Title
Identifying environmental and agricultural values and opportunities for regional planning:a GIS approach

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Identifying Environmental and Agricultural Values and Opportunities For Regional Planning: A GIS Approach

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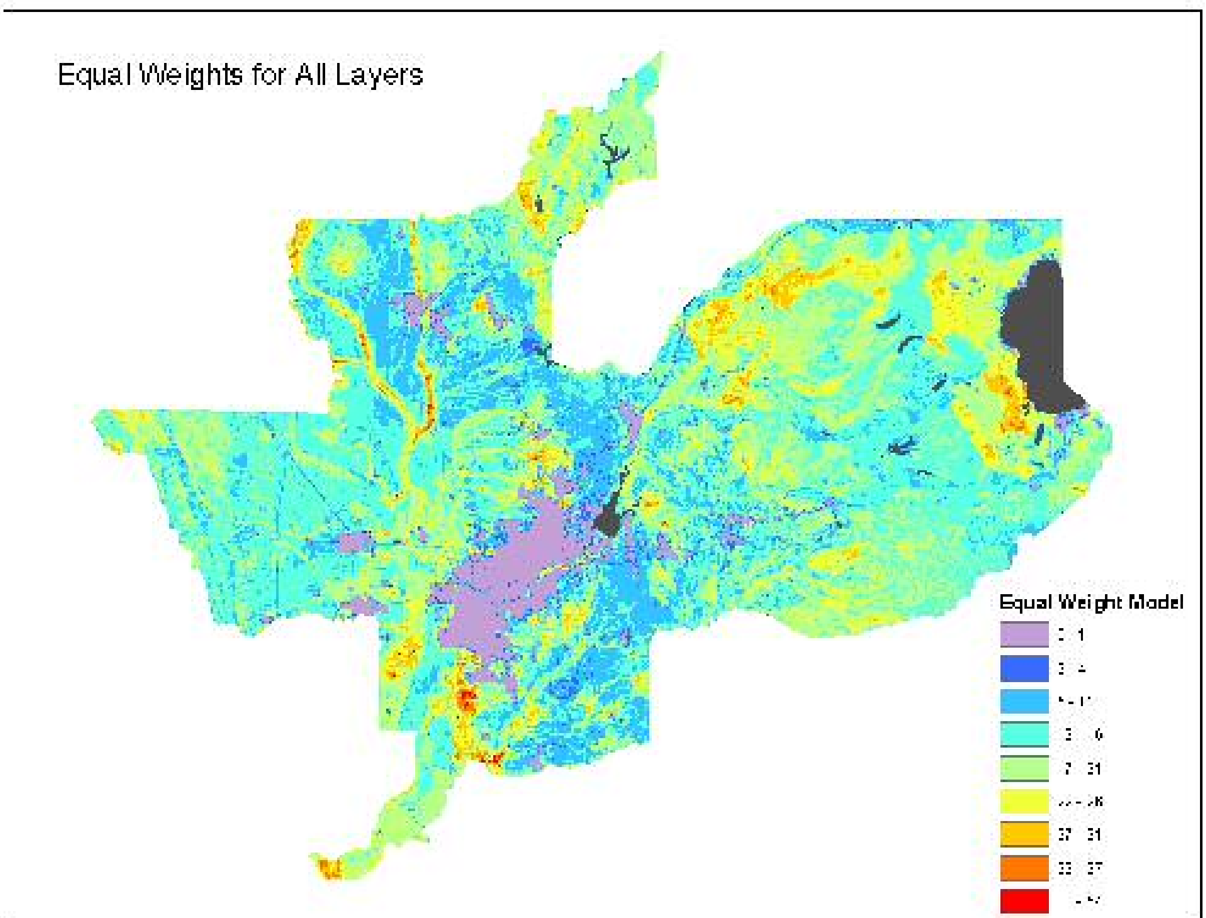


Abstract

The Sacramento, California, U.S.A, Area Council of Governments (SACOG) commissioned the Information Center for the Environment, University of California, Davis (ICE) to assemble a suite of the best available region-wide GIS data depicting natural resource values and conservation opportunities for the six County, 6,500 square mile (16,830 square kilometer) Sacramento, California region. This region is planned and managed by a large and diverse number of government entities and it contains a population of approximately 2,000,000 with a wide range of natural resource and economic interests. The purpose of this commission was to create a visual, conceptual tool depicting and weighting natural resource variables that are of value to the many parties of interest in land use and conservation planning in the region.

