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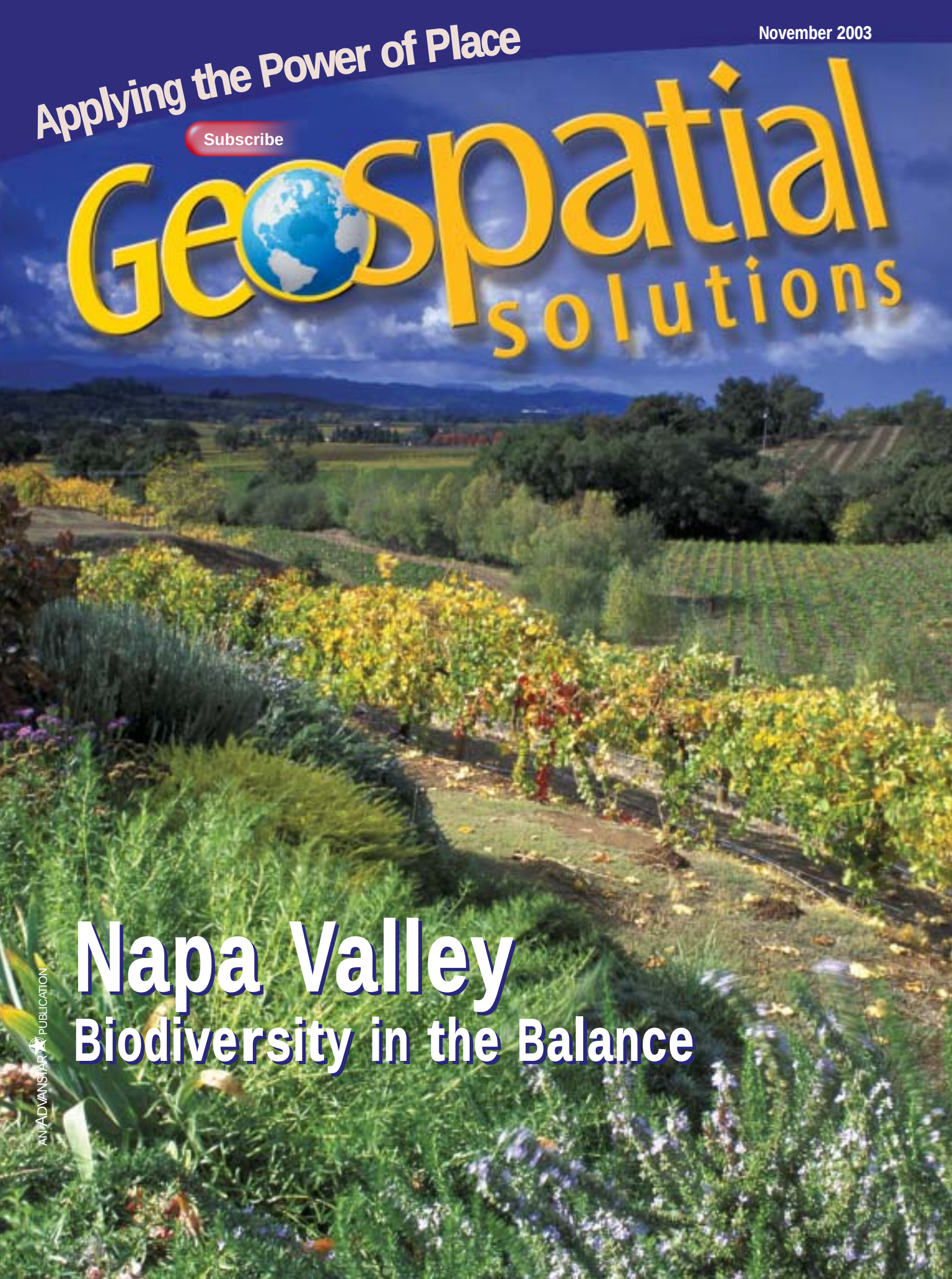
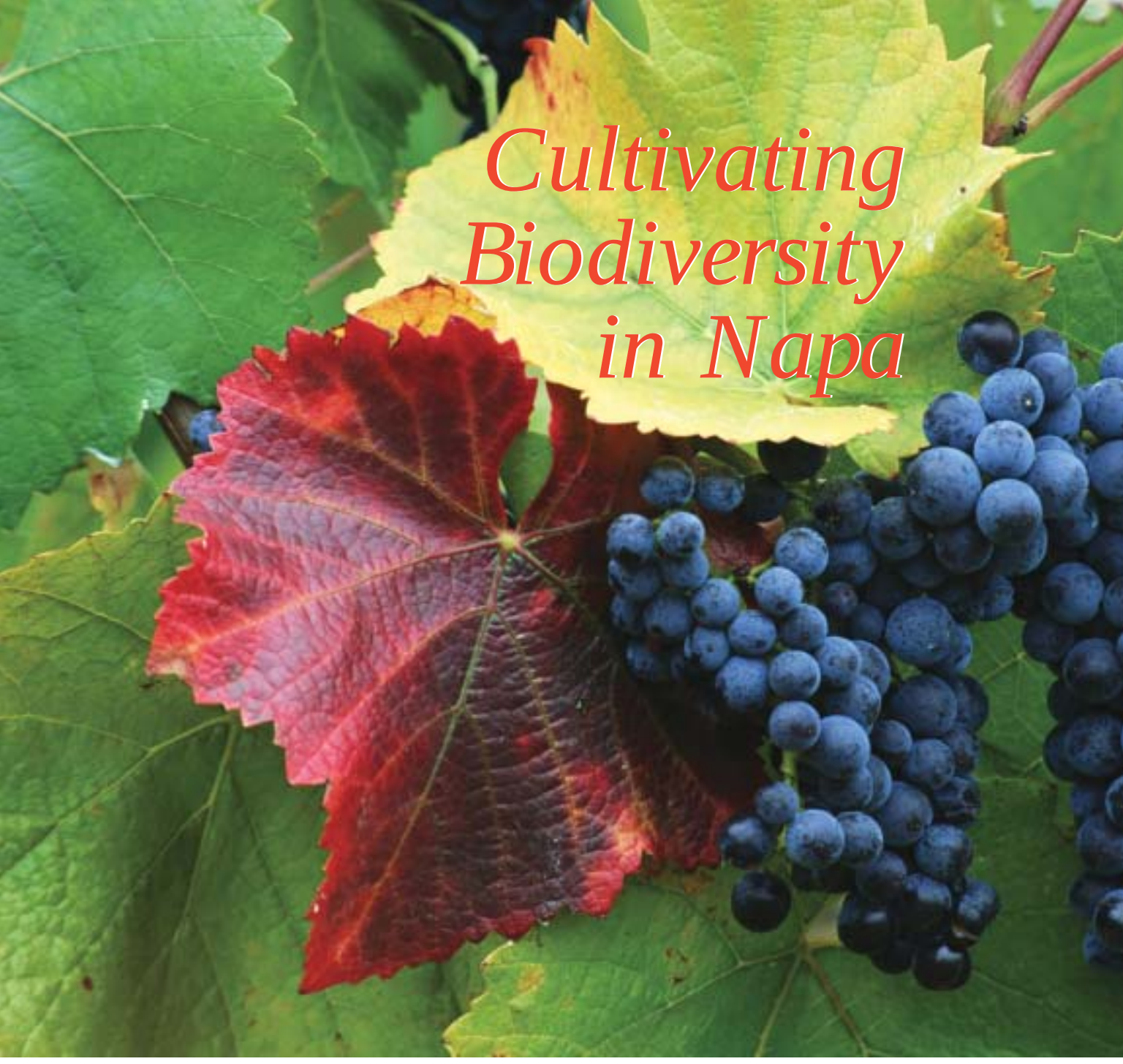


