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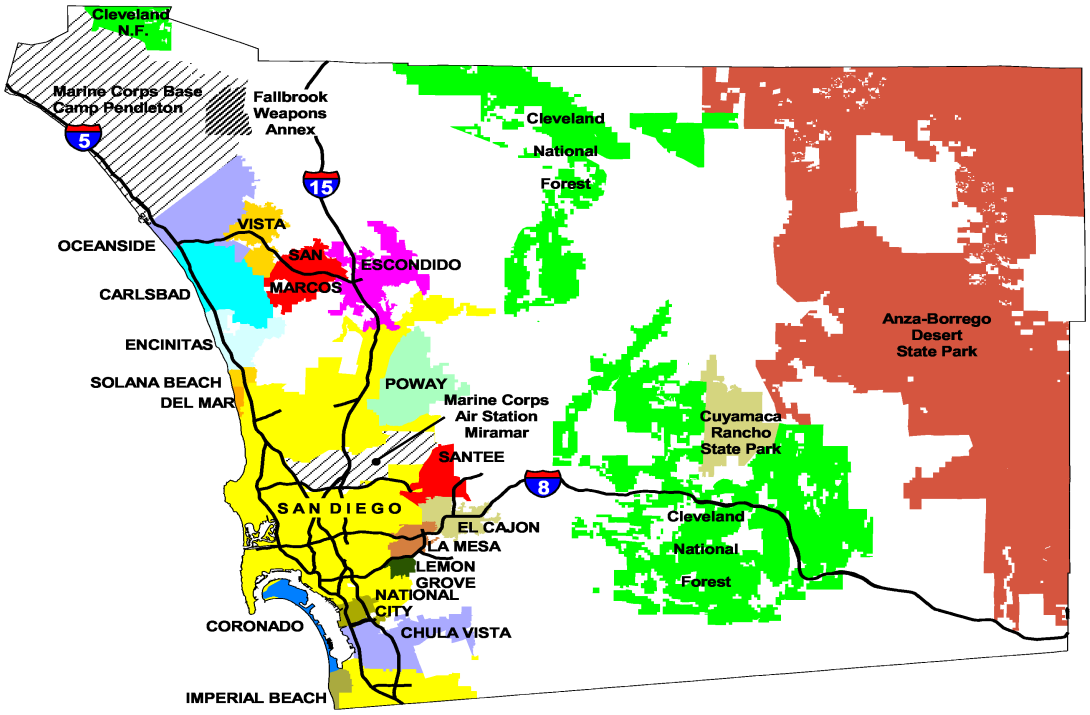
Transportation Case Studies in GIS

Case Study 5: SANDAG's Multiple Species/ Habitat Conservation Programs and Transportation Planning



Project Summary

Planning for transportation facilities in a region that has nearly 200 threatened or endangered species is a major challenge for San Diego Association of Governments (SANDAG). Many conflicts arise from pressing demands to accommodate growth while at the same time preserving natural habitats. The region has launched a massive effort to complete multiple jurisdiction, multiple habitat, and multiple species conservation programs. These programs are responsible for the development and management of extensive biological and land management databases. Geographic Information Systems (GIS) was chosen as the best method for maintaining and analyzing these data. These databases are invaluable for transportation planners. They can use them to make decisions of where transportation facilities can be built and determine what mitigation options are available. By maintaining continuous and comprehensive habitat conservation programs, the region's transportation planners have access to timely and accurate environmental data.

Project Benefits

- Habitat and species data are maintained in a GIS format and are always accessible to transportation planners
- Allows better decision making in the early planning stages of a transportation project
- GIS saves time and money in managing quality environmental data
- GIS format allows transportation planners to conduct various types of analyses which they could not do before
- A more coordinated and comprehensive approach to environmental impact analyses
- Quicker resolution of conflicts between transportation projects and preservation of the natural environment
- Early recognition of design alternatives to avoid or mitigate the impact to the natural environment

Case Study Background and Regulatory Problem Definition

Overview of SANDAG

The San Diego Association of Governments (SANDAG) is the regional planning agency for all of San Diego County. This regional planning forum includes members from the 18 cities and the County government. SANDAG also has non-voting representatives from the U.S. Department of Defense, California Department of Transportation (Caltrans), the San Diego Unified Port District, the San Diego County Water Authority, and the City of Tijuana in Mexico.

As a regional decision-making agency, SANDAG addresses significant regional issues such as growth, transportation, environmental management, housing, open space, air quality, energy, fiscal management, economic development, and criminal justice. SANDAG's Directors establish policies, adopt plans and allocate transportation funds. They are also responsible for developing programs for regional issues which are used by local governments as well as other public and private organizations.

SANDAG conducts transportation planning on a regional level. Other agencies that are involved with the planning of transportation facilities within the region are Caltrans, San Diego Unified Port District, San Diego Metropolitan Transit Development Board, North San Diego County Transit Development Board, AMTRAK, and various local agencies. SANDAG assists these agencies to ensure that transportation facilities connect communities in an efficient, safe and environmentally sound manner.

SANDAG is responsible for long-range planning and programming for the region's publicy-owned transportation system. The long-range plan has a horizon of 20 years and is compiled and outlined in the Regional Transportation Plan (RTP). The short-range program is the Regional Transportation Improvement Plan which currently covers a six-year planning horizon.

Current and Future Transportation Issues Being Addressed

According to current projections, population and employment are each expected to increase over forty percent in the next twenty years. Although these rates are slower they than have been historically, travel demand will continue to grow at a faster rate than the transportation system. An insufficient transportation system could result in poor air quality as well as excessive consumption of energy. This would be detrimental not only to the residents of the region but also to the natural environment. A safe, efficient, and environmentally sound transportation system is vital to the region's quality of life.

The RTP proposes major highway improvements that would add 47 miles of new freeways and expressways as shown in Figure 1. However, transportation planners realize that there is a limit on how many more miles of freeways that can be added. They also consider options for mass transit as well as transit-oriented land development. As a result, transit and bicycle corridors are also proposed to provide commuters with an alternative to driving. To make transit services and facilities more cost-effective, the RTP also proposes transit-oriented land use strategies. These strategies include increasing development densities near transit stations and centers. According to the San Diego Centre City Plan, 40 percent of the downtown commuter trips will be made by transit by the year 2015. Figure 2 shows the existing and proposed rail transit system.

