Applied Geography (1993), *13*, 9–27

The application of GIS in urban and regional planning: a review of the North American experience

Trevor M. Harris and Gregory A. Elmes
Department of Geology and Geography, 425 White Hall, West Virginia University, Morgantown, WV 26506, USA

Abstract

The diffusion of GIS within North American planning has occurred at a remarkable rate. Growing awareness, institutional acceptance, falling system costs and product diversity have led to a plethora of planning applications, varying in maturity and sophistication. The field is now sufficiently well established to allow meaningful trends, evaluations and directions to be reviewed. GIS applications in planning are characterized by geographical scale and the dominant influences shaping GIS utilization in planning are examined at the national, regional, trans-regional, metropolitan and neighbourhood scales. Transformations brought about by the interplay of GIS and planning are presented.

Planning, and the technology which supports it, reflects the culture of the society it serves. North America is currently experiencing a revolution in the linking of computer-based Geographical Information Systems (GIS) to planning issues. This symbiotic relationship reflects the vernacular approach to urban and regional planning, and an emphasis on high-technology solutions to economic development. North America serves well as a focus for examining trends arising from these GIS–planning initiatives. The continent has a long history of GIS applications in planning and resource management dating back to the mid-1960s. The diffusion of GIS into the planning sphere has continued at a remarkable rate. This process is reasonably well documented, albeit in disparate and mostly informal sources. Growing awareness, institutional acceptance, falling system costs, product diversity, the introduction of microcomputers and the availability of PC-based GIS software have led to a plethora of planning-based applications. Given the longevity and rate of growth of GIS in planning in North America, the field is now sufficiently well established to allow meaningful trends, evaluations and directions to be reviewed.

No single source is yet available that enumerates the diversity and scope of GIS applications in urban and regional planning in North America. Early studies by Dueker (1979), Tomlinson (1987) and Wellar (1975) identified major trends and impediments to the development of GIS in the planning domain. More recently, studies by Warnecke (1992), Vonderohe and Saleh (1991), Huxhold (1990), and Scholten and Stillwell (1990) have focused on the use of GIS in specific planning roles or in a non-American context. Because of the variety and extent of GIS usage at the continental scale, these assessments have necessarily been subjective and partial. Trends in software, hardware and application area have largely been interpreted on the basis of personal involvement and knowledge. The rapid spread of GIS, coupled with the diversity of planning applications, precludes any review from remaining current for long, though many trends will remain extant for some

0143-6228/93/01/0009-19

time. Landis (1990), for example, comments on the rapid obsolescence of GIS software in planning practice within only 18 months. Bracken and Webster (1989) reject an applications-orientated approach and propose a typology of GIS built on system architecture. This approach, however, overemphasizes the technical characteristics of GIS in the planning context and is swiftly outmoded as rapid software evolution reduces the differences between various system architectures. While recognizing the bias inherent in a subjective approach, our focus is on examining the GIS–planning process within an overarching and influential political-social-economic framework.

Despite the lack of a cohesive body of literature, this paper is neither a chronology nor an exhaustive census detailing the many individual applications of GIS in planning. Furthermore a basic understanding of the principles and functionality of GIS is assumed (for introductory GIS texts see Burrough 1986; Aronoff 1989; Star and Estes 1990; Tomlin 1990). This paper seeks to identify trends in the integration of GIS in urban and regional planning in North America, and to characterize the relationships and forces which have been instrumental in shaping the impact of GIS technology on the planning system. The paper teases out the complex multi-dimensionality of this field, identifies the numerous forces at work which have contributed to a headlong advance of GIS into the planning field, and considers the implications and prospects of such an alliance. Some themes are currently significant yet, in all probability, are highly transitory. As the literature tends to emphasize the innovative, it is evident that many 'run-of-the-mill' applications go unpublished and thus unrecognized. Consequently, it is reasonable to suppose that smaller, standard applications may be under-represented in this report. As GIS becomes more commonplace it will become increasingly less profitable to document its acceptance for standard applications. The diversification of applications, emerging benefits, and their interrelationships with the technology and sociology of the planning process are of central interest in our review. The human contribution is significantly more important in the planning process than the hardware and software, and this raises a number of questions concerning the nature of GIS implementation within planning.

Planning and society in North America

As GIS is integrated within planning, so it comes under the influence of societal forces acting on the planning process itself. As Bromley suggests, planning is 'an unstable decision-making process which is affected by forces beyond the dictates of the planning rationale or strategy' (Bromley *et al.* 1989). In North America the impact of GIS must be understood in a planning context which still bears the imprint of earlier societal and political experiences. These underlying forces continue to pervade and shape the course of urban and regional planning on the continent. GIS thus becomes part of a broader ongoing debate about the role of planning and planners in late global capitalist societies (Burchell and Steinlieb 1978; Dear and Scott 1981). Whether GIS is seen as a return to the logical positivism and model-building of the quantitative revolution (Openshaw 1991; Taylor and Overton 1991), or as an enabling wealth-creating technology (Fainstein 1991), or as an element in democratization and the surveillant society (Pickles 1991), the debate about the role of GIS in planning will extend far beyond the purely technological. Much of this debate may occur outside the more pragmatic confines of the practising planning community. However, planning is a heavily politicized activity and GIS cannot be divorced from the socioeconomic-political environment in which it is used for policy formulation, resource allocation and decision-making.

