Using GIS Technology to Assess Potential Hardwood Loss

in the Northern Sacramento Valley, California

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Since early 1994, The Northern Sacramento Valley Sustainable Land scapes Project (SLP)[2] has focused on facilitating informed discus sions between public policy makers and resource stakeholders, including the general public, on long term management of the extensive oak woodland landscape (fig.1). As part of its goal to develop an acceptable framework for discussing issues related to sustainability, the SLP has chosen to utilize geographical information system (GIS) technology. By incorporating land use and population projections into a GIS, it is possible to begin a spatial assessment of present and future growth patterns.

Like most of California's inland valleys, the population of the northern Sacramento Valley is forecast to more than double by the year 2040 (California Department of Finance 1993). Population growth in the region typically takes the form of low density development (averaging 1 to 3 dwelling units per acre) within the planning areas of incorporated cities. In addition, rural residential lots of one to 40 acres per dwelling unit develop around farming communities and in oak woodland and timbered landscapes.

Increased growth implies that additional land will be placed under development pressure for urban and rural residential uses. If this pattern of lower density urban development and extensive rural residential development is

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1This paper is the update to a paper by Nelson and Radabaugh (1996). Base information and data are the result of research conducted by Mark Radabaugh and are described in a report (Radabaugh 1995).

2The Northern Sacramento Valley Sustainable Landscape Project includes Butte, Colusa, Glenn, Shasta and Tehama Counties, California. These five counties contain approximately seven percent of California's land area. Oak woodlands cover approximately 21 percent of the landscape in the five county region and the region accounts for approximately 14 percent of the State's oak woodland inventory based on Pillsbury (Pillsbury 1991).

projected past the 15- to 20-year time frames of local area plans, significant oak woodland acreage will be affected.

Methodology

A review of past and present population patterns and growth trends in the five county SLP region resulted in a series of GIS coverages depicting future land use and population density (Radabaugh 1995). Land-use polygons were identified and population distribution forecasts were made based on key factors including:

- An estimate of existing population based on the 1990 Census, county assessors records and other data;
- An estimate of population build-out potential described in terms of average density; and
- The estimated average annual population growth rate to be expected within each polygon.

Paper maps of each of the five counties were prepared and digitized using one of five general land use categories. These categories included:

- *Incorporated city spheres* of influence or areas specifically designated for future urban growth and expansion;
- *Unincorporated communities* where water and/or sewer services are provided and residential build- out density is less than one dwelling unit per acre;
- *Rural residential lands* where build-out density is between one and 40 acres per dwelling unit and resource production from the parcel is not the primary land use. They are generally located on agricultural, grazing and range, and timber producing land;
- *Agricultural lands* were divided into small-scale agriculture (less than 20 acres per dwelling unit) and large- scale agriculture (greater than 20 acres); and

- *Other resource producing lands* including lands utilized for grazing, timber production, mining, wildlife habitat and open space. Resource lands were divided into foothill rural and timber. Acreages are greater than 40 acres per dwelling unit.

For the purposes of assessing impacts in the oak woodland interface, the first three categories were considered sensitive to population change. As more information like riparian data along the Sacramento River and its tributaries becomes available, impacts in the valley oak areas along the river can be added as well.

Information from data collection was digitized using ArcInfoÓ software, a GIS product developed by Environmental Systems Research Institute (ESRI) in Redlands, California. ESRI desktop GIS software, ArcViewÓ, was utilized for plotting maps and for statistical analysis.

TABLE 1-TOTAL ACREAGE OF HARDWOOD RANGELANDS

County	Total Acreage of Hardwood Rangelands	Percent of County
Butte County	242,771	22.6
Colusa County	158,881	21.5
Glenn County	142,646	16.8
Shasta County	304,849	12.4
Tehama County	672,189	35

contd. on pg. 114

Using GIS Technology . . .

contd. from pg. 113

GIS Analysis

A geographical information system (GIS) is best defined as the marriage of the map and the database. GIS technology combines the qualities of a mapping system with the ability to analyze geographic locations and and information linked to those locations. GIS information is database driven. Results can be accessed from the map or from the database (ESRI 1995).

Map information compiled by Pillsbury (Pillsbury 1991) showing California hardwood types was obtained from the California Department of Forestry and Fire Protection (CDF) as a digital file (fig.2). Using ArcView software, it was easy to generate statistics showing the total acreage of hardwood rangelands in the five county SLP region.

Examination of the potential impact of population growth on the oak interface requires overlaying Radabaugh's land use layer (coverage) with the Pillsbury's hardwood coverage. Incorporated city spheres, unincorporated communities, and foothill rural residential area were used as they are population sensitive and have the greatest impacts in the oak woodland interface. Those land-use areas not within the hardwood region were deleted; i.e., the agricultural areas on the valley floor were skipped. In addition, the timber and foothill rural resource areas were deleted if their densities were greater than 40 acres per dwelling unit.

TABLE 2 -TOTAL ACREAGE IMPACTED BY DEVELOPMENT

County	Total Acreage Impacted By Development	Percent of County
Butte County	117,972	48.6
Colusa County	535	0.3
Glenn County	68	0.05
Shasta County	166,929	54.8
Tehama County	33,392	4.9

When this step is completed and statistics are generated, the impacts of potential build out within the oak woodland interface become very apparent and the true extent of the foothill rural residential area becomes defined (fig. 3). Further, when examined on a regional scale, it becomes apparent that not all of the counties are significantly impacted.

One of the advantages of using GIS technology as a tool to examine impacts is that it gives the user the opportunity to quickly see which areas are impacted and to ask "why?". In this case, it becomes obvious that the major impacts are tied to land use and will occur where major growth is projected; i.e., in Butte and Shasta Counties.

