GIS Implementation in the Grassroots

R. E. Sieber

As increasing numbers of grassroots organizations use geographic information system (GIS) programs, the debate grows on whether or how they should adopt the technology. However, we know little about the GIS implementation processes within these organizations. This paper presents the results of five-year case study research of GIS implementation patterns by grassroots conservation organizations in northern California. This paper investigates alternatives that four cases have found to traditional models of GIS implementation and factors of successful usage. It also explores how these strategies might extend the traditional views of implementation and inform other institutional users, such as local governments, with innovations in GIS implementation and use.

Introduction

Increasingly nonprofits are following the lead of public agencies and private industry by implementing a GIS. They are drawn to a GIS because it can combine large amounts of data from disparate sources and on different media, order them into layers or themes, and analyze or display various relationships. The greater promise of the technology, to nonprofits such as grassroots organizations (GROs) and nongovernmental organizations (NGOs)[1], is that it may assist in influencing public policy, through the sophistication of analysis and presentation of powerful images. With increasing visibility that successful GIS adoption is possible (e.g., see the growing presence of GROs/NGOs in the annual map books produced by Environmental Sciences Resource Institute [ESRI]), GIS skills in the grassroots are being viewed as useful and even indispensable (Aberley 1993).

The potential of geographic information systems to empower the GROs has led to the emergence of supportive institutional structures, such as vendor foundations and technological assistance programs (Sawicki and Craig 1996, Barndt 1998, Leitner et al. 1998). At the same time that studies explore the process of GIS diffusion to GROs by external organizations (Leitner et al. 1998, Sawicki and Peterman 1998), a growing debate questions the appropriateness of geographic information systems in the grassroots: whether it empowers or marginalizes GRO impact (Pickles 1995, see also http://www.nciga.ucsb.edu/varenius/ppgis/papers/index.html). However, these studies and arguments ignore the process of GIS implementation within the GRO itself.

R. E. Sieber *is an assistant professor at McGill University, jointly appointed to the department of Geography and the School of the Environment. There she teaches GIS and researches the use of GIS and other computer technologies in social movement organizations.*

This paper describes the processes, requisite resources, and organizational characteristics of grassroots GIS implementation. It considers how GRO implementation mirrors or contrasts with the existing implementation literature, which to date has been conducted solely in the public sector. The nonprofit and grassroots literatures suggest that experiences in public sector agencies, such as municipalities, provide a poor barometer for GRO activities; their literatures are scanned for likely approaches to GIS implementation. A case study methodology allows for the framing of distinct implementation models and a list of implementation factors specific to GROs. Four conservation GROs from northern California are presented in the context of these models and factors. Their experiences allow us to reassess existing implementation approaches and provide valuable lessons to others in their implementation of a GIS.

GIS Implementation in Government

Governmental agencies have discovered that how a GIS is implemented influences its successful usage (Onsrud and Pinto 1993). Implementation, defined as the "activities necessary to put the innovation into practice and incorporate it into existing and developing operations" (Onsrud and Pinto 1993: 21), encompasses a complex array of organizational, contextual, and technical issues that spans the initial hardware installation to the desired end of routinization of tasks involving the GIS (Azad 1993, Rogers 1993). Although implementation involves a considerable degree of technical issues, such as system design and installation, the technical issues are equaled or surpassed by organizational issues (Croswell 1991). GIS implementation tends to alter the organization substantively because it is expensive and complex. Depending on the scope of the system and the promised organization-wide utility, implementation frequently crosses de-

partmental/subunit lines and alters power relations as the control of information changes (described in Pinto and Onsrud 1995). In the past, many systems have failed because management focuses on technical installation and does not realize the scope of change and additional expenses for implementation.

Effects of Organizational Structure and Culture

During the dynamic process of any innovation, an organization adapts the technology to suit its needs; however, the organization also is modified by the technology. Certainly, innovation must be sufficiently flexible to fit the organization. Within the organization, GIS implementation suggests that, for the effective adoption of an innovation—that is, a nonrountinized technology—an organization also must be sufficiently flexible to re-invent itself. Simply laying an innovation on top of old processes will not induce the implementation to succeed (Markus 1983). Organizational structures must be able to withstand a state of instability—to "unfreeze" while integrating the technology and then "freeze" into an adapted structure (Kwon and Zmud 1987). This limits the implementation capacity of organizations with structures that are rigid, extremely hierarchical, highly centralized or formalized, multi-layered (with management), and complex (Rogers 1995). Conversely, sufficient structure is needed for communications channels as well as for resolution of power and control conflicts (Campbell 1991).

Because an innovation is inherently destabilizing (Rogers 1995), organizations subject to high levels of internal and external uncertainty (a city government with a contentious elected council, for example) will suffer under GIS introduction (Campbell 1991). Recognizing the shockwaves induced by innovation, Budic (1997) emphasized internal stability as the necessary structural element for effective GIS implementation in: 1) resources (in terms of staff size, tenure, and organizational budgets); 2) degree of centralization, complexity, and formalization (in varying degrees dependent on the stage of adoption); and 3) internal politics. Budic (1997) added that these elements vary in importance—some may even become detrimental—depending upon the stage of the implementation process. This rather contradictory message—an organization need for flexibility/"instability" and a simultaneous need for stability—plus the time-dependent application of structural elements, alerts us to the need to more fully understand the role of organization structure in the process of implementation. Implementation researchers seek but have yet to find the equilibrium point, primarily because the limited amount of time available for organizational research may allow the capture of only one implementation stage.

Structure presents one dimension for analyzing organizational impacts and impediments; the organizational culture reveals yet another clue to the dynamics of GIS implementation. Whereas organizational structure comprises the formal arrangement of the organization, such as mission statements and organizational charts, organizational culture comprises the informal beliefs and values inherent in organizational units and how they shape attitudes and practices (Goldhaber 1990, p.71). Regardless of the organization's intent, an individual department's culture may not complement the diffusion of GIS innovation. For instance, departmental values and goals, cognitive styles, levels of commitment, previous computing/innovation experiences, and the style of leadership may inhibit successful incorporation into departmental practices (Croswell 1991, Onsrud and Pinto 1993). Superimposed on these are what Feldman (1993) considered distinctly American cultural icons that can enhance or impede organizational change: idealism, conformity, and selfishness. Idealism and selfishness, for instance, may nurture innovative behavior yet breed mistrust and territoriality.