Napa Valley
Biodiversity in the Balance

AN ADVANSTAR PUBLICATION



Cultivating Biodiversity in Napa

A GIS-enabled decision-support system is helping Napa County environmentalists, vintners, and farmers to draft a road map for protecting the environment while maintaining a sustainable agricultural base and a vibrant urban community.

Rob Riordan and Kristin Barker

California's Napa Valley. The name conjures images of verdant valleys and scenic hillsides, a place where tourists cruise down two-lane country roads in search of world-class merlot, chardonnay, and cabernet sauvignon.

Good weather, good soils, and good marketing have made the Napa Valley synonymous with the American winemaking industry. But the valley has another distinction. Napa is also located in the heart of one of America's most important biodiversity hotspots. Its rolling oak-covered hills, clear streams, and rugged mountains are home to many rare species of plants and animals.

At least 68 imperiled species, and several important natural communities, are found in Napa County — one of the highest figures for any county in the

Decision Support

U.S. Fish and Wildlife Service

The California red-legged frog (top) and golden eagle (bottom), are among those increasingly threatened species that The Land Trust of Napa County aims to protect.

United States. Residents here are looking for ways to protect the wild places that are home to this wildlife. In fact, the natural beauty of the place is what attracted many of the 125,000 people who live here.They are also drawn by the economic opportunity afforded by a climate and landscape that is ideal for grape growing and the tourism boom it has brought.

Like hundreds of other communities, though, Napa faces the challenge of finding a balance between economic growth and environmental protection. In the past decade, more and more hillsides have been converted from natural oak woodlands into vineyards. As the grapevine monocultures squeeze out habitat for native plants and animals, species such as the California red-legged frog have become increasingly threatened, and land-use conflicts have grown more common. Now vintners, farmers, and environmentalists are together seeking a roadmap for protecting the environment while maintaining a sustainable agriculture base and a vibrant urban community.

One local group, the Land Trust of Napa County, works to conserve the county's natural diversity, scenic open space, and agricultural vitality. John Hoffnagle, the trust's executive director, points out that his organization, like most of the 1,200 local land trusts in the United States, has operated on a mostly reactive basis — protecting land as opportunities arise, such as through donations from conservation-minded landowners.

But which places in Napa County are the most important to conserve? Would it be possible to turn that reactive approach into a proactive one by systematically analyzing the county's landscape to prioritize and protect the most ecologically significant places? This challenge has drawn a group of conservation biologists, information scientists, and GIS experts to scenic Napa.

Decision support for conservation

Napa County is hardly unique in the challenges it faces. Across the United States, communities are struggling with the complex task of balancing environmental protection and economic growth to enhance their quality of life.

The bottom line demonstrates the importance of these concerns. In 2002 alone, U.S. voters approved an astounding $10 billion in public funds for open space protection and land acquisition through local and state ballot initiatives. The question is whether that money will be invested in a way that conserves biodiversity while also meeting other important community goals.

Much of the answer will depend on how thousands of policy makers — from local planners to regional land trusts to state officials — decide which places to protect. These decision makers need reliable, scientifically accurate information about habitats and species, delivered in an understandable and accessible format, and integrated with other aspects of their organization's decision-making process. They will need, in short, a decision-support system (DSS) for conservation.

Enter NatureServe, a nonprofit conservation group that brings together science and information technology to enable conservation action. With three decades of experience and a network that includes several hundred scientists across the United States and beyond, NatureServe is a leading source for information about rare and endangered species and threatened ecosystems.

