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Modeling vegetation pattern using digital terrain data

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Introduction

Distribution of plant species or vegetation of particular locality depend on the distribution patterns of biotic and abiotic site factors

Technique of defining vegetation

- **Classic: Vegetation and site measurements from scattered samples are analyzed to develop empirical equations relating vegetation composition to measured site variables**

- **Modern: Using GIS**

Limitations of classic technique

- Mixed success in even in relatively undisturbed areas because of the dynamic behavior of plant communities on spatial and temporal scale (Rowe & Sheard 1981)
- Inadequate sampling: Ground samples are not representative enough to model unsampled areas (Generalization error)
- Sampling bias: Homogenous stands were selected (Selective sampling)
- Prediction Error: Predicted pattern of vegetation is different to the actual pattern

Introduction (Contd.)

Map of site model variables: Geology
Topography
Soils and other biotic and abiotic factors

GIS
Map weighting
and overlaying

Predicted
vegetation
maps

Overlay

RS
Thematic Mapper
Simulator (TMS)

Actual
vegetation
map

To analyze
spatial pattern
of disagreement

Limitations

- Very difficult as the errors can originate from map of site variables, actual vegetation and from inadequacies of the site model

Solutions

- Expert Knowledge
- Statististical test (goodness of fit)

Objectives

- To calculate total area and patch size distribution of observed and predicted oak forest

- To calculate the amount and patch size distribution of predicted vegetation types for the areas of observed oak forest

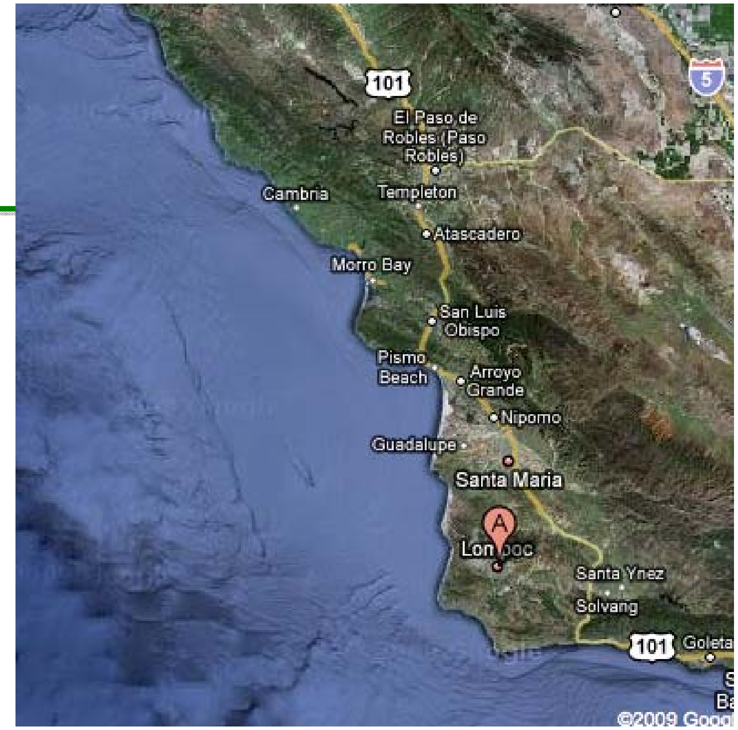
- To calculate the amount and patch size distribution of observed vegetation types for the areas of predicted oak forest

- To measure the degree of disagreement between predicted and observed maps with respect to geology and topography

Study area

72 km^2 area NE of Lompoc, California
(latitude 34°42'N, longitude 120°27'W

Climate: Mediterranean, cool summers and mild winters
> 90% annual precipitation falls between Nov and April



Physiographic zones

Burton Mesa
- Marine terrace underlain by marine sedimentary rocks covered with sandstone
- Elevation 100-120m (low land area)
- Maritime chaparral dominated by evergreen shrub
- Multi-stemmed coast live oak
- Coastal sage scrub
- Annual grassland

Purisima Hills
- Northwest-southeast trending anticline of marine sedimentary rocks
- Elevation 225-450m (rolling hill & steep slope)
- Coastal sage scrub
- Chaparral
- **Coast live oak woodland**
- **Coast live oak forest**
- Bishop pine forest (*Pinus muricata*)