The RTP also includes freight and aviation element plans, which are vital to the region's economy.

Overview of Multiple Species/Habitat Conservation Programs

The San Diego region encompasses 4,200 square miles (6216 km2) of coniferous forests, sparsely vegetated deserts, maritime-influenced chaparral and scrub communities, wetlands, estuaries and beaches. This makes the region one of the most biologically diverse environments in the country. Due to its biological diversity, the San Diego region is home to roughly 1,700 types of plants, 80 types of mammals, 435 types of birds, 75 types of reptiles and amphibians, 125 types of butterflies and over 10,000 types of terrestrial and aquatic invertebrates.

The mild climate and unique natural environment also makes the San Diego region one of the most desirable places in the country to live and work. The region's population has doubled since 1970 to 2.7 million. Fur-

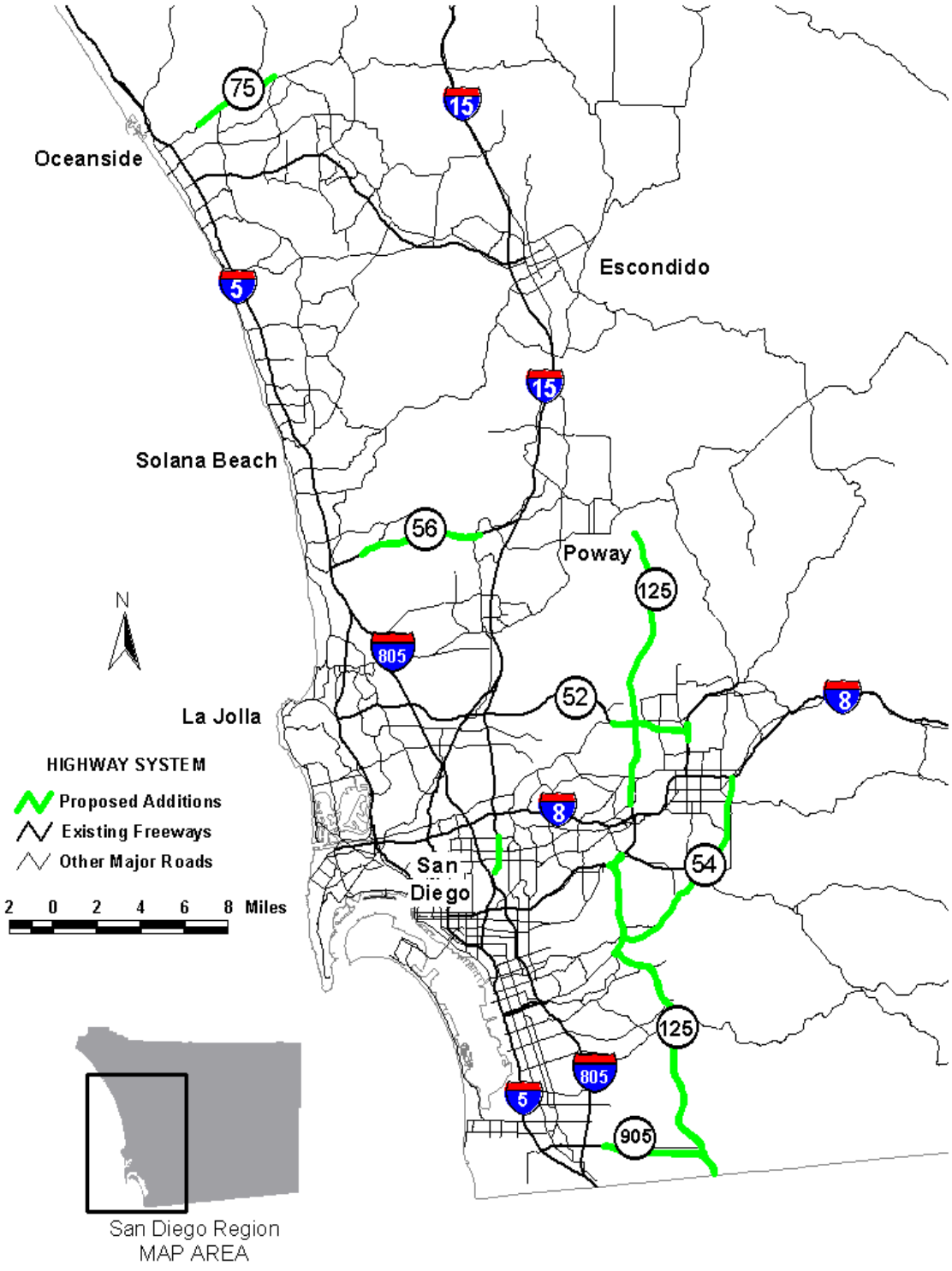


Figure 1. Existing Highway Network and Proposed Additions

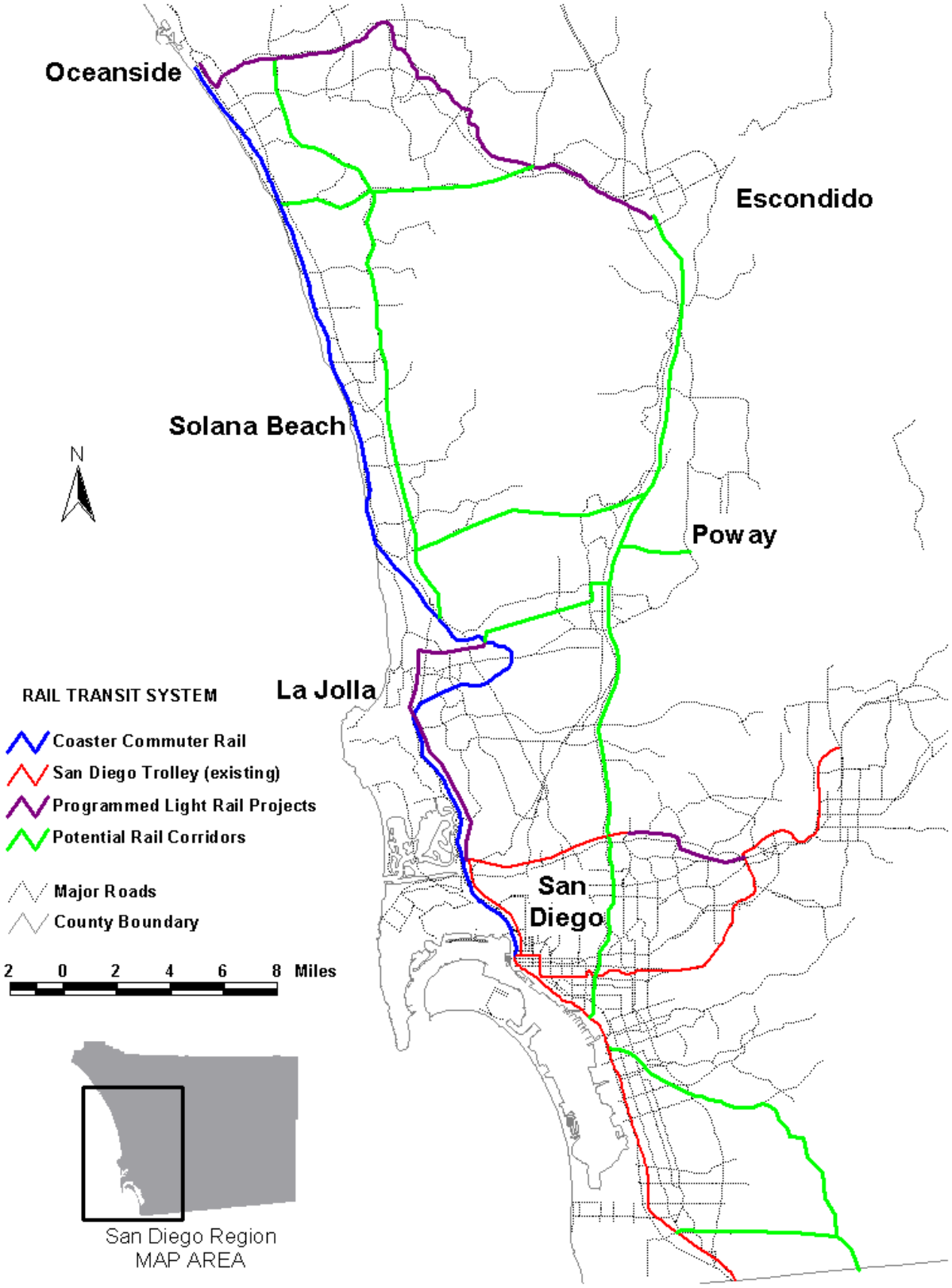


Figure 2. Existing and Proposed Rail Transit System

thermore, almost 41 percent of the land in the western part of the San Diego region has already been disturbed by agriculture or urban development. The population is expected to grow to 3.8 million by 2020. As the population increases so will the need for more developable land. Consequently, more future development may lead to the continued loss of natural habitats and species. The San Diego region currently has over 200 plant and animal species that are either listed or proposed for listing as threatened, rare, or endangered species. This is more than any other county in the continental United States.

One approach that the region has taken to address these issues is to develop comprehensive habitat conservation programs. These plans are a more proactive approach compared to the project-by-project, reactive, piecemeal, single species recovery plans of the past. The main goal of habitat conservation programs is to protect species by developing a regional system of interconnected multiple habitat preserves. The design of these preserves takes into account the biological and economic needs of the region. Habitat conservation programs attempt to resolve the conflicts between economic development and preservation of natural habitats by incorporating the following objectives:

- Accommodate future growth in the region while at the same time preserve habitats and species
- Provide the development community assurances of where they can and cannot develop
- Provide a means for long-term protection of viable populations of species and their habitats