Of the underlying forces which have shaped planning in North America, the much vaunted concern for individual freedom and individualism remains a paramount factor defining its role. This attitude is reflected in a deep reluctance to accept interference or controls, perceived or real, from 'external' authorities. This ethos is not spatially well defined. Depending on the occasion, it can be seen at work at all levels of government. One outcome of this attitude is an entrenched system of vested governmental interests, each espousing a vibrant defence of local, county, state, provincial or regional rights and autonomies by elected representatives, business interests and government agencies with stewardship responsibilities over public land. Furthermore, the perceived similarities of regional and national planning with the monolithic economic plans of previous communist eastern-bloc countries continues to have a profound influence on the role of planning in North America. These forces are reflected in the very nature of planning on this continent. At one level they are seen in the selective use of terms such as 'programmes', 'projects' and 'schemes' to denote planning related initiatives (Bromley *et al.* 1989). At other levels they have been instrumental in determining the constrained role allocated to planners and perforce the role of GIS in planning.

These societal attitudes have led to regional planning in North America being equated with regional economic development strategies. Such a role falls more comfortably within the bounds of acceptability and the goals of an unrestricted capitalist economy. This economic mind-set is reflected in the number of statewide/regional GIS which have been established to act as high-profile technological focuses to attract business and to promote regional economic development. While there is substantial evidence of GIS being established to support the development and management of regional economic growth, there is no documented evidence of systems being developed to manage regions undergoing decline, especially in the so-called 'rust belt'. There is a concern, particularly in the context of a global economy, that these initiatives are in fact part of a zero-sum game in which regions compete for a slice of a diminishing or static economic pie (Goodman 1979). What is of particular interest in the development of GIS in the context of regional (economic development) planning is that the acquisition of GIS capability is seen as a minimum base with which regions compete for scarce economic opportunities. There is a suggestion that GIS are being viewed as the late-twentieth-century equivalent of the Victorian town hall edifice. It is as much for their role as high-profile, high-technology status symbols that GIS are being sought for regional planning as their problem-solving, future-predicting, data-handling functionality.

In addition to these developments, GIS have also been fostered within a second major area of regional planning: that of environmental protection and environmental risk management. This trend has been encouraged by the need to meet statutory environmental protection and monitoring requirements. The most well known of these is the 1969 National Environmental Protection Act, which requires an environmental impact assessment for major development projects on federal lands. The Resource Conservation and Recovery Act 1976 (with subsequent amendments in 1980 and 1984) may have even greater impact on the use of GIS for environmental management and monitoring. Statutory requirements, the 'greening' of North American politics and industry, vocal environmental pressure groups, growing public awareness, highly visible cases of environmental pollution, have all contributed to greater emphasis being placed on environmental monitoring and protection. It is noteworthy that GIS is being introduced both to facilitate and encourage economic development and to minimize environmental degradation.

Urban planning in general has fared somewhat better than its regional counterpart in its general acceptability. Although urban planning could be considered as a subset of regional planning, it would be unwise to think of urban and regional planning as distinguished only by their position on the continuum of scale. There are no clear boundaries to distinguish regional or subregional entities from metropolitan or urban units (Branch 1988). Indeed the linkages between them, especially with the competing interests in the urban–rural fringe (Lindhult *et al.* 1988; Ventura *et al.* 1988), suburbanization (Befort *et al.* 1988) and transportation issues, often implies a substantial overlap between urban and regional planning. The trend is such that urban planning has now become 'institutionalized throughout the country' (Bromley *et al.* 1989: 355). Much of this growth has been based on retaining local tax revenues and services while resisting subordination to larger regional entities.

Planning in a changing technological environment

The rapid adoption of GIS into urban and regional planning in North America could be considered part of the continuing computerization of planning (Sawicki 1985; Adler 1987; Dueker 1987b; Marble and Amundson 1988; Levine and Landis 1989; Wiggins and French 1990). Early, primarily academic, computing initiatives emphasized large, mathematically complex models as a means of optimizing urban and regional structures (Brail 1989; Harris 1989), and plan design (Hopkins 1984). The generality of these models, and the inability to determine local or global optima from the infinite model permutations, led to these models falling into disfavour (Harris 1989). With the exception of handling the heavy administrative and regulatory load of planning agencies (Klosterman 1986; Klosterman and Landis 1988) and digital mapping (Wiggins 1986), there had been a loss of impetus in computer modelling in planning. GIS may now provide the integrative analytical framework originally envisaged for large-scale optimizing models.

Underlying the widespread adoption of GIS in planning have been spectacular technical and marketing developments in the computer and GIS industries. The progression from mainframe and timeshare computing to low-cost, powerful, flexible, user-friendly microcomputer and workstation computing of the 1990s has greatly contributed to the growth of GIS applications in planning. In the process the commercial vendor has become a crucial agent in the diffusion of GIS technology. The widespread availability of computer platforms has enabled most planning agencies to obtain the basic hardware for GIS implementation. Indeed, many planning agencies have grafted GIS onto computer hardware acquired for office automation. While this does not remove the necessity to acquire other system components, it has enabled a number of GIS applications to evolve in stages.

Dramatic changes have also occurred in the availability, price and product range of GIS software (Marble and Amundson 1988; Levine and Landis 1989). The microcomputer and workstation market has greatly stimulated the development of the GIS software market, which has changed substantially from the limited offerings of less than a decade ago. Expensive mainframe, multi-user GIS software packages have been ported to less expensive microcomputers and thereby encouraged the adoption of GIS by many planning agencies. The GIS user market has also attracted many new vendors, not all of whom provide full GIS functionality. While funding for planning initiatives is limited, many agencies have sought and acquired money for GIS implementation. As a result, some form of GIS capability is now both available and affordable to most planning agencies. Perhaps of greater purport is the high cost and effort of generating suitable planning databases, though even here a growing number of geographical databases are freely available from federal agencies. These provide both a stimulus to GIS adoption and the basis of a planning database.

