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Applied Geographic Information Systems in Cooperative Natural Resource Projects: A California Example

Abstract

The Information Center for the Environment (ICE) at the University of California, Davis has been cooperating with various federal, state, and local agencies on the Natural Resource Projects Inventory (NRPI) to locate and catalog watershed-scale environmental management and restoration projects throughout the State. One of the goals of NRPI is to represent these projects spatially so they can be viewed in conjunction with other critical data layers. Currently, 1,464 projects are spatially referenced out of a total of over 1,700 projects in the NRPI database. This spatial online database will allow the public and decision makers to derive more effective conclusions regarding ecological restoration.

Prepared for presentation at the 1999 ESRI Users Conference, San Diego, California

Background

The University of California, Davis (UCD) Information Center for the Environment (ICE) has been involved in a collaborative effort with the California Biodiversity Council (CBC) to catalog project data for several thousand major resource-management efforts being developed and implemented throughout the state of California. This collaborative effort has culminated in the formation of the Natural Resources Projects Inventory (NRPI). This database is an expansion and combination of core elements of previous inventories developed by ICE and a number of public agency collaborators.

NRPI has adapted information from the California Watershed Projects Inventory (CWPI), which is now the Watershed Projects Inventory (WPI), which began in 1993 with funding from the CBC, the California Department of Fish and Game (CDFG), and the State Water Resources Control Board (SWRCB). WPI catalogs past, present, and proposed resource-based restoration projects within or near the borders of California. The criteria for inclusion in WPI include that the project address, multiple resource issues, involve multiple cooperators, and that it be funded.

The California Ecological Restoration Projects Inventory (CERPI), which began in 1996 with funding from the California Department of Conservation and the U.S. Environmental Protection Agency (USEPA) and the California Chapter of the Society for Ecological Restoration, is the second core element of the NRPI Database. This inventory is a catalog of on-the-ground projects that attempt to restore some aspect of an indigenous ecosystem.

The third major component of the NRPI core, is the California Interagency Coordinating Committee's California Noxious Weeds Projects Inventory (CalWeeds). The projects contained in this database are those that attempt to reduce or eradicate the number of noxious weeds in California and primarily focus on localized eradication or sustained suppression. Supporters include the California Department of Food and Agriculture and the Bureau of Land Management.

These inventories have been joined together by their core data elements into the NRPI Database. These core elements are a superset of the GILS (Government, or Global, Information Locator Service - see http://www.gils.net/). The GILS core unites the NRPI Database, allowing searches of all the underlying databases at the same time

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Objective

The primary purpose of NRPI is to function as a public decision-support tool, providing readily accessible information on restoration efforts ongoing throughout the state to the general public and decision makers, and thus supporting more efficient resource allocation and decision making. Detailed analysis using the database has included public land managers assessing the degree to which funding has been directed to the highest priority environmental changes and most sensitive communities, watershed groups assessing the effectiveness of alternative restoration strategies, and political scientists examining the properties of successful vs. unsuccessful stakeholder negotiations about land use and water policy.

California is complex, ecologically, culturally, and institutionally. Habitats recognized as threatened include rivers, deserts, montane areas, grasslands, and old growth wet forests. It is also politically complex. Over 1900 agencies within the state have been lead agencies in construction/development and restoration reports filed under the California Environmental Quality Act. We have also identified over 500 "watershed groups" (loosely defined) that represent a multi-organization initiative for environmental planning and management (see http://endeavor.des.ucdavis.edu/groups/).

California also has many pieces of legislation requiring or providing for restoration type projects. For instance, the Clean Water Act of 1972 (CWA) requires, under section 303(d) and 305(b), that an assessment of the quality of the Nation's waterbodies be submitted to Congress annually. For those watebodies that do not meet the water quality standard of "fishable, swimmable," the CWA requires that each state submit a prioritized

list of those waterbodies that do not meet water quality standards. In addition to this, states must also establish Total Maximum Daily Loads (TMDLs) for these waterbodies, which is a quantified written statement of the water quality problems and the contributing pollutant sources. The TMDL establishes quantities of pollutant reduction needed, allocates pollution control responsibilities among pollutant sources, and provides a basis for taking the necessary actions to restore the waterbody to a proper functioning condition (Clifford et. al, 1994).

