Using GIS in Agricultural Land Assessment for Property Taxes

Richard B. Standiford, James W. Bartolome, William Frost, Neil McDougald

Integrated Hardwood Range Management Program, University of California
160 Mulford Hall, #3114, Berkeley, CA 94720-3114

Abstract
This study illustrates the application of range productivity models across a broad spatial scale. A series of relevant data layers for these range models were constructed using photo-interpretation and digital elevation models. A geographic information system was used to merge the data layers to evaluate total livestock carrying capacity for individual land parcels. This approach has application for county tax assessors interested in a scientific basis for appraising rural land values. The study was carried out in the foothills of California's San Joaquin Valley in response to policy concerns raised about the implementation of the California Land Conservation Act, a property tax system designed to conserve agricultural and open space values.

I. INTRODUCTION

The California Land Conservation Act (CLCA), popularly known as the Williamson Act, was established by the State of California in 1965 [2]. It provides a tax assessment methodology for agricultural land that bases property taxes on the use of the land for agricultural purposes, rather than on its market value for its "highest and best use" [8]. This provided a tax incentive to private agricultural landowners to maintain their land in agricultural production. This method of property taxation has had a major effect in reducing the pressure to subdivide and develop agricultural lands due to high taxes. The Act applies to all forms of agriculture, including extensively managed rangelands, which cover 40 percent of California [4]. The Williamson Act is one of the major policies implemented to conserve rangeland open space values, which are provided mostly by private livestock producers.

The Williamson Act functions by assigning land value based on its agricultural productivity, for the purpose of property tax assessment. On rangelands, the Williamson Act requires local County Assessors to determine the livestock carrying capacity of the land and the value that each unit of productive capacity represents in the current agricultural market.

Tulare County is a predominantly agricultural county, located in California's San Joaquin Valley just south of Fresno. In 1995, the California State Board of Equilization, the state agency responsible for administration of the Williamson Act, reported that the assigned carrying capacity ratings for rangeland enrolled in the Williamson Act in Tulare County were 40 percent below their actual carrying capacity [1]. The ratings used for the productive potential of grazing land in the county were established in the 1950's when the County Assessor canvassed local cattle ranchers throughout the county. These ranchers provided the estimated animal unit carrying capacity for each private rangeland parcel. The State Board of Equilization informed the County that they needed to develop a scientifically defensible methodology to determine rangeland productivity in order to continue to utilize the tax advantages of the Williamson Act.

In Tulare County, there are an estimated 2,301 parcels, representing over 500,000 acres of grazing land currently under Williamson Act contract. The County Assessor approached University of California researchers in the Integrated Hardwood Range Management Program (IHRMP) and the Center for Assessment and Monitoring of Forest and Environmental Resources (CAMFER) to develop a scientifically defensible approach to assessing rangeland productivity.

II. METHODS

Four landowners agreed to cooperate in this project by providing historic grazing information and access to their land for field verification of various estimates. Thirty-three parcels were included in this project.

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Parcel sizes ranged from about 30 acres to over 775 acres, representing a total of over 11,000 acres, or about 2% of Tulare County's Williamson Act grazing lands. The selected parcels were representative of the combinations of canopy cover, slope, and elevation of grazing land under the Williamson Act within the County. Individual parcel analyses were generated detailing the animal unit months (AUMs) per acre, acres per class, and total AUMs by slope and canopy cover classes present. An AUM is the amount of forage necessary to maintain a cow and its calf for one month.

It was necessary to develop a basic assessment of the factors that influence rangeland productivity, and then to apply this assessment across the landscape to the parcels in the County. Various studies of rangeland productivity have been conducted in the annual grasslands of California's foothills [3, 5, 6, 9, 11]. Long-term clipping studies, including 50 years of forage production at the San Joaquin Experimental Range, located in a similar range type, showed that local-based grazing scorecards could be developed for a given area [10]. These scorecards contain average annual grazing capacities based on: 1) the productivity of a site, expressed as the relationship between forage production and canopy cover percent of various tree and brush species; 2) grazing use, expressed as the relationship between slope and grazing pressure; and 3) a level of residual dry matter or litter, which indicates proper grazing use. These relationships vary by location in the state and annual rainfall levels. They were calibrated to the study area given the long-term relationships in the literature, and the actual grazing capacity of the sample ranches.