ICE investigators were charged with using their best professional judgment regarding central and salient variables to include in study. Where necessary they were required to use surrogate data to estimate the location and value of some natural resources. They were also responsible for choosing methods for combining data in ways that reflected the interests of various constituencies in a manner that would inform land use decisions. The investigators were also required to submit their choices for data inclusion and combination to peer review.

ICE reviewed its own extensive holdings of GIS data, surveyed metadata from other organizations and called upon knowledgeable parties statewide to discover the range of available GIS data for the region. Investigators reviewed all available data for fitness to purpose, judging the salience, quality and discrimination ability of candidate data sets. Twenty-six GIS data sets of approximately 100 reviewed were chosen for inclusion. These data sets each addressed a single environmental or land-use theme, such as “plant community.”

Thirty-six values within the twenty-six chosen themes were identified and given a preliminary rank according to their centrality to a particular resource question. Themes were organized into four content domains, such as “biodiversity,” or “water resources.” The relative weight of all values, themes and domains were programmed to be manipulable throughout the study in order to test a variety of approaches and to allow response to peer review and possible future community ranking.

A daylong peer review session involving academic and planning professionals was held to consider the sufficiency and quality of data used in the study and the appropriateness of treatments applied in weighting and combining the data for decision support. Peer review resulted in discarding 1 data set and adding 14 data sets. The number of domains was increased from 3 to 4. Three methods of combining variables were used. They were “equal weighted,” “domain weighted,” and “policy weighted.” Peer reviewers favored “domain weighting” wherein a related family of values could be seen independent of other themes. It is important to note that, while peer reviewers had minor differences on the centrality and weighting of data, all agreed that the general methodology being employed was highly desirable for the decision process at hand. Resulting maps and metadata were transmitted to SACOG along with original data for future study and use by SACOG and their constituent agencies.

Data

General Description

Twenty-six GIS data sets, termed “themes” in our study, were used. Data sets depicted from 1 to 5 conditions, termed “values” in our study. A total of thirty-six values were used. Data sets generally grouped into four thematic domains. Domains included, biodiversity, water resources and wetlands, agriculture and open space and conservation opportunities. A listing of datasets, their values and domain membership are found in table 1.

Table 1

DOMAIN	THEME	Source	Description
bio	nwi	U.S.F.W.S	National Wetlands Inventory
bio	Vernal Pool (Sensetive)	California Department of Fish and Game	Holland Vernal Pools
bio	Riparian Forest	California Department of Forestry	Riparian Vegetation (FRAP)
bio	Hardwood Forest	California Department of Forestry	Hardwood Vegetation (FRAP)
bio	Threatened +Endangered	California Department of Fish and Game	National Diversity Database
bio	Land Cover	California GAP Analysis Project (UCSB)	GAP Land Classes
bio	Important Geology	California Geological Survey (DOC)	Important Geology
bio	Significant Natural Areas	California Department of Fish and Game	Significant Natural Areas
bio	Wetland + Riparian Area	California Department of Fish and Game	Ducks Unlimited Wetlands and Riparian
bio	Natural Waterways	U.S. Geological Survey	Naturally Occuring Waterways, buffered
water	Polluted Rivers (303d)	Regional Water Quality Board	RWQCB 303d Rivers
water	100 Year Floodplain	Federal Emergency Management Agency	FEMA Floodplain Data
water	Wild and Scenic Rivers	National Parks Service	Wild and Scenic Rivers
farm	Important Farmlands	California Department of Conservation	Important Farmlands
farm	Agricultural Easements	California Department of Conservation	Agricultural Easements
main	SACOG (6 County Border)	California Spatial Information Library	Study Area Boundary
mask	Current Urban	California Department of Forestry	Urban Areas
mask	Lakes	California Spatial Information Library	Lakes
potential	Public Managed Lands	California GAP Analysis Project; DFG; ICE	Combined Managed Lands
potential	Parcel Size	SACOG	Parcel Size
potential	Urban Sphere of Influence	SACOG	Spheres of Influence
potential	Water Delivery Watersheds	ICE	Watershed Potential/Delivery Watersheds
potential	Slope	California Spatial Information Library	Slope
potential	Wildfire Fuels	California Department of Forestry	Fuel Rank (FRAP)
potential	Buffers Around Public Land	ICE	Buffer around Combined Managed Areas
Potential	Protected Resources	California Department of Conservation	Mitigation Banks