Disturbances eg. constructions, wildfire, grazing and clearing have persistent effect on actual vegetation and site variables

Methods

TMS collected in July 1984 (28m resampled to 30m)

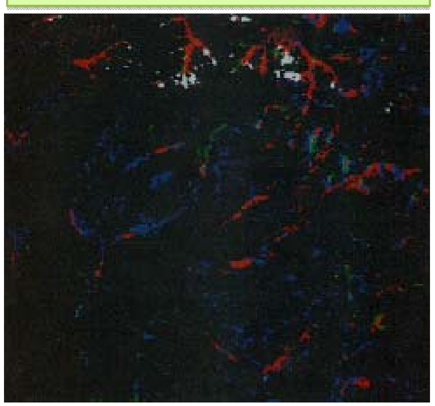
Accuracy testing (89%)

Co registered in UTM projection

Vegetation map

2 vegetation types excluded (willow wood, grassland)

Reclassified Actual Vegetation Map (4)



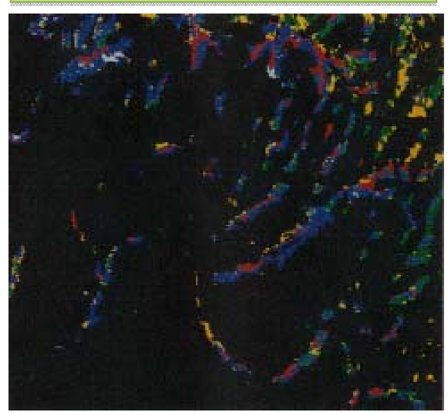
Geological map (Dibble 1950) digitized using ERDAS in 1:50000

Classify

Reclassified Geological Map

Logical regression model (Regression equations)

Predicted Vegetation Map

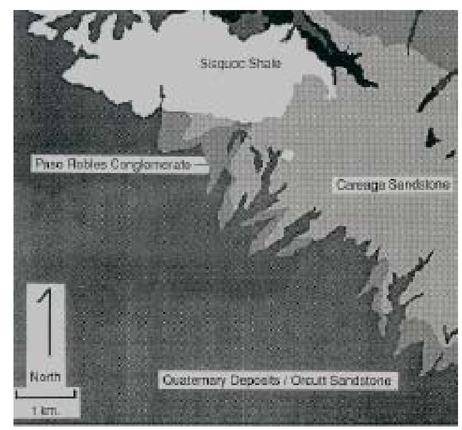


DEM 30m (USGS)

Software UCSB

Elevation, Slope, Angle, Aspect, Clear sky solar radiation, Drainage area

To analyze spatial pattern of disagreement



Results

Table 1. Classification system used to map dominant natural vegetation types in the study region. For logistic regression analysis, oak woodland and chaparral were merged into a 'woodland/chaparral' category. Grassland and Willow woodland were excluded from the analysis. Map accuracy for each class is the proportion of samples classified correctly in the TMS-derived vegetation map, based on 141 test sites (see Davis (1987) for details).

Class	% Oak cover	Dominant species	Map accuracy (%)
Coast live oak forest	>60	*Quercus agrifolia* *Toxicodendron diversilobum*	79
Coast live oak woodland	20-60	*Quercus agrifolia* *Adenostdma fasciculatum* *Arctostaphylos spp.*	86
Chaparral	0-20	*Quercus agrifolia* *Adenostoma fasciculatum* *Ceanothus ramulosus* *C. impressus* *Arctostaphylos rudis* *A. purisima*	89
Coastal Scrub	0-20	*Salvia mellifera* *Baccharis pilularis* *Ericameria ericoides* *Artemisia californica*	86
Conifer Forest	0-30	*Pinus muricata* *Quercus agrifolia* *Heteromeles arbutifolia*	92
Grassland	0-20	*Bromus spp.* *Vulpia spp.* *Avena barbata* *Brassica spp.*	89
Willow woodland	0-20	*Salix spp.*	100

Vegetation Types	Percentage
Oak Forest	4.5%
Oak Woodland and Chaparral	19.4%
Coastal Scrub	20.0%
Conifer Forest	2.9%
Others (residential, cropland, grassland, willow woodland)	53.2%
Total	100%

