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CALIFORNIA RIPARIAN EVALUATION SYSTEM: AN ARCVIEW DECISION SUPPORT TOOL FOR ENVIRONMENTAL MANAGEMENT

The California Riparian Evaluation System (CARES) is a habitat evaluation tool designed to be used by decision makers who are not experienced with GIS. The current version was designed for the Wildlife Conservation Board of the California Department of Fish and Game to support their analysis of how riparian habitat restoration funds should be allocated. CARES, developed by the California Rivers Assessment (CARA) staff at the University of California, Davis, allows for the identification of riparian areas of high quality and diversity which are at risk or which have a high potential for conservation or restoration. The system is comprised of a state-of-the-art ArcView 3.0 graphical user interface through which users may alter evaluation criteria priorities to match conservation goals. The application operates by allowing users to specify a mapping of the domain of a coverage onto a [-1,1] score. The users may then specify relative weightings for each variable and construct a map of the normalized sum of the weighted scores. Results are displayed as ArcView shapefiles which highlight potential sites for conservation based on criteria chosen. Currently five data layers are available for inclusion in the user-defined criteria selection: Land Use/Land Cover, Land Management Status, Flow Regime (Natural or Altered), Potential Plant Species Richness, and Potential Vertebrate Species Richness. It is straightforward to add more layers to CARES as requested by users. The CARES system has recently been ported to Spatial Analyst which dramatically reduces processing time.

INTRODUCTION

Environmental information systems are only as useful as the willingness of policy makers to use the information provided. In this paper we describe a simple decision support tool designed to help state officials who are not experienced GIS users effectively allocate bond funds and other public monies intended to support acquisition or restoration of river and riparian habitats for the purposes of enhancing wildlife, fisheries, and water quality. The design of the application is very general, and may be easily adapted to the general problem of visualizing potential value and identifying promising locations for focused natural resource management, conservation or restoration. The use of this kind of scenario builder is particularly appropriate when different participants in a political process hold very different views on the relative importance of values regarding land use, species, and environmental amenitites.

BACKGROUND

Information Center for the Environment

The Information Center for the Environment (ICE) is housed in the Division of Environmental Studies at the University of California, Davis (UCD) and is part of the Center for Ecological Health Research (CEHR). ICE is a cooperative facility supporting projects of an interdepartmental faculty with funding from a diverse group of collaborators and grant programs, including the Biological Resources Division of the USGS, the California Biodiversity Council, the California Department of Fish and Game, the California Department of Parks and Recreation, the California Water Resources Control Board, the U.S. Man and the Biosphere Directorate at the State Department, the National Park Service, the National Science Foundation, The Nature Conservancy, the US Environmental Protections Agency (EPA), and the U.S. Forest Service.

The main goals of ICE include providing GIS, database systems, and modelling support to environmental resource projects, and developing easy-to-use public access to a wide variety of environmental information. ICE also serves to train students, planners, and environmental professionals to develop and use environmental information. We support databases and Internet tools for numerous organizations and have helped hundreds of users who had no previous access or experience get connected to the Internet. ICE also maintains extensive lists of on-line environmental and other bibliographies, of data management and meta-data sources, and of other environmental sites on the Internet. The ICE Web server is now accessed over 17,000 times per week from all over the world.

ICE may be accessed over the World-Wide Web at

```
http://ice.ucdavis.edu/
```

or from numerous other environmental or governmental servers.

California Rivers Assessment

The UC Davis Information Center for the Environment (ICE) serves as the principal technical contractor for California Rivers Assessment (CARA). CARA is an interagency program at the University of California, Davis, co-sponsored by 28 federal, state, and private resource agencies and conservation programs. Its goal is to map and assess the status of selected riparian and instream resources to assist in managing water allocations and other aspects of environmental planning. Data collection began in December 1993, with the California Resources Agency, several programs within EPA, and the National Park Service all providing substantial support (approximately $900,000 to date). Many more programs have provided data and technical assistance. CARA now holds statewide or regional ARC/INFO coverages for nearly 100 themes related to river resources, land use, and conservation and restoration related projects and organizations.

In support of these goals, CARA staff have developed several decision support tools allowing the public and decision makers better access to environmental and ecological information. One such tool, the Interactive California Environmental Management, Analysis, and Planning System (ICE MAPS), is a powerful interactive mapping query system that allows World-Wide Web users to create and download customized maps. The system allows Internet users to navigate to an area of interest within California, select the data layers desired for a final map, and have the ICE Web server and GIS software produce the map. The user then has the option to download GIF or PostScript files of the custom-made map and its legend. The URL for ICE MAPS is http://ice.ucdavis.edu/ice_maps and a detailed description of the system can be found in Beardsley and Quinn (1996).