- Determine and provide areas for off-site mitigation to compensate for habitats lost elsewhere in the region
- Involve local, state and federal agencies as well as special purpose agencies, environmental agencies, developers, environmental groups and private individuals

Habitat Conservation Programs in the San Diego Region

Three major habitat conservation programs are currently underway in the San Diego Region. They are the Multiple Habitat Conservation Program (MHCP), the Multiple Species Conservation Program (MSCP), and the Multiple Habitat Conservation and Open Space Program (MHCOS). Each program covers a conservation planning area and they are each shown in Figure 3.

The MHCP is designed to meet the needs of approximately 90 target species in the natural areas of northern San Diego County. This program is managed by SANDAG and consists of a consortium of local, regional, and special purpose agencies. Their goal is to develop a plan to conserve habitats for state and federally listed threatened, endangered, and other key species.

The MSCP is similar to the MHCP and provides protection for approximately 85 species in the southwestern portion of the San Diego region. Adopted by the San Diego City Council and the County Board of Supervisors, the MSCP allows a total of twelve participating local jurisdictions to proactively plan a regional preserve system that will meet future needs of public and private development.

The MHCOS is similar to both the MHCP and MSCP and was created for the unincorporated area of eastern San Diego County. The MHCOS includes an open space system that will guide future development to the less sensitive areas. Another goal of this program is to protect the interface areas with the federal and state land holdings in the Cleveland National Forest, Bureau of Land Management lands and the Cuyamaca Rancho and Anza Borrego Desert State Parks.

Habitat Conservation Programs and GIS

Much of the data needed to design and maintain habitat conservation programs is spatial in nature. The locations of habitats preserved may be more critical than the actual quantity being preserved. Geographic Information Systems (GIS) are capable of creating, storing, processing, analyzing, and displaying spatial data. One major task of the habitat conservation programs is to develop and maintain a GIS for habitat design, analysis and management. There are two types of data bases that are used by the habitat conservation programs: biological and land management. The layers that make up each of the two GIS data bases are listed below:

Biological Data Bases

- Vegetation
- Sensitive Plant Locations
- Sensitive Animal Locations
- Soil Types

