

# URBAN GIS APPLICATIONS

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*This chapter illustrates the role of GIS in urban planning through the example of its use in the San Diego Association of Governments (SANDAG). Though the detailed uses of GIS for urban areas will vary between (and even within) countries because of legal, fiscal and administrative differences in the roles of local government, the SANDAG example is one in which information-based planning strategies covering both the long and the short term have been used. The principles underlying it are thus relevant to the situation in many other urban environments. A primary use of GIS has been for modelling purposes: four example applications described illustrate the use of GIS in finding land for development; emergency planning; determining the ideal location for fire stations; and assistance in crime control and documentation.*

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## INTRODUCTION

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The uses of GIS for urban applications are, not surprisingly, many and varied. Recent examples from just one conference include applications as disparate as: industrial location modelling (Cowen, Mitchell and Meyer 1990); supply and demand forecasting in real estate markets (Gurd 1990); dynamic vehicle routing (Lee and Russell 1990); and redistricting (Sullivan and Chow 1990). Other chapters of this book deal with utility applications (Mahoney 1991) and land suitability and facility siting (Siderelis 1991; Berry 1991; Cowen and Shirley 1991). More general reviews of urban GIS applications are to be found in Newkirk (1987), Sommers (1987) and Dueker (1988). This chapter therefore concentrates on an in-depth analysis of urban applications in a single urban area, namely San Diego.

The population of the San Diego region increased by over half a million people between 1979 and 1988, making it one of the fastest growing metropolitan areas in the United States. In 1984, the San Diego region reached 2 million residents. During 1987, the region experienced a growth rate of 3.6 per cent bringing the total population to 2 328 328 residents by the end of the year and 2.5

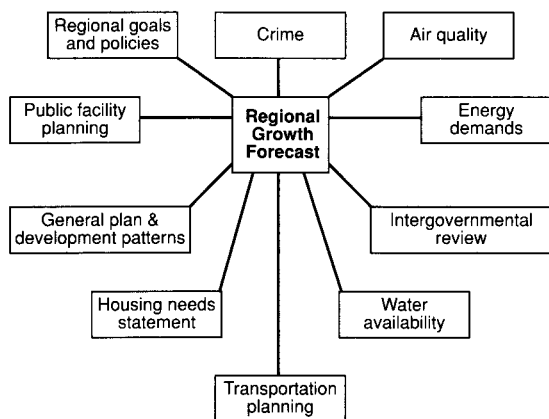
million by 1990. San Diego County is currently the fifteenth largest metropolitan area in the nation in terms of population and the fifth largest legal city. It is the fourth largest county in the nation (behind Los Angeles, California; Cook, Illinois; and Harris, Texas). Overall, the county also experienced the third largest numeric increase in population between 1980 and 1988, behind Los Angeles, California and Maricopa County in Arizona. It is evident that such rapid development creates many problems in the provision of physical and social infrastructure at acceptable cost, in preserving the quality of the environment, in safeguarding the safety of the populace and much else.

The San Diego Association of Governments (SANDAG) is a quasi-government agency consisting of the County of San Diego in the southwestern corner of California as well as 18 cities located therein. It has a Board of Directors comprised of elected officials from each local jurisdiction and has three main functions:

- To promote regional planning among local governments.
- To maintain a regional information system.

- To provide technical planning assistance to the 19 member government agencies.

A key input to these functions is SANDAG's long-range forecast of population, housing and economic activities for the entire San Diego region and for the smaller geographical areas within it. Locally, this product is known as the Regional Growth Forecast (RGF). The RGF has a wide variety of uses and applications and is based on a large GIS. It helps determine the need for transportation systems and the size and location of public facilities such as fire stations, schools, hospitals and sewage and water treatment plants. The RGF is also used to assess water and energy demands for county agencies and geographical areas and can help predict the future quality of the region's air based on developmental aspects of land uses and population growth. Local governments which do not have a large planning and GIS capacity make use of the RGF and other products of local technical assistance from SANDAG as they evaluate housing needs for their constituencies and update their general and community plans. Uses of the RGF are summarized in Fig. 52.1.

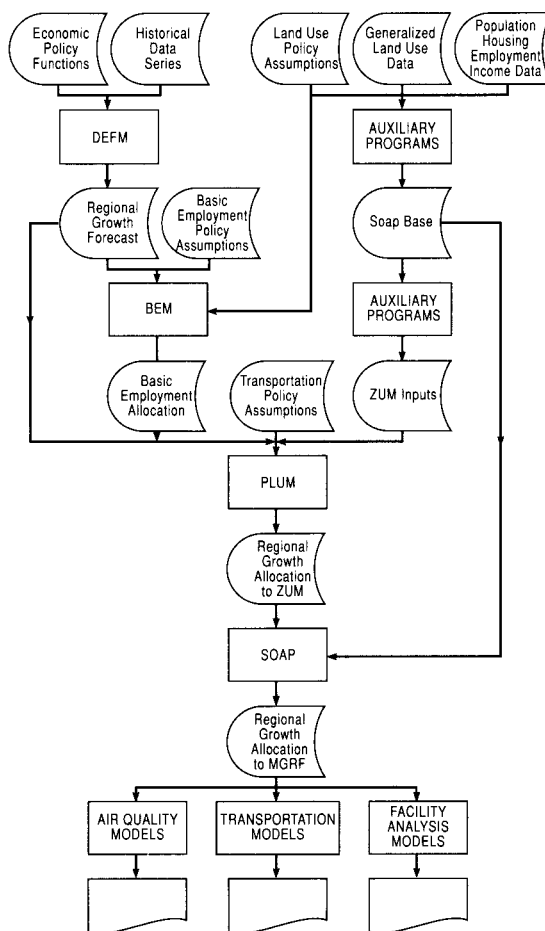


**Fig. 52.1** How SANDAG uses the forecast data for Regional Growth Forecasts (RGFs).

This chapter describes the urban development modelling system of SANDAG used for San Diego County in southern California. Four applications of the use of urban information systems as a solution to geographic problems are described. Some more general points about urban information systems are made in various places in this chapter.