Effects of Employee Perceptions

Like many innovations in information technology, a GIS can result in substantial change to job descriptions and organizational units. People naturally are apprehensive of organizational change (Kanter 1983). GIS implementation further exacerbates this anxiety in government because so many departments collect geographic data and are thus impacted by an organization-wide implementation (Perkins 1990; Antenucci et al. 1991). It should be noted that people often have reason to fear change, because authority/status, control over work, career opportunities, and job satisfaction can be diminished. These dynamics may or may not improve with the addition of GIS responsibilities (Crain 1990). Employee attitudes toward GIS implementation run the gamut from the desire to sabotage adoption, through resistance, ignorance, apathy, passive acceptance, active participation, and facilitation, to leadership and even evangelism (Brown and Friedley 1988, Croswell 1991). Often, success can hinge on the perceived advantage a GIS may bestow upon the individual as well as the alignment of personal values and experiences with the technology (Budic and Godschalk 1996). Therefore, employee attitudes are more complex than just ensuring "happy" staff. Employee acceptance of the technology has been correlated to successful usage (Igbaria and Nachman 1990); conversely, employee resistance has suspended the most technically advanced system (Er 1989).

Factors of Successful Implementation

Given the impacts of structure and perception, just how does one implement a GIS? Overall, researchers have concluded that successful implementation of a GIS in local government is dependent on a number of well-documented factors. They include: 1) evaluation of user needs; 2) long-term upper management commitment to the project; 3) sufficient allocation of resources; 4) adequate staffing; 5) timely and sufficient training; 6) someone, called a "GIS champion," who will shepherd the project from acquisition to use; and 7) organizational communication or diffusion to smooth the transition to full utilization (Croswell 1991, Huxhold 1991, Azad 1993, Onsrud and Pinto 1993, Budic 1994).

Clearly, management plays a key role in achieving GIS adoption. In addition to commitment to the system and the securing of resources, implementation depends on the upper echelon's ability to articulate organizational goals for the GIS, including

management of possibly conflicting departmental goals (Budic and Godschalk 1994, Huxhold and Levinsohn 1995). Enthusiasm for a GIS must be balanced with realistic expectations (Antenucci et al. 1991), particularly when vendors are willing to manipulate the image of the product to fit any desire. Moreover, management must involve users of innovation from the beginning (Cheney and Dickson 1982). Management may nurture staff to engage in innovation and risk-taking, through rewards and recognition; alternately, the structure may espouse change, but in reality organizations may not recognize new responsibilities and reward changes in employees' job descriptions.

GIS champions function as the innovators, the first wave of diffusion in an organization. They introduce the technology, promote its use throughout the organization, gather information about it, and join technology user groups. They likely will create the first project with the software. Paradoxically, these same champions, who provide a service to the organization (because their activities typically exceed the bounds of their jobs), are generally in conflict with the norms of the organization and may symbolize to other organization members "social deviants" (Rogers 1995). For example, by using technical (i.e., ill-understood) jargon champions may alienate themselves from their own organizations. Huxhold and Levinsohn (1995) contended that the role of champion is unnecessary with increased GIS diffusion, yet the diffusion literature suggests that for sectors of organizations with little exposure to the technology, the need remains.

GIS Implementation within Grassroots Organizations

The literature on GIS implementation suggests that these generic factors, employee perceptions, and structural elements should extend to all organizations, regardless of function or size. The nonprofit literature shows that similarities abound; resources and politics will affect both government and GROs. Much of the literature on the smaller GROs challenges traditional implementation approaches, which are based on larger and more stable organizations.

Similarities to Governmental Organizations

The literature on the general use of computers by nonprofit groups suggests that GIS implementation will mirror those observed in municipalities. Rubinyi (1985), in his study of computer use in community-based organizations, identified a mixture of technical and organizational barriers to extensive use, including uncoordinated efforts, lack of time, technical problems, and budget constraints. Schoech (1982) found that, historically, the cost of equipment has been a major limitation to the full implementation of information technologies (ITs).

Schoech (1982) identified numerous technical barriers to IT adoption by nonprofits but still traced successful development back to the existence of organizational elements: a key leader, executive involvement and commitment of resources, policies and procedures geared toward easy installation, and user participation throughout the process. Prospective adopters of computing technology are advised by nonprofit consultants and other technical experts to put someone in charge (ideally someone who expresses a "passion for computers") before system acquisition, remember the organizational mission (and that you work for people/clients), seek expert advice (including resources offered by universities, such as student projects, interns, or faculty assistance), do not minimize maintenance and support, be cautious of donations that can be costly to maintain, build a system from the software and the data, plan for the costs, conduct a user needs assessment, and understand the extra demands on staff (Cohen and Perrault 1991, Smith 1991, Nonprofit World 1994).

Differences to Governmental Organizations

Notwithstanding similarities to governmental experience with geographic information systems, GROs likely will face their own set of challenges in implementation. The primary difference lies in the much more fragile nature of the grassroots group, both in its ability to attract and retain resources (Gittell 1980, Wolch 1990, McCullough 1991) and its capacity to hold together a many times loosely knit assemblage of individuals with diverse goals and varying strategies to accomplish them (Crowfoot and Wondolleck 1990). This instability may inhibit the adoption of a new technology. As one nonprofit consultant reported in Rubinyi (1985, p. 92): "When you're living at the edge of existence, innovation is not a top priority."

Also their role in society is different. GROs are unlikely to operate with mandates or require accountability. They generally do not deliver public services. This looser arrangement, in terms of structures (decentralized, informal, participatory) and culture (receptive to innovation), actually might promote innovation within GROs. Indeed, Wolch (1990) found flexibility to be the primary reason why governments contract out to nonprofits, because the latter are viewed as efficient alternatives to rigid bureaucracies. However, excessive organizational flexibility also may constrain adoption. Organizations that are very democratic in decision making may lack sufficient structure upon which to establish procedures/rules and communications channels for integrating an organization-wide sophisticated information system.

Organizational culture, as witnessed in governmental departments, can be antithetical to adoption. GROs may exhibit a culture dramatically more hostile to innovation. Among social movements, the conservation movement has a long history of anti-progress, anti-capitalism, and anti-technology sentiment. This attitude is expressed by some modern-day environmentalists, such as Earth First!, the deep ecology movement, and even among members of the GIS-using Wildlands Project (Manes 1990, Coveny 1992, Snow 1992).[2] Many members of these organizations reject technology because it defines and then consigns the environment to an exploitable resource; accordingly technology must be opposed in order to regain the balance with nature. Frans (1993) observed "ideological antipathies" to computers in human services nonprofits; that is, some staff found the use

of computers incompatible with the humane provision of services to disadvantaged individuals.