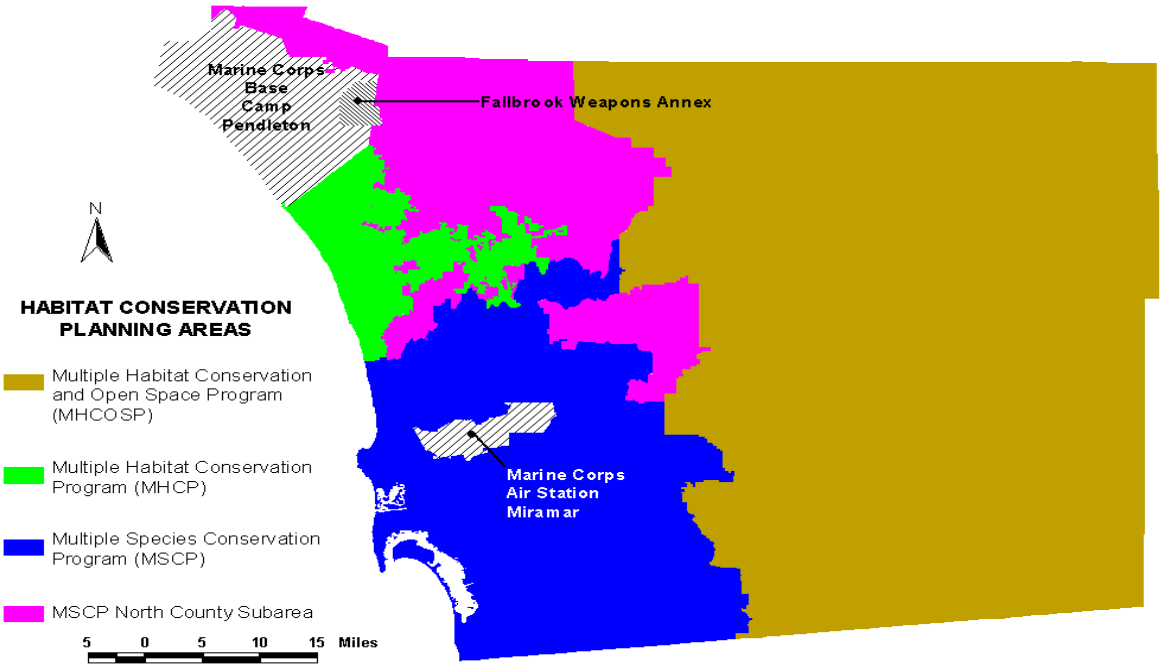


Figure 3. Habitat Conservation Planning Areas

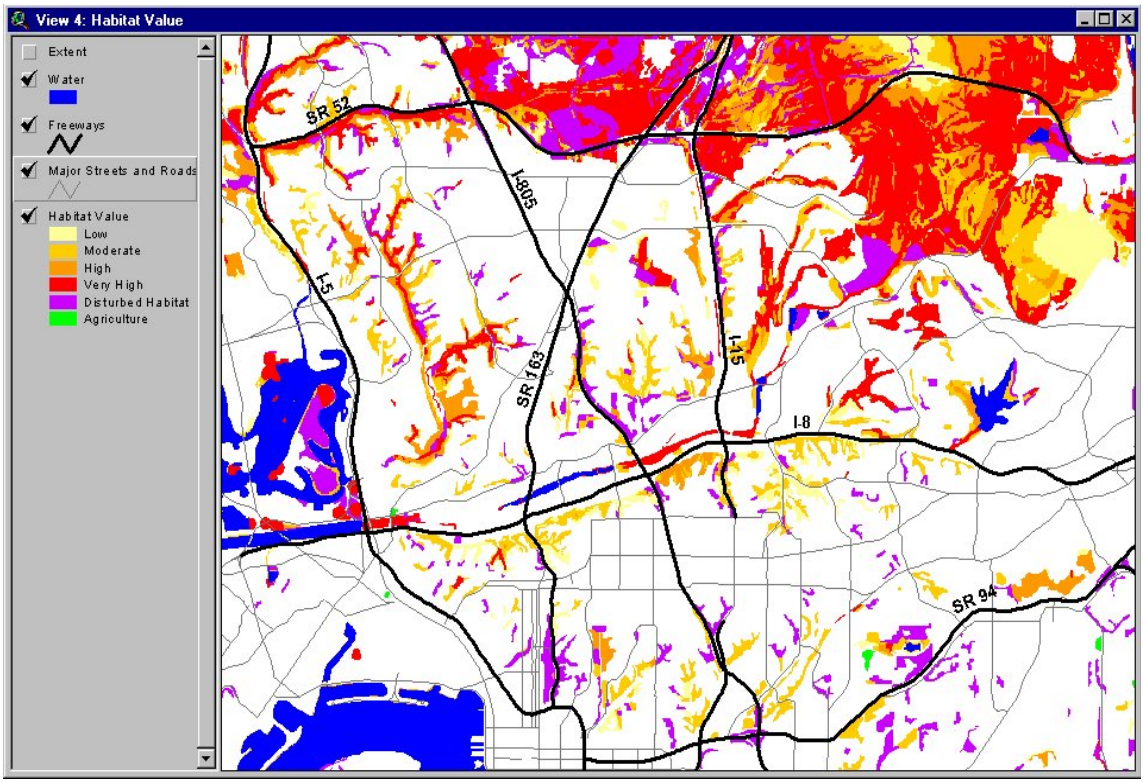


Figure 4. Habitat Values in the Mission Valley Area

- Vernal Pool Locations
- Elevation
- Slope
- Wetlands
- Animal Micro Habitats (cliffs, mines, ponds)

Land Management Data Bases

- Planned Land Use
- Land Ownership
- Open Space Parks
- Habitat Preserves
- Land Values
- Areas With Policy Constraints to Development

These data layers were developed from a variety of sources which include aerial and satellite photos, environmental impact reports, existing environmental databases, and local, general and community plans. The size of these data layers range from a few Kilobytes to 160 Megabytes. Once compiled, these layers are used to perform analyses to identify habitats that are at risk.

Habitat Evaluation Model

In order to maintain high-quality interconnected habitat system, the habitat programs needed to evaluate and rank lands according to their habitat value. For this, a detailed biological inventory of species locations and habitat quality indicators throughout the planning areas were needed. However, there was a lack of resources to conduct such an inventory. Therefore, a Habitat Evaluation Model was developed to determine habitat value of lands within the region. This model is a predictive tool that examines many habitat quality parameters such as habitat size and shape; elevation and slope factors; habitat diversity; proximity to development; number of species supported by each habitat; and the rarity of each habitat type.

The output of this model is a GIS database indicating the relative habitat value of natural areas in the region. An example of this is shown in Figure 4 for the Mission Valley area.