## THE URBAN DEVELOPMENT GIS MODELLING SYSTEM

There are two phases to the Regional Growth Forecasting process and four major models are used to obtain the projected population and land use values. The first phase uses the Demographic and Economic Forecasting Model (DEFM) which produces a forecast for the San Diego region as a whole. The second phase employs three allocation models to disaggregate the RGF tabulations to each of the sub-areas in the county. Figure 52.2 presents the overall relationships between the various models, databases and GIS for the Regional Growth Forecasting system.



**Fig. 52.2** SANDAG's urban development modelling system flowchart.

The first of the allocation models is the Basic Employment Allocation Model (BEM). It provides the future distribution of basic employment in the region, primarily on the basis of the policies of the local jurisdictions on industrial development and on the present split between industrial and service employment. This distribution then becomes the input to the Projective Land Use Model (PLUM). PLUM allocates other activities such as population, housing units, persons per household and local serving (or non-basic employment) to sub-areas based on the location of the basic employment, the availability of usable land, physical accessibility to major activity centres, residential locations in the region and land use policies of the local jurisdictions. This allocation is made for Zones for Urban Modelling (ZUM), which are collections of census tracts and traffic analysis zones within a local jurisdiction. The last regional model involved is the Sophisticated Allocation Process (SOAP). It allocates population, housing and employment activities to the smallest geographical level, the Master Geographical Reference Area (MGRA). The principal aim of this chapter however is not to discuss the population growth models and the land use allocation models used by SANDAG nor the GIS architecture itself. The bulk of this effort will be spent demonstrating, in a non-technical manner, four of the many uses of such a GIS modelling system.

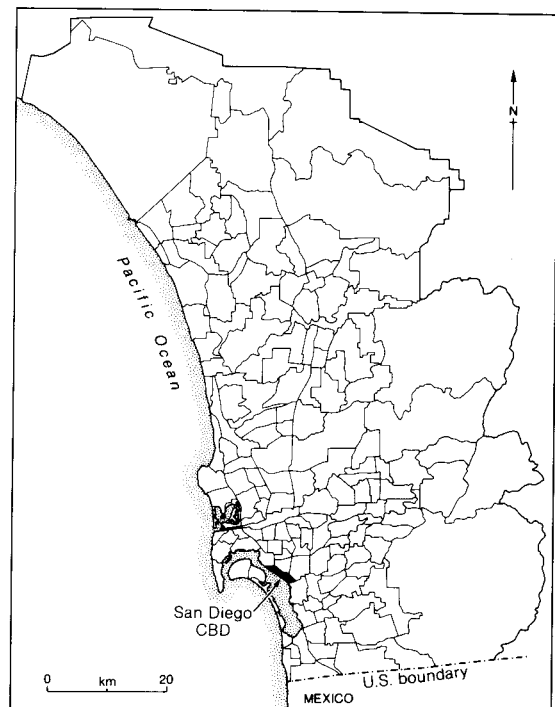
### SANDAG'S GIS

Two key elements comprise the SANDAG GIS: the geographical database and the tools available. Both are described below.

#### The area units in the geographical database

SANDAG uses two geographical reference systems. The first of these is a multi-level nested system in which the census tract is the basis of the hierarchy of spatial units. There are four levels of aggregation and the boundaries at one level do not cross over the other. Smaller subdivisions and larger aggregations are created from the census tract system. The Traffic Analysis Zones (TAZ) are the smallest areas of reference. Geographical

aggregations of census tracts form the larger Sub-Regional Areas (SRA) and Major Statistical Areas (MSA). Thus there are 759 TAZs, 380 census tracts, 41 SRAs and 7 MSAs covering the San Diego region in a nested system. In addition to these four basic levels, others are generated by aggregation: the PLUM zonal system, for instance, is composed of 161 Zones for Urban Modelling (ZUM), which are shown in Fig. 52.3. The zones are groups of census tracts within each city's corporate boundaries. For the City of San Diego, ZUM conforms to community planning area boundaries. Projection of population, housing or land use can be retrieved for any user-defined region for 10, 20 or 25 years hence.



**Fig. 52.3** San Diego County Zones for Urban Modelling (ZUM).

The second geographical referencing system is a non-nested one and its basis is the grid cell. It is independent of the nested system mentioned above. The grid cells form a matrix of 2000 ft by 2000 ft (610 × 610 m) squares, each containing approximately 90 acres (220 ha). There are roughly 15 000 such land-based grid cells covering the county. A Sub-Regional Forecast, however, is

needed for geographical areas and jurisdictions in addition to those mentioned above. Data must be prepared by the coarsest geographical units that will support the detailed needs. As a consequence, account must be taken of grid cells split by boundaries of government jurisdictions, traffic analysis zones and the city and county of San Diego community planning areas. There are approximately 25 000 split grid cells within the county and these comprise the Master Geographical Reference Areas (MGRAs).

The files generated by the SOAP program allow forecast data to be retrieved in one of several ways, depending on the needs of each city within the county. SANDAG has developed report programs to display data either for a single variable or as a complete profile. Table 52.1 is an example report: it gives sub-regional forecast model outputs. This information can be retrieved and printed out for standard geographical areas such as TAZ, census tracts or entire cities or for any user-defined geographical area. Results for the last of these are accomplished by a program which aggregates MGRA-level data to approximate to the non-standard shape of the user-defined polygons. Forecast data can also be retrieved for any radial distance, driving distance or driving time from a given point (such as particular land parcel, street intersection or major activity centre such as shopping centre, stadium or employment node). An example of output from the projection programs is Fig. 52.4 which shows total change in population by grid cell between 1986 and the year 2010.