Staff provides another flashpoint. Part of GROs' fragility results from their heavy reliance on the support and skills provided by volunteers and by underpaid staff. It has long been known that volunteers bring with them varying levels of commitment and quality of work (Schindler-Rainman and Lippit 1975, Clifton and Dahms 1980). For GIS work, even high levels of commitment are insufficient; quality and continuity of work are essential. Because a GIS is only as accurate as the data entered—on the scale of most natural resource maps, misplacing a line by one-eighth inch might misclassify data by one-half mile—good data-entry personnel are crucial. Even if digital spatial data is procured from other sources, technical knowledge is required to use the data properly in a spatial analysis.

Staff-led GROs, irrespective of size, tend to attain greater institutional stability than their all-volunteer counterparts (Snow 1992). Attracting expert staff still may be difficult. A prime reason lies in the fact that the nonprofit sector as a whole has lagged far behind other sectors in its ability to compensate staff (Barbeito et al. 1998). Expertise in computers enhances employability, which may mean their esteem inside the nonprofit may soar (Nonprofit World 1994), but so will their attractiveness to other higher-paying organizations. Conservation organizations already experience a high turnover rate (Snow 1992); GIS may exacerbate that rate. Reported the vice president of the NGO, Conservation International: "It's been my experience that as soon as we trained someone in the GIS and they became fairly good at it, that person would be offered a salary three times higher by someone in the private sector." (Specht 1996, p. 43.)

Methodology

To compare and contrast the experiences of GROs relative to traditional implementation strategies, this research employs a case study methodology. Researchers consider a case study methodology to be the richest way to examine the nature and use of a sophisticated technology that is implemented within a complex medium (Yin, Bateman, and Moore 1985, Lee 1989) and ideally suited for GIS implementation (Onsrud and Pinto 1991, Onsrud, Pinto, and Azad 1992). The intricate combination of environmental activism and innovative GIS applications produces a detailed model that can best be analyzed with this type of methodology. A scan of the public participation GIS literature (e.g., see the *Cartography and GIS* special issue on Public Participation GIS 1998, 25 (2)) shows that case studies are the preferred approach to analyze GIS in GROs.

To identify a sufficiently large pool of cases and to provide controls on political issues and group character, the research focused on a specific geographic area: northern California (split horizontally approximately at San Luis Obispo). Northern California was chosen for four reasons: 1) California, especially the northern portion, is a state at the forefront of environmental policy and activism (Benenson 1990, Fulton 1991, Hall and Kerr 1991, Walton 1992); 2) California is an innovative state with regard to implementing geographic information systems and other information technologies (Sprecher 1994); 3) because it has been shown that environmentalists, on the whole, quickly adopt—if not surpass—the technology utilized by influential government or target agencies (Hays 1987), there likely will be higher GIS adoption rates among environmentalists in this region; and 4) preliminary research (Sieber 1997b) with environmental organizations indicates that a sufficient number of GIS adopters exists in this geographic area to conduct case study work.

This last point suggests extensive GIS use in the grassroots. Survey research (Sieber 1997b) revealed that 20 percent of environmental/conservation nonprofits surveyed in a random sample mail survey used or accessed GIS. GIS was adopted despite significant resource scarcity; 60 percent had no paid staff. Estimates of GROs range from 12,000 to 15,000 environmental and conservation groups in the United States (Snow 1992, Wikle 1995), which implies large numbers of GROs using GIS software. This adds a fifth reason. Comparison of adoption rates with other grassroots GIS users, such as community development corporations (Obermeyer 1998), suggests that environmentalists and conservationists play an early adopter role in GROs' GIS diffusion. The study of early adopters is important because they represent a bellwether of the use of innovation in similar groups (Rogers 1995).

To further refine the selection of cases, a set of expert interviews was conducted at the ESRI Users Conference in 1994, where 25 of the approximately 30 conservation GROs present at the meeting were interviewed. These individuals were asked to identify organizational characteristics and requisite resources of successful grassroots GIS adopters. This was followed by consultation in 1994 and 1995 with representatives from GIS vendors, private firms, academics, conservation scientists, and GROs (some new and some from the original set). These interviews identified four best-practice cases of successful GIS implementation.

Successful implementation has been defined by Clapp et al. (1989) and subsequently used in other work (Budic 1994, Sieber 1997a) as a hierarchy of benefits that build upon each other. Benefits range from operational efficiencies, such as increased cartographic capacity; operational effectiveness, such as improved information access, program effectiveness such as augmented decision making; and contribution to well-being, such as the delivery of social justice. Successful implementation was gauged by interviewing case study participants on their satisfaction of the system; user satisfaction is correlated with successful usage (Igbaria and Nachman 1990). Overall, respondents were very satisfied with the benefits of the system (reported in Sieber 1997a), and reported the greatest benefit to be the highest, the contribution of GIS to social change.

Onsrud, Pinto, and Azad (1992) reported that case study methodology often is criticized for its apparent lack of rigor, hypothesis generation capacity, cross comparability, validity, and replication. However, they and others (Lee 1989, Yin 1989) demonstrated that rigor can be achieved through the use of formalized measurement protocols. Therefore, the case study

methodology combined observations structured with a case study protocol, interview instruments for open-ended interviews with key personnel, and pattern matching (discussed below) as components to fortify and triangulate each case study. Hypotheses were generated and tested through pattern matching. At the same time, flexibility was retained to balance rigor with the exploratory nature of the research.

Approximately one week was spent on-site in each of the four case studies at the end of 1995. This was followed by "progress report" phone or in-person interviews at the end of 1996 and 1997. Instead of a producing a snapshot of these organizations, this approach provided a critical longitudinal view of the fragile and constantly evolving GROs.

Models of Implementation

According to Lee (1989), as reported in Onsrud, Pinto, and Azad (1992), generalization in case study methodology is achieved by repeatedly testing theory across a range of circumstances. One investigates groups that have similar goals but dissimilar attributes, groups that express "natural variations in the real world" (Onsrud, Pinto and Azad 1992, p. 35). The selected cases hold successful GIS implementation as a common goal but employ different tactics to achieve that implementation. A wide spread of strategies allowed for a stringent test of traditional successful implementation factors and a way to extend case study experiences to a larger community.

The expert interviews revealed that alternate models of implementation exist in the GROs compared to organizations documented in the literature. These counter the traditional model of implementation, which implies that hardware, software, trained technical staff, and data are internal to the organization. Such an in-house model requires considerable financial investment and may be cost-prohibitive to small organizations. The models also challenge the notion that implementation assumes some threshold of system usage by the organization. A GRO may incorporate a GIS into routine activities without owning the technology.

The key points and differences among four models that were identified by the expert interviews are highlighted (Table 1).