Unique among national conservation groups,

Glossary

DSS: Decision-support system

FGDC: Federal Geographic Data Committee

ICE: Information Center for the Environment

NASA REASON: Research, Education, and Applications Solutions Network

XML: eXtensive markup language

USGS: U.S. Geological Survey

Decision Support

NatureServe specializes in applying information technology to environmental issues. The group maintains a database that documents nearly 500,000 precise localities for at-risk species and natural communities — the result of 25 years of fieldwork and research. NatureServe also designs the customized GIS software used by its network of natural heritage programs to manage this storehouse of ecological knowledge, and the biodiversity data model widely used for collecting and managing data about plants, animals, and habitats (see www.natureserve.org/prodServices/biodatamodel.jsp).

For the past two years, NatureServe has led a team of scientists, conservation planners, economists, GIS specialists, and software engineers to develop a DSS for land-use and conservation planning. The project aims to help planners understand local ecosystems, identify high-priority lands and waters, and evaluate competing land-use plans. Team members include the University of California at Santa Barbara Biogeography Laboratory, the U.S. Geological Survey (USGS), the Wyoming Natural Diversity Database, the Florida Natural Areas Inventory, and ESRI.

Bridging the gap. In many places, considerable scientific data about species and habitats is available, yet decision makers have difficulty incorporating it into the policy process. Several factors are at work here: lack of time and resources, lack of access to the data in readily usable formats, and even a cultural gap between the scientists who develop the data and the policy makers (and general public) who need it.

By building GIS mapping technology and scenario modeling onto a solid foundation of conservation biology, DSS can integrate complex information about biological issues (such as sensitive habitats, threatened species), physical issues (including land cover, soil types), and socioeconomic issues (such as land costs, roads, and agricultural productivity). Because many decision makers understand visual information best, DSS uses the power of mapping and scenario visualization to help bridge the gap between scientists and policy makers.

NatureServe's approach to DSS emphasizes flexibility and local control. "One thing we've heard over and over again from local officials is that they want involvement in how analyses are done and how plans are made. Top-down conservation based on static maps produced by outside experts is often not accepted at the local level where conservation must occur," says Patrick Crist, who manages the scientific component of the DSS project for NatureServe. "DSS brings solid science into the planning equation in a way that incorporates local values and gives people the sense of control that they are looking for."

DSS has great promise, but technological solutions often run the risk of becoming too complex for the very people they are intended to help. To ensure that the system meets the needs of the users, the NatureServe project is steered by an advisory panel of local and state officials and conservation leaders. The project was launched in 2001 with generous support from the Doris Duke Charitable Foundation, the Surdna Foundation, The Nature Conservancy, and the NASA REASON program. Napa County has been the site of the first pilot project.

The conservation planning process

Building a DSS for conservation combines twin disciplines: conservation biology to assess and calculate biodiversity values across the landscape, and software engineering to generalize this process into working software functions. The result is a multistep conservation planning process that unites the planner's expertise about local conditions with biodiversity expertise from a scientific support team, enabled and assisted by the DSS software.

For the planning process to produce scientifically credible results, an accurate and reliable conservation planning database for the local area must be assembled. The cornerstone of this database is the set of elements to be conserved (species, communities, and ecological systems) and the data layers that depict their local distribution. The scientific support team combines these data with other essential GIS and tabular data, then delivers this database to the planner for analysis related to local conservation issues.

In summary, the conservation planning process consists of the following steps: 1) identify conservation elements; 2) generate conservation element data layers; 3) produce conservation value summary; 4) evaluate current land use against conservation goals and identify gaps in protection; 5) import and evaluate conservation scenarios to fill the gaps; and 6) reach a planning decision or repeat the process as conditions change.

Identifying conservation elements. The project begins with the scientific support team setting up a basic database for the planning area, establishing essential context layers, such as elevation, roads, and hydrography, and defining planning units, such as parcels or watersheds. The team then analyzes the planning area's biodiversity to produce the default list of conservation elements — the units of conservation concern. This task includes acquiring, formatting, and assessing the quality of the needed data from multiple sources. The system automates the process of producing FGDC-compliant metadata that describe the data source, the data standards, and the confidence measure associated with each conservation element distribution layer.

