2. STUDY AREA AND METHODS

STUDY AREA

Based on guidance from staff at The County of Santa Barbara Planning and Development Department (SBCPD), the study area was defined as the San Antonio Creek watershed exclusive of Vandenberg Air Force Base. This watershed includes the Los Alamos Valley, which has high priority for oak inventory and monitoring due to the recent loss of oaks associated with vineyard expansion. We extended the study eastward to include the Zaca Creek and Figueroa Creek watersheds in order to capture extensive oak woodlands in those drainages as well as UCSB's Sedgwick Reserve. In all, the study area covers approximately 44,000 hectares (108,726 acres) and includes much of the vineyard development within Santa Barbara County (Figure 2.1).

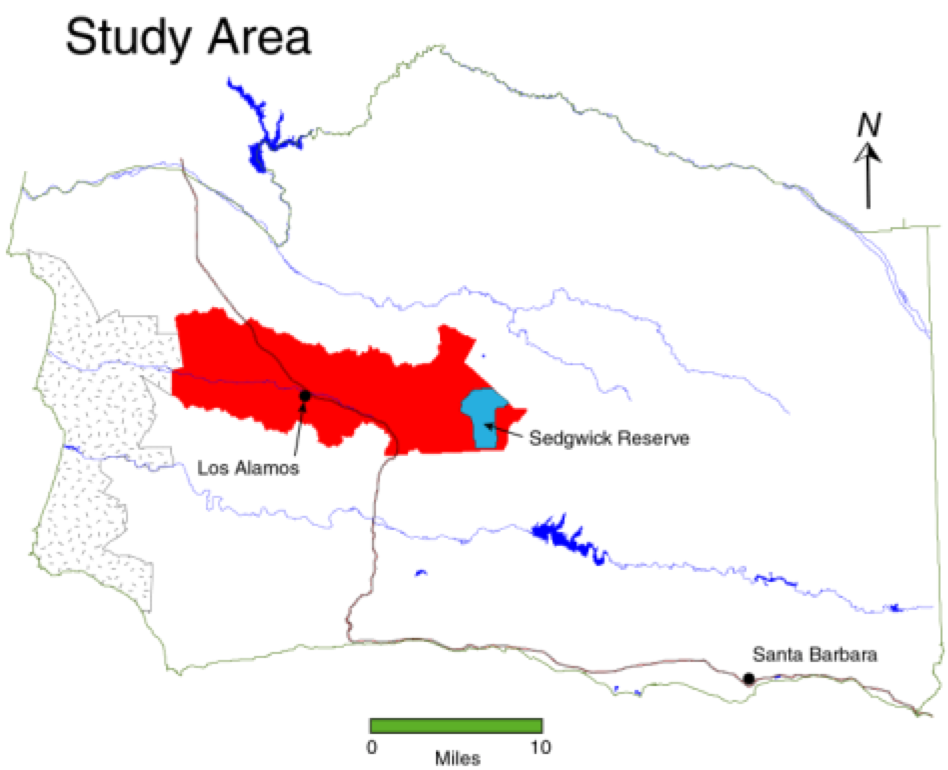

Figure 2.1. Study area within Santa Barbara County shown in red.

Within the study area, 94.3 percent of the land is privately owned while the remaining 5.7 percent is owned by a few public entities. Of the approximately 2,500 hectares publicly managed, 98 percent of this is Sedgwick Reserve, owned and managed by the University of California, while the remaining two percent is distributed between small BLM holdings and a County park.

BASE MAPS AND PROJECTION SYSTEM

Given the extent of the study area, we elected to use 1994 SPOT satellite imagery as the cartographic base for co-registering all other geospatial data. We chose this imagery because of its recentness, its known cartographic accuracy (which exceeds that of widely used 1:24,000 7.5-minute topographic maps), and its relatively high spatial resolution (10 m).