Spatial databases were developed for the key variables necessary to implement the grazing scorecard across the landscape. Database layers of slope and canopy cover were developed using the Arc/Info geographic information system (GIS) for the thirty-three parcels in the sample.

Slope classes were developed by using United States Geological Survey (USGS) Digital Elevation Models (DEM). The DEM data was transferred into Arc/Info Grid, and a percent slope was determined. Four different slope classes were classified to be consistent with the range scorecard categories (0 – 10 percent; 11 – 20 percent; 21 – 40 percent; over 40 percent).

The rangeland areas had an overstory cover of various oak (*Quercus sp.*), pine (*Pinus sp.*), and brush species. The canopy cover layer was generated by using existing aerial photography, and manually mapping canopy cover classes onto a mylar overlay. These canopy cover classes correspond to the grazing capacity scorecard developed for Tulare County (see below). Five broad canopy cover classes were mapped (0 – 10 percent; 11 to 25 percent; 26 to 50 percent; 51 to 75 percent; and over 75 percent). A zoom transfer scope was used to match the landscape features from the aerial photo mylar to those of a mylar developed from topographic maps. These sheets were digitized to record the data collected. Preliminary analysis of photo-ecometrics as a method for automated analysis of crown cover estimation was evaluated [7].

Arc/Info was used to combine the values in the crown cover class layer (from the aerial photos) and the slope class coverage (from USGS Digital Elevation Models). Given the grazing capacity scorecard matrix, Arc/Info was used to produce tables with carrying capacity estimates and maps to display the information spatially. Carrying capacity estimates generated through this procedure were referenced with parcels of known carrying capacity based upon historic grazing and residual dry matter information.

III. RESULTS

Table 1 shows the results of the rangeland scorecard developed by calibrating previous rangeland productivity approaches with results from the samples selected in Tulare County. The range in annual precipitation in the study area necessitated development of two scorecards. This is because relationship between forage yield and canopy cover varies by rainfall zone [9]. These show average productivity figures in animal unit months (AUM) per acre for two broad rainfall zones. This scorecard was used with the spatial data layers to determine the grazing capacity of each parcel.

Table 1. Grazing capacity scorecards. Figures are AUMs per acre for different canopy cover and slope classes in Tulare County.

Less than 12" average annual precipitation

Slope Classes	% Canopy Cover			
(%)	<10	11~20	21~40	>40
<25	0.7	0.4	0.3	0.1
25~50	0.4	0.3	0.2	0.1
51~75	0.2	0.1	0.0	0.0
>75	0.1	0.0	0.0	0.0

More than 12" average annual precipitation

Slope Classes	% Canopy Cover			
(%)	<10	11~20	21~40	>40
<25	1.2	0.8	0.3	0.1
25~50	1.4	1.0	0.4	0.2
51~75	1.6	1.2	0.6	0.3
>75	0.8	0.4	0.2	0.0

Figure 1 shows an example of the various data layers and the resulting tables developed in this study. This shows how the slope and canopy cover layers were combined to give AUMs for the entire 594 acre parcel. The sum of the AUMs for this parcel is 445. This approach was used on all 33 parcels in the sample.

The measure of rangeland productivity used by Tulare County rates each parcel based on the number of acres required to provide the forage needed to support one animal unit (one cow with a calf) for one year (AUY). The values for the 33 parcel pilot sample from the 1950's assessment range from 15 to 50 acres per animal unit year. The estimates produced with the GIS database and range scorecard methodology ranged from 13 to 72 acres per AUY. Table 2 provides a direct comparison of the percentage change in acres per AUY estimates between the 1950's approach and this new methodology. Eighteen percent of the parcels, and 7 percent of the acres, had an increase in acres per AUY of over 10 percent with this new methodology (increase corresponds to less productive, less valuable grazing land). Seventy-four percent of the acres, and 50 percent of the parcels, had a decrease in acres per AUY of over 10 percent (decrease corresponds to more productive, more valuable grazing land). Nineteen percent of the acres and 21 percent of the parcels were within 10% of each other. Figure 2 shows the number of acres in the sample for different AUY categories for the original assessment and the new assessment.

The old grazing capacity ratings for tax purposes averaged 27 acres per AUY. Estimates from the scorecard method on the same parcels averaged 20 acres per AUY, about 25% higher than the old figures, but considerably less than the 40% difference claimed by the Board of Equalization.

