5.0 FIELD-SURVEY ASSESSMENT OF THE GAP GIS DATABASE IN NATURAL VEGETATION AREAS OF SAN DIEGO COUNTY

5.1 Introduction

As discussed in Section 2.0, developing reliable biogenic emission inventories depends on quantifying BHC emission rates, leaf mass constants, and the spatial distribution and species composition of vegetation. Under long-term ARB and SCAQMD funding, BHC emission rates and leaf mass constants have been developed for numerous species relevant to California (Winer et al. 1983, 1992, Miller and Winer 1984, Horie et al. 1991, Karlik and Winer 1998). Of the Southern California airsheds, spatial distribution and species composition of vegetation have been established for urban and natural areas within the SoCAB, which includes Orange County and the non-desert portions of Los Angeles, Riverside, and San Bernardino Counties (Winer et al. 1983, Miller and Winer 1984, Horie et al. 1991, Benjamin et al. 1997). As discussed earlier, several BHC emissions inventories varying in comprehensiveness have been reported for the SoCAB, including a recent spatially- and temporally-resolved inventory (Benjamin et al. 1997). A limited BHC emission study for Santa Barbara and Ventura Counties which are part of the SCOS97 domain have also been reported (Chinkin et al. 1996b). However, a validated spatial distribution and species composition inventory of vegetation, specifically for BHC emissions applications, has not been established for urban and natural areas of the San Diego County airshed, which was also an important part of the SCOS97 domain. At the request of ARB staff, a portion of the present project was redirected to an investigation of the composition and dominance of natural vegetation in San Diego County, with an emphasis on obtaining data to evaluate vegetation databases in this region.

A potential source of information concerning vegetation in the natural areas of San Diego County is the Gap Analysis Program (GAP) database, which is coordinated by the National Biological Service to identify the distribution and management status of plant species. The GAP database is a geographic information system database based primarily on remote-sensing data describing vegetation type and dominance in terms of areal coverage. Unlike other vegetation maps which describe geographic areas using plant communities, the GAP database describes the vegetation in given geographic areas

using plant species. Because BHC emissions inventories rely on species-specific measurements of both leaf mass and emission rates, the GAP database offers the advantage of providing species-specific vegetation distribution data. Moreover, the GAP GIS database is recent for Southern California (Davis et al. 1995), and therefore in principle more up to date than older vegetation databases employed in California such as the vegetation type map (VTM) surveys conducted in the 1930s and CALVEG generated in the 1970s (Sawyer and Keeler-Wolf 1995). Although large-area, small-scale GIS databases based on remote-sensing data such as GAP offer a potentially inexpensive and straightforward approach to characterizing the distribution and foliar identity of natural vegetation within an airshed, incorporation of such GIS databases into BHC emissions inventory development requires evaluation of their accuracy and reliability through ground-based observations.

This chapter reports the results of a ground-based assessment of the GAP GIS database for San Diego County through vegetation surveys of representative GIS polygons using a modified stratified random sampling approach and a survey protocol based in part on the recommendations of the developers of the GAP database (Stoms et al. 1994). Data gathered from vegetation field surveys conducted from September, 1997 to April, 1998 in San Diego County were used to assess the agreement with the GAP GIS database in predicting distribution and species identity of vegetation, and to provide a quantitative description of plant species assemblages.

5.2 Previous Studies Estimating Coverage of Vegetation in Natural Areas in California for the Purpose of Generating BHC Emissions Inventories

The first study attempting to estimate the plant species distribution and abundance within natural areas of California for the purpose of generating BHC emissions inventories was performed by Winer et al. (1983). As part of a study estimating the BHC emissions inventory for a portion of the SoCAB, their research estimated the green leaf biomass distribution of urban and natural portions of the SoCAB (Miller and Winer 1984). For natural vegetation areas, the study relied on data collected from VTM surveys, a sampling system developed by A.E. Wieslander and executed by the USDA Forest Service to collect data on plant cover and composition for natural plant

communities from 1928 to 1940 (Wieslander 1946). Each sample element covered 100 milliacres within a 132 ft x 33 ft study plot, subdivided into 100 milliacre subplots, each 6.6 ft x 6.6 ft in dimension. The dominant plant cover within each milliacre subplot was recorded and the percent cover of each plant was determined by the number of milliacre subplots dominated by the plant species within the whole VTM plot.

Winer et al. (1983) used the 106 VTM plots within the SoCAB boundaries to estimate the areal cover of plant species within their study area. The VTM plot data were grouped into five cover classes: grassland, sagebrush, chamise chaparral, chaparral, and woodland. From the VTM data, percent areal cover of each plant species was estimated for each broad vegetation class, and total areal cover in square kilometers for each cover class within the SoCAB study area was determined. The areal cover for each species in a cover class was obtained by multiplying the percent cover of a species within a class times the total areal cover for the cover class. The resulting data served in part as the basis for a BHC emissions inventory estimate by Winer et al. (1983) and for subsequent BHC emissions inventory estimates by Horie et al. (1991), Arey et al. (1995), and Benjamin et al. (1997)

In the study of Horie et al. (1991), researchers estimated the areal coverage of natural plant species from a point sampling procedure. The natural areas within the SoCAB were first divided into eight natural provinces to account for geographic variation in species composition. A transparency with 25 regularly spaced points was placed on 5 km x 5 km grid cells of the vegetation maps, and the plant communities beneath each point were recorded. The areal proportions of each plant community was estimated from the proportion of points falling within each plant community. Species composition was estimated from VTM surveys.

Tanner et al. (1992) developed a BHC emissions inventory for the San Joaquin Valley Air Basin (SJVAB). Plant communities were distinguished within the air basin using the Landsat Thematic Mapper satellite imagery of 1983-85 utilizing six spectral bands coupled to CALVEG, a GIS ARC/INFO vector database compiled by the California Division of Forestry. CALVEG listed 99 plant community types, and the GIS had a minimum mapping unit of 400 hectares. Areal calculations for species were based on community descriptions and literature values.

Sidawi and Horie (1992) also developed a BHC emissions inventory for the San Joaquin Valley Air Basin. Areal coverage data for the natural areas were obtained solely from field surveys. Sidawi and Horie surveyed fifteen 2.5 hectare plots within the SJVAB and in adjacent coastal and Bay Area counties, measuring crown volume and cover.

Several nationwide studies based on remote-sensing data also estimated vegetation cover for California, and these studies, summarized in Guenther (1997), coarsely categorized vegetation into broad classes such as deciduous versus evergreen forests and scrub versus grassland. These studies used potential vegetation maps (maps describing vegetation in its natural, climax community state in the absence of anthropogenic influence), satellite data, and limited ground observations, resulting in a spatial resolution ranging from 0.0064 km^2 to 3,000 km^2 (Guenther 1997).

All of the above-mentioned studies have limitations. VTM plots in Southern California did not emphasize woodlands and forests or the species composition within those vegetation classes. Thus, the VTM plots ignored distinctions between pine forests (a low monoterpene-emitting vegetation class) versus oak-pine woodland (a dominantly isoprene-emitting vegetation class). The studies based on CALVEG were limited by CALVEG's accuracy, which has been criticized (Davis et al. 1991, Sawyer and Keeler-Wolf 1995). Furthermore, the minimum mapping unit of 400 hectares (4 km^2) was large and may have resulted in the omission of areas of vegetation smaller than the minimum mapping unit. Furthermore, CALVEG was based on plant community classification and required additional data in order to be used with species-specific emission rates and leaf masses. The studies based on remote-sensing data also experienced the same problem of large minimum mapping units. Furthermore, these studies generated coarse inventories based on broad vegetation classes such as woodland, scrub, and grassland, ignoring distinctions in California vegetation such as chamise chaparral (essentially a non-emitting vegetation class) versus sagebrush scrub (a high monoterpene-emitting class). For these reasons, and after consultation with ARB staff, we elected to base the present study of vegetation coverage in natural areas in San Diego County on the GAP database.

5.2.1 Previous GAP Validation Studies for San Diego County

In a recent study, Stoms (1996) used San Diego County's Multi-Species Conservation Program (MSCP) map to validate the GAP database for a 2,240 km^2 study region in southwestern San Diego County. The MSCP map incorporated color infrared photos, helicopter overflights, and SPOT-TM satellite imagery to create a 1:24,000 scale, 1 ha MMU GIS map with polygons categorized by the Holland vegetation classification. Although the MSCP map does not provide species-specific data for each polygon, the maplet does provide a small area map with a smaller minimum mapping unit useful for some levels of assessment. This validation (Stoms 1996) focused on the assessment of polygons for broad community types (annual grassland, coastal scrub, valley-foothill hardwood, etc.) rather than at a species-specific level and excluded vegetation communities in eastern and northern portions of San Diego County such as oak woodlands and all forests. Although the Stoms (1996) study was not performed for purposes related to BHC emission inventory development, Stoms' method of using small area maplets to validate large area maplets has the potential to be useful as a coarse filter for the GAP database.

5.3 GAP Analysis Program Database

As noted earlier, developing a spatially-resolved BHC emissions inventory incorporating distinctions between plant species requires a database of species- or genus-specific emission rates and leaf-mass constants, and a spatial database composed of land cover or land use classifications describing plant species and distributions. With the proposal of a taxonomic methodology for assigning isoprene and monoterpene emission rates to unmeasured plant species (Benjamin et al. 1996), emission rates can in principle be estimated for many of the 6,000 plant species in California in the absence of direct experimental measurements. As emission rates for additional species are measured (as part of the present project, for example), this taxonomic methodology can become an even more effective tool for assigning BHC emission rates to plant species with unknown rates. As discussed earlier, the development of the GAP database established a plant species-specific GIS database for all of California (Davis et al. 1995). These recent

developments facilitate the generation of BHC emissions inventories which incorporate plant species distinctions within various land covers and land uses.

The Gap Analysis Program's purpose was to identify the distribution and management status of selected components of biodiversity and was coordinated by the US Fish and Wildlife Service and the National Biological Service. The main goal of this program was to prevent additional species from being listed as threatened or endangered. This nationwide program involved over 200 collaborating organizations including private businesses, special interest groups, and universities, as well as governments on the local, state, and federal levels. In California, the project was managed by the Department of Geography at the University of California at Santa Barbara (UCSB).

The central tool generated by this program was the GAP database, an ARC/INFO GIS database with plant species and vegetation class attributes associated with polygons or areas within a defined geographic region. This database was generated from summer 1990 Landsat Thematic Mapper satellite imagery, 1990 high altitude color infrared photography, VTM surveys based on field surveys conducted between 1928 and 1940, and miscellaneous vegetation maps and ground surveys (Davis et al. 1995). Polygons were delimited based on climate, physiography, substrate, and disturbance regime. Landscape boundaries were subjectively determined through photointerpretation by expert personnel so that between-polygon variation was greater than within-polygon variation. The final result was a vegetation map with a 100 hectare minimum mapping unit and a 1:100,000 mapping scale (Davis et al. 1995).

Species data were obtained from field surveys, air photos, VTM surveys, and soil-vegetation maps. For each polygon in the database, one primary and one secondary vegetation assemblage was listed (see Table 5-1 for a glossary of GAP-related terms). Each assemblage consisted of one dominant and up to two co-dominant overstory species, each covering a minimum of 20% of the relative cover of the assemblage. The primary assemblage is the assemblage covering the majority of the polygon, and the secondary assemblage is the assemblage covering the remainder of the polygon. Relative cover is the proportion of total vegetation cover occupied by a given plant species, and excludes vegetation purposely excluded, such as plants below a pre-established height and bare ground. Although the term "overstory" is traditionally defined as "taller plants

Table 5-1. Glossary of GAP-Related Terms

Relative Cover	= Areal cover of a given species / Areal cover of all vegetation
Crown Closure	= Total cover by all overstory species
Co-Dominant	= A species that covers 20% or greater relative cover
Overstory	= Vegetation that can be viewed from above
Minimum Mapping Unit	= Smallest area that can be distinguished from a given map; 100 ha in this study
Species Assemblage	= A grouping of plant species in an area (plant species do not necessarily have an ecological relationship as plants do in a community)

in a vegetation type that form the uppermost canopy layer" (Hunter and Paysen 1987), the GAP database often referred to plants of different heights within an assemblage, such as manzanitas and oaks, as dominants and co-dominants. Thus, overstory in the GAP database refers to those plants viewable directly from above.

For the purpose of the present study, no distinction was made between dominant and co-dominant species. Thus, the term "co-dominant" in the present study was used to refer to both dominant and co-dominant species listed in the GAP database. In addition, the GAP database listed plant community classifications with respect to each species assemblage and the degree of crown closure and the percent crown cover of each assemblage in the polygon.

In summary, the GAP database was chosen for examination in the present study for three reasons. First, the database describes which species are found in defined areas and provides data on the relative abundance of the species in terms of relative percent cover and total crown cover. Second, the database has a large geographic extent, covering all of California and many other states, with the goal of developing similar databases for all 50 states. Third, the GAP database is in a standard, vector GIS format

(ARC/INFO), allowing for easy manipulation and analysis on a microcomputer through the use of GIS software, spreadsheets, and database programs.

5.4 Assessment Methodology

Assessment of the agreement of the GAP database with field survey observations is a prerequisite to its use in developing species-based BHC emissions inventories for California. The assessment protocol developed in the present study was designed to assess the accuracy of the GAP database in predicting the distribution and identity of plant species in a given location, particularly BHC-emitting species, and in providing a quantitative description of plant species assemblages. The present research focused on obtaining "ground-truth" data through field vegetation surveys at selected sites. As noted earlier, the region selected for the field surveys was San Diego County, in support of ARB's proposed development of a BHC emissions inventory for the SCOS97 study domain (Benjamin et al. 1998). Of the airsheds in the SCOS97 domain, San Diego County's BHC inventory is perhaps the least reliably understood, and the results of the present study have immediate applicability in developing a BHC emissions inventory for San Diego County.

5.4.1 Acquisition and Preparation of the GAP database

The GAP database for the southwest ecoregion was downloaded in August of 1997 from http://www.biogeog.ucsb.edu/projects/gap/gap_data.html, the UCSB Department of Geography's internet site. The southwest ecoregion covers all or portions of Santa Barbara, Ventura, Kern, Los Angeles, San Bernardino, Orange, Riverside, and San Diego Counties. The southwest ecoregion contains the western two-thirds of San Diego County. The remaining eastern third of San Diego County is located in the Sonoran ecoregion, which was not downloaded for use in the present study, because it is located far from the major urbanized centers of San Diego County, and because the ecoregion is composed mostly of deserts with little biomass.

The database was downloaded as an ARC/INFO coverage with an Albers equal-area projection. Because most of the data manipulation would be conducted in ArcView 3.0a, the ARC/INFO coverage was converted into ArcView format with a geographic

projection. From the 2014 original polygons for the southwest ecoregion, the San Diego County subset of 437 polygons was extracted.

5.4.2 Vegetation Survey Protocol

The vegetation survey protocol for a sample element was initially based on recommendations for a GAP database validation study made by Stoms et al. (1994) who suggested using 1 square kilometer units. Because the GAP database is a large-area land cover map, the suggested large size of the sample element avoids the problem of overlooking heterogeneity below the intended resolution of the map. Large elements also minimize site selection bias. Within large sample elements, the sampling will take the surveyor into less accessible areas, avoiding bias arising out of convenience. Stoms et al. (1994) further noted the relevance of other issues affecting vegetation surveying such as the need to obtain legal access from private land-owners, safety, and proximity of the selection of sample elements to roads. These logistical constraints may hamper the application of a protocol, but any protocol must be practiced within such constraints. The specific shape of the vegetation survey unit was left unresolved by Stoms et al. (1994).
The initial protocol for the present study based on the recommendations of Stoms et al. (1994) was developed by Karlik and Winer (1997) with input from appropriate UCLA faculty, namely Dr. Richard Ambrose, a specialist in applied ecology and Dr. Johannes Feddema, a geographer with a strong background in GIS. The proposed protocol involved surveying one sample element per polygon from 10 polygons in the naturally vegetated areas of San Diego County (Table 5-2). Each sample element consisted of two perpendicular 1000 meter long, 20 meter wide belt transects running north to south and east to west, respectively. The point of bisection of the two elements was termed the centerpoint. Essentially, transects were to be run north, south, east, and west of the centerpoint for 500 m. It was proposed surveyors would walk in a direction away from the centerpoint and record vegetation data 10 meters on each side of the transect centerline. For every shrub or tree whose stem grew from within the belt transect, the surveyor would measure the crown height and two crown diameters perpendicular to each other. The two perpendicular diameters can be used to estimate the areal coverage of the crown using the formula, crown cover = $\pi(D^2)/4$. The crown height in conjunction with

Table 5-2. Evolution of the survey protocol for estimating plant species composition and dominance in GAP database polygons for the purpose of generating an inventory of biogenic hydrocarbons emissions.

Protocol	Elements per Polygon	Center Plot Size	Transect Type	Transect Length	Transect Width
Original	1	50 m x 50 m	belt	1000 m	20 m
Revision 1	3	30 m x 30 m	belt	500 m	10 m
Revision 2	3	no plot	belt	500 m	6 m
Revision 3[1]	4	no plot	line	300 m	-

[1]Revision 3 was added specifically to survey shrubby habitat such as coastal sage scrub and chaparral.

the areal cover allows the calculation of the volume of the crown, which can be used to estimate green leaf biomass in developing a BHC emissions inventory. For bushes and smaller trees, crown height would be measured with a tape measure. For large trees, the protocol called for the crown height to be measured using a clinometer which measured the height as a percentage of the distance of the observer from the tree. The diameter at breast height was also to be measured for trees, for later use in developing a linear regression model between crown volume and diameter at breast height. In this initial protocol, vegetation data were also to be recorded within a 50 m x 50 m plot at the centerpoint.

Preliminary surveys in Central Valley blue oak savanna and woodlands to evaluate the original proposed protocol (see Section 6.0) resulted in revision 1 shown in Table 5-2. In the preliminary survey, two individuals working at the savanna location took 5 hours to set up the central plots and record the plot data, and 12 hours to record data along the transects. For two individuals at the blue oak woodlands location, it took 8 hours to set up the central plot and record data in the plots. Thus, the length and width of the transects and the size of the center sample plots were judged too great even for sparsely vegetated savannas and woodlands. As seen in Table 5-2, the transect length and width were shortened to 500 m and 10 m, respectively, and the center sample plot was reduced to 30 m on a side. The size of a square parcel of land needed to contain this sample element was 25 hectares or 62.5 acres. It was clear the labor needed for more

densely vegetated areas (e.g., forests and chaparral) would have been excessive without these changes. Shortening the transect length also facilitated gaining permission to access properties covering an entire sample element. Because of the possibility a large element would cross several properties, successful completion of the element would be hindered if even one property owner denied access. To compensate for the shortening of the transects, the number of elements per polygon was increased from one to three, allowing sampling of other portions of a polygon to detect heterogeneity in vegetation composition and dominance within the polygon.

An additional trial survey in a pine-oak forest in Rancho Cuyamaca State Park in San Diego County resulted in a second revision of the proposed GAP survey protocol. For two individuals, it took approximately 24 hours over four days to complete the sample element. This pine-oak forest was much denser than the oak woodlands in the Central Valley and measuring the plants to 5 meters on each side of a transect's centerline was extremely time-consuming. Accordingly, the width of the transect was decreased to 6 m (3 m on each side of the centerline). Other researchers have encountered similar limitations and decreased the width of their transects to 6 m to make the mechanics of sampling easier while not significantly compromising accuracy (Lindsey 1955). Since the area covered by the transects was 6000 m^2 while the sample plot covered only 900 m^2 at the intersection of the transects, the time and effort required to set up the plots and gather data within them was judged excessive relative to the small amount of additional data obtained. Thus, the center sample plots were removed from the protocol in the second revision (Table 5-2).

For the densely vegetated scrub and chaparral communities, a different type of sample element was used. Bauer (1943) compared line transect sampling versus plot sampling in chaparral. Line transect sampling estimates the areal coverage of species by measuring the length of a measuring tape occupied by a plant species. The fraction of the measuring tape intersected by the plant species represents its areal coverage (also as a fraction). Bauer (1943) showed data gathered from the line transects were comparable to 3 meter plots of equivalent length, especially for the more common chaparral species. However, the time it took for two individuals to perform the line transects for 270 meters was only 3 hours compared to 160 hours for plots totaling 270 m x 3 m (Bauer 1943).

Although Bauer recommended line transects for dense chaparral vegetation, line transects have also been recommended or have been used for sage scrub to estimate areal coverage (Kent and Coker 1992, Zippin and Vanderwier 1994).

Preliminary line transects were performed in a chaparral community using a 50 m tape. Like the belt transects, the line transects were run north, south, east, and west of the centerpoint. Chaparral at times was impenetrable and much time was spent maneuvering through the plants, often crawling on hands and knees. Because of these difficulties, the transects for chaparral and sage scrub communities were further shortened to 150 m in each direction in the final revision to the sampling protocol (Table 5-2). The size of a square parcel of land needed to contain the final sample element was 22.5 acres. To compensate for shortening the transect length, a fourth sample element was added for such polygons to better assess any vegetation heterogeneity.

In these line transects, the number of 0.1 m segments occupied by a plant species along the meter tape was recorded. In situations where two different species occupied the length along the meter tape, the topmost or overstory plant was recorded. In chaparral and scrub, understory plants were not common and ignoring such species had little effect on the final results. For each plant, the net height of each crown was recorded to the nearest 0.1 m. The crowns were envisioned as rectangular prisms and measured as such.

The survey team located the centerpoint of a particular sample element using a global positioning receiver (GPS) locked onto the universal transmercator (UTM) coordinates gathered from the GAP database and the ArcView GIS program. A Garmin 12XL handheld GPS unit, with an accuracy of ± 100 m 99% of the time, was employed. At the centerpoint, photographs were taken facing north, east, south, and west to visually record the vegetation type. The survey team then recorded the species identity and recorded data depending on the type of transect being performed, as described above. The identities of unusual trees and shrub species were noted even if they were outside the confines of the transect. For forested polygons (areas where crowns of trees interlocked), only data from plants greater than waist height were recorded. For woodland polygons (areas where crowns of trees did not interlock), only plants greater than knee height were recorded. For scrub and chaparral, all plant species except for understory species and grasses were recorded. All plants were identified in the field, and samples of

unidentifiable plants were taken to Dr. Barry Prigge, the herbarium curator at UCLA, for identification.

5.4.3 Selection of Polygons from the GAP Database

Polygons were chosen for potential inclusion in the present study based on an index estimating isoprene

$$I_I = A\sum_{j=1}^{m}\left(p\frac{\sum_{i=1}^{n}E_I}{n}\right) \qquad (5\text{-}1)$$

or monoterpene emissions by polygon for comparison on a relative basis.

$$I_M = A\sum_{j=1}^{m}\left(p\frac{\sum_{i=1}^{n}E_M}{n}\right) \qquad (5\text{-}2)$$

where

I_I = isoprene emission index
I_M = monoterpene emission index
E_I = emission rate for species *i* in (μg isoprene) * (g dry foliar mass)$^{-1}$ * (h^{-1})
E_M = emission rate for species *i* in (μg monoterpene) * (g dry foliar mass)$^{-1}$ * (h^{-1})
n = number of species in an assemblage
p = per cent cover of the assemblage
m = number of assemblages in the polygon
A = area of the polygon

Polygons were ranked by the isoprene emission index, and the 40 polygons estimated to have the highest isoprene fluxes were selected for further consideration (Figure 5-1). Polygons were also ranked by the monoterpene emission index and the 40 polygons estimated to have the highest monoterpene emissions were selected for further consideration (Figure 5-2). Selection of polygons based on these indices allowed the GAP field validation to focus on those polygons estimated to have the largest biogenic hydrocarbons emissions based on the presence of high-emitting plant species and their areal coverage within a polygon.

Further considerations for selecting from among the eighty polygons with the highest BHC emissions involved an iterative process accounting for representativeness

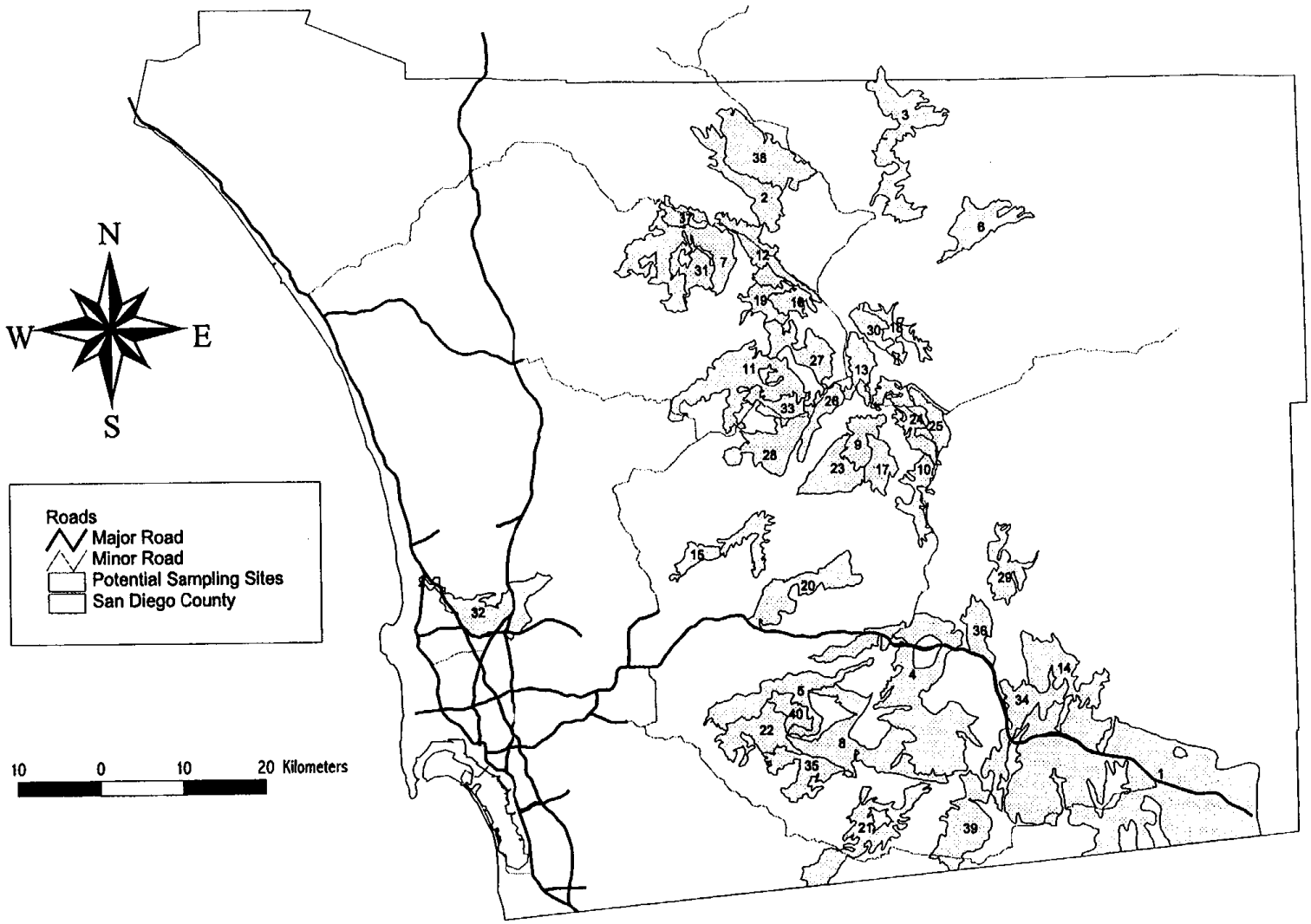

Figure 5-1. Potential sampling sites for high isoprene emitters in San Diego County ranked by the isoprene emission index.

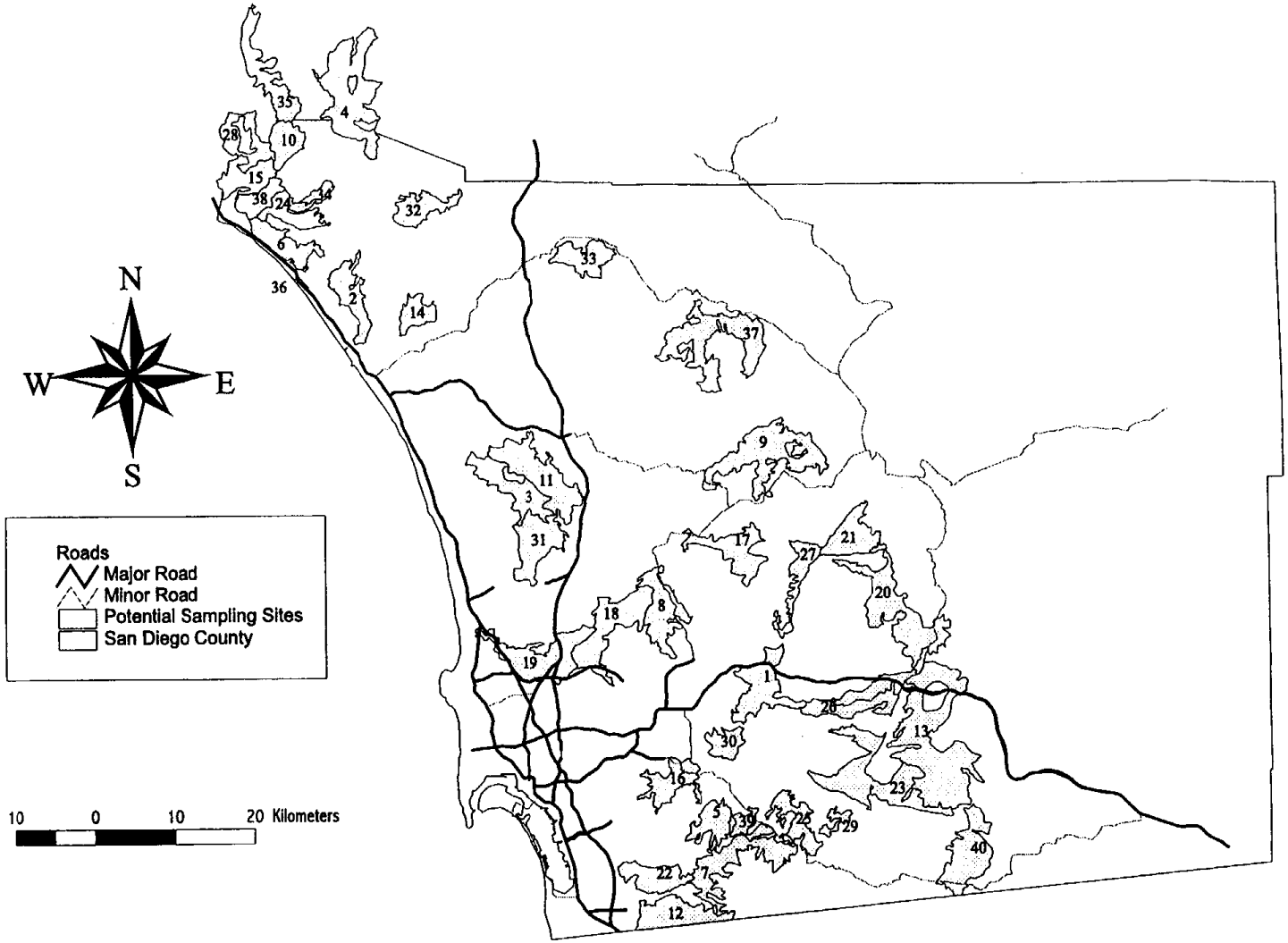

Figure 5-2. Potential sampling sites for high monoterpene emitters in San Diego County ranked by the monoterpene emission index.

and feasibility. In considering representativeness, polygons were selected to provide roughly equal numbers with woodland/forest vegetation and scrub/chaparral vegetation, the two main classes of natural vegetation in San Diego County. Another representativeness consideration was to select polygons spread throughout all geographic regions of the county except the desert regions.

In considering feasibility, physical access and permission to survey vegetation on private or military property were important. Using county and topographic maps, polygons were included for further consideration based on accessibility of large portions of the polygon from roads. The likelihood of acquiring permission to access portions of the polygon also determined whether the polygon was included. Polygons with a large public land component (e.g., California State Parks, San Diego County Parks, United States National Forest, Bureau of Land Management, and local parks) were favored due to the relative ease of gaining permission to conduct surveys on such properties compared to privately-owned properties.