Gap Analysis

To identify constraints in designing a habitat preserve system, the habitat evaluation data was combined with land management information for a process called "Gap Analysis". Gap Analysis helped determine the areas of high biological diversity that are currently being protected and identify spatial "gaps" where conservation should be applied to prevent fragmentation of the interconnected habitats. It was used to identify economic opportunities as well, such as suitable locations for private development and public facilities.

Habitat Preserve Design

The information from the land management and biological databases, the Habitat Evaluation Model, and the Gap Analysis can be used to design a habitat preserve. This is an iterative process that involves the determination of various preserve alternatives. A tabular and spatial biological evaluation of each alternative is performed to determine the size and shape of habitats and how well they can be linked. Following the biological analysis, an economic analysis is performed to determine the fiscal feasibility of the preserve. Finally, the most economically and biologically viable alternatives are brought before various agencies and committees. It is important that all agencies agree upon the issues related to maintaining the habitat preserve in the future. Figure 5 shows the locations of the habitat preserves in the Mission Valley area of San Diego.

Once the habitat preserve locations have been established, planners can incorporate them into a GIS database of development constraints. This database assures developers of where they can and cannot develop. It also provides information on how future transportation corridors may affect the habitat preserve. Figure 6 shows locations where developers, both public and private, must avoid. These locations represent habitats for sensitive species in the Chula Vista area.

The habitat planning process is summarized in Figure 7. A GIS is employed for nearly all phases of the process. The overall benefit of using a GIS is that habitat data can be maintained on a continuous and comprehensive basis within the same format as other spatial information. This offers the opportunity to overlay habitat data with transportation infrastructure data. All of the GIS datasets developed are available to the region for various planning purposes.