GIS also reshapes the planning organization and workplace. Many observers suggest that reorganization is a prerequisite for successful GIS implementation (Crain 1987; Eason 1988). Institutional advances have not kept pace with technical innovation. Existing hierarchical organizational structures tend to maximize the operation of 'manual' data handling systems. New organizational structures to support shared GIS databases are obligatory, though they are invariably postponed. Furthermore, legal issues concerning privacy, information ownership, data access and product liability have also been thrown into prominence by GIS (Epstein 1988a, 1988b; Dansby 1991; Dando 1991). These non-technological issues represent some of the biggest challenges to the integration of GIS with planning, and yet they have been overshadowed by the more immediate desire to acquire the technology (Chrisman 1987; Dueker 1987a; Saarinen 1987; Somers 1987).

GIS in the planning environment

Geographic scale, in the form of geographical extent and spatial resolution, is used as an organizing framework to examine the diversity of urban and regional planning. Dueker (1988), for example, suggests a spatial hierarchy to categorize urban GIS applications as 'wide-area planning', service dispatching, locational analysis, facilities management and engineering design. Certain types of GIS applications are more prevalent at one scale of a planning project than at another. To illustrate this point, Appendix 1 (see pp. 22–7) provides a sample of current GIS and planning initiatives drawn from publications of the Urban and Regional Information Society of America (URISA). URISA is a major forum focusing on developments in the field of GIS and planning. The table is representative of current developments across a range of geographic scales and application areas and provides the rationale for reviewing GIS applications in urban and regional planning at the national, state–provincial–regional, metropolitan–municipal–county and neighbourhood levels of scale.

National initiatives

In spite of the antipathy toward national-level planning in the US, and to a lesser extent Canada (Cannon 1989), there have been some major contributions to national GIS–planning applications. Many regional planning activities exist under the auspices of federal government even if they are not directly identified as such. Federal departments such as the Bureau of Land Management, Environment Canada, Environmental Protection Agency, Statistics Canada, US Geological Service (USGS), USDA Forest Service and National Parks Service have been among the early innovators of GIS–planning developments. The development of the GRASS GIS software by the Army Corps of Engineers, MOSS by the Bureau of Land Management, the Canadian Geographic Information System and the creation of national digital databases bears witness to this fact.

Other important national initiatives have supported the wider adoption of GIS technology in planning. In a decentralized political system, cooperation between federal, state and local government agencies takes place in many differing forms. Digital data standards and specifications for data transfer are critical in this respect and have been addressed by central government in recent years. One programme that will influence the potential of GIS applications in urban and regional planning stems from the publication of *A Study of Land Information* by the Department of the Interior. A second programme originates from the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC).

The Department of Interior report identified the need to provide oversight for a 'comprehensive, consistent, nationwide network of compatible land information for use by federal, state, and local levels of government as well as the private sector' (Ventura 1990: 632). The executive recommendations focused on the need for geodetic controls, standard base map information, property boundaries and land attributes, including legal rights. All these are data elements that are essential components in planning. In an analogous role, the FICCDC is responsible for supporting the development of standards, specifications, procedures and guidelines for data transfer in anticipation of the needs of a nationally distributed database. Interaction and cooperation between government agencies in the US at all levels was deemed best effected by establishing data transfer standards rather than imposing data specifications and standards at source. The addition of meta-data assessments of data error and data lineage to federally produced data, as with the DLG-E (extended) files, will be a model for other digital data producers and will improve the ability of end-users to recognize the real limitations of nationally produced digital data.

In the US, national databases such as USGS Digital Line Graph (DLG-3) and Digital Elevation Model (DEM) files, US Bureau of Census Topologically Integrated Geographic Encoding and Referencing (TIGER) data files, and digital orthophotographs are in the public domain and distributed to planning agencies for the mere cost of media reproduction. The availability of nationwide data has unquestionably encouraged the adoption of GIS within planning (a recently released CD-ROM, for example, contains every road and street address in the US and costs $99). Private firms are able to sell digital data obtained in this way and an extensive value-added digital data industry has spawned to meet user demand for 'clean' data. The frenetic marketing of GIS to undertake statutory political redistricting is indicative of the close links between national data production, private vendors and planners. Conversely, the equivalent data in Canada, such as the Area Master File (AMF) census data, is crown property and not available for widespread resale for private profit.

Given the high costs involved in creating databases for planning, the benefits of nationally available, subsidized databases are far from insignificant. Furthermore, the creation of GIS–planning demonstration projects at an early stage smooths the path for further support and funding. However, there is widespread misconception and misuse of these national databases by many planning organizations. Important issues such as scale, data resolution, data error and accuracy are often ignored by users at the cost of the quality of the resulting information products.

State, provincial and regional-scale applications

GIS–planning applications at the state or provincial level may be addressed in three groups (see Appendix 1). The first group comprises early, broad-based, experience-driven developments as in Minnesota (Minnesota State Planning Agency 1983), Maryland (State of Maryland 1981), and British Columbia (Wiebe 1986). Issue-driven applications form the second group and include, for example, natural hazard management in California (Wilson and Perkins 1991) and transportation issues in Massachusetts (Taupier and Terner 1991). The third group of incentive-driven acquisitions, which comprises the majority of state level initiatives identified by Warnecke (1992), is largely based on the demonstration effect of earlier GIS applications. The demonstration effect is an apposite descriptor of GIS adoption at this scale. GIS is seen by many state legislators as a single, high-tech solution to multiple problems, which range from political and judicial redistricting to site selection for industrial development. Unfortunately single, simple solutions to complex planning problems do not exist (Parr 1988). Since provincial and state planning policy is heavily politicized, a strong incentive exists to seek highly visible GIS solutions to problems that support prevailing political ideology and practice.

