Linking Geographic Information Systems and Trip Reduction: Success and Failure in a Pilot Application

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Travel demand management policies are the focus of a national debate on ways to limit the growth of local highway congestion and improve urban air quality (Bae, 1993; Orski, 1989). One innovative approach, trip reduction programs, requires changes in individual travel behavior, usually in journey to work trips. While precise local goals and requirements vary, major trip reduction programs focus on large employers who must persuade drive-alone employees to increase vehicle occupancy, limit miles traveled, and eliminate travel (Ferguson, 1990).

Geographic information systems (GIS) are an innovative technical method with the potential to assist trip reduction marketing, education, and travel analysis activities. Geographic information systems are best understood as a computer-based information technology with five related components: locational data, hardware, software, personnel, and operating procedures (Epstein, 1991). This paper provides a case study of implementation success and failure in a pilot GIS application for the Arizona State University trip reduction program.

Academic documentation of application experience is essential as a step toward developing principles to guide future practice in diverse situations (Innes and Simpson, 1993; McGuire, Goodchild, and Rhind, 1991). This paper first discusses the potential benefits of linking GIS and trip reduction. The few available studies of

GIS failures provide insights on successful organizational conditions. These insights identify administrative and technical problems that limited the full integration of GIS and trip reduction in the Arizona State University application.

The Potential of GIS and Trip Reduction

The locational nature of many transportation planning and engineering activities make transportation an attractive GIS applications area. Multiple datasets can be stored, combined, and displayed. Specific data manipulations identify buffers or zones along highways, overlay engineering, environmental, and demograpic variables, and query the location of intersecting characteristics. Spatial analyses for optimal routing and facility location can be compared under varying assumptions. These spatial associations can be displayed at multiple scales on computer-generated maps.

Combining GIS with on-going transportation activities requires both management and technical decisions. State highway department experience shows that introducing GIS requires organizational changes in the ways that transportation data is gathered, stored and used. Traditional technical tasks such as traffic engineering and highway maintenance are made more efficient, while additional analyses with a strong spatial component can be conducted (Abkowitz, Walsh, Hauser, and Minor, 1990). New applications for existing transportation agencies include optimal routing for hazardous materials shipments and emergency evacuation planning. These applications require existing route and engineering data as well as demographic, environmental, and public services information. This information may already exist in different sections of an agency or be gathered by other agencies whose managers may not be willing share their data resources.

Technical GIS analyses in the new agency settings of trip reduction programs can complement existing state, regional, and local transportation planning efforts. Program requirements for yearly employee surveys, reported at the zip code or major street intersection scale, provide spatial, travel, and demographic data that can be matched with employer worksite location and characteristics. Employee commuting areas can be defined for single and multiple employers. Existing transit planning can be expanded by identifying market areas for bus and shuttle service for specific employers. Rideshare efforts can be assisted by matching the addresses and schedules of potential riders. Change in travel mode can be spatially monitored and the locational impact of specific trip reduction measures can be simulated.

Implementation Success and Failure

For uncritical supporters, the attraction of GIS technology is assumed sufficient to ensure successful applications. Limited attention is currently paid to the organizational concerns that establish a good fit between a program and GIS. Clarke (1991) illustrates this application approach by outlining the ideal situation of a large agency with clearly-defined activities. Ideally, this agency uses a linear approach to introducing GIS. The agency evaluates the need to replace and expand current operations, conducts analysis and specification of user requirements, and compares hardware and software alternatives before adoption. Experimental applications with short-term deadlines are not as likely to succeed as activities that are part of long-term operations in a stable organizational setting.

This ideal is unlikely to match reality in all implementation situations. Numerous public policy studies document the difficulty of implementing new public programs (Gares, 1989; Goggin, Bowman, Lester, O'Toole, 1990; Pressman and Wildavsky, 1973). Fewer studies document the difficulties of implementing new technical systems, but clues to successful GIS adoption are found in the literature of technological innovation. Rogers (1983) derived key broad principles for innovation success: simplicity, observable benefits, relative advantage, ability to make small trials, and compatibility. Innes and Simpson (1993) emphasize that GIS is a "socially constructed technology" (p. 230) whose character will be determined by both human and technical systems. In their view, GIS is the most recent stage in the continuing effort to incorporate large-scale computing into state and local agencies.