Results

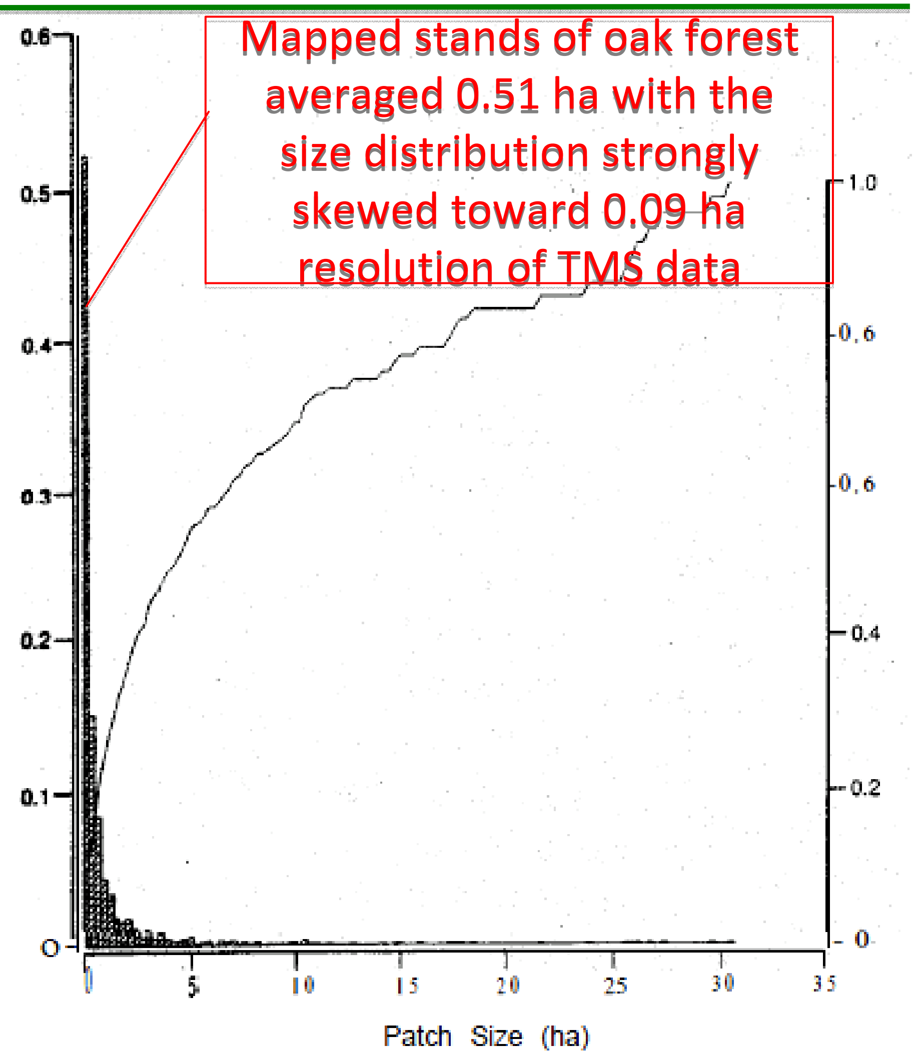


Fig. 4. Patch size distribution of observed oak forest in classified TMS image (bars) and cumulative proportion of forested area as 'a function of patch size (line).

Results

Table 2. Frequencies and relative percentages of 4 natural vegetation classes and other land cover types *on* four geologic substrates in the study area (n = 79,605 cells). Percentages for each substrate sum to 100%.

Geology	Oak forest		Oak woodland/chaparral		Coastal scrub		Conifer forest		Other	
Quaternary deposits	2423	0.05	18824	0.39	8572	0.18	4	0.00	18530	0.38
Paso Robles conglomerate	588	0.12	1335	0.26	1343	0.26	3	0.00	1811	0.36
Careaga sandstone	1927	0.11	6468	0.37	6195	0.36	8	0.00	2848	0.16
Sisquoc shale	939	0.11	5034	0.58	1434	0.16	500	0.06	819	0.09

Coniferous forest is restricted to diatomaceous shale of Sisquoc formation (Cole 1980)

Results

Table 4. Relative proportions of observed oak forest on predicted vegetation types as a function of substrate type (columns sum to 1).