There was no correlation between size of parcel and carrying capacity estimates, nor between the parcel size and whether estimates were higher or lower than the current ratings. There also was no uniform adjustment to current ratings that would bring them in line with our estimates. To accurately assess the carrying capacities of grazing capacities of grazing lands as enrolled in the Williamson Act, each parcel will have to be individually assessed.

Table 2. Percentage change of grazing capacity based on GIS methodology compared with original 1950s mapping.

Change in Grazing Capacity*	% of Acres	% of parcels
Over 50 percent increase.	5.60%	9.10%
30 to 50 percent increase	34.40%	30.30%
10 to 30 percent increase	34.00%	21.20%
±10 percent of original	18.90%	21.20%
10 to 30 percent decrease.	5.90%	9.10%
Over 30 percent decrease.	1.10%	9.10%

* Note: Increase in grazing capacity means more animal units per acre, or fewer acres per animal (the acres per AUY decreases).

The pilot study on the use of the photo-ecometrics approach developed by CAMFER researchers [7] appears to hold considerable promise for future work in this area. This would eliminate the costly step of manual photo-interpretation (PI) and zoom transfer work onto mylar overlays. Eighty percent of the labor input for preparation of each parcel analysis included these manual steps for canopy cover estimation.

IV. DISCUSSION

This study provided a useful way to coordinate range productivity research with GIS technology for the purpose of agricultural land appraisal for property taxes. The State Board of Equilization was satisfied with this science-based approach to determine land productivity, and the County will be able to continue using the Williamson Act as an incentive to maintain agricultural land use by applying the approach described. The County is using the described approaches to contract for assessments of the entire grazing land base in the county. Other counties in the San Joaquin Valley in California have expressed interest in this approach, and will be investigating it to assess the productive capacity of their grazing lands for tax purposes. This methodology is being improved through the use of automated methods for estimating crown cover percentages.

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Tulare County
Range Quality Assessment

Sample Parcel

Slope Class	Cover Class	AUMs/Acre	Acres	Total AUMs
1	1	1.2	3.70	4.44
1	2	1.4	47.61	66.66
1	3	1.6	26.94	43.11
1	4	0.8	1.50	1.20
1	5	0.2	5.30	1.06
2	1	0.8	11.59	9.27
2	2	1.0	118.24	118.24
2	3	1.2	71.07	85.29
2	4	0.4	2.00	0.80
2	5	0.0	3.15	0.00
3	1	0.3	24.77	7.43
3	2	0.4	119.82	47.93
3	3	0.6	69.35	41.61
3	4	0.2	8.94	1.79
3	5	0.0	1.51	0.00
4	1	0.1	8.20	0.82
4	2	0.2	24.46	4.89
4	3	0.3	34.31	10.29
4	4	0.0	11.20	0.00
4	5	0.0	0.020	0.00