Decision Support

NatureServe's planning approach posits that the most effective way to conserve biodiversity is to identify conservation elements using two scales — a coarse filter and a fine filter. The coarse filter is applied to identify the representative ecosystems comprising most of the area's biodiversity, such as Napa's coastal redwood forests, mixed oak savannas, and coastal salt marsh, described according to a national classification of ecological systems developed by NatureServe (see www.natureserve.org/publications/usEcologicalsystems.jsp). These ecosystems are habitat for Napa's common and characteristic species, as well as its rare ones. The ecosystem types provide units that are readily mappable, often from remote sensing imagery, and readily identifiable in the field. Next, the fine filter is applied to identify the rare plants, animals, and natural communities, such as specific rare wetland or forest types, missed by the coarse filter.

Spatial data come in various shapes and sizes — from polygons to points to pixels. To build a biodiversity database for Napa County, the team had to assess exactly what data were available, their quality, and how they would fit together. Datasets came from several different sources:

- Representative ecosystems were mapped with land-cover data developed by the University of California at Davis's Information Center for the Environment (ICE). These 74 land-cover classes were consolidated by NatureServe ecologists into 36 ecosystem types and represented by more than 18,000 polygons.
- Significant natural communities — 14 in all — were mapped from the ICE land-cover map and from data from the California Natural Diversity Database, NatureServe's state affiliate.
- Nearly 1,400 precise locations for 75 imperiled plant and animal species were identified and merged into a single dataset using field survey data from the California Natural Diversity Database and the California Native Plant Society.

Generating conservation element layers. Once the conservation elements are identified, spatial data relating to each element are used to generate an individual data layer (see Figure 1). This layer provides an initial indication of the relative conservation value of each place where the element is found — all the known occurrences in Napa County, for example, of Napa milkvetch, a federally listed endangered species that grows only on volcanic soils in Napa and Sonoma counties. The system scores each occurrence based on two factors — the viability of the occurrence and the confidence level of the data. Viability is ranked based on such factors as the number of breeding individuals, the size and species diversity of the habitat patch, and surrounding land uses. Data confidence is based principally on the currency and spatial precision of the observation. The most recent observations, for instance, are weighted more heavily.

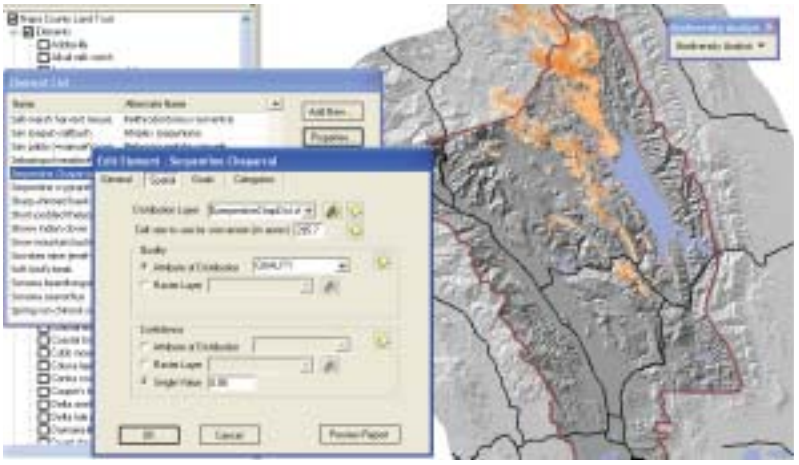


FIGURE 1 Element distribution layers are created for each conservation element. Shown here is the distribution of the serpentine chaparral ecosystem type. Darker orange indicates areas of greater data quality and confidence.

FIGURE 2 This Conservation Value Summary grades the entire Napa County landscape based on a selected set of elements (ecosystems and imperiled species). Here, the most ecologically significant areas are shown in dark red.