In this paper we describe a second decision support tool, known as the California Riparian Evaluation System (CARES), developed by CARA staff in response to a need identified by the Wildlife Conservation Board (WCB) of the California Department of Fish and Game. In cooperation with Scott Clemons of the WCB, we developed a tool to allow WCB to better determine how and where riparian habitat restoration funds from bond initiatives and legislative appropriations should be allocated. CARES provides an ArcView 3 -based tool to visualize the identification of riparian areas of high quality and diversity which are at risk or which have a high potential for conservation under a wide variety of policy assumptions and priority sets. The CARES graphical user interface permits users to alter (in a user-friendly manner) evaluation criteria priorities to match conservation goals.

METHODS

California Riparian Evaluation System (CARES) Description

The purpose of CARES is to provide a user-friendly decision support system for the Wildlife Conservation Board to evaluate Riparian Habitat restoration and conservation potential in California. The system was developed based on existing data sets CARA has acquired for the state.

We used a simple 2-step additive algorithm to develop a measure of the potential "value" of sites (either polygons, when in the vector realm, or grid elements, when using Spatial Analyst). "Value" is user defined. For example, depending upon the priorities of the user, "value" might reflect number of species of either plants or animals, or some combination of the two, at a site, and might be conditioned on the site being on public land and upstream from the most upstream dam. In this case, "value" might be related to potential for a wild and scenic river designation. Conversely, being on private land and downstream of dams might represent high "value" for riverbank restoration to decrease sediment load into an estuary.

The first step maps each possible state in the domain of a coverage to a number on the [-1,1] interval. In the examples above, one might score a stretch of river (within a 1:24,000 USGS quadrangle) with the highest number of wildlife species as 1.0, the lowest as -1.0, and the others between the two by *2(rank) / (max. rank) - 1* (in other words, linearly by rank). In the first example, public land and above a dam would each receive a score of 1.0, and private land and below the dam would each score as -1.0. In the second example, the scores would be reversed.

The second step is for the user to apply a weighting to each variable (i.e., potential plant richness carries twice the weight of potential vertebrate richness). The overall "value" is just a linear combination of the scores multiplied by the relative weights, normalized so that the minimum possible score is -1, and the maximum score is 1. (The results could, of course, be just as easily normalized to any other interval, say 0 - 100%, for display, without any change in the information content.)

The current version of CARES uses three sets of variables, representing human impact, management regime, and potential species richness. The following provides a brief description of each of the data layers used, and the procedures performed on these layers, that make up the CARES program.

Data Categories

Human Impact

The first type of data included in CARES provides information about the "naturalness" of the habitat. The two GIS layers are included in this category, Land Use/Land Cover and Flow Regime, were derived from existing CARA GIS coverages and modified slightly in order to group the fields into a smaller number of categories. The Land Use/Land Cover data set is at a scale of 1:250,000 and was derived from USGS 1:250,000 Land Use and Land Cover Data. The USGS tiles were appended together by ICE staff, then categorized into Cutural and Natural Land uses (with Cultural Land Use includuding Agricultural, Urban and Mining categories, and Natural composed of all other categories). The default values assigned in CARES are:

```
Cultural:      -1
Natural:       1
```

These values can be modified by the user based on desired goals, and for each data layer the user will be prompted by a popup window to change these values if desired. In the default case, the system will rate cultural land uses as lowest priority (negative 1) and Natural land uses as highest priority (plus 1).

Flow Regime is a second data layer that indicates quality of the land. Since we were unable to identify an existing data layer indicating areas above and below dams, we built a data set that is a combination of the CALWATER watershed units and the Jurisdictional Dams) layer, both at a 1:100,000 scale. To produce this layer, we first ran a point-in-polygon overlay of the dams (point) layer and the CALWATER units (polygon) layer. Any CALWATER unit (planning watershed) that contained a dam was coded as such so that CALWATER units containing dams and those not containing dams were distinguishable. Next, using both a shaded relief and a hydrography layer in the background, each CALWATER unit that was determined to be above all jurisdictional dams was coded appropriately. All other units either contained a dam, or were considered to be below a dam. In CARES these CALWATER units are then assigned valued based on their flow regime using the following values as a default:

```
Above Dam:      1
Contains Dam:   -1
Below Dam:      -1
```

Management Regime

The next category of data included in CARES is management regime. The Managed Areas GIS layer, compiled by the Biogeography Laboratory at the University of California, Santa Barbara as part of their Gap Analysis project, was used to indicate the level of biodiversity protection afforded areas under different ownership and management. The Managed Areas data set was derived from the Teale Data Center's Government Ownership layer. (A PostScript version of the Managed Areas metadata can be found on the UC Santa Barbara Biogeography Laboratory anonymous ftp server.)