Data Transformation

Data for the SACOG GIS model were gathered from a variety of sources. The model requires that all the data be uniform in shape, size, format, and projection. Therefore, a process was applied to each layer as necessary. Shapefiles were converted to coverages. Data were projected to California Albers. Statewide coverages were clipped to the study area, and countywide coverages were appended or merged together to form the full study area. Grids were converted to a uniform cell size. Because acres are a common unit of land-use measurement, the grid cell size was chosen to represent 63.615 meters, which is equivalent to 1 acre.

We then developed selection rules for the individual layers to best extract representative data for that theme. Some themes represent a single category of resource distribution. Those layers, polygons (or grid cells) that fit a selection rule were assigned a value of 1, and all other areas were assigned a value of 0. A zero score would drop a polygon out of the coverage. Some themes had multiple categories, and in those cases the polygons were assigned a value from 0-1 dependent on the importance of representing that value so that some categories of resource obtained a higher "representation score" than others. See Figure. 1 and Table 2 below.

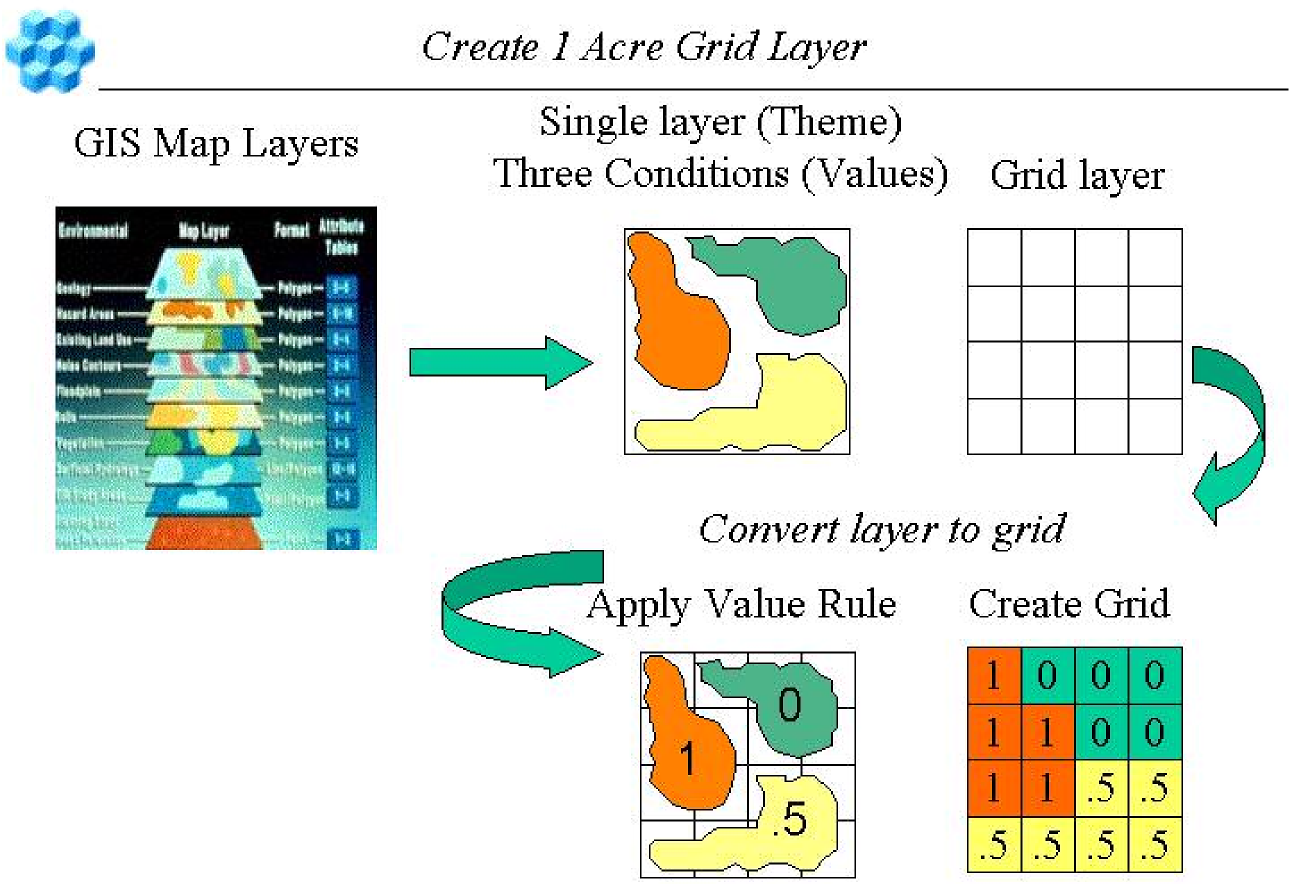


Figure 1

Table 2

VALUE SCORES MULTIVARIATE COVERAGES (ALL OTHER COVERAGES 0-1)

Theme	Categories	Score
Farmlands	Prime	1
	Unique	1
	Statewide Importance	0.75
	Local Importance	0.5
	Grazing	0.25
Slope	slope > 30 degrees	1
	10 < slope < 30 degrees	0.5
	slope < 10 degrees	0
Managed Areas	Public - wilderness	1
	Public - protected	1
	Public - multi-use	0.5
	Private	0
Fuel Rank	Very High	1
	High	0.67
	Moderate	0.33
	Non-Fuel	0
Parcel Size	area > 40 acres	1
	1 < area < 40 acres	0.5
	area < 1 acre	0

A field (WCODE) was added to each theme to hold the 0 to 1 values, and grids were created from that completed WCODE field. Each grid cell would then contain the value assigned to it. An AML script processes the grids using a user-supplied multiplicative value that weights the grids according to expert opinion of the salience and centrality of the variable and then adds the weighted grids together. The user can adjust the weights to explore the relative effects of differential ranking of values. The output is the sum of all the weighted grids in the study area. See figures 2 and 3 and table 3 below.