As discussed earlier, the minimum area needed to survey a sample element within a polygon was determined to be 62.5 acres for forests and woodlands and 22.5 acres for scrub and chaparral, and owners of parcels of land of these sizes within selected polygons were identified using information from the San Diego County assessor's records. A letter was prepared requesting permission to conduct a vegetation survey, stating the goals of the research, and enclosing a form to be returned offering or denying access. Out of 69 mailers, 10 owners agreed to participate in the study, 15 declined and the rest were non-responders, for a success rate of about 14%. Those polygons with a large private response and/or a large public land component were included for further consideration.

Based on these criteria and the time and resources available for this research, eight polygons were selected for the present study. Four polygons consisted primarily of woodland/forest vegetation, and four polygons consisted primarily of shrub/chaparral vegetation (Table 5-3). Of these eight polygons, five were estimated to be dominated by isoprene emissions, two were estimated to be dominated by monoterpene emissions, and one exhibited both high isoprene and high monoterpene emissions. Table 5-3 lists data for each of these eight polygons according to the GAP database, including the expected

Table 5-3. Polygons from the GAP database selected for field survey of species composition and abundance.

ID	Area (ha)[a]	Polygon Type	Primary or Secondary[a]	Species Assemblage[a]	Assemblage Cover[a]	Crown Closure[a]	Holland Classification[a]	Rank by I_I	Rank by I_M
F1	1,990	Forest	P	*Quercus kelloggii*, *Quercus chrysolepis*, and *Quercus agrifolia*	60-70%	60-100%	Black Oak Forest	10	159
			S	*Pinus lambertiana*, *Pinus coulteri*, and *Libocedrus decurrens*	30-40%	60-100%	Coulter Pine Forest		
F2	2,317	Forest	P	*Quercus kelloggii* and *Pinus jeffreyi*	50-60%	40-59%	Black Oak Forest	29	136
			S	*Quercus cornelius-mullerii*, *Cercocarpus betuloides*, and *Adenostoma fasciculatum*	40-50%	60-100%	Semi-Desert Chaparral		
W1	1,904	Woodland	P	*Quercus agrifolia*, *Quercus engelmannii*, and *Quercus kelloggii*	60-70%	25-39%	Dense Englemann Oak Woodland	9	170
			S	*Ceanothus leucodermis*, *Adenostoma fasciculatum*, and *Quercus berberidifolia*	30-40%	60-100%	Northern Mixed Chaparral		
W2	1,778	Woodland	P	*Quercus kelloggii*, *Quercus agrifolia*, and *Quercus engelmannii*	60-70%	60-100%	Dense Englemann Oak Woodland	16	249
			S	*Adenostoma fasciculatum*, *Arctostaphylos tomentosa*, and *Cercocarpus betuloides*	30-40%	60-100%	Chamise Chaparral		
C1	6,578	Chaparral	P	*Quercus berberidifolia* and *Ceanothus leucodermis*	50-60%	60-100%	Scrub Oak Chaparral	7	37
			S	*Adenostoma fasciculatum*, *Cercocarpus betuloides*, and Buckbrush	40-50%	60-100%	Buckbrush Chaparral		
C2	3,986	Chaparral	P	*Adenostoma fasciculatum*, *Quercus berberidifolia*, and *Ceanothus leucodermis*	80-90%	60-100%	Northern Mixed Chaparral	20	56
			S	*Ceanothus greggii* and *Arctostaphylos pungens*	10-20%	60-100%	Semi-Desert Chaparral		
S1	3,650	Sage scrub	P	*Artemisia californica*, *Eriogonum fasciculatum*, *and Salvia apiana*	60-70%	40-59%	Coastal Scrub	102	8
			S	*Adenostoma fasciculatum*, *Ceanothus sorediatus*, and *Quercus berberidifolia*	30-40%	40-59%	Northern Mixed Chaparral		
S2	2,718	Sage scrub	P	*Artemisia californica*, *Salvia mellifera*, and *Malosma laurina*	80-90%	60-100%	Coastal Scrub	251	2
			S	*Avena spp.*, *Bromus spp.*, *etc.* and *Baccharis pilularis*	10-20%	25-39%	Coastal Scrub		

[a] From GAP database (University of California at Santa Barbara Department of Geography, 1997)

species assemblages, cover by each assemblage and crown closure, and the Holland natural communities classification code. In addition, Table 5-3 lists the polygon rank by the isoprene or monoterpene emission index. Figure 5-3 shows the location of the polygons investigated in the present study.

5.4.4 Selection of Sample Elements Within a Polygon

After a polygon was chosen by the process described above, sample elements were chosen. The centerpoints of the elements were located so all transects were at least 100 meters away from the polygon boundary. If permission was obtained to access most of the polygon, sample elements were selected by overlaying a 500 meter UTM grid on the polygon, assigning sequential numbers to every grid element within 1 km of a road, and randomly selecting the needed number of 500 meter grid elements. This method was similar to the one employed in the Utah GAP validation project (Edwards et al., 1995). Only for four polygons was enough area accessible by roads or was sufficient permission obtained for this process. For the other four polygons, large portions of the polygon were physically or legally inaccessible, and sample elements were chosen from within the accessible areas. To minimize bias in site selection for these four polygons, the final selection of sample elements was decided before entry into the polygon. In several cases, suitable survey sites were not available within the vicinity of a road, so hikes of up to two hours along a trail were needed to reach the desired area within the polygon.

5.4.5 Data Acquisition

Data were acquired using the survey protocol outlined in Section 5.4.1. Within survey elements dominated by trees, two individuals conducted the survey along belt transects. One measured the crown radii, diameter at breast height, and crown height of shrubs (plants with more than one stem), while the other measured the crown height of trees (plants with one stem) and recorded the field data. Crown radii in trees were measured with a 10 m tape measure in four directions (north, south, east, and west). For shrubs, two diameters perpendicular to each other were measured. Readings were taken to the nearest tenth of a meter. Diameter at breast height was approximated from measurements of the circumference at breast height to two significant digits. The crown

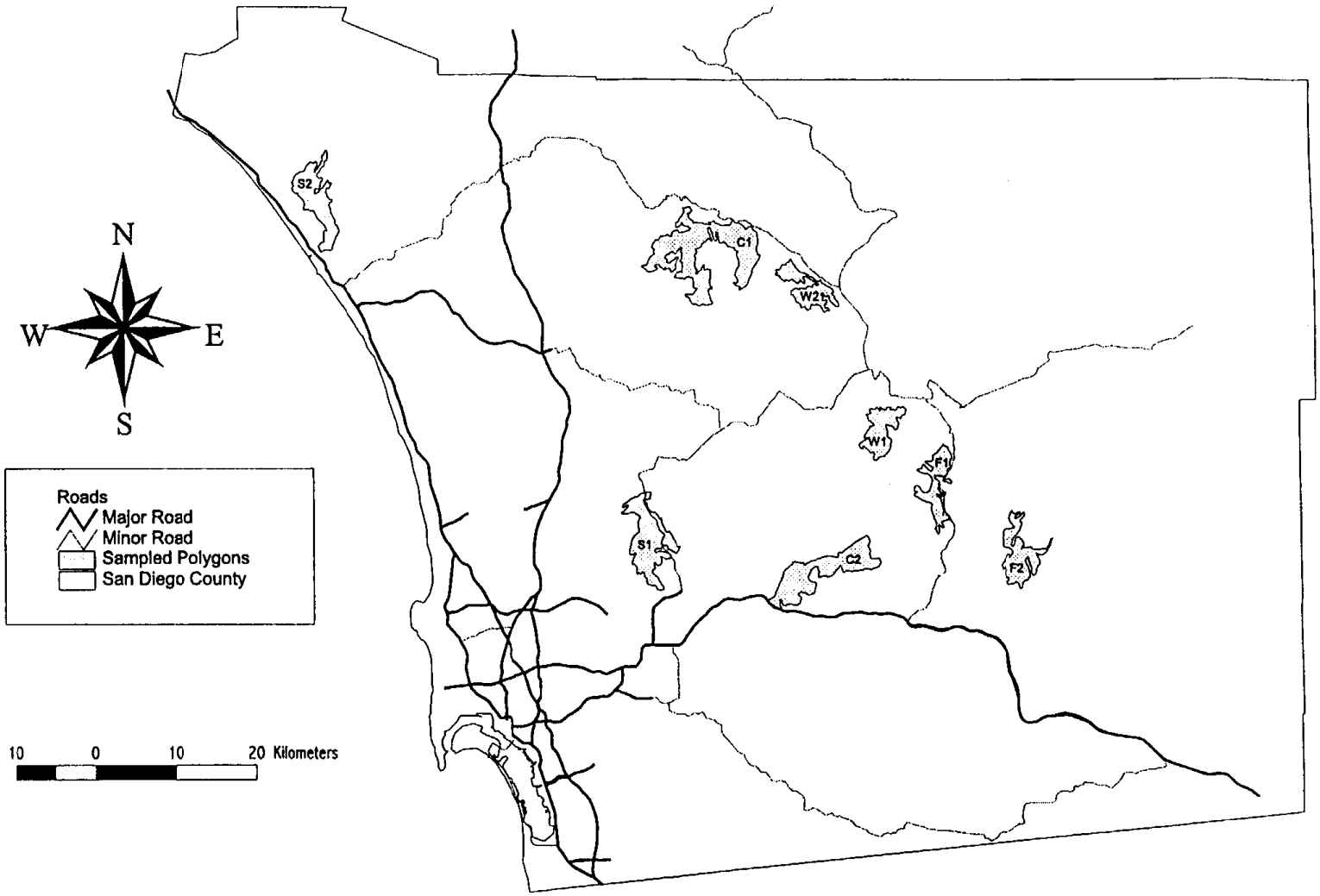

Figure 5-3. GAP polygons surveyed in San Diego County for plant species composition and dominance.

height was obtained from a clinometer. From a distance of approximately 10-20 meters, the observer measured the distance from the tree to the observer to the nearest meter using an optical rangefinder. With a clinometer, the observer determined the crown height as a percentage of the observer's distance away from the tree.

For belt transects, the surveyors walked 250 m north, south, east, or west away from the centerpoint, using a magnetic compass to maintain course. All vegetation within the belt transects above waist height in forests and above knee height in woodlands were identified and measured. From the centerpoint, photographs were taken facing each of the four directions and regularly along the transect to visually record the vegetation. When a densely vegetated and nearly impenetrable thicket was encountered, the vegetation composition was visually approximated in lieu of direct quantitative measurement, and the average height of the thicket was measured. Dense thickets represented a small portion of forested areas, so any error from approximating species present would not affect the overall results. Samples from species unidentifiable in the field were collected and later identified using taxonomy books or with the help of the UCLA herbarium curator. Most of the survey elements in forests and woodlands were accessible immediately from roads. Completion of surveys in these elements required from less than a day in some of the sparser woodlands to two days in the denser forests.

Within survey elements dominated by scrub or chaparral, one individual conducted the survey. Because line transects were used to gather data, only three types of measurements were taken. Along a 50 m tape, the identity of the topmost plant species directly over the meter tape was determined, the number of 0.1 m segments occupied by that plant species was recorded, and the height of the crown was measured for each individual plant to the nearest 0.1 m. The crowns were envisioned as rectangular prisms and measured as such.

The 150 m transects running north, south, east, and west from the centerpoint were completed using 50 m segments. The laying of each 50 m segment involved securing one end of the tape into the ground using a metal rod, extension of the tape along a defined direction with guidance from a magnetic compass, securing the other end, and then returning to the start of the tape to begin identifying and measuring plants lying over the line transect. This process was repeated three times for each of the north, south, east,

and west transects. From the centerpoint, photographs were taken facing each of the four directions, and also regularly along the transect to visually record the vegetation.

Although vegetation coverage for dense, impenetrable thickets within forests could be estimated by visual approximation, this was not an option for surveying vegetation in chaparral. In chaparral, the entire sample element could be considered impenetrable and visual approximation in lieu of direct measurement would not yield any quantitative data. Therefore, it was necessary to move through dense "impenetrable" vegetation as best as possible. For example, the laying of a 50 m tape in chaparral involved much crawling, climbing, and contorting. In some cases, dead branches of neighboring plants along the tape were broken in order to provide space to move. Coastal sage scrub was less dense and did not involve as much crawling and contorting.

Survey elements in chaparral and scrub were also less accessible from roads. Areas accessible from roads often were owned by private individuals who were not willing to participate in the study. Consequently, hikes of up to two hours were sometimes required to reach a desired survey element area. The completion of 600 m of line transects in chaparral took an additional two days on average. Coastal sage scrub was less dense and could be completed within one day to one and a half days.

5.4.6 Data Analysis

As noted earlier, the GAP GIS database provides semi-quantitative information on the abundance and distribution of plant species. For each polygon, the GAP database lists species assemblages and the estimated percent cover (p) of that assemblage within a polygon. Each species in a listed assemblage is a co-dominant, providing $\geq 20\%$ relative cover. Relative cover is the proportion of total vegetation cover occupied by a species, and excludes bare ground and vegetation below a pre-established height. The expected relative cover of a species listed in the GAP database for a polygon is then $\geq 0.2p$. For example, in polygon F1, *Quercus agrifolia* is a co-dominant in an assemblage that provides 60-70% cover. Using a mean value of 65% for the cover for a species with $\geq 20\%$ relative cover, one can expect $\geq 13\%$ of the polygon to be covered by *Quercus agrifolia*.

The relative cover of plant species inferred from the GAP database by this procedure was compared with the observational data gathered from the surveys in the eight selected polygons. From the field-collected cover data, the mean relative cover and the upper limit of the two standard error (SE) confidence interval were calculated for each species within a polygon. First, the relative cover of each species within each sample element of a polygon was calculated. Within sample elements surveyed with belt transects, relative cover for a given species was determined by dividing the total cover of overstory plants of that species by the total area of all the overstory plants within the belt transects in that sample element. Within sample elements surveyed with line transects, relative cover for a given species within each sample element was determined by dividing the total length of line transect occupied by overstory plants of that species by the total length of the line transect occupied by all overstory plants in that sample element. From the species relative cover for each sample element, the mean relative cover and upper limit of the two SE confidence interval was calculated, corresponding to an 85% confidence interval (McClave and Dietrich 1985).

The traditional 95% confidence interval based on the t-statistic was considered, but not used. The confidence intervals calculated from a t-statistic for some uncommon plants were exceedingly high due to the small degrees of freedom resulting from using 3 or 4 sample elements per polygon. Views from a panoramic point within the polygon or observations during hikes to the sample element suggested such shrubs were not common enough to warrant co-dominant designation. The two SE confidence interval was used instead as a more conservative standard for comparison between observational data and the GAP database.

If the upper limit of the two SE interval for the relative cover of a species observed in the field survey was greater than its predicted relative cover from GAP, then the species was considered a "correct" listing in the GAP database as a co-dominant. However, if the upper limit of the uncertainty interval for the relative cover of a measured species was less than its GAP-predicted relative cover, then the species was considered an "incorrect" listing as a co-dominant in the GAP database. An observed species not listed by GAP as a co-dominant was considered a "potential" co-dominant if the upper limit of the uncertainty interval was greater than the predicted relative cover value of any co-

dominant in the secondary assemblage in that polygon. For example, in polygon F1, the smallest predicted relative cover is that of a co-dominant in the secondary assemblage which provides 30-40% cover for that polygon. Using a mean value of 35% for the secondary assemblage in polygon F1 and a relative cover value of ≥ 20% for a co-dominant, then ≥ 7% of the polygon is expected to be covered by a co-dominant of a secondary assemblage in polygon F1. Any plant species observed in polygon F1 with a relative cover ≥ 7% was considered a potential co-dominant in that polygon.

Crown closure from the GAP database was also compared to the field data. Crown closure is equivalent to the percent coverage by all overstory plants within a polygon divided by the area of the polygon. For belt transects, the coverage of all overstory plants was determined by dividing total areal coverage of all overstory plants by the total area of the belt transect. For line transects, the coverage of all overstory plants was determined by dividing total line coverage of all overstory plants by the total length of the line transect. A confidence interval within two standard errors was calculated from these data and compared with the data predicted from the GAP database.

Crown volume was estimated for each polygon from the collected data. Estimates for volumes from field data have no comparable equivalent in the GAP database, because the GAP database provides only information on species identity and areal cover. Crown height data gathered from the field surveys were used in estimating crown volumes. For the belt transects, the volume of the crowns of each species was calculated assuming a parabolic crown geometry. In a separate study within the project, a parabolic crown geometry was shown to give calculated crown masses within 50% of the experimentally-derived crown mass for most cases (See Section 4.0 and Karlik and Winer 1998). The volume of a parabolic crown is half the volume occupied by a cylinder enclosing the crown or $0.5(\pi)r^2h$, where r is the crown radius and h is the crown height. The total crown volume for each species within all the elements of a polygon was calculated. Assuming the rest of the polygon resembled the sample elements in terms of species composition, the crown volume for each species within the sample elements was extrapolated to the polygon area by multiplying by the ratio of (area of the polygon)/(area of the all belt transects in the polygon).

For the line transects for the scrub or chaparral communities, individual crown volumes were not calculated. Unlike the belt transects which measured area and height, the line transects measured only length and height. Because volume calculations require areal and height data, the direct calculation of a crown volume was not possible from the line transect data. However, a species' percent occupation of the line transects approximated the species' absolute percent cover. Assuming the rest of the polygon resembled the sample elements in terms of species composition, the areal cover of each species within the polygon was estimated as the product of a given species' percent occupation of the line transect times the polygon area. This species areal coverage within a polygon multiplied by the average crown height of that species gave the crown volume of that species within a polygon. The crown volumes were then adjusted for a parabolic geometry by multiplying the result by 0.5. Within a polygon, average crown height was determined by summing the height of a species within each 0.1 m segment and dividing by the total number of 0.1 m segments occupied by the plant species.

5.5 Results

5.5.1 Species Composition and Abundance Within GAP Polygons

Table 5-4 summarizes the overall data results, listing the 10 most abundant species observed for each polygon, the percent composition predicted from the GAP database, the percent composition determined by the field surveys, and the upper limits of a two SE interval of the percent composition. Because GAP focused on overstory vegetation and because overstory plants represented most of the relative cover, Table 5-4 lists data only for the overstory plants of a given species. In polygons F1, F2, W1, and W2 (the wooded and forested polygons), overstory plants accounted for 88%, 91%, 92%, and 87% of the relative crown cover, respectively, according to our data. In the polygons dominated by scrub and chaparral, there was little or no understory.

Most of the relative cover was attributable to a few species. For all polygons, the ten most abundant species were responsible for over 90% of the relative cover (Table 5-4). Of the ten most abundant species observed for each polygon, many of them were listed as co-dominants by the GAP database. For polygons F1, F2, W1, W2, C1, C2, S1, and S2, GAP co-dominants provided 64%, 65%, 76%, 85%, 78%, 59%, 69%, and 75% of

Table 5-4. Measured species cover composition of the 10 most abundant plant species observed in selected GAP polygons.

Polygon	Species	Predicted Cover (%)	Sampled Cover (%) (s)	(s + 2 SE)
F1	*Quercus chrysolepis*	≥ 13	23	70
	Pinus jeffreyi	-	19	47
	Quercus kelloggii	≥ 13	19	26
	Quercus agrifolia	≥ 13	11	24
	Arctostaphylos pungens	-	7	17
	Pinus coulteri	≥ 7	6	18
	Quercus berberidifolia	-	6	11
	Calocedrus decurrens	≥ 7	4	7
	Cercocarpus betuloides	-	3	6
	Quercus wislizenii	-	1	1
	**Pinus lambertiana*	≥ 7	0.0	-
	Top 10		99	
	GAP Co-dominants		64	
F2	*Quercus kellogii*	≥ 11	34	37
	Pinus jeffreyi	≥ 11	18	39
	Quercus berberidifolia	-	13	23
	Ceanothus palmeri	-	11	26
	Cercocarpus betuloides	≥ 9	7	14
	Adenostoma fasciculatum	≥ 9	5	12
	Pinus coulteri	-	4	9
	Ceanothus greggii	-	2	6
	Arctostaphylos pringlei	-	2	7
	Artemisia tridentata	-	2	5
	**Quercus cornelius-mulleri*	≥ 9	0.0	-
	Top 10		99	
	GAP Co-dominants		65	

Polygon	Species	Predicted Cover (%)	Sampled Cover (%) (s)	(s + 2 SE)
W1	*Quercus engelmannii*	≥ 13	39	56
	Quercus agrifolia	≥ 13	26	41
	Arctostaphylos glandulosa	-	10	27
	Adenostoma fasciculatum	≥ 7	8	25
	Salvia apiana	-	4	12
	Eriogonum fasciculatum	-	4	11
	Symphoricarpos mollis	-	2	4
	Quercus kelloggii	≥ 13	2	3
	Marrubium vulgare	-	2	5
	Rhus trilobata	-	1	3
	**Ceanothus leucodermis*	≥ 7	0.2	2
	**Quercus berberidifolia*	≥ 7	0.0	-
	Top 10		99	
	GAP Co-dominants		76	
W2	*Quercus engelmannii*	≥ 13	62	121
	Quercus kelloggii	≥ 13	17	46
	Quercus berberidifolia	-	10	27
	Quercus agrifolia	≥ 13	3	6
	Pinus coulteri	-	2	6
	Arctostaphylos glandulosa	≥ 7	2	4
	Adenostoma fasciculatum	≥ 7	1	3
	Salvia apiana	-	0.7	1
	Cercocarpus betuloides	≥ 7	.05	1
	Garrya veatchii	-	0.5	1
	Top 10		99	
	GAP Co-dominants		85	

Table 5-4. (Continued)

Polygon	Species	Predicted Cover (%)	Sampled Cover (%) (s)	(s + 2 SE)
C1	*Quercus berberidifolia*	≥ 11	39	67
	Adenostoma fasciculatum	≥ 9	36	54
	Eriogonum fasciculatum	-	5	15
	Quercus engelmannii	-	4	12
	Ceanothus crassifolius	-	2	4
	Heteromeles arbutifolia	-	2	4
	Cercocarpus betuloides	≥ 9	2	4
	Prunus ilicifolia	-	1	2
	Unidentified	-	1	2
	Salvia apiana	-	1	2
	**Ceanothus leucodermis*	≥ 11	0.4	1
	*Buckbrush	≥ 9	0.0	-
	Top 10		94	
	GAP Co-dominants		78	
C2	*Adenostoma fasciculatum*	≥ 17	51	73
	Xylococcus bicolor		13	25
	Eriogonum fasciculatum		8	15
	Quercus berberidifolia	≥ 17	5	6
	Malosma laurina		4	9
	Rhus ovata		4	7
	Ceanothus greggii	≥ 3	3	7
	Cneoridium dumosum		2	7
	Ceanothus oliganthus		2	5
	Arctostaphylos glandulosa		2	4
	**Ceanothus leucodermis*	≥ 17	1	1
	Top 10		94	
	GAP Co-dominants		59	
S1	*Eriogonum fasciculatum*	≥ 13	26	49
	Adenostoma fasciculatum	≥ 7	21	48
	Artemisia californica	≥ 13	20	33
	Malosma laurina	-	14	26
	Xylococcus bicolor	-	6	14
	Ceanothus oliganthus	-	3	10
	Salvia mellifera	-	3	8
	Quercus berberidifolia	≥ 7	1	3
	Salvia apiana	≥ 13	1	1
	Baccharis sarothroides	-	1	2
	**Ceanothus sorediatus*	≥ 7	0.0	-
	Top 10		96	
	GAP Co-dominants		69	
S2	*Artemisia californica*	≥ 17	41	68
	Salvia mellifera	≥ 17	16	31
	Malosma laurina	≥ 17	14	24
	Rhus integrifolia	-	6	15
	Baccharis pilularis	≥ 3	4	12
	Malacothamnus fasciculatus	-	4	10
	Eriogonum fasciculatum	-	3	7
	Lotus scoparius	-	3	6
	Mimulus sp.	-	2	4
	Galium sp.	-	2	3
	Top 10		94	
	GAP Co-dominants		75	

* Species listed in the GAP database as a co-dominant, but not ranked in the top 10 species observed for the polygon.

the observed relative cover, respectively. In general, the GAP co-dominants provided roughly two-thirds to three-quarters of the relative cover observed in the field surveys.

The observed relative cover of some co-dominants in GAP polygons often substantially exceeded the predicted values for both forest/woodland and chaparral/scrub polygons (Table 5-4). For example, in polygon F2, *Quercus kelloggi* provided 34% of the relative cover when ≥ 11% was predicted, and in polygon W1, *Q. engelmannii* provided 39% of the relative cover when ≥ 13% was predicted. In polygon C1, *Q. berberidifolia* and *Adenostoma fasciculatum* provided 39% and 36% of the relative cover, respectively, when ≥ 11% and ≥ 9% were predicted by the GAP database. In polygon S1, *Eriogonum fasciculatum* provided 26% of the relative cover when ≥ 13% was predicted. Clearly, although a lower limit for species relative cover can be inferred from the data provided by the GAP database, the GAP database does not provide an upper limit for species relative cover.

Table 5-5 shows the number of species listed as GAP co-dominants which agreed with field observations, the species listed as co-dominants which were not observed in significant amounts in our field surveys for a particular polygon, and species that could have been listed as a co-dominant within each of the polygons studied. As stated before, those species whose observed composition was within 2 standard errors of the predicted percent composition were considered potential co-dominants within the polygon.

For all the polygons listed in Table 5-5, 59% of the GAP co-dominants were observed in the field survey in large enough proportions in the polygons to justify their co-dominant designation. Of the species listed as co-dominants in the primary assemblages, this percentage increased to 73%. Conversely, for species listed as co-dominants within the secondary assemblages of the GAP database, only 45% were observed in the field survey with sufficient abundance to match the predictions.

The "correct" listing of GAP co-dominants was more common in forested or wooded polygons. Within such polygons, 61% of the GAP co-dominants were observed in large enough proportions in the polygons to justify their co-dominant designation. Among primary and secondary assemblage co-dominants within forested or wooded polygons, this percentage was 82% and 42%, respectively.

Table 5-5. Species listed correctly and incorrectly as co-dominants within surveyed GAP polygon ordered by decreasing mean relative cover.

Polygon	GAP Species Observed in Significantly Large Quantities	GAP Species Not Observed in Significantly Large Quantities	Potential Co-Dominants
F1	*Quercus chrysolepis* (p) *Quercus kelloggii* (p) *Quercus agrifolia* (p) *Pinus coulteri* (s) *Calocedrus decurrens* (s)	*Pinus lambertiana* (s)	*Pinus jeffreyi** *Arctostaphylos pungens* *Quercus berberidifolia**
F2	*Quercus kelloggii* (p) *Pinus jeffreyi* (p) *Cercocarpus betuloides* (s) *Adenostoma fasciculatum* (s)	*Quercus cornelius-mulleri* (s)	*Quercus berberidifolia* *Ceanothus palmeri** *Pinus coulteri*
W1	*Quercus engelmannii* (p) *Quercus agrifolia* (p) *Adenostoma fasciculatum* (s)	*Quercus kelloggii* (p) *Ceanothus leucodermis* (s) *Quercus berberidifolia* (s)	*Arctostaphylos glandulosa** *Eriogonum fasciculatum** *Salvia apiana**
W2	*Quercus engelmannii* (p) *Quercus kelloggii* (p)	*Quercus agrifolia* (p) *Adenostoma fasciculatum* (s) *Arctostaphylos tomentosa* (s) *Cercocarpus betuloides* (s)	*Quercus berberidifolia**
C1	*Quercus berberidifolia* (p) *Adenostoma fasciculatum* (s)	*Cercocarpus betuloides* (s) *Ceanothus leucodermis* (p) Buckbrush (s)	*Eriogonum fasciculatum** *Quercus engelmannii**
C2	*Adenostoma fasciculatum* (p) *Ceanothus greggii* (s)	*Quercus berberidifolia* (p) *Ceanothus leucodermis* (p) *Arctostaphylos pungens* (s)	*Xylococcus bicolor** *Eriogonum fasciculatum** *Malosma laurina** *Rhus ovata* *Cneoridium dumosum* *Ceanothus oliganthus* *Arctostaphylos glandulosa**
S1	*Eriogonum fasciculatum* (p) *Adenostoma fasciculatum* (p) *Artemisia californica* (s)	*Quercus berberidifolia* (s) *Salvia apiana* (p) *Ceanothus sorediatus* (s)	*Malosma laurina* *Xylococcus bicolor** *Salvia mellifera* *Ceanothus oliganthus*
S2	*Artemisia californica* (p) *Salvia mellifera* (p) *Malosma laurina* (p) *Baccharis pilularis* (s) *Avena* spp., *Bromus* spp., etc. (s)	-	*Rhus integrifolia* *Malacothamnus fasciculatus* *Eriogonum fasciculatum** *Lotus scoparius*

(p) GAP primary assemblage species
(s) GAP secondary assemblage species
* Potential co-dominant listed as a co-dominant in an adjacent GAP polygon

Field observation agreement with GAP co-dominants was less common in chaparral and scrub polygons. Within such areas, 57% of the GAP co-dominants were observed in large enough proportions in the polygons to justify their co-dominant designation. Among primary and secondary assemblage co-dominants within chaparral and sage scrub polygons, this percentage was 64% and 50%, respectively.

There were several instances where species listed in either the primary or secondary assemblage were not observed at all in the polygon in our field observations. In some cases, a taxonomically similar species was found instead. For example, *Quercus cornelius-mulleri* (a scrub oak with tomentose hairs on the underside of the leaves) was not identified in polygon F2, but *Q. berberidifolia* was observed as a co-dominant based on the field data. In another case, the species listed in the GAP database did not even exist within the county according to botanical experts, although a closely-related species was found instead in our study. For example, *Ceanothus sorediatus* was not recognized as a species found in San Diego County by local botanists (Beauchamp 1986) let alone polygon S1, but *C. oliganthus*, a similar species with subtle differences was found instead in our surveys for that polygon. This situation occurred again in polygon W2 where *Arctostaphylos tomentosus* was not recognized by Beauchamp (1986) as a species found in the county, but *A. glandulosa*, a similar hairy manzanita with a basal burl, was found instead in our surveys for that polygon. In two other cases, a species listed by GAP was not observed in any of the sample elements we surveyed. *Pinus lambertiana* was not found in the sample elements in polygon F1, although rangers indicated they thrived at higher elevations within the polygon away from roads and in areas close to the polygon boundary. In the other case, buckbrush was not found in any of the sample elements within polygon C1. (Although the GAP database listed the species as "buckbrush" instead of its Latin name, we considered the species to be *Ceanothus cuneatus*.)

Similar to the experience with *Pinus lambertiana*, observations of polygon areas away from the sample elements suggested that in some cases the elements did not encompass the representative vegetation found elsewhere in the polygon. In polygon S1, large portions of roadside areas in the northern part of the polygon were covered with *Salvia apiana*. However, permission to access those areas was not granted and no sampling could be performed. In polygon C2, large portions of north-facing slopes in the southern part of the polygon were covered by continuous stands of *Quercus berberidifolia*, but permission was not granted to access those areas. Although unavoidable, these experiences indicate limits to the representativeness of our sampling protocol.

Conversely, there were numerous species within the polygons observed in high enough abundance to warrant possible designation as a co-dominant although they were not listed as co-dominants by the GAP database (Table 5-5). For most of these species, their abundance was modest, but given the SE interval about the mean sampled composition (Table 5-4), the case could be made for designating such species as co-dominants. Most of these omitted potential co-dominants were shrubs (e.g., *Arctostaphlos glandulosa, Quercus berberidifolia, Ceanothus palmeri, Eriogonum fasciculatum*), except for the case of *Pinus jeffreyi* in polygon F1 and *P. coulteri* in polygon F2.

Although not listed by the GAP database as co-dominants within an investigated polygon, these potential co-dominants were often listed as co-dominants in neighboring GAP polygons (see Table 5-5), suggesting the influence of adjacent polygons on species composition of the surveyed polygons. Of the twenty-seven species listed as potential co-dominants, fifteen were listed as co-dominants in adjacent polygons by the GAP database (Table 5-5).

