat for the Ione manzanita one of the factors to take into consideration is whether enough of those stands include *E. apricum*. *A. myrtifolia* may act somewhat like an umbrella species to the *E. apricum*. If proper amounts of habitat for *A. myrtifolia* are preserved then the *E. apricum* will most likely be maintained within that area, although the manager should be aware that field observation did detect *E. apricum* in areas without *A. myrtifolia*.

Amador County is an extremely rural county. The population was 30,000 in 1999 and 35,100 in 2000 (US Census Bureau 2002). Although both of these numbers are very small for an entire county of 605 square miles, the 17 percent increase demonstrates how the county is rapidly growing. This is a perfect time to be planning environmental preservation for this area, because there are still many hectares of potential wildlands that could be targeted for open space preservation.

An additional important factor that involves the Ione plant community is surface mining. Amador County is one of the largest surface mine materials exporters in the nation. Mineral extraction is an important economic base for Amador County, and in fact, the majority of the western part of the county relies on it for income. The Amador County mining industry and the Ione plant community share the same areas, so the majority of the mining activities are occurring on potential Ione plant community habitat (Sanders per. comm. 2002). The mining industry can play a very important role in the survival of the Ione manzanita plant community. Partnerships with mining landowners to increase reclamation efforts and restore *A. myrtifolia* communities should be a priority.

2. Contain *Phytophthora cinnamomi* Disease

The second largest concern for the Ione plant community is the recently identified pathogen, *Phytophthora cinnamomi*. Once habitat is secured for Ione manzanita, maintaining the health of this habitat will be critical. Conservationists will need to act swiftly to find the best way to prevent the spread of this aggressive, lethal disease. These steps are clearly outlined in the *Phytophthora cinnamomi* section of this report (See Appendix B). Examining areas identified on the foliage analysis map as being in poor health can provide additional information for analysis and spread of the disease.

3. Involve and educate local landowners and public

Habitat preservation will need to include local conservation and citizen organizations. It appears that buying large amounts of property is not a realistic option, so conservation organizations and interested stakeholders are going to have to collaborate and pursue creative methods for maintaining healthy Ione plant community habitat. They will need to form partnerships with each other and use strategies such as conservation easements with local landowners and include government organizations and groups such as the Amador Band of Indians and local homeowners in the partnerships. Public support will also be essential to the success of Ione manzanita conservation.

The public and local government needs to be included. Without public support, conserving Ione plant communities could be a long, unforgiving and unfruitful battle. Currently Amador County does not emphasize environmental support or planning, but with proper local meetings, public education and awareness campaigns the attitude could be shifted. The local people need to be informed of this precious resource that they can be proud of and can be a part of preserving. If local landowners and the public are included in the conservation planning process, they may be more inclined to cooperate and become part of the solution.

4. Continue research

To better understand the biology of the Ione plant community, a long-term monitoring program needs to be set in place. The Inventory Monitoring and Assessment Program (IMAP) monitoring protocol would be an excellent method because its protocol has been standardized by the State of California making it easily repeatable (Woodward 2002). A successful monitoring program begins with identifying the plant community's critical habitat, selecting the monitoring area, counting species, evaluating the health of the plants and the condition of the habitat as well as the threats to the plant community over time.

Once viable habitat is secured, creative and adaptive management will have to be utilized to ensure *A. myrtifolia*'s recovery. There is a great need to increase biological research on the plant community to learn more about its regeneration needs, germination, pollination and dispersal mechanisms, its genetic diversity and relationships between population islands and how fungi, invertebrates, small mammals and birds are an integrative part of its community.

Some very basic questions have yet to be answered regarding the components of the Ione plant community. These include: Is there a direct correlation between disturbance and healthy buckwheat populations? Would including disturbance in a management program be beneficial to the buckwheat populations? Would reclamation efforts in mining areas that include introduction of Ione manzanita and Ione buckwheat be successful? Under what conditions *E. apricum* might be restored to reclaimed areas? What is the source of seed for Ione buckwheat growing on highly disturbed areas? How old is the species? Have the populations increased or decreased in recent time?

The role of fire in the Ione plant community needs to be better understood. The effects of fire in stimulating germinations as well as possibly lessening the expansion of the pathogen *Phytophthora cinnamomi* is as of yet unknown.

Additionally, the role fire might play in these plant life cycles needs to be fully examined to assess whether fire should be a part of a management program. Monitoring of recently burned areas containing *A. myrtifolia* may help to shed light on this issue. An assessment of previous fires and their effects on the plant community would also provide longer temporal analysis. This would also assist in informing management decisions.

Questions also arise regarding metapopulation dynamics throughout these disjunct populations. Are there genetic effects due to geographic isolation between populations?

The answers to these questions would facilitate more effective management of the Ione plant community. Funding will be a key component to getting the answers to these questions.

This study has attempted to determine the distribution of *Arctostaphylos myrtifolia and Eriogonum apricum* using remotely sensed and ancillary data, Geographic Information Systems and intensive field evaluation. Areas of plant populations and their associated communities were mapped and defined for *A. myrtifolia*. Since *Eriogonum apricum* is so sparsely distributed, only known populations were mapped with no accurate estimate of area provided. Two diseases that are affecting these populations were identified. A branch canker of the species *Fusicoccum* was identified as causing scattered dieback. Perhaps more importantly *Phytophthora cinnamomi* was newly identified in these populations and is thought to be causing significant mortality of manzanita. Immediate management and experimental attention must be paid to these endangered communities to ensure their existent into the future.

CONCLUSION

Efforts towards mapping *Arctostaphylos myrtifolia* and *Eriogonum apricum* yielded excellent distribution maps that reveal vital statistics of the two species. A map of the associated vegetation has added information about the plant associations surrounding the Ione plant community and health analysis mapping efforts support studies of the two pathogens that are causing large amounts of dieback through out the *Arctostaphylos myrtifolia* stands.