The literature on failed information systems and GIS, in particular, confirms the importance of this fit between the needs of users, as individuals and in organizational settings, and actual technical performance. These studies identify a common source for failure: a GIS application does not meet major supporters' expectations (Giles, 1987; Openshaw, Cross, Charlton, Brunsdon, Lillie, 1990; Lyytinen, 1987). A United Kingdom Department of the Environment report expands this point with four issues: agency overambition, insufficient attention to user needs, user conservatism, and over-optimism regarding the difficulty and cost of converting existing data (Department of the Environment, 1987).

These organizational insights from academic and governmental studies are becoming more widely discussed in the professional literature used by practitioners and students. McGuire, Goodchild, and Rhind (1991) advise agencies to conduct more cost-benefit analyses comparing existing operations to new operations using a GIS. At the same time, they view application problems as primarily related to "...organizational weaknesses or political naivety, rather than technical factors" (p. 9).

Contribution to Trip Reduction Success

Trip reduction program success can be defined in terms of organizational goals, including program continuation and compliance of program participants with program requirements, as well as reduction in commuter travel. Recent program evaluations focus on this single goal of measurable reduction in commuter trips and the progress of major programs (Federal Highway Administration, 1990) including the South Coast Air Quality District in Los Angeles (Guiliano, Hwang, and Wachs, 1993). A broader definition of success or failure considers whether an application meets multiple goals that program managers consider important. Six factors identify GIS problems as part of an organizational setting (Department of the Environment, 1987).

<u>Geographical information is essential to operational efficiency</u>. The recent creation of trip reduction programs means that this new technology is being considered in management

situations where guiding policies and procedures are still being developed. A trip reduction computer database for documenting employer compliance and trip reduction monitoring is essential, but does not require a full GIS. While locational analysis can assist with implementing trip reduction measures such as carpool match lists, program managers who have major employer compliance and trip reduction plan review responsibilities may not make GIS research and analysis their highest priority.

<u>The agency can afford some experimental work and trials</u>. Leeway on deadlines for GIS installation and production contribute to an application's success. Uncertainties can be expected on hiring and training personnel, dealing with technical issues including data entry and transfer, and trial production runs. Inflexible or unrealistic deadlines may reflect misperceptions and lead to disappointed program managers. Trip reduction programs have strict deadlines for employer compliance that add time pressure on both the employer and program staff.

<u>A corporate approach exists to geographical information and a tradition of sharing information</u>. Shared data within a program and easy access to multiple data sets are essential if timely, complex analyses are to be completed. If all program participants have similar data requirements, trip reduction employee surveys can generate key information on commuter origins and destinations, travel behavior, and mode preferences. This information can be combined with data from multiple, nearby employers, data on traffic conditions, and bus or shuttle scheduling. Common data standards, shared effort in coding data, and sharing of regional street

network files are examples of desirable joint efforts.

There is a multidisciplinary approach tradition. Trip reduction program activities directly involve economics, geography, marketing, public relations, as well as urban and transportation planning. Program staff members are likely to be drawn from a wide range of professional and academic backgrounds. Locational analyses that integrate these related fields is likely to be used by a wider audience within and outside a trip reduction program.

Management provides strong leadership and enthusiasm. If trip reduction program managers are not supportive, a GIS application will have no future. This support must include budget for hiring and retraining staff and purchase of hardware and software. Hardware costs have decreased considerably in the past five years through the increased availability of personal computed-based software. Not all program managers understand the full range of GIS contributions to trip reduction activities. At a minimum, management patience with GIS experiments and delays is essential.

There is some experience with and commitment to information technology and use of existing data bases in digital form. Managers need to be familiar with computer technology to have realistic expectations. A trip reduction program manager who expects GIS to solve every data analysis problem will be disappointed.
Experienced staff members familiar with computer use have a broad knowledge base that allows easier adoption.