Once the scientific support team has set up the project area database, identified the conservation elements, and generated the element data layers, elements are weighted and quantitative conservation goals are established. The result is a customized conservation planning database that is delivered to the planner along with the software.

Producing a conservation value summary. The local planner now has in hand a scientifically credible database depicting local biodiversity conditions. His or her first step is to produce a summary of the relative conservation value of each location in the planning area. The summary aggregates all of the individual distribution layers for elements (species, communities, and ecological systems), including their viability and confidence scores, and weights them according to their relative conservation importance. The result is a raster map of biodiversity hotspots that highlights the most important places for conservation in the region (see Figure 2).

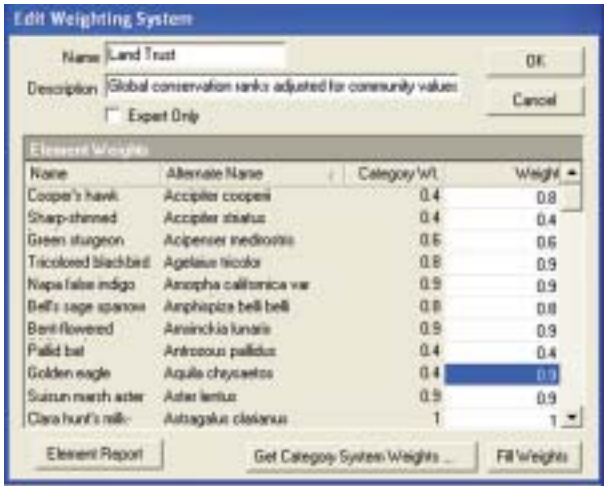


FIGURE 3 The element weighting system assigns each conservation element a default weight based on its global rarity. Local planners can create their own weighting system to reflect individual or community values.

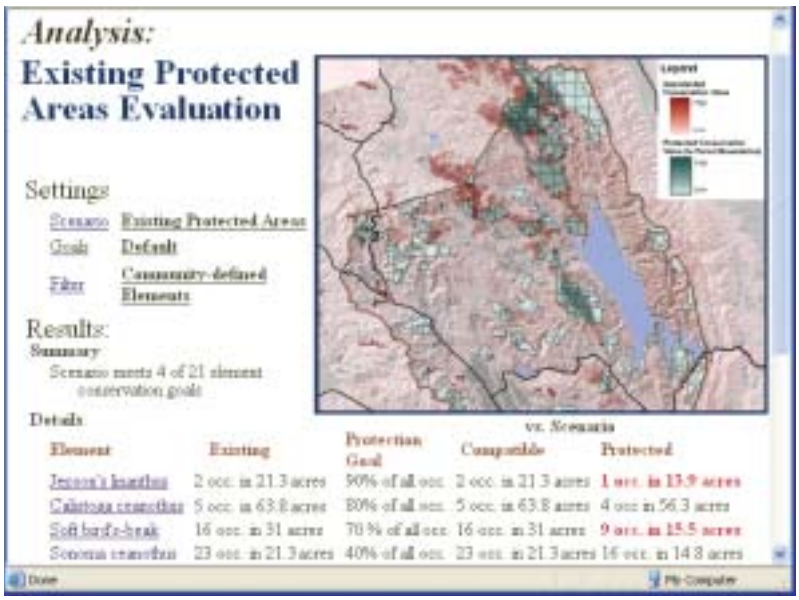


FIGURE 4 The baseline report analyzes how well the existing portfolio of protected areas meets element conservation goals. The map shows all high-value conservation areas on both protected lands (dark green) and unprotected lands (dark red). Reports are produced in HTML for publication or XML for further analysis.