Wants GIS. This model reflects an organization's desire to have the representational and analytic capacity of the GIS in-house. In that sense, the model represents the traditional model of GIS implementation: the user agency acquires and maintains most of the hardware, software, and data. Paid staff generally manages the system. An in-house model offers greater control than outsourcing (see below) over the design and timely delivery of analysis and output, and is very important when the technology is considered a strategic function (Nam et al. 1996). The individual(s) who develops the system is a paid or volunteer staff member. The predominant "end-user" of GIS services is within the organization.

Wants Map. The second model reflects a desire to possess GIS output (and possibly limited analytic or thematic mapping capacity) but neither the hardware/system nor the technical expertise to maintain a system. The predominant "end-user" of GIS services is within the organization.

The prime difference between this and the previous model is that this type of organization outsources to one or more external contractors for its GIS needs, including data, system, trained personnel, and expertise. Outsourcing represents an attractive alternative to organizations for several reasons: When employee skills are insufficient or scarce, a technology is rapidly changing to make it cost-prohibitive to keep up, or the external environment is uncertain and forces a firm to concentrate on its core functions (Slaughter and Ang 1996). Historically, environmentalists have relied on outside experts to conduct scientific analyses and create environmental models (Hays 1987, Gottlieb 1993).

Table 1 GIS implementation model types

Model Name	Description	Technical Details	GIS Developer Location	End-user
Wants GIS	Wants presentation/ analytic capacity in-house	Owns/accesses hardware, software, data, trained staff	In organization or organizational subset	Members/staff of organization
Wants Map	Wants output, limited analysis	Outsources for all system components	Outside consultant	Members/staff of organization
Wants Consortium	Wants to share system costs OR Wants to operate as service bureau	Owns/accesses hardware, software, data, trained staff	In member organization	Members/staff of organization, outside clients
Wants Independence	Individual wants complete capacity	Member owns/accesses hardware, software, data, is trained	Individual member of organization	Members/staff of organization, Individual

Snow (1992, p. 25) noted: "The smaller [conservation] groups often increase their technical firepower by reaching outside: They recruit volunteers or paid consultants who are the same kinds of specialists employed by the larger groups." By outsourcing for GIS services, both large and small groups likely will benefit from the additional and timely expertise, while remaining focused on their core functions of activism.

Wants Consortium. A GRO in this model operates predominantly as a service center to support the GIS needs of other organizations. The model may take several forms and serve different end-users: existing solely to support other GROs within a formalized structure, acting as a third-party nonprofit consulting firm seeking clients for its GIS services, or functioning as a technology assistance center or a data center. The organization may evolve into this role, spin off from another organization, or be created precisely for this GIS service. GIS staffing, digital data, and system equipment reside within this organization. Service centers allow user GROs to pool resources (including expertise and data), feel safer about their data (because it is off-site), maintain computing support, and build capacity to keep up with the latest versions of software (Nonprofit World 1990).

Conservation-specific service centers are emerging as a dominant model for conservationists (Ferber 1992, Specht 1996, Conservation GIS Consortium 1998, CTSP 1999). GROs should benefit as GIS resources and skills would be tailored to their needs—according to Rogers (1995), a reciprocal fitness of technology to the organization—in an affordable and more distributed manner. The greatest beneficiaries would be the smallest GROs that might otherwise lack the skills and financial resources to adopt GIS. Conservationists also may view service centers as an alternative to individual organization use—viewed as inherently "undemocratic"—because only a few conservation organizations might afford a full GIS (Ferber 1992).

Wants Independence. The last model refers to a sole individual who is an expert in GIS technical issues. The individual owns most, if not all of the hardware and software and can obtain/enter data (or already may possess much of the data). Far from an isolated instance, expert interviews revealed five of the interviewees as this type of "environmental entrepreneur," who wish to make a vocation out of an avocation. The individual may join an existing organization (or leave and join another) or create a new organization to ensure personal compatibility with a mission. The individual can best be described as an in-house technical consultant, with ties to a mission if not an organization, who likely requires reimbursement for GIS skills. The predominant "end-user" of GIS services is the current organization and the individual who builds a portfolio of equipment and products.

Pattern Matching

To compare and contrast GRO implementation with government, each of these models was tested against the factors of implementation. These diverse models test the assumption that factors represent universals across organizational type (e.g., nonprofit and government) and implementation strategy. This was effected through a technique called pattern matching. Pattern matching also allowed me to establish operational implementation and ensure consistency among cases.

GIS pattern matching compares observed factors of implementation to the theory of GIS implementation (Lee 1989, Onsrud, Pinto, and Azad 1992). As an example, if upper management commitment is important to effective implementation, one can assign a threshold amount of necessary commitment (e.g., 50 percent or more of the board members express support) and then observe or interview for that behavior in the case. If the same degree of commitment is observed, the pattern is effectively matched. Pattern matching in this research serves two purposes. First, it determines whether these effective GIS-using GROs match the implementation patterns of documented success stories (in government). Second, the method offers a way to test rival explanations for successful implementation in these cases.

The base pattern set was drawn from the review of the GIS implementation, management information system (MIS), and nonprofit literature. Possible values for the matches (+ for match, - for no match, or m for mixed) were assigned to items in the set. This follows other case study research of GIS implementation (Budic 1994, Azad 1998). Direct observation, group member interviews, and document examination for comparisons of cases to the set of theoretical propositions was then utilized. Results were compared to determine whether they matched existing conditions or established rival patterns. Factors are shown in Table 2.

Cases

The following briefly describes each case and furnishes some examples of GROs' response to specific factors of GIS implementation.

Case 1: Wants GIS

The Greenbelt Alliance, in San Francisco, is a moderate-sized metropolitan nonprofit dedicated to preserving open space in the nine-county Bay area. Formed more than 20 years ago, it employs 13 staff, spread among 3 field offices. This GRO builds on its already substantial resource base of computing, funding (including support from major corporations), and passionate staff and volunteers to operate GIS programs.

The predominant application has been the biennial nine-county Greenbelt Mapping Assessment Program (GMAP), identifying "Open Space At Risk." Begun in 1988, two employees (the current and previous director) would draw land use patterns onto U.S. Geological Survey topographic maps and then outsource the GIS portion to the local universities. Volunteers would assist staff in collecting data from each municipality and generating maps from the GIS output.