The Arizona State University Trip Reduction Program

These organizational conditions suggest that GIS have distinctive risks as part of trip reduction program settings. This case study examines one large employer's efforts to introduce GIS as the trip reduction program started. Arizona State University is the largest employer participating in the local trip reduction program with 5,300 faculty and staff employees and 39,000 full-time equivalent students. The case study reviews regional trip reduction program requirements, the university's trip reduction program approach, the GIS effort, and the measurable trip reduction between first and second program years.

The regional trip reduction program. The 1988 Arizona Legislature, responding to Environmental Protection Agency concerns about continuing metropolitan Phoenix noncompliance with federal air quality standards, passed the Air Quality Bill (House Bill 2206) initiating the Maricopa County Regional Travel Reduction Program. This program is noteworthy for the large number of employer participants (491) and employees (214,571) in the first program year (Maricopa County Regional Travel Reduction Program, Oct. 31, 1991). With a 1990 population of 2,122,101, this metropolitan area has ozone levels of moderate severity and continuing pollution problems from carbon monoxide and particulates.

This program's goal is an absolute reduction in drive-alone commuting. All employers with 100 or more full-time equivalent employees at a single worksite must participate. The program encourages changed commuting behavior from a drive-alone mode to increased alternate mode use, including carpools of two or more persons, bus, bicycle, walking, vanpools and trip elimination measures of telecommuting and flexible work schedule options. The initial legislation set a first and second year target for each employer of a 5% reduction in either the percentage of commuters driving alone or the average number of commute miles traveled (Burns, 1992). Yearly employee surveys monitor this performance using county survey forms that include questions on current mode, preferences for incentives to use other modes, a single preferred alternate mode and limited demographic information: gender, occupation, and age. Residential origin and worksite destinations are recorded as major cross street intersections on the metropolitan arterial street grid.

Employer compliance requires both a good faith effort toward these trip reduction goals and four program activities. Major employers must: (1) conduct a survey of all employees, (2) disseminate alternate mode information, (3) appoint a transportation coordinator, and (4) produce a trip reduction plan, stating how the program will be implemented. School districts and universities are required to reduce student travel. The regional program staff focuses on educating employers to encourage compliance; no employers have been cited with civil penalties to date for noncompliance. Regional Rideshare program staff assist employers in developing trip reduction measures and plans.

Arizona State University program activities. This campus is a prominent regional destination where trip reduction measures can be expected to be effective. Located in suburban Tempe, the compact campus has accommodated past parking demand by providing a total of 18,000 parking spaces in multi-story parking structures surrounding central academic and administrative buildings and peripheral surface lots served by shuttles. A key factor in reducing trips, for-fee parking, already exists. Both employees and students are charged a maximum yearly parking fee of $105. The City of Tempe minimizes spillover parking on nearby residential streets through resident-only on-street parking permits. Students who live near campus rely on bicycling and walking to reach campus.

From 1988 to 1990, Arizona State University delayed participating in the regional program. A series of confrontations took place between county staff and university administrators. Administrative and legal arguments included the university's autonomy under the State of Arizona Board of Regents and new costs of survey administration and trip reduction measures to the large employee and student population. The regional program was considered unfair for requiring reduction in student commuting. The university's position was that, if students were considered customers coming to campus for educational services, then other service employers should be required to regulate their customers' travel. The program staff, charged with implementing state law, took the position that the university had to participate.

The university's program began after the new university president demonstrated his support by being photographed riding his bicycle to campus. The program was considered an outreach activity and initially administered through the Office of the Vice-President for University Relations. A key administrator, the acting provost, understood that travel behavior research was needed to support marketing and educational activities. With his influence, the transportation research center received a thirteen-month contract (May, 1990 - June, 1991) to develop specific travel reduction measures and write the required plan.