Total Acres: 594

Total AUMs: 445

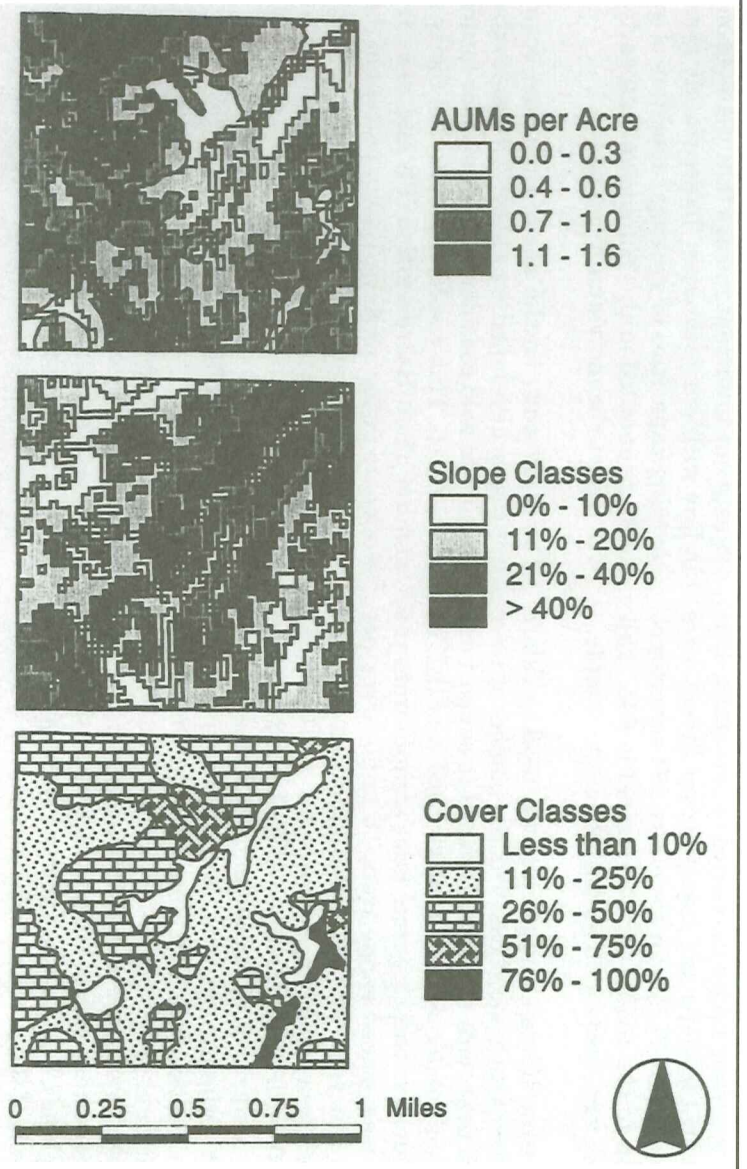

Figure 1. Example of data layers and calculations of range quality assessment.

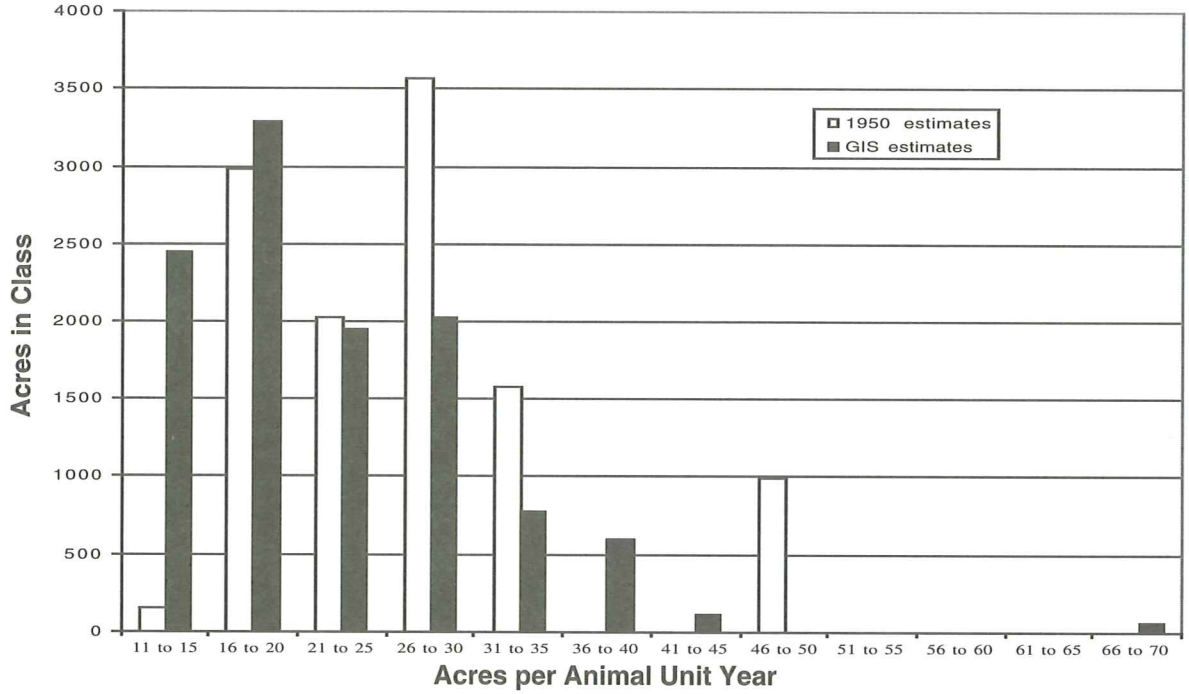

Figure 2. Comparison of number of acres in the various acres per animal unit year classes for 1950 and current assessment estimates.

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