5.5.2 Crown Closure

Table 5-6 summarizes the predicted and measured crown closure for the GAP polygons studied. When the GAP-predicted crown closure of both primary and secondary assemblages were the same, the measured crown closure was within both ranges (polygons F1, C1, and S1). When the GAP-predicted crown closure of both primary and secondary assemblages were different, the measured crown closure was within the crown closure range of one of the assemblages (polygon F2) or between the crown closure ranges of both assemblages (polygon W1).

Thus, total crown closure as predicted by the GAP database generally matched the field observations in the present study. This correspondence between predictions and observations can be attributed to the relative ease of accurately estimating crown closure from aerial photographs or remote sensing.

Table 5-6. Predicted and measured crown closure for selected GAP polygons.

Polygon	Primary or Secondary	Predicted Crown Closure (%)	Measured Crown Closure (%) (c)	(c - 2SE, c + 2SE)
F1	P	60 - 100	72	(54, 90)
	S	60 - 100		
F2	P	40 - 59	54	(44, 63)
	S	60 - 100		
W1	P	25 - 39	42	(20, 63)
	S	60 - 100		
W2	P	60 - 100	56	(35, 76)
	S	60 - 100		
C1	P	60 - 100	81	(63, 99)
	S	60 - 100		
C2	P	60 - 100	74	(66, 83)
	S	60 - 100		
S1	P	40 - 59	54	(36, 72)
	S	40 - 59		
S2	P	60 - 100	63	(45, 80)
	S	25 - 39		

5.5.3 Polygon Heterogeneity

Within the GAP database polygons, vegetation heterogeneity was a common phenomenon, with species within one assemblage often found in specific locations due to the influence of localized environmental factors. In polygon W1 for example, *Quercus engelmannii* favored xeric, south-facing slopes whereas *Q. agrifolia* favored mesic, north-facing slopes and valleys. Similarly, for polygon W2, *Q. engelmannii* favored the xeric, south-facing slopes and *Q. kelloggii* formed monotypic stands on mesic, north-facing slopes. Thus, the listing of species within an assemblage as co-dominants for a GAP polygon does not indicate a homogenous mixture of plant species.

This heterogeneity can be represented by the community classification of each sample element within a polygon (Table 5-7). Based on field observations of the species composition of a sample element, a classification of the vegetation community was assigned using Holland classification definitions (Holland 1986). Although the classifications provided by Holland gave detailed definitions, there was no systematic method to apply these definitions to field observations, especially for similar community classifications. Nevertheless, community classifications provide a broad view of the communities within each element within a certain degree of uncertainty.

Table 5-7. Holland community classifications assigned by GAP for entire polygons and by this survey for each sample element within the polygon based on field observations.

Polygon	Holland Classifications Assigned by GAP	Sample Element	Major Holland Classifications	Other Possible Holland Classifications
F1	Black Oak Forest or Coulter Pine Forest	1	Black Oak Forest	Jeffrey Pine Forest
		2	Canyon Live Oak Forest	-
		3	Coulter Pine Forest	-
F2	Black Oak Forest or Semi-Desert Chaparral	1	Black Oak Woodland	-
		2	Black Oak Woodland	Northern Mixed Chaparral
		3	Black Oak Woodland	Northern Mixed Chaparral
W1	Dense Engelmann Oak Woodland or Northern Mixed Chaparral	1	Dense Engelmann Oak Woodland	-
		2	Dense Engelmann Oak Woodland	-
		3	Dense Engelmann Oak Woodland	Northern Mixed Chaparral
W2	Dense Engelmann Oak Woodland or Chamise Chaparral	1	Open Engelmann Oak Woodland	-
		2	Black Oak Forest	Northern Mixed Chaparral
		-		
C1	Scrub Oak Chaparral or Buck Brush Chaparral	1	Chamise Chaparral	-
		2	Scrub Oak Chaparral	-
		3	Northern Mixed Chaparral	-
		4	Chamise Chaparral	Northern Mixed Chaparral
C2	Northern Mixed Chaparral or Semi-Desert Chaparral	1	Chamise Chaparral	Semi-Desert Chaparral
		2	Chamise Chaparral	Northern Mixed Chaparral
		3	Southern Mixed Chaparral	Coastal Scrub
		4	Chamise Chaparral	
S1	Buckbrush Chaparral or Coastal Scrub	1	Coastal Scrub	-
		2	Southern Mixed Chaparral	-
		3	Southern Mixed Chaparral	Coastal Scrub
		4	Coastal Scrub	-
S2	Coastal Scrub	1	Coastal Scrub	-
		2	Coastal Scrub	-
		3	Coastal Scrub	-
		4	Coastal Scrub	-

Some of these assigned Holland classifications of sample elements differed from the GAP database. For example, the community classifications listed in GAP for polygon F1 were black oak forest and coulter pine forest. However, in one sample element, significant amounts of canyon live oak (*Quercus chrysolepis*) over a large area suggested the area encompassing the sample element could be classified as a canyon live oak forest. Also, significant amounts of jeffrey pine (*Pinus jeffreyi*) over a large area suggested the area encompassing the sample element could be classified as a jeffrey pine forest. Areas within polygon W2 were covered by monotypic stands of black oak, warranting a classification of black oak forest, but such a classification was not listed by GAP.

A detailed listing of the species composition of each sample element is given in Appendix C. The tables in Appendix C illustrate the heterogeneity on a species level, with sometimes dramatic species composition changes from one sample element to another within a polygon. A co-dominant listed by GAP may even dominate an area to the exclusion of other co-dominants, as was the case with *Quercus chrysolepis* in sample element 2 in polygon F1 and *Adenostoma fasciculatum* in sample element 1 in polygon C2 (Appendix C).

5.5.4 Crown Volumes

Table 5-8 summarizes the crown volume data results for forested and wooded polygons, listing (a) the 10 species with the greatest crown volume for each polygon, (b) the species crown volumes within the sample elements of the polygons, and (c) species crown volumes extrapolated to the entire polygon. Because overstory plants represented most of the relative cover, Table 5-8 lists data only for the overstory plants of a given species. In polygons F1, F2, W1, and W2 (the wooded and forested polygons), overstory plants accounted for 94%, 95%, 96%, and 95% of the extrapolated total crown volume.

The majority of the estimated crown volume was attributable to a few species. For all forest and woodland polygons, the ten most abundant species were responsible for virtually the entire crown volume of the polygon (Table 5-8). Of the ten most abundant species for each polygon, many were listed as co-dominants by the GAP database. For polygons F1, F2, W1, and W2 GAP co-dominants represented 64%, 85%, 96%, and 93% of the extrapolated total crown volume of the polygon. The species with the most crown volumes were always tree species.

Table 5-9 summarizes the crown volume data for scrub and chaparral polygons, listing the 10 species with the greatest crown volume for each polygon and species crown volumes extrapolated to the entire polygon. As was the case with forest and woodland polygons, the majority of the estimated crown volume was attributable to a few species. The ten most abundant species were responsible for virtually the entire crown volumes of the scrub and chaparral polygons (Table 5-9), and GAP co-dominants accounted for a large portion of the extrapolated total crown volume. For polygons C1, C2, S1, and S2,

Table 5-8. Calculated crown volumes in the sample elements of forested polygons and estimates of crown volumes for entire polygons for the ten most voluminous species.

Polygon	Polygon Area (ha)	Sample Element Area (ha)	Species	Calculated Crown Volume in Sample Elements (m^3)	Estimated Crown Volume for the Polygon (m^3)
F1	1,990	1.8	*Quercus chrysolepis**	15,000	17,000,000
			Pinus jeffreyi	14,000	16,000,000
			*Quercus kelloggii**	9,800	11,000,000
			*Quercus agrifolia**	5,300	5,700,000
			*Pinus coulteri**	2,800	3,100,000
			*Calocedrus decurrens**	2,500	2,800,000
			Quercus berberidifolia	560	620,000
			Arctostaphylos pungens	540	590,000
			Cercocarpus betuloides	380	420,000
			Quercus wislizenii	380	410,000
			Top 10	52,000	58,000,000 (100%[1])
			GAP co-dominants	35,000	39,000,000 (67%[1])
			Total	52,000	58,000,000
F2	2,317	1.8	*Quercus kellogii**	14,000	18,000,000
			*Pinus jeffreyi**	8,000	10,000,000
			Pinus coulteri	2,500	3,300,000
			Quercus berberidifolia	660	850,000
			Ceanothus palmeri	580	740,000
			*Cercocarpus betuloides**	410	520,000
			*Adenostoma fasciculatum**	250	320,000
			Ceanothus greggii	130	160,000
			Arctostaphylos pringlei	110	140,000
			Artemisia tridentata	100	130,000
			Top 10	27,000	35,000,000 (100%[1])
			GAP co-dominants	23,000	29,000,000 (85%[1])
			Total	27,000	35,000,000
W1	1,904	1.8	*Quercus engelmannii**	11,000	12,000,000
			*Quercus agrifolia**	7,700	8,200,000
			*Quercus kelloggii**	660	700,000
			Arctostaphylos glandulosa	500	550,000
			*Adenostoma fasciculatum**	370	390,000
			Eriogonum fasciculatum	80	87,000
			Salvia apiana	80	85,000
			Symphoricarpos mollis	60	66,000
			*Ceanothus leucodermis**	60	63,000
			Juniperus californicus	20	23,000
			Top 10	21,000	22,000,000 (100%[1])
			GAP co-dominants	20,000	21,000,000 (96%[1])
			Total	21,000	22,000,000

Table 5-8. (Continued)

Polygon	Polygon Area (ha)	Sample Element Area (ha)	Species	Calculated Crown Volume in Sample Elements (m^3)	Estimated Crown Volume for the Polygon (m^3)
W2	1,778	1.2	*Quercus engelmannii**	16,000	24,000,000
			*Quercus kelloggii**	6,417	9,500,000
			Pinus coulteri	900	1,300,000
			*Quercus agrifolia**	780	1,200,000
			Quercus berberidifolia	730	1,100,000
			Arctostaphylos glandulosa	90	130,000
			Garrya veatchii	60	94,000
			Cercocarpus betuloides	60	84,000
			Adenostoma fasciculatum	50	68,000
			Rhamnus ilicifolia	20	24,000
			Top 10	26,000	38,000,000 (100%[1])
			GAP co-dominants	24,000	35,000,000 (93%[1])
			Total	26,000	38,000,000

[1] Percent of the total for the polygon
* GAP co-dominant for the polygon

GAP co-dominants represented 75%, 55%, 59%, and 70% of the total extrapolated crown volume of the polygon.

5.6 Discussion

5.6.1 Species Composition Within the GAP Database

In our study, the apparent accuracy of the GAP database was high for forest/woodland species and lower for scrub/chaparral species. As noted earlier, the accuracy of the GAP database is linked to the accuracy of VTM and soil-vegetation maps, and to more recent remote sensing data used to create this database. The original VTM and soil-vegetation maps may have been quite accurate for forests and woodlands, because there were fewer barriers for conducting accurate surveys in those areas and more incentives. Specifically, high accuracy for forests and woodlands may be explained by the ease of conducting studies in those relatively open areas combined with the economic incentive of producing accurate data for these potential timber sources. Scrub and chaparral have little or no commercial value, and the effort required to maneuver through dense thickets discourages data collection.

Successional changes may explain discrepancies in species composition between the GAP database and the present study for certain chaparral species. Although previous

Table 5-9. Estimates of crown volumes for the ten most voluminous species in chaparral and sage scrub polygons.

Polygon	Polygon Area (ha)	Species	Average Crown Height (m)	Absolute Cover (%)	Estimated Crown Volume for the Polygon (m^3)
C1	6,578	*Quercus berberidifolia**	1.8	36	42,000,000
		*Adenostoma fasciculatum**	0.8	28	7,600,000
		Quercus engelmannii	4.7	4	5,700,000
		Ceanothus crassifolius	1.2	2	730,000
		*Cercocarpus betuloides**	1.6	1	730,000
		Heteromeles arbutifolia	1.3	2	700,000
		Quercus agrifolia	3.3	1	590,000
		Eriogonum fasciculatum	0.7	3	580,000
		Prunus ilicifolia	1.0	1	430,000
		Unknown	1.1	1	200,000
		Top 10		77	39,000,000 (97%[1])
		GAP co-dominants		66	30,000,000 (75%[1])
		Total		81	40,000,000
C2	3,986	*Adenostoma fasciculatum**	0.8	37	5,900,000
		Xylococcus bicolor	1.1	10	2,300,000
		*Quercus berberidifolia**	1.6	3	980,000
		Rhus ovata	1.2	4	870,000
		Malosma laurina	1.1	3	740,000
		Eriogonum fasciculatum	0.6	6	720,000
		Ceanothus oliganthus	1.2	2	390,000
		*Ceanothus greggii**	0.8	2	280,000
		Arctostaphylos glandulosa	1.2	1	230,000
		Cneoridium dumosum	0.7	2	230,000
		*Ceanothus leucodermis**	1.1	0	89,000
		Top 10		70	13,000,000 (96%[1])
		GAP co-dominants		43	7,200,000 (55%[1])
		Total		74	13,000,000
S1	3,650	*Adenostoma fasciculatum**	1.0	13	2,300,000
		Malosma laurina	1.2	8	1,800,000
		*Eriogonum fasciculatum**	0.7	12	1,600,000
		*Artemisia californica**	0.7	10	1,200,000
		Xylococcus bicolor	1.3	4	1,000,000
		Ceanothus oliganthus	1.2	2	400,000
		*Quercus berberidifolia**	1.9	1	290,000
		Salvia mellifera	0.8	2	240,000
		Cercocarpus betuloides	2.2	0	75,000
		Cneoridium dumosum	0.7	0	51,000
		Top 10		52	8,900,000 (98%[1])
		GAP co-dominants		35	5,300,000 (59%[1])
		Total		54	9,100,000

Table 5-9. (Continued)

Polygon	Polygon Area (ha)	Species	Average Crown Height (m)	Absolute Cover (%)	Estimated Crown Volume for the Polygon (m^3)
S2	2,718	*Artemisia californica*	0.7	35	2,000,000
		Malosma laurina	1.1	15	1,500,000
		Salvia mellifera	0.7	19	1,100,000
		Rhus integrifolia	1.5	8	970,000
		Malacothamnus fasciculatus	0.7	5	350,000
		Baccharis pilularis	0.6	3	160,000
		Eriogonum fasciculatum	0.6	3	150,000
		Lotus scoparius	0.5	3	120,000
		Mimulus sp.	0.5	2	74,000
		Galium sp.	0.3	1	71,000
		Top 10		59	6,500,000 (96%[1])
		GAP co-dominants		46	4,800,000 (70%[1])
		Total		63	6,800,000

[1] Percent of the total for the polygon
* GAP co-dominant for the polygon

studies estimating natural cover of vegetation for BHC inventory generation assumed little change in chaparral vegetation over time (Winer et al. 1983), this may not be the case. Chaparral follows certain successional trends after fires. Ceanothus chaparral and coastal sage scrub may emerge immediately after a fire depending on the elevation, aspect, and antecedent vegetative conditions, but may be displaced by chamise or scrub oak chaparral (Hanes 1977). *Ceanothus cuneatus* is one species which within 50 years can die out completely (Gordon and White 1994). Other species of *Ceanothus* tend to thin with time because recruitment of new individuals does not occur in the absence of fire (Keeley 1975). Some of the more underrepresented species in our field observations which were predicted by the GAP database were members of the genus *Ceanothus* (*C. leucodermis*, *C. oliganthus*, *C. greggii*, and *C. cuneatus*). A successional process could explain the absence of ceanothus species from some of the field data even though it was predicted in the GAP database.

Within forests and woodlands, studies have evaluated the accuracy of VTM plots over time. For example, Allen-Diaz (1993) found little natural change in species composition in VTM plots within blue oak woodlands in the Central Valley but some increase in the size and number of oak species individuals over a period of 50-60 years. Minnich et al. (1995) reported gradual species change in VTM plots within the San Bernardino Mountains from ponderosa and sugar pines to white fir and incense cedar

attributable to fire suppression. Some of these changes in San Bernardino Mountain mixed conifer species were attributable to effects of air pollution on beetle-induced mortality and seedling recruitment of pine species (Miller et al. 1997). However, these studies did not report wholescale replacement of species within forested and wooded VTM plots.

According to our survey data, a discrepancy also existed in the accuracy of primary versus secondary assemblages in GAP, since primary assemblage co-dominants were correctly listed by the GAP database more often. In a GAP polygon, primary assemblages by definition are more prevalent. In the present study, a sample element was more likely to be placed in the more prevalent assemblage, resulting in the gathering of more data on primary assemblage species and higher representation by those species. With only three or four elements, there was a smaller chance of sampling a species from a secondary assemblage with a frequency proportional to the area occupied by that assemblage. In the future with more resources, and hence a larger number of randomly-placed sample elements, representation by species from either assemblage should be proportional to each assemblage's cover within the polygon.

As noted above, for some polygons, the species predicted by GAP were not found within the surveyed sample elements. In some cases, this discrepancy could be attributed to the GAP database, as in the case of those species not recognized by local botanists as present in the study region. However, as noted earlier, some of these discrepancies have little impact on the utility of the database, because taxonomically-related species were found instead. In other instances where a plant species listed in GAP was not found in our survey, this may have been due to limitations in siting the sample elements. By sampling only near roads, away from polygon boundaries, and only with the permission of land owners, large areas were removed from inclusion in the study. These limitations were recognized and accepted as a condition to performing this type of survey. Observations from a distance and input from individuals knowledgeable about local botany was helpful in identifying additional plant species outside the selected sample elements but did not add to the quantitative estimations of vegetation cover reported here.

The heterogeneity of plant communities within a polygon was expected because the minimum mapping unit of the GAP database was 100 hectares. Consequently, the

GAP database is not capable of describing communities and areas smaller than 100 hectares. Since in the present study, the square areas enclosing a sample element in the forested/wooded and chaparral/scrub polygons were 25 and 9 hectares, respectively, vegetation communities observed during the surveys were below the spatial resolution of the GAP database. Consequently, microhabitats of less than 100 hectares have been observed in the present study that differed from the overall community predicted by the GAP database for entire polygons. These observations indicate the data listed by the GAP database for a given polygon must be considered as generalized to the entire polygon and not necessarily completely descriptive of specific locations within the polygon.

5.6.2 Utility of the GAP Database in Developing BHC Inventories

The GAP database provides potentially valuable information for developing BHC emissions inventories. Compared to previous databases estimating percent cover of vegetation in natural areas, the GAP database is species-specific and has a higher spatial resolution. The four classes of information predicted by the GAP database useful for the development of a BHC emissions inventory are crown closure of an assemblage, assemblage cover, species composition within an assemblage, and abundance of species within an assemblage.

Crown closure information predicted by the GAP database was consistent with our field observations. In almost all the cases, the measured crown closure was within the range or ranges predicted by GAP. Although the crown closure data were generally accurate, the classes describing crown closure were broad: 25-39%, 40-59%, and 60-100%, respectively. For the purpose of developing a BHC inventory, mean values for each class could be used. For the three crown closure classes cited above, using mean values of 32%, 50%, and 80% would result in maximum errors of ± 22%, ± 20%, and ± 25%, respectively.

Because the GAP database does not delineate the boundaries of primary versus secondary assemblages within a polygon, the assemblage cover could not be validated from this study. Specifically, it was not possible to determine where a species assemblage began and ended from a ground level perspective and scale. Like crown

closure, percent assemblage cover was determined in the GAP database from aerial photographs and satellite imagery. The species assemblages data might be expected to have the same degree of accuracy as the crown closure data due to the relative ease of delineating large features such as broad vegetation classes within a polygon. For the purpose of developing a BHC inventory, mean values for each assemblage cover class could be used. For the nine assemblage cover classes (10-20%, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%, and 90-100%), using the mean values for each class would result in a range of errors from ± 33% for the 10-20% assemblage cover class to ± 5% for the 90-100% cover class.

In terms of species composition, there were some discrepancies between the GAP database and the present field observations. As noted earlier, these discrepancies took two forms: apparent omissions of observed species and apparent misassignment of species. One important explanation for the former is the limit in GAP of the number of reported species (i.e. three) per assemblage. Clearly, if additional species had been listed by GAP, for example in the primary assemblage, there would have been greater agreement with the field observations.

Using the two standard error criterion discussed earlier and the field survey data, about 40% of the GAP co-dominants were misassigned. For the purpose of the development of BHC emissions inventories, species composition errors have adverse effects only when a plant species listed in GAP as a co-dominant for a polygon should actually be a species with a different measured BHC emission rate and/or biomass constant. For example, if a co-dominant listed by GAP is a high isoprene-emitting species, but the actual plant species which occurs in the polygon is a low- or non-emitting species, the resulting BHC emission flux calculated for that polygon will over-estimate isoprene.

Another source of uncertainty is that the taxonomic method (Benjamin et al. 1996) of assigning BHC emission rates will necessarily be used for BHC inventory development (when experimental data are not available). Thus, the degree of error introduced by GAP species misassignment will depend on the taxonomic relationship between the predicted versus the observed co-dominant. For example, the substitution for a GAP co-dominant of a distantly-related plant species observed in the field (with a likely

quite different assigned emission rate) has the greatest potential to quantitatively affect a BHC emission inventory. However, based on the present field surveys, at least some of these discrepancies should be of little or no significance in developing BHC emissions inventories, because, as discussed earlier, species misassignments usually involved the replacement of a predicted co-dominant in GAP by a taxonomically-similar species. For example, for polygon F2, there was a large abundance of *Quercus berberidifolia* based on field surveys instead of the GAP-listed species, *Q. cornelius-mulleri*. Even with the substitution of a distantly-related species for a GAP co-dominant, there will be a significant quantitative effect only if the emission rates and/or biomass constants for the two species are very different, and also only if the species has a substantial species abundance. Thus, the substitution of one non-emitting species for another non-emitting GAP co-dominant will have no effect on BHC emissions inventory. Conversely, the most serious differences will occur when a high-emitting species is found to be abundant in a field survey but is not listed as a GAP co-dominant, or as noted above, an abundant high-emitting GAP species is not actually present.

Because the agreement between the GAP database and our field observations varied with vegetation type and assemblage, these factors must be taken into account as well when developing a BHC emissions inventory. For example, the present study showed accuracy was greater for forest and woodland polygons than for chaparral and sage scrub. The present study also showed accuracy was greater for primary assemblages than for secondary assemblages, although as noted, this may be partly an artifact of the study design.

The species abundance predicted by the GAP database accounted for a large portion of the plant material. For forested polygons, the species area predicted by GAP accounted for 65-85% of the observed relative cover based on our surveys. Similarly for forested polygons, the species predicted by GAP accounted for 60-90% of the crown volume.

However, the observed abundance of individual GAP co-dominants within a polygon was not evenly distributed among the listed species in the GAP database. Often, one or two co-dominants occupied the majority of the assemblage and the polygon, using relative cover as the metric. As stated previously, the GAP database provides

information allowing the determination of a possible lower limit to the abundance for a co-dominant, but not a possible upper limit. Consequently, the range of the relative cover for a co-dominant may be anywhere from 20% to 100% of its assemblage within the polygon. This range can be reduced knowing other plants are co-dominants, but the generic nature of the data prevents precise quantification. Even then, a precise characterization of each assemblage by relative cover cannot be performed without additional data from field observations or the literature. Also, the relative cover of species that are not co-dominants will be unaccounted for by the process outlined above. Because co-dominants in the polygons surveyed for the present study accounted for only 60-85% of the relative cover, the remaining 15-40% of the relative cover was attributable to species whose identity cannot be determined from the GAP database.

Also, biomass as measured by crown volume cannot be determined solely from data contained within the GAP database. Thus, auxiliary data providing average crown height of a plant species, or plant crown volume on an area basis, are required for the GAP database to be useful in determining biomass for development of BHC emissions inventories. Literature describing the average height of California plant species exists from taxonomy texts (Munz and Keck 1959, Hickman 1993), and volume and mass data on an area basis exist for major coastal sage scrub and chaparral species (Gray and Schlesinger 1981, Miller 1981). Alternatively, field data concerning crown height can be obtained as done in the present study.

Using the data for polygon F1 from Table 5-3 as an example, crown closure, assemblage cover, species composition, and species abundance data from the GAP database can be used to calculate the areal coverage by major species. Using mean values for assemblage cover and crown closure, the vegetation of the primary assemblage covers (0.65)*(0.8) or 52% of the polygon area, and the vegetation of the secondary assemblage covers (0.35)*(0.8) or 28% of the polygon. Since this calculation incorporates crown closure, these figures represent actual vegetation cover and not relative cover. Using the extreme ends of the assemblage cover and crown closure ranges, the vegetation of the primary assemblage may cover between 36% and 70% of the polygon, and the vegetation of the secondary assemblage may cover between 18% and 40% of the polygon.

5.6.3 Limitations in the Present GAP Assessment Study

As noted earlier, the GAP assessment in San Diego County posed special problems in terms of sampling representative areas within privately-owned parts of a polygon. In the Utah GAP validation project, 42% of the state was under the control of the US Bureau of Land Management, with private interests owning only 21% (Edwards et al. 1995). In San Diego County, the San Diego County Association of Government 1990 ownership database indicated private interests owned 41% of county land (San Diego Association of Governments 1997). Private land owners typically purchase land in accessible areas within the vicinity of roads. For the purposes of conducting a GAP assessment project, suitable public lands within the vicinity of roads was limited. Although a 14% success rate for our mailers seeking property access was high by the standards of some surveys, obtaining permission to access private property was a limiting factor. For example, no polygon contained more than two private land owners volunteering to participate in the present study. The lack of suitable sites to randomly place sample elements in four of the polygons resulted in extended hikes from established roads to reach a United States National Forest or county park area. Even with such effort, our ability to conduct surveys in representative areas of a polygon's major vegetation types as listed in the GAP database was limited for these four polygons.

As noted earlier, given the effort needed to gather the field data, it was necessary to reduce the area sampled. Moreover, the sample area required to estimate the true relative cover of individual species in a polygon is not known. The literature suggested surveying 7% of a forested area using parallel belt transects provided a 65% chance the sample mean of the basal area of the trees would be within 10% of the true mean for more common species (Bormann 1953). The effort needed to obtain an accurate measure of relative cover may be similar. In the present study, the belt transects directly sampled 1.8 hectares within polygons of about 1,800 to 2,300 hectares, or about 0.1% of the polygon area. The line transects approximating 3 m belt transects directly sampled 0.72 hectares in polygons ranging in size from 3,600 to 6,600 hectares, or about 0.01%.

On the other hand, the effective size of the samples may be larger. The vegetation cover composition within the transects may approximate the cover composition of a square which immediately bounds the ends of the perpendicular transects. If this was the

case, the three sample element in each forest/woodland polygon may have effectively sampled 75 hectares or about 4% of the polygon area, while the four sample elements in the chaparral/scrub polygons may have effectively sampled 36 hectares or about 0.9% of the polygon area.

5.6.4 Improvements to the Methodology

Some steps can be undertaken to improve the assessment methodology for the GAP database within California. Since many parts of California will follow San Diego County's pattern of land ownership, large portions of roadside areas may be inaccessible to surveyors because of lack of cooperation by local land owners. Certain steps could increase rates of participation. There was some resistance to UCLA researchers' requests for access. Local agencies with established recognition and relationships with local individuals such as cooperative extension agencies, local fire departments and councils, and state or national forest agencies could be enlisted to assist in this type of research. Such agencies may act as intermediaries, identify sympathetic land-owners, or at least offer the use of their agency name as references in contact letters and phone conversations.

Based on recommendations by land owners, local environmental impact reports may be used to understand some of the vegetation composition of private lands. Many environmental impact reports contain sections assessing the natural resources of the subject area, including vegetation within the study area, and many environmental impact reports are on file at public agency offices and libraries.

An alternative method of assessment may involve the use of maplets. As stated in Section 5.2, Stoms (1996) used San Diego County's Multi-Species Conservation Program (MSCP) map to validate the GAP database for southwestern San Diego County. Although the resulting map does not provide species-specific data for each polygon, the maplet does provide a small area map with a smaller minimum mapping unit useful for some levels of validation. For example, this approach can detect obvious errors in the assignment of vegetation communities to polygons (e.g., assigning a black oak forest attribute to a manzanita chaparral polygon). The results of Stoms' work does not have direct application to the present study, because Stoms' study covered the southwestern

portion of San Diego County whereas the present study examined eight polygons spread throughout the entire county. Therefore, overlap between the two studies was minimal.

A more dense stratified sampling methodology may ensure the survey of less representative areas. The secondary assemblage species by definition are more uncommon and may be overlooked by a survey with a small number of sample elements. A stratified sampling system can enhance the possibility less common species within assemblages would be surveyed.

There are ways to minimize the amount of time spent in one area. Other studies have shown the use of alternating segments along a transect can reduce the time invested without sacrificing accuracy (Bormann 1953). One paradigm of chaparral ecology stipulates there is little significant stand-to-stand variation over wide areas within chaparral, with major variation occurring mostly over large distances and between chaparral types such as chamise chaparral versus mixed chaparral (Keeley 1986). This homogeneity over a small area allows one to measure along every *n*th meter, reducing the effort invested in the survey without compromising accuracy.

Within forested and woodland areas, understory plants may be ignored. Because overstory plants accounted for 88-92% of the total relative cover and 94-96% of the total crown volume in the forest/woodland polygons of the present study, ignoring understory plants would have little impact. Since understory plants outnumber overstory plants, the time not spent measuring these smaller plants will free larger amounts of time for additional measurements.

6.0 MEASUREMENTS OF ISOPRENE AND ITS ATMOSPHERIC REACTION PRODUCTS METHACROLEIN AND METHYL VINYL KETONE IN AMBIENT AIR

6.1 Introduction and Background

Volatile organic compounds (VOC) of biogenic origin (BHC, biogenic hydrocarbons) were measured in California's South Coast Air Basin (SoCAB) during the Southern California Ozone Study (SCOS97) conducted in the summer 1997. Anthropogenic hydrocarbons are measured on a routine basis in the SoCAB, but few ambient measurements of biogenic hydrocarbons or their atmospheric reaction products have been conducted in the basin. While on a global scale the dominance of BHC over anthropogenic VOC is estimated to be as much as a factor of 10 (WMO, 1995), U.S. emission inventories put the two sources of VOC at comparable strengths (Guenther et al. 1994) and in urban areas such as the SoCAB anthropogenic VOC clearly dominate (Benjamin et al. 1997). Biogenic hydrocarbons are generally highly reactive in the atmosphere (Carter 1994; Atkinson 1997) and thus can play an important role in tropospheric chemistry (Trainer et al. 1987, Chamedies et al. 1988). Because of their rapid atmospheric reactions, however, the ambient concentrations of BHC are generally low and additional measurements of their atmospheric reaction products are necessary to understand the full impact of BHC on photochemical processes such as ambient ozone formation (Montzka et al. 1993, 1995). For this reason, measurements of isoprene, the BHC emitted in greatest quantity by vegetation (Guenther et al. 1995), and its principal reaction products, methacrolein (MACR) and methyl vinyl ketone (MVK), were undertaken during the SCOS97 campaign.

The SCOS97 campaign took place during June 16 – October 15, 1997, with six intensive sampling periods and a total of 13 days of intensive sampling. Sampling for biogenic VOC was generally conducted simultaneously at three sites chosen as a mid-basin receptor site for anthropogenic VOC (Azusa), a down-wind receptor site (Banning) and a high elevation site impacted by biogenic VOC (Pine Mountain or Mount Baldy). Solid adsorbent tubes with mass flow controllers were utilized for VOC sample collection and concentration. After sample collection, the adsorbent tubes were cooled and transported to the laboratory where they were analyzed by gas chromatography with mass selective

detection (GC-MSD) using a GC-MSD equipped with an Entech thermal desorption/ preconcentrator unit.

Results for ambient diurnal profiles of isoprene and its atmospheric reaction products, methacrolein and methyl vinyl ketone, for the twelve SCOS97 intensive sampling days between August 4 and October 4 are given in this report.

6.2 Sampling Sites and Sampling Times

The sampling sites in this study were Azusa, Pine Mountain, Mount Baldy, and Banning. During a single intensive period sampling was also performed at a Los Angeles, North Main Street site. The six intensive sampling periods and sampling sites are presented in Table 6-1.

Table 6-1. Intensive sampling periods and sampling sites.