The project team of geographers and transportation planners developed a linear planning process intended to select a rational set of measures most likely to produce measurable trip reduction. Current travel information was summarized by county staff from employee and student surveys. Telephone interviews identified the range of costs and services provided by parking and trip reduction programs in other comparable Western universities. A comprehensive set of trip reduction measures was developed from review of current literature. A GIS was authorized to analyse the survey data for several possible trip reduction measures, including carpool matches, bicycle lanes, and an off-campus shuttle service.

The campus trip reduction plan attempted to meet employee alternate mode preferences for bus and carpool measures and student alternate mode preferences for carpool and bicycle measures. Fifteen trip reduction measures was developed on the basis of per capita cost. High total and per capita cost estimates were estimated by the project team. They assumed that travel behavior would change only if improved facilities and monetary subsidies for alternate mode use were substantial. The employee trip reduction plan was completed in August, 1990, to meet the county's deadline, but the budget was based on the lowest per capita costs consistent with current university operations. The final plan was submitted in January, 1991 after revision to include student survey analyses.

University administrators insisted on a plan focused on measures that the university could control to some measure. Subsidized bus passes were eliminated as a proposed trip reduction measure as the university could not ensure improved regional bus service. Limited incentives were provided for carpoolers purchasing parking decals. Low cost measures included a telecommuting pilot program for employees who already had computer equipment in their homes and required no additional capital expenditures. Measures requiring no cost to the university were emphasized including alternate work schedules.

The Geographic Information Systems Application

The GIS application had two purposes: (1) research support for multiple trip reduction activities and (2) direct assistance in increasing carpool use. Once the university was participating in the regional trip reduction program, administrators and the project team expected that a high quality effort using university strengths would serve as a model for other metropolitan employers. The regional program did not have staff or technical resources at this time to develop GIS applications. Mapping the present and potential markets for specific alternate modes was expected to complement the combined efforts of the Regional Rideshare agency, the City of Tempe, and the university to establish a joint carpool matching list.

Both technical and administrative problems complicated GIS activities. The database of travel, demographic, and locational characteristics included 3,825 employee surveys completed in April 1990 and 9,344 surveys from students who purchased parking decals in August 1990. This student survey approach was a university compromise accepted by county program staff to minimize administrative costs for the first two program years. This approach understates the full extent of student alternate mode use, incompletely reports residential locations, and overstates drive alone commutes. At the time, university administrators did not support alternate survey approaches of a census or a random sample.

Baseline drive alone employee commute trips were 71.4% of one-way trips per week; carpool trips were 11.4%; bicycle trips were 9.1%; and walking trips were 3.3%. Automobile-dependent students who purchased parking decals drove alone for a slightly higher 77.6% of one-way trips per week. These students carpooled for 5.9%, used bicycles for 5.8%, and walked for 6.6% of one-way student trips per week (Table 1). Bus trips were only 2.4% of employee trips and 1.0% of student trips. A lower employee response rate and higher student response rate in the second program year survey changed the number of reported commute trips in the second program year survey.

Early technical decisions contributed to delays that disappointed university administrators. No GIS products were ready to submit with the final trip reduction plan in January, 1991. When the project started, IBM's Geographic Facilities Information System software was already analyzing trip reduction survey data sets of up to 2,500 cases for other research projects. This software allows point to point and network analysis useful for the physical networks operated by utility companies and appropriate for transportation planning. IBM eagerly supported this new application by making Arizona State University a field test site for its new geoManager relational database program. This program was installed on the university's mainframe computers and used with IBM's Graphics Program Generator software to generate GIS analyses and graphics.

These advantages were outweighed incomplete IBM software. County staff optically scanned the surveys onto a computer tape with residential origins and the campus destination in alphanumeric characters. Data screening at Arizona State University eliminated 20% of the surveys with inaccurate or missing cross street locations. An address matching program had to associate each case's data with the appropriate origin on the metropolitan street network. Computer consultants were delayed in delivering this program until May, 1991. A student team finished digitizing of origin and destination locations in June, 1991. Little time remained for GIS analysis before the end of the contract period.