To facilitate oak mapping and eventual use of the database by others, we assembled and co-registered maps of geographic features including roads, parcel boundaries, river networks, ownership patterns, and zoning boundaries. The original digital data were supplied by SBCPD in AutoCAD format. All map themes received from SBCPD were translated into ARC/INFO format and projected into UTM (Universal Transverse Mercator) Zone 10. We chose this map projection after considerable discussion and deliberation. The study area spans UTM Zones 10 and 11, and cartographic properties such as distance, area and direction show maximum distortion at the edge of UTM zones. Furthermore, SBCPD maintains most of its geospatial data in the State Plane projection system. However, we did not want to re-project the SPOT imagery, not only because of the computational problem but because we did not want to introduce any new distortions into our base map. Ultimately, we employed UTM Zone 10, North American Datum (NAD83) as the projection for all geospatial themes or "coverages." Technical descriptions of each coverage are provided in Appendix A.

The study area was divided into smaller "terrain units" for inventorying oaks, land use, and land cover. Because we anticipated that Santa Barbara County would be using and maintaining this database to monitor changes in oak woodlands through time, we chose stable inventory units that could be re-measured any future point in time using the same techniques. We decided not to take the more conventional approach of defining our mapping units based on land use or land cover. Map units based on these more dynamic variables would change both in shape, area and composition and inventory results and change detection would be sensitive to changes in analysts, data sources and mapping approaches. One alternative would be to use a fixed grid system, but this imposes an arbitrary size and shape. Furthermore, the units would not have any ecological meaning and not be easily recognizable in the field. We also considered using parcel boundaries, but most parcels in the area are larger and more ecologically heterogeneous than the desired inventory scale. We settled on using soil units as mapped at 1:24,000 by the USDA Natural Resource Conservation Service (USDA 1972). These polygons provide relatively stable, meaningful, and recognizable land units both for monitoring vegetation change as well as for predicting site potential for alternative land uses and for oak restoration.

A digital map of the County Soil Survey was provided to the UCSB Biogeography Lab by SAIC, Inc. under the agreement that only the portion of the database covering the study area would be used and made public. The original USDA maps were created from air photos that contain large spatial distortions. For this reason we had to invest a large amount of time rectifying the soils polygons and co-registering this map with the SPOT imagery. In areas of low relief it was possible to align the soil boundaries and SPOT image within 1-3 pixels (10-30 m). In steeper terrain this was not always possible, but we generally kept positional errors to less than 50m.

Based on discussions with SBCPD staff, we aimed for a minimum mapping unit for the oak inventory of 10-25 hectares (25 to 62 acres). Although initially the average soil polygon size was 26.3 hectares, many soil polygons were too large and of mixed land cover to be most useful. We split such large polygons into two or more smaller polygons using obvious topographic or cultural features. In cases where a large soil unit was obviously partitioned into intensively used areas (e.g., cultivation or residential development) and natural vegetation, we split the polygon based on land use. In other cases where a large assessment unit did not contain significant differences in land use but still warranted size reduction, the unit would be split into smaller areas along topographic or man made features (e.g. ridges, valleys, roads). In many cases though, converted lands covered a small portion of the assessment unit. In such cases, the polygons remained unsplit or intact. After editing, the study area was divided into 1990 assessment units with a mean size of 22.1 hectares (54.6 acres).

AIR PHOTOS

The primary data source was a series of aerial photographs taken by Pacific Western in July of 1997. A total of 66 photos, which have approximately 30% overlap, cover the entire study area.

Prepared transparencies of the aerial photographs were scanned at 600 dots per inch (dpi) resolution using a Sharp JX6 scanner. These digital true-color images were geo-rectified and co-registered to the SPOT image using ERDAS© Imagine 8.3 image processing software. Despite considerable effort, we were not able to consistently achieve accurate co-registration of the photos to the base imagery in areas of high relief. Results were far better in areas of lower relief (where valley oaks mainly occur). The digital photos are an extremely valuable resource, especially when used in conjunction with other geographic information. However, because of their relatively large size (120 megabytes per photo) we did not use them for initial photointerpretation of land use and land cover, relying instead on the analog transparencies.