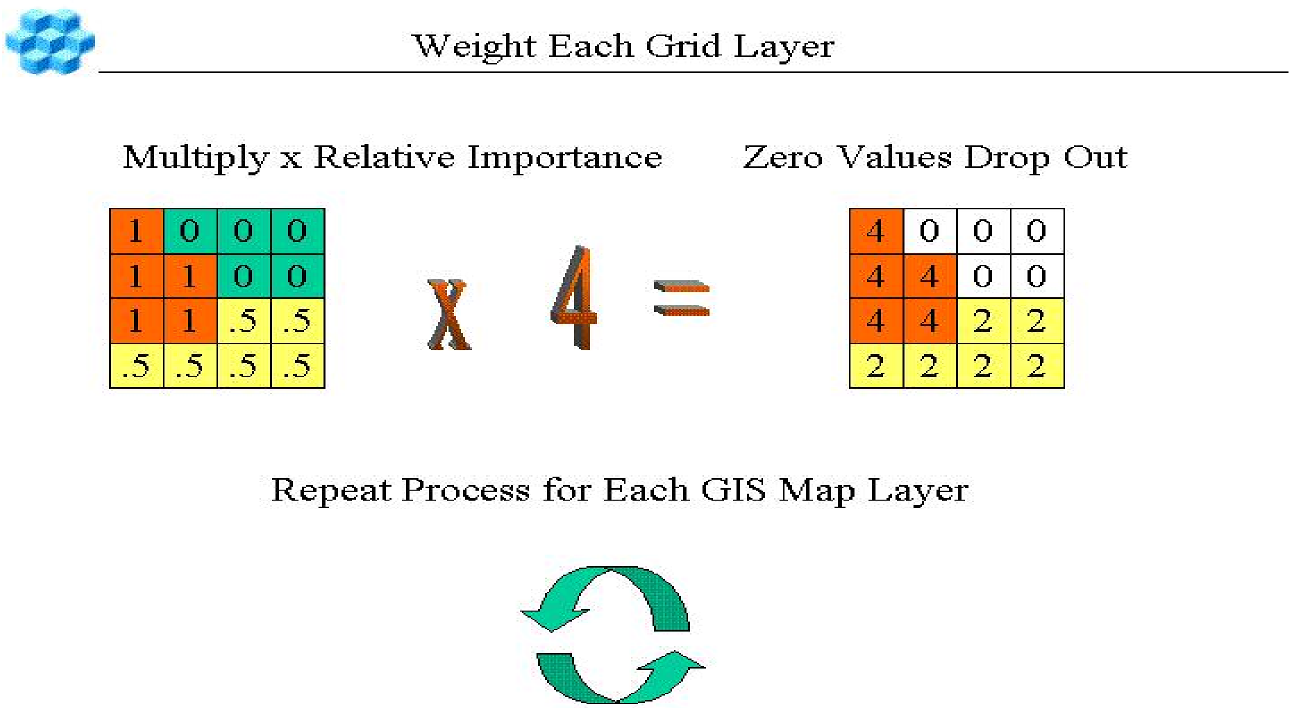


Figure 2

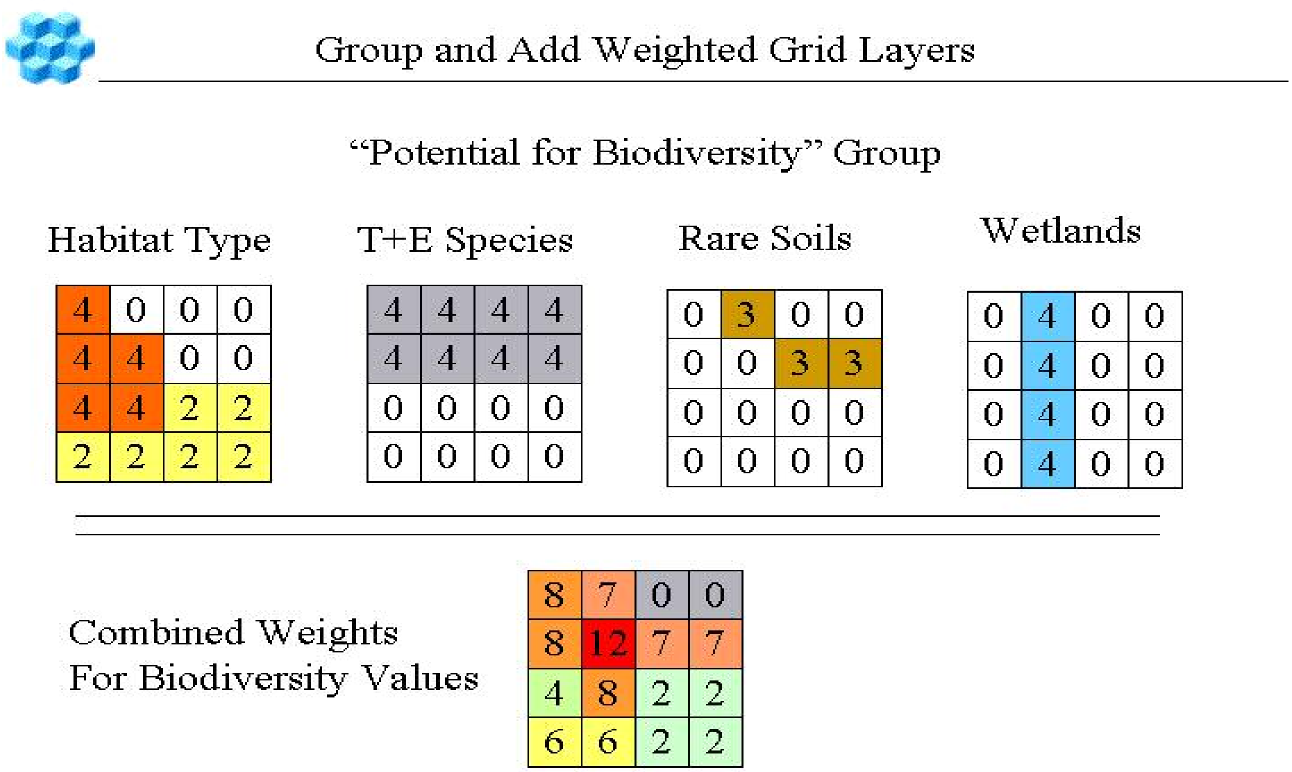


Figure 3

Table 3

Domain	Theme	Equal Theme Weight	Bio Domain Weight	Farmland Domain Weight	Potential Domain Weight	Culture Domain Weight	Agricultural Orientation	Habitat Orientation	Wetlands Orientation
bio	National Wetlands Inventory	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00
bio	Holland Vernal Pools	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00
bio	Riparian Vegetation (FRAP)	1.00	1.00	0.00	0.00	0.00	0.25	0.50	1.00
bio	Hardwood Vegetation (FRAP)	1.00	1.00	0.00	0.00	0.00	0.25	0.25	0.00
bio	National Diversity Database	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00
bio	GAP	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00
bio	Important Geology	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00
bio	Significant Natural Areas	1.00	1.00	0.00	0.00	0.00	0.50	1.00	0.00
farm	Important Farmlands	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
culture	RWQCB 303d Rivers	1.00	0.00	0.00	0.00	1.00	0.25	0.25	1.00
potential	Combined Managed Lands	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
potential	Parcel Size	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00
potential	Spheres of Influence	1.00	0.00	0.00	1.00	0.00	0.50	0.50	0.00
potential	Watershed Potential/Delivery Watersheds	1.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00
mask	Mask of Lakes and Urban combined	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
culture	FEMA Floodplain Data	1.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00
culture	Wild and Scenic Rivers	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00