Initial GIS products were aggregate carpooling and bicycling analyses prepared for the university's second trip reduction plan completed in June, 1992. Figure one (employees) and figure two (students) are examples of these aggregate analyses. Residential locations are shown for current bicycle riders and present drive alone commuters who indicated a willingness to bicycle. University administrators felt these maps showed county staff that considerable expenditure of time and money was being spent on in-house research. No joint carpool match effort has yet been conducted with the City of Tempe whose 1,100 employee addresses need to be added to the database. To date, one direct trip reduction benefit from this locational analysis is improvement in local bicycle paths to campus by the City of Tempe.

Lessons Learned

The criteria used above to evaluate the contribution of GIS to the success of trip reduction programs are applied to the Arizona State University situation.

Geographical information was not essential to operational efficiency. Arizona State University is in compliance with the county trip reduction program because participation requirements are met, not because GIS helped achieve measurable trip reduction. First and second year surveys did not document achievement of trip reduction targets, but the university is considered to be making a good faith effort. From 1991 to 1992, drive alone employee commuters decreased by only 0.53%; students drove alone for 1.4% fewer trips. Average drive alone vehicle miles increased 1.39% for employees and 3.11% for students.

The university could not support experimental work and trials. Short timelines for plan development and trip reduction implementation made a contribution from the new GIS system unlikely. Both university administrators and project staff had unrealistic expectations about the speed at which the GIS could be developed. Although technical problems are now resolved, the administrators remain cautious and keep GIS activities peripheral to the full trip reduction program.

A corporate approach did exist to geographical information. The Maricopa County Regional Travel Reduction Program shared survey information in a digital form that minimized data transfer problems. County staff did not screen the data for origin location errors that need to be removed before GIS analysis. Sharing datasets with other agencies remains limited because different GIS systems and data coding standards are used.

A multidisciplinary approach was not successful. Project staff focused on the technical contributions of GIS and cost-revenue analysis to trip reduction. University administrators, however, viewed trip reduction as a marketing and education effort requiring less sophisticated analysis.

Management provided varying leadership and enthusiasm. The university's reluctant participation in the regional trip reduction program provided a weak basis for an ambitious technical effort. Once the campus program started, administrators provided generous budgetary support for plan development and GIS research. Early management enthusiasm waned as GIS delays continued.

There was limited experience with information technology and use of existing data bases in digital form. In retrospect, a microcomputer GIS could have been adopted immediately. Positive experience with the existing mainframe GIS and software led to overoptimism that technical problems related to the large datasets, address matching and digitizing could be quickly solved. A different decision would have required learning a new GIS system while still trying to produce GIS products in six months for the January, 1991, trip reduction plan deadline.

Conclusions

The Arizona State University GIS application continues in spite of the difficult initial experience. Microcomputer GIS software with address matching capabilities eliminates many of the early technical problems. Campus administrative shifts created a permanent location for the trip reduction program. Permanent staff housed in the Office of Parking and Transit Services provides a minimum budget for GIS data entry and analysis. The 1992 employee survey included additional questions on marital status, number of vehicles in a household, and age of children to support the guaranteed ride home program and childcare center.

Changed requirements make the county trip reduction program less onerous. The June 1993 Maricopa County Trip Reduction ordinance requires an employer to work over a period of five years toward a drive alone rate of 65% for commute trips and average vehicle miles traveled. Student travel will be documented by an August, 1993, random survey. Drive alone trips and average miles traveled should be lower than values reported by students who purchased parking decals.

This case study documents the difficult initial experience of one GIS trip reduction application. Its lessons can be applied to other situations. The six factors identifying GIS organizational problems are a checklist that can be used before, during, and after an application is completed. If weaknesses are identified and changed, chances for success are improved. At Arizona State University, the gap between administrators' expectations and actual GIS progress became apparent soon after the trip reduction program began and was not resolved. General research goals were too vague, but analyses for specific trip reduction activities such as expanded bicycle lanes eventually generated continuing managerial support.

Academic researchers contribute to appropriate GIS applications by informing planners about implementation issues. Integration of GIS and trip reduction programs will not happen without careful planning. Geographic information systems can directly contribute to multiple program goals. Clearly, support is most likely if GIS analysis is essential to a program's continuation. Additional case studies refining these findings will support planners who must act on this knowledge. This joint effort between researchers and planners will increase the probability that actual trip reduction occurs.