An accuracy assessment found that *A. myrtifolia* populations were primarily correctly labeled and no Ione manzanita communities were labeled as other series, although there were a few plots labeled as Ione manzanita that were not. Accurate remote spectral analysis was not possible without supervised interpretive analysis and ground surveys. This was particularly evident in differentiating chamise from Ione manzanita. Although remotely sensed imagery allows for a faster evaluation, the necessity for on the ground evaluation continues to be crucial in mapping these rare populations.

The study also provides the first extensive quantitative examination of the Ione manzanita plant community using thirty releve plots. This evaluation identifies specific characteristics and commonalities among the Ione manzanita stands. The data will be provided to the California Native Plant Society to further their data on the community.

By researching this rare endemic plant community, we are better able to understand its distribution and the characteristics of the community, to allow us to make recommendations for future studies and proper management. Immediate management, research, protection and continuous monitoring will play a crucial role in maintaining stable populations into the future.

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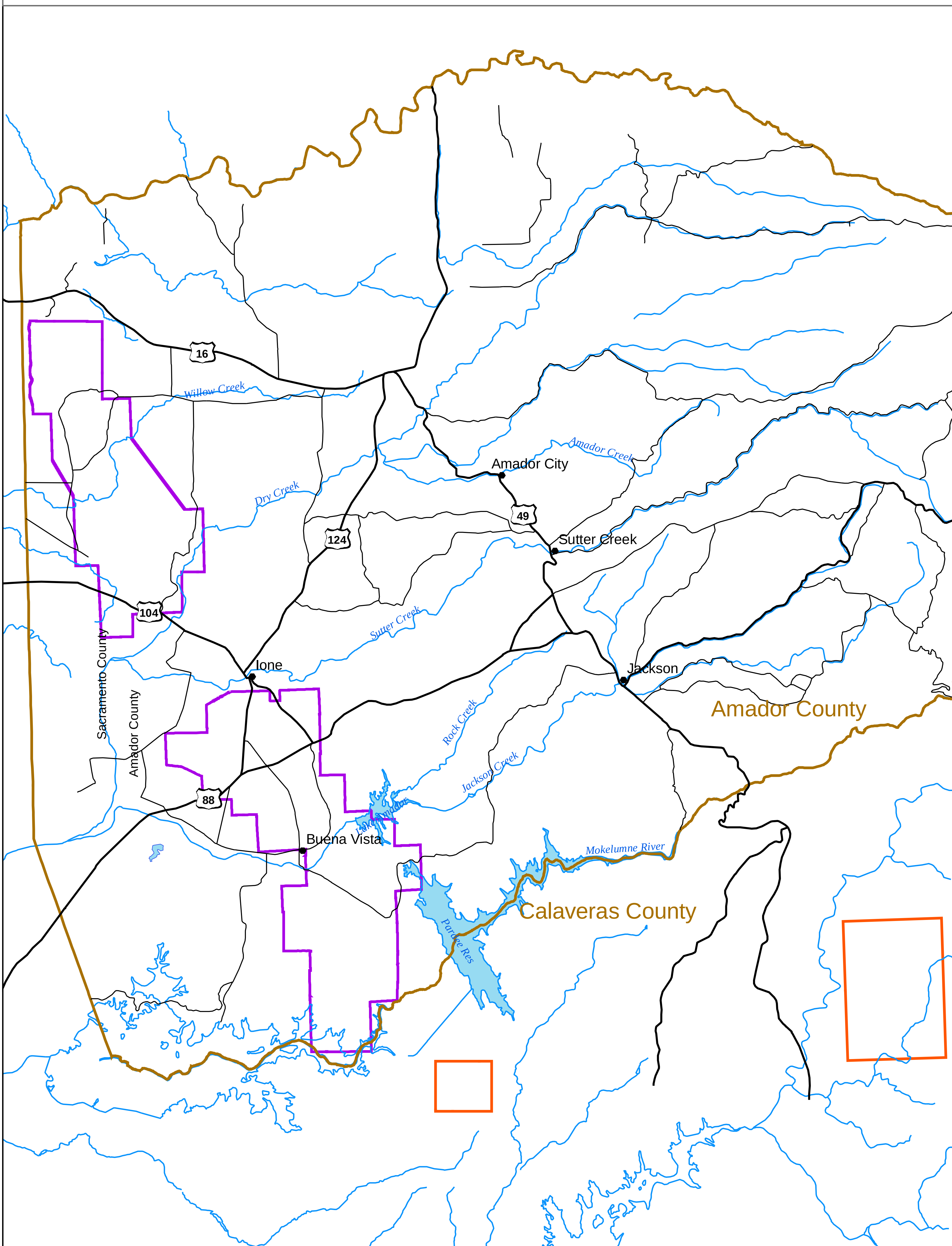
APPENDIX A