Section 319 (h) of this act, passed in 1987, established a national program to control non-point source pollution; this is defined by the EPA as "caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into lakes, rivers, streams, wetlands, estuaries, other coastal waters, and ground water. Atmospheric deposition and hydrologic modification are also sources of nonpoint source pollution" (Elder, 1999). Section 319(h) makes grant money available to the states for projects that attempt to reduce the amount of nonpoint source pollution from agriculture, forestry, and urban sprawl (Elder, 1999).

The California Environmental Quality Act requires that an Environment Impact Report (EIR) be composed to address the environmental impacts of development projects. One required component is the inclusion of measures necessary to mitigate the negative impacts to the environment. These often occur in areas other than the development project.

The Endangered Species Act is yet another example of legislation spawning restoration projects. Under section 10 (a) of this act, the incidental "taking" of endangered species due to private actions can be permitted if the principal actor prepares a Habitat Conservation Plan (HCP), minimizing the impacts of these "takings" (Percival et al 1992). These are but a few of the projects that are currently ongoing within the state. NRPI attempts to catalog these projects and guide the decision making process in such a way that these projects are undertaken in the most efficient manner without duplication of effort.

Methods

Technology Used

The NRPI data is stored in a Microsoft Visual FoxPro 5.0 database containing 13 relational tables. The Database currently holds information on 1646 individual projects. The front-end application was developed in Visual FoxPro 5.0 using the GE Capital Consulting Visual MaxFrame Professional Framework and makes use of the Micromega Systems FoxFire! Report Writer.

Data Acquisition

The data for the NRPI Database has been acquired in several different ways. First at the inception of NRPI each of the 25 CBC agencies (see Appendix A) signed on to pledge one employee to serve as a point of contact (POC). The POC's collect the project information for the qualifying projects within their respective agencies and submit them to the NRPI coordinator at ICE to be entered into the database. Data is also acquired through individual contracts. For example, ICE was contracted by the U.S. Bureau of Land Management (BLM) to enter a series of programs into the database. Another example of an individual contract, is the Department of Water Resources (DWR) contract to enter into the NRPI Database the individual projects under their Urban Streams Program. Continued outreach is another means for data acquisition. An entry form for NRPI projects is also available to download and submit from the NRPI website (see - http://endeavor.des.ucdavis.edu/nrpi/).

Data Dissemination

In order to make the data readily available, ICE has utilized web technology in a variety of ways. The NRPI homepage makes the database available online via Microsoft's Active Server Pages. The online database allows the user to perform queries on attributes that include county, cooperator, title, and abstract, and return a list of projects meeting the criteria of the query performed. From the returned list the user can view all of the information associated with a project. The NRPI web site also has links to the homepages of the three underlying inventories, which are queriable in much the same way as the NRPI homepage. When the data for an individual project is on screen, links are present to the other inventories so that the user can quickly and easily view more detailed information if needed.

NRPI also has a very large spatial component, which is addressed through a linkage to two online products developed by ICE. From the NRPI page, the user can connect to the California Rivers Assessment (CARA) site and also to ICEMAPS2 (Interactive California Environmental Management, Assessment, and Planning System Mark 2 - see http://ice.ucdavis.edu). CARA includes an online database utilizing a Relational FoxPro 5.0 database, Microsoft Active Server Pages, JAVAScript, and ESRI's MapObjects Internet Map Server within HyperText Markup Language. CARA provides an assortment of data related to evaluating the environmental conditions of California's rivers. The data is organized by the watershed (8-digit USGS Hydrologic Cataloging Units). CARA enables the user to query the database on several levels: watershed, county, congressional districts, etc. Once the user chooses the appropriate spatial extent, a list of data/descriptors is given, including river miles of naturally occurring waterways, number of dams, and number of Natural Resource Projects. The user can then click on the resource projects and link to the NRPI database and retrieve a list of those projects within that watershed, county, etc. From this list a single project can be chosen; all the data associated with that project will be shown in the same manner as on the NRPI homepage. By including the NRPI data within the framework of the CARA site, the public and decision-makers can more easily visualize what problems, and on-the-ground measures to rectify them. These tools in combination can help users locate opportunities for

restoration or improved environmental management, and help identify those with the knowledge and infrastructure to attack the problems.