References

Abkowitz, M., S. Walsh, E. Hauser, L. Minor. 1990. "Adaptation of Geographic Information Systems to Highway Management." Journal of Transportation Engineering 116: 310-327.

Bae, Chang-Hee Christine. 1993. Air quality and travel behavior: untying the knot. Journal of the American Planning Association 59:65-74.

Burns, E. K. 1992. Arizona's Metropolitan Travel Reduction Programs. In Proceedings of the National Conference on Transportation Planning and Air Quality, pp. 76-84, R. Wayson and A. Chatterjee, eds. New York: American Society of Civil Engineers.

Clarke, A. L. 1991. "GIS Specification, Evaluation, and Implementation." In Geographical Information Systems, Volume 1: Principles, pp. 477-488, D. J. McGuire, M. F. Goodchild, and D. W. Rhind, eds. New York: John Wiley & Sons, Inc.

Federal Highway Administration. 1990. Evaluation of Travel Demand Management Measures to Relieve Congestion. Washington, D.C.: U.S. Department of Transportation.

Department of the Environment. 1987. Handling Geographic Information. London: Her Majesty's Stationery Office.

Epstein, E. P. 1991. "Legal Aspects of Geographic Information Systems." In Geographical Information Systems, Volume 1: Principles, pp. 389-502. D. J. McGuire, M. F. Goodchild, and D. W. Rhind, eds. New York: John Wiley & Sons, Inc.

Gares, P. A. 1989. Geographers and Policy-Making: Lessons Learned from the Failure of the New Jersey Dune Management Plan. The Professional Geographer 41: 20-29.

Giles, R. H. 1987. "The Creation, Uses and Demise of a Virginia U.S.A. Geographical Information System." In Proceedings of the International Geographical Union GIS Workshop: pp. 507-524. Beijing: International Geographical Union.

Guiliano, G., K. Hwang and M. Wachs. 1993. "Tmployee Trip Reduction in Southern California: First Year Results." Transportation Research A: 125-137.

Innes, J. E. and D. M. Simpson. 1993. "Implementing GIS for Planning: Lessons from the History of Technological Innovation." Journal of the American PLanning Association 59: 230-236.

Lyytinen, K., R. Hirschheim. 1987. "Information Systems Failures - A Survey and Classification of the Empirical Literature." Oxford Surveys in Information Technology 4: 257-309.

Maricopa County Regional Travel Reduction Program. July 17, 1991. Results of Companies in the Baseline and the First Compliance Year of the Travel Reduction Program. Phoenix, Arizona.

McGuire, D. J., M.F. Goodchild, and D. W. Rhind. "Introduction." In Geographical Information Systems, Volume II: Applications, pp. 3-10. D. J. McGuire, M. F. Goodchild, and D. W. Rhind, eds. New York: John Wiley & Sons, Inc.

Openshaw, S., A. Cross, M. Charlton, C. Brunsdon, J. Lillie. 1990. "Lessons Learnt from a Post-Mortem of a Failed GIS." In Proceedings of the Association for Geographical Information Annual Conference, pp. 2.3.1-2.3.5.

Orski, C.K. 1990. "Can Management of Transportation Demand Help Solve our Growing Traffic Congestion and Air Pollution Problems?" Transportation Quarterly 44: 483-498.

Rogers, E. 1983. Diffusion of Innovation. 3d ed. New York: Free Press.