Conservation and Recovery of Ione Endemic Plants

Map 1: Project Area

California Department of Fish and Game/ San Francisco State University 2004



Project Area

- Area mapped in Amador County
- Area mapped in Calaveras County
- streams

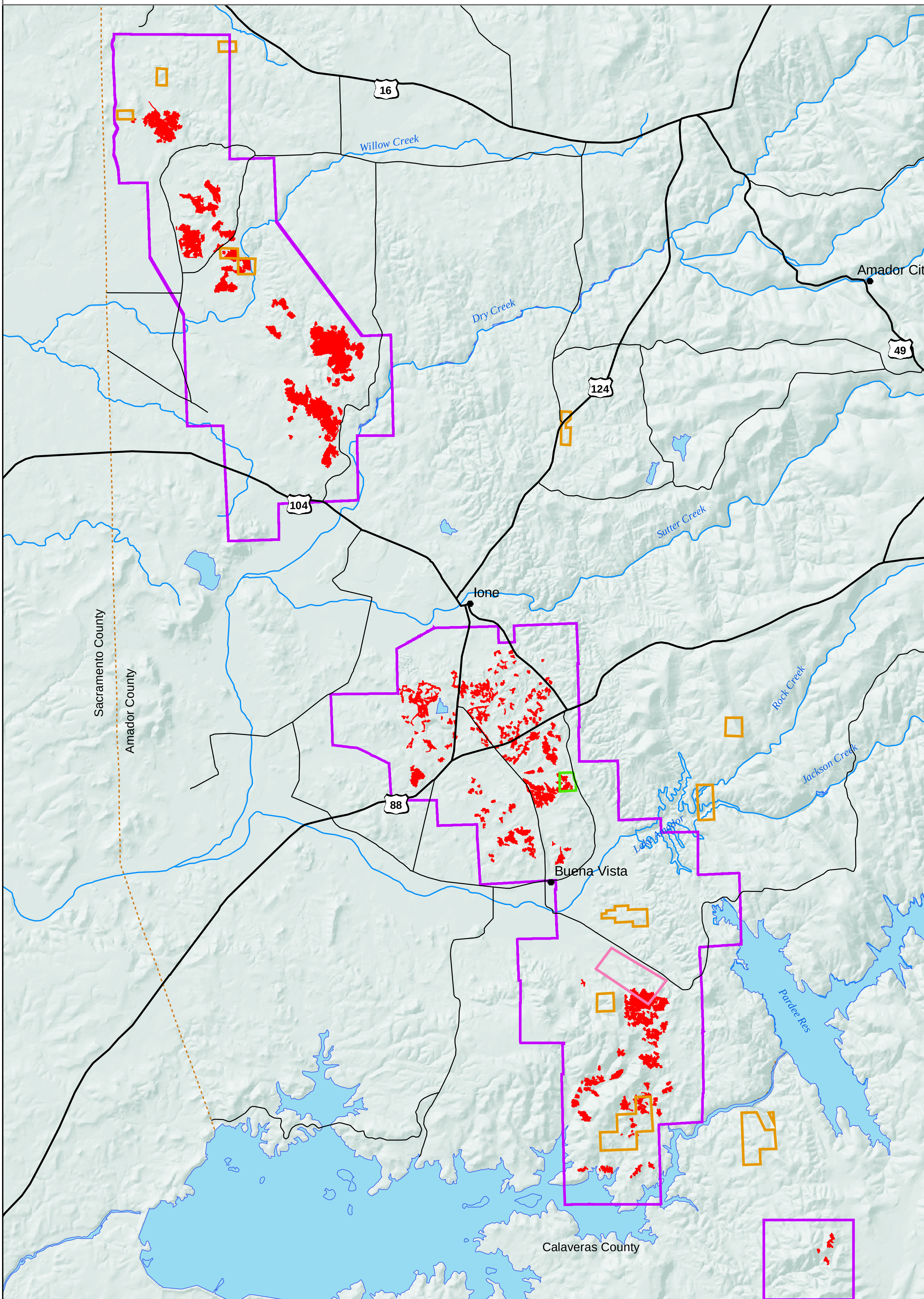
0 0.5 1 2 3 4 Miles

By: Tiffany Meyer

Conservation and Recovery of Ione Endemic Plants

Map 2: Ione Manzanita Distribution