### The software and hardware tools

The software component of SANDAG's GIS is ARC/INFO, a product from Environmental Systems Research Institute of Redlands, California. For urban and regional planners this provides the important capabilities to automate mapped information, overlay different types of map information, perform network routing and allocation analysis, and produce maps at any level of aggregation. The hardware used for running SANDAG's regional forecasting model system and GIS includes a Prime 9955 and peripherals such as a digitizer, plotter and various Tektronix colour graphics display terminals.

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## APPLICATIONS OF GIS IN URBAN PLANNING WITHIN SAN DIEGO COUNTY

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Four applications are considered in turn. These are finding land for development, emergency planning, determining the ideal location for fire stations and assistance in crime control and documentation.

### Finding land for development

The location of land suitable for new land use activities is a well known and widely practised GIS application. Typical applications include suitability of land for locating waste disposal sites (e.g. Estes *et al.* 1987; Stewart 1987; Maguire *et al.* 1991; Siderelis 1991 in this volume), large processing plants (e.g. Siderelis 1991 in this volume) and resource planning (e.g. Berry 1991 in this volume; Cowen and Shirley 1991 in this volume).

San Diego County is composed of 18 incorporated cities and the unincorporated county area. Each city maintains a general plan which identifies land use classification for the areas it governs. Land use classifications differ between cities. SANDAG reviewed the general and community classifications used in each jurisdiction and developed a generic coding system to apply to all jurisdictions. Classifications from each city's plan were converted to the new SANDAG system and overlaid. The resulting database is shown in Fig. 52.5. Calculations of the gross extent allotted for different land use types and the number of vacant developable acres remaining were then created under the new coding system. With this overlay system, SANDAG has the capability to examine the development quality of any area within the county. In addition, vacant land for a particular type of development can be identified and located. Demographic profiles, expenditure patterns of residents and employment levels for surrounding areas can even be examined and land use suitability modelling can be performed.

Through digitizing, the general or community plan for each city in San Diego County was entered into the SANDAG GIS database. The general plan database was analysed in conjunction with other information. Land already developed was identified using the 1986 generalized land use inventory. Lands constrained from private development through general plan policy, public ownership or

**Table 52.1** SANDAG sub-regional forecast model outputs.

|   |                                  |
|---|----------------------------------|
| <b>Population</b>                                 | <b>Occupied housing units</b>    |
| Total population                                  | Total occupied units             |
| Household   | Single family                    |
| Group quarters                                    | Multiple family                  |
| Civilian  | Mobile homes                     |
| Military  | Persons per household            |
| <b>Employment</b>                                 | <b>Land use</b>                  |
| Total employment                                  | Total acres                      |
| Civilian  | Developed                        |
| Basic   | Single family                    |
| Agriculture (SIC 1–9)                             | Multiple family                  |
| Mining (SIC 10–14)                                | Mobile homes                     |
| Manufacturing (SIC 20–39)                         | Basic                            |
| Transportation (SIC 40, 42, 44–47)                | Local serving                    |
| Wholesale (SIC 50, 51)                            | 1986 Freeway                     |
| State and federal government<br>(SIC 90, 91, 92)  | Vacant developable               |
| Hotel (SIC 70)                                    | Low density single family        |
| Basic military <sup>1</sup>                       | Single family                    |
| Local serving                                     | Multiple family                  |
| Retail trade (SIC 52–59)                          | Mixed use                        |
| Retail services (SIC 72, 74–88)                   | Local serving                    |
| Business services (SIC 73, 89)                    | Industrial                       |
| Construction (SIC 15–17)                          | Unusable                         |
| Finance, insurance and real estate<br>(SIC 60–67) | Redevelopment/infill acres       |
| Local government (SIC 93, 94)                     | Single family to multiple family |
| Local serving transportation<br>(SIC 41, 48–49)   | Single family to mixed use       |
| Uniformed military <sup>2</sup>                   | Single family to local serving   |
|   | Multiple family to mixed use     |
|   | Multiple family to local serving |
|   | Single family intensification    |
|   | Multiple family intensification  |