Table 1: Arizona State University Commute Mode Split (n = trips per week)

	Employees		Students Who Purchased a Parking Decal	
	1990-91 (19,157)	1991-92 (16,019)	1990-91 (40,097)	1991-92 (49,008)
Drive Alone	71.4	71.3	77.6	76.5
Carpool	11.4	11.7	5.9	7.1
Bicycle	9.1	9.4	5.8	5.3
Bus	2.4	2.3	1.0	1.0
Walk	3.3	2.8	6.6	7.2
Motorcycle, Vanpool, Work at Home	2.4	2.5	3.1	2.9

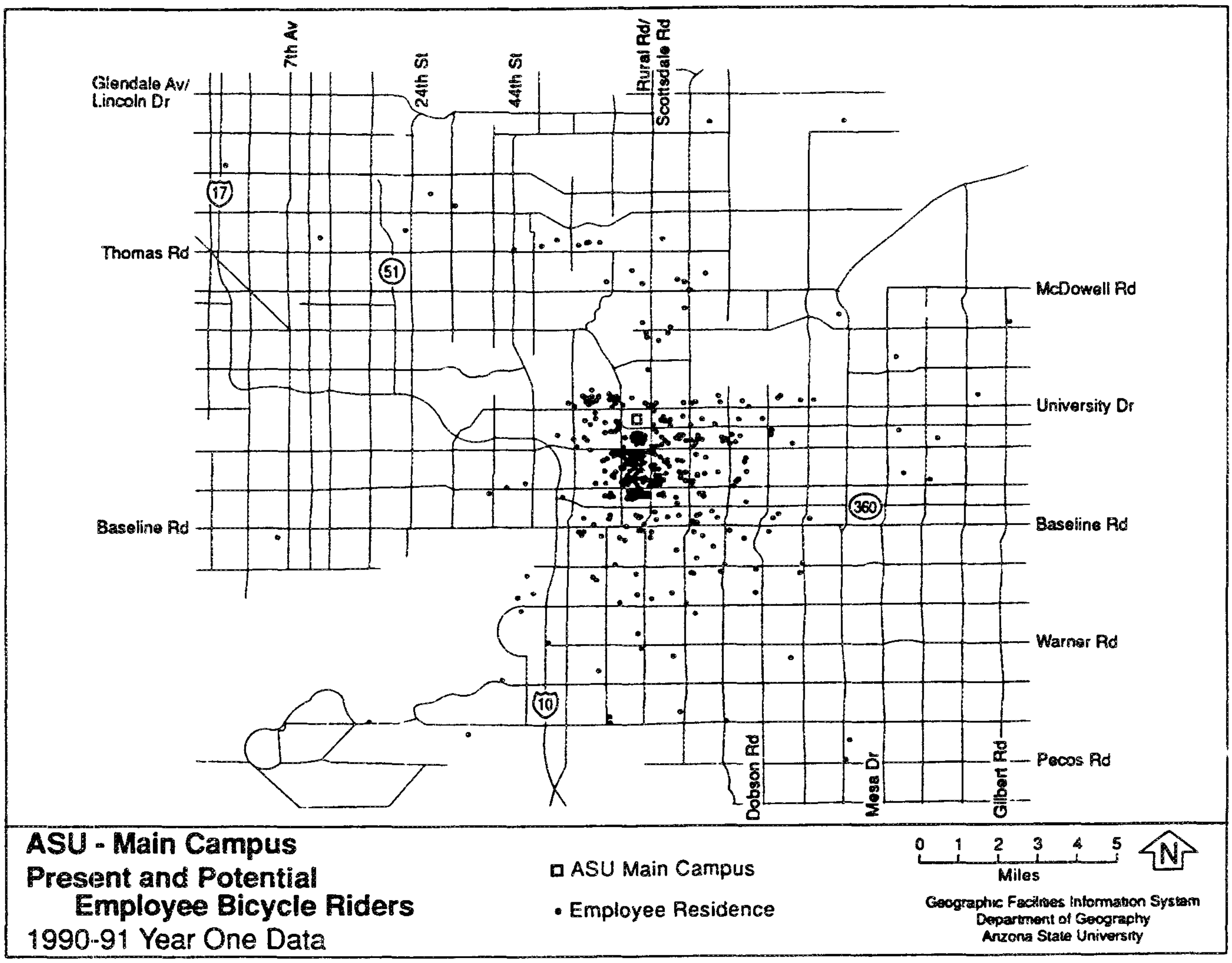

Figure 1. Combined residential locations of present and possible future employee bicycle riders: Arizona State University, 1990-1991.