Sampling Period	Sampling Site
July 14	Azusa, Banning
August 4 - 6	Azusa, Banning, Pine Mtn.
August 22 - 23	Azusa, Banning, LA North Main
September 4 - 6,7	Azusa, Banning, Pine Mtn.
September 28 - 29	Azusa, Mt. Baldy
October 3 - 4	Azusa, Banning, Mt. Baldy

Azusa represents a mid-basin receptor site east of the main source area of downtown Los Angeles, Pine Mtn. is an elevated site (4539 ft) north of Azusa in the San Gabriel Mountains and Mt. Baldy (sampling at 4000 ft) is situated east of Pine Mtn. The Banning site is located approximately 80 miles east of downtown Los Angeles.

The sampling intervals were 3 hours during daytime and 7-9 hours during nighttime. Typically the sampling periods at Azusa, Pine Mtn., and Mt. Baldy were 0300-0600, 0600-0900, 0900-1200, 1300-1600, 1600-2000, 2000-0300. VOCs were measured at Azusa during the four daytime sampling periods by other investigators participating in SCOS97. At Banning the sampling periods were 0300-0600, 0600-0900, 0900-1200, 1200-1500, 1500-1800, 1800-0300, chosen to coincide with the schedule of the Photochemical Assessment Monitoring Station (PAMS) VOC sampling conducted by the

South Coast Air Quality Management District (SCAQMD) at this site. During August 22 - 23 all sites followed the Banning sampling protocol. During September 4 - 7 nighttime sampling was performed more frequently at Azusa and Pine Mtn. with 3 - 4 hour sampling periods (1700-2000, 2000-2400, 0000-0300, 0300-0600).

6.3 Experimental Methods

6.3.1 Sampling

Ambient samples were collected on solid adsorbents housed in borosilicate glass tubes (length 130 mm, outer diameter 6 mm, inner diameter 4 mm). For collection of isoprene, methacrolein and methyl vinyl ketone, the tubes were filled with 250 mg of Carbotrap (20/40 mesh, Supelco, Inc.). Prior to packing, tubes were cleaned by sonicating in methanol and annealed at 480°C. The Carbotrap tubes were conditioned by heating overnight at 350 °C with a constant flow of helium through the tubes. After conditioning and while still warm, the adsorbent tubes were capped with brass nuts, caps (Swagelock) and PTFE ferrules (Alltech Associates, Inc.). The tubes were placed in a cleaned glass jar which was sealed with a metal lid lined with Teflon film. A tube containing activated charcoal (MCB Reagents) was kept in the jar during storage of tubes. Blank samples were treated the same way as samples, excluding actual sampling. Two sampling tubes in series were used, with analyses of the second tube serving to verify that no breakthrough occurred. Jars were stored in a refrigerator at 4 °C before transportation to sampling sites. Tubes were freshly desorbed prior to each intensive sampling period.

To prevent ozone from reacting with labile compounds in the adsorbent during sampling, a scrubber housed in a PTFE compression fitting was placed in front of the first sampling tube (Juttner 1988, Hoffmann 1994, Helmig 1997). The scrubber contained eight copper plyes coated with manganese dioxide (Dasibi Corp.). Each scrubber was tested by pumping ozone (250 ppb) through the scrubber and monitoring the mixing ratio with an ozone monitor (Model 1003-AH, Dasibi Corp.). The scrubbers were tested before and after each intensive sampling period.

At each site the sampling equipment consisted of a diaphragm pump (Model no. 107CAB 050-TFE, Thomas), mass flow controllers (FC-280SAV and FC-280AV, Tylan General) and a mass flow control unit with four channels (RO-28, Tylan General). The tubes

were mounted at a height of 1.8 - 2.0 m (at Azusa the sampling equipment was located on the roof of the SCAQMD station). Each pump, mass flow controller, and control unit was checked for flow rate against a bubble flow meter before and after each intensive sampling period.

Carbotrap samples were collected in duplicate with each sampling tube followed with a back tube. Blank samples transported to the sites were treated the same way as samples, excluding actual sampling. Collected samples were transported to the laboratory as soon as possible for spiking with internal standards, and analysis.

6.3.2 Analysis

Before analyses the samples were spiked with gaseous deuterated internal standard of isoprene-d_8. Known concentrations of isoprene-d_8 were introduced into a Teflon chamber (7900L) from a vacuum rack with an MKS Baratron 1-100 Torr sensor head and a volume-calibrated Pyrex bulb. After ambient sampling each tube was spiked with 100cc of this standard. External calibration samples were prepared by introducing known amounts of isoprene, isoprene-d_8, methacrolein and methyl vinyl ketone into the chamber, sampling known volumes onto adsorbent tubes, and running calibration samples using the identical method as used for the ambient samples. From these calibration samples, response factors for the compounds against the internal standard compound were determined with isoprene-d_8 serving as the internal standard for isoprene, methacrolein and methyl vinyl ketone.

The analyses were performed with a preconcentrator (Entech 7000, Entech Instruments Inc.) connected to a gas chromatograph (Hewlett Packard, 5890) and a mass selective detector (Hewlett Packard, 5971A). The adsorbed compounds were desorbed in a single tube desorber by heating the Carbotrap tube to 325 °C. Concentration prior to injecting the sample into the gas chromatograph was accomplished using a two-step cryofocusing cold trap dehydration method. The analytical column used for separation of compounds was a DB-5 capillary column (length 60 m, diameter 0.32 mm, phase thickness 1 mm, J&W Scientific) and the oven was programmed from 35 °C to 80 °C at the rate of 4 °C/min, then up to 280 °C at 8 °C/min.

The compounds were identified according to their retention times and selected characteristic ions as determined by running pure gaseous standards adsorbed onto sampling

tubes. Compound identifications were previously verified by full mass spectra, operating the mass selective detector in the scanning mode (SCAN). The samples were quantified using the selected ion monitoring (SIM) mode with two or more characteristic ions for each compound and using the areas of the ion chromatograms for quantitation. The ion 68 m/z was used for quantification of isoprene, and 76 m/z for isoprene-d_8. The ion 70 m/z was used for quantification of methacrolein and methyl vinyl ketone.

6.3.3 Intercomparison for Isoprene

On August 1, 1997 isoprene sampling was conducted at the University of California, Riverside, Air Pollution Research Center (APRC) between 1430-1815 to allow an intercomparison between the APRC adsorbent tube sampling and canister sampling. Carbotrap tubes were used to collect 5 simultaneous samples for analysis and quantification of isoprene at APRC, as detailed above. Two canister samples (using pre-cleaned canisters supplied by Desert Research Institute and Biospheric Research Corporation) were co-located with the APRC adsorbent samplers. The canisters were mailed to Desert Research Institute and Biospheric Research Corporation for analysis. The results of the adsorbent tube sampling are provided below.

6.4 Results

Tables 6-2 through 6-5 give the average mixing ratios of isoprene, methacrolein, and methyl vinyl ketone for the five intensive SCOS97 sampling periods between August and October, 1997. The replicate sample values are given in Appendix D. The isoprene, methacrolein and methyl vinyl ketone values are reported in ppbv, calculated for 760 Torr and 0°C. Following these tables are figures of the isoprene time-concentration profiles for the three (or in one instance two) sampling sites monitored during each intensive sampling period. Azusa was a sampling site during every sampling period and the isoprene values at Azusa are given in the top graph, plotted with a 0.8 ppbv ordinate scale for each intensive (Figures 6-1 through 6-5). Pine Mtn. was monitored along with Azusa during Intensives 2 and 4 (Figures 6-1 and 6-3), while Mt. Baldy was monitored during Intensives 5 and 6 (Figures 6-4 and 6-5). Reflecting the higher ambient isoprene concentrations at these elevated sites, an ordinate scale value of 2.5 ppbv has been utilized for graphing isoprene at these

mountain sites. Isoprene was monitored at the down-wind Banning site during Intensives 2, 3, 4, and 6 and is shown as the lower graph with a 0.3 ppbv ordinate scale. During Intensive 3, LA North Main was a monitoring site in addition to Azusa and Banning (Figure 6-2).

6.4.1 Precision of Sampling and Analysis

Table 6-6 gives the results for the five replicate isoprene samples taken during the August 1 Intercomparison Sampling. A 6.3% relative standard deviation in the measured isoprene concentration was obtained for these samples.

6.5 Discussion

The highest isoprene mixing ratios were found in samples from the two mountain sites, Pine Mtn. and Mt. Baldy. Both were late afternoon/early evening samples with sampling times of 1700-2000. The highest value observed at Pine Mtn. was 2.2 ppbv on August 4, and the maximum isoprene value for Mt. Baldy was 2.3 ppbv observed on September 28. At Azusa the highest mixing ratios for isoprene were in the range 0.5 – 0.8 ppbv during all sampling intensives, except the final one on October 3-4, when the highest values were only about 0.2 ppbv. Thus, the highest values at the mountain sites were three to four times higher than the maximum mixing ratios observed at the urban valley site. The maximum isoprene values at the Banning site in the eastern portion of the air basin were 0.2 – 0.3 ppbv, consistently lower than at the other sites.

Consistent with light-dependent biogenic sources, the lowest values for isoprene were usually measured during nighttime. The diurnal variation of isoprene at the different sites generally followed a similar pattern: higher mixing ratios during the daylight hours, lower during nighttime. However, as may be seen in Figures 6-1, 6-3, 6-4 and 6-5, the difference between day and night was most apparent at the mountain sites, where the daytime values ranged between 0.4 – 2.3 ppbv and the nighttime values did not exceed 0.1 ppbv. At Azusa and Banning the day-night variation was much less pronounced and sampling at the Los Angeles North Main site gave low isoprene concentrations with little decrease during the single night sampled (see Figure 6-2).

For methacrolein and methyl vinyl ketone the highest mixing ratios were observed at Azusa. On August 22–23 for the 1800–0300 sampling interval the methacrolein mixing

ratio was 3.3 ppbv, and on September 28 between 0300–0600 the methyl vinyl ketone mixing ratio was 2.3 ppbv. At Banning on August 22–23 at 1800–0300 mixing ratios for both MACR and MVK were high, being 2.4 ppbv and 2.9 ppbv, respectively. At Pine Mtn. and Mt. Baldy the highest values for MACR were measured in the afternoon/early evening reaching 1.1 ppbv and 0.5 ppbv, respectively, and the highest values for MVK were 1.6 ppbv and 1.0 ppbv, respectively.

At the mountain sites during the daytime, the isoprene values generally exceeded the MACR and MVK concentrations, while during the nighttime the isoprene values were <0.1 ppbv and the combined MACR and MVK levels reached 1.7 ppbv. The isoprene, MACR and MVK concentrations at Pine Mtn. for the Sept. 4-7 intensive are shown in Figure 6-6. Note that the isoprene begins to increase early in the morning (0600-0900) with increases in MACR and MVK lagging behind temporally. The highest MACR and MVK levels observed at the mountain sites occurred at Pine Mtn. during Intensives 2 and 4 (see Intensive 4 in Figure 6-6) when the MVK + MACR reached 2.5 ppbv. The ratio of MVK/MACR during the daytime was relatively constant at the mountain sites, with average values for this ratio ranging from 1.6 to 2.2. A ratio of 1.5 for MVK/MACR would be expected from the OH radical-initiated reaction of isoprene if negligible further reaction of MVK and MACR occurred, while at steady-state this ratio would be expected to increase to 2.4 (Atkinson, 1997). Thus the daytime MVK/MACR ratio at the mountain sites is consistent with the source of MACR and MVK being photooxidation of isoprene (Montzka et al. 1993, 1995).

In contrast to the mountain sites, at Azusa, Banning, and LA North Main the MACR and MVK levels generally exceeded those of isoprene. The isoprene, MACR and MVK values for the Sept. 4-7 intensive are shown in Figures 6-7 and 6-8 for measurements taken at Azusa and Banning, respectively. The ratios of MVK/MACR were generally similar at Azusa during Intensives 2 and 4, but unusual ratios occurred during Intensives 3, 5 and 6. For example, high MVK values at Azusa producing high MVK/MACR ratios were observed on Sept. 28 and Oct. 4 both for the 0300-0600 sampling period. These data suggest that a source other than the photooxidation of isoprene may exist for some of the MVK observed at Azusa, at least during certain

sampling periods. Further interpretation of these data may be possible when the anthropogenic VOC data for Azusa and Banning become available.

6.6 Conclusions and Implications

Isoprene concentrations were highest at the two mountain sites, Pine Mtn. and Mt. Baldy, and showed very pronounced diurnal profiles consistent with light-dependent biogenic emission sources. The maximum isoprene concentrations observed at these sites were 2.2 and 2.3 ppbv. At the mountain sites during the daytime, the isoprene values generally exceeded the MACR and MVK concentrations and the MVK/MACR ratios were consistent with their source being photooxidation of isoprene.

In contrast to the mountain sites, at Azusa, Banning, and LA North Main the MACR and MVK levels generally exceeded those of isoprene, reaching combined MACR + MVK values of 4.9, 5.3 and 2.2 ppbv, respectively. The isoprene concentrations were generally highest during the daytime at these sites, but did not decrease at night as much as at the mountain sites. Occasional, unusual MACR/MVK ratios at Azusa and Banning suggest potential anthropogenic sources for these compounds, and the anthropogenic VOC data from these sites should facilitate further interpretation of the data for isoprene and its atmospheric reaction products.

Table 6-2. Average mixing ratios for isoprene, methacrolein, and methyl vinyl ketone at Azusa.

AZUSA	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Aug 4-6, 1997	8/4/97	0600-0900	0.23	0.09	0.46
	8/4/97	0907-1206	0.52	0.47	0.77
	8/4/97	1306-1603	0.46	0.51	0.92
	8/4/97	1700-2000	0.75	0.71	1.06
	8/4/97	2006-0300	0.16	0.34	0.59
	8/5/97	0307-0600	0.24	1.01	0.58
	8/5/97	0618-0900	0.47	0.82	1.73
	8/5/97	0907-1202	0.66	0.74	1.61
	8/5/97	1300-1600	0.61	0.70	1.49
	8/5/97	1701-2000	0.73	0.46	0.72
	8/5- 8/6/97	2005-0300	0.44	0.41	1.20
	8/6/97	0306-0600	0.23	0.62	0.90
	8/6/97	0616-0900	0.37	0.60	1.24
	8/6/97	0906-1200	0.51	0.35	0.75
	8/6/97	1300-1600	0.51	0.44	0.81
	8/6/97	1700-2000	0.40	0.15	0.23
Aug 22-23, 1997	8/22/97	0318-0600*	0.24	0.29	0.53
	8/22/97	0610-0900*	0.21	0.45	0.77
	8/22/97	0905-1157	0.41	0.33	0.69
	8/22/97	1210-1500*	0.52	0.44	0.78
	8/22/97	1504-1800	0.45	0.69	1.07
	8/22-23/97	1815-0300	0.30	3.34	1.52
	8/23/97	0304-0600	0.25	0.55	0.98
	8/23/97	0615-0900*	0.26	0.70	0.94
	8/23/97	0903-1200	0.51	0.53	0.74
	8/23/97	1208-1500	0.31	0.49	0.82
	8/23/97	1505-1800*	0.37	0.46	0.70
Sep 4-7, 1997	9/4/97	0300-0600	0.28	0.89	1.29
	9/4/97	0606-0900	0.22	0.55	0.56
	9/4/97	0904-1200	0.57	0.46	1.54
	9/4/97	1300-1600	0.35	0.62	1.00
	9/4/97	1700-2000	0.61	0.40	0.50
	9/4/97	2014-2400	0.13	0.26	0.25
	9/5/97	0006-0300	0.06	0.17	0.26
	9/5/97	0305-0600	0.06	0.16	0.25
	9/5/97	0615-0900*	0.17	0.48	0.38
	9/5/97	0903-1200	0.43	0.57*	0.98*
	9/5/97	1300-1600	0.31	0.39	1.01
	9/5/97	1700-2000	0.37	0.32	0.41
	9/5/97	2006-2400	0.18	0.58	0.57
	9/6/97	0008-0300	0.11	0.22	0.28
	9/6/97	0306-0600	0.09	0.30	0.36

Table 6-2. (Continued)

AZUSA	Sample Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
	9/6/97	0615-0900	0.15	0.33	0.27
	9/6/97	0903-1200	0.35	0.50	0.65
	9/6/97	1300-1600	0.29	0.44	0.88
	9/6/97	1700-1959	0.29	0.32	0.50
	9/6/97	2010-2400	0.08	0.16	0.18
	9/7/97	0005-0300	0.11	0.21	0.23
	9/7/97	0306-0600	0.11	0.30	0.52
	9/7/97	0604-0900	0.13	0.35	0.31
Sep 28-29, 1997	9/28/97	0301-0600	0.15	0.28	2.31
	9/28/97	0609-0900	0.23	0.31	0.53
	9/28/97	0904-1200	0.50	0.37	0.83
	9/28/97	1300-1600	0.42	0.41	0.68
	9/28/97	1700-2000*	0.34	0.25	0.31
	9/28-29/97	2015-0300	0.07	0.19	0.23
	9/29/97	0310-0600	0.13	0.36	0.29
	9/29/97	0616-0858	0.30	0.44	0.65
	9/29/97	0900-1200	0.37	0.30	0.46
	9/29/97	1300-1600	0.38	0.61	0.74
	9/29/97	1700-2000	0.44	0.22	0.40
Oct 3-4, 1997	10/3/97	0301-0600	0.06	0.13	0.26
	10/3/97	0614-0900	0.06	0.07	0.12
	10/3/97	0904-1200	0.12	0.10	0.22
	10/3/97	1300-1600	0.21	0.19	0.38
	10/3/97	1700-2000	0.15	0.15	0.44
	10/3-4/97	2011-0300	0.06	0.19	0.50
	10/4/97	0304-0600	0.12	0.18	0.99
	10/5/97	0612-0900	0.07	0.08	0.26
	10/4/97	0901-1200	0.16	0.16	0.36
	10/4/97	1300-1600*	0.24	0.29	0.64
	10/4/97	1700-2000	0.14	0.11	0.22

*Single sample value reported. See Appendix for details.

Table 6-3. Average mixing ratios for isoprene, methacrolein, and methyl vinyl ketone at Pine Mtn. and Mt. Baldy.

PINE MTN.	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Aug 4-6, 1997	8/4/97	1710-2000	2.21	0.91	1.58
	08/4-08/5/97	2025-0259	0.03	0.58	1.11
	8/5/97	0314-0559	0.04	0.14	0.25
	8/5/97	0617-0858	1.96	0.09	0.16
	8/5/97	0911-1200	1.00	0.33	0.83
	8/5/97	1302-1600*	0.59	0.46	0.71
	8/5/97	1700-2000	1.09	0.44	0.72
	8/5/97	2015-0255	0.08	0.08	0.19
	8/6/97	0310-0600	0.03	0.03	0.07
	8/6/97	0615-0900	0.80	0.07	0.14
	8/6/97	0915-1200	0.41	0.19	0.36
	8/6/97	1300-1600	0.62	0.59	1.03
Sep 4-7, 1997	9/4/97	1702-2000	0.41	0.52	0.72
	9/4/97	2008-2400	0.03	0.33	0.54
	9/5/97	0010-0338	0.02	0.10	0.16
	9/5/97	0349-0600	0.02	0.09	0.18
	9/5/97	0615-0900	0.63	0.10	0.20
	9/5/97	0908-1200	0.93	0.21	0.38
	9/5/97	1300-1600	1.71	1.07	1.38
	9/5/97	1700-2000	0.59	0.30	0.49
	9/5/97	2007-2355	0.03	0.26	0.39
	9/6/97	0000-0255	0.02	0.10	0.17
	9/6/97	0301-0600	0.03	0.10	0.14
	9/6/97	0610-0900	0.48	0.08	0.16
	9/6/97	0905-1200	0.60	0.17	0.17
	9/6/97	1300-1600	1.58	0.25	0.35
	9/6/97	1700-2000	0.55	0.33	0.54
	9/6/97	2007-2355	0.05	0.18	0.26
	9/7/97	0000-0255	0.03	0.16	0.24
	9/7/97	0300-0555	0.05	0.10	0.15
	9/7/97	0600-0900	1.88	0.10	0.21
Sep 28-29, 1997	9/28/97	0904-1200	1.90	0.23	0.40
	9/28/97	1300-1600	1.17	0.37	0.93
	9/28/97	1700-2000	2.27	0.40	0.85
	9/28-29/97	2005-0300	0.08	0.24	0.47
	9/29/97	0307-0600	0.06	0.06	0.17
	9/29/97	0606-0900	0.65	0.06	0.15
	9/29/97	0903-1200	1.84	0.27	0.63
	9/29/97	1300-1600	1.07	0.29	0.61
	9/29/97	1700-2000	1.92	0.39	0.79

Table 6-3. (Continued)

MT. BALDY	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Oct 3-4, 1997	10/3/97	0619-0900	0.42	0.02	0.12
	10/3/97	0903-1200	1.38	0.13	0.28
	10/3/97	1301-1600	1.23	0.48	1.01
	10/3/97	1703-2003*	1.29	0.37	0.72
	10/3-4/97	2010-0302	0.05	0.13	0.26
	10/4/97	0310-0601	0.04	0.06	0.11
	10/4/97	0612-0900	0.26	0.04	0.10
	10/4/97	0903-1200	1.53	0.12	0.25
	10/4/97	1300-1600	0.88	0.32	0.75
	10/4/97	1700-2000	1.29	0.36	0.66

*Single sample value reported. See Appendix for details.

Table 6-4. Average mixing ratios for isoprene, methacrolein, and methyl vinyl ketone at Banning.

BANNING	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Aug 4-6, 1997	8/4/97	0600-0855	0.25	0.14	0.33
	8/4/97	0902-1157	0.06	0.09	0.19
	8/4/97	-	-	-	-
	8/4/97	1504-1800	0.21	0.12	0.28
	8/4-5/1997	1807-0255	0.08	0.35	0.68
	8/5/97	0303-0550	0.02	0.16	0.26
	8/5/97	0604-0855	0.33	0.20	0.31
	8/5/97	0901-1153	0.08	0.07	0.15
	8/5/97	1159-1452	0.10	0.04	0.11
	8/5/97	1458-1800	0.13	0.07	0.13
	8/5- 8/6/97	1816-0255	0.07	0.22	0.39
	8/6/97	0301-0550	0.01	0.04	0.10
	8/6/97	0605-0855	0.02	0.02	0.04
	8/6/97	0901-1150	0.02	0.02	0.05
	8/6/97	1155-1455	0.03	0.02	0.06
	8/6/97	1500-1800	0.18	0.05	0.16
Aug 22-23, 1997	8/22/97	0600-0855	0.12	0.07	0.36
	8/22/97	0900-1155	0.27	0.10	0.26
	8/22/97	1200-1455	0.20	0.09	0.23
	8/22/97	1500-1800	0.28	0.14	0.32
	8/22-23/97	1813-0300	0.08	2.37	2.93
	8/23/97	0303-0555	0.01	0.16	0.42
	8/23/97	0603-0900	0.14	0.12	0.27
	8/23/97	0903-1200	0.22	0.07	0.18
	8/23/97	1202-1500	0.20	0.05	0.12
	8/23/97	1502-1800	0.22	0.07	0.25

Table 6-4. (Continued)

BANNING	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Sep 5-6, 1997	9/5/97	0600-0855	0.12	0.21	0.39
	9/5/97	0900-1155	0.19	0.09	0.21
	9/5/97	1158-1458	0.17	0.03	0.11
	9/5/97	1501-1800	0.17	0.18	0.59
	9/5-6/97	1824-0257	0.05	0.45	0.53
	9/6/97	0308-0550*	0.01	0.29	0.29
	9/6/97	0610-0855*	0.10	0.33	0.44
	9/6/97	0900-1158	0.03	0.05	0.14
	9/6/97	1202-1458	0.12	0.04	0.11
	9/6/97	1502-1800*	0.21	0.06	0.18
Oct 3-4, 1997	10/3/97	0600-0858	0.05	0.08	0.25
	10/3/97	0900-1158	0.06	0.07	0.14
	10/3/97	1200-1458	0.03	0.03	0.08
	10/3/97	1500-1800	0.19	0.15	0.36
	10/3-4/97	1807-0258	0.04	0.14	0.18
	10/4/97	0300-0553	0.04	0.18	0.32
	10/4/97	0601-0858	0.10	0.16	0.29
	10/4/97	0900-1158	0.14	0.10	0.30
	10/4/97	1200-1458	0.12	0.10	0.28
	10/4/97	1500-1800	0.11	0.16	0.46

*Single sample value reported. See Appendix for details.

Table 6-5. Average mixing ratios for isoprene, methacrolein, and methyl vinyl ketone at Los Angeles, North Main Street.

LOS ANGELES N. MAIN ST.	Date	Sampling	Isoprene ppbv	MACR ppbv	MVK ppbv
Aug 22-23, 1997	8/22/97	0558-0855	0.37	0.77	0.50
	8/22/97	0900-1155	0.11	1.26	0.98
	8/22/97	1202-1457	0.21	0.49	0.67
	8/22/97	1500-1755	0.17	0.27	0.47
	8/22-23/97	1806-0556	0.23	0.28	0.41
	8/23/97	0605-0857	0.21	0.44	0.44
	8/23/97	0900-1156	0.12	0.33	0.73
	8/23/97	1202-1458	0.15	0.39	0.82
	8/23/97	1500-1800	0.21	0.27	0.50

Table 6-6. Isoprene intercomparison sample results.

Sample no.	mg/m^3		ppbv
1	15.77		5.19
2	14.83		4.88
3	16.70		5.49
4	16.57		5.45
5	17.54		5.77
Average	16.3		5.4
Standard dev. (1s)	1.0		0.3
Relative st. dev. (%)	6.3	6.3	