In the decade since GMAP's inception, Greenbelt has amassed considerable knowledge about GIS operations; nonetheless, understanding of the mechanics remains with just a few individuals. This caused one staff member to comment, "The GIS is pretty much an isolated braintrust. They keep it tight inside the 'beltway.'" In its desire to integrate the GIS into other

Table 2 Implementation factors used in pattern matching method

Implementation Factor	Description
Upper Management Commitment	The support and commitment offered by board members, directors, and other decision makers
Allocation of Resources	Adequate allocation by organizational decision makers of time, money, equipment, and personnel to GIS operation
Sufficient Training, Understanding	Timely and sufficient training about GIS to increase user understanding and carry out GIS tasks *or* adequate understanding extant in organization
GIS Champion	A person who takes over direction of GIS development in organization
System Use	Ease of data entry and output production; quality of user interface
Organizational Communication/ Coordination	Communication/diffusion of GIS knowledge between organizational decision makers and GIS users, GIS developers; coordination among participants of GIS-related activities
Lack of Resistance	Participants' lack of resistance to, or apathy about, GIS implementation
Voluntarism	Participation of volunteers in the implementation and utilization of GIS
Scarcity of Resources	Lack of, fragility, and/or unevenness of resources in the grassroots groups that impact GIS implementation
External Sources of Funding	Influence of external funding sources on the implementation and use of a GIS
Tension between Passion and Progress	Members who resist, or missions that run contrary to, GIS implementation because the GIS technology represents "progress"

activities, upper management spends substantial time demonstrating the GIS to staffers and members. Staffers have responded with interest and are eager to incorporate a GIS into their activities. Simultaneously they have felt short of time and other resources: "It's not resistance to the GIS [that prevents me from learning] but inertia . . . . We are thin already on our policy and advocacy work." Questions have arisen regarding the future of GIS decentralization. The past director would like rudimentary diffusion, not of feature creation per se, but simple spatial analysis and map production. Some staffers have appreciated the utility of the GIS maps but not the need for software training; they want to be consumers of output but not analyzers of data.

During the course of this research, Greenbelt went from briefly possessing in-house capacity to spinning off its capacity into a GIS technical assistance center. This center functions as the technology transfer hub of a regional GIS nonprofit consortium. In this way, the new organization could concentrate on helping not only Greenbelt, but assisting other nonprofits as well.

Case 2: Wants Map

The Nature Conservancy of Lanphere-Christensen Dunes Preserve (TNC-Dunes), in Arcata, is an autonomous chapter of a national land trust organization dedicated to preservation of rare and endangered habitats on a 450 acre parcel of coastal dunes that they own. The chapter's two employees conduct ecological research and monitoring. TNC-Dunes is closely allied with another organization, Friends of the Dunes, that conducts public outreach and restoration of native vegetation. TNC-Dunes has applied the GIS to inventory vegetation on the dunes and track mitigation of non-native species.

TNC-Dunes outsources all GIS programs to the local university. This follows the cultural ethic of national organization. According to interviews, TNC discourages the development of in-house GIS capacity at the regional and chapter levels, preferring instead to build capacity in like-minded institutions, such as public agencies. When a chapter wants the analytic capacity and output, it hires out for the service.[3]

By outsourcing to the local university, TNC-Dunes's director relies on its resources: equipment, data, students, and professors. TNC-Dunes benefits from the university's multimillion dollar GIS lab and extensive geo-registered spatial database. The director has been satisfied with the quality and the accuracy of most student work: "All the Master's projects I've been thrilled with. The class projects, like trail maps, we didn't even keep them, because the quality was low." It is inexpensive, too: "We're fortunate that we don't have to pay professional consultants at $30 an hour." One distinct disadvantage about the arrangement is that non-funded students must use the lab during off-hours and yield to the funded/formally-arranged projects. Further, work fluctuates with the semester schedule, "so that slows us down and puts us at the mercy of the traffic in the lab." Work also depends on the interests of the professors. As one reminded me, professors must remain mindful of the researchable quality of the contract and its contribution to "RTP-retention, tenure, and promotion." Therefore, contract projects should transcend the prosaic—become an article in a peer-reviewed journal—even if all TNC-Dunes needs is another thematic map.

TNC-Dunes has been successful in using its GIS to direct its mitigation efforts and obtain additional funding from the parent organization. Unfortunately, in 1999 TNC transferred the preserve to the U.S. Fish and Wildlife Service, which has expressed little interest in continuing GIS analysis on the preserve. The Friends of the Dunes board have attempted to interest members in data collection and entry, but to no avail.

Case 3: Wants Consortium

Trinity Community GIS was established by an economic development NGO in Hayfork as a separate GIS service center to support its programs and programs of affiliated groups. Operating with three employees, Trinity's applications have been in identification of non-timber forest products, contract work for area public agencies, and training of unemployed loggers in GIS operations, global positioning system (GPS) operations, and data collection techniques.

Affording and using the technology remain a vexing problem for Trinity. Allocation of resources to GIS has been promising, although the group has survived from one grant or contract payment to the next. Trinity owns three personal computers with GIS software; all were obtained from grants. For peripherals and data conversion, the organization has relied on a university that is a five-hour drive from Hayfork. The direction toward more sophisticated contract work clearly demands a workstation-based system. According to the director, "If we're really going to be able to fulfill our potential as a repository for GIS data, we're going to need to be able to make that jump." The transition from personal computers to a workstation means a more complex operating system and greater resource outlays. The director continued, "What happens if it crashes? We certainly can't afford the kind of system manager who knows UNIX." Staff offered these frustrating details about current conditions: "The conversion from AUTOCAD to GIS left me in tears one midnight." "The manual said 'transform' but it doesn't tell you what steps you have to do [prior to] that and [in] what order you have to do [them]. They [data suppliers] had a projection on [only] one part of it; I've banged my head against the wall for three days".

The internal diffusion of GIS expertise has formed an integral component of Trinity's vision. Staff receives continual exposure to the mechanics and application of the technology. The director epitomizes the GIS champion but the staff, trained by the director, "are more techies than I am." Despite the extensive training they have received, respondents in 1995 were rightfully concerned about the director's gradual departure (by 1998 only 10 percent of her time was spent at Trinity). One employee wondered "whether we can strategically replace that [expertise] with bits and pieces. That's one of the reasons that we're trying so hard to learn."

The community of Hayfork is slowly healing from the battle between loggers and environmentalists. Trinity originated as a middle ground, serving both populations. Unfortunately, some affiliate GROs have viewed Trinity (including its non-native director) as allied with the opposition because it accepts contracts from public agencies. This view offers one explanation for why some of the affiliates have shown up "late at night," after the director is gone, to use the GIS.

Case 4: Wants Independence

In 1995, Samuel Jones[4] was leaving one organization (Friends of the Tecate Cypress) in Orange County to form the San Andreas Land Conservancy (SALC), a land trust headquartered in Jones's home just north of Santa Cruz. His applications have included thematic maps of the proposed land trust for SALC, mountain lion movements, and the impacts of a toll road for Tecate.