NRPI is also integrated into ICEMAPS2, an online mapping service provided by ICE. ICEMAPS2 uses ESRI's MapObjects, MapObjects Internet Map Server, JAVAScript, and HTML, and allows the user to pan, zoom in/out, select layers, and identify features. One of the datasets within the ICEMAPS2 interface is the NRPI coverage, which is a point coverage of project center points with the project number as a label. The user can select this layer from the list of available datasets and have it drawn on screen. The user can then "identify" any given point and an info box will spawn showing the project number, lat./long, and project title. The user can then query for more information on this project from the NRPI site. The user can also look at the NRPI data in conjunction with other critical datasets, in order to determine whether or not certain restoration needs are being met.

Discussion

NRPI Today

The NRPI Database currently holds information on a total of 1646 projects. All of these projects are referenced to the watershed level, using both the USGS 8-digit Hydrologic Units and the SWRCB Hydrologic Sub-areas. 1464 of these projects are spatially referenced by a lat./long. centroid and are viewable through the ICEMAPS2 NRPI data layer.

For the last year and a half, the focus of the NRPI project has been primarily data collection and data entry. That focus has shifted to increasing the detail on smaller more regional datasets. For example, ICE has been contracted by CalFed to enter and digitize the 135 CalFed sponsored projects ongoing throughout the Bay/Delta area. Also, ICE has been involved in gathering project information for restoration efforts in or near the Cosumnes River Preserve. In addition to these, ICE is also completing work on entering the California Department of Water Resources (DWR) Urban Streams Restoration Projects. These are community level projects, which attempt to restore the environmental, economic and aesthetic values of streams. These projects represent cooperative efforts between local agencies and local citizen groups. This effort to increase detail is resulting in smaller datasets that will be available to the users in ICEMAPS2 at a regional level.

ICE is also working with the California Department of Transportation to tie in Management Practices to each of the Projects in the NRPI Database. To help address the ongoing problem of non-point source pollution. Also, in the works is a direct tie-in to the NRPI Database from ICEMAPS2. As it is now, the "identify" tool spawns a window showing the project number, Lat./Long., and project name. With the new tie-in, the "identify" tool will connect to the database and spawn a window with all the information

available for the project, making it easier to access the data from the ICEMAPS2 interface.

Problems/Solution

One of the main problems facing NRPI in the beginning stemmed from the fact that it was an aggregation of existing inventories. The attribute sets for the Watershed Projects Inventory and the Restoration Projects Inventories were developed independently by different interagency working groups, and as a result used rather different vocabularies. After the fact, both were parsed into a GILS-based structure, but this involved completely reworking the data structure of the older CWPI database so that unique elements could be treated as part of a different controlled vocabulary rather than under the same data framework. Standardizing attribute usages did, however, provide an opportunity for improved quality control.

The initial phase of the watershed projects inventory used students to survey for qualifying activities. This approach proved expensive, partially because of the quasi-formal nature and diverse funding sources of watershed management efforts. For the last, the Biodiversity Council provided in-kind support by designating a contact person within each agency to incorporate its qualifying projects into the inventory. As a result, the number of identified projects has increased from some 450 to over 2000, most of which have now been cataloged. As with many databases, voluntary participation has increased as the inventory has become more complete, and therefore more useful.

Another major problem was how to represent projects in a statewide framework. A polygon coverage might show the size and scope of the project well, but many of the projects did not have accurate boundary descriptions included with the project data forms, and some (e.g. education efforts) are only vaguely geolocated. As a result, we chose watersheds to represent most projects spatially. USGS Hydrologic Cataloging Units were used for very large projects and SWRCB Hydrologic Sub Areas were used for smaller projects. This has worked well with some exceptions, such as countywide or statewide projects. Large numbers of projects addressing some locales also lead to difficulties in displaying mapped projects. Another approach was to use buffered centroids. Not all projects had centroids in the data form, so implied centroids were derived from project descriptions and bounding boxes using mapping tools developed for ArcView 3.0 using several Avenue scripts or other visual aids (e.g., Delorme's digital mapping software.) Once the centroids were gotten an AML was used to buffer these points using the project's area. The buffered centroid approach is effective for very localized projects. However, some of the larger projects generate implied circular buffers so large that they extended outside the borders of California. As a result, the current MapInfo application simply displays a point coverage, labeled with project number so that they can be referenced in the database easily. In the future, many CBC members would like to have all actual project boundaries digitized. If this is accomplished, projects will probably be divided into different coverages, permitting the ICEMAPS2 technology to display boundaries in appropriately localized views.