potential	Slope	1.00	0.00	0.00	1.00	0.00	0.00	0.50	0.00
potential	Fuel Rank (FRAP)	1.00	0.00	0.00	1.00	0.00	0.00	0.25	0.00
main	Study Area Boundary	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
bio	Duck Unlimited Wetlands and Riparian	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00
bio	Naturally Occuring Waterways, buffered	1.00	1.00	0.00	0.00	0.00	0.50	0.00	1.00
potential	Buffer around Combined Managed Areas	1.00	0.00	0.00	1.00	0.00	1.00	0.50	0.00
potential	Mitigation Banks	1.00	0.00	0.00	1.00	0.00	0.25	1.00	0.00
farm	Agricultural Easements	1.00	0.00	1.00	0.00	0.00	1.00	0.25	0.00

Metadata

All data and data transformations were recorded in a brief metadata format consistent with the CERES metadata catalog and emerging National Biological Information Infrastructure standards.

Peer Review

Professional peer review was sought in order to measure the degree to which the work of the principal investigators reflected mainstream conservation and planning practice. A cross section of academic and community and resource planners were invited. Fifteen attended. Seven from local government, two from state government, five from academic institutions and one from a conservation organization. All were familiar with GIS and the uses of GIS in planning. Most were affiliated with parties of interest in land use planning in this region. They were asked to act as representatives of their profession and not their institution but their professional and institutional biases were understood and, when within the range of responsible professional commentary, were welcomed as representative of responsible regional concerns.