Jones embodies GIS implementation. He personally owns the workstation and software, has received formal GIS training, and has entered most of the data. In his organizations, GIS expertise has remained concentrated with little internal diffusion. Tecate board members know little about system functionality and capability. Jones has not attempted to train SALC board members in GIS. Involving others in the GIS would just slow him down and cloud his agenda for GIS use in the organization.

Jones has adopted an uncompromising stance to conservation that has limited his GIS implementation. Orange County, in cooperation with a developer, had launched a conservation plan to avoid the listing of a bird species as endangered by the federal government. Because of Jones's refusal to negotiate with the developer, Tecate was shut out of those meetings—other GROs were not—and was unable to obtain the county-collected species data. Tecate was not entirely pleased with his actions. Jones has remedied this conflict in his new organization through the careful selection of board members who agree with his goals.

Jones has survived on the odd GIS job and temporary work in computer consulting (experience he gained largely from his GIS work). Full-time employment would detract from his GIS activism. He has overextended his credit cards and has endured occasional eviction. Jones's uncompromising stance may place a

Table 3 Results of pattern matching for cases

Factor	Greenbelt	TNC-Dunes	Trinity	Jones
Factors Mirroring Documented Organizations				
Upper Management Commitment	+	—	+	m
Allocation of Resources	+	—	+	—
Sufficient Training, Understanding	m	—	+	+
GIS Champion	+	—	+	+
System Use	—	N/A	—	—
Organizational Communication/Coordination	m	—	+	—
Lack of Resistance	—	m	—	m
Factors Unique to Groups				
Voluntarism	+	+	m	+
Scarcity of Resources	—	—	+	+
External Sources of Funding	+	+	+	—
Tension between Passion and Progress	—	—	m	+

(+ = positive match, — = negative match, m = mixed)

further barrier in the path of financial security. Jones has desired a funded position within his organization, yet his unwavering vision may have precluded him from attracting donations, because donors may desire participation in the organization's decision making. Alternately, a charismatic vision may draw donors to him.

Discussion

The pattern matching of the cases to factors observed in documented organizations ("Upper Management Commitment" to "Lack of Resistance") and factors likely to be found in GROs ("Voluntarism" to "Tension between Passion and Progress") is shown below (Table 3). Case results are reported in columns.

Description of Factors Mirroring Documented Organizations

Upper Management Commitment. Upper management commitment emerged as the highest rated factor in a prior mail survey (Sieber 1997b) among GROs when asked about their general use of IT. Nonetheless, this factor received mixed reviews in case studies. Greenbelt exemplified upper-level commitment, with direct involvement from both its current and past directors. Conversely, TNC-Dunes has received no encouragement from its parent organization, despite internal supports for GIS development. The Jones's case exhibited both sides: the current board has been chosen for its acquiescence; conversely, one of Tecate's board members showed open hostility to the GIS. Clearly, this factor proved important but not essential to successful environmentalist implementation.

Allocation of Resources. Despite importance in the literature, this factor was mixed in the cases. For instance, Trinity's director and staff not only have appreciated the need for sufficient resources but also have been aware of the perils of expansion with an insufficient computing infrastructure. Jones has allocated what meager resources are available. TNC-Dunes has allocated sufficient resources, although it has encountered resistance in acquiring grants for GIS-specific projects.[5] Adequate allocation sped GIS implementation; however, as will be discussed, a case's "resourcefulness" could substitute for missing essentials.

Sufficient Training, Understanding. Consistent with that traditional factor, Trinity's director has instructed her employees in the technical details of GIS and GPS operations; these employees, in turn, have been training others. Otherwise, findings revealed case training experiences that were patchy, informal, concentrated, on the job, or outsourced. At one extreme, the extent of TNC-Dunes's knowledge lay in a single GIS overview short course. At the other end of the spectrum, the least stable organization (Jones) received formal GIS training from ESRI. These two cases called into question the definition of "sufficient" extant in the literature and gave mixed results on training as a factor of implementation success.

A **GIS Champion**. GIS champions were present in all four; excepting TNC-Dunes, the champions also were technically involved in system development. This factor emerged as essential to furthering GIS adoption, insofar as Jones's departure from one GRO signified the end of its GIS.

System Use. Cases rated system use almost uniformly poor. In Greenbelt's case, poor cartographic-handling system capacity has caused the organization to import GIS output into Adobe Photoshop™. Difficult system use may complicate GIS implementation but does not prevent GIS adoption.

Organizational Communication/Coordination. Cases ranged from strong diffusion programs (Trinity), attempts at diffusion (Greenbelt), and minimal diffusion of GIS skills or GIS information (TNC-Dunes and Jones). With the exception of Trinity, research revealed the isolated nature of GIS knowledge within cases.

Lack of Resistance. I had anticipated greater resistance than was found in the mixed pattern matching. Attitudes range from

aversion (a Tecate board member) and distaste (a TNC-Dunes staff member), through ignorance (Tecate and some Trinity board members) and passive acceptance (a few Greenbelt board members and staff), to enthusiasm (all the champions) and devotion (Jones). Consternation may result from staff resentment over the concentration of resources and fear of changing job descriptions (Greenbelt) or a lingering suspicion of academics and remnants of old animosities (Trinity). Notwithstanding some mixed feelings, individual resistance was limited and only marginally impacted GIS development.

Description of Factors Unique to Groups

Having compared case study experiences to factors well documented in the implementation literature; I turn now to more exploratory factors suggested in the nonprofit literature.

Voluntarism. All cases relied on volunteers, presumably to create a more fluid, dedicated, and cost-effective workforce. Even Trinity, which operates as a staffed GIS enterprise, has been assisted by students from its training courses in data collection, use of GPS, and digitizing. Volunteers have been utilized to reduce implementation costs and allow Trinity and Greenbelt's spin-off to offer low-cost consulting rates to other organizations. The downside of voluntarism—turnover and burnout—has been limited but not avoided as students leave with expanded résumés.

Scarcity of Resources. Experiences of these cases falsified this factor as groups found effective alternatives to resources; nonetheless, scarcity slowed implementation as the case participants scrambled to maintain their systems. Two cases (Trinity and Jones) have experienced difficulty in, for example, obtaining grants and data, which adversely affect their ability to complete contracts. Conversely, Greenbelt's implementation demonstrated the advantages of a more secure base of institutional and fiscal support.

External Sources of Funding. External resources may greatly enhance GRO capacity and a GRO's own influence; alternately, such support may control or divert its activities. Most cases were affected to some degree by the conditions and constraints of their external funding, however benign. Respondents stated that the stature of Greenbelt and Trinity was augmented by their successes in grant acquisition and institutional cooperation. In turn, Greenbelt grant writers believe that they must avoid appearing too technical in its approach so as not to alienate funders. To ensure continued access to data, equipment, and contracts, Trinity must continue to conform to the overall goals of its partner agencies. TNC-Dunes's implementation model and project funding proceeded directly from its relations with the parent organization. Only Jones has seemed immune (except to the overall lack of funding).