The software allows the user to customize this summary in two ways. By default, the summary includes all elements considered critical to conservation by the scientific support team. However, the user can change these elements and also weight individual elements differently to reflect local priorities and concerns (see Figure 3). For example, protecting federally listed species might be a high priority, assigned a weight of 1.0. Conserving habitat for rare species that are not legally protected might be a lesser priority, assigned a weight of 0.7. Protecting habitat for certain emblematic species, such as the golden eagle, might be very important to the community, and could be given a high weight, such as 0.9.

Evaluating current land use. With the conservation value summary in hand, the planner is on the way to setting conservation priorities. He or she now understands which lands are most important for conservation and which may be better suited for development, such as housing or vineyards. The planner or other DSS software user can now set conservation goals, explore the compatibility of the current land-use status with these goals, and identify the gaps in protection (see Figure 4).

Default, element-specific conservation goals are established by the scientific support team and included in the database. The software allows the land-use planner to create alternative goals that reflect local values. Examples of goals might be "Protect all viable occurrences of federally listed endangered species," or "Retain at least fifty percent of the area for each forest type in patches of at least 500 acres." By setting quantitative conservation goals, the user establishes a baseline against which both the existing land-use policies and scenarios for future land use can be compared, and progress tracked over time. Through this analysis, the planner now begins to see where current land use is incompatible with conservation goals, and where potential land-use conflicts may arise.

Prior to this point, the analysis has been purely about ecological considerations. But to judge conservation compatibility, the system must integrate biodiversity value with socioeconomic factors, such as current land use, conservation status, ownership, and land costs. For the Napa County pilot project, data about these topics were acquired from the Napa County planning department, the Green Info Network, the USGS California GAP program, and the Bureau of Land Management.

Weighing conservation scenarios. One of the most powerful features of the NatureServe DSS is its ability to compare various land-use and conservation scenarios — in other words, alternate plans for which places to conserve and which places to designate for development. The software allows users to import scenarios from independent sources and evaluate their impact on biodiversity protection. An import wizard helps the user to identify the land-use status of each planning unit and whether this status is compatible with biodiversity conservation. Based on this information, the DSS can assess the performance of that scenario with respect to a given set of conservation goals, as well as the effect on the goals of protecting (or losing) a single planning unit, such as a specific parcel. This allows planners to evaluate the relative importance of a given parcel in the context of a long-term conservation plan.

For the Napa pilot project, scenarios were developed using complex mathematical algorithms that weigh the various factors and calculate tradeoffs among them. This approach — developed primarily by Dr. Frank Davis, Dr. David Stoms, and colleagues at the University of California, Santa Barbara— emphasizes the marginal value of each parcel, defined as the contribution the parcel makes towards achiev-

ing a given conservation goal. This model assumes that the dollars available are limited, and is a useful guide for seizing conservation opportunities in a strategic manner.

A parcel's marginal value score is based on a number of biodiversity and economic factors. The more unique the parcel's biodiversity, the more threatened, and the lower the cost to conserve it, the higher its marginal value for conservation. Once marginal value is calculated for each parcel, it can be used to rank individual parcels. The parcel rank makes the results of the analysis particularly useful to groups such as The Land Trust of Napa County. NatureServe provided the land trust with an analysis and map that identifies and ranks the county's 400 most important parcels for conservation (see Figure 5).

These conservation value summary maps are especially useful, says Hoffnagle. "The maps show all the elements that we're seeking to protect in Napa County, from spotted owls to the Tiburon paintbrush. They're trying to take all the elements together and say, 'which point on the map is more important than others?'"

Reaching a planning decision. The ultimate purpose of any conservation planning effort is to build consensus and make sound decisions that conserve biodiversity and support the community's goals. The NatureServe DSS makes this possible through its solid scientific foundation combined with a dynamic approach that empowers the planner to explore different options.

Throughout the process, the user has the power to choose the conservation goals for each scenario, the elements to conserve, and how to weight them. The user can also choose which local planning policies (such as Napa's streamside buffer ordinance) should be in force. Changing any of these assumptions could result in a different set of parcels being identified as priorities. This process can be repeated as often as needed to test alternate land-use scenarios, or re-run scenarios as new data becomes available.