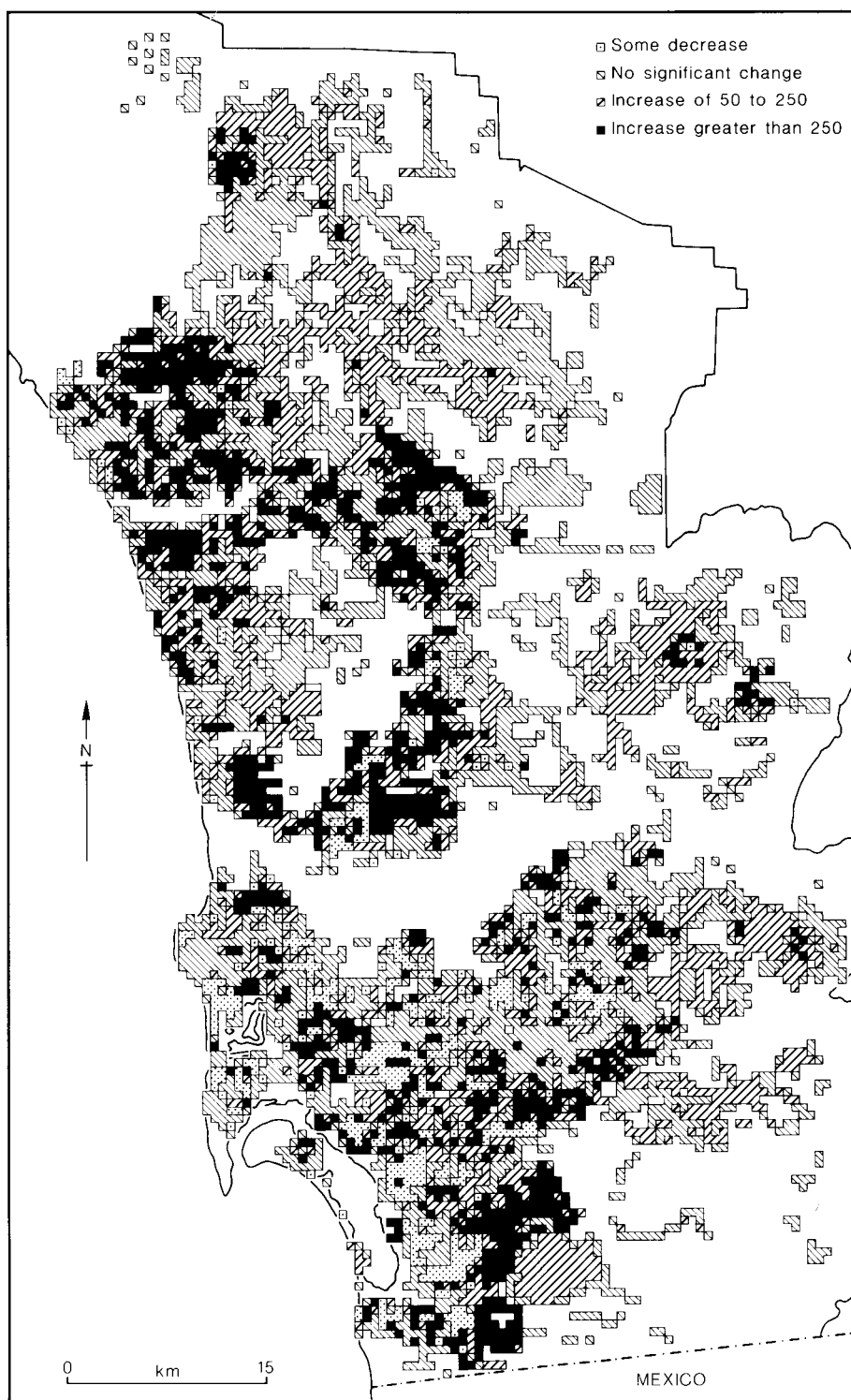
<sup>1</sup> All military persons at their place of work, excluding persons living on-base in barracks or on-board ships. Civilian persons working on military bases are included in the State and federal government category.

<sup>2</sup> Basic military + military group quarters.

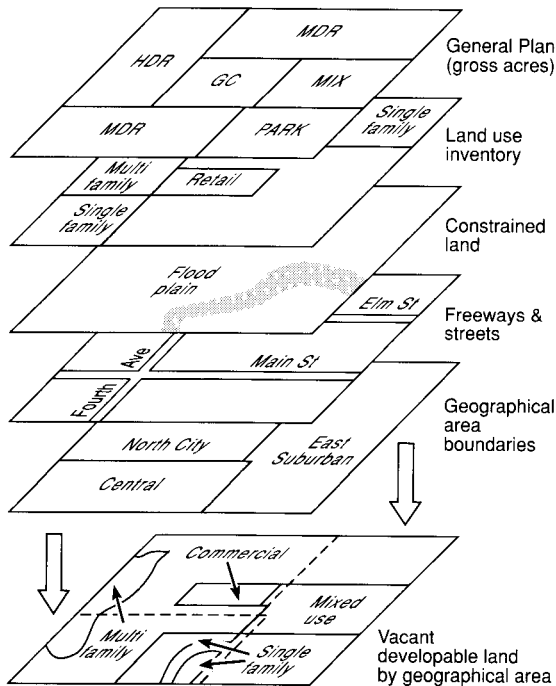
SIC: Standard Industrial Classification.

because of environmental reasons were also identified for the GIS. Flood areas, steep slopes, publicly owned lands, areas of endangered species, riparian habitats, transmission line easements, airport noise contours and land set aside for future freeways all limit the type and amount of land development which may occur in a given area. The 19 study areas defined were each given 17 generic land use designations as follows:

- Low Density Single Family Residential
- Single Family Residential
- Multiple Family Residential
- Mobile Home Parks
- Mixed Use Commercial and Multi-Family Residential
- Commercial and Office Shopping Centre Business Parks
- Tourist, Commercial, Motel, Recreation
- Schools, Colleges, Universities
- Government, City Halls, Federal Facilities
- Hospitals, Health Services, Medical Centres
- Other Services, Churches, Cemeteries, Civic Centres