PHOTO INTERPRETATION

Data on oak woodland composition and structure, land use and land cover were collected by laying mylar transparencies of the soil assessment unit boundaries onto the photo transparencies and examining the transparencies under magnification on a high-intensity light table. The Soil Survey of Northern Santa Barbara County (USDA Soil Conservation Service, 1972) was used as a guide to properly align each unit on top of the photo. Three interpreters were trained and assisted by Rusty Brown of the UCSB Map and Imagery Laboratory at UCSB. Mr. Brown has extensive experience in the photo interpretation of vegetation and especially oaks in Santa Barbara County.

For each assessment unit the following data were recorded:

1. Dominant land use type (Level 2 Anderson Classification System (Anderson et al. 1976)
2. Dominant plant communities (Sawyer and Keeler-Wolfe 1995)
3. Historical land use/land cover based on Vegetation Type Mapping Survey maps (Wieslander 1946)
4. Dominant land form or terrain type
5. Oak counts and/or density using one of two counting methods for each oak species
6. Visually estimated percentage canopy cover of each oak species
7. Photograph used

Full descriptions of the data collected for this project are provided in Appendix A.

LAND COVER

To classify natural vegetation, we used a combination of the classification system developed by Sawyer and Keeler-Wolf (1995) and the U.S. Federal Geographic Data Committee (FGDC, 1997). Sawyer and Keeler-Wolf (1995) have catalogued vegetation series of California based on dominant overstory species (e.g., coast live oak series). However, they do not provide quantitative criteria such as minimum canopy cover or density for defining dominance or for distinguishing herbaceous, shrubland, woodland and forest types. The FGDC national vegetation standard defines woodland as 25 to 60 percent tree cover and forest as greater than 60 percent tree cover (FGDC 1997). Neither Sawyer and Keeler-Wolf (1995) nor FGDC (1997) explicitly recognizes savanna systems. Unfortunately, nearly all valley oak stands in the study have less than 25 percent tree canopy cover and most are classified as grasslands under the current national system. To be consistent with these schemes, we classify oak cover types as mixed oak woodland or forest if two or more oak species co-dominate and total oak cover exceeds 25 percent, and as grassland or shrubland if total oak cover is below 25 percent. A complete description of each vegetation class can be found in Appendix A.

VEGETATION TYPE MAPPING (VTM) DATA

For a historical perspective on the vegetation of the area, we obtained vegetation information from the Vegetation Type Mapping (VTM) survey maps made from data collected in the 1930s (Wieslander, 1946) (see also Section 2 of this report). The VTM maps contain presence/absence and rough distribution boundaries of many plant species found at that time including coast live oak, valley oak, blue oak, and many other prominent trees, shrubs, and perennial plants. The VTM crews did not record all occurrences of tree species but used a minimum threshold. The presence of a tree species was recorded only if, within a specified area, the total tree canopy cover (from all species) was at least 20 percent of the area, and within the same area, the species comprised at least 20 percent of the total tree canopy cover.

Transparencies of the soils or assessment units layer were overlaid on copies of the original VTM maps and a species was recorded as present for each assessment unit if its boundary intersected the distribution of that particular plant species as recorded on the VTM maps. Vegetation boundaries were delineated and color-coded on the VTM maps. All assessment units were assessed for VTM information except 26 that could not be attributed since they lie along a north-south line between adjacent VTM maps where a narrow section of the maps is missing.

OAK DENSITY AND COVER

The density (number of overstory trees per unit area) and cover of three arborescent oaks (coast live oak, valley oak, blue oak) were inventoried separately in each assessment unit. Tree density was estimated by complete census for sparsely stocked stands and by subsampling using a dot grid for denser stands where complete census was not practical. WE used a regular grid of dots with a spacing distnace on the ground of approximately 50 m (163 ft).