Predicted vegetation	Quaternary deposits	Paso Robles conglomerate	Careaga sandstone	Sisquoc shale
Oak forest	0.24	0.27	0.42	0.50
Oak woodland	0.73	0.37	0.42	0.02
Coastal scrub	0.03	0.36	0.16	0.13
Conifer forest	0.00	0.00	0.0	0.35

The proportion of observed oak forest that occurred on predicted oak forest sites was 40% overall but varied substantially between substrates

60% times that doesn't fit or Low predicted success, Observed oak forest on Quaternary deposits mapped onto predicted oak woodland sites

Error is due to

- Cartography error (Confusion between forest types)
- Ecological error (forest was not restricted on certain locality as model predicted)

Results

The proportion of observed oak forest on predicted oak forest sites also depended strongly on patch size

Higher the rate of success for large patch size
Higher error for the smaller patch size.
Excluding the path less than 2 ha in size, 60% of remaining forest occurred on the predicted site

3 higher patch is perfectly located with in the predicted Oak forest

Smaller patch size are random
Larger patch are homogenous and easily depicted in DEM

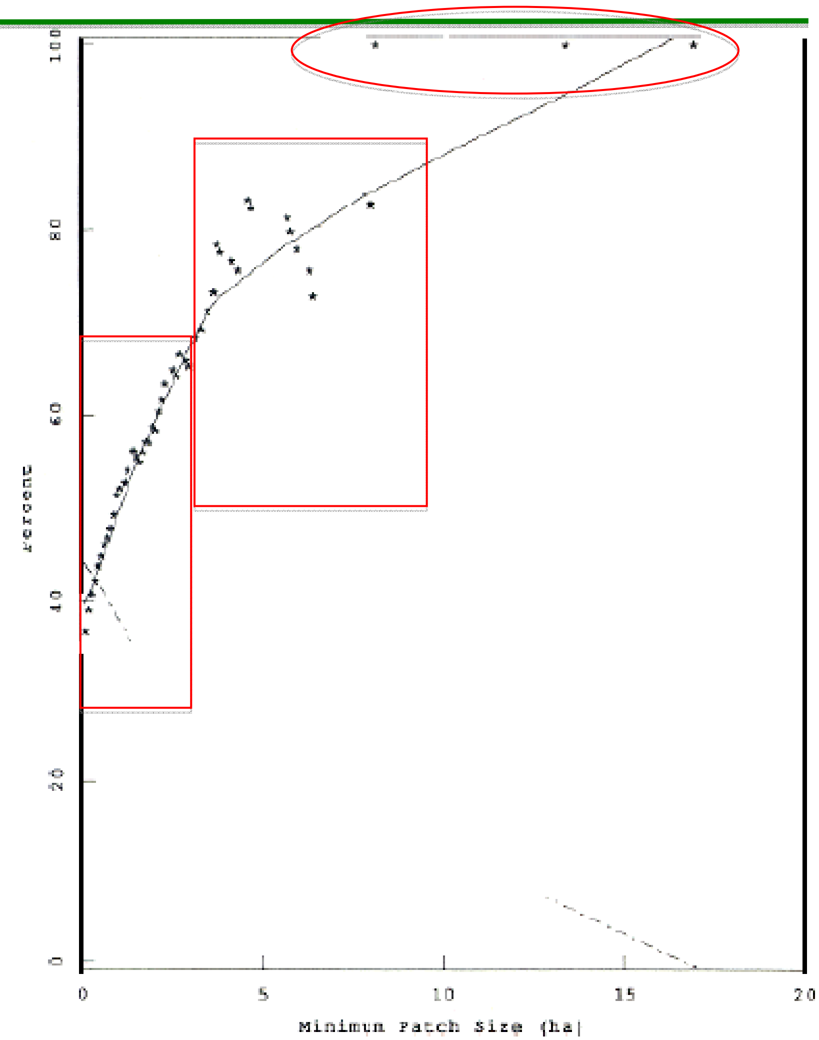


Fig. 6. Percent of observed oak forest occurring on predicted oak forest sites as a function of mmimum forest patch size analyzed. Asterisks are actual data values. Solid line was fitted using locally weighted regression (Chambers et *al.* 1983). Broken line shows corresponding percent of observed oak forest on predicted oak woodland sites.