Butte County is the most populous of the five-county SLP area. Although this county contains the region's largest urban area population, the population of its unincorporated community centers and towns is the smallest

TABLE 3 -TOTAL ACREAGE OF HARDWOOD RANGELANDS BY TYPE

Hardwood Type	Butte County (in acres)	Shasta County (in acres)
Blue Oak/Foothill Pine	82,765	212,187
Blue Oak woodlands	10,623	87,386
Montane Hardwoods	148,020	5,271
Other Hardwoods	1,364	16

of the five-county area. Nonetheless, Butte County has the second largest inventory of rural residential land and population, following Shasta County. The City of Chico accounts for roughly 44% of the county's population.

Shasta County is the second most populated county. It contains the largest inventory of rural residential land which has accounted for much of the past growth within the unincorporated area. The City of Redding and its sphere of influence account for over 50% of the county's population.

In order to better quantify impacts in these two counties, an examination of the Pillsbury's hardwood coverage gives the following breakdown of hardwood rangelands by type.

Examination of the impact of potential growth on the oak interface requires overlaying the land use coverage with the hardwood layer. When this step is completed and statistics are generated, a third set of data was generated illustrating potential vegetation loss by hardwood type. Percentages can be easily calculated and statistical summaries can be generated as needed, including number of new polygons created (fragmentation rate), average area, and percent of total area impacted. Below are the numbers of acres in each county impacted by the projected build outs.

Each impacted hardwood is the result of a land-use impact. Therefore, it is also possible to generate impacts by land-use type or by development density. From these figures, new questions can be formulated and new GIS inquiries made. Results can be viewed as a table or on maps. These maps help facilitate discussions which can lead to better decisions.

Implications

Impact statistics, while significant, can be misleading and are open to debate. For instance, resource professionals suggest that the impact of one dwelling unit per 40 acres may be significant to oak habitat. Others question this

contd. on pg. 116

TABLE 4 – POTENTIAL BUILDOUT IMPACTS IN BUTTE AND SHASTA COUNTIES

Hardwood Type	Butte County (in acres)	Build-out Impact (in percent)	Shasta County (in acres)	Build-out Impact (in percent)
Blue Oak/Digger Pine	42,600	51.5	123,911	58.4
Blue Oak woodlands	4,828	45.4	38,219	43.7
Mixed Hardwoods	71,575	48.4	2,018	38.3
Other Hardwoods	330	6.0	7	45.9

Using GIS Technology . . .

contd. from pg. 115

assumption. With a GIS, it is easy to re-evaluate impacts as new research becomes available or as policy shifts occur.

The information generated in this project was based on growth projections and should not be used to stop development in Butte and Shasta County or anywhere else in the five county region. Rather, it should be used to guide responsible growth. Maps and statistical information merely give planners, decision makers and the interested public the ability to examine potential impacts, initiate discussion, and try to formulate workable growth strategies.

Further, techniques used to do the above analysis are general in nature and assume a level plane with little or no regard to local development policies and practices. While this works well on a regional level, clearly a more sophisticated GIS approach is needed before major policy decisions are made. These decisions should be made using large scale parcel level maps and the best environmental information available within each local jurisdiction.

Conclusions

The ability to graphically illustrate growth projections in a GIS gives the SLP an important planning tool. Some of the potential uses for this type of data are:

- The improved ability to assess changes in the oak woodland landscape on a comparative basis with other resources can lead to new or expanded ideas regarding oak woodland sustainability. Digital maps and statistical information can be used as tools to help counties formulate general plan policy in the hardwood rangelands.
- New thematic digital map layers including riparian, wetlands, vernal pool, deer herd, and land ownership are available for many of the SLP counties and have been incorporated into a map data base developed by the Geographical Information Center at California State University, Chico (GIC);
- The GIC has begun making SLP data available via the Internet (http://phobos.lab.csuchico.edu/ hosted/sustainable/index.html). Maps can be obtained as .pdf files which can be loaded at scale, viewed and printed using Adobe Acrobat ReaderÓ. Acrobat Reader is a shareware product linked to the GIC's download site or available free of charge from Adobe ;
- Inclusion of a method to spatially assess population growth impacts on a variety of other natural resource components will likely lead to more related research in the region;
- A GIS data system is adaptable and can be easily updated to accommodate new spatial information. Monitoring and classifying California's rangelands is an ongoing endeavor. As new digital maps are developed, information can be used to update existing oak woodland or land use statistics. In fact, a new digital hardwoods layer has recently been completed by CDF; and
- Mapping provides a clear visual format for area residents to understand relationships between land use and population growth. Low cost software like ArcView makes desktop GIS and SLP data readily available to local decision makers who will ultimately decide the fate of the oak woodland interface.

References Cited

California Department of Finance. 1993. **Official population projections and average**

annual growth rate. Report 93P-1. Sacramento: California Department of Finance.

Environmental Systems Research Institute, Inc. 1995. **Getting to Know Desktop GIS.** Redlands, CA: Environmental Systems Research Institute, Inc.; 120 p.

Nelson, C. and Mark Radabaugh. 1996. **Using population distribution forecasts and GIS technology to assess potential hardwood loss in the northern Sacramento Valley**. Proceedings of the symposium on oak woodlands: ecology, management, and urban interface issues; 19-22 March 1996; San Luis Obispo, CA. Gen. Tec. Rep. PSW-GTR-160. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 7 p.

Pillsbury, N. 1990. **Hardwoods**. Digital map. Sacramento: California Department of Forestry and Fire Protection.

Radabaugh, M. 1995. **Population growth trends and allocation of pattern in the northern Sacramento Valley**. Davis, CA: Common Ground: Center for Cooperative Solutions, University of California Extension.