Warnecke (1992) has identified GIS 'initiatives' in all 50 states though many, such as Mississippi and Utah (Mississippi R&D Center 1987; Maas 1991), have a political mandate but little financial backing. In 1991, 20 states had formally begun to address the legal ramifications of GIS implementation (Dansby 1991) but comprehensive strategies for assisting the practical implementation of GIS in state and local governments were limited. There are few fully operational state-level systems. Some state systems that have failed to meet their designed functionality have been decommissioned, as with the New York Land Use and Natural Resource Information System (LUNR), or have been forced to undertake hardware, software, database, institutional or budgetary modifications. Others have developed greater functionality through metamorphosis, such as those in Burnaby, BC, and in Minnesota. The group of failed systems is not well publicized in the literature, being subsumed in the welter of affirmative accounts from GIS proponents.

GIS in the public sector at the provincial–state scale are especially subject to the swing of the political pendulum. Despite its pioneering position, the Minnesota Land Management Information System has consistently failed to obtain sufficient permanent funding from the Minnesota legislature. Under the Growth Management Act of 1988 (Act 200), Vermont established one of the few multi-governmental, multi-organizational GIS to facilitate land use planning. The support of Vermont's governor was instrumental in the passage of Act 200, but the loss of a 1990 election has seriously weakened support for state-wide GIS. Privacy issues, budget cuts and mistrust by local governments of state intentions were among the issues that opponents used to attack the original state mandate (Van Buren 1991). To avoid similar partisan power struggles some states have encouraged and coordinated data transfer standards between different levels of state and local government. The specification of, and adherence to, data formats for acquisition and transfer between agencies is one alternative to centralized control over a state-wide system and circumvents the negative outcomes of fiercely defended local governmental interests.

Trans-regional initiatives

Federal planning for equity in regional economic development has little support in the US or Canada. The Appalachian Regional Commission (ARC) and Tennessee Valley Authority (TVA), for example, are maintained only by virtue of political power groups in federal government maintaining budgetary support from year to year. TVA has been a noted centre for GIS development and experiment and has established a profitable activity in data conversion and GIS contracting for other federal, state and local agencies. Other non-federal trans-regional organizations have arisen to address common concerns. Associations of local governments have been created to contend with cross-jurisdictional issues of public safety, natural hazard mitigation, evacuation routing and hazardous material monitoring. Foremost among these is BASIS, an extensive information system developed during the 1970s and 1980s in the San Francisco Bay area (Wilson and Perkins 1991). The Association of Bay Area Governments (ABAG) is another regional planning agency supporting private consultants and government agencies at all levels (see Appendix 1 for typical applications).

In developing from a multi-user, mid-size, timeshare computer environment towards a network of single-user workstations and microcomputers, BASIS is typical of many GIS implementations. This trend shifts the emphasis of GIS integration in planning towards providing greater system access to the decision-takers and lessens their dependence on intermediary technicians. For a number of technological and sociological reasons, decentralized decision-making is difficult to achieve in practice (Eason 1988). One approach being explored is the development of spatial decision support systems and intelligent user interfaces for GIS non-specialists (Armstrong *et al.* 1991; Densham and Rushton 1988).

Metropolitan, county, and municipal systems

The largest group of organizations to have adopted GIS are municipal, county and metropolitan authorities which have substantial responsibilities for day-to-day planning. It is here that the greatest potential exists for the continued expansion of GIS-assisted planning. Invariably these GIS projects tend to become trans-jurisdictional and involve both public and private authorities. Milwaukee typifies many such implementations (Huxhold 1990). In large metropolitan areas, comprehensive multipurpose GIS operations are still rare due to the sheer size and complexity of the combined database and the managerial tasks of the agencies involved. The politics and fractured nature of urban jurisdictions, and the difficulty of inter and intra-departmental coordination, have also constrained the creation of corporate GIS. GIS-based planning applications in the major metropolitan areas of New York, Los Angeles, Chicago, Toronto and Montreal are departmental in nature. Where corporate inter-agency GIS do exist, they frequently stem from existing computer-intensive departments such as transportation planning, public safety, or infrastructure management. Although it is not possible to discuss in detail the full range of urban planning and GIS activities, it is at this scale that GIS is likely to have its greatest impact on the planning process itself, if only because of the availability of extensive tax-based information. More rapid decision-making, greater public participation, if not a restructuring of the planning process itself, are further outcomes of improved information availability.

Local and neighbourhood-scale developments

Applications involving GIS at a sub-city scale are now beginning to appear (Haskins *et al.* 1991). These local information systems generally stem from local planning organizations, the public, or private enterprise. As yet, very few neighbourhood information systems can handle spatial data, but GIS at this level could emerge rapidly because of the promise of greater public participation in planning. Insecure funding and institutional factors work against a rapid deployment of top-down neighbourhood schemes and many appear more regularly in print than in reality. At the grass-roots level the considerable benefits of accurate land use inventory and control, enumeration of housing units, tenure, rent, vacancy, value and condition have long been recognized by private business, neighbourhood organizations and advocacy groups. Public information networks, such as Santa Monica's PEN system, connect to elected officials, other neighbourhoods and cities. Such systems provide information and coordination that could translate into political influence and power. In modifying Huxhold's model of the planning pyramid, Van Buren (1991) argues for a change in the relative mix of policy formulation, management and operations as one moves down the planning hierarchy from state agencies to local offices. Currently, the greatest control over planning policy is exerted by those at the top of the planning administration pyramid. A GIS fully implemented at the local level would have the potential to challenge existing organizational bureaucracies, and lead to increased public involvement in policy formulation and decision-making. At present, however, public access to GIS is likely to be limited to local libraries and public agencies, and many Americans are more likely to encounter GIS first in vehicle navigation devices.