Tree cover – the percent of the assessment unit covered by vertically projected tree canopy - was estimated for dense stands using the dot grids. Here, percent cover by a species is estimated as the number of dots that intercept canopy of that species divided by the total number of dots in the assessment unit. Species cover in sparse stands was estimated by multiplying tree counts by estimated canopy area per tree. To estimate average canopy size for each species, a representative sample of 34 trees per species was taken based on examining the digital air photos. Crown diameter was measured from the digital photos using the measuring tool in ArcView, and area was estimated assuming circular crown shape (Table 2.1).

Table 2.1: Summary statistics of tree canopy size and diameter based on measurments taken from a representative sample of trees from the study area (n = 34 trees per species).

	Valley oak		Coast live oak		Blue oak	
	Diameter (m)	**Area (m^2)**	**Diameter(m)**	**Area (m^2)**	**Diameter (m)**	**Area (m^2)**
Mean	16.7	229.9	11.9	119.3	12.1	117.8
Std. Error	0.7	18.7	0.5	11.9	0.3	6.2
Std. Dev.	3.9	109.2	3.2	69.3	1.9	36.4
Range	16.5	465.2	12.5	281.8	9.5	182.8
Minimum	9.7	73.9	8.1	51.5	7.5	44.2
Maximum	26.2	539.1	20.6	333.3	17.0	227.0
Count	34.0	34.0	34.0	34.0	34.0	34.0

PHOTOINTERPRETATION ACCURACY

Although we did extensive roadside reconnaissance to support our photo interpretation and mapping, with only limited resources and access to private lands we could not conduct quantitative field surveys to estimate the accuracy of the oak inventory data. However, we did test for inconsistency among photo interpreters that get an indication of potential error and bias in the final database.

In order to quantify variation among interpreters, we selected 88 assessment units at random for re-interpretation by a second analyst. Tables 2.2-2.4 display the difference in interpretation between the second and first analysts. We should note that direct comparison of interpreters was not possible in cases where the two interpreters chose different measurement techniques (complete census vs. dot count).

Coast Live Oak. In 21/88 re-interpreted polygons, either direct counts (complete census) were made by both interpreters or both found no trees. The two interpreters differed in their interpretation by an average of only 1.81 trees per polygon. Complete census was used when the number of trees was low (<40) and individual trees were distinguishable. Of these 21 polygons, both interpreters recorded no trees in 11 of them, while in 10 of them both interpreters recorded trees present. From these 10 polygons, the calculated tree density difference between both interpreters was a relatively low 0.26 trees per hectare. Based on dot counts, difference in estimated cover was 5.54 percent. Interpreters agreed on the presence of coast live oak 96% of the time. Of the 75 polygons in which both interpeters found coast live oaks, both interpreters agreed on the visually estimated cover class 62 percent of the time, differed by one cover class 33 percent of the time and differed by 2 cover classes 5 percent of the time.

Table 2.2: Comparison of coast live oak inventories by two independent analysts

	# polygons	Density difference	Cover Difference
Complete census	10	0.26 trees/ha	
Dot Counts made by	75		5.54%
	Agree	**Disagree**	
Coast live oaks present	75	3	
	Same Cover	**Differ by one cover class**	**Differ by two cover**
Cover class	62%	33%	5%

valley oak. Both interpreters recorded actual counts of valley oaks or they both recorded no trees in 66 of the 88 reinterpreted polygons. Interpretation of these polygons differed by an average of 1.70 trees per polygon. Interpreters varied considerably in whether they elected complete census or dot count methods. Although one interpreter recorded tree counts in 18 polygons and the second interpreter recorded tree counts in 24 polygons, both applied this method in only 8 polygons. Within these 8 polygons, the difference in density between the two interpreters was 0.5 trees/hectare. When both interpreters used the dot grid, the average difference in estimated tree cover based on 16 polygons was 2.85%.