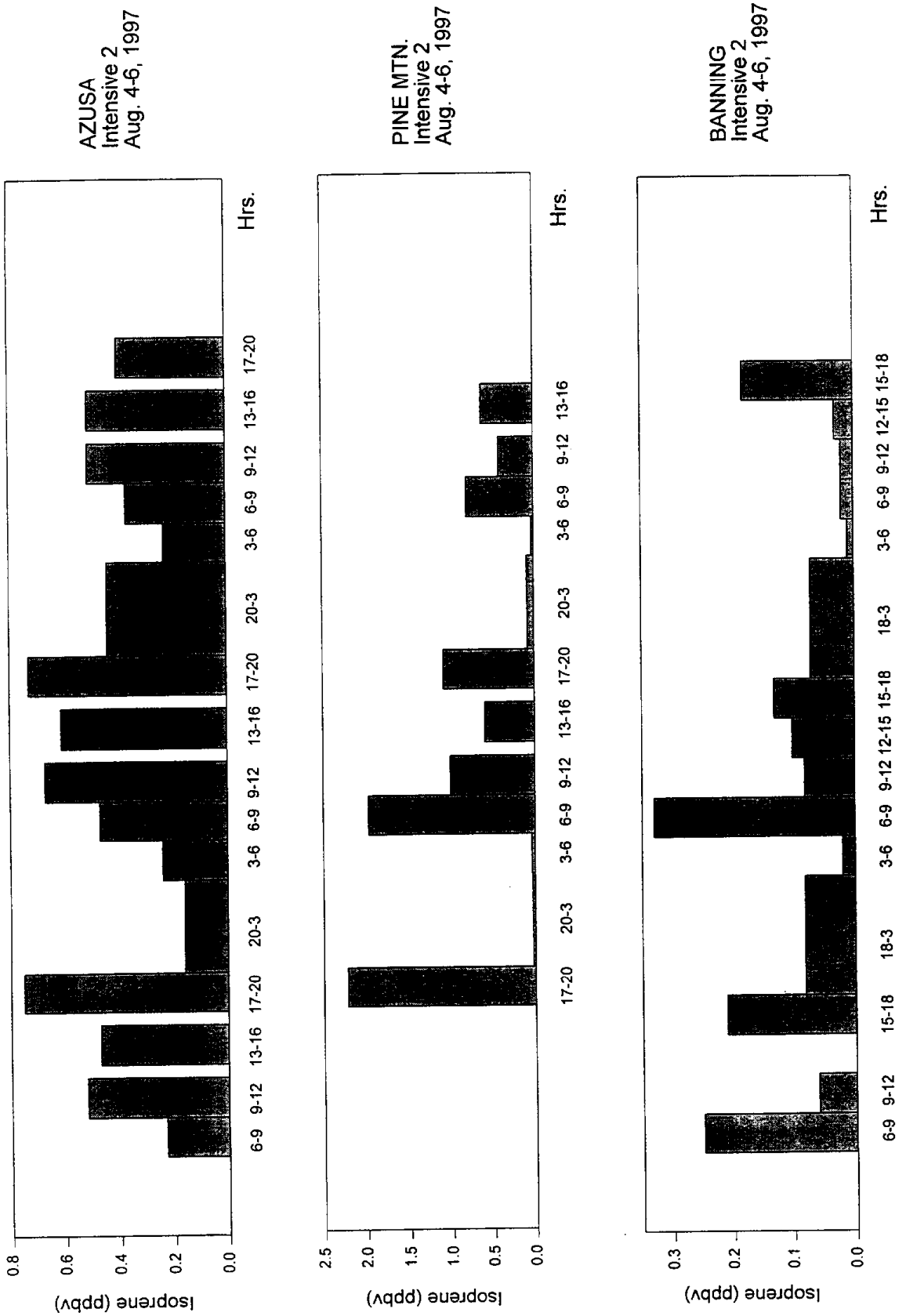

Figure 6-1. Isoprene values during Intensive 2, Aug. 4-6, 1997

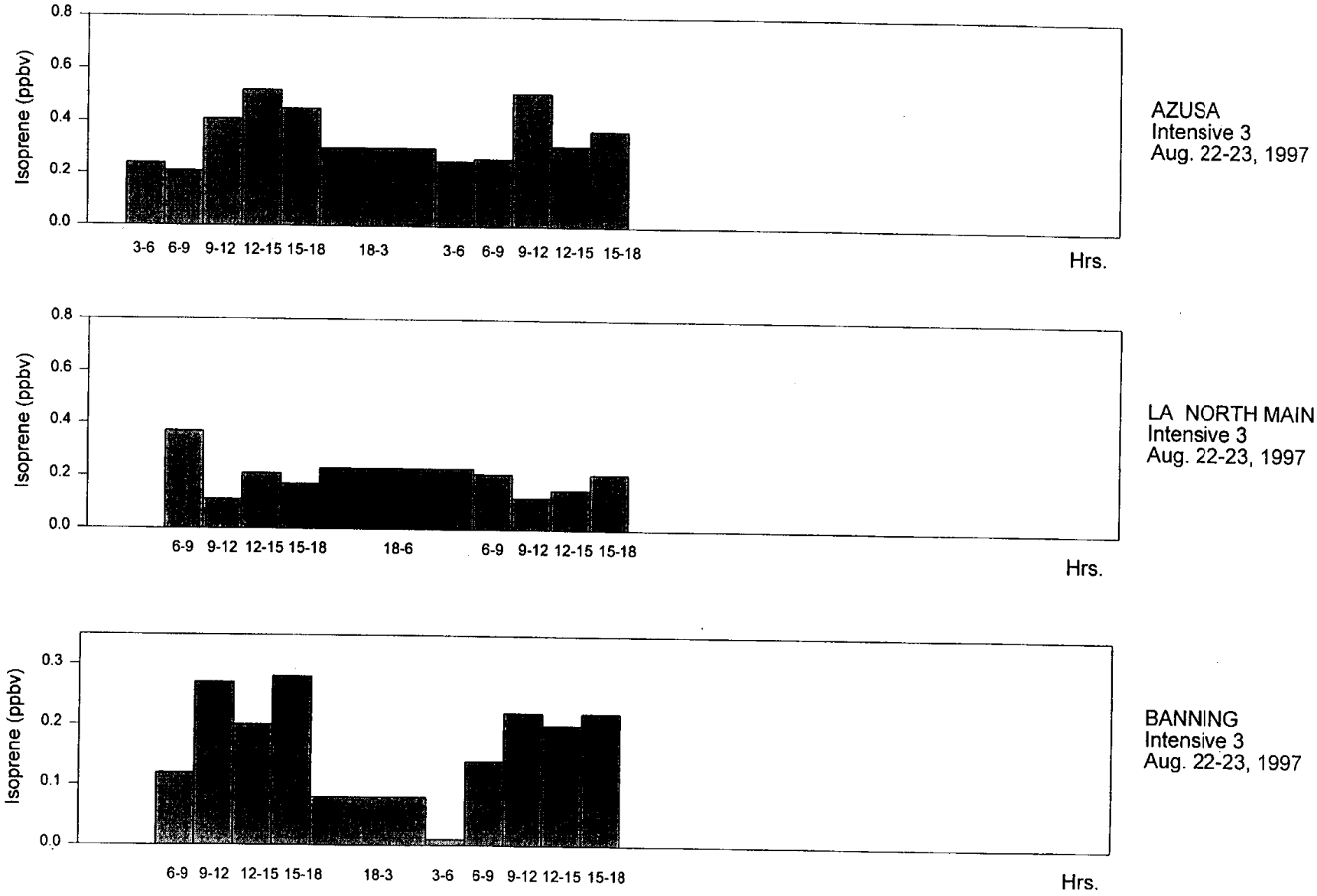

Figure 6-2. Isoprene values during Intensive 3, Aug. 22-23, 1997

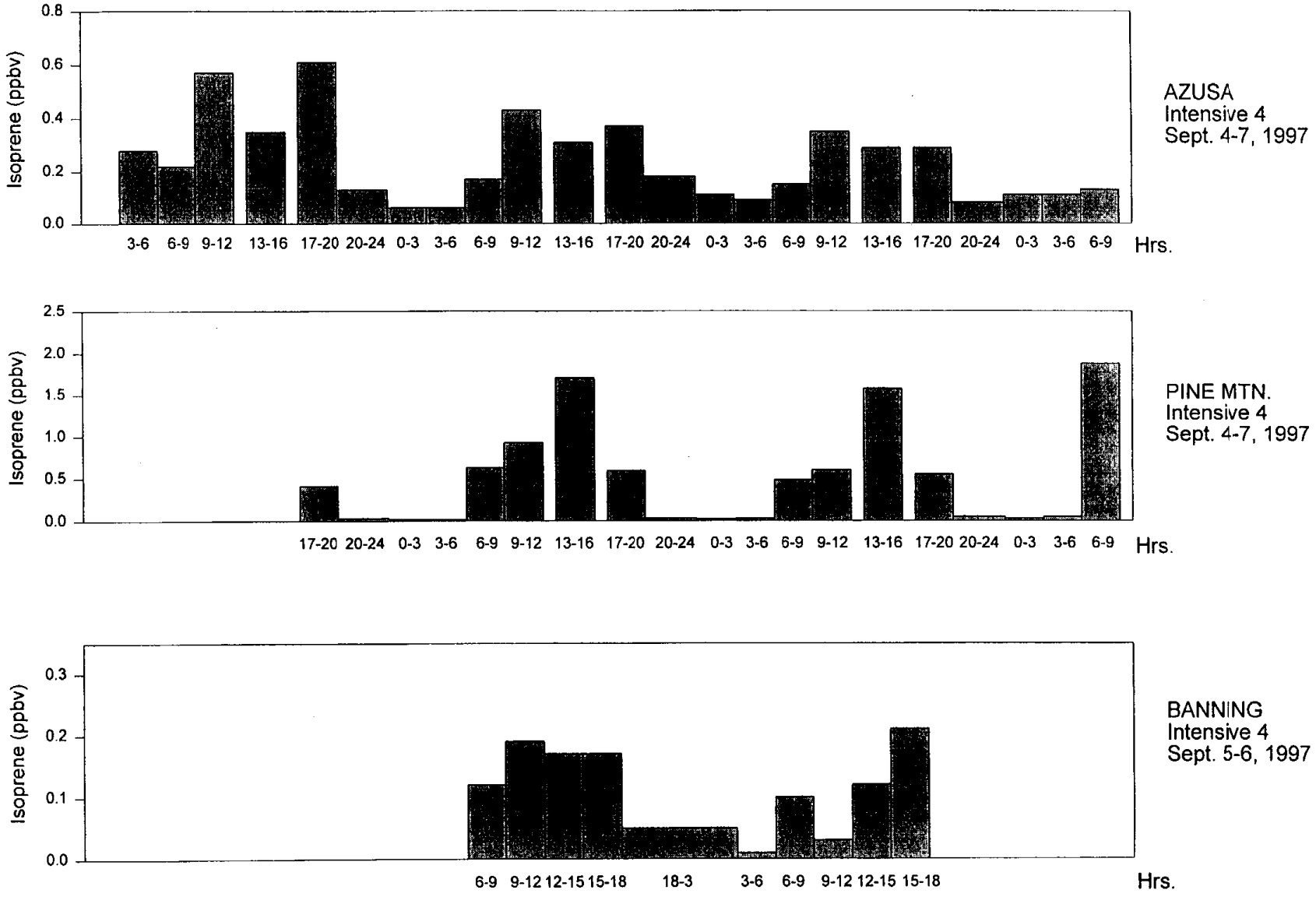

Figure 6-3. Isoprene values during Intensive 4, Sept. 4-7, 1997

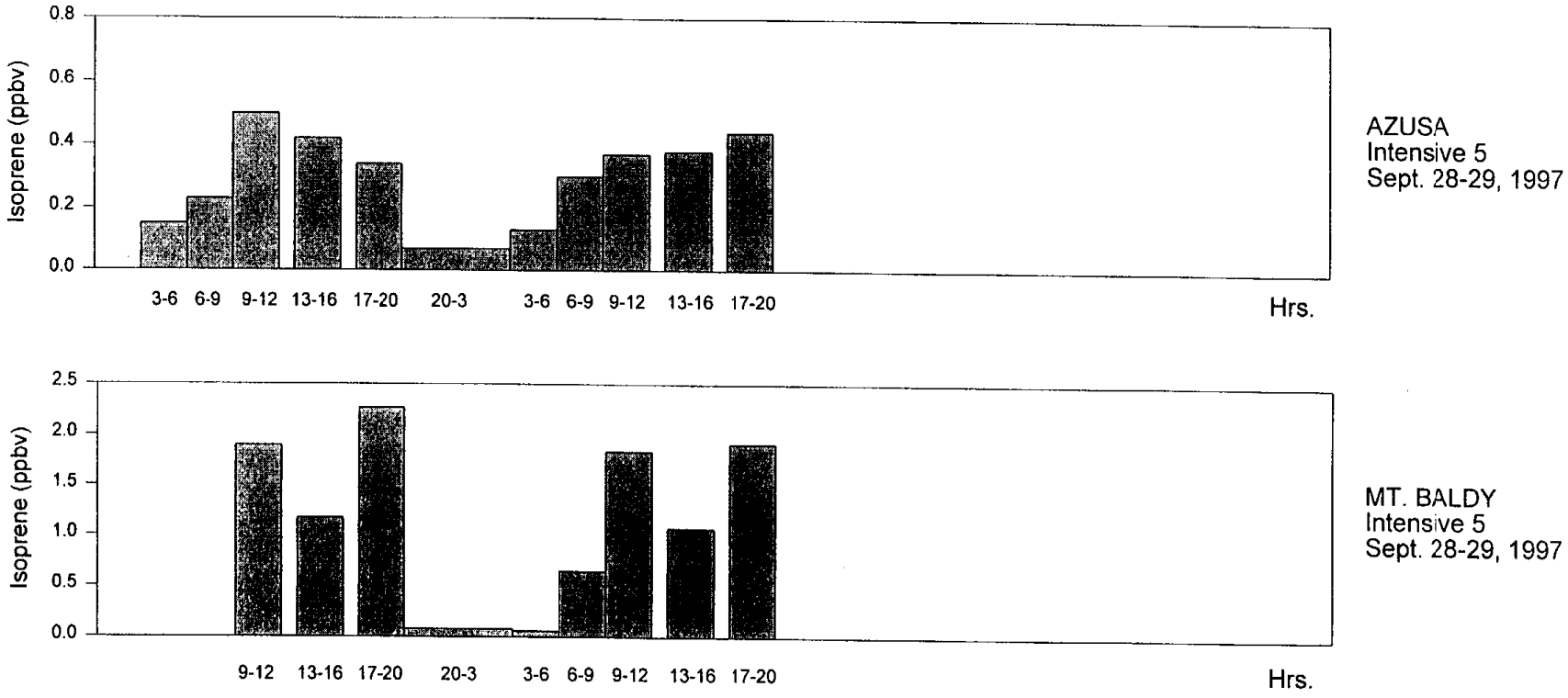

Figure 6-4. Isoprene values during Intensive 5, Sept. 28-29, 1997

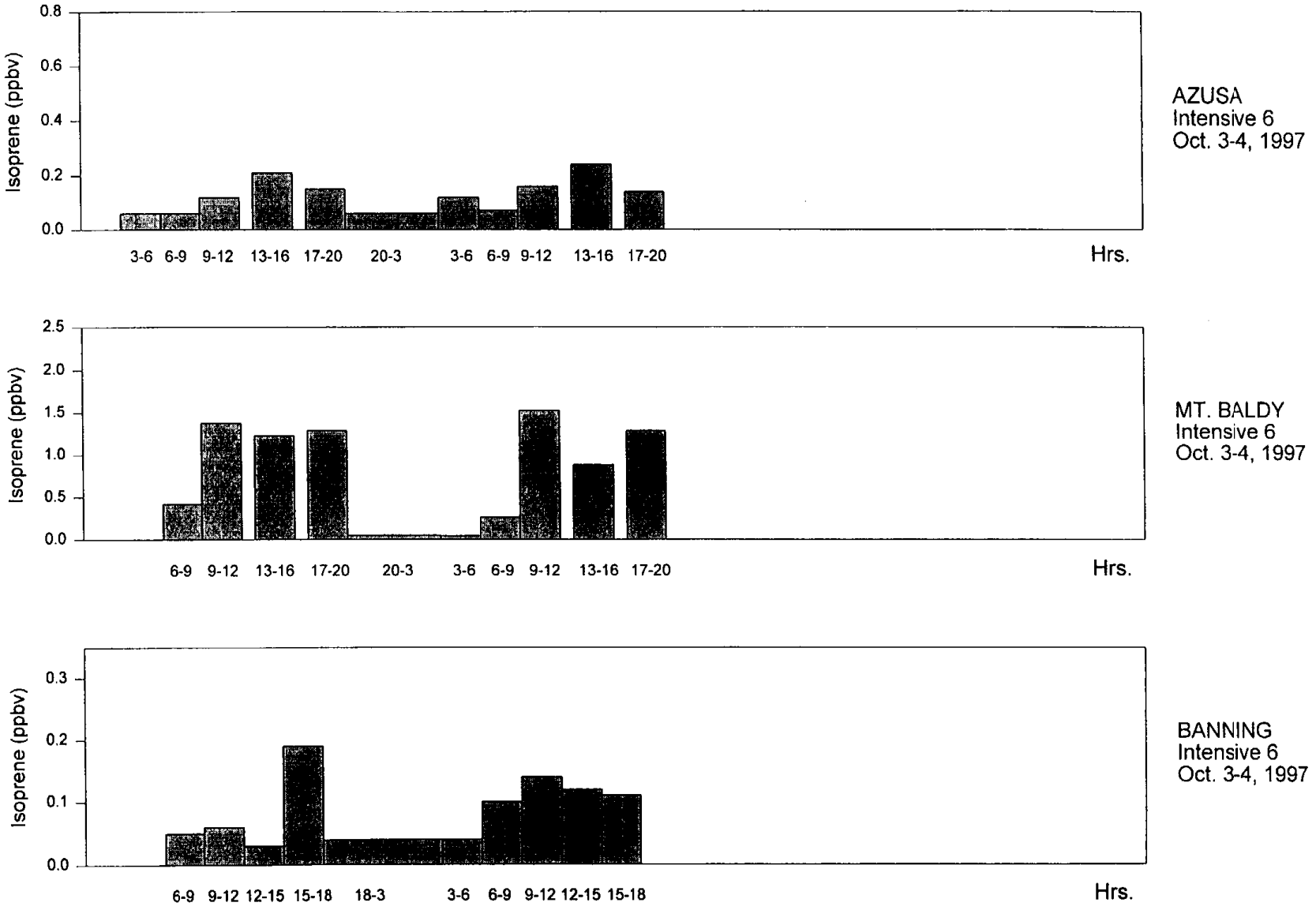

Figure 6-5. Isoprene values during Intensive 6, Oct. 3-4, 1997

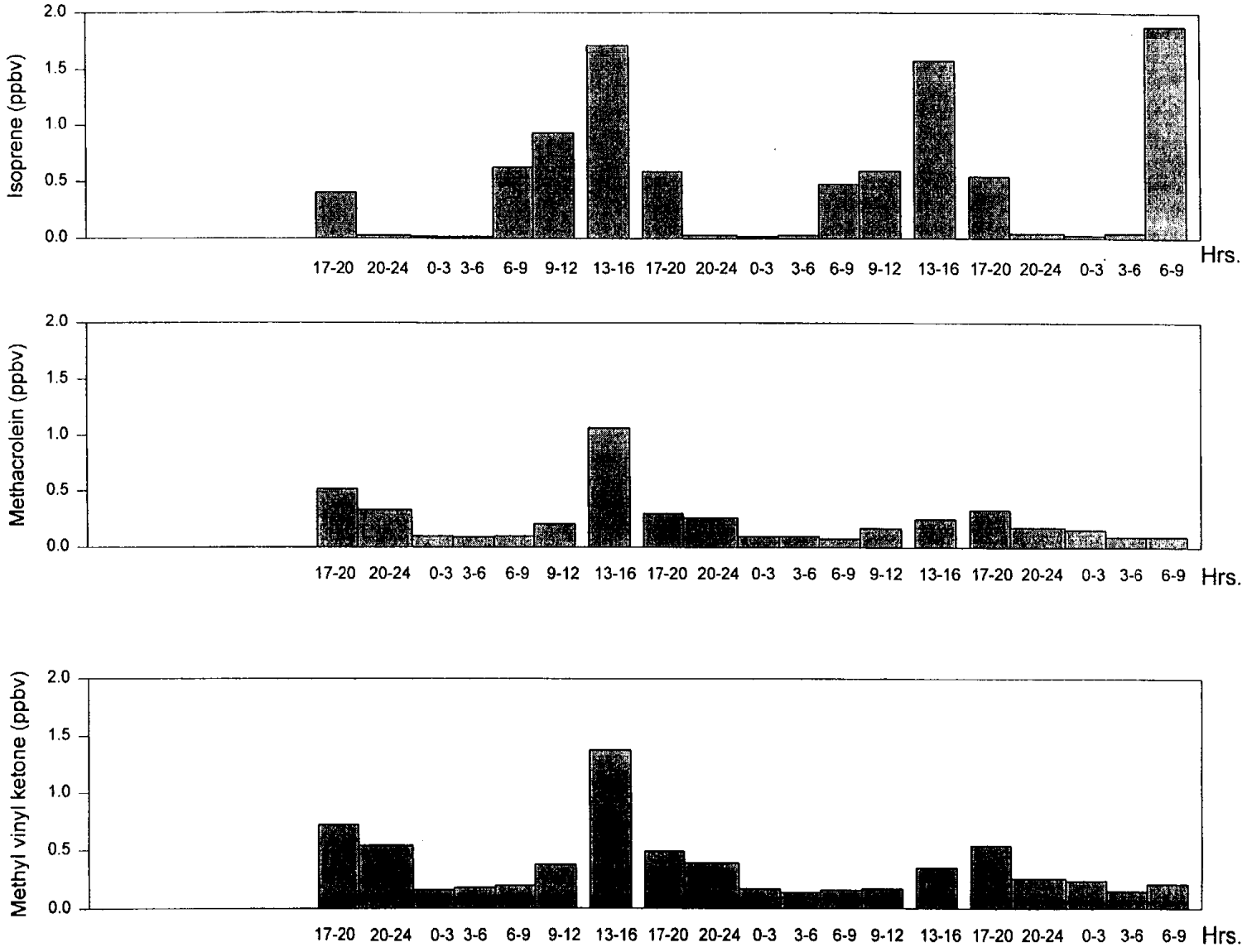

Figure 6-6. Isoprene, methacrolein and methyl vinyl ketone values at Pine Mtn. during Intensive 4, Sept. 4-7, 1997

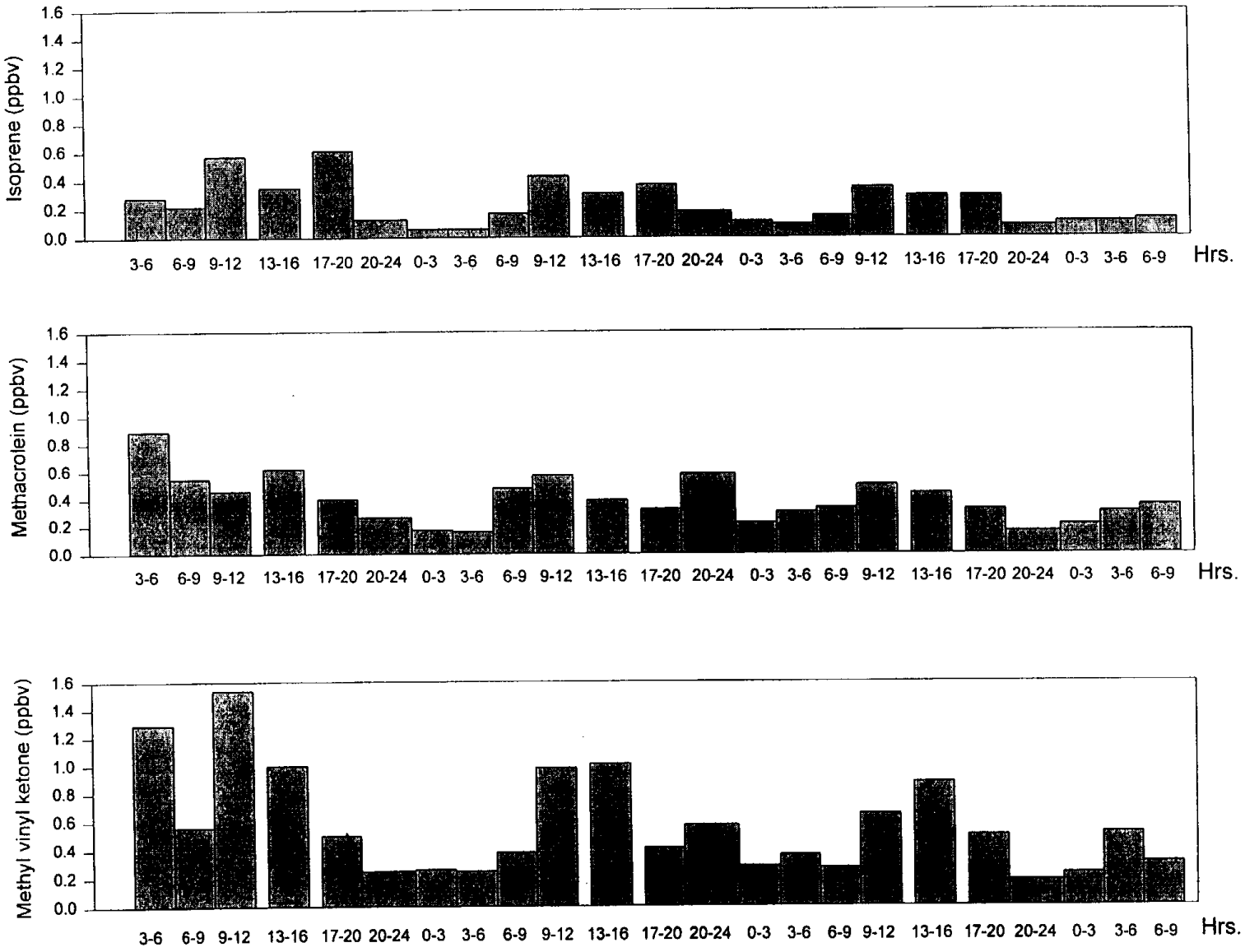

Figure 6-7. Isoprene, methacrolein and methyl vinyl ketone values at Azusa during Intensive 4, Sept. 4-7, 1997

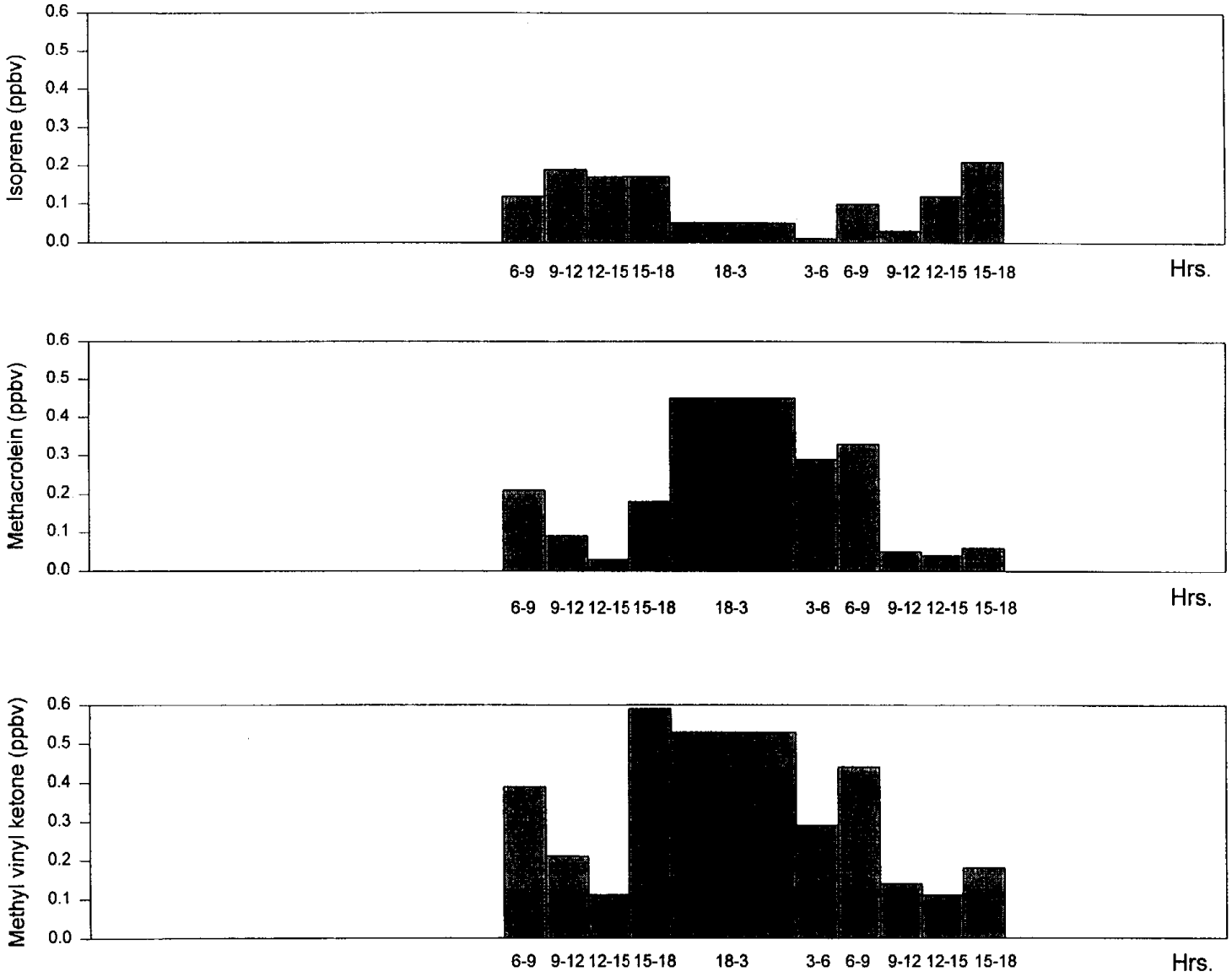

Figure 6-8. Isoprene, methacrolein and methyl vinyl ketone values at Banning during Intensive 4, Sept. 4-7, 1997

7.0 SUMMARY AND CONCLUSIONS

7.1 Isoprene Emission Rate Measurements: Taxonomic Method

Data from the present study for more than 60 plant species represent a significant expansion of the published isoprene emission rate database, and will be useful for building BHC emissions inventories in California, as well as other regions where these plants are found. Based on the present measurements, the taxonomic method proposed by Benjamin et al. (1996) is seen to work well for isoprene in most cases investigated, particularly at the genus level. However, there are important exceptions and the most troublesome genus for taxonomic predictions at this time (from both the present study and published literature) is *Quercus* (oaks). Further characterization of this genus is recommended. Oaks are important for BHC emission inventories in California because of their wide distribution in both urban and natural settings, and their high leafmass. In this study we have reported isoprene emission rates for four additional native oak species.

Given the enormous number of plant species in California and worldwide, a reference framework for understanding and categorizing emissions rates, and for assigning rates to unmeasured species, will be necessary. Within an order of magnitude uncertainty for families (Benjamin et al. 1996) and for many genera within factors of two to five, or even $\pm$50% as shown in the present study (see below), plant taxonomy appears to be a reasonable framework for organizing isoprene emission rate information, and taxonomy seems to be increasingly useful when descending to the lower levels of hierarchical classification (i.e. to subfamilies and genera). As Benjamin et al. (1996) emphasized, the taxonomic relationship they proposed to meet this need is possible because there is a range of almost four orders of magnitude in emission rates of isoprene from the lowest to the highest emitting plant species. With the important exceptions noted, the data developed in the present study support the taxonomic predictive methodology for isoprene, especially if previous measurements within specific families, sub-families, genera and species are considered and compared (see below), and the results of such assignment treated with proper caveats.

7.1.1 Emission Rates: Family and Genus-Level Results

All plant species sampled within 19 of the families investigated in this study had isoprene emissions below detection limit. These results are consistent with the literature cited in Benjamin et al. (1996) for ten families, including Anacardiaceae (cashew), Betulaceae (birch), Bignoniaceae (bignonia), Caprifoliaceae (honeysuckle), Compositae (composite), Cupressaceae (cypress), Juglandaceae (walnut), Lamiaceae (mint), Oleaceae (olive), Rosaceae (rose) and Taxodiaceae (bald cypress), all of which may be regarded as containing mostly, if not all, negligible-emitters. These results are important because the Rosaceae and Compositae in particular are very large families, well-represented in agriculture, native plant communities and urban landscapes.

Certain families appear to contain predominately negligible emitters, but with several moderate or high emitters, while other families seem to be dominated by plants emitting isoprene at moderate-to-high rates, such as the Palmae family (palms), or high emissions rates, such as the Salicaceae family (willows and poplars.)

For 13 of 19 "predictions" found in Benjamin et al. (1996) isoprene emission rates measured in the present study were within ±50% of the predicted rate. Nine of the nine species expected to have zero isoprene emissions were measured as BDL. By considering subfamily taxonomy of the Leguminosae, the predictive accuracy (±50%) rises to 15 of 19 species. If oaks are not considered, since *Quercus* is so variable, the proportion rises to 14 of 16. Thus the taxonomic approach is seen to work particularly well at the genus level, with a few important exceptions.

7.1.2 Species Selection for Large-Scale Planting Programs

Among the oaks, preference for planting species with low isoprene emissions rates and low OFP may offer horticultural benefits in addition to reduction of BHC emissions. For example, many of the eastern North American deciduous oak species, such as *Q. borealis* (northern red oak), *Q. coccinea* (scarlet oak), *Q. palustris* (pin oak) and *Q. rubra* (red oak) display chlorotic foliage and lack vigor, typical symptoms of iron deficiency. However, other oak species, such as *Q. suber* (cork oak), have negligible isoprene emission rates and possess desirable horticultural characteristics, including

tolerance to alkaline soils. Therefore, the latter are better choices for many California landscapes than are oak species native to the eastern United States.

In any large-scale tree planting program, it is important to include the ozone-forming potential of specific plant species (Benjamin and Winer 1998) along with other criteria for plant species selection, such as adaptability, pest resistance, irrigation requirement, aesthetic qualities and other horticultural and landscape factors.

7.2 Leafmass and Leaf Area Relationships Determined from Sampling and Whole-Tree Harvest: Implications for Leafmass Estimation Methods

Results from this study suggest leafmass estimates developed for individual trees through a volumetric approach may generally be within approximately 50% of actual values. Summation of leafmass estimates generated using the preferred solid, vertical ellipsoid and sphere solid for all 21 trees in this study gave values within 20% of the measured total leafmass. Although use of the sphere solid resulted in a total leafmass value within 10% of the measured total leafmass, data for individual trees using a sphere solid were more scattered than those for the vertical ellipsoid, which was judged to be the best solid overall for modeling tree crowns in this study.

A volumetric approach may not precisely account for clumping of tree foliage and the change in leafmass density as tree crowns expand and mature, especially for larger species. Despite these limitations, a volumetric approach to estimating leafmass may have particular utility in California because of the enormous number of both native and introduced tree species and the moderate size of many trees as compared to the mature urban forests found in the eastern United States. Also, a further advantage of a volumetric method is its applicability to shrubs.

Based on results from the present study, literature values for experimentally-determined leafmass constants appear to be reasonably accurate for the species tested. However, a larger dataset including additional tree species is needed to more accurately quantify leafmasses of urban trees and to better understand structural class values.

In urban areas with subtropical climates, including many cities of California, deciduous tree species are mingled with broadleaf evergreen species. Mean values of leafmass per unit area of crown projection for such species in the present study were

factors of 2 to 5 higher than leafmass per unit ground area data cited in the literature for eastern deciduous forests. Thus, leafmasses may be underestimated for trees in many of California's urban areas if calculations based on areal coverage and literature data do not take into account this difference. In summary, despite more limited areal coverage than natural forests, urban areas may contain a disproportionate density of leafmass when compared to natural vegetation due to irrigation and fertilization in urban landscapes.

7.3 Field-Survey Assessment of the GAP GIS Database in Natural Vegetation Areas of San Diego County

The four classes of information predicted by the GAP database useful for the development of a BHC emissions inventory are crown closure within a polygon, cover of species assemblages within a polygon, species composition within an assemblage, and abundance of species within an assemblage. Crown closure within a polygon as predicted by the GAP database was generally consistent with our field observations. The accuracy of areal cover of GAP species assemblages within a polygon could not be assessed in this study, because the GAP database does not delineate the boundaries of primary versus secondary assemblages within a polygon. However, the species assemblages data in GAP might be expected to have the same degree of accuracy as the crown closure data.

About 60% of the co-dominants listed in the GAP database for the polygons studied were observed in our field survey in large enough proportions to justify their co-dominant designation. Field observation agreement with GAP was more common in polygons dominated by forests and woodlands than in polygons dominated by chaparral and sage scrub.

GAP co-dominants provided 60-85% of the observed relative cover. However, the observed abundance of individual GAP co-dominants within a polygon was not evenly distributed among the listed species in the GAP database. Often, one or two co-dominants occupied the majority of the assemblage and the polygon.

It is important to note that biomass as derived from crown volume cannot be determined solely from data contained within the GAP database. Auxiliary data, either from field studies or from the literature, are needed to account for the 15-40% of the

relative cover attributable to species whose identity cannot be determined from the GAP database, as well as to estimate crown volume and biomass using GAP.

7.4 Ambient Measurements of Isoprene and Its Atmospheric Reaction

The highest isoprene mixing ratios during SCOS 97 were found in samples from the two mountain sites, Pine Mtn. (2.2 ppbv on August 4) and Mt. Baldy (2.3 ppbv on September 28) in late afternoon/early evening samples. At Azusa the highest mixing ratios for isoprene were generally in the range 0.5 – 0.8 ppbv. Thus, the highest values at the mountain sites were three to four times higher than the maximum mixing ratios observed at the urban valley site. The maximum isoprene values at the Banning site in the eastern portion of the air basin were 0.2 – 0.3 ppbv, consistently lower than at the other sites.

Consistent with light-dependent biogenic sources, the lowest values for isoprene were usually measured during nighttime. However, the difference between day and night was most apparent at the mountain sites, where the daytime values ranged between 0.4 – 2.3 ppbv and the nighttime values did not exceed 0.1 ppbv. At Azusa and Banning the day-night variation was much less pronounced.

The highest mixing ratios for methacrolein and methyl vinyl ketone observed at Azusa were up to 3.3 ppbv and 2.3 ppbv, respectively, and at Banning highest values were 2.4 ppbv and 2.9 ppbv, respectively. At Pine Mtn. and Mt. Baldy the highest values for MACR were measured in the afternoon/early evening reaching 1.1 ppbv and 0.5 ppbv, respectively, and the highest values for MVK were 1.6 ppbv and 1.0 ppbv, respectively.