The meeting was held for 8 hours on September 20th at the Alumni Center at UC Davis. The group received a presentation of the project, its current data, and its current methodology as it was on that date. Presentations included maps of all resources that principal investigators had, to that point included in the project. Each data layer was examined for quality and applicability to the project. An overall review of data quality and sufficiency was also considered. In general, peer reviewers found that data did represent the best available data but they did identify some gaps, as mentioned above, which were subsequently rectified.

Methods for combining data layers were discussed and a clear consensus emerged regarding what we call the "domain weighting" runs. More discussion of that will follow in the sections on methods and results.

Though the data had shortcomings we, and peers, found it to be good enough to embark on long term, large area planning. This is important to note as non-GIS based attempts to reach this level of consensus among professional staff or political leadership had been stalled for several years. In the spirit of the peer review we embarked on a method that allowed maximum flexibility for the expression of particular interests.

Method

Value Scores for Attributes

The attributes of any coverage, whether they fell into one, or more, categories were assigned value scores ranging from 0-1 through best professional judgment of the salience and centrality of an attribute to a resource domain or policy interest. The farmlands coverage is a good example of this.

Farmlands has five attribute types and professionals agreed that they represented different levels of importance for farmland conservation. Therefore, the following rankings were given:

Table 4

Farmlands	Prime	1
	Unique	1
	Statewide Importance	0.75
	Local Importance	0.5
	Grazing	0.25

Relative Weighting of Themes

The Farmland theme in the above example was then combined with a map of agricultural easements and a mask of urban and lakes within the study boundry to create a composite map showing a value surface for the different types of farmland, farmland status and farmland location. Another example would be the combined map creating a biological value surface. It consists of data from the following coverages:

Table 5

National Wetlands Inventory
Holland Vernal Pools
Riparian Vegetation (FRAP)
Hardwood Vegetation (FRAP)
National Diversity Database
GAP
Important Geology
Significant Natural Areas
Duck Unlimited Wetlands and Riparian
Naturally Occuring Waterways, buffered
Mask of Lakes and Urban combined
Study Area Boundary

This approach allows tests of classes or domains of values that are of general interest to special constituencies. Most peer reviewers favored this approach as it allowed interest groups to refine their goals and improve the maps about which they were apt to know the most.

Policy scenarios

Policy scenario runs were mixed domains. In these runs we attempted to scale the weight of farmlands against the weight of biological resources for example. This is as opposed to the domain method where only like themes were combined (i.e. biological values grouped together, or farmland related values grouped together). The purpose of this was not to advocate one domains ranking above another but to demonstrate that the weighting process could be used to depict any level of consensus about such ranking that diverse interests might arrive at. Our three runs included an agricultural theme dominant run, a habitat dominant theme run and a wetland dominant theme run. Here table 6, for example, are the values and weightings of the habitat orientation run.