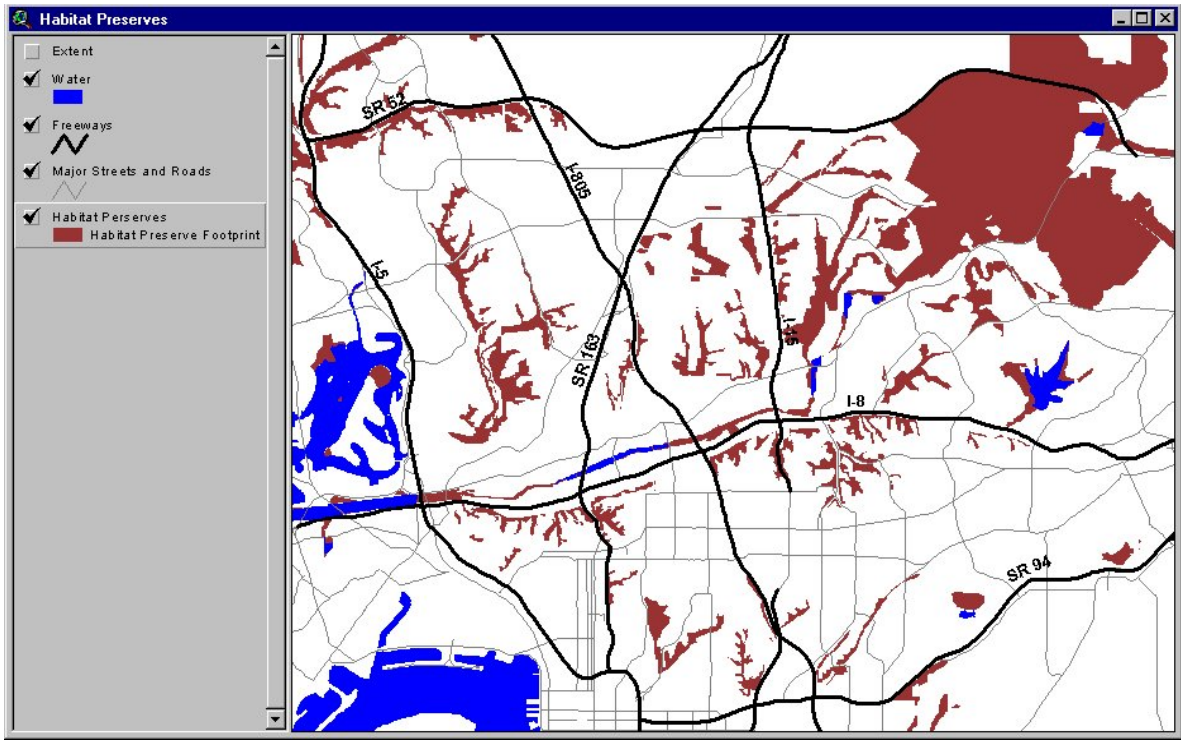


Figure 5. Habitat Preserves in the Mission Valley Area

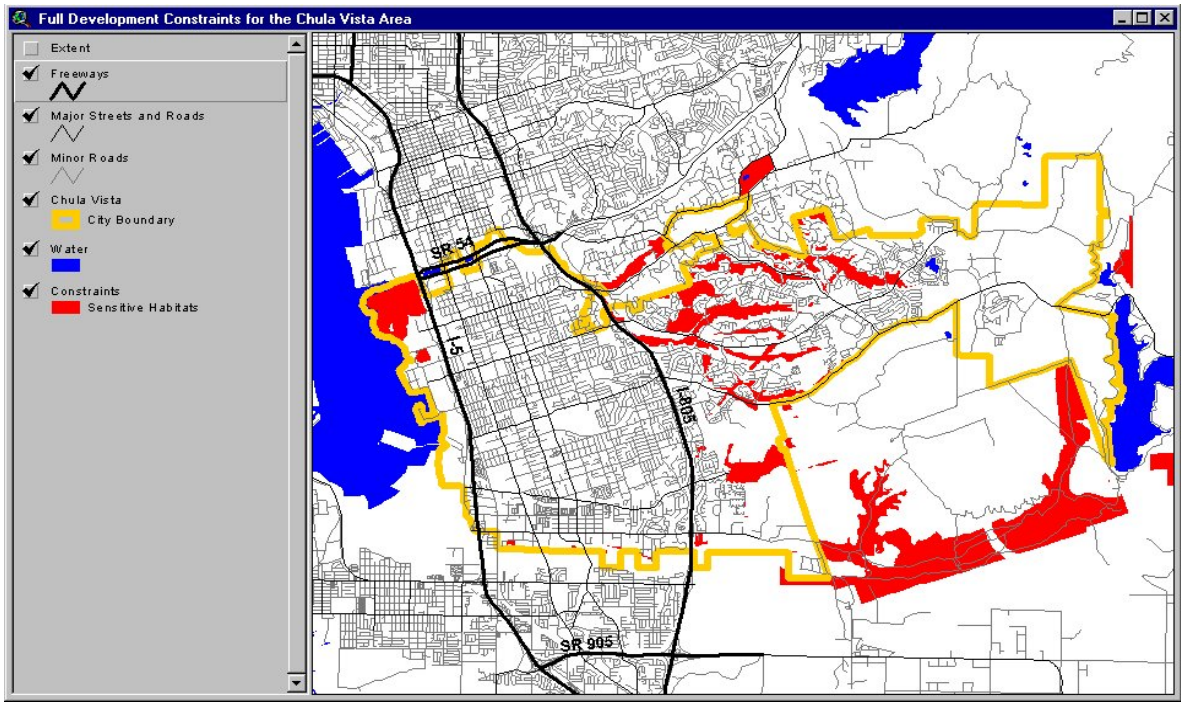


Figure 6. Sensitive Habitats as Development Constraints in the City of Chula Vista

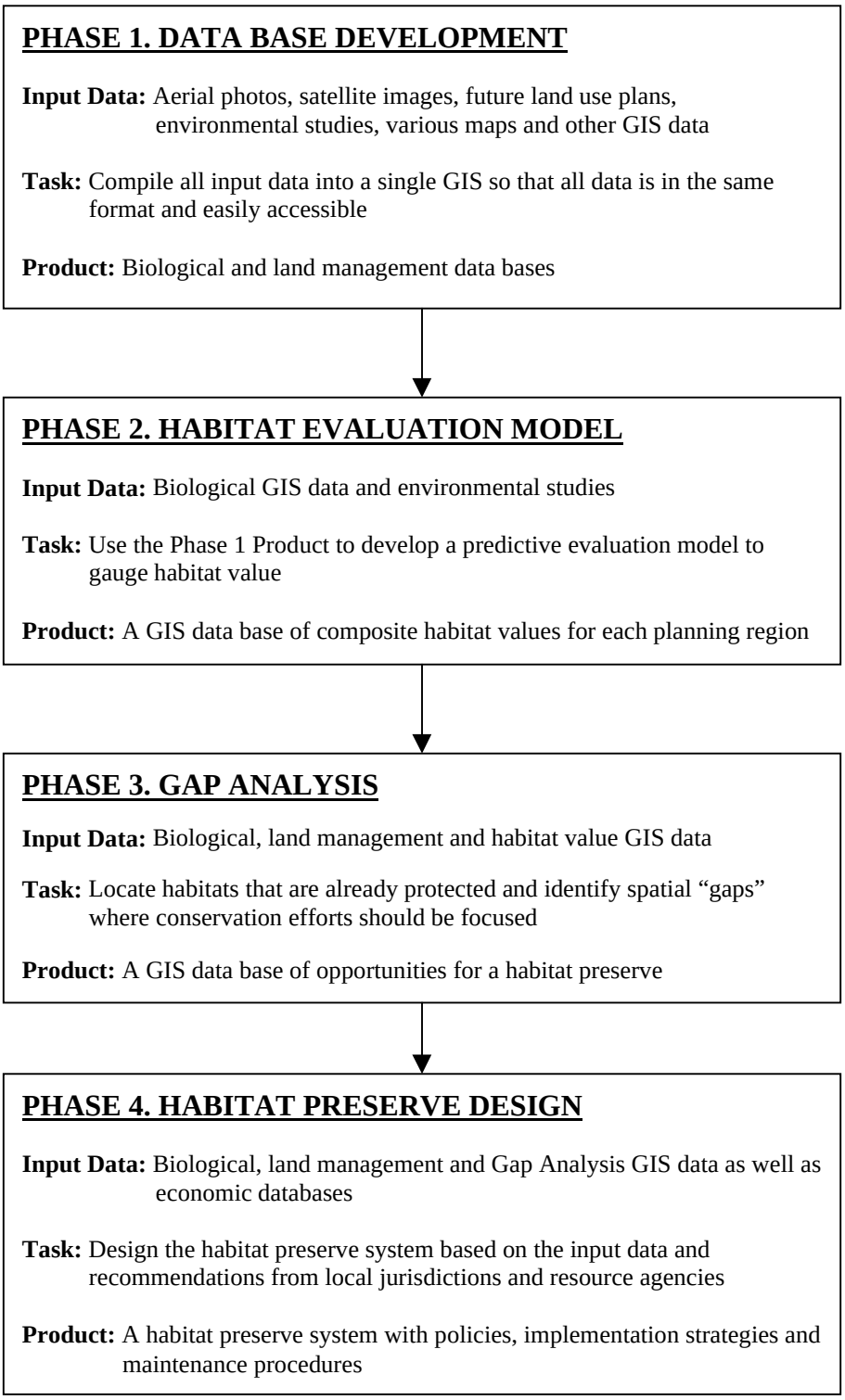


Figure 7. Four Phases of the GIS-Based Habitat Planning Process

Role of GIS in Supporting the Transportation Planning Process

The days of constructing a new highway or railway wherever land was available are gone. Today a proposed highway or rail alignment is subject to strict environmental, socioeconomic, and aesthetic constraints. What appears to be a prime site for building a highway or railway may in fact be an extremely sensitive habitat or a site containing unique social, aesthetic or cultural qualities.

Usually, a detailed environmental study is required for a transportation project. These studies can be extremely expensive and time consuming. The biggest expense of performing an environmental analysis is getting quality data. However, if the data already exists and is maintained properly on a continuous basis, the transportation planners can quickly determine what is feasible and develop alternative routes or a mitigation plan.

The benefit of having reliable GIS data in the early planning stages of transportation project planning is the ability to make sound decisions. When decisions are made earlier, overall project costs are minimized due to less wasted time and avoidance of lawsuits.

Transportation planners are increasingly using GIS for all types of planning purposes. The ability to integrate transportation data with environmental data within a GIS is among the most useful applications of this technology. Transportation planners are discovering that this is extremely useful for corridor and feasibility studies. Within a GIS a transportation planner can overlay the alignments of proposed highways or railways on a multitude of datasets available, and quickly assess the feasibility of alternate alignments.