**Fig. 52.4** Projected change in population in San Diego County by grid cell between 1986 and 2010.



**Fig. 52.5** The use of geographical overlay to isolate vacant developable land.

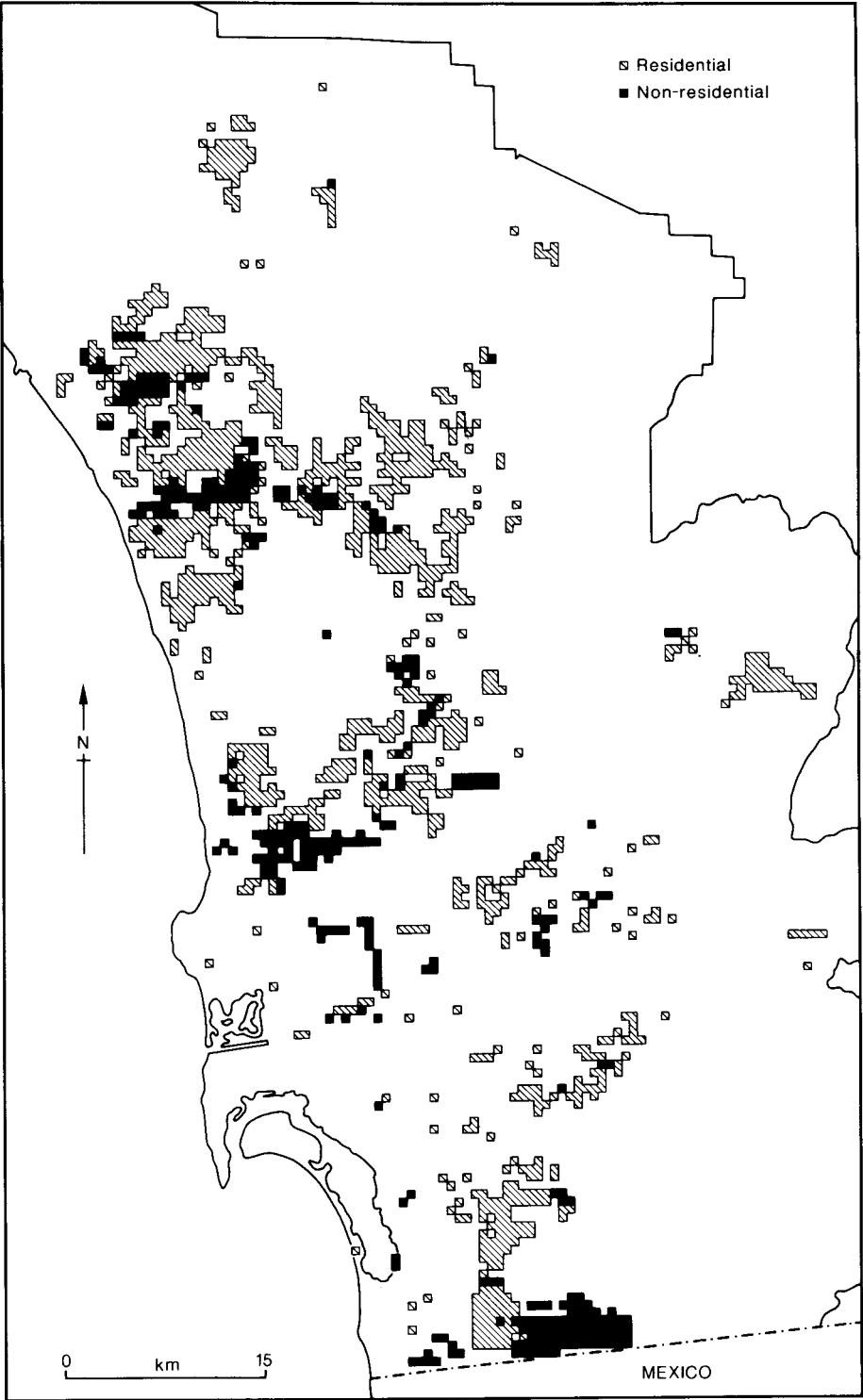
- Industrial Manufacturing and Research
- Transportation, Public Utilities, Airports, Broadcasting
- Electrical Power Plants, Sewage, Freeways
- Open Space, Parks, Recreational, Non-commercial
- Reserve Land, Open Space
- Agricultural, Dairies, Orchards
- Public/Semi-Public
- Solid Waste

Figure 52.5 shows the process used to calculate the vacant land acreage. Once the plan classifications for the 19 study areas were reassigned with the new generic land use system described above, the resulting file was overlaid on files of land use inventories and constrained lands. The resulting file was then overlaid on land set aside for freeways and traffic circulation. Through this process, the total number of vacant lands available for prior development for the 17 private land use

designations was determined. SANDAG's geographical area boundary files were then overlaid and the information was aggregated for Major Statistical Areas (MSA). The land available for urban development as indicated by this overlay process is shown for 1986 in Fig. 52.6. With such a map, planning for new major public and private facilities such as a new regional and international airport – which San Diego desperately needs – can proceed. Moreover, since one key determinant underlying the sub-area forecast of the SOAP model is the amount of land available for development, this overlay process is also a key component of the Regional Growth Forecasting System.

A further example of this process is given by the Municipality of El Cajon, a city in eastern San Diego County comprising 80 000 people. Plate 52.1(a) depicts the general plan for El Cajon. Community plan land use codes were placed into seven categories for consistency in the computer model. The seven vertical and horizontal green lines represent unusable land designated for freeways in the city plan. Plate 52.1(b) shows existing land use in El Cajon. These data were obtained from aerial photographs derived from low altitude aircraft flown in 1986. The process included identifying 39 separate land uses on 90 maps at 1 : 24 000 scale. This information was translated to a mylar base and entered into the computer. Plate 52.1(c) shows land constrained from development because of flood areas, steep slopes, publicly owned lands, airport noise contours and future freeways. This plate also includes areas identified on El Cajon's general plan as undevelopable. To these, planners added new constraints such as riparian habitats and transmission line easements.

A vital requirement in order to prepare the RGF sub-regional SOAP forecast for El Cajon is the amount and type of land available for development, referred to as 'developable land'. This information is produced by a computer matching of the existing information shown in the three figures just described; the general plan, existing land uses and constrained and private lands. Beginning with the general plan, areas of existing development were subtracted. From the remaining vacant acreage, constrained land was removed as well as areas designated in the plan as undevelopable. The result is a computer file of developable land with associated general plan



**Fig. 52.6** Land parcels of 25 acres (62 ha) or more available for urban development in 1986.

designations and the generalized land use codes used in the forecast. This is shown in Plate 52.1(d).

### **Emergency planning and population shifts between day and night**

Planning for emergencies has to take account of where people are at the relevant moment of time (Gatrell and Vincent 1990). The night-time location and distribution of a region's population is easy to identify. Many sources, from the federal census (see Rhind 1991 in this volume) to the local telephone directory, indicate where people live during the evening hours. The day-time population distribution, on the other hand, is equally important but almost impossible to ascertain. Exactly where people work, where people shop, where they go to school and – as a result – the location and the magnitude of the highest population densities taxing transportation and local community services are elusive. Sport stadia, employment centres and emergency evacuation bottlenecks are but a few of the places and infrastructures that must be considered in planning a wide variety of public uses and emergencies. For example, the routing of hazardous wastes should be done as far away from large day-time population clusters as is possible – but where are those clusters? Again, earthquakes and civil defence preparedness measures must also account for variations in day-time and resident population and should be based ideally on a knowledge of population shifts by each hour of the day; evacuation routes and emergency services are greatly affected depending on the time of day at which a disaster occurs.