California Department of Fish and Game/ San Francisco State University 2004



Ione manzanita
Project Boundary

Public Ownership
BLM
DFG
TRIBAL LANDS

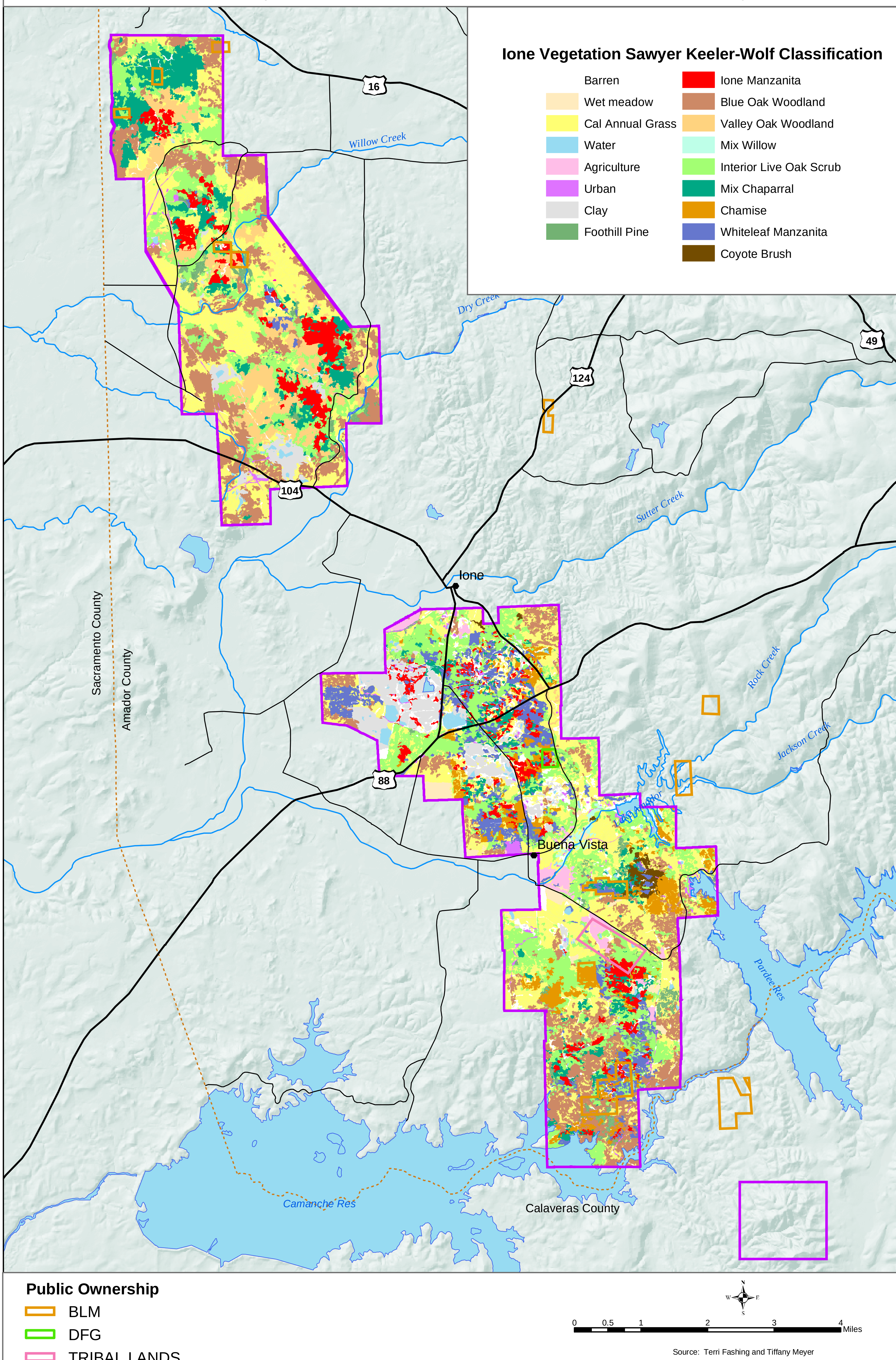
0 0.5 1 2 3 4 Miles

Source: AIRIS 1 meter imagery
IKONOS 1 meter imagery
By: Tiffany Meyer

Conservation and Recovery of Ione Endemic Plants

Map 3: Ione Vegetation Series

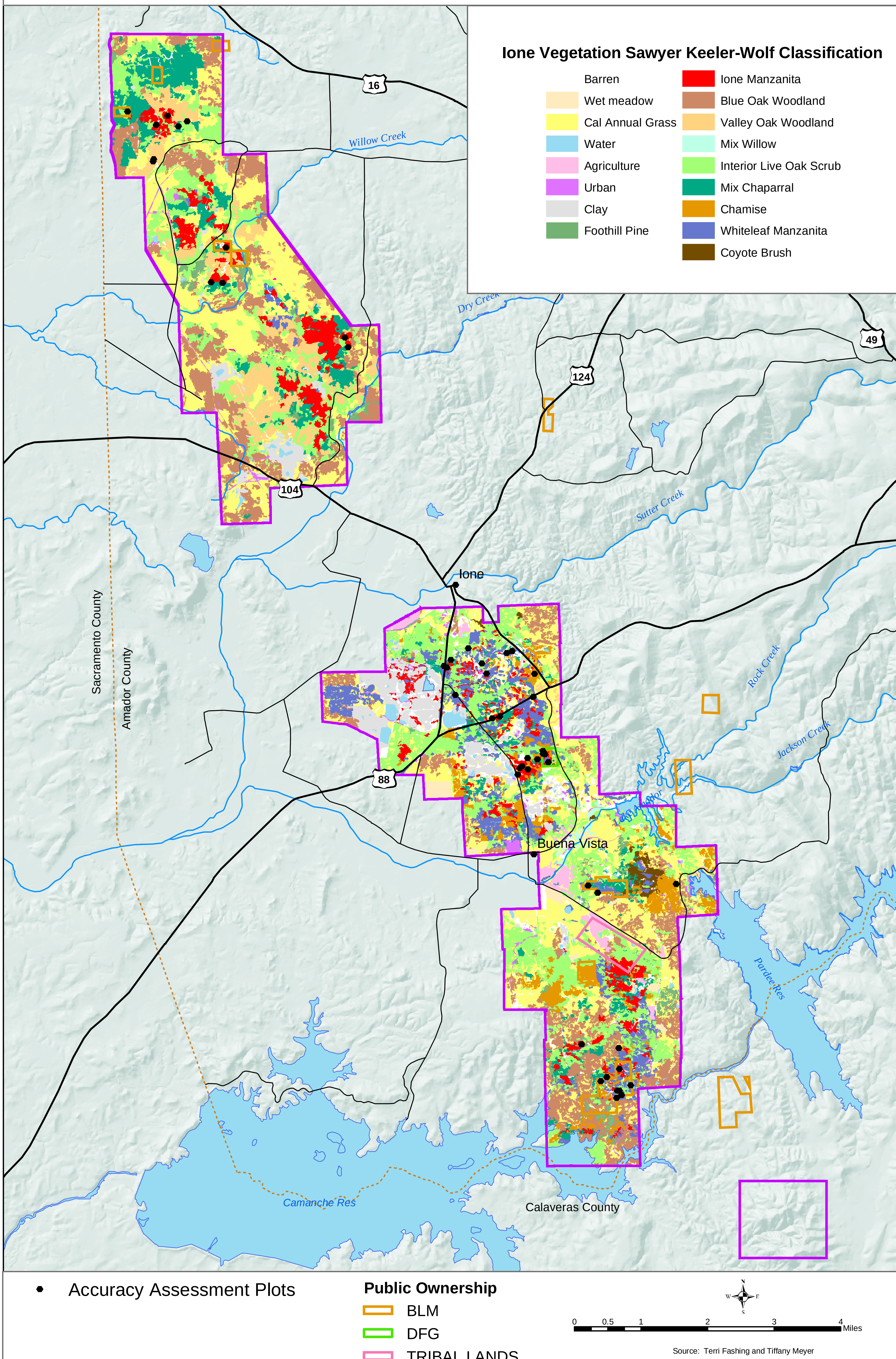
California Department of Fish and Game/ San Francisco State University 2004