At the mountain sites during the daytime, the isoprene values generally exceeded the MACR and MVK concentrations, while during the nighttime the isoprene values were <0.1 ppbv and the combined MACR and MVK levels reached 1.7 ppbv. The daytime MVK/MACR ratios at the mountain sites were consistent with the source of MACR and MVK being photooxidation of isoprene.

In contrast to the mountain sites, at Azusa, Banning, and LA North Main the MACR and MVK levels generally exceeded those of isoprene. A source other than the photooxidation of isoprene may exist for some of the MVK observed at Azusa, at least during certain sampling periods.

8.0 RECOMMENDATIONS FOR FUTURE RESEARCH

8.1 Background

As discussed above, quantifying BHC emissions and understanding the atmospheric reactivity of isoprene, monoterpenes and other BVOC are critical elements in the development of effective ozone attainment strategies. ARB-funded research has produced a wealth of data related to biogenic hydrocarbon emissions in California and substantial progress has been made in characterizing the atmospheric chemistry of BHC. However, even allowing for the fact not all plant species emit significant quantities of BHC, because of the enormous diversity and complexity of California's vegetation (i.e. 6000 species), as well as the large areal extent of its airsheds, substantial gaps remain in the data needed to produce gridded, speciated, day-specific BHC inventories for the entire state.

For example, to date less than 5% of all California plant species have undergone even qualitative measurements of BHC emissions. Although a taxonomic predictive method recently proposed from this research group shows promise, additional validation is needed to place such a system on a robust statistical foundation. Similarly, to date less than 1% of California species have had experimental leafmass-to-volume ratio determinations. Although additional data, some from the first systematic whole tree measurements ever conducted for urban species, were produced from the current project described in this report, these data have not yet been tested on the basis of taxonomy or structural class to permit more accurate extrapolation to the more than 95% of California plant species for which no data are available. The lack of such species-specific leafmass measurements has forced the use of structural class averages for recently generated BHC inventory estimates for Ventura and Santa Barbara Counties, an unsatisfactory approach. Of particular concern for natural plant communities are oaks which are high isoprene emitters and, given their populations and biomass, are a dominant genus of trees in California in producing BHC fluxes. Whole tree leafmass is not well characterized among oaks, especially for oaks in rangeland settings.

Assignment of spatial allocation of vegetation and species identity (i.e. characterization of composition and dominance) may be the weakest link in the entire BHC inventory development process at this time. Newly available GIS-based landcover

databases such as GAP may be a valuable source of plant species identity and distribution. However, apart from the limited prototype study being conducted in San Diego County as part of our present ARB study, we are unaware of any large-scale attempts to validate the GAP database for California, and certainly this has not been done for the purpose of assembling BHC emission inventories. Nor has this been done for the USGS vegetation database. Moreover, plant communities in California are unlike those of eastern temperate forests, differing both quantitatively and qualitatively, requiring caution in applying data from the eastern and northwest regions of the U.S. to California.

It must be emphasized that only with the development and validation of the databases described above, can reliable spatially- and temporally-resolved BHC emissions models be developed for the rest of California, comparable to the inventory we have developed, with partial ARB support, for the South Coast Air Basin (Benjamin et al. 1997).

Additional study is needed in four key areas, including qualitative measurements of total BHC emissions from a large number (i.e. several hundred) of California species not previously measured for BVOC emissions; leafmass-to-volume relationships for key California species, including oaks in rangeland communities; ground-based assessment of the GAP GIS vegetation database for the California Central Valley and other important airsheds; and further development of predictive methods for species-specific emissions and biomass. Moreover, further development and refinement of the initial methodology, created with ARB support, for development of a BVOC emission inventory for the SCOS97 Study domain is needed. The intent is to produce a methodology suited to the creation of a statewide BHC emission inventory.

The data and methods generated in such research program could then be used by ARB to evaluate and improve current BHC emissions models in use by ARB, and to lay the foundations for assembling gridded, speciated, hour-specific BHC emissions inventories for California's airsheds.

8.2 Specific Recommendations

The specific recommendations for future BHC research relevant to California are to:

- Experimentally survey the total BHC emissions for at least 300 key California plant species not previously measured, using a PID system to identify emitters vs. non-emitters of BHC. Use of a PID would allow rapid surveying of a much larger number of species than has been possible with either a Teflon enclosure or leaf cuvette approach. Emphasis should be on suspected "high" emitters of either isoprene, monoterpenes, sesquiterpenes or oxygenated BHC, and on plant species which can provide further tests and validation of our taxonomic approach to predicting BHC emission rates. The data generated in such a study would be directly useful for emission inventory building, particularly since it would readily identify "non-emitting" plant species.

- Develop and test taxonomic and structural class methodologies for estimating leafmass constants, including evaluation of precision and accuracy of the resulting predictive methods. This study would extend our recent research on quantitatively evaluating various methods for estimating foliar biomass by experimentally measuring leafmass, including for whole trees, and comparing experimental data for representative tree species to estimates obtained from literature algorithms and volumetric methods.

- Conduct biomass sampling among high-emitting oak species in rangeland environments to develop statistically robust data on leafmass per volume ratios, including whole tree sampling. This research would focus specifically on one of the most important genera for natural landscapes in California, the very high isoprene emitting oak species, which can dominate isoprene inventories in certain airsheds. Lack of reliable biomass constants for oaks has been a weakness in past BHC inventories in California.

- Conduct a quantitative, field-based analysis of the GAP GIS landcover vegetation database for the San Joaquin Valley. This task would extend to the Central Valley our research on the validity of the GAP database for portions of the SCOS97 domain, conducted at the request of the ARB. In our present project we have developed and refined a field-based protocol for experimentally evaluating the reliability of GAP and for obtaining field data needed to convert the "flat" GAP landcover map to a three dimensional map permitting estimation of biomass.

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10.0 APPENDICES

Appendix A: Isoprene Emission Rate Measurements of Plants in Urban and Natural Environments in California

Appendix B: Leaf Areas and Leafmasses of Trees, Shrubs and Selected Herbaceous Plants, With Calculated Specific Leaf Weight and Specific Leaf Areas and Location Within the Plant CrownWhere the Sample was Taken

Appendix C: Detailed Data from Field Survey of Natural Vegetation in San Diego County

Appendix D: Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air

APPENDIX A

Isoprene Emission Rate Measurements of Plants in Urban and Natural Environments in California

Appendix A. Isoprene emission rate measurements of plants in urban and natural environments in California.

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Anacardiaceae											
Pistacia chinensis	Chinese Pistache (1)	07/30/97	12:15	BDL BDL BDL	36	50	1,780	37.1	2,400	BDL BDL BDL	0.1
Betulaceae											
Betula nigra	River Birch (3)	09/03/97	08:50	BDL BDL BDL	33	33	1,000	23.1	2,200	BDL BDL BDL	0.3
		09/17/97	13:55	BDL BDL BDL	29	37	1,000	27.0	no value	BDL BDL BDL	0.5
		10/14/97	14:35	BDL BDL BDL	32	30	1,600	26.1	no value	BDL BDL BDL	1.0
Betula papyrifera	Paper Birch (9)	07/29/97	12:30	BDL BDL BDL BDL	43	18	1,990	20.4	2,200	BDL BDL BDL BDL	0.5
Bignoniaceae											
Macfadyena unguis-cati	Cat's claw Vine (1)	08/14/97	13:15	BDL BDL BDL	38	30	1,930	9.1	1,100	BDL BDL BDL	0.6
		09/09/97	09:05	BDL BDL BDL	34	48	890	18.7	no value	BDL BDL BDL	0.4
			14:05	BDL BDL BDL	44	43	1,780	10.1	no value	BDL BDL BDL	0.6

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Caprifoliaceae											
Viburnum trilobum	American Highbush Cranberry (9)	07/29/97	13:45	BDL BDL BDL	39	21	2,010	11.7	1,600	BDL BDL BDL	0.4
		09/11/97	07:45	BDL BDL	32	24	800	37.3	3,000	BDL BDL	0.2
Chenopodiaceae											
Atriplex polycarpa	Saltbush (2)	09/16/97	13:30	BDL BDL BDL	32	27	1,110	12.1	no value	BDL BDL BDL	0.7
Compositae (Asteraceae)											
Artemisia ludoviciana	Silver Wormwood (1)	08/27/97	14:50	BDL BDL BDL	37	38	1,890	12.4	no value	BDL BDL BDL	0.5
		09/09/97	11:50	BDL BDL BDL	44	63	1,750	31.3	no value	BDL BDL BDL	0.2
Baccharis pilularis	Coyotebrush (1)	08/27/97	11:05	BDL BDL BDL BDL	34	38	1,500	17.9	1,000	BDL BDL BDL BDL	0.4
		09/10/97	11:45	BDL BDL BDL	39	30	1,790	13.1	no value	BDL BDL BDL	1.1
Chrysothamnus nauseosus	Rubber Rabbitbrush (9)	08/26/97	11:30	BDL BDL BDL	33	31	1,320	12.6	1,100	BDL BDL BDL	0.7
		09/11/97	08:35	BDL BDL BDL	33	25	900	17.1	no value	BDL BDL BDL	0.5

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Compositae (Asteraceae) (continued)											
Euryops pectinatus	Euryops Daisy (2)	07/30/97	08:30	BDL BDL BDL	37	30	1,500	13.9	1,000	BDL BDL BDL	0.3
		09/04/97	14:35	BDL BDL BDL	39	40	1,980	12.1	1,300	BDL BDL BDL	0.5
		09/16/97	11:45	BDL BDL BDL	32	29	1,120	13.1	no value	BDL BDL BDL	0.7
Cornaceae											
Cornus stolonifera	Redtwig Dogwood(9)	07/08/97	11:50	BDL BDL BDL BDL	39	42	1,910	17.4	2,500	BDL BDL BDL BDL	0.9
		07/29/97	10:30	BDL BDL BDL BDL	38	50	1,870	28.3	3,400	BDL BDL BDL BDL	0.3
		08/26/97	14:30	BDL BDL BDL	36	34	1,790	27.6	2,100	BDL BDL BDL	0.4
Cupressaceae											
Cupressocyparis leylandii	Leyland Cypress (1)	08/20/97	09:05	BDL BDL BDL	31	45	1,100	131.1	3,200	BDL BDL BDL	0.1
		09/09/97	17:25	BDL BDL	42	20	740	39.5	no value	BDL BDL	0.4

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Euphorbiaceae											
Sapium sebiferum	Chinese Tallow Tree (2)	07/25/97	12:50	BDL BDL BDL BDL	38	34	1,970	35.7	2,000	BDL BDL BDL BDL	0.3
		09/04/97	13:50	BDL BDL BDL	38	41	1,910	21.3	2,300	BDL BDL BDL	0.3
		09/16/97	12:20	BDL BDL BDL	32	29	1,020	37.1	no value	BDL BDL BDL	0.2
Fagaceae											
Quercus chrysolepis	Canyon Live Oak (10)	07/01/97	11:00	19 25 26	31	68	1,820	129.5	no value	16 20 21	0.2
	Canyon Live Oak (8)	07/10/97	11:20	24 49 40	36	35	1,900	26.1	no value	12 26 22	0.7
			12:10	33 25 28	33	32	1,980	30.3	no value	23 17 17	0.7
Quercus douglasii	Blue Oak (10)	07/01/97	13:53	23 13 17	34	45	1,970	84.4	no value	14 8.7 11	0.9
	Blue Oak (8)	07/02/97	10:00	38 26 38	33	36	1,880	18.6	1,300	26 18 27	1.1
	Blue Oak (6)	10/02/97	12:35	38 53 33	29	43	1,330	19.9	no value	44 59 37	1.9
		11/03/97	14:40	24 14	28	16	1,480	19.9	no value	28 17	1.6

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Fagaceae (continued)											
Quercus kelloggii	California Black Oak (10)	07/01/97	12:44	72 78 80	33	63	2,030	34.1	no value	51 53 57	2.4
	California Black Oak (12)	10/13/97	14:00	41 60	32	31	1,410	26.1	no value	33 48	1.0
Quercus lobata	Valley Oak (4)	08/19/97	13:00	27 40	39	53	1,860	33.5	2,100	13 19	0.3
	Valley Oak (1)	09/03/97	12:47	21 57 57	39	65	1,750	40.4	2,700	10 28 29	0.4
	Valley Oak (5)	10/02/97	10:30	28 25 8.9	27	37	1,100	26.1	no value	41 34 10	1.8
	Valley Oak (4)	11/03/97	09:50	1.9 2.1 1.8	27	15	1,100	16.1	no value	2.5 2.8 2.6	2.3
	Valley Oak (5)	11/03/97	13:20	44 15 40	29	16	1,410	20.1	no value	49 17 42	1.5
	Valley Oak (1)	11/07/97	11:35	BDL BDL BDL	24	45	1,020	10.2	no value	BDL BDL BDL	5.8
Quercus palustris	Pin Oak (3)	07/25/97	09:00	38 47 58	36	50	1,680	34.5	3,900	28 26 28	0.6
Quercus suber	Cork Oak (1)	07/17/97	09:47	BDL BDL BDL BDL	39	47	1,530	47.2	4,400	BDL BDL BDL BDL	0.2

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Hamamelidaceae											
Liquidambar styraciflua	Sweetgum (10)	07/01/97	11:40	21 17 19	35	52	1,920	45.2	no value	14 11 13	0.4
	Sweetgum (10)	07/01/97	12:14	17 15 17	32	58	1,970	130.8	no value	14 12 13	0.2
	Sweetgum (8)	07/02/97	11:30	50 51 46	32	16	2,020	45.6	4,000	37 43 38	0.5
	Sweetgum (3)	09/04/97	10:05	49 78 69	38	42	1,450	36.0	3,400	25 39 35	0.5
	Sweetgum (8)	10/14/97	09:15	29 42	29	30	1,290	29.3	no value	34 43	1.2
	Sweetgum (4)	11/03/97	10:30	12 14	31	25	1,220	31.9	no value	10 12	0.7
Hippocastanaceae											
Aesculus californica	California Buckeye (8)	07/10/97	13:00	BDL BDL BDL	37	39	2,000	24.4	3,400	BDL BDL BDL	0.7
		07/10/97	13:40	BDL BDL BDL	37	41	2,040	21.8	3,200	BDL BDL BDL	0.7
Juglandaceae											
Carya illinoensis	Pecan (3)	08/21/97	08:45	BDL BDL BDL	36	62	1,100	23.5	1,900	BDL BDL BDL	0.3
		09/23/97	11:55	BDL BDL BDL	38	33	1,710	21.0	no value	BDL BDL BDL	0.3

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Lamiaceae											
Rosmarinus officinalis	Rosemary (9)	08/26/97	12:20	BDL	33	30	1,460	17.1	1,300	BDL	0.5
				BDL						BDL	
				BDL						BDL	
		09/11/97	09:45	BDL	32	25	1,000	11.3	no value	BDL	0.7
				BDL						BDL	
				BDL						BDL	
Salvia greggii	Autumn Sage (1)	08/27/97	13:25	BDL	37	37	1,660	12.1	no value	BDL	0.5
				BDL						BDL	
				BDL						BDL	
		09/10/97	08:15	BDL	33	26	890	12.1	no value	BDL	1.8
				BDL						BDL	
				BDL						BDL	
Leguminosae (Fabaceae)											
Acacia aneura	Mulga (3)	07/23/97	09:00	BDL	34	41	1,440	41.2	470	BDL	0.6
				BDL						BDL	
				BDL						BDL	
				BDL						BDL	
Acacia melanoxylon	Blackwood Acacia (1)	08/20/97	07:45	BDL	30	74	710	103.6	5,600	BDL	0.1
				BDL						BDL	
				BDL						BDL	
		09/09/97	10:20	BDL	34	46	1,240	27.9	no value	BDL	0.2
				BDL						BDL	
				BDL						BDL	
			16:50	BDL	45	23	960	33.1	no value	BDL	0.6
				BDL						BDL	
Caesalpinia gillesii	Desert Bird of Paradise(1)	08/20/97	10:40	BDL	42	44	1,600	20.5	no value	BDL	0.3
				BDL						BDL	
				BDL						BDL	
		09/10/97	09:55	BDL	38	30	1,310	32.1	no value	BDL	0.2
				BDL						BDL	
				BDL						BDL	

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}hr^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Leguminosae (Continued)											
Cassia artemisiodes	Feathery Cassia (1)	08/27/97	12:15	BDL BDL BDL	35	38	1,580	16.0	no value	BDL BDL BDL	0.4
		09/10/97	09:00	BDL BDL BDL	35	28	1,000	16.1	no value	BDL BDL BDL	1.2
Cassia nemophila	Desert Cassia (1)	08/20/97	11:35	BDL BDL BDL	35	46	1,820	21.4	no value	BDL BDL BDL	0.3
		09/09/97	14:45	BDL BDL	45	25	1,710	9.9	no value	BDL BDL	0.6
Ceratonia siliqua	Carob (3)	08/13/97	08:30	BDL BDL BDL	33	31	1,000	2BDL	2,000	BDL BDL BDL	0.4
Cercidium floridum	Blue Palo Verde (1)	08/20/97	09:55	BDL BDL BDL	33	45	1,410	17.0	no value	BDL BDL BDL	0.5
		09/09/97	09:40	BDL BDL BDL	30	51	1,110	19.3	no value	BDL BDL BDL	0.5
Cytisus spachianus (= C. racemosus) (= Genista racemosus)	Broom (7)	09/30/97	11:35	BDL BDL BDL	35	31	1,730	15.1	no value	BDL BDL BDL	1.2
Lysiloma thornberi	Feather Bush (1)	07/30/97	11:00	BDL BDL BDL	38	30	1,650	33.2	1,500	BDL BDL BDL	0.1
		09/10/97	10:50	BDL BDL BDL	39	29	1,520	37.9	no value	BDL BDL BDL	0.1

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Leguminosae (continued)											
Prosopis alba 'Colorado'	Colorado Mesquite (1)	07/17/97	10:30	BDL BDL BDL BDL	41	10	1,690	22.5	670	BDL BDL BDL BDL	0.5
Sophora secundiflora	Texas Mountain Laurel (1)	10/15/97	11:45	48 48 62	36	27	1,480	27.4	no value	38 27 31	0.7
		11/05/97	09:00	35 37 23	29	20	1,090	17.1	no value	39 43 26	1.9
Spartium junceum	Spanish Broom (9)	09/24/97	13:45	29 13	32	26	740	19.9	no value	25 11	1.3
		10/13/97	09:00	24 27 13	29	28	1,200	16.1	no value	27 29 14	2.3
Malvaceae											
Gossypium barbadense	Cotton 'Pima' (4)	08/19/97	11:00	BDL BDL BDL	36	62	1,550	17.3	1,000	BDL BDL BDL	0.4
Gossypium hirsutum	Cotton 'Maxxa' (4)	08/19/97	12:00	BDL BDL BDL	37	54	1,950	15.1	1,400	BDL BDL BDL	0.4
Hibiscus rosa-sinensis	Chinese Hibiscus (1)	10/15/97	14:10	BDL BDL BDL	36	15	1,520	16.6	no value	BDL BDL BDL	1.0

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Oleaceae											
Fraxinus velutina 'Modesto'	Modesto Ash (3)	10/09/97	13:35	BDL BDL BDL BDL	35	38	1,380	23.1	no value	BDL BDL BDL BDL	0.9
Syringa vulgaris	Common Lilac (9)	07/29/97	08:30	BDL BDL BDL BDL	39	33	1,680	18.7	1,800	BDL BDL BDL BDL	0.5
		09/11/97	10:45	BDL BDL BDL	33	29	1,200	20.2	2,000	BDL BDL BDL	1.0
Palmae (Arecaceae)											
Syagrus (=Arecastrum) romanzoffiana	Queen Palm (3)	08/21/97	10:15	BDL BDL BDL	37	58	1,400	16.1	700	BDL BDL BDL	0.3
		09/23/97	12:50	BDL BDL BDL	39	32	1,820	27.1	no value	BDL BDL BDL	0.2
Washingtonia robusta	Mexican Fan Palm (3)	11/07/97	no time	4.8 7.1 6.4	24	61	670	33.4	no value	11 17 15	1.9
Pinaceae											
Abies concolor	White Fir (9)	08/26/97	13:20	BDL BDL BDL	34	33	1,600	23.1	2,600	BDL BDL BDL	0.3
Picea pungens	Blue Spruce (9)	07/08/97	12:47	BDL BDL BDL BDL	39	40	2,000	27.1	no value	BDL BDL BDL BDL	0.6

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Proteaceae											
Grevillea robusta	Silk Oak (3)	08/13/97	11:20	BDL	38	38	1,550	21.3	1,900	BDL	0.3
				BDL						BDL	
				BDL						BDL	
		09/17/97	12:45	BDL	32	38	980	23.1	no value	BDL	0.4
				BDL						BDL	
				BDL						BDL	
Rosaceae											
Rosa hybrida 'Simplicity'	'Pink Simplicity'(1)	08/14/97	08:45	BDL	35	31	1,100	12.1	1,200	BDL	0.6
				BDL						BDL	
				BDL						BDL	
Rosa hybrida	Rose (3)	08/21/97	12:15	BDL	39	64	1,800	14.0	1,100	BDL	0.3
				BDL						BDL	
				BDL						BDL	
Salicaceae											
Populus alba	White Poplar (9)	09/24/97	12:00	29	33	32	830	29.1	no value	24	0.8
				33						20	
		09/24/97	15:52	17	29	31	440	29.1	no value	24	1.5
				25						35	
				15						22	
Populus euramerica 'R111'	Hybrid Poplar (2)	09/04/97	11:50	72	39	41	1,790	2BDL	2,200	36	0.8
				89						44	
				67						33	
		09/16/97	10:30	25	31	29	1,200	37.1	no value	22	0.8
				22						19	
				41						34	
Populus euramerica 'R112'	Hybrid Poplar (2)	09/16/97	09:40	37	31	28	1,100	31.0	no value	32	0.9
				29						26	
				31						27	
		09/26/97	11:37	51	38	63	1,510	47.2	no value	25	0.4

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Proteaceae											
Grevillea robusta	Silk Oak (3)	08/13/97	11:20	BDL BDL BDL	38	38	1,550	21.3	1,900	BDL BDL BDL	0.3
		09/17/97	12:45	BDL BDL BDL	32	38	980	23.1	no value	BDL BDL BDL	0.4
Rosaceae											
Rosa hybrida 'Simplicity'	'Pink Simplicity'(1)	08/14/97	08:45	BDL BDL BDL	35	31	1,100	12.1	1,200	BDL BDL BDL	0.6
Rosa hybrida	Rose (3)	08/21/97	12:15	BDL BDL BDL	39	64	1,800	14.0	1,100	BDL BDL BDL	0.3
Salicaceae											
Populus alba	White Poplar (9)	09/24/97	12:00	29 33	33	32	830	29.1	no value	24 20	0.8
		09/24/97	15:52	17 25 15	29	31	440	29.1	no value	24 35 22	1.5
Populus euramerica 'R111'	Hybrid Poplar (2)	09/04/97	11:50	72 89 67	39	41	1,790	2BDL	2,200	36 44 33	0.8
		09/16/97	10:30	25 22 41	31	29	1,200	37.1	no value	22 19 34	0.8
Populus euramerica 'R112'	Hybrid Poplar (2)	09/16/97	09:40	37 29 31	31	28	1,100	31.0	no value	32 26 27	0.9
		09/26/97	11:37	51	38	63	1,510	47.2	no value	25	0.4

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Salicaceae (continued)											
Populus fremontii	Western Cottonwood (9)	07/08/97	08:30	82 73 88	36	23	1,480	34.8	3,500	45 41 47	0.5
		09/24/97	15:21	27 25	29	26	350	34.8	3,500	41 39	1.4
Populus nigra italica	Lombardy Poplar (9)	07/08/97	09:20	82 61 80	35	45	1,740	28.2	3,600	41 30 39	0.5
		09/24/97	10:47	72 63 54	36	39	1,520	31.3	no value	41 34 30	0.5
			14:47	16 24	28	41	350	31.3	no value	30 39	1.7
Sterculiaceae											
Brachychiton populneus	Bottle Tree (3)	07/30/97	07:35	BDL BDL BDL BDL	35	30	1,390	13.7	1,600	BDL BDL BDL BDL	0.8
		08/13/97	09:50	BDL BDL BDL	33	33	1,240	18.7	1,800	BDL BDL BDL	0.4
Taxaceae											
Torreya californica	California Nutmeg (10)	07/01/97	13:21	BDL BDL BDL	35	20	1,970	96.2	no value	BDL BDL BDL	0.7
Taxodiaceae											
Sequoia sempervirens	Coast Redwood (2)	07/31/97	09:15	BDL BDL BDL	35	31	1,600	23.2	2,600	BDL BDL BDL	0.3

Appendix A. (Continued)

Scientific Name	Common Name (Sample Location)	Date Sampled	Time Sampled (PDT)	Isoprene Emiss. Rate (unadjusted) (ug $g^{-1}h^{-1}$)	Chamber Temp. (°C)	Relative Humidity (%)	Light Intensity (umol $m^{-2}sec^{-1}$)	Leaf Mass (g)	Leaf Area (cm^2)	Isoprene Emiss. Rate (Adjusted) (ug $g^{-1}h^{-1}$)	Isoprene Detection Limit (ug $g^{-1}h^{-1}$)
Taxodiaceae (continued)											
Sequoiadendron giganteum	Giant Sequoia (9)	07/29/97	09:30	BDL BDL BDL	41	29	1,700	114.7	1,500	BDL BDL BDL	0.1
		09/11/97	11:35	BDL BDL BDL	33	30	1,410	12BDL	no value	BDL BDL BDL	0.1
Verbenaceae											
Latana camara	Lantana (3)	07/25/97	08:00	BDL BDL BDL	33 -	39	1,510	14.2	910	BDL BDL BDL	0.6
Vitex agnus-castus	Chaste Tree (1)	07/17/97	11:00	BDL BDL BDL BDL	39	53	1,790	15.0	1,500	BDL BDL BDL BDL	0.7
Zygophyllaceae											
Larrea tridentata	Creosote Bush (11)	09/18/97	10:42	BDL BDL BDL	36	33	1,700	36.7	no value	BDL BDL BDL	0.5
			11:29	BDL BDL BDL	36	38	1,730	33.3	no value	BDL BDL BDL	0.5

Sample Locations:
(1) Cooperative Extension Office, Bakersfield
(2) California State University, Bakersfield
(3) Various locations throughout Bakersfield
(4) University of California Shafter Research and Extension Center
(5) Caliente
(6) Hart Flat
(7) Dead Ox Ranch
(8) California Hot Springs
(9) Mourning Cloak Ranch
(10) Placerville
(11) Mojave Desert
(12) Other

APPENDIX B

Leaf Areas and Leafmasses of Trees, Shrubs and Selected Herbaceous Plants, With Calculated Specific Leaf Weight and Specific Leaf Areas and Location Within the Plant Crown Where the Sample was Taken

Appendix B. Leaf areas and leafmasses of trees, shrubs and selected herbaceous plants, with calculated specific leaf weight and specific leaf areas and location within the plant crown where the sample was taken. Samples were taken with a 0.0283 m^3 volume PVC cube unless otherwise noted. Actual values for specific leaf area are table values x 10^{-3}.

	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location[1]
Scientific Name	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Acacia aneura	0.069	0.041	0.020	34.0	19.5	10.2	489	473	11.8	2.04	2.11	0.0524	O
	0.035			16.3			460			2.17			O
	0.022			10.2			471			2.12			O
	0.037			17.6			473			2.12			O
Acacia melanoxylon	0.062	0.080	0.015	9.7	13.2	3.0	157	163	9.0	6.37	6.15	0.332	M
	0.076			11.8			155			6.45			O
	0.086			15.0			175			5.72			O
	0.098			16.2			165			6.07			I
Aesculus californica	0.047	0.047	0.003	5.0	4.2	0.7	106	89.1	12.3	9.46	11.4	1.47	O
	0.050			4.6			90.9			11.0			O
	0.046			3.7			80.4			12.4			O
	0.043			3.4			79.2			12.6			O
Atriplex polycarpa [2,3]	0.029	0.020	0.007	7.5	5.2	1.9	261	254	17.9	3.84	3.95	0.298	O
	0.011			2.9			263			3.81			O
	0.020			4.5			228			4.39			O
	0.022			5.8			266			3.76			O
Alnus rhombifolia	0.189	0.117	0.052	17.4	10.7	5.3	91.9	89.7	15.3	10.9	11.4	2.09	O
	0.106			11.3			107			9.32			O
	0.066			4.6			69.9			14.3			I
	0.106			9.5			89.8			11.1			M

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Baccharis pilularis [3]	0.041	0.057	0.016	6.5	11.2	3.4	161	194	26.8	6.22	5.22	0.758	N/A
	0.056			12.4			220			4.53			N/A
	0.078			14.5			186			5.38			N/A
	0.053			11.3			211			4.75			N/A
Betula nigra	0.093	0.088	0.015	10.4	8.5	2.6	113	96.8	27.8	8.88	11.2	4.07	O
	0.106			10.1			94.9			10.5			O
	0.081			4.8			58.4			17.1			I
	0.073			8.8			121			8.25			M
Betula papyrifera	0.031	0.035	0.013	2.5	2.7	1.0	80.1	76.7	5.6	12.5	13.1	0.943	O
	0.049			3.6			72.3			13.8			O
	0.041			3.4			82.7			12.1			M
	0.019			1.4			71.7			14.0			I
Brachychiton populneus	0.208	0.145	0.060	16.5	12.5	4.5	79.2	88.0	6.7	12.6	11.4	0.902	O
	0.068			6.3			91.6			10.9			I
	0.133			12.5			94.6			10.6			M
	0.172			14.8			86.5			11.6			O
Caesalpinia gillesii [2]	0.072	0.052	0.017	6.5	5.3	2.7	90.1	98.4	34.0	11.1	11.2	4.16	O
	0.031			1.9			59.2			16.9			I
	0.058			8.2			141			7.08			O
	0.046			4.8			103			9.68			M
Cassia artemisiodes [2,3]	0.004	0.007	0.004	0.7	1.3	0.9	182	190	29.3	5.49	5.36	0.822	O
	0.010			2.0			194			5.15			O
	0.003			0.5			157			6.38			M
	0.009			2.1			227			4.40			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Cassia nemophila	0.088	0.060	0.024	24.6	16.2	7.6	279	262	29.6	3.58	3.85	0.473	O
	0.065			18.7			287			3.49			O
	0.030			6.5			221			4.53			I
	0.058			15.1			263			3.80			O
Chrysothamnus nauseosus [3]	0.027	0.019	0.011	7.8	5.2	3.3	287	257	46.9	3.48	4.02	0.885	N/A
	0.003			0.5			187			5.34			N/A
	0.026			7.0			268			3.73			N/A
	0.019			5.4			284			3.52			N/A
Citrus limon	0.225	0.127	0.091	32.3	18.3	12.2	143	150	22.3	6.97	6.79	1.02	O
	0.092			16.4			177			5.64			M
	0.019			2.9			154			6.49			I
	0.173			21.4			124			8.07			O
Citrullus lanatus	0.196	0.205	0.028	14.8	17.6	2.6	75.4	86.1	7.9	13.3	11.7	1.13	N/A
	0.240			20.5			85.2			11.7			N/A
	0.210			18.9			89.9			11.1			N/A
	0.173			16.3			93.8			10.7			N/A
Cornus stolonifera	0.109	0.140	0.027	7.1	8.4	3.0	65.2	59.3	12.6	15.3	17.5	3.86	O
	0.175			12.8			73.5			13.6			O
	0.139			7.5			53.9			18.6			O
	0.137			6.1			44.7			22.4			M
Citrus sinensis	0.316	0.264	0.132	38.9	34.3	18.6	123	126	15.0	8.12	8.04	1.03	O
	0.403			54.4			135			7.40			O
	0.090			9.5			106			9.46			I
	0.246			34.3			139			7.18			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Eucalyptus camaldulensis 'C2'	0.056	0.102	0.048	8.5	14.3	6.5	152	141	18.4	6.58	7.20	0.966 [4]	O
	0.167			22.1			132			7.55			M
	0.079			9.4			119			8.39			M
	0.106			17.0			160			6.27			O
Eucalyptus grandis 'GCT'	0.216	0.163	0.057	29.6	19.7	9.0	137	118	17.5	7.30	8.65	1.38	O
	0.119			14.4			120			8.30			O
	0.208			24.8			119			8.41			O
	0.107			10.1			94.6			1.06			I
Eucalyptus sideroxylon	0.092	0.196	0.143	13.2	26.5	17.7	143	139	10.1	6.97	7.24	0.540	M
	0.088			11.9			136			7.38			O
	0.393			49.5			126			7.93			I
	0.210			31.4			145			6.69			M
Euryops pectinatus [3]	0.027	0.049	0.025	6.2	11.3	6.7	231	226	19.3	4.33	4.46	3.88	O
	0.035			7.0			202			4.96			O
	0.084			20.8			248			4.03			O
	0.051			11.2			222			4.51			O
Garrya flavescens [3]	0.031	0.037	0.010	6.5	8.2	3.3	206	220	26.1	4.85	4.58	0.487	O
	0.037			7.6			204			4.90			I
	0.050			13.0			259			3.86			M
	0.028			5.8			211			4.73			O
Gossypium hirsutum 'Maxxa'	0.138	0.142	0.040	10.3	9.8	2.7	75.2	69.6	4.9	13.3	14.4	1.01	N/A
	0.200			13.4			67.1			14.9			N/A
	0.111			8.0			71.9			13.9			N/A
	0.119			7.6			64.2			15.6			N/A