NRPI Versatility

NRPI is a very versatile tool because it can be used as a stand-alone tool to help guide restoration efforts, but it can also be integrated into other analysis tools. NRPI has been integrated into the GeoSpatial Waterbody System (GeoWBS) and the San Diego Storm Water Pollutant Load Model both developed by ICE. GeoWBS is ArcView 3.0a interface using developed for use by the state and regional water boards to gain increased spatial accuracy and data standardization in their annual Clean Water Act 303(d) assessments submitted to the EPA. NRPI is available as a dataset within this interface and also allows the user to tie Natural Resource Projects to an assessment of a waterbody. If a river is non-supporting for a certain beneficial use, but there exists a project in the vicinity that is addressing the sources of impairment, the user can tie the project to the assessment to be included in the report sent to the USEPA and then Congress. Identifying existing management efforts has proven useful in identifying potential duplications of effort. NRPI has also been instrumental in identifying opportunities to couple regional policy issues, such as forest practices permitting, affecting multiple watersheds or counties.

NRPI has also been linked to the San Diego Storm Water Pollutant Load Model. This is an ArcView 3.1 interface which connects to an excel based Pollutant Load Model developed by Larry Walker and Associates. The work is presently in prototype form to test coupling of institutional data with operational models. This model/interface allows the user to place management practices for land use types within watersheds to determine the amount of reduction of pollutant constituents. Because management practices are being included into the NRPI Database, this dataset will aid in determining how well certain practices work in the real and provide information on current efforts. For example, if a certain set of management practices is found to adequately reduce fecal coliform concentrations in a watershed, the user can then compare them to what is currently ongoing via the NRPI dataset. The model can also test to see how well the strategies being undertaking match up with other potential practices. This can then redirect current efforts if they are found to be inconsistent with findings instead of launching totally new projects.

Future Directions

Future NRPI activities include creating and more dynamic link between ICEMAPS2 and the NRPI Database, and a dedicated MapObjects driven watershed query system on the NRPI homepage. The next generation will allow casual users to select watersheds of interest and locate projects at this level and retrieve data on these projects quickly and easily. In collaboration with state and federal non-point source pollutant programs, NRPI will also link to a richer and more standardized vocabulary of management measures and legal authorities (e.g., permitting programs) for each of the projects within the current database. Finally, the content of NRPI will continue to expand and evolve. NRPI is substantially complete in listing current activities of some programs (for example, bond funded restoration efforts in the Sacramento River Delta system under CalFed, and CWA

Sect. 319 projects), but is incomplete to an unknowable degree for some other kinds of projects such as volunteer replanting developed with the support of local businesses or private foundations. However, the service continues to be heavily used (roughly 8,000 accesses per week), and is likely to continue developing as a prominent service of an unusual coalition of natural resource programs in California.

Appendix A

California Biodiversity Council Agencies
National Parks Service
Bureau of Land Management
Bureau of Reclamation
U.S. Forest Service
Natural Resource Conservation Service
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Geological Society
Ca. Coordinated Resource Management Plan Council
Ca. Department of Forestry and Fire Protection
Ca. Energy Commission
Ca. Department of Fish and Game
Ca. Wildlife Conservation Board
CSU Chico
Ca. Association of Resource Conservation Districts
San Diego Association of Governments
Ca. Department of Parks and Recreation
State Water Resources Control Board and the 9 Regional Water Quality Control Boards
Ca. Department of Transportation
Ca. Department of Transportation
Ca. Department of Water Resources
UC Cooperative Extension
Ca. Department of Food and Agriculture
The Nature Conservancy
Audubon Society

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