### **A methodology for establishing the day-time population**

During 1986, SANDAG produced a comprehensive travel behaviour survey of the region's residents to update transportation models, thus permitting an estimate of day-time population. For each regional grid cell, information on the number and type of trips and land use at origin and destination, vehicular categories and the times of trips made was stored. Forty demographic characteristics of the surveyed respondents were also made.

Trip generation was one of the aspects included in the transportation models. The number of daily person trips leaving or entering each of the 753

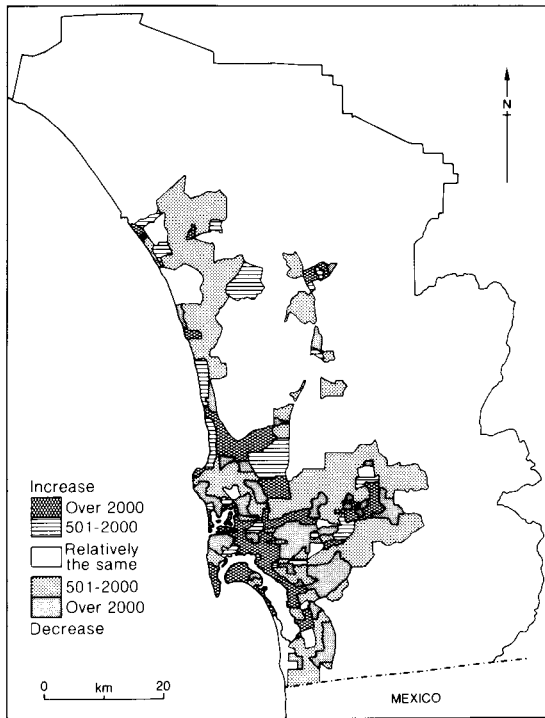
Traffic Analysis Zones (TAZ) was calculated by hour of day, day of week, type of trip and demographic characteristics of the traveller. Rates of trip generation were computed for the population to determine the amount and type of daily trips that will be made. These rates vary according to the zone's population and employment characteristics. For example, the number of trips generated at TAZ with relatively small income households are lower than TAZ with higher incomes, everything else being equal.

Day-time population by hour of day at each TAZ throughout the county and the reasons for trips by time of day and type of trip (i.e. home-to-work, work-to-shop, etc.) were calculated using the travel behaviour survey. These reasons were converted to proportions of all trips and applied to daily trip productions and attractions obtained from the transportation models. In the terminology used, factored trip productions refer to the number of trips leaving a zone: these are related to population and income data. Factored trip attractions refer to the number of trips entering a zone: they are dependent upon the type and amount of employment and land use in the zone. Therefore, a zone with high employment and low residential levels would have more attractions than productions. To calculate the locations of the population throughout San Diego County for every hour of the day, the number of factored trip productions was subtracted from the zone's resident population. Visitors and tourists residing in hotels and motels were included in the resident population values. Factored trip attractions were then added to the resulting values to produce the day-time population estimate by hour of day.

### **Day-time population shifts**

The results for San Diego County are shown in Fig. 52.7. Of the 37 sub-regional areas in San Diego, 28 had net losses of population during the day-time and nine gained population for the time period shown in the figure (11 a.m. on an average weekday). The areas of largest gain correspond to areas of central San Diego which house major employment centres and the military bases. The areas of net numerical loss are primarily residential territories.

'Maximum population' refers to the distribution of non-typical accumulations of people. These estimates include productions and attractions



**Fig. 52.7** Estimated changes from night-time to average 11 am population within census tracts in San Diego County.

for each zone, including special or unusual events. One such example is an event at San Diego Stadium which may add up to 70 000 people to a single zone. A warm summer day may add hundreds of thousands of people to zones along the Pacific Ocean beaches. The result is not necessarily 'typical': the value of such calculations produced from the GIS is to target localized worst-case scenarios which can be helpful in warding off traffic jams and emergency situations. 'Maximum population densities' within census tracts represent the maximum populations that would be likely to occur throughout the course of the year during the most crowded times and for which appropriate levels of emergency services, transportation facilities, water, sewer and fire protection should be provided.

#### **Public facilities modelling: determining the optimal locations for fire stations**

SANDAG has regularly provided support for decision making on the location of public facilities

for the 18 incorporated cities within San Diego County. The City of La Mesa, for instance, requested SANDAG's assistance in determining the optimum number and location of fire stations for their city which is located adjacent to El Cajon in eastern San Diego County. One of the three existing fire stations is in the path of a planned freeway extension and will be closed in the early 1990s. Major changes in travel patterns will also result from a ramp construction to produce a service interchange between two other freeways. The city wanted to know how alternative fire station configurations would affect fire response times, given these anticipated changes. SANDAG's Public Facilities Model, the ARC/INFO Allocate program, the San Diego DIME File and the RGF were used to provide information on the impacts of service area response times as a consequence of proposed new site locations and closure of other sites.