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Grevillea robusta	0.187	0.178	0.097	24.2	22.5	13.5	129	123	11.1	7.75	8.21	0.753	O
	0.051			5.6			110			9.10			I
	0.287			38.6			134			7.45			O
	0.186			21.8			117			8.55			O
Hibiscus rosa-sinensis	0.015	0.020	0.007	1.1	1.7	0.6	74.6	84.5	7.8	13.4	11.9	1.14	N/A
	0.029			2.4			82.0			12.2			N/A
	0.015			1.4			91.1			11.0			N/A
	0.020			1.8			90.5			11.1			N/A
Juglans regia	0.144	0.125	0.046	5.8	6.4	5.0	40.4	46.6	19.4	24.8	23.7	7.26	O
	0.181			13.6			75.4			13.3			O
	0.090			3.3			37.1			27.0			I
	0.086			2.9			33.6			29.8			M
Koelreuteria paniculata	0.144	0.109	0.025	14.2	9.3	3.7	98.7	83.6	16.8	10.1	12.4	2.86	O
	0.089			7.3			81.7			12.2			M
	0.108			10.1			93.4			10.7			I
	0.094			5.7			60.7			16.5			O
Lycopersicon esculentum	0.151	0.155	0.035	14.1	13.8	3.2	93.4	88.9	6.5	10.7	11.3	0.837	N/A
	0.117			9.5			81.3			12.3			N/A
	0.201			17.2			85.6			11.7			N/A
	0.150			14.2			95.1			10.5			N/A
Lycopersicon esculentum 'Roma'	0.165	0.160	0.027	12.1	11.6	1.0	73.3	74.1	15.2	13.6	14.0	3.07	N/A
	0.137			12.6			91.9			10.9			N/A
	0.195			10.7			55.0			18.2			N/A
	0.141			10.7			76.3			13.1			N/A

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Liquidambar styraciflua	0.309	0.226	0.092	32.5	22.9	11.2	105	99.4	16.8	9.53	10.3	2.09	O
	0.302			32.8			109			9.19			O
	0.166			12.3			74.4			13.4			I
	0.129			14.2			110			9.13			O
Lysiloma [2] thornberi	0.053	0.073	0.037	8.6	8.1	3.7	160	116	39.8	6.24	9.42	3.30	O
	0.086			12.0			139			7.20			O
	0.118			8.8			74.9			13.4			O
	0.033			3.0			91.7			10.9			O
Morus alba 'Fruitless'	0.178	0.123	0.040	16.0	9.1	4.7	89.9	71.6	15.8	11.1	14.5	3.31	O
	0.084			6.5			78.0			12.8			O
	0.114			7.4			65.3			15.3			M
	0.118			6.3			53.4			18.7			I
Nerium oleander	0.142	0.136	0.055	26.8	20.9	9.1	188	152	26.3	5.31	6.74	1.07	M
	0.058			7.4			129			7.77			M
	0.161			24.6			153			6.55			M
	0.182			24.9			137			7.31			O
Pistacia chinensis	0.278	0.213	0.053	21.0	16.8	5.4	75.8	77.8	12.1	13.2	13.1	1.99	O
	0.148			9.5			64.3			15.6			I
	0.221			20.7			93.6			10.7			O
	0.203			15.8			77.7			12.9			M
Pistacia vera (mature)	0.303	0.146	0.109	46.5	21.9	17.0	153	149	19.3	6.52	6.79	0.973	O
	0.128			19.8			154			6.47			O
	0.099			12.1			122			8.20			I
	0.056			9.3			167			5.97			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Pistacia vera (5 yr old)	0.028	0.085	0.042	4.3	14.2	6.7	151	167	29.9	6.62	6.12	0.992	O
	0.129			18.3			142			7.06			I
	0.093			15.5			167			6.00			M
	0.089			18.6			209			4.78			O
Populus alba	0.064	0.078	0.030	4.8	6.8	2.2	75.9	88.3	12.1	13.2	11.5	1.58	I
	0.056			5.6			100			9.99			O
	0.122			9.8			80.1			12.5			M
	0.071			6.9			97.0			10.3			O
Populus euramerica	0.232	0.107	0.091	21.8	9.6	8.9	94.1	84.6	13.1	10.6	12.1	2.16	O
	0.114			10.5			92.2			10.9			M
	0.036			2.4			65.6			15.3			I
	0.044			3.9			86.8			11.5			M
Populus fremontii	0.148	0.157	0.034	14.0	14.0	4.3	94.6	87.6	10.3	10.6	11.5	1.50	O
	0.205			19.5			95.2			10.5			O
	0.124			9.1			72.9			13.7			I
	0.151			13.3			87.6			11.4			M
Populus nigra italica	0.121	0.123	0.035	8.0	8.4	3.3	66.5	66.7	7.1	15.0	15.1	1.59	O
	0.096			6.3			66.1			15.1			O
	0.104			6.1			58.5			17.1			I
	0.173			13.1			75.7			13.2			O
Prosopis alba 'Colorado' [2]	0.050	0.037	0.009	10.6	8.1	2.5	212	215	30.6	4.72	4.73	0.698	O
	0.037			9.3			251			3.98			M
	0.028			4.9			177			5.66			I
	0.034			7.5			220			4.54			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Prunus	0.153	0.105	0.038	15.8	8.4	5.6	103	74.4	25.0	9.70	14.8	5.46	O
cerasifera	0.114			9.7			84.5			11.8			O
'Krauter Vesuvius'	0.064			4.2			64.8			15.4			M
	0.087			3.9			45.1			22.2			I
Prunus	0.100	0.066	0.032	9.8	6.3	3.3	98.3	94.1	8.6	10.2	10.7	1.07	O
dulcis (mature)	0.080			8.0			100			9.98			O
	0.025			2.4			96.4			10.4			I
	0.059			4.8			81.4			12.3			M
Prunus	0.107	0.102	0.044	14.6	12.2	6.3	136	115	21.3	7.33	8.99	1.88	O
dulcis (5 yr)	0.159			19.3			122			8.22			O
	0.052			4.4			85.6			11.7			I
	0.090			10.3			114			8.73			M
Quercus	0.043	0.061	0.046	5.2	9.3	7.7	122	147	20.5	8.21	6.93	1.01	
lobata	0.027			3.7			138			7.23			
	0.045			7.5			167			5.98			
	0.129			20.6			159			6.28			
Quercus	0.086	0.134	0.044	8.8	12.0	2.2	102	93.6	20.7	9.81	11.1	2.34	O
palustris	0.110			13.1			119			8.40			O
	0.160			12.4			77.3			12.9			I
	0.180			13.7			76.2			13.1			M
Quercus	0.118	0.108	0.029	9.4	7.3	2.6	79.6	65.9	10.9	12.6	15.5	2.58	O
robur	0.075			4.0			53.1			18.8			I
	0.097			6.5			66.6			15.0			M
	0.144			9.2			64.2			15.6			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Querus rubra	0.061	0.088	0.032	4.4	7.7	2.8	72.0	87.3	13.4	13.9	11.7	1.79	I
	0.076			7.9			104			9.59			O
	0.135			11.3			83.5			12.0			O
	0.081			7.2			89.6			11.2			M
Quercus suber	0.082	0.090	0.058	11.5	14.7	7.5	140	220	143.4	7.16	5.62	2.24	O
	0.156			24.4			156			6.40			O
	0.106			15.9			150			6.64			O
	0.016			6.9			435			2.30			I
Quercus virginiana	0.061	0.094	0.028	13.0	16.1	4.0	215	176	35.0	4.66	5.85	1.17	O
	0.089			12.4			139			7.21			I
	0.130			20.2			156			6.41			M
	0.096			18.8			196			5.10			O
Quercus wislizenii	0.044	0.050	0.005	9.1	8.9	1.0	205	180	31.9	4.88	5.70	1.16	O
	0.056			7.6			136			7.36			M
	0.049			8.7			179			5.59			O
	0.050			10.1			202			4.95			O
Rhus lancea	0.111	0.121	0.059	12.1	17.4	14.2	108	130	39.5	9.23	8.15	2.07	M
	0.097			12.2			126			7.92			O
	0.206			38.4			187			5.35			O
	0.071			7.0			99.1			10.1			I
Rhus ovata	0.046	0.067	0.029	13.5	21.6	10.2	297	321	16.8	3.36	3.12	0.169	O
	0.108			36.2			334			2.99			M
	0.050			15.9			320			3.12			I
	0.063			20.9			331			3.02			O

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Rosmarinus officinalis [3]	0.027	0.031	0.006	11.3	8.8	2.1	419	292	86.0	2.39	3.61	0.850	N/A
	0.031			8.4			269			3.71			N/A
	0.026			6.3			246			4.07			N/A
	0.039			9.1			234			4.28			N/A
Salvia leucophylla	0.028	0.065	0.037	7.0	15.6	8.1	249	246	19.4	4.02	4.08	0.335	N/A
	0.038			10.2			267			3.75			N/A
	0.101			22.2			220			4.55			N/A
	0.092			22.9			249			4.02			N/A
Sapium sebiferum	0.245	0.189	0.061	16.9	13.9	4.6	69.1	73.5	3.9	14.5	13.6	0.711	O
	0.234			18.3			78.4			12.7			O
	0.115			8.5			74.1			13.5			I
	0.161			11.7			72.6			13.8			M
Spartium junceum	0.007	0.013	0.004	2.0	3.8	1.5	284	309	92.3	3.52	3.42	0.842	N/A
	0.017			4.7			274			3.65			N/A
	0.012			5.4			444			2.25			N/A
	0.014			3.2			235			4.26			N/A
Syagrus romanzoffiana	3.518	0.208	0.206	641	619	30.9	182	184	2.1	5.49	5.45	0.0616	N/A
	3.227			597			185			5.40			N/A
Ulmus parvifolia	0.072	0.100	0.061	11.9	12.6	7.3	166	123	37.1	6.03	8.80	2.97	O
	0.114			15.3			134			7.46			O
	0.038			2.9			77.4			12.9			I
	0.178			20.3			114			8.77			M

Appendix B. (Continued)

Scientific Name	Leaf Area (m^2)			Leafmass (g)			Specific Leaf Weight ($g\ m^{-2}$)			Specific Leaf Area ($m^2\ g^{-1}$) x 10^3			Sample Location
	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	Samples	Mean	Std. Dev.	
Vitex	0.116	0.055	0.042	17.4	7.7	6.5	149	135	11.8	6.69	7.47	0.642	O
agnus-castus [2]	0.023			3.2			139			7.20			O
	0.043			5.4			126			7.91			O
	0.037			4.6			124			8.07			M
Vitis	0.149	0.150	0.027	11.5	10.2	2.4	77.6	67.6	9.0	12.9	15.0	2.08	O
vinifera	0.185			12.2			66.0			15.2			O
'Thompson Seedless'	0.147			10.4			70.7			14.1			I
	0.120			6.8			56.3			17.8			M
Washingtonia	0.081	0.404	0.655	11.5	95.8	170	141	166	59.0	7.07	6.48	1.78	M
robusta	0.057			7.1			123			8.11			O
	0.090			13.3			147			6.80			I
	1.39			351			254			3.94			O

[1] Locations within the crowns are identified as O = outer part of the crown, sun leaves; M = middle third of the crown; I = inner third of the crown, shade leaves; N/A = not applicable.

[2] Leaves of these species were more difficult than the others to measure for leaf area due to their morphology.

[3] Samples were taken with a cube volume of 0.00354 m^3.

APPENDIX C

Detailed Data from Field Survey of Natural Vegetation in San Diego County

Table C-1. Species composition, areal coverage, and crown volume of overstory vegetation within the sample elements in polygon F1 ordered by decreasing total areal cover.

Species	Areal Coverage								Crown Volume							
	Elem 1		Elem 2		Elem 3		Total*		Elem 1		Elem 2		Elem 3		Total*	
	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)
Quercus chrysolepis	0	0	3700	70	0	0	3700	29	0	0	15000	80	0	0	15000	29
Pinus jeffreyi	2000	46	27	1	390	11	2400	18	11000	54	86	0	3400	27	14000	28
Quercus kelloggii	860	20	640	12	840	25	2300	18	4300	21	1700	9	3800	30	9800	19
Quercus agrifolia	930	22	0	0	420	12	1300	10	3500	17	0	0	1800	14	5300	10
Arctostaphylos pungens	180	4	0	0	580	17	760	6	200	1	0	0	340	3	540	1
Quercus berberidifolia	13	0	340	6	350	10	700	5	19	0	350	2	200	2	560	1
Pinus coulteri	0	0	0	0	610	18	610	5	0	0	0	0	2800	22	2800	5
Calocedrus decurrens	270	7	180	4	73	2	530	4	1200	6	1000	5	330	3	2500	5
Cercocarpus betuloides	13	0	290	5	130	4	430	3	13	0	280	1	80	1	380	1
Quercus wislizenii	11	0	68	1	0	0	79	1	13	0	360	2	0	0	380	1
Ceanothus integerrimus	0	0	24	1	28	1	53	0	0	0	19	0	22	0	41	0
Arctostaphylos pringlei	0	0	33	1	0	0	33	0	0	0	26	0	0	0	26	0
Ceanothus leucodermis	0	0	0	0	13	0	13	0	0	0	0	0	11	0	11	0
Adenostoma fasciculatum	2	0	0	0	0	0	2	0	2	0	0	0	0	0	2	0
Total*	4200	100	5300	100	3400	100	13000	100	20000	100	19000	100	13000	100	52169	100

* May not add to totals shown due to rounding

Table C-2. Species composition, areal coverage, and crown volume of overstory vegetation within the sample elements in polygon F2 ordered by decreasing total areal cover.

Species	Areal Coverage								Crown Volume							
	Elem 1		Elem 2		Elem 3		Total*		Elem 1		Elem 2		Elem 3		Total*	
	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)
Quercus kellogii	1200	37	1200	33	880	33	3300	34	5100	44	5900	54	3200	69	14000	52
Pinus jeffreyi	1300	39	350	9	140	5	1700	18	5100	44	2400	23	510	11	8000	30
Quercus berberidifolia	130	4	520	14	570	21	1200	13	63	1	270	2	330	7	660	2
Ceanothus palmeri	43	1	210	6	690	25	940	10	27	0	160	1	400	8	580	2
Cercocarpus betuloides	220	7	490	13	62	2	770	8	110	1	250	2	48	1	410	2
Adenostoma fasciculatum	0	0	200	6	290	12	500	5	0	0	100	1	150	3	250	1
Pinus coulteri	190	6	260	7	0	0	450	5	1000	9	1500	14	0	0	2500	9
Ceanothus greggii	0	0	200	5	54	2	250	3	0	0	98	1	30	1	130	0
Artemisia tridentata	0	0	230	6	0	0	230	2	0	0	99	1	0	0	99	0
Arctostaphylos pringlei	170	5	19	1	24	1	220	2	90	1	10	0	12	0	110	0
Rhamnus ilicifolia	47	1	0	0	0	0	47	1	25	0	0	0	0	0	25	0
Quercus agrifolia	8	0	0	0	0	0	8	0	27	0	0	0	0	0	27	0
Rhus trilobata	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Total*	3300	100	3700	100	2700	100	9700	100	12000	100	11000	100	4700	100	27000	100

* May not add to totals shown due to rounding

Table C-3. Species composition, areal coverage, and crown volume of overstory vegetation within the sample elements in polygon W1 ordered by decreasing total areal cover.

Species	Areal Coverage								Crown Volume							
	Elem 1		Elem 2		Elem 3		Total*		Elem 1		Elem 2		Elem 3		Total*	
	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)
Quercus engelmannii	520	39	1400	54	920	26	2800	38	1700	48	5400	81	4400	40	11000	54
Quercus agrifolia	410	31	280	11	1300	35	2000	26	1500	43	800	12	5400	50	7700	37
Adenostoma fasciculatum	0	0	0	0	900	25	900	12	0	0	0	0	370	3	370	2
Arctostaphylos glandulosa	360	27	47	2	87	2	490	7	330	9	45	1	140	1	520	2
Salvia apiana	0	0	310	12	43	1	360	5	0	0	70	1	10	0	80	0
Eriogonum fasciculatum	6	0	280	11	40	1	330	4	1	0	71	1	10	0	82	0
Symphoricarpos mollis	0	0	80	3	120	3	200	3	0	0	32	0	30	0	62	0
Quercus kelloggii	5	0	31	1	120	3	160	2	5	0	190	3	470	4	660	3
Marrubium vulgare	0	0	120	5	0	0	120	2	0	0	18	0	0	0	18	0
Ceanothus leucodermis	0	0	0	0	55	2	55	1	0	0	0	0	59	1	59	0
Rhus trilobata	36	3	0	0	14	0	50	1	7	0	0	0	6	0	13	0
Rhamnus ilicifolia	0	0	2	0	13	0	15	0	0	0	1	0	6	0	7	0
Juniperus californica	0	0	10	0	0	0	10	0	0	0	22	0	0	0	22	0
Rhamnus californica	0	0	10	0	0	0	10	0	0	0	10	0	0	0	10	0
Artemisia californica	0	0	0	0	4	0	4	0	0	0	0	0	1	0	1	0
Salix lasiolepis	0	0	3	0	0	0	3	0	0	0	3	0	0	0	3	0
Ribes indecorum	0	0	0	0	2	0	2	0	0	0	0	0	1	0	1	0
Lonicera subspicata	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Lotus scoparius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total*	1300	100	2600	100	3600	100	7500	100	3600	100	6700	100	11000	100	21000	100

* May not add to totals shown due to rounding

Table C-4. Species composition, areal coverage, and crown volume of overstory vegetation within the sample elements in polygon W2 ordered by decreasing total areal cover.

Species	Areal Coverage						Crown Volume					
	Elem 1		Elem 2		Total*		Elem 1		Elem 2		Total*	
	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^3)	(%)	(m^3)	(%)	(m^3)	(%)
Quercus engelmannii	2700	98	1000	25	3700	55	14000	99	2200	20	16000	64
Quercus kelloggii	0	0	1400	35	1400	21	0	0	6400	57	6400	25
Quercus berberidifolia	0	0	800	20	800	12	0	0	730	7	730	3
Quercus agrifolia	13	0	200	5	210	3	64	0	720	6	780	3
Pinus coulteri	0	0	180	4	180	3	0	0	900	8	900	4
Arctostaphylos glandulosa	0	0	130	3	130	2	0	0	86	1	86	0
Adenostoma fasciculatum	0	0	110	3	110	2	0	0	46	0	46	0
Salvia apiana	24	1	23	1	47	1	5	0	5	0	10	0
Cercocarpus betuloides	0	0	41	1	41	1	0	0	56	1	56	0
Garrya veatchii	0	0	39	1	39	1	0	0	64	1	64p	0
Rhamnus ilicifolia	8	0	15	0	24	0	6	0	10	0	16	0
Ceanothus leucodermis	0	0	11	0	11	0	0	0	7	0	7	0
Heteromeles arbutifolia	0	0	11	0	11	0	0	0	7	0	7	0
Yucca whipplei	0	0	10	0	10	0	0	0	2	0	2	0
Eriogonum fasciculatum	2	0	4	0	7	0	0	0	1	0	2	0
Lonicera subspicata	0	0	6	0	6	0	0	0	2	0	2	0
Ceanothus integerrimus	0	0	2	0	2	0	0	0	1	0	1	0
Total*	2700	100	4000	100	6700	100	14000	100	11000	100	26000	100

* May not add to totals shown due to rounding

Table C-5. Species composition, line transect coverage, and mean crown height of vegetation within the sample elements in polygon C1 ordered by decreasing total line transect coverage.

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Quercus berberidifolia	11	4	330	64	330	58	160	31	820	44	2.1	2.0	1.6	1.9	1.8
Adenostoma fasciculatum	160	57	75	15	190	34	200	39	620	34	1.0	0.9	0.7	0.7	0.8
Quercus engelmannii	0	0	0	0	0	0	83	17	83	5	-	-	-	4.7	4.7
Eriogonum fasciculatum	54	20	0	0	0	0	2	0	56	3	0.7	-	-	0.4	0.7
Ceanothus crassifolius	0	0	22	4	13	2	6	1	40	2	-	1.3	1.1	1.3	1.2
Heteromeles arbutifolia	0	0	27	5	1	0	8	2	36	2	-	1.2	0.5	1.8	1.3
Cercocarpus betuloides	0	0	23	4	9	2	0	0	32	2	-	1.5	1.6	-	1.6
Prunus ilicifolia	2	1	14	3	0	0	7	1	23	1	1.7	0.9	-	0.9	1.0
Rhamnus ilicifolia	0	0	3	1	7	1	6	1	16	1	-	0.8	0.6	0.6	0.7
Salvia apiana	8	3	2	0	1	0	4	1	15	1	0.4	0.5	0.4	0.3	0.4
Unknown 1	11	4	2	0	0	0	0	0	13	1	1.1	1.0	-	-	1.1
Quercus agrifolia	7	2	5	1	0	0	1	0	12	1	4.5	1.9	-	1.2	3.3
Arctostaphylos glandulosa	0	0	2	0	0	0	8	2	10	1	-	2.0	-	1.1	1.3
Malosma laurina	5	2	0	0	0	0	4	1	9	1	1.5	-	-	1.2	1.4
Ceanothus leucodermis	0	0	0	0	5	1	3	1	9	0	-	-	1.4	1.6	1.5
Yucca whipplei	4	1	1	0	0	0	3	0	7	0	0.4	0.9	-	0.5	0.5
Mirabilis californica	6	2	0	0	0	0	0	0	6	0	0.2	-	-	-	0.2
Mimulus sp.	0	0	1	0	1	0	5	1	6	0	-	0.5	0.3	0.4	0.4
Salvia mellifera	0	0	0	0	0	0	5	1	5	0	-	-	-	0.5	0.5
Xylococcus bicolor	5	2	0	0	0	0	0	0	5	0	1.4	-	-	-	1.4
Rhus ovata	1	0	1	0	0	0	1	0	4	0	1.3	0.7	-	0.9	1.0
Arctostaphylos glauca	0	0	0	0	3	1	0	0	4	0	-	0.6	0.7	-	0.7
Lotus scoparius	3	1	0	0	0	0	0	0	3	0	0.4	-	-	-	0.4
Lonicera subspicata	0	0	1	0	1	0	1	0	3	0	-	0.4	0.4	0.5	0.4
Artemisia californica	2	1	0	0	0	0	0	0	2	0	0.8	-	-	-	0.8
Galium sp.	0	0	1	0	0	0	1	0	1	0	-	0.5	-	0.2	0.4
Ribes indecorum	0	0	1	0	0	0	0	0	1	0	-	1.1	-	-	1.1
Ceanothus greggii	1	0	0	0	0	0	0	0	1	0	0.8	-	-	-	0.8

Table C-5. (continued)

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Hazardia squarrosus	0	0	0	0	0	0	1	0	1	0	-	-	-	0.4	0.4
Pellea mucronata	0	0	0	0	0	0	1	0	1	0	-	-	-	0.2	0.2
Unknown 2	0	0	0	0	0	0	1	0	1	0	-	-	-	0.5	0.5
Total*	280	100	500	100	560	100	500	100	1800	100	1.1	1.7	1.3	1.8	1.5

* May not add to totals shown due to rounding

Table C-6. Species composition, line transect coverage, and mean crown height of vegetation within the sample elements in polygon C2 ordered by decreasing total line transect coverage.

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Adenostoma fasciculatum	290	75	280	54	100	22	230	54	900	50	0.8	0.8	0.8	0.8	0.8
Xylococcus bicolor	0	0	37	7	120	27	83	20	240	14	-	1.3	1.0	1.3	1.1
Eriogonum fasciculatum	4	1	44	9	78	17	19	4	150	8	0.8	0.6	0.6	0.7	0.6
Rhus ovata	22	6	30	6	22	5	13	3	86	5	1.2	1.0	1.5	1.2	1.2
Malosma laurina	0	0	25	5	46	10	10	2	82	5	-	1.2	1.0	1.1	1.1
Quercus berberidifolia	0	0	33	6	29	6	9	2	71	4	-	1.9	1.4	1.4	1.6
Ceanothus greggii	34	9	10	2	0	0	0	0	44	2	0.8	0.9	-	-	0.8
Cneoridium dumosum	0	0	0	0	0	0	40	9	40	2	-	-	-	0.7	0.7
Ceanothus oliganthus	0	0	31	6	8	2	0	0	39	2	-	1.3	1.1	-	1.2
Arctostaphlos glandulosa	23	6	1	0	0	0	1	0	24	1	1.2	0.8	-	0.8	1.2
Artemisia californica	0	0	0	0	15	3	3	1	18	1	-	-	0.6	0.7	0.6
Salvia apiana	4	1	1	0	11	2	2	0	18	1	0.3	0.4	0.5	0.5	0.5
Ceanothus leucodermis	2	1	3	0	6	1	0	0	10	1	0.9	1.3	1.0	-	1.1
Yucca whipplei	1	0	3	1	2	0	4	1	10	1	0.5	0.7	0.6	0.7	0.7
Mirabilis californica	0	0	0	0	8	2	0	0	9	0	-	-	0.3	0.3	0.3
Rhamnus ilicifolia	0	0	5	1	0	0	2	1	8	0	-	0.6	0.4	0.8	0.6
Salvia mellifera	5	1	2	0	0	0	0	0	6	0	0.5	0.4	-	-	0.5
Marah macrocarpus	0	0	0	0	2	1	3	1	5	0	-	-	0.3	0.5	0.4
Eriodictyon crassifolium	0	0	3	1	1	0	0	0	5	0	-	0.7	0.6	-	0.6
Salvia clevelandii	0	0	4	1	0	0	0	0	4	0	-	0.5	-	-	0.5
Lotus scoparius	1	0	0	0	1	0	1	0	3	0	0.4	-	0.5	0.5	0.4
Lonicera subspicata	0	0	0	0	0	0	2	0	3	0	0.3	0.4	-	0.6	0.4
Trichostema lanatum	2	0	1	0	0	0	0	0	3	0	-	0.4	-	0.7	0.6
Brickellia californica	0	0	0	0	2	1	0	0	2	0	-	-	0.6	-	0.6
Heteromeles arbutifolia	0	0	2	0	0	0	0	0	2	0	-	1.3	-	-	1.3
Mimulus sp.	0	0	0	0	0	0	1	0	2	0	0.4	0.5	-	0.4	0.4
Prunus ilicifolia	0	0	2	0	0	0	0	0	2	0	-	0.8	-	-	0.8
Cercocarpus betuloides	0	0	0	0	0	0	1	0	1	0	-	-	-	1.2	1.2
Unknown 4	0	0	0	0	1	0	0	0	1	0	-	-	0.3	-	0.3

Table C-6. (continued)

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Unknown 2	0	0	1	0	0	0	0	0	1	0	0.2	0.3	-	-	0.2
Pellea mucronata	0	0	0	0	0	0	0	0	1	0	0.2	-	0.2	0.3	0.2
Yucca schidigera	0	0	0	0	0	0	1	0	1	0	-	-	-	0.5	0.5
Galium sp.	0	0	0	0	0	0	0	0	0	0	0.3	-	-	0.3	0.3
Unknown 5	0	0	0	0	0	0	0	0	0	0	-	0.4	-	-	0.4
Cardus pycnocephalus	0	0	0	0	0	0	0	0	0	0	-	-	0.2	-	0.2
Unknown 1	0	0	0	0	0	0	0	0	0	0	-	-	-	0.3	0.3
Hazardia squarrosus	0	0	0	0	0	0	0	0	0	0	-	-	-	0.5	0.5
Unknown 3	0	0	0	0	0	0	0	0	0	0	-	-	0.5	-	0.5
Total*	390	100	510	100	560	100	430	100	1800	100	0.8	0.9	0.9	0.9	0.9

* May not add to totals shown due to rounding

Table C-7. Species composition, line transect coverage, and mean crown height of vegetation within the sample elements in polygon S1 ordered by decreasing total line transect coverage.

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Adenostoma fasciculatum	6	2	190	58	100	24	0	0	300	24	1.1	0.9	1.0	-	1.0
Eriogonum fasciculatum	100	33	14	4	56	13	98	54	270	22	0.6	0.5	0.7	1.0	0.7
Artemisia californica	100	32	4	1	72	17	51	28	230	18	0.7	0.7	0.7	0.6	0.7
Malosma laurina	84	27	2	1	95	22	14	7	190	15	1.2	1.2	1.2	1.4	1.2
Xylococcus bicolor	0	0	28	8	73	17	0	0	100	8	-	1.5	1.2	-	1.3
Ceanothus oliganthus	0	0	44	13	0	0	0	0	44	4	-	1.2	-	-	1.2
Salvia mellifera	2	1	36	11	0	0	0	0	39	3	0.8	0.8	-	-	0.8
Quercus berberidifolia	0	0	0	0	20	5	0	0	20	2	-	-	1.9	-	1.9
Salvia apiana	3	1	0	0	5	1	2	1	11	1	0.5	-	0.5	0.4	0.5
Cneoridium dumosum	0	0	9	3	0	0	0	0	9	1	-	0.7	-	-	0.7
Mirabilis californica	3	1	2	1	0	0	1	1	7	1	0.2	0.4	-	0.3	0.3
Lotus scoparius	2	1	0	0	2	1	2	1	7	1	0.3	-	0.4	0.5	0.4
Baccharis sarothroides	0	0	0	0	0	0	6	3	6	0	-	-	-	1.1	1.1
Cercocarpus betuloides	0	0	0	0	4	1	0	0	4	0	-	-	2.2	-	2.2
Hazardia squarrosus	4	1	0	0	0	0	0	0	4	0	0.7	-	-	-	0.7
Rhamnus crocea	0	0	0	0	0	0	3	2	3	0	-	-	-	1.1	1.1
Ericameria sp.	0	0	0	0	0	0	3	2	3	0	-	-	-	0.3	0.3
Mimulus sp.	1	0	1	0	1	0	0	0	3	0	0.5	0.6	0.9	-	0.7
Yucca whipplei	1	0	0	0	1	0	0	0	2	0	0.7	0.6	0.5	-	0.6
Gutierrezia californica	2	1	0	0	0	0	0	0	2	0	0.3	-	-	-	0.3
Ribes indecorum	0	0	0	0	2	0	0	0	2	0	-	-	0.7	-	0.7
Rhamnus ilicifolia	0	0	0	0	1	0	0	0	1	0	-	-	1.2	-	1.2
Ceanothus greggii	0	0	1	0	0	0	0	0	1	0	-	0.7	-	-	0.7
Unknown 1	0	0	0	0	0	0	0	0	0	0	0.1	-	0.2	-	0.2
Trichostema lanatum	0	0	0	0	0	0	0	0	0	0	0.2	-	-	-	0.2
Total*	310	100	330	100	440	100	180	100	1300	100	0.8	1.0	1.0	0.9	0.9

* May not add to totals shown due to rounding

Table C-8. Species composition, line transect coverage, and mean crown height of vegetation within the sample elements in polygon S2 ordered by decreasing total line transect coverage.