Conservation and Recovery of Ione Endemic Plants

Map 4: Ione Manzanita Accuracy Assessment Plots

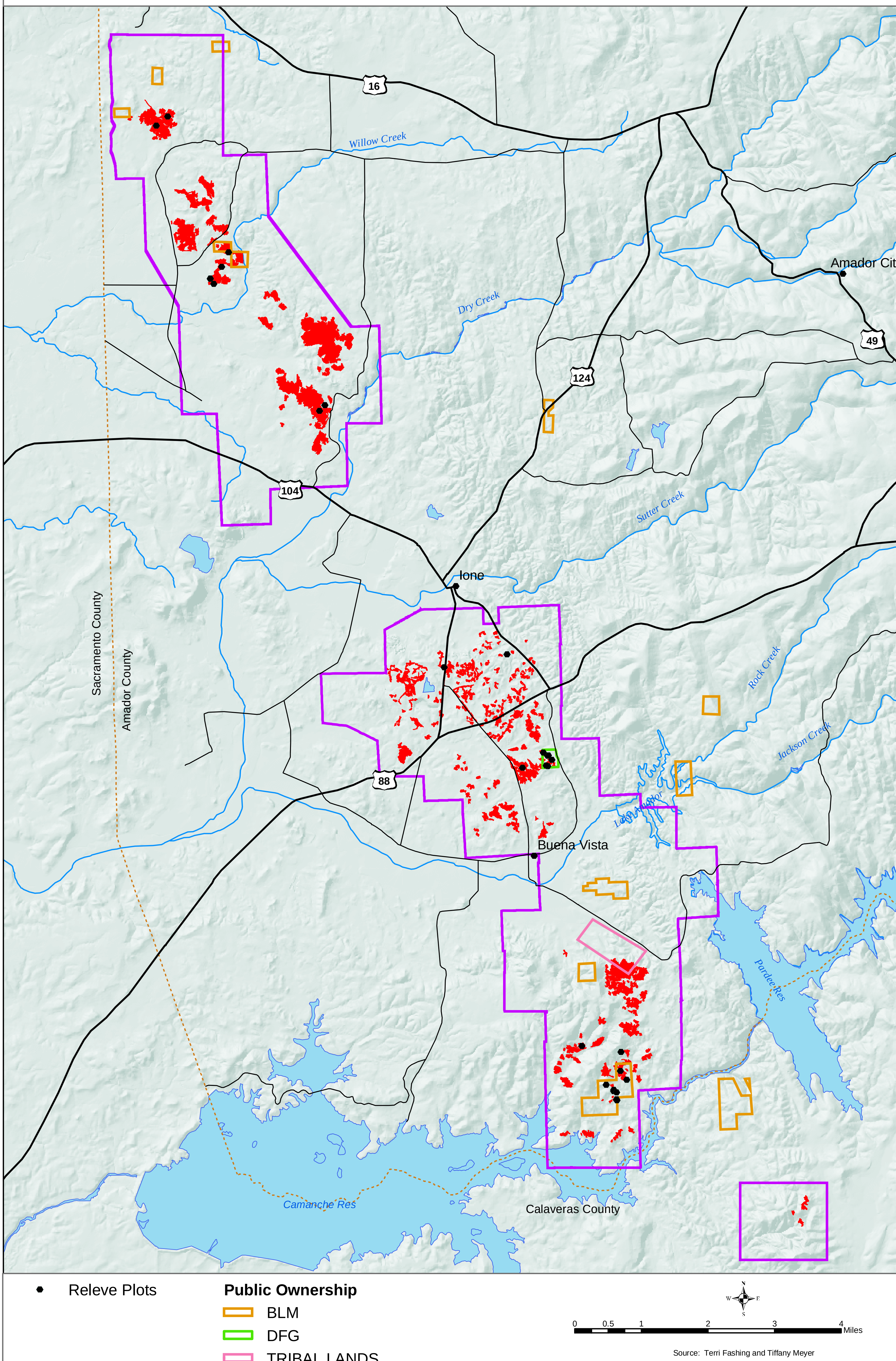
California Department of Fish and Game/ San Francisco State University 2004



Conservation and Recovery of Ione Endemic Plants

Map 5: Ione Manzanita Releve Plots

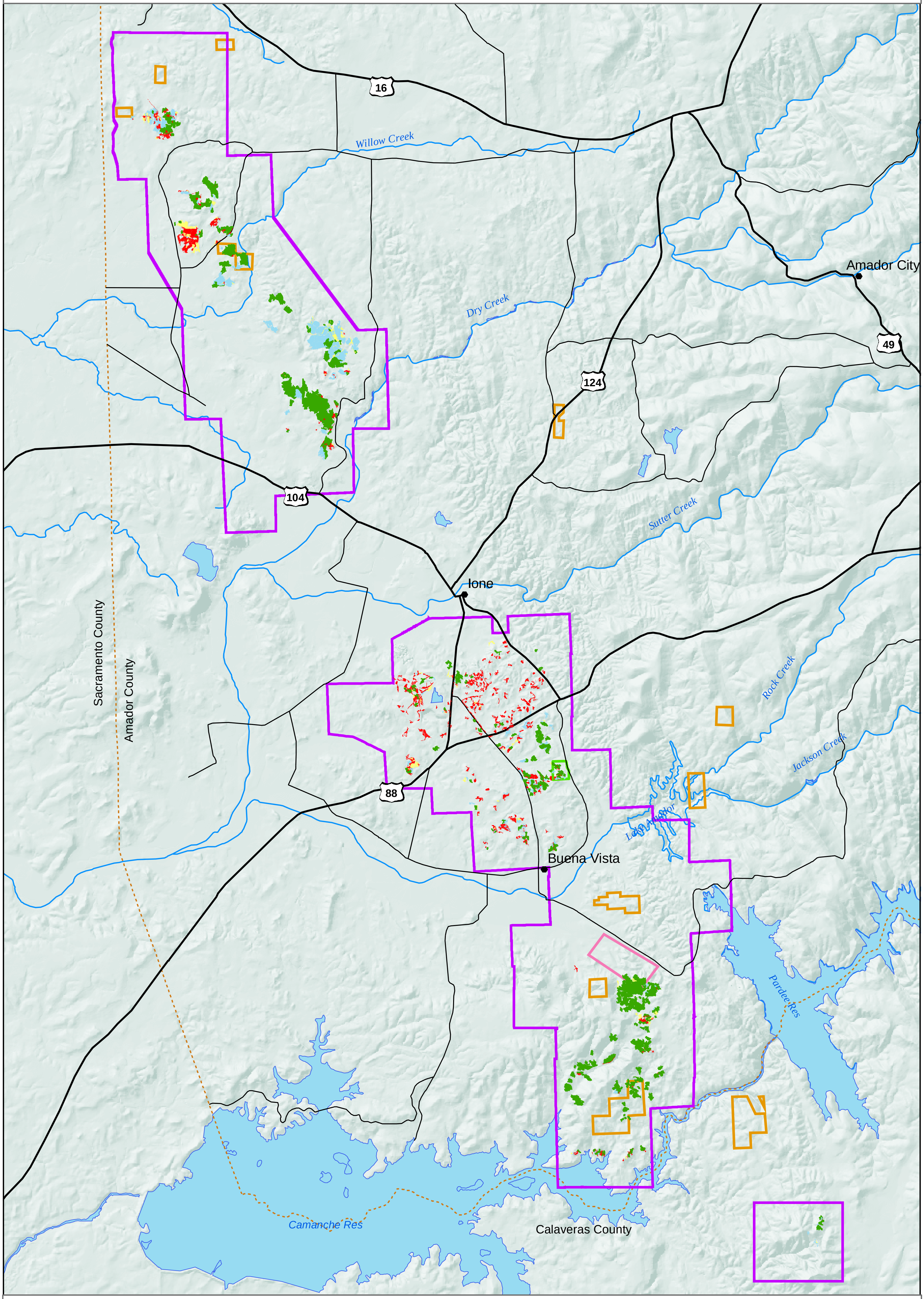
California Department of Fish and Game/ San Francisco State University 2004