Table 2.3: Comparison of Valley oak inventories by two independent analysts

	# polygons	Density difference	Cover Difference
Complete census	8	0.52 trees/ha	
Dot Counts	16		2.85%
	Agree	**Disagree**	
Valley oaks present	25	17	
	Same Cover	**Differ by one cover class**	**Differ by two cover**
Cover class	92.0%	8.0%	0%

Interpreters agreed on the presence of valley oak in only 25/42 (60%) polygons. This is not surprising given that valley oaks are often rare elements of the tree layer. For the 25 polygons with valley oaks, both interpreters agreed on the visually estimated cover class 92 percent of the time and differed by only one cover class the remaining 8% of polygons.

Blue oak. Both interpreters agreed on the absence of blue oak in 78/88 polygons and on the presence of blue oaks in 8/88 polygons. In these eight polygons, blue oaks dot counts differed by an average of 19.6%, although much of this difference was due to one outlier. There were a total of 10 polygons that both interpreters, either together or singly, believed to contain blue oaks. Eighty percent of the time they agreed and 20% of the time they disagreed on whether a polygon contained blue oaks. The interpretation of blue oaks proved more difficult than for either coast live or valley oaks. For the eight polygons that both interpreters agreed had blue oaks, they agreed on the cover class 62.5 percent of the time, and differed by only one cover class the remaining 37.5 percent of the time.

Table 2.4. Comparison of blue oak inventories by two independent analysts

	# polygons	**Density difference**	**Cover Difference**
Direct census	0	0.0 trees/ha	
Dot Counts	8		14.8%
	Agree	**Disagree**	
Blue oaks present	8	2	
	Same Cover	**Differ by one cover class**	**Differ by two cover**
Cover class	62.5%	37.5%	0%

Land use and land cover. Interpreters agreed only 56 percent of the time in their assignment of Anderson land use/land cover class. This high disagreement is partly due to the lack of experience of the interpreters with this classification system. Some of the differences between classes (e.g. Mixed forest vs. Evergreen forest) can be relatively subtle. Another source of disagreement was the heterogeneity of land use/land cover in some polygons. For example, where one interpreter may have perceived a polygon to be dominated by cropland, the other may have perceived the polygon to be dominated by annual grasslands.

The interpreters agreed 68% of the time on the dominant Sawyer vegetation class. Some of this disagreement stems from confusion among closely related vegetation types (e.g., Mixed oak vs.

coast live oak Series). In addition, interpreters sometimes differed in their opinion regarding which cover type dominated the polygon.

Summary. The comparison of interpreters indicates that there is relatively low uncertainty in estimating the density and cover of coast live oak and valley oak. There was greater uncertainty in inventorying blue oak, which tends to occur as smaller trees in denser woodlands and forest where density is more difficult to estimate. In the future, consistency among analysts could be increased by more extensive training and by adopting more explicit rules for applying complete census vs. dot count methods. Rare valley oaks may still be missed in large polygons dominated by other cover types.

The largest uncertainty is associated with the assignment of dominant land use/land cover class and vegetation type. This will vary depending on the experience of the analysts in photonterpretation and with experience and training in the application of the standard classification schemes. Use of interpretive keys, more explicit decision rules, and perhaps the adoption of smaller (and thus purer) minimum mapping units would also improve the reliability of these database fields.

MAPPING MAJOR AREAS OF VALLEY OAK HABITAT

The oak inventory database provides detailed information regarding oak density and cover. During the course of the project, staff at Santa Barbara County Planning and Development expressed the additional need for a simple vegetation map that would show the major areas of extant valley oak woodland and savanna. In response to this need, we used the digital air photos and field reconnaissance to produce a generalized map of valley oak habitats in the pilot study area. This map includes 99 areas ranging in size from 0.7 acres to 622 acres, with a median polygon size of 18 acres. For each polygon, relative valley oak canopy cover (that is, valley oak cover as a percent of total tree cover) is classified into one of three cover classes, 0-10%, 10-50%, and >50%. We have not conducted a formal accuracy assessment of this database.

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