#### **The DIME file**

The study area road network was determined from the regional Dual Independent Map Encoding (or DIME) file. This is a computerized street network originally developed by the US Bureau of Census and later supplanted by TIGER files (see Rhind 1991 in this volume). It contains geographical coordinates defining the location of street segments and information about each street, including the street name, address ranges and census tract codes. Attributes added to the network file of existing road systems included maximum speeds possible on each link. Other input included SANDAG's 'circulation element' or traffic on existing and future planned major roads. Each street segment was assigned an impedance value representing travel time in seconds for fire equipment to drive from one end to the other. The impedance value is based on the segment length and assigned speed. These values were calculated from travel speeds reviewed and adjusted by the La Mesa Fire Department and from street segment lengths. According to the RGF described earlier, the 1995 La Mesa population will be 53 794 people and the detailed forecasts of population dwelling units and employment levels were allocated to road networks from Master Geographical Referencing Area data (MGRA). In this case, MGRA data were derived from the intersections of incorporated city limits, the city's sphere of influence boundaries, community planning areas, census tracts and traffic analysis

zone boundaries, all overlaid on a matrix of the 2000 by 2000 ft square ( $610 \times 610$  m) grid cells. Finally, the MGRA data were allocated to street segments based on the proportion of each segment's length to the total MGRA street length.

### **Evaluation of alternative fire station locations**

Response times were calculated for alternative station configurations. The ARC/INFO Allocate model performs competitive allocations wherein each street segment is allocated to the closest site based on travel time. For each alternative, tables of 1995 population at place of residence, the occupied dwelling units and employment at place of work by two minute response time bands were produced. Table 52.2 shows the city of La Mesa's population, housing units and places of employment within two minute response time bands for six of the eleven alternatives that were calculated. Tabulations of high priority sites designated by the fire department by two minute time bands were also produced. High priority sites included commercial shopping centres, schools, rest homes and hospitals. According to Fig. 52.8, which shows model comparison of average response time, Model 3B has the most favourable response time for total population averaging just less than two minutes.

This study was restricted to the analysis of fire station response times involving existing and relocated stations in relation to La Mesa's population, employment locations and high priority response sites. The study did not consider other factors important in siting fire stations, such as acquisition costs, compatibility with adjacent land uses, physical site size and suitability and driveway access. None the less, the city of La Mesa is currently acquiring new space in order to bring its response times into line with model values presented in this study.

### **Crime reporting and crime prevention planning**

The Crime Reporting and Interactive Mapping Environment (CRIME) was developed from the City of Tacoma, Washington, Crime Analysis Mapping System. It is a reporting and planning device for the Regional Urban Information System (RUIS). CRIME is a menu-driven system with which law enforcement personnel can analyse criminal data and plan for emergency enforcement

and prevention. It also utilizes ARC/INFO and ESRI's Network software; indeed, it is written using the ARC Macro Language (AML) and other interface tools. CRIME provides the user with the capability of point mapping of crime occurrences or polygon-shaded (or choropleth) mapping of crime statistics; it can create reports on individual crimes or on aggregations of crimes by various geographical areas. The user of CRIME can also perform small area analysis by entering individual territories of law enforcement (Beats), entering radii of search areas around an address or interactively creating a polygonal area. The crime data used in this system were developed from the Automated Regional Justice Information System (ARJIS) of San Diego County and the Crime Analysis Statistical System (CASS). The street data are from the DIME file maintained and updated by SANDAG (see above). Land use data are from SANDAG's 1986 generalized land use inventory and population data are from the Series 7 RGF and housing allocation estimation described earlier. Polygon files were also digitized by SANDAG.

### **The necessary inputs**

These included two CASS files – an incident file and a violation file – for each time period to be analysed. Both of these files contain data for crime cases and arrest incident types by dates and street address. Citation, field interview and traffic accident incident types may also be incorporated. Address matching was completed by the ARJIS with x,y coordinates in California State plane feet included on each record. Address information is included in the incidents file. All other geocodes except county community plan areas and supervisorial districts are in the violations file. The two files have a common incident number, facilitating the establishment of relationships.

Geographical units digitized as ARC/INFO coverages and available for analysis purposes are police beats (and sheriff territories), community planning areas, common census tracts and districts and divisions. These districts are either council or supervisorial districts. Each division is either a police division or a sheriff's command area.

The function CALK DATA calculates the above-average number of crimes, the number of crimes per square mile ( $2.59 \text{ km}^2$ ), the crimes per 1000 population and the property crimes and crimes against persons for every beat, community planning

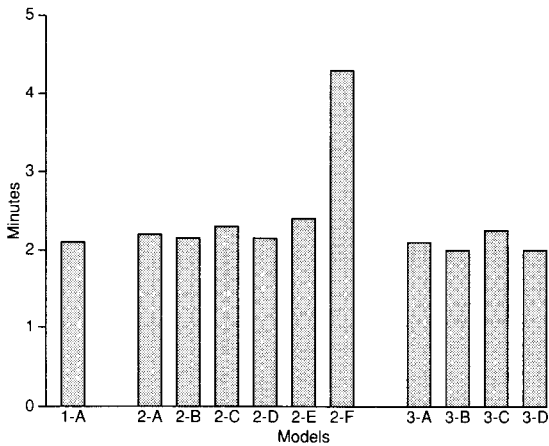
**Table 52.2** Comparisons of model runs – total population, housing units and employment served within specified response times (all model runs include automatic AID).