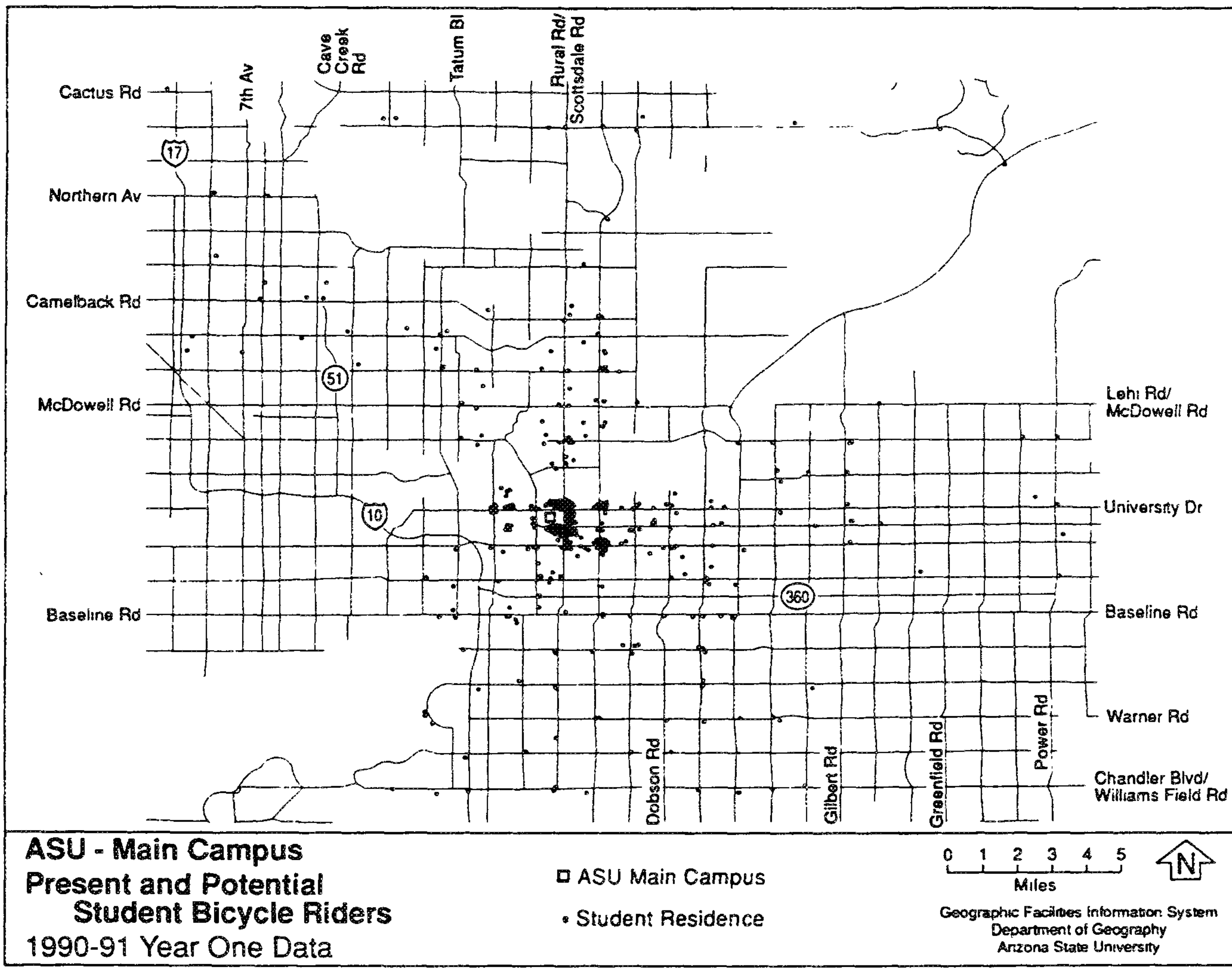

Figure 2. Combined residential locations of present and possible future student bicycle riders: Arizona State University, 1990-1991.