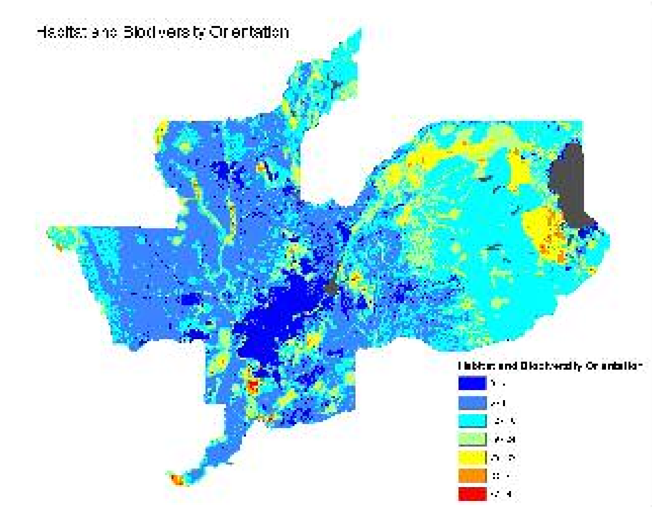
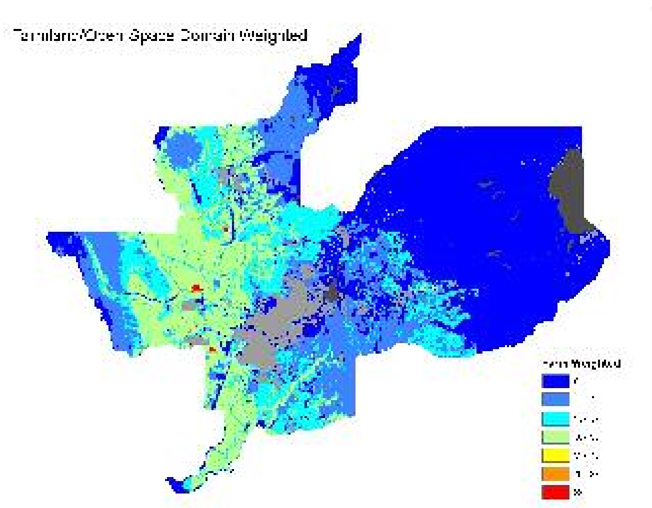
Table 6

Description	Habitat Orientation
Agricultural Easements (Dedicated ag land)	0.25000
Buffer around Combined Managed Areas	0.50000
City Spheres of Influence	0.50000
Combined Government Managed Lands	1.00000
Fire Fuel Rank (FRAP)	0.25000
Floodplain Data (100 year flood)	0.00000
GAP (U.S. Protection Map)	1.00000
Hardwood Vegetation	0.25000
Important Farmlands	0.00000
Important Geology	1.00000
Mask of Lakes and Urban combined	1.00000
Mitigation Banks (Protected Lands)	1.00000
National Wetlands Inventory	1.00000
Natural Diversity Database (Species)	1.00000
Naturally Occuring Waterways, buffered	0.00000
Parcel Size	1.00000
Riparian Vegetation	0.50000
RWQCB 303d (polluted) Rivers	0.25000
Significant Natural Areas	1.00000
Slope	0.50000
Study Area Boundary	1.00000
Vernal Pools (Endangered Species)	1.00000
Water Potential/Delivery Watersheds	0.00000
Wetlands and Riparian (esp. Waterfowl)	1.00000
Wild and Scenic Rivers	1.00000

Conclusions

This exercise illustrates a method of professional exchange that allows for interests to be expressed as spatial data elements.   The process of planning for natural resources and open space in this region had been gridlocked for many years by competing interests who were unable to bargain effectively for their positions. A part of this inability was due to a lack of common understanding of the resource and opportunity base represented regionally. Parties of interest had little incentive to give up any element in their focus when they were unaware of other and perhaps greater opportunities to achieve their interests regionally. The first step in brining this regional picture to the parties of interest has now been taken. Professional agreement about the general sufficiency and appropriate combination of this data has been reached. This milestone was the first goal of this study and it was achieved.

This process was not meant to conclude that any particular pattern of conservation was preferable to any other. It was designed to create a common conceptualization of values on the landscape. It was meant to inform and encourage planners to venture forth and try a variety of scenarios that might best suit the physical, cultural and biological needs of the region as seen by a variety of constituents. This greater process will begin with a meeting of political leaders, professional planners, and members of the interested public on October 18th, 20002 in Sacramento, California. This GIS work and the wide variety of options it represents will form the starting point for the regional political dialog that will begin this new phase of regional planning. We believe that using a flexibly weightable GIS with representation of all of the themes salient to each important interest group will allow this dialog to more fully represent the interests of groups while not locking them into hard positions about particular solutions too early in the process. The desired outcome will be for major interests to find combinations of land uses that satisfy the majority of values of concern to all. This remains to be seen and this report will be updated as progress is made in this next project phase.

Habitat and Biodiversity Orientation	
Farmland Orientation	
Water and Wetlands Orientation