Species	Line Transect Coverage										Mean Crown Height				
	Elem 1		Elem 2		Elem 3		Elem 4		Total*		Elem 1	Elem 2	Elem 3	Elem 4	Total*
	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(%)	(m)	(m)	(m)	(m)	(m)
Artemisia californica	161	45	189	74	44	9	130	38	524	35	0.6	0.6	0.7	0.7	0.7
Salvia mellifera	90	25	0	0	163	31	32	9	284	19	0.7	-	0.7	0.7	0.7
Malosma laurina	40	11	0	0	95	18	86	25	221	15	1.1	-	1.4	0.9	1.1
Rhus integrifolia	1	0	0	0	101	19	9	3	111	8	1.1	-	1.5	1.3	1.5
Malacothamnus fasciculatus	1	0	0	0	71	13	9	3	81	5	0.5	-	0.7	0.9	0.7
Baccharis pilularis	7	2	39	15	2	0	0	0	47	3	0.6	0.6	0.7	-	0.6
Lotus scoparius	1	0	0	0	25	5	19	5	45	3	0.4	-	0.5	0.4	0.5
Eriogonum fasciculatum	6	2	0	0	4	1	31	9	42	3	0.6	-	0.5	0.6	0.6
Mimulus sp.	19	5	0	0	2	0	2	1	23	2	0.5	-	0.6	0.6	0.5
Galium sp.	14	4	3	1	1	0	3	1	20	1	0.3	0.3	0.6	0.3	0.3
Opuntia littoralis	2	0	1	0	1	0	13	4	17	1	0.4	0.3	0.3	0.8	0.7
Isocoma menziesii	9	2	7	3	0	0	0	0	16	1	0.4	0.3	-	-	0.3
Foeniculum vulgare	2	0	7	3	0	0	0	0	9	1	0.3	0.3	-	-	0.3
Encelia californica	2	1	7	3	0	0	0	0	9	1	0.4	0.5	-	-	0.5
Lonicera subspicata	0	0	0	0	6	1	0	0	6	0	-	-	0.5	-	0.5
Ceanothus spinosus	0	0	0	0	5	1	0	0	5	0	-	-	2.2	-	2.2
Gnaphalium bicolor	0	0	0	0	0	0	4	1	4	0	-	-	-	0.5	0.5
Unknown 1	1	0	0	0	0	0	3	1	4	0	0.1	-	-	0.2	0.2
Unknown 3	3	1	0	0	0	0	0	0	3	0	0.7	-	-	-	0.7
Isomeris arborea	0	0	3	1	0	0	0	0	3	0	-	1.1	-	-	1.1
Solanum parishii	1	0	0	0	0	0	0	0	2	0	0.4	-	-	0.3	0.4
Toxicodendron diversilobum	0	0	0	0	2	0	0	0	2	0	-	-	0.8	-	0.8
Calystegia macrostegia	0	0	0	0	0	0	1	0	1	0	-	-	-	0.2	0.2
Ribes indecorum	0	0	0	0	1	0	0	0	1	0	-	-	0.7	-	0.7
Hazardia squarrosus	0	0	0	0	1	0	0	0	1	0	0.3	-	0.6	-	0.5
Mirabilis californica	0	0	0	0	0	0	1	0	1	0	-	-	-	0.3	0.3
Unknown 2	0	0	0	0	0	0	0	0	0	0	-	0.4	-	-	0.4
Total*	359	100	256	100	522	100	342	100	1480	100	0.7	0.6	1.0	0.7	0.8

* May not add to totals shown due to rounding

APPENDIX D

Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air.

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
AZUSA	**Aug 4-6, 1997**							
8/4/97	0600-0900	0.23	0.23	0.11	0.09	0.41	0.46	
8/4/97	0600-0900	0.23		0.08		0.52		
8/4/97	0907-1206	0.51	0.52	0.48	0.47	0.76	0.77	
8/4/97	0907-1206	0.53		0.46		0.78		
8/4/97	1306-1603	0.46	0.46	0.65	0.51	1.06	0.92	
8/4/97	1306-1603	0.47		0.36		0.78		
8/4/97	1700-2000	0.74	0.75	0.56	0.71	0.79	1.06	
8/4/97	1700-2000	0.76		0.86		1.33		
8/4/97	2006-0300	0.14	0.16	0.33	0.34	0.50	0.59	
8/4/97	2006-0300	0.18		0.34		0.69		
8/5/97	0307-0600	0.23	0.24	1.01	1.01	0.57	0.58	
8/5/97	0307-0600	0.24		1.02		0.58		
8/5/97	0618-0900	0.46	0.47	0.72	0.82	1.46	1.73	
8/5/97	0618-0900	0.48		0.92		2.00		
8/5/97	0907-1202	0.63	0.66	0.72	0.74	1.55	1.61	
8/5/97	0907-1202	0.70		0.75		1.68		
8/5/97	1300-1600	0.59	0.61	0.61	0.70	1.29	1.49	
8/5/97	1300-1600	0.62		0.78		1.70		
8/5/97	1701-2000	0.74	0.73	0.45	0.46	0.70	0.72	
8/5/97	1701-2000	0.72		0.48		0.75		
8/5- 8/6/97	2005-0300	0.47	0.44	0.42	0.41	1.22	1.20	
8/5-8/6/97	2005-0300	0.41		0.41		1.19		
8/6/97	0306-0600	0.23	0.23	0.60	0.62	0.90	0.90	
8/6/97	0306-0600	0.23		0.64		0.89		
8/6/97	0616-0900	0.37	0.37	0.65	0.60	1.26	1.24	
8/6/97	0616-0900	0.38		0.55		1.23		
8/6/97	0906-1200	0.50	0.51	0.37	0.35	0.74	0.75	

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Sample	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
8/6/97	0906-1200	0.52		0.33		0.75		
8/6/97	1300-1600	0.51	0.51	0.45	0.44	0.83	0.81	
8/6/97	1300-1600	0.51		0.43		0.79		
8/6/97	1700-2000	0.40	0.40	0.11	0.15	0.17	0.23	
8/6/97	1700-2000	0.40		0.18		0.29		
AZUSA	**Aug 22-23, 1997**							
8/22/97	0318-0600	0.24	0.24*	0.29	0.29*	0.53	0.53*	
8/22/97	0318-0600	0.67		1.15		2.04		Sampling tube contents transferred from broken tube
8/22/97	0610-0900	0.02	0.21*	0.09	0.45*	0.08	0.77*	All results low, seems like a back sampling tube
8/22/97	0610-0900	0.21		0.45		0.77		
8/22/97	0905-1157	0.39	0.41	0.34	0.33	0.66	0.69	
8/22/97	0905-1157	0.44		0.32		0.71		
8/22/97	1210-1500	0.61	0.52*	1.33	0.44*	1.50	0.78*	Sampling tube contents transferred from broken tube
8/22/97	1210-1500	0.52		0.44		0.78		
8/22/97	1504-1800	0.47	0.45	0.79	0.69	1.17	1.07	
8/22/97	1504-1800	0.44		0.59		0.97		
8/22-23/97	1815-0300	0.28	0.30	2.82	3.34	1.01	1.52	
8/22-23/97	1815-0300	0.32		3.87		2.03		
8/23/97	0304-0600	0.27	0.25	0.45	0.55	1.16	0.98	
8/23/97	0304-0600	0.22		0.65		0.80		
8/23/97	0615-0900	0.26	0.26*	0.70	0.70*	0.94	0.94*	
8/23/97	0615-0900	-		-		-		(Mass detector stopped during analysis, sample destroyed)
8/23/97	0903-1200	0.53	0.51	0.57	0.53	0.61	0.74	
8/23/97	0903-1200	0.48		0.49		0.88		
8/23/97	1208-1500	0.34	0.31	0.56	0.49	0.72	0.82	
8/23/97	1208-1500	0.29		0.41		0.92		

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
8/23/97	1505-1800	0.37	0.37*	0.46	0.46*	0.70	0.70*	
8/23/97	1505-1800	0.42		0.55		0.98		Sampling tube contents transferred from broken tube
AZUSA	**Sep 4-7, 1997**							
9/4/97	0300-0600	0.27	0.28	0.88	0.89	1.43	1.29	
9/4/97	0300-0600	0.28		0.89		1.15		
9/4/97	0606-0900	0.22	0.22	0.55	0.55	0.63	0.56	
9/4/97	0606-0900	0.22		0.55		0.50		
9/4/97	0904-1200	0.58	0.57	0.49	0.46	1.77	1.54	
9/4/97	0904-1200	0.56		0.44		1.31		
9/4/97	1300-1600	0.35	0.35	0.38	0.62	0.75	1.00	
9/4/97	1300-1600	0.35		0.86		1.25		
9/4/97	1700-2000	0.59	0.61	0.34	0.40	0.63	0.50	
9/4/97	1700-2000	0.63		0.47		0.36		
9/4/97	2014-2400	0.14	0.13	0.29	0.26	0.28	0.25	
9/4/97	2014-2400	0.12		0.23		0.22		
9/5/97	0006-0300	0.07	0.06	0.15	0.17	0.32	0.26	
9/5/97	0006-0300	0.06		0.20		0.20		
9/5/97	0305-0600	0.06	0.06	0.15	0.16	0.30	0.25	
9/5/97	0305-0600	0.06		0.16		0.19		
9/5/97	0615-0900	-	0.17*	-	0.48*	-	0.38*	High toluene, analysis in the SCAN mode
9/5/97	0615-0900	0.17		0.48		0.38		
9/5/97	0903-1200	0.40	0.43	0.57	0.57*	0.98	0.98*	
9/5/97	0903-1200	0.46		0.05		0.38		Analyzed much later than other samples
9/5/97	1300-1600	0.32	0.31	0.41	0.39	1.08	1.01	
9/5/97	1300-1600	0.30		0.37		0.94		
9/5/97	1700-2000	0.36	0.37	0.27	0.32	0.33	0.41	
9/5/97	1700-2000	0.38		0.37		0.48		

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
9/5/97	2006-2400	0.19	0.18	0.37	0.58	0.42	0.57	
9/5/97	2006-2400	0.18		0.78		0.73		
9/6/97	0008-0300	0.11	0.11	0.22	0.22	0.33	0.28	
9/6/97	0008-0300	0.10		0.23		0.24		
9/6/97	0306-0600	0.09	0.09	0.23	0.30	0.36	0.36	
9/6/97	0306-0600	0.10		0.37		0.37		
9/6/97	0615-0900	0.14	0.15	0.30	0.33	0.27	0.27	
9/6/97	0615-0900	0.15		0.35		0.27		
9/6/97	0903-1200	0.34	0.35	0.48	0.50	0.54	0.65	
9/6/97	0903-1200	0.35		0.53		0.76		
9/6/97	1300-1600	0.30	0.29	0.43	0.44	0.89	0.88	
9/6/97	1300-1600	0.28		0.45		0.86		
9/6/97	1700-1959	0.29	0.29	0.31	0.32	0.44	0.50	
9/6/97	1700-1959	0.30		0.32		0.56		
9/6/97	2010-2400	0.09	0.08	0.18	0.16	0.17	0.18	
9/6/97	2010-2400	0.08		0.13		0.18		
9/7/97	0005-0300	0.10	0.11	0.20	0.21	0.22	0.23	
9/7/97	0005-0300	0.11		0.22		0.23		
9/7/97	0306-0600	0.11	0.11	0.29	0.30	0.47	0.52	
9/7/97	0306-0600	0.12		0.31		0.57		
9/7/97	0604-0900	0.12	0.13	0.31	0.35	0.37	0.31	
9/7/97	0604-0900	0.13		0.39		0.25		
AZUSA	**Sep 28-29, 1997**							
9/28/97	0301-0600	0.16	0.15	0.32	0.28	2.30	2.31	
9/28/97	0301-0600	0.14		0.25		2.33		
9/28/97	0609-0900	0.23	0.23	-	0.31	0.66	0.53	MACR not resolved from overlying 70
9/28/97	0609-0900	0.22		0.31		0.39		
9/28/97	0904-1200	0.50	0.50	0.42	0.37	0.99	0.83	

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
9/28/97	0904-1200	0.50		0.32		0.66		
9/28/97	1300-1600	0.44	0.42	0.41	0.41	0.66	0.68	
9/28/97	1300-1600	0.39		0.40		0.69		
9/28/97	1700-2000	0.60	0.34*	0.78	0.25*	1.23	0.31*	Very low isoprene-d_8
9/28/97	1700-2000	0.34		0.25		0.31		
9/28-29/97	2015-0300	0.06	0.07	0.19	0.19	0.16	0.23	
9/28-29/97	2015-0300	0.08		0.18		0.30		
9/29/97	0310-0600	0.13	0.13	0.38	0.36	0.34	0.29	
9/29/97	0310-0600	0.12		0.33		0.23		
9/29/97	0616-0858	0.31	0.30	0.45	0.44	0.45	0.65	
9/29/97	0616-0858	0.30		0.43		0.86		
9/29/97	0900-1200	0.38	0.37	0.37	0.30	0.60	0.46	
9/29/97	0900-1200	0.36		0.24		0.32		
9/29/97	1300-1600	0.38	0.38	0.31	0.61	0.62	0.74	
9/29/97	1300-1600	0.37		0.92		0.85		
9/29/97	1700-2000	0.40	0.44	0.22	0.22	0.44	0.40	
9/29/97	1700-2000	0.48		0.21		0.36		
AZUSA	**Oct 3-4, 1997**							
10/3/97	0301-0600	0.05	0.06	0.12	0.13	0.31	0.26	
10/3/97	0301-0600	0.07		0.14		0.21		
10/3/97	0614-0900	0.06	0.06	0.08	0.07	0.11	0.12	
10/3/97	0614-0900	0.06		0.06		0.12		
10/3/97	0904-1200	0.12	0.12	0.10	0.10	0.21	0.22	
10/3/97	0904-1200	0.12		0.09		0.24		
10/3/97	1300-1600	0.21	0.21	0.21	0.19	0.42	0.38	
10/3/97	1300-1600	0.21		0.16		0.34		
10/3/97	1700-2000	0.17	0.15	0.18	0.15	0.53	0.44	
10/3/97	1700-2000	0.13		0.12		0.35		

Table D-1. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
10/3-4/97	2011-0300	0.06	0.06	0.21	0.19	0.66	0.50	
10/3-4/97	2011-0300	0.05		0.18		0.33		
10/4/97	0304-0600	0.12	0.12	0.18	0.18	0.98	0.99	
10/4/97	0304-0600	0.13		0.19		1.01		
10/5/97	0612-0900	0.07	0.07	0.07	0.08	0.24	0.26	
10/4/97	0612-0900	0.07		0.10		0.29		
10/4/97	0901-1200	0.17	0.16	0.17	0.16	0.35	0.36	
10/4/97	0901-1200	0.16		0.16		0.38		
10/4/97	1300-1600	0.36	0.24*	0.51	0.29*	1.06	0.64*	Sampling tube contents transferred from broken tube
10/4/97	1300-1600	0.24		0.29		0.64		
10/4/97	1700-2000	0.14	0.14	0.12	0.11	0.22	0.22	
10/4/97	1700-2000	0.14		0.11		0.23		

*Used single value

Table D-2. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air.

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
PINE MTN.	**Aug 4-6, 1997**							
8/4/97	1710-2000	2.12	2.21	0.89	0.91	1.54	1.58	
8/4/97	1710-2000	2.30		0.94		1.63		
08/4-08/5/97	2025-0259	0.04	0.03	0.60	0.58	1.15	1.11	
08/4-08/5/97	2025-0259	0.02		0.55		1.07		
8/5/97	0314-0559	0.05	0.04	0.15	0.14	0.26	0.25	
8/5/97	0314-0559	0.03		0.13		0.24		
8/5/97	0617-0858	1.85	1.96	0.09	0.09	0.15	0.16	
8/5/97	0617-0858	2.08		0.09		0.17		
8/5/97	0911-1200	0.96	1.00	0.30	0.33	0.81	0.83	
8/5/97	0911-1200	1.05		0.35		0.85		
8/5/97	1302-1600	0.59	0.59*	0.46	0.46*	0.71	0.71*	
8/5/97	1302-1600	-		-		-		Sampling tube missing
8/5/97	1700-2000	1.04	1.09	0.42	0.44	0.68	0.72	
8/5/97	1700-2000	1.15		0.47		0.77		
8/5/97	2015-0255	0.08	0.08	0.07	0.08	0.18	0.19	
8/5/97	2015-0255	0.08		0.08		0.20		
8/6/97	0310-0600	0.03	0.03	0.03	0.03	0.07	0.07	
8/6/97	0310-0600	0.04		0.03		0.07		
8/6/97	0615-0900	0.76	0.80	0.07	0.07	0.14	0.14	
8/6/97	0615-0900	0.84		0.07		0.15		
8/6/97	0915-1200	0.41	0.41	0.18	0.19	0.38	0.36	
8/6/97	0915-1200	0.41		0.20		0.34		
8/6/97	1300-1600	0.58	0.62	0.54	0.59	0.92	1.03	
8/6/97	1300-1600	0.65		0.65		1.13		
9/4/97	1702-2000	0.52	0.41	0.72	0.52	0.86	0.72	
9/4/97	1702-2000	0.31		0.32		0.57		
9/4/97	2008-2400	0.03	0.03	0.35	0.33	0.57	0.54	

Table D-2. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
9/4/97	2008-2400	0.03		0.32		0.52		
PINE MTN.	**Sep 4-7, 1997**							
9/5/97	0010-0338	0.03	0.02	0.10	0.10	0.23	0.16	
9/5/97	0010-0338	0.02		0.10		0.09		
9/5/97	0349-0600	0.01	0.02	0.08	0.09	0.17	0.18	
9/5/97	0349-0600	0.02		0.09		0.20		
9/5/97	0615-0900	0.66	0.63	0.10	0.10	0.18	0.20	
9/5/97	0615-0900	0.60		0.11		0.21		
9/5/97	0908-1200	0.96	0.93	0.21	0.21	0.38	0.38	
9/5/97	0908-1200	0.89		0.21		0.38		
9/5/97	1300-1600	1.73	1.71	1.05	1.07	0.96	1.38	
9/5/97	1300-1600	1.68		1.09		1.79		
9/5/97	1700-2000	0.62	0.59	0.31	0.30	0.53	0.49	
9/5/97	1700-2000	0.55		0.28		0.46		
9/5/97	2007-2355	0.04	0.03	0.21	0.26	0.32	0.39	
9/5/97	2007-2355	0.02		0.31		0.46		
9/6/97	0000-0255	0.02	0.02	0.09	0.10	0.18	0.17	
9/6/97	0000-0255	0.02		0.10		0.16		
9/6/97	0301-0600	0.03	0.03	0.11	0.10	0.17	0.14	
9/6/97	0301-0600	0.03		0.08		0.11		
9/6/97	0610-0900	0.52	0.48	0.08	0.08	0.17	0.16	
9/6/97	0610-0900	0.44		0.08		0.15		
9/6/97	0905-1200	0.56	0.60	0.20	0.17	0.04	0.17	
9/6/97	0905-1200	0.64		0.15		0.30		
9/6/97	1300-1600	1.62	1.58	0.36	0.25	0.45	0.35	
9/6/97	1300-1600	1.54		0.15		0.25		
9/6/97	1700-2000	0.56	0.55	0.33	0.33	0.54	0.54	
9/6/97	1700-2000	0.54		0.34		0.54		
9/6/97	2007-2355	0.06	0.05	0.17	0.18	0.28	0.26	

Table D-2. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
9/6/97	2007-2355	0.03		0.18		0.23		
9/7/97	0000-0255	0.03	0.03	0.18	0.16	0.23	0.24	
9/7/97	0000-0255	0.03		0.15		0.25		
9/7/97	0300-0555	0.05	0.05	0.13	0.10	0.19	0.15	
9/7/97	0300-0555	0.04		0.08		0.11		
9/7/97	0600-0900	1.83	1.88	0.12	0.10	0.27	0.21	
9/7/97	0600-0900	1.92		0.07		0.15		
MT. BALDY	**SEP 28-29, 1997**							
9/28/97	0904-1200	1.91	1.90	0.70	0.23*	0.32	0.40	(Ion 69 used to quantitate MACR)
9/28/97	0904-1200	1.90		0.23		0.48		(Ion 69 used to quantitate MACR)
9/28/97	1300-1600	1.14	1.17	0.37	0.37	0.91	0.93	
9/28/97	1300-1600	1.21		0.36		0.95		
9/28/97	1700-2000	2.15	2.27	0.39	0.40	0.82	0.85	
9/28/97	1700-2000	2.38		0.40		0.88		
9/28-29/97	2005-0300	0.09	0.08	0.24	0.24	0.44	0.47	
9/28-29/97	2005-0300	0.07		0.23		0.50		
9/29/97	0307-0600	0.06	0.06	0.07	0.06	0.17	0.17	
9/29/97	0307-0600	0.06		0.06		0.17		
9/29/97	0606-0900	0.69	0.65	0.06	0.06	0.15	0.15	
9/29/97	0606-0900	0.62		0.06		0.15		
9/29/97	0903-1200	1.84	1.84	0.28	0.27	0.65	0.63	
9/29/97	0903-1200	1.85		0.26		0.61		
9/29/97	1300-1600	1.08	1.07	0.29	0.29	0.60	0.61	
9/29/97	1300-1600	1.07		0.28		0.61		
9/29/97	1700-2000	1.94	1.92	0.44	0.39	0.91	0.79	
9/29/97	1700-2000	1.89		0.34		0.66		

Table D-2. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
MT. BALDY	**OCT 3-4, 1997**							
10/3/97	0619-0900	0.42	0.42	0.02	0.02	0.11	0.12	
10/3/97	0619-0900	0.41		0.02		0.13		
10/3/97	0903-1200	1.39	1.38	0.13	0.13	0.28	0.28	
10/3/97	0903-1200	1.37		0.12		0.28		
10/3/97	1301-1600	1.22	1.23	0.41	0.48	0.77	1.01	
10/3/97	1301-1600	1.23		0.55		1.25		
10/3/97	1703-2003	1.29	1.29*	0.37	0.37*	0.72	0.72*	
10/3/97	1703-2003	1.91		0.60		1.07		Very low isoprene-d_8
10/3-4/97	2010-0302	0.05	0.05	0.12	0.13	0.24	0.26	
10/3-4/97	2010-0302	0.05		0.13		0.27		
10/4/97	0310-0601	0.04	0.04	0.06	0.06	0.11	0.11	
10/4/97	0310-0601	0.04		0.05		0.12		
10/4/97	0612-0900	0.26	0.26	0.04	0.04	0.10	0.10	
10/4/97	0612-0900	0.27		0.04		0.10		
10/4/97	0903-1200	1.54	1.53	0.11	0.12	0.24	0.25	
10/4/97	0903-1200	1.51		0.12		0.25		
10/4/97	1300-1600	0.86	0.88	0.33	0.32	0.77	0.75	
10/4/97	1300-1600	0.90		0.31		0.73		
10/4/97	1700-2000	1.30	1.29	0.36	0.36	0.67	0.66	
10/4/97	1700-2000	1.28		0.36		0.65		

*Used single value

Table D-3. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air.

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
BANNING	**Aug 4-6, 1997**							
8/4/97	0600-0855	0.21	0.25	0.12	0.14	0.25	0.33	
8/4/97	0600-0855	0.29		0.16		0.40		
8/4/97	0902-1157	0.06	0.06	0.05	0.09	0.16	0.19	
8/4/97	0902-1157	0.07		0.12		0.23		
8/4/97	-	-	-	-	-	-	-	Wind knocked over sampling equipment, no sample
8/4/97	-	-		-		-		Wind knocked over sampling equipment, no sample
8/4/97	1504-1800	0.18	0.21	0.15	0.12	0.34	0.28	
8/4/97	1504-1800	0.24		0.09		0.21		
8/4-5/1997	1807-0255	0.08	0.08	0.40	0.35	0.76	0.68	
8/4-5/1997	1807-0255	0.08		0.30		0.59		
8/5/97	0303-0550	0.02	0.02	0.16	0.16	0.25	0.26	
8/5/97	0303-0550	0.02		0.16		0.27		
8/5/97	0604-0855	0.32	0.33	0.21	0.20	0.30	0.31	
8/5/97	0604-0855	0.34		0.20		0.32		
8/5/97	0901-1153	0.07	0.08	0.07	0.07	0.15	0.15	
8/5/97	0901-1153	0.08		0.06		0.15		
8/5/97	1159-1452	0.08	0.10	0.04	0.04	0.10	0.11	
8/5/97	1159-1452	0.12		0.04		0.12		
8/5/97	1458-1800	0.12	0.13	0.07	0.07	0.12	0.13	
8/5/97	1458-1800	0.14		0.07		0.14		
8/5- 8/6/97	1816-0255	0.06	0.07	0.15	0.22	0.30	0.39	
8/5- 8/6/97	1816-0255	0.08		0.28		0.48		
8/6/97	0301-0550	0.01	0.01	0.03	0.04	0.07	0.10	
8/6/97	0301-0550	0.02		0.06		0.14		
8/6/97	0605-0855	0.02	0.02	0.02	0.02	0.04	0.04	

Table D-3. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
8/6/97	0605-0855	0.02		0.02		0.04		
8/6/97	0901-1150	0.02	0.02	0.02	0.02	0.04	0.05	
8/6/97	0901-1150	0.03		0.02		0.05		
8/6/97	1155-1455	0.04	0.03	0.02	0.02	0.05	0.06	
8/6/97	1155-1455	0.03		0.02		0.07		
8/6/97	1500-1800	0.16	0.18	0.04	0.05	0.14	0.16	
8/6/97	1500-1800	0.19		0.05		0.17		
BANNING	**Aug 22-23, 1997**							
8/22/97	0600-0855	0.11	0.12	0.06	0.07	0.31	0.36	
8/22/97	0600-0855	0.12		0.08		0.41		
8/22/97	0900-1155	0.24	0.27	0.10	0.10	0.25	0.26	
8/22/97	0900-1155	0.29		0.10		0.27		
8/22/97	1200-1455	0.19	0.20	0.09	0.09	0.22	0.23	
8/22/97	1200-1455	0.21		0.09		0.23		
8/22/97	1500-1800	0.28	0.28	0.12	0.14	0.26	0.32	
8/22/97	1500-1800	0.28		0.17		0.37		
8/22-23/97	1813-0300	0.09	0.08	2.45	2.37	3.08	2.93	
8/22-23/97	1813-0300	0.07		2.29		2.79		
8/23/97	0303-0555	0.01	0.01	0.13	0.16	0.32	0.42	
8/23/97	0303-0555	0.02		0.18		0.51		
8/23/97	0603-0900	0.14	0.14	0.12	0.12	0.26	0.27	
8/23/97	0603-0900	0.14		0.12		0.27		
8/23/97	0903-1200	0.20	0.22	0.06	0.07	0.16	0.18	
8/23/97	0903-1200	0.24		0.08		0.20		
8/23/97	1202-1500	0.19	0.20	0.05	0.05	0.12	0.12	
8/23/97	1202-1500	0.21		0.05		0.12		
8/23/97	1502-1800	0.20	0.22	0.08	0.07	0.25	0.25	
8/23/97	1502-1800	0.23		0.07		0.25		

Table D-3. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
BANNING	**Sep 5-6, 1997**							
9/5/97	0600-0855	0.12	0.12	0.20	0.21	0.44	0.39	
9/5/97	0600-0855	0.13		0.21		0.34		
9/5/97	0900-1155	0.18	0.19	0.09	0.09	0.19	0.21	
9/5/97	0900-1155	0.19		0.09		0.22		
9/5/97	1158-1458	0.16	0.17	0.04	0.03	0.11	0.11	
9/5/97	1158-1458	0.18		0.03		0.10		
9/5/97	1501-1800	0.17	0.17	0.18	0.18	0.59	0.59	
9/5/97	1501-1800	0.18		0.18		0.60		
9/5-6/97	1824-0257	0.03	0.05	0.35	0.45	0.50	0.53	
9/5-6/97	1824-0257	0.06		0.55		0.57		
9/6/97	0308-0550	0.01	0.01*	0.29	0.29*	0.29	0.29*	
9/6/97	0308-0550	-		-		-		Sampling tube contents expelled from tube desorber
9/6/97	0610-0855	0.01	0.10*	0.11	0.33*	0.19	0.44*	Results low, seems like a back sampling tube
9/6/97	0610-0855	0.10		0.33		0.44		
9/6/97	0900-1158	0.03	0.03	0.08	0.05	0.16	0.14	
9/6/97	0900-1158	0.02		0.03		0.13		
9/6/97	1202-1458	0.11	0.12	0.04	0.04	0.11	0.11	
9/6/97	1205-1458	0.13		0.04		0.10		
9/6/97	1502-1800	0.21	0.21*	0.06	0.06*	0.18	0.18*	
9/6/97	1502-1800	1.64		0.60		1.85		Very low isoprene-d_8
BANNING	**Oct 3-4, 1997**							
10/3/97	0600-0858	0.05	0.05	0.07	0.08	0.27	0.25	
10/3/97	0600-0858	0.05		0.10		0.22		
10/3/97	0900-1158	0.06	0.06	0.05	0.07	0.14	0.14	

Table D-3. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air (continued).

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
10/3/97	0900-1158	0.06		0.08		0.14		
10/3/97	1200-1458	0.03	0.03	0.03	0.03	0.10	0.08	
10/3/97	1200-1458	0.03		0.03		0.07		
10/3/97	1500-1800	0.19	0.19	0.15	0.15	0.36	0.36	
10/3/97	1500-1800	0.20		0.15		0.35		
10/3-4/97	1807-0258	0.04	0.04	0.17	0.14	0.17	0.18	
10/3-4/97	1807-0258	0.03		0.11		0.18		
10/4/97	0300-0553	0.03	0.04	0.19	0.18	0.30	0.32	
10/4/97	0300-0553	0.04		0.18		0.33		
10/4/97	0601-0858	0.10	0.10	0.17	0.16	0.32	0.29	
10/4/97	0601-0858	0.10		0.16		0.27		
10/4/97	0900-1158	0.14	0.14	0.10	0.10	0.32	0.30	
10/4/97	0900-1158	0.13		0.10		0.27		
10/4/97	1200-1458	0.13	0.12	0.11	0.10	0.31	0.28	
10/4/97	1200-1458	0.12		0.09		0.24		
10/4/97	1500-1800	0.10	0.11	0.13	0.16	0.45	0.46	
10/4/97	1500-1800	0.13		0.19		0.47		

*Used single value

Table D-4. Detailed Data from Measurements of Isoprene and its Atmospheric Reaction Products in Ambient Air.

Date	Sampling	Isoprene ppbv	Isoprene av, ppbv	MACR ppbv	MACR av, ppbv	MVK ppbv	MVK av, ppbv	Reason for discarding data
LOS ANGELES, NORTH MAIN STREET			**Aug 22-23, 1997**					
8/22/97	0558-0855	0.40	0.37	0.75	0.77	0.53	0.50	
8/22/97	0558-0855	0.35		0.80		0.47		
8/22/97	0900-1155	0.10	0.11	1.12	1.26	1.10	0.98	
8/22/97	0900-1155	0.11		1.41		0.85		
8/22/97	1202-1457	0.22	0.21	0.50	0.49	0.72	0.67	
8/22/97	1202-1457	0.19		0.48		0.62		
8/22/97	1500-1755	0.14	0.17	0.22	0.27	0.41	0.47	
8/22/97	1500-1755	0.19		0.33		0.54		
8/22-23/97	1806-0556	0.19	0.23	0.22	0.28	0.20	0.41	
8/22-23/97	1806-0556	0.28		0.35		0.61		
8/23/97	0605-0857	0.18	0.21	0.34	0.44	0.32	0.44	
8/23/97	0605-0857	0.24		0.54		0.56		
8/23/97	0900-1156	0.13	0.12	0.34	0.33	0.62	0.73	
8/23/97	0900-1156	0.12		0.32		0.83		
8/23/97	1202-1458	0.14	0.15	0.36	0.39	0.85	0.82	
8/23/97	1202-1458	0.16		0.42		0.79		
8/23/97	1500-1800	0.21	0.21	0.30	0.27	0.45	0.50	
8/23/97	1500-1800	0.21		0.24		0.54		