Other Uses of GIS for SANDAG's Transportation Planning Efforts

SANDAG is on the forefront of utilizing GIS for transportation planning. They currently maintain an extensive regional transportation database, using ESRI's ARC/INFO, that represents existing and planned transportation facilities. The data for planned facilities were gathered from a variety of State route studies and general plans of the 19 local agencies.

One significant use of the SANDAG transportation database is travel demand forecasting. Many roadway attributes are needed for accurate travel demand modeling. These attributes include type of facility, number of lanes, speed, and intersection types. GIS helps planners in maintaining these attributes for the entire regional transportation network.

Digital imagery is also becoming an extremely useful type of data for SANDAG. Transportation planners use imagery in conjunction with GIS to maintain and verify their regional transportation database. Imagery also allows them to examine land use patterns for SANDAG's land use inventory database.

Integrating SANDAG's Transportation and Habitat Data

SANDAG maintains transportation GIS databases that cover the entire County of San Diego. These databases include proposed highway and railway alignments which planners can overlay onto the habitat data. This allows them to prepare maps that show the alignments with respect to the natural habitats. Then they can determine which alignments might encroach or bisect sensitive areas and are most likely to require more detailed environmental studies.

Having habitat preserves geographically defined can also assist transportation planners in determining if a transportation project impacts the preserve. If so, the realization and evaluation of design alternatives to avoid the preserve or mitigate the impacts can be determined up front.

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Transportation Planning Applications

Since the habitat conservation programs are relatively new, only a few transportation projects to date have had the benefits of using the habitat data. Therefore, a formal procedure for employing habitat data for transportation planning has not yet been established. However, more and more projects are employing this rich information. The future of transportation planning in the San Diego region will increasingly involve the use of such data since it is now available. SANDAG currently has a multitude of habitat data that is available for virtually any type of planning activity. Some transportation projects that have utilized these biological and habitat GIS data bases are described below.

State Route 56

State Route 56 is an east-west freeway in the northern portion of the City of San Diego. Its future corridor traverses an immense tract of undeveloped natural habitats. An environmental impact study (EIS) was performed to determine the impacts of various proposed alignments. The habitat data was used extensively to determine potential impacts and mitigation options. The EIS is currently being reviewed.

State Route 54

State Route 54 is an east-west route that begins at Interstate 5 in National City and extends up to Interstate 8 in El Cajon. A major investment study is currently underway (1998) to evaluate the feasibility of an expressway through this corridor. Using the habitat data, County of San Diego, Caltrans and SANDAG are determining what potential impacts could arise due to the construction of this route.

Figure 8 shows the possible alignment of SR 54 with respect to the habitat values database. Figure 9 shows the possible alignment of SR 54 with respect to location of habitat preserves.

Future Transit Corridor Evaluation

The Future Transit Corridor Evaluation study conducted by SANDAG examined the feasibility, cost and impacts of eight potential transit corridors in the San Diego region. An initial assessment of potentially significant environmental impacts was part of this study. This assessment included an analysis of potential adverse impacts to biological resources. As a result, habitat data was needed. At the time of the study, digital habitat mapping was available from the Multi-Species Conservation Program. These habitat maps helped indicate areas where potential future adverse environmental impacts could occur with the development of the future transit corridors.

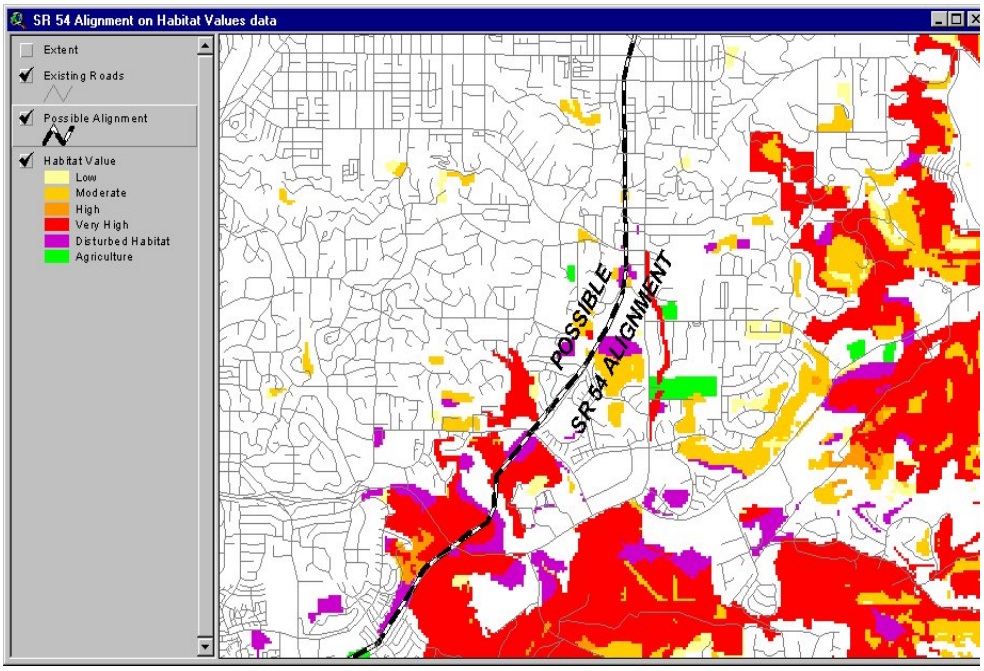


Figure 8. Habitat Value of Lands Adjacent to the Possible State Route 54 Alignment