Conservation and Recovery of Ione Endemic Plants

Map 6: Ione Manzanita Foliage Analysis

California Department of Fish and Game/ San Francisco State University 2004



0 - 25% Live Vegetation
26 - 50% Live Vegetation
51-75% Live Vegetation
> 75% Live Vegetation

Public Ownership

BLM
DFG
TRIBAL LANDS

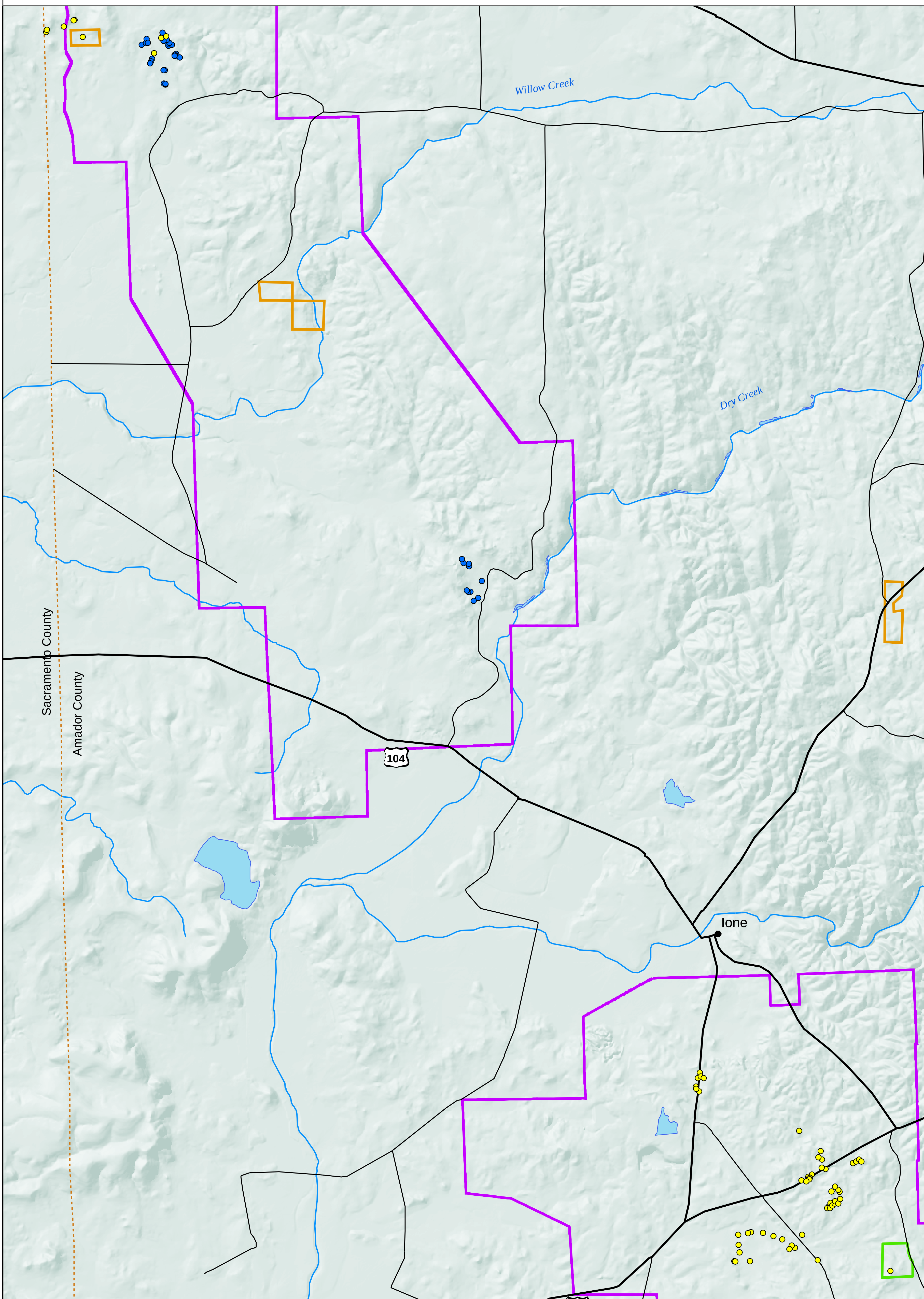
0 0.5 1 2 3 4 Miles

Source: AIRIS 1 meter imagery
IKONOS 1 meter imagery
By: Tiffany Meyer

Conservation and Recovery of Ione Endemic Plants

Map 7: Ione Buckwheat Distribution