Tension between Passion and Progress. Observed to varying degrees in three of the cases, Jones exemplified the factor in experiencing personal struggles between sitting in front of a computer and communing with nature. To a much lesser extent, the factor manifested itself among Hayfork environmentalists who desired GIS functionality but were suspicious of Trinity's associations. Alternately, some Greenbelt and TNC-Dunes members had expressed personal resistance to innovation and its resultant changes, but they did not oppose the technology spiritually. I expected to find abundant evidence of conflicts, but discovered that the passion and progress tension was largely absent. Respondents viewed computing technology as a useful tool for completing work tasks and aggressively pursued implementation.

Cases Do Not Mirror Traditional Factors of Implementation

Case study groups neither uniformly followed nor opposed the factors found in the literature for governmental agencies (Table 3). Therefore, these best practice cases used GIS implementations to their satisfaction but did not comply with all of the recommendations cited in the implementation literature. One could postulate that groups would have preferred to conform to all these norms (i.e., groups might desire greater organizational diffusion of GIS skills) but were prevented by various limitations. However, little evidence supported this assertion; overall, traditional factors were irrelevant as case respondents improvised when resources or support were absent. In the case of TNC-Dunes, traditional factors offered an inadequate prediction of successful usage. More important, these factors did not necessarily describe case study problems because many problems were still technical—for example, handling unusual data formats—and not organizational.

Issues in Conceptualizing Factors. One problem in using traditional factors is that GROs do not resemble larger institutions. Government agencies are sufficiently large so that upper management must coordinate multi-departmental system development/funding, and policymakers (administrators or elected officials) generally are separated from GIS champions or the details of GIS implementation. Therefore, factors such as organizational communication/coordination and upper management commitment do not hold the same meaning. In three of four case studies (Greenbelt, Trinity, Jones), GIS champions form an integral component of upper management, leading the organizations and the technical innovation.

Further, factors actually can oppose each other. For instance, a GIS champion concentrates technical expertise, GIS development decisions, and catalytic action; success provides the champion with a sense of worth and power. This factor appeared to conflict with organizational communication/coordination and training, which can produce more experts and thus dilute individual power. The presence of strong GIS champions likely explains the limited diffusion found in several cases. The GIS implementation literature presents factors as a normative list of best practices distilled from government cases but neglects to compare and critique the factors as a set.

Another problem is that the implementation model largely offers an apolitical and mechanistic view of implementation and workers. Much of that literature has neglected the social and political attributes of the implementing environment. Instead, it has been based on an idealized view of how organizations and

procedures should operate and assumes that logical management strategies will enable effective utilization (Campbell 1996). As noted in Eason (1993, p. 29), the use of rational and technical language "makes it difficult to express all the needs and issues that may exist in the organisation[s] which do not lend themselves to this kind of representation." Many GROs—many of which are rich in member passion, frequently exist in a dynamic (even hostile) political arena, and try to survive with limited resources—do not readily submit to this type of analysis.

This dissonance between government and GRO implementation emphasizes the problems in generating theory based on a limited sample of organizations. Initial criticisms of the explorations into GIS implementation showed that, although rich in anecdotal evidence, they lacked "grounded" theory for a framework of implementation (Onsrud and Pinto 1993, Campbell 1996); this gap was addressed by Onsrud, Pinto, and Azad (1992). Theory construction is a necessary step in the maturation of the literature. Nonetheless, this grounded theory has implied a normative universality in GIS implementation, even though the universe of study has been quite circumscribed. While the study of governmental agencies and their departments might indeed form the backbone of a model of implementation, it is by no means all-inclusive. Identifying factors of success implies that only one process of implementation is the right one; that is, an organization must match all (or a large percentage) of the factors or else it will fail. Likewise, the inference is that only one outcome (accept/not accept) is possible (Azad 1998). Indeed, this research demonstrated that concentrating on a subset of institutions obscured assumptions or overlooked findings in the research, such as the importance of volunteers, that might prove fundamental to other types of organizations.

The Dynamic and Fragile Nature of GIS Implementation. Unexpectedly, three of the cases were undergoing substantive shifts in their GIS capacity during this research. Greenbelt spun off its GIS capacity; ownership of TNC-Dunes was transferred; the director of SALC left Tecate and removed its GIS capacity. Change may represent growth: Greenbelt and its spin-off may actually extend functionality to other nonprofits. In other cases, it may result in a loss of GIS-related advocacy. Even in Trinity, concerns have arisen over the long-term sustainability of the organization when its director leaves. Indeed, these changes offer new meaning to Eason's (1993) phrase "partial implementation"—if the organization ceases to exist during a successful implementation—and lends support to his assertion that implementation of complex IT innovations should not be measured along one diffusion curve.

Additionally these cases illustrate the problematic nature of assigning what are dynamic processes to factors of successful implementation. Factors imply non-longitudinal toggle switches: once "ON" (or "+") then normatively solved. Therefore, a researcher may assume groups' implementation needs are solved only to miss what will remain ongoing challenges to implementation for any organization. This finding also reinforces the proposition, advanced by Azad (1993) and others, that implementation itself is a process and not simply a task to be completed. The picture only emerges over time.

Neither Are Differences Strictly a Function of Factors Unique to Grassroots Groups

If implementation in GROs does not explicitly match experiences in documented organizations, it may differ by issues of voluntarism, scarcity of resources, external sources of funding, and tensions between advocates of traditional activities and supporters of this more "progressive" technology. As a set, this did not happen. Voluntarism cut across all models and drove system operation and implementation. External funding exerted a definite impact (this influence was not necessarily negative) as cases minded the watchful eyes of their funders. Scarcity and tension were otherwise mixed. Scarcity may have slowed implementation, but these GROs still utilized GIS implementations effectively. They accomplished this through what this author terms resource substitution and passionate commitment.

Resource Substitution. Cases circumvented scarcity and traditional factors largely because they learned to substitute an abundance of one resource for an absent or deficient resource. Mail survey research on the general use of computers (Sieber 1997b) supported case study findings that GROs were improvising with limited resources and that even the "poorer" groups—operating with no paid staff—could "make do." They did it in three ways. First, donations of hardware/software and access to borrowed systems (e.g., from members, universities, public agencies, and vendors) allowed groups to substitute for equipment they otherwise could not afford. All four cases, for instance, received free GIS software from ESRI's Conservation Program.