Craig (1991) documents the considerable barriers to the use of small-area data that will impede the adoption of GIS at the neighbourhood scale and reduce the democratizing influence of public access planning GIS. Even with currently available small-area data the level of disaggregation is still insufficient for neighbourhood use. Furthermore, concerns about individual confidentiality have resulted in restricted access to such data. A traditionally narrow official focus on departmental goals will also limit the availability of data to other organizations. If short-term departmental interests prevail then useful historical records may be discarded. On the other hand, the genuine cost of maintaining and providing such data is frequently a valid reason for a reluctance to disseminate it. Unfortunately the legal status of data access charges is equivocable, particularly in the light of 'sunshine' laws and issues of data in the public domain. Legislation is currently before the US Congress to formalize such procedures. In Canada there is no automatic right of access to government-generated data and public access to small-area GIS is thereby hampered from the outset.

Because of the links between data acquisition and GIS development, and the changing relationship between planning and private enterprise, it is no longer possible to ignore the relationships between the planner and private developer (Dueker and DeLacy 1990; Peiser 1990). The nationwide availability of street centre-line and land parcel data, combined with census information, provides planners and developers alike with a valuable access to regularly updated, spatially registered socioeconomic data. Statistics on race, ethnicity, age, mobility, income, employment, public assistance, health and crime extrapolated to blocks or even individual addresses provide for precise market targeting. This information also allows for greater public and commercial awareness of neighbourhood conditions. Although this information is available to both public and private groups, the investment costs could limit its use to powerful special interest groups. The coordination of data standards at federal, state and local levels does not yet include these central questions of information access. Clearly, if for no other reason than keeping abreast of potential infringements of regulations, planning agencies must integrate their GIS activities with those of public and private small-area users.

The adoption of GIS technology in planning is not a neutral process. It has different consequences in the hands of the powerful in contrast to the powerless. Pickles (1991), for example, questions the potential of GIS as a surveillant technology capable of the control or 'normalization' of individuals by the state or other institutions. In contrast to readily accountable profits of improved economic efficiency, the benefits of more democratic planning through GIS are less readily assessed. Previous participatory planning initiatives do suggest that greater public access to information does not necessarily result in greater public participation. There is a clear responsibility to take a pro-active role on the question of public access to information.

Conclusions

Any attempt to classify the role and status of GIS in North American planning at the beginning of the 1990s must consider the effects of various tensions existing in GIS and planning. As with any technological innovation, GIS is evolving in a political space economy, and conflicts between central and local decision-makers and between commercial, private and public interests are sharpened. The delineation of these non-technological tensions and their resolution in planning is an emerging focus of enquiry.

The foregoing review suggests that scale is an important factor distinguishing GIS applications in planning. GIS meets a fundamental need for efficient spatial data-handling capability in planning at all levels. There is a heavy emphasis on the application of GIS for regional economic planning. Statutory requirements for environmental conservation have also encouraged the development of GIS–planning applications. Significantly, while the planner may identify a need for the data handling and analytic capabilities of GIS, much of the support and encouragement for GIS has originated for other reasons. The perception of GIS as a high-profile, hi-tech, single-source solution to multiple problems, and the allure of a centralized, all-encompassing database has stimulated the necessary political support and funding for GIS adoption. This perception has been fuelled by GIS vendors, armed with inexpensive national databases, in the search for greater market penetration. While the technology of GIS is able to communicate across administrative boundaries, inter-agency and inter-personal barriers suggest that the potential will not be realized without political instructions. Sociological considerations prevail over technical issues, and the need to coordinate group access to the system is a prominent concern.

The extent to which GIS is transforming planning is a matter of conjecture. Whether the pace of change is sufficient to be called a revolution or whether GIS will simply be assimilated into current planning practice is still unclear. What is apparent is that GIS is revolutionizing the traditional methods of handling spatial data in planning. Changes in the nature of planning itself, as GIS brings about a space–time compression, are evolving more slowly. GIS confronts well-established, politically favourable, non-automated procedures that are able to obfuscate the decision-making process through inefficiency and lack of documentation. In enforcing rigorous methods of evaluation, GIS challenges existing institutional organiization and power structures.

References

Adler, S. (1987) The new information technology and the structure of planning practice. *Journal of Planning Education and Research*, 6, 93–99.

Armstrong, M. P., Rushton, G., Honey, R., Dalziel, B. T., De, S. and Densham, P. (1991) Decision support for regionalization: a spatial decision support system for regionalizing service delivery systems. *Computers, Environment and Urban Systems*, 15, 37–53.

Aronoff, S. (1989) *Geographic information systems: a management perspective.* Ottawa: WDL Publications.

Befort, W. A., Luloff, A. E. and Morrone, M. (1988) Rural land use and demographic change in a rapidly urbanizing environment. *Landscape and Urban Planning*, 16(4), 345–356.

Bracken, I. and Webster, C. (1989) Towards a topology of geographical information systems. *International Journal of Geographical Information Systems*, 3(2), 137–152.

Brail, R. K. (1989) The evolution of spatial modeling in the USA. *Ekistics*, 56, 249–253.

Branch, M. C. (1988) *Regional planning: introduction and explanation.* New York: Praeger.

Bromley, R., Hall, P., Dutt, A., Mookherjee, D. and Benhart, J. E. (1989) Regional development and planning. In *Geography in America* (G. L. Gaile and C. J. Willmott, eds). Colombus, OH: Merrill.