California Department of Fish and Game/ San Francisco State University 2004



E. apricum v. apricum

E. apricum v. prostratum

Public Ownership

BLM

DFG

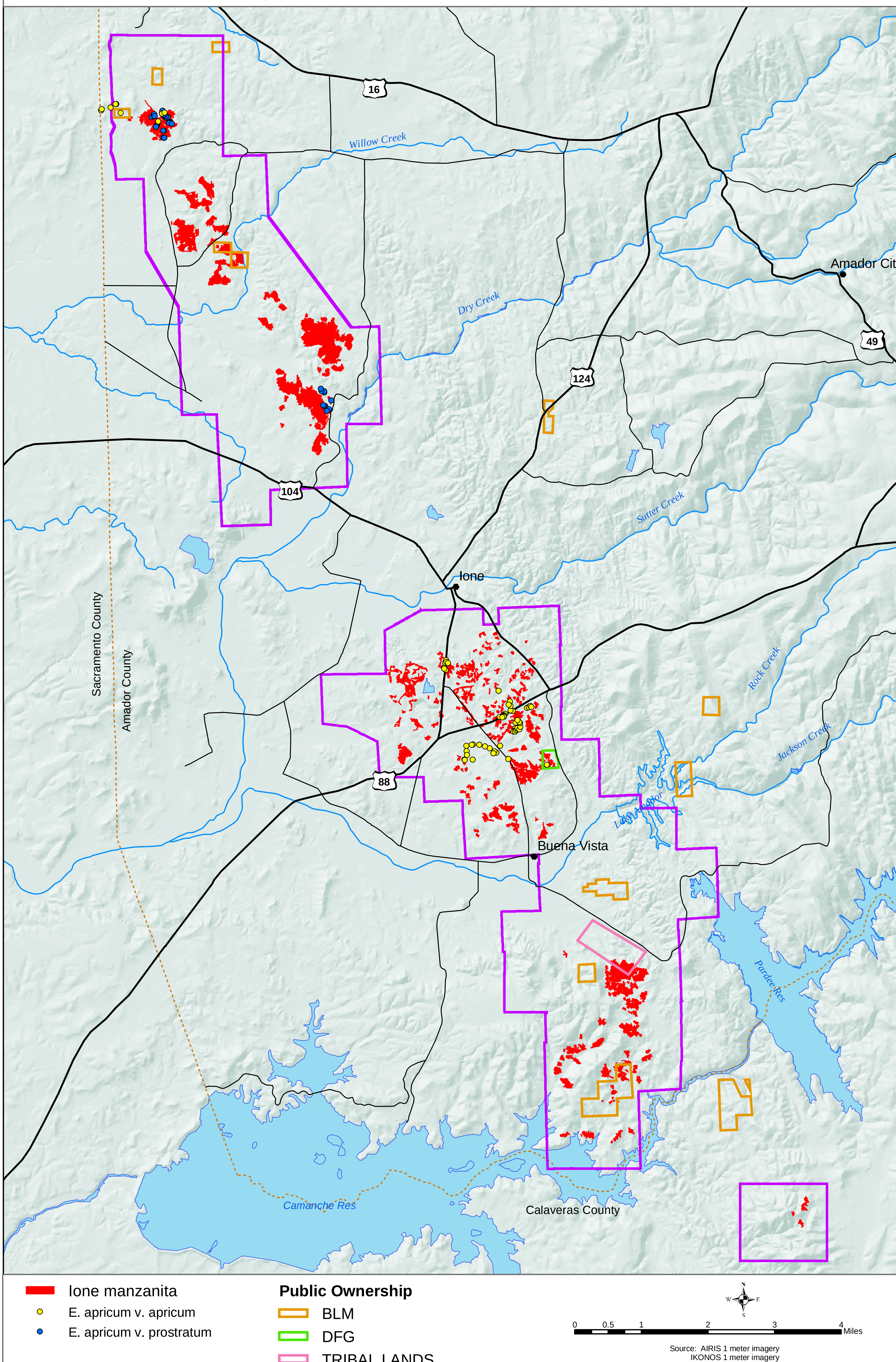
0 0.25 0.5 1 1.5 2 Miles

Source: GPS field identified locations
By: Tiffany Meyer

Conservation and Recovery of Ione Endemic Plants

Map 8: Ione Manzanita and Ione Buckwheat Distribution

California Department of Fish and Game/ San Francisco State University 2004



APPENDIX B

Swiecki, T. and E. Bernhardt. 2003.
Diseases Threatening the Survival of Ione Manzanita