Decision-support systems have impressive potential benefits for the local user and for conservation. Planning can be done more efficiently; tax dollars can be spent more wisely; and costly legal conflicts can be averted. Using DSS, the community can develop a plan to conserve what it values most, balancing diverse land uses and priorities, such as natural habitats, farmland, and historic preservation.

In Napa County, Hoffnagle is optimistic that his county can safeguard its scenic landscape, its rare species, and its agricultural heritage. Although he is excited about the potential of DSS, Hoffnagle also emphasizes that "successful conservation will never be just about running a software program. That human interaction will always be needed with planners, conservation biologists, local officials, and landowners."

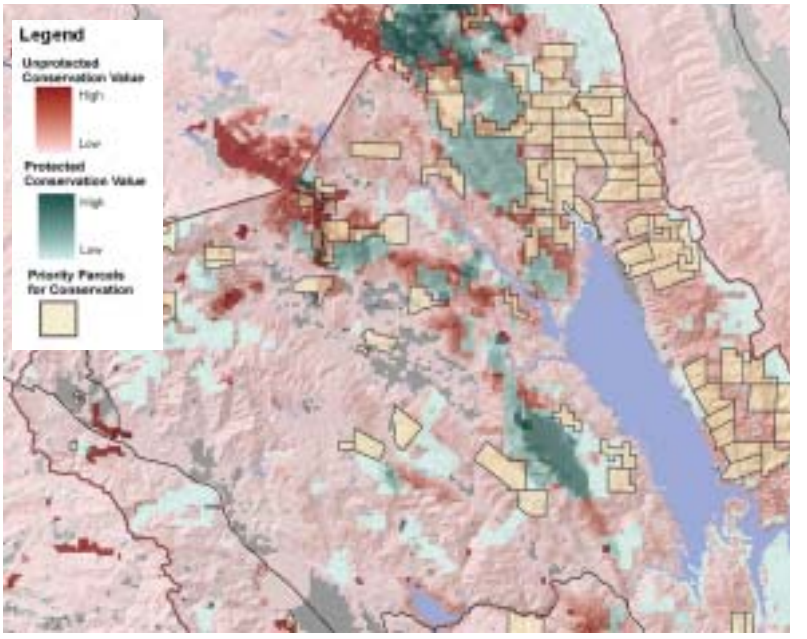


FIGURE 5 Various conservation scenarios can be evaluated in the context of land-use status. This map, based on evaluating one hypothetical scenario, shows a selection of parcels in northwest Napa County that, if conserved, could advance a specific set of conservation goals. The emphasis is on protecting parcels that link high-biodiversity areas, creating conservation corridors.

The land trust is encouraging Napa County officials to use the analysis as it updates the county's 25-year-old general plan. And the group is developing its own long-term strategic plan that includes components for agriculture, open space, and biodiversity. "One of the early steps in our plan is to analyze every project that we undertake against the results of the DSS work. Every project will go through this filter: is it one of the highest-priority parcels?" says Hoffnagle.

An early indicator will come in the next few months, when landowners start to learn that their parcels rank among the most important in the county. "This fall we're going to take the map, go visit with the owners of the top 10 or so sites, and see how they react. Will it turn them off, or will it excite them?" questions Hoffnagle. But the real test of the project's impact, he says, will come in five to ten years, when conservation results can be compared against the priorities set in 2003.

Manufacturers

A custom desktop GIS application, the **NatureServe DSS** is an extension to **ESRI**'s (www.esri.com) ArcMap platform with Spatial Analyst. Spatial data are captured by default in a personal geodatabase, but outside data sources may be referenced. The software is written in **Microsoft**'s (www.microsoft.com) C# language on the .NET client platform.

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NatureServe is a non-profit organization dedicated to providing the scientific information and tools needed for effective conservation action.