Burchell, R. W. and Steinlieb, G. (eds) (1978) *Planning theory in the 1980s.* New Brunswick: Center for Urban Policy Research, Rutgers University.

Burrough, P. A. (1986) *Principles of geographical information systems for land resources assessment.* Oxford: Clarendon Press.

Cannon, J. B. (1989) Directions in Canadian regional policy. *The Canadian Geographer*, 33(3), 230–238.

Chrisman, N. (1987) Design of Geographic Information Systems based on social and cultural goals. *Photogrammetric Engineering and Remote Sensing*, 53(10), 1367–1370.

Craig, W. J. (1991) Empty promises for small area data: monitoring our neighborhoods using operational records. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 4, pp. 220–229. San Francisco.

Crain, I. K. (1987) Non-technical factors in the design, selection and implementation of geographic information systems. In *Geomatics applied to municipal management: symposium proceedings, Montreal, 1987*, pp. 327–334. Montreal: Canadian Institute of Surveying & Mapping.

Dando, L. P. (1991) Open records law, GIS and copyright protection; Life after *Feist*. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 4, pp. 1–17. San Francisco.

Dansby, H. B. (1991) A survey and analysis of state GIS legislation. In *GIS/LIS '91 Proceedings*, Vol. 1, pp. 441–450. Atlanta.

Dear, M. and Scott, A. J. (eds) (1981) *Urbanization and urban planning in capitalist society.* London: Methuen.

Densham, P. and Rushton G. (1988) Decision support systems for local planning. In *Behavioural modelling in geography and planning* (R. G. Golledge and H. Timmermans, eds), pp. 56–90. London: Croom Helm.

Dueker, K. J. (1979) Land resource information systems: a review of fifteen years experience. *Geo-Processing*, 1, 105–128.

Dueker, K. J. (1987a) Geographic information systems and computer-aided mapping. *Journal of the American Planning Association*, 53(3), 383–390.

Dueker, K. J. (1987b) Multipurpose land information systems: technical, economic and institutional issues. *Photogrammetric Engineering and Remote Sensing*, 53(10), 1361–1365.

Dueker, K. J. (1988) Urban applications of geographic information systems technology: a grouping into three levels of resolution. In *1988 Annual Conference of the Urban and Regional Information Systems Association*, Vol. 2, pp. 104–109.

Dueker, K. J. and DeLacy, P. B. (1990) GIS in the land development planning process: balancing the needs of land use planners and real estate developers. *Journal of the American Planning Association*, 56(3), 483–491.

Eason, K. (1988) *Information technology and organisational change.* London: Taylor and Francis.

Epstein, E. (1988a) Legal aspects of global databases. In *Building databases for global science* (H. Mounsey and R. F. Tomlinson, eds). London: Taylor and Francis.
Epstein, E. (1988b) Litigation over information: the use and misuse of maps. In *Proceedings International Symposium on GIS: The Research Agenda*, Vol. 1, pp. 177–184. Washington, DC: NASA.
Fainstein, S. S. (1991) Promoting economic development: urban planning in the United States and Great Britain. *Journal of the American Planning Association*, 57(4), 22–33.
Goodman, R. (1979) *The last entrepreneurs: America's regional wars for jobs and dollars*. Boston: South End Press.
Harris, B. (1989) Beyond geographic information systems : computers and the planning professional. *Journal of the American Planning Association*, 55(1), 85–90.
Haskins, B. R., Buchan, L. A., Thum, P. G. and Ventura , S. J. (1991) Empowering local land use planning officials through use of land information system technology. In *Urban and Regional Information Systems Association Proceedings, Annual Conference 1991, San Francisco*, Vol. 1, pp. 79–89.
Hopkins, L. (1984) Evaluation of methods for exploring ill-defined problems. *Environment and Planning B: Planning and Design*, 11, 339–348.
Huxhold, W. E. (1990) *An introduction to urban geographic information systems*. Oxford: Oxford University Press.
Klosterman, R. E. (1986) An assessment of three microcomputer software packages for planning analysis. *Journal of the American Planning Association*, 52(2), 199–202.
Klosterman, R. E. and Landis, J. D. (1988) Microcomputers in US planning: past, present, and future. *Environment and Planning B: Planning and Design*, 15(3), 355–367.
Landis, J. D. (1990) Microcomputer-based GIS systems. *Journal of the American Planning Association*, 56(2), 373–376.
Levine, J. and Landis, J. D. (1989) Geographic information systems for local planning. *Journal of the American Planning Association*, 55(2), 209–220.
Lindhult, M. S., Fabos, J., Brown, P. and Price, N. (1988) Using geographic information systems to assess conflicts between agriculture and development. *Landscape and Urban Planning*, 16(4), 333–343.
Maas, K. J. (1991) Development of the Utah state geographic information database. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 2, pp. 124–133. San Francisco.
Marble, D. F. and Amundson, S. E. (1988) Microcomputer-based geographic information systems and their role in urban and regional planning. *Environment and Planning B: Planning and Design*, 15(3), 305–324.
Minnesota State Planning Agency (1983) *Minnesota Public Lands, 1983*. St Paul, MN: Land Management Information Center.
Mississippi Research and Development Center (1987) *Mississippi Automated Resource Information System, MARIS: goals and objectives*. Jackson, MS: Mississippi R&D Center.
Openshaw, S. (1991) A view on the GIS crisis in geography, or, using GIS to put Humpty-Dumpty back together again. *Environment and Planning A*, 23, 621–628.
Parr, D. M. (1988) Urban geographic information systems: technology without solutions. In *Proceedings of the International Symposium on GIS: The Research Agenda*, Vol. 1, pp. 197–206. Washington, DC: NASA.
Peiser, R. (1990) Who plans America? Planners or developers? *Journal of the American Planning Association*, 56(3), 496–503.
Pickles, J. (1991) Geography, GIS, and the surveillant society. In *Papers and Proceedings of Applied Geography Conferences*, Vol. 14, pp. 80–91. Toledo, OH.
Saarinen, A. O. (1987) Improving information systems development success under different organizational conditions. Paper presented at the URISA annual conference.
Sawicki, D. S. (1985) Microcomputer applications in planning. *Journal of the American Planning Association*, 51, 209–215.
Scholten, H. J. and Stillwell, J. C. H. (1990) *Geographic information systems for urban and regional planning*. Boston: Kluwer Academic Publishers.