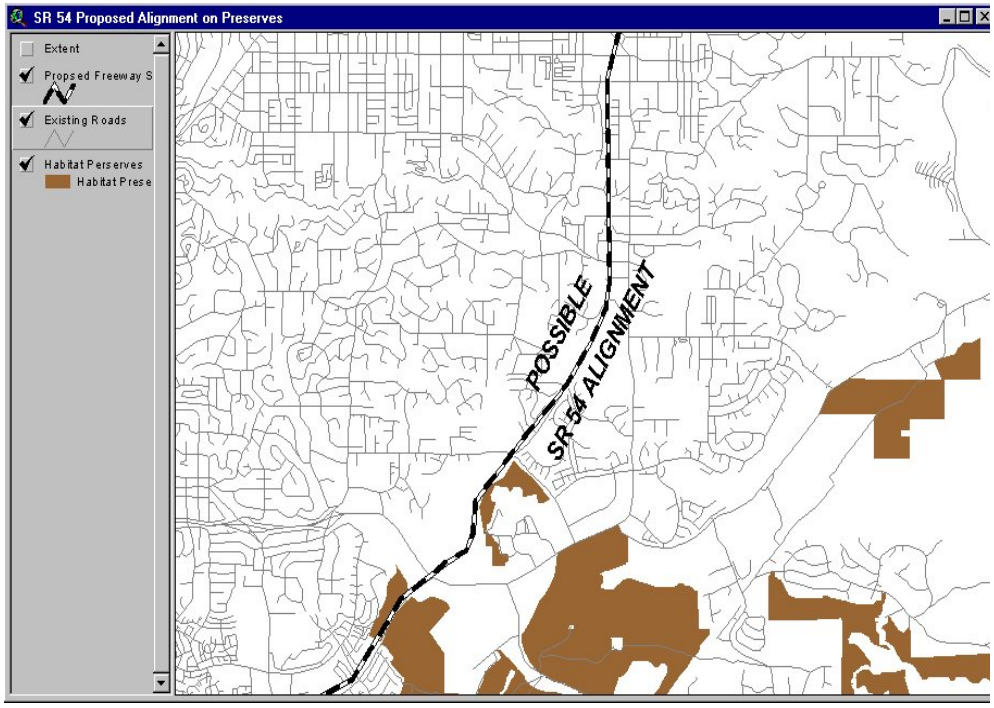
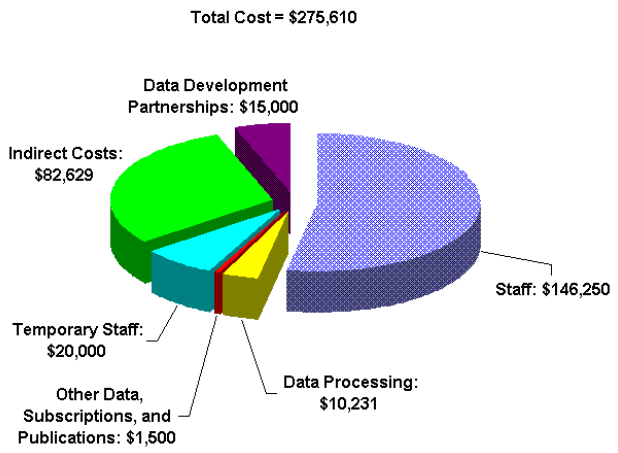


Figure 7. Habitat Preserves Nearby the Proposed State Route 54

GIS Infrastructure Costs

It is difficult to pinpoint the specific cost of the applications described above. However, it is possible to determine the yearly costs of SANDAG's regional planning efforts. The yearly cost of maintaining SANDAG's GIS databases and applications are outlined in SANDAG's "Overall Work Program". This document is prepared every fiscal year and describes SANDAG's work program on a project-by-project basis. The fiscal year 1999 work program reported a yearly cost of $275,610 to maintain the regional GIS. A breakdown of this cost is illustrated in the chart below.

SANDAG's GIS Costs For Fiscal Year 1999



It is important to note that SANDAG's GIS databases and applications are utilized for many other purposes besides environmental and transportation planning. Furthermore, SANDAG conducts most of their GIS work in-house. Their GIS is also used for the location of public facilities, urban development monitoring, criminal justice, economic development, and the analysis of current and projected demographic and economic data.

SANDAG uses UNIX workstations and personal computers to perform the data processing for their GIS. Three color InkJet plotters are used to produce maps and other plots. SANDAG also uses a variety of software to perform other computer-related tasks such as data base management, statistical analysis, numerical modeling and image processing.

SANDAG's work program also reports the fiscal year costs of other work elements related to the habitat conservation programs. They are listed below.

Work Element	Fiscal Year 1999 Costs
Sensitive Lands Analysis	$ 244,955
Regional Open Space and Natural Resource Planning	$ 451,342
Multiple Habitat Conservation Program (MHCP)	$ 421,003
Total	$ 1,119,299

Once again, it is important to note that these work elements assist in other planning efforts besides transportation.

Description of Benefits of the Habitat Conservation Programs

- The maintenance of a GIS based habitat conservation program supports a proactive approach. Instead of waiting for the problems to arise, SANDAG and local agencies have taken the initiative to develop their habitat conservation programs. More transportation facilities are needed to accommodate growth while at the same time habitats and species need to be protected and maintained. GIS is the most optimal way for SANDAG to maintain a continuous and comprehensive habitat and species database. As a result, the planning process for transportation, habitat conservation and other regional needs can be proactive and comprehensive.

- Storing the available data in a GIS increases the ability to make sound decisions early in the planning process. Since habitat data is available on a continuous basis, it can be acquired quickly. Therefore, critical decisions can be made earlier which will reduce wasted efforts in later stages of the planning process.

- Transportation and habitat data are managed and stored in a GIS. Therefore, both of these data bases can be easily integrated for analysis and visualization. Furthermore, having both types of data in a GIS environment leads to a more coordinated effort between all involved in the planning process.

- A major benefit is potentially lower costs in the long run. Most transportation projects in the San Diego region will require some sort of environmental analysis regardless of their size and impact. Environmental data (especially wildlife and habitat data) is very expensive to gather and analyze on a project-by-project basis. A habitat conservation program ensures that habitat data is easily available to transportation planners at a low cost. As a result they have the ability to allocate more of the resources for the analysis rather than data acquisition. Furthermore, when investigating the cost of maintaining continuous habitat data in a GIS, a planning organization should always consider the cost of getting a particular species off the endangered list.

- Finally, the overall goal of resolving the conflicts between transportation projects and preservation of the natural environment is met. All efforts to make resolutions easier will increase the confidence that conflicting parties have for each other.

Conclusions

Two separate planning efforts within SANDAG, are now able to reach a consensus through GIS. On one hand we have the habitat conservation program whose goal is to protect endangered species. On the other hand we have the transportation agency whose goal is to develop the transportation system to meet future needs. Since they are both able to integrate their data within a GIS they are able to work together more effectively and quickly make critical planning decisions early in the process.

Without the region's habitat conservation efforts and GIS databases many transportation projects would require more time, effort and funds to perform environmental studies.

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