The Managed Areas layer includes a field for biodiversity protection status, and includes the following levels:

```
Level 1 -- High -- Managed for biodiversity protection
Level 2 -- Medium -- Other public lands
Level 3 -- Low -- Other private lands
Level 9 -- High -- Small size, managed for biodiversity
           protection (Level 1, but less than 100 ha)
```

The CARES default values are:

```
Level 1 and Level 9    -1
Level 2                0
Level 3                1
```

For their purposes, the California Wildlife Conservation Board (Scott Clemons, personal communication) has used the following for a goal of identifying areas of high restoration potential:

```
Level 1 and Level 9    1
Level 2                0
Level 3                -1
```

Alternatively, for conservation purposes the values could be set to:

```
Level 1 and Level 9    -1
```

```
Level 2                 1
Level 3                 1
```

Potential Species Richness

1. Plants

   According to the Jepson Manual (Hickman 1993), 33 sub-ecoregions exist in California. These areas are further divided into elevation zones at 500m intervals. John Hunter (CARA biologist/botanist) used the Jepson manual to select all wetland/riparian species and entered their potential distribution (Jepson sub-ecoregion and elevation zone) into a table. From this table, we extracted a species richness value for each sub-ecoregion/elevation band combination. These species richness values were sorted, given a value for rank order, divided by the highest rank order, and finally subtracted from 1. This normalizes the values to between 0 and 1, with 0 being the lowest rank and 1 being the highest. For a more detailed description of this process, see the metadata for this layer.

2. Vertebrates

   We used the Wildlife Habitat Relation (WHR) system to select only riparian species for California, and then used a table of species and quad codes linked with the 1:24,000 USGS quadrangle layer to get a coverage of quads including a value for species richness for each 1:24,000 quad. The species/quadcodes data set was obtained from Tom Lupo of the Wildlife Management Division of the Department of Fish and Game. The species richness values were then put in rank order in the same way the plant species were ranked. The result is a value for species richness normalized from 0 to 1, with 1 being the highest ranking and 0 the lowest. For a more detailed description of this process, see the metadata for this layer.

RESULTS

The version of the CARES application described above is currently being used by the California Wildlife Conservation Board to conduct preliminary regional evaluations of opportunities for acquiring riparian lands for public use as parks and greenbelts, and to protect wildlife, water quality, and water supplies. While the particular layers used were chosen by WCB on the basis of availability (through the California Rivers Assessment) and maximum applicability to WCB's mission, a variety of other layers, ranging from flooding characteristics to land costs, will be added to refine the possible queries. Other versions of the application are under design for use in prioritizing watershed-scale restoration efforts (particularly candidates for funding under California's Proposition 204 and the Federal Clean Water Act, Section 319). Other versions may easily be developed as demands from users arise.

DISCUSSION AND CONCLUSIONS

As information technology improves, non-technical policy makers are often confronted with a confusing mass of complex, partially integrated data. Often even simple visualization tools permit decision makers to investigate qualitative consequences of varying assumptions. Such tools can be of substantial value in identifying options, developing intuition, and identifying needs for targeting more extensive (and expensive) data acquisition and analysis. CARES is a conceptually straightforward application designed to meet these needs in the context of land use planning and public spending on rivers and riparian zones.

As with many visualization tools, the value of CARES is less in its precision (which is suspect), than in its flexibility, ease of use, and ease of comprehension. Simplicity, of course, comes at a cost in the sophistication of potential analyses. For example, the additive model permits fairly complex scoring rules within a variable, but only allows summations of effects among variables (i.e., no nonlinear interactions between variables are allowed.) As with all mapping exercises, care must also be taken not to take attractive graphical output more seriously than justified by the quality of the input data. On the statewide scale of the current CARES layers, the data are fairly sketchy on the local scale of individual restoration efforts. Nevertheless, experienced public officials, who understand the underlying data and the pitfalls of misinterpreting it, find that the simple visualization offered in this pilot study can reasonably well mimic the results of much more detailed analyses carried out at greater expense over smaller areas. To the degree that this continues to be true, and if new data continues to add value, spatial visualization will become an increasingly valuable tool for cost-effective environmental protection and restoration of California's river ecosystems.

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