Somers, R. (1987) Geographic information systems in local government: a commentary. *Photogrammetric Engineering and Remote Sensing*, 53(10), 1379–1382.

Star, J. and Estes, J. (1990) *Geographic information systems: an introduction.* Englewood Cliffs, NJ: Prentice Hall.

State of Maryland, Department of State Planning (1981) *MAGIS, Maryland Automated Geographic Information System.* Baltimore: Department of State Planning, Publication 81-13.

Taupier, R. and Terner, M. (1991) MassGIS: a case study of the Massachusetts environmental/geographic information system. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 2, pp. 87–96. San Francisco.

Taylor, P. J. and Overton, M. (1991) Further thoughts on geography and GIS. *Environment and Planning A*, 23, 1087–1094.

Tomlin, C. D. (1990) *Geographic information systems and cartographic modeling.* Englewood Cliffs, NJ: Prentice Hall.

Tomlinson, R. F. (1987) Current and potential uses of geographical information systems: the North American experience. *International Journal of Geographical Information Systems*, 1(3), 203–218.

Van Buren, T. S. (1991) Rural town geographical information systems: issues in integration. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 3, pp. 136–151. San Francisco.

Ventura, S. J. (1990) Federal land and geographic information system activities. *Photogrammetric Engineering and Remote Sensing*, 56(5), 631–634.

Ventura, S. J., Niemann, B. J., Jr and Moyer, D. D. (1988) A multipurpose land information system for rural resource planning. *Journal of Soil and Water Conservation*, 43(3), 226–229.

Vermont General Assembly (1988) *Growth Management Act* (Act 200).

Vonderohe, A. P. and Saleh, R. (1991) Status of GIS within state transportation agencies (abstract). Technical Papers 1991 ACSM-ASPRS Annual Convention, 2 Cartography and GIS/LIS, 324, Baltimore.

Warnecke, L. (1992) *State geographic information activities compendium.* Lexington: Council for State Governments.

Weber, G. (1987) Transferring GIS technology to community decision makers. In *Applied Geography Conferences*, Vol. 10, pp. 52–61. Binghampton: SUNY.

Wellar, B. S. (1975) Urban data management systems. In *Canada: A federal perspective. Papers from the 12th Annual URISA Conference, Urban and Regional Information Systems: Resources and Results*, Vol. 1, pp. 377–391. Montreal.

Wiebe, V. N. (1986) The Burnaby experience with computerized mapping. In *Proceedings Auto-Carto London*, Vol. 2, pp. 102–111. London: The Royal Institution of Chartered Surveyors.

Wiggins, L. L. (1986) Three low-cost mapping packages for microcomputers. *Journal of the American Planning Association*, 52(4), 480–488.

Wiggins, L. L. and French, S. P. (1990) Desktop mapping and GIS. *Journal of the American Planning Association*, 56(2), 370–373.

Wilson, P. M. and Perkins, J. B. (1991) Evaluation of the Bay Area Spatial Information System (BASIS) following the Loma Prieta earthquake. In *Urban and Regional Information Systems 1991 Annual Conference Proceedings*, Vol. 1, pp. 220–225. San Francisco.

Appendix 1: Selected GIS applications in urban and regional planning, 1991

Location	Scale	Computer system	Main applications	Agency(ies)	Data sources
California	State 1:24 000 (Selected Zones)	Unspecified	Seismic hazard-zone mapping	California Dept of Conservation, Division of Mines and Geology	USGS quads—DLG Manual digitizing: geology soils faults geotechnical Imagery
Massachusetts	State-wide 1:25 000	ARC/INFO ORACLE	Multipurpose Environmental management Hazardous waste siting Groundwater management	Commonwealth of Massachusetts Executive Office of Environmental Affairs	Land use 1971/1985 Surficial geology Hydrology/drainage Political boundaries Transportation networks Open space/aquifers Census geography Public water supplies
Utah	State-wide 1:24 000 1:100 000 1:250 000 1:500 000	ARC/INFO Various RDBMS	Multiple purpose/data transfer standards	State of Utah, Automated Data Reference Center (ADRC)	DLG DEM TIGER ADRC contract production Contributed data
South Carolina	State-wide 1:100 000 1:24 000	ARC/INFO	Infrastructure policy Economic development Community development Regional strategic planning Site selection/resource allocation	S Carolina State Development Board	DLG TIGER Land cover/SPOT imagery

San Francisco	Regional 1-hectare grid	pc Raster	Multipurpose Regional planning Site selection Economic development Environmental assessment Hazard management	Association of Bay Area Governments (ABAG)	Multiple DIME/TIGER
New York	Regional not to scale	MAC/SE30 Hypercard GPS	Decision support Real-time control (Hazardous materials transport)	Rensselaer Polytechnic Institute, Center for Urban and Environmental Studies	Schematic road network
Florida	Regional 16 counties	ComputerVision AutoCAD ERDAS ARC/INFO ORACLE	Monitor/protect natural resources Flood control Water supply Agricultural/urban development	South Florida Water Management District	Aerial photographs Imagery Engineering drawings Thematic layers
East Texas	Regional	Unspecified vector	Economic development Regional planning Emergency response Tax appraisal Client services Solid waste management	Deep East Texas Development Association Deep East Texas Council of Government	Control, parcels, Political boundaries Transportation Cultural facilities Environmental Imagery
MIT Planning Dept	Regional	Unspecified	Transportation needs assessment Service planning Scheduling Marketing—passenger info system Engineering—Facilities management	Massachusetts Bay Transport Authority, MBTA Central Transportation Planning Staff, CTPS MIT, Transportation Center	TIGER CAD Route maps

Appendix 1: Cont.