Results

Only 21% of predicted oak forest sites supported oak forest (lowest accuracy)

55% supported oak woodland (Highest accuracy)

24% supported coastal scrub, conifer forest or other cover types

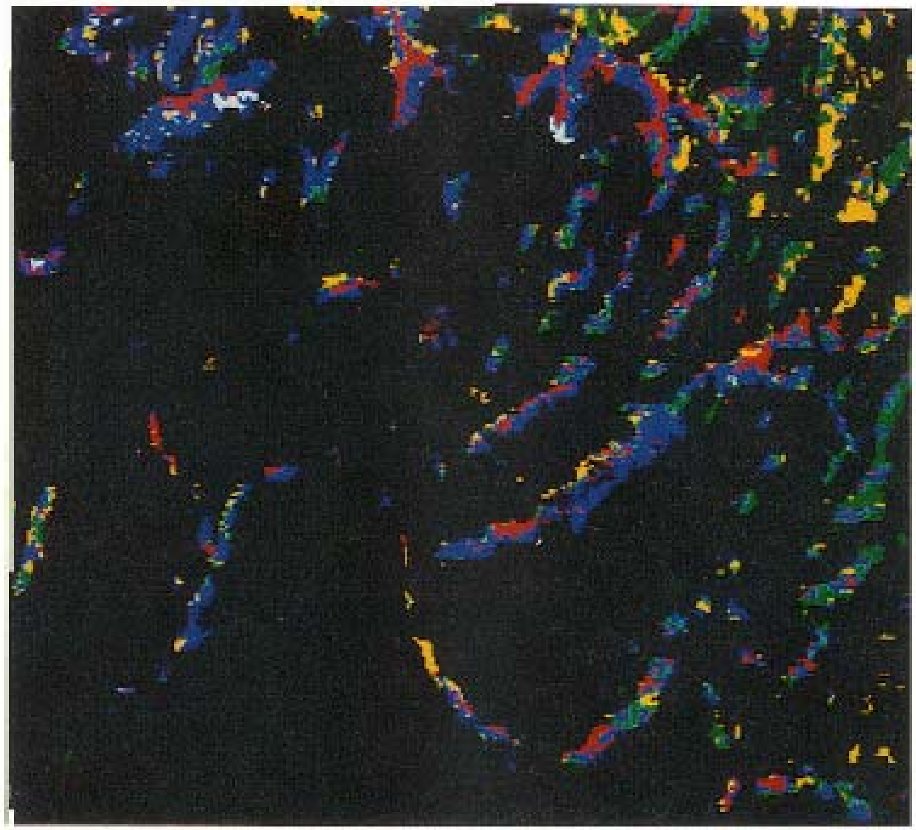


Fig. 7. Predicted distribution of coast live oak forest based on geology, topography and insolation. Black areas are predicted vegetation other than oak forest. Colored areas are predicted oak forest sites on which mapped existing vegetation was oak forest (red), oak woodland (blue), coastal scrub (green), conifer (white) or other land cover types (yellow). Image orientation and area are as in Fig. 1.

Table 5. Relative proportions of observed vegetationor land cover types on areas predicted as oak forest sites, as a function of substrate type (columns sum to I).

Observed vegetation	Quaternary deposits	Paso Robles conglomerate	Careaga sandstone	Sisquoc shale
Oak forest	0.17	0.14	0.18	0.13
Oak woodland	0.54	0.24	0.35	0.65
Coastal scrub	0.14	0.34	0.33	0.05
Conifer forest	0.00	0.00	0.00	0.04
Other	0.14	0.28	0.15	0.13

Conclusion

The accuracy depends on

•Substrate (Geology)

•Size of vegetation patch (Ecology)

•Disturbances: Hard to differentiate the disturbed and undisturbed areas (site variable).

•Flaw in Model (Much of the observed oak forest occurred only on lower portion of slopes. It indicates less intense disturbances on lower slope areas)

•Trade off between model complexity and model reliability

Recommendation:

•Accuracy of the data (High resolution DEM)

•Data with less cartographic noise

•Accurate operational process such as digitization and registration

GIS based cartographic technique is not substitute for field sampling and testing technique but is a complement to that technique and useful for analysis of large heterogeneous areas.