APPENDIX C
Selected Releve Data

Releve #	Date	Elevation (m)	Slope (degrees)	Aspect (degrees)	Alliance Name	Adjacent Alliance N	Adjacent Alliance S	Adjacent Alliance E	Mapped Community Type	Soil Texture Code	Soil Texture	ARMY Health Cover Class	ARMY Health (% live)	ARMY Percent Cover	Bare Ground Percent Cover	Number Other Species Present	% Cover other Species	ARVI Percent Cover	ADFA Percent Cover	PISA Percent Cover	ERCA Percent Cover	BAPI Percent Cover	GrassPercent Cover	ERAP Percent Cover	ARMA Percent Cover	QUWI Percent Cover	Hybrid ARMY/ARVI percent cover	Unknown Forb Percent Cover
1	23-Nov-02	138.67	28	78	ARMY	ARMY	disturbed, barren	ARVI	99	FISA	sandy clay	6	85	70	24	3	6	<5	<1	0	0	0	0	0	0	1	0	0
2	24-Nov-02	142.45	26	308	ARMY	ARVI, ARMY	ARVI, ARMY	ARVI, QUWI	99	FISA	sandy clay	6	80	55	7	4	38	30	1	0	0	0	0	0	0	6	0	0
3	23-Nov-02	125.3	3	2	ARMY	QUWI, mixshrub	ARVI, ARMY	QUWI	99		loamy clay with silt	5	75	84	10	3	6	<5	0	0	0	0	0	0	0	<1	0	0
4	23-Nov-02	122,58	3	360	ARMY	QUWI, ARMY	QUWI, PISA, ARMY, ARVI	QUWI, ADFA	99	FISA	sandy clay	6	92	72	17	3	11	4	0	0	0	0	0	0	0	6	0	0
5	23-Nov-02	124.35			ARMY	QUWI, ARMY, ARVI	QUWI, ARMY	QUWI, ARVI	99		loamy clay with silt	6	95	76	4	3	20	12	0	0	0	0	0	0	0	7	0	0
6	23-Nov-02	76.19	2	48	ARMY	PISA, ARMY, ARVI	QUWI, ARMY	QUWI, ARVI, ARMY			loamy clay with silt	5	70	86	12	2	2	0	0	0	0	0	0	0	0	<1	0	0
7	23-Nov-02	76.49	0		ARMY	ARVI, ADFA, QUWI	ARVI, ADFA, QUWI	ARVI, ADFA, QUWI			loamy clay with silt	6	85	30	10	4	60	10	36	0	0	0	0	0	0	12	0	0
8	23-Nov-02	122.1	50	296	ARMY	ARMY, ARVI	ARMY, ARVI	ARMY, ARVI			Sandy Silt	5	60	96	3	2	1	1	0	0	0	0	0	0	0	0	0	0
9	23-Nov-02	98.32	4	58	ARMY	QUWI, ARMY	QUWI, ARMY, ARVI	QUWI, ARMY, ARVI		CLAY	Clay	6	92	77	20	4	3	<2	0	0	0	0	0	<1	0	<1	0	0
10	1-Dec-02	91.8	5	158	ARMY	ARMY	QUWI, ARVI	QUWI, ARVI			Sandy Loam	burn	burn	76	23	2	1	0	0	0	0	0	0	0	0	0	0	0
11	1-Dec-02	91.9	2.9	230	ARMY						Sandy Clay	burn	burn	27	72	1	1	0	0	0	0	0	0	1	0	0	0	0
12	6-Apr-03	122.36	19	75	ARMY	ARMY, ARVI, PISA	ARMY, ARVI	ARMY, ARVI	99	FISA		6	98	44	0	3	56	54	0	0	0	0	0	0	0	1	0	0
13	6-Apr-03	123.25	6.8	80	ARMY	ARVI, ARMY	ARVI, ARMY	ARVI, ARMY	99	MESAL	Sandy loam	6	98	82	6	1	12	12	0	0	0	0	0	0	0	0	0	0
14	1-Jul-03	110.85	5	142	ARMY	Road	QUWI	PISA, QUWI	178		Sandy	6	99	48	16	4	36	30	0	3	1	0	1	0	0	1	0	0
15	1-Jul-03	117.36	1.7	195	ARVI	ARVI, ARMY	ARVI, ARMY	ARVI, ARMY	161	FISA	sandy clay	6	99	44	1	2	55	55	0	0	0	0	0	0	0	<1	0	0
16	7-Jul-03	91.89	1.7	210	ARMY	ADFA, ARMY	QUWI, ERAP	QUWI, ARVI	99	MESAL	Sandy Loam	4	26	26	58	4	16	nr	0	0	nr	0	0	2	0	nr	0	0
17	7-Jul-03	101.28	14	200	ARMY	ARVI, ADFA	ARVI, ARMY	ADFA, ARVI	99	FISA	sandy clay	5	nr	28	68	4	4	1	1	0	0	0	0	1	0	1	0	0
18	11-Aug-03	153.53		80	ARMY	ARVI, PISA	NR	ARMY, ARVI, PISA, QUWI	178	MFSA	sandy clay loam	6	99	75	20	1	5	5	0	0	0	0	0	0	0	0	0	0
19	11-Aug-03	124.15		270	ARMY	ARMY, ARVI	ARMY, ARVI	ARMY,ARVI	99			6	99	70	25	1	5	5	0	0	0	0	0	0	0	0	0	0
20	11-Aug-03	125.96	14	95	ARMY	ARMY, PISA, QUWI		ARMY, PISA, QUWI,	99	MESAL	Sandy Loam	5	75	60	25	3	15	nr	0	nr	0	0	0	0	0	nr	0	0
21	4-Oct-03	124.32	2.9		ARMY	ARMY, QUWI, ARMA	ARMY	ARMY, QUWI, ARMA	99	MELS	loamy sand	6	90	75	22	2	3	0	0	0	0	0	0	0	nr	nr	0	0
22	4-Oct-03	109.52		85	ARMY	Mix Shrub, grass	Mix Shrub, road	road	99	MFSA	sandy clay loam	6	99	22	70	4	8	2	0	0	0	2	2	0	0	2	0	0
23	4-Oct-03	117.46	9	190	ARMY	ARVI, QUWI	ARVI, QUWI, ARMY	ARMY	99	MFSA	sandy clay loam	6	nr	68	15	3	17	nr	0	0	0	0	0	0	nr	nr	0	0
24	5-Oct-03	122.96	4.6	320	ARMY	QUWI	Mix Shrub	ARMY	99	MFSA	sandy clay loam	6	92	70	9	2	21	20	0	0	0	0	0	0	0	0	0	0
25	10-Nov-03	146.8	7.4	155	ARMY	ARMY, ARVI, ERCA	ARMY, ARVI, ERCA	QUWI, ADFA	3	MELS	loamy sand	5	75	47	45	3	8	3	0	0	1	0	<1	0	0	0	0	0
26	11-Nov-03	74.27	2.9	330	ARMY	ARVI	ARVI, PISA, QUWI	ARVI, PISA, QUWI	155	nr	nr	6	99	89	5	3	6	2	2	0	0	0	0	0	0	2	0	0
27	11-Nov-03	85.09	2.9	185	ARMY	ARMY, ARVI, PISA	ARMY, ARVI, QUWI	ARVI, ADFA	161	MELS	loamy sand	6	95	93	7	0	0	0	0	0	0	0	0	0	0	0	0	0
28	5-Oct-03	95.19	4.6	200	ARMY	ARMY	ARMY	Mix Shrub	99	MESAL	Sandy Loam	6	97	75	5	3	20	18	1	0	0	0	0	0	0	2	0	0
29	27-Feb-04	123.2	16.2	187	ARMY	ARMY, ARVI	ARMY, ARVI, PISA	ARMY, ARVI	99	MFSA	sandy clay loam	6	90	65	17	4	18	16	0	0	<1	0	0	0	0	0	1	0
30	27-Feb-04	155.63	42	206	ARMY	ARVI	ARMY, QUWI, PISA,			nr	nr	6	90	60	24	3	16	15	0	0	0	0	<1	0	0	0	0	0