Location	Scale	Computer system	Main applications	Agency(ies)	Data sources
San Luis Obispo, CA	County 1:12 000	Unspecified pc Vector DBaseIII	Land development policies Development trends Impact on agricultural and environmental resources	San Luis Obispo County Cal Poly State Univ	Tax assessor's parcel data USGS quads Planning Dept map series CA Division of Forestry Fire Hazard
Lane County, OR	County Unspecified	Common mapping project	Roadside inventory Emergency services	Lane County Public Works Dept Regional Information System Lane Council of Governments	Digitized parcels County road maps
Hillsborough County, FL	County 1:200 base	Genamap ORACLE pcARC/INFO	Land records management Property appraisal Infrastructural management Land use planning Zoning Emergency management	County Engineering Services Southwest FL Water Management District Emergency Operations Center	Aerial photo base USGS DLG TIGER
Clark County, NV	County Urban 1:1 200	Unspecified	Multipurpose	Cities (e.g. Las Vegas, Boulder City) Regional Flood Control District Regional Transport Commission Las Vegas Valley Water District	Orthophotos Land records GBF/DIME

				Metropolitan Police Dept Clark County School District Clark County Sanitation District	
Prince William County, VA	County 1:2 000	ARC/INFO	Multiple purpose	Dept of Development Administration Offices of Planning Assessments Service Authority Dept of Health Clerk of the Court Dept Public Works Dept of Fire & Rescue Services Police Mapping Public Schools General Registrar Economic Development	Multiple
Jefferson County, TX	County 1:2 400 1:4 800	ARC/INFO	Development opportunities Land-based resource info Tax appraisal Incident mapping	Jefferson County Appraisal District	Control Parcels Zoning County base map Facilities, storm drainage Political boundaries Transportation Environmental
Orange County, FL	County 1:63 360 base 1:126 720 Large-scale parcels	GEOVISION ORACLE	Property appraisal Land use management Traffic analysis and planning	Orange County, Property Appraiser, City of Orlando Orange County Planning Dept	Control Parcels Traffic Analysis Zones Existing land use

Appendix 1: Cont.

Location	Scale	Computer system	Main applications	Agency(ies)	Data sources
Dupage County, IL	County Large scale	TEK Plot 10 Contract Fortran code IBM 4381 mainframe	Land records modernization Automated cartography	County Maps and Plans Dept	Manual digitizing of PLSS
Albuquerque, NM	Urban Large-scale Multiple	ARC/INFO	Automated mapping Map overlay	City of Albuquerque Public Service Corporation of New Mexico	City departments Utilities
Tacoma, WA	Urban	Video Inventory AutoCAD ARC/INFO	Street maintenance Street inventory	City of Tacoma—Depts of Public Works, Fire and Police Public utilities	
Soldotna, AK	Urban 1:6 000	Graphic Design System (McDonnell Douglas) ORACLE	Environmental protection Regulation and enforcement	Kenai Peninsula Borough Land Planning Division City of Soldotna Planning and Zoning Dept	Land parcels Soils and vegetation Hydrology
City of Winnipeg, Manitoba	Urban	McDonnell Douglas GDS DB2 Multiple RDBMS	Multiple purpose Managing land-based business	Depts of Assessment, Planning, Hydro and Water, Finance, Planning, Land Surveys, Real Estate	Multiple
City of Edmonton, Alberta	Urban High-precision	Geographically Based Info Systems (GBIS)	Land records Tax assessment Address matching	Planning and Development Transportation	Multiple AMF

		PACE Address Coord.		Property assessment Civic census Business assessment	
Anoka, MN	Urban 1:100 000	EPPL7	Fiscal impact of land development	City Planning Dept	GBF/DIME Census blocks/tracts Streets and intersections Land use Parcels records
Middleton, WI	Township 1:12 000 1:24 000 base 1:4 800 tax	ARC/INFO	Formulation of goals and policies Delineate land-use plan districts Identify implementation strategies	Town of Middleton Planning Commission	Public Land Survey System USGS DLG Orthophoto Tax parcels
Arlington, TX	Rural/Sub county	Unspecified pc raster DbaseIII SAS	Facility siting Land use alternatives	University of Texas at Arlington	USGS US Army Corps of Engineers USDA Soils Conservation Service
Ohio University Department of Geography	Rural	OSUMAP pc CLIPS	Landfill site selection	Ohio University, Athens, OH	Ohio, Environmental Protection (Revisions to Solid Waste Regs)
Galston Technical Services, Syracuse NY	Rural/Urban	Unspecified pc Air dispersion model	Air pollution management Plume modelling		US EPA Air quality regulations
Pinellas County, FL	District 1:3 600	pcARC/INFO	Floodplain management Flood mitigation	Pinellas Park Water Water Management District Pinellas County Property Appraiser's Office	Federal Emergency Management Agency (FEMA) (FIRM) Flood zone maps SW Florida Water Management District Floodplain topology Parcels base map

Source: URISA 1991, Annual Conference Proceedings, San Francisco