| Model La Mesa Stations    | Response | Popn.  | Housing units | Employment |
|---------------------------|----------|--------|---------------|------------|
| <b>EXISTING CONDITION</b> |          |        |               |            |
| Model 1–A                 |          |        |               |            |
| 11, 12, 13                | <2 min   | 23 132 | 9 968         | 19 103     |
|                           | 2–4 min  | 29 749 | 13 102        | 8 896      |
|                           | 4–6 min  | 913    | 417           | 25         |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| <b>CONSOLIDATION</b>      |          |        |               |            |
| <b>RUNS</b>               |          |        |               |            |
| Model 2–A                 |          |        |               |            |
| 11 & 13                   | <2 min   | 19 904 | 8 669         | 18 404     |
|                           | 2–4 min  | 32 918 | 14 375        | 9 586      |
|                           | 4–6 min  | 972    | 443           | 34         |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| Model 2–B                 |          |        |               |            |
| 11 & alternative A        | <2 min   | 20 786 | 8 926         | 15 956     |
| Fletcher                  | 2–4 min  | 31 982 | 14 095        | 12 027     |
| Parkway                   | 4–6 min  | 1 026  | 466           | 41         |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| Model 2–C                 |          |        |               |            |
| 11 & alternative C        | <2 min   | 17 438 | 7 595         | 16 403     |
| Brier Patch               | 2–4 min  | 35 171 | 15 360        | 11 562     |
|                           | 4–6 min  | 1 185  | 532           | 59         |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| Model 2–D                 |          |        |               |            |
| 11 & alternative B        | <2 min   | 20 981 | 9 282         | 10 963     |
| Sunset Park               | 2–4 min  | 31 633 | 13 678        | 16 963     |
|                           | 4–6 min  | 1 180  | 527           | 98         |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| Model 2–E                 |          |        |               |            |
| 11                        | <2 min   | 14 712 | 6 555         | 9 762      |
|                           | 2–4 min  | 37 645 | 16 292        | 18 147     |
|                           | 4–6 min  | 1 436  | 640           | 115        |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |
| Model 2–F                 |          |        |               |            |
| No La Mesa                | <2 min   | 2 268  | 968           | 569        |
| stations                  | 2–4 min  | 17 060 | 6 995         | 10 486     |
|                           | 4–6 min  | 31 807 | 14 279        | 16 397     |
|                           | 6–8 min  | 2 562  | 1 200         | 569        |
|                           | 8–10 min | 97     | 46            | 3          |
|                           | TOTAL    | 53 794 | 23 487        | 28 024     |

area, census tract, council or supervisorial district and division or command area. The function AGCBATA generates aggregated data of incidents and violations by the same areas. The data are stored in ARC/INFO data files.

#### Point mapping and reporting of crime incidents

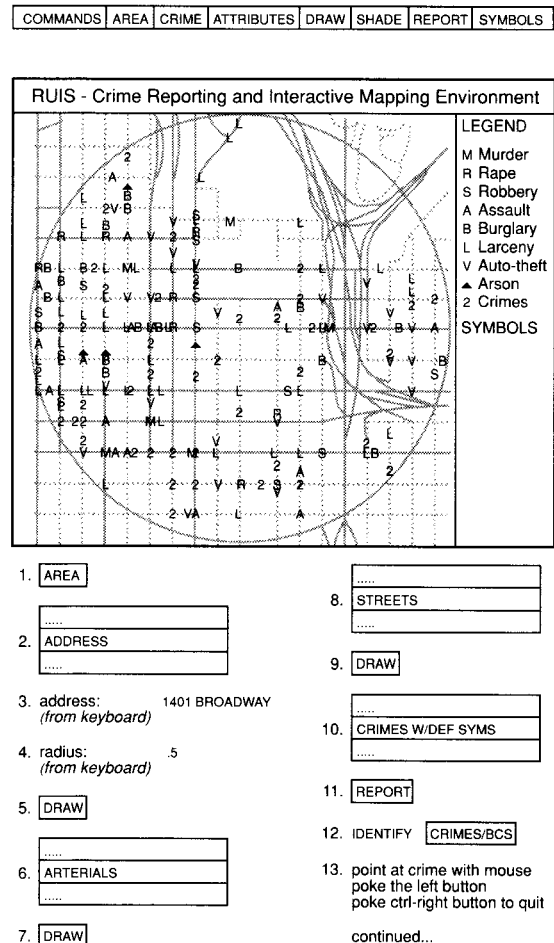
A simple point mapping option is available to CRIME users. Selecting the 'Beats' box on a menu sets the geographical area to beats and requests user



**Fig. 52.8** Average response time to service population with different models of fire station provision.

input for the beat number to be entered from the keyboard. Entering 113 from the keyboard causes the system to select all crimes geocoded to that beat. Messages will be displayed in the dialogue area describing the procedure the system is performing. The mapping area will be cleared and beat boundaries drawn. The last message displayed in the dialogue area is the number of points currently selected. By selecting the 'Crimes' box, the system draws currently selected crimes and their level of occurrence. By selecting 'arterials', the freeways, ramps and other roads are drawn in various colours.

Figure 52.9 displays the point reporting option. Choice of 'Address' sets the area to the address given and requests user input from the keyboard concerning crimes. For this figure, the street address 1401 Broadway has been chosen as the centre of the radius search. The radius has been set at 0.5 mile (0.8 km). 'Draw' displays the draw menu. 'Arterials' will draw freeways and ramps in red and major roads in green. By touching 'Crimes', the system draws the currently selected crimes with default symbols. Positioning the mouse on the crime symbol and clicking the left button displays the code and descriptions of the crime for that particular crime. Thus the system is easy to use even by those unskilled in GIS operations.



**Fig. 52.9** Interactive mapping and analysis of crimes within 0.5 mile (0.8 km) of a specified point using RUIS.

## CONCLUSIONS

Because of the myriad of geographical reporting regions in San Diego County and because of the burgeoning population growth in the region, planning for a wide variety of facilities and programmes requires the use of a large-scale GIS. SANDAG has streamlined the GIS in San Diego County so that 18 cities, the County of San Diego's unincorporated area plus a large number of private commercial groups, can use standardized information to provide compatible results and planning activities. A regional information system is the responsibility of each large regional area in order to meet the increasing economic,

environmental and public facility needs and analysis. In this rapidly developing county at least, GIS has proved a major boon in urban and regional planning.

The example case studies chosen here illustrate graphically the range of urban GIS applications. Already much of the potential of GIS in urban environments is being realized in San Diego, in other US cities and, indeed, throughout the world. There are extremely large urban GIS projects well underway in cities as diverse as Baghdad, Glasgow, Mexico City and Stockholm (Gault and Peutherer 1990; Yeh 1990). Each of these has its own particular problems and utilize GIS in different ways. Nevertheless, the requirement of managing large quantities of disparate spatial referenced data is common to them all.

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