Second, volunteers and pre-trained staff offered these groups experienced workers for minimal operating outlay compared to public agencies or private firms. Volunteers provided groups, such as Tecate and Trinity, with teams of primary data collectors who generated detailed and ground-true data, tailored to group needs. Several groups have utilized student interns, supported by the expertise of a supervising faculty member; these volunteers have provided on-the-cutting-edge technical and scientific skills more compatible with rapidly changing GIS technology.

Third, cases implemented geographic information systems within a rich network of supportive institutions and groups. This network compensated for the lack of resources, such as income and access to spatial data. Thus, the cases benefited from a university offering the use of its expensive peripherals and a sympathetic engineering firm disseminating its data (for an extensive discussion on universities and GROs see Sieber, 1997c); in turn, GROs extended their GIS experience to others. The network served as the conduit through which the substitution of equipment, personnel, data, experience, and encouragement was effected.

Substitution or not, these GROs could not escape the resource demands of GIS. GIS use commanded significant efforts of at least one individual, consumed time for grant writing and on-the-job learning, and required extensive data collection/entry/correction. Even outsourcing required administration. More-

over, as a short-term or long-term strategy, resource substitution exhibited a limited elasticity. For instance, dependence on the largesse of foundations or the expertise of grant writers might render free yet unwieldy software (Greenbelt with GRASS and groups with ArcInfo). Reliance on university staff and students (Greenbelt, TNC-Dunes) and low-paid staff/volunteers (Trinity, Jones) could provide expertise and workers, yet group projects must compete with regular university courses, well-funded contracts, differing priorities, and loss of skilled volunteers. Hardware might be available, yet staff from two organizations must travel eight hours to gain access to peripheral equipment (Trinity, Jones). This last example suggests that abundant resources such as time or volunteers can be stretched only so far before the substitution becomes ineffective.[6] Passion may exhibit the least elasticity: The Friends of the Dunes volunteers mitigated nonnative dunes vegetation by manually extracting plants, yet their dedication was not transferable to computing activities, such as data entry.

Resource substitution may exact a greater price. As GROs increase their dependency either on the technology or the external support network, they may effect a diversion or co-optation of goals. Greenbelt spun off its GIS capacity precisely because it represented an unacceptable diversion—the means replacing the ends—from the core mission. Co-optation may occur if GROs must conform inordinately to the values of institutions or individuals. Trinity has employed a compromising and negotiation stance when dealing with public agencies and therefore has ensured continued access to data and contracts. Conversely, Jones has found access blocked because he prefers to confront his opponents. Overall, diversion or co-optation appeared to exert a limited effect because most cases already had shifted their strategies as a precondition for accommodating GIS. Nonetheless, the potential shift underscores the need to understand the price that this substitution holds for "nonconformers."

Passionate Commitment. Grassroots organizations' experiences suggest that some factors might be distilled to their essential elements: commitment; in terms of upper management commitment, the presence of a GIS champion; and passion from the groups' members and associates toward GIS. If strong commitment arises from any or all of these sources, then the GIS implementation will likely succeed. Hence, Greenbelt and Trinity were supported and guided in their system development with both upper management commitment and a strong GIS champion. In TNC-Dunes, faculty and students supplied the commitment, as well as all the labor and equipment. Alternately, Jones's passion enabled implementation, despite scarce resources and some resistant members. Indeed, the literature on GIS implementation emphasizes the need for upper management commitment and the sufficient allocation of resources but could not have predicted this interpretation: that a GIS user would sacrifice his personal comfort to maximize GIS functionality. To these cases, upper-level commitment may be low and resources may be scarce; however, if the will exists, then GIS can be implemented.

Conclusion

This paper has presented GIS implementation in the grassroots and placed GROs in the context of strategies found in local government. It has shown that organizationally, GROs did not follow traditional factors because they could substitute resources and employ different implementation models that suited each organizational culture while minimizing or outsourcing the impacts. At the same time GROs were not fully represented by the nonprofit literature, which implied that GIS might be out of reach of these fragile entities.

These lessons hold significant validity for implementation in larger organizations and public sector agencies. GROs engaged in complex arrangements that account for an interdependency of equipment, staff, and data. They utilized several alternatives to the traditional in-house model, which could be tailored to fit organizational criteria and could evolve with changing needs. These results match newer arrangements that suggest (Budic and Pinto 1999) the need for greater interorganization cooperation and enterprise solutions. The Wants Consortium or Wants Map models may benefit initial GIS development in smaller towns, coping with their own set of fragile resources. Both large and small agencies may benefit from factors such as the use of volunteers to conduct GIS-related activities, like spatial data collection.

The paper challenged the construction of factors of GIS implementation. Instead of a mechanistic and normative list, GROs showed implementation to be a colorful, contradictory, evolving, and highly political process. Factors provide the framework but should be tested and retested in light of new types of organizations adapting a GIS to their needs and adapting to a GIS.

Clearly, this study would benefit from further research. How well do GRO-specific factors survive against additional testing? What combination of factors does each model support? Can unsuccessful implementation be attributed to a failure to heed certain factors of implementation? How does the importance of factors vary by time? This research highlighted numerous difficulties in the fluid environment of changing individuals and strategies. TNC-Dunes demonstrated that even best-practice cases need not survive. It is quite possible that the dynamic nature of GRO implementation will prohibit most GROs from ever "rountinizing" a GIS; instead organizations may exist in a perpetual state of implementation. Presumably, the most stable GROs will mature in their GIS usage as they build data sets and interact with the larger conservation and GIS community. But they also increasingly may resemble the institutions from which they obtain resources and decreasingly like the activists from which they drew their strengths. Therefore, how do GROs and other organizations change in response to GIS implementation? Exploring the smallest implementers can produce large results.

Notes

1. I utilize the Edwards and Hulme's (1995) definition of grassroots organizations as membership organizations interested in social transformation. This definition distinguishes GROs from NGOs, which are intermediary organizations offering funding and other forms of support to communities and other organizations
2. Certainly this sentiment varies within the conservationist and environmentalist movement. The dissonance between enthusiastic adoption of and resistance to a GIS by conservationists was explored in Sieber (1997a).
3. Recently (August 1999) the Californian office has contracted out some work to Greenbelt's spin-off. Such is the small world of conservation NGO/GRO GIS users.
4. Not his real name.
5. Ironically, including GIS output in applications improves the likelihood of obtaining more general grants.
6. It should be emphsized that North American GROs exist in a wealth of resources and networks relative to GROs in the developing and Third World. No amount of passion will substitute for a lack of software (although the GRO might consider a paper GIS).

Acknowledgements

The author would like to thank the members of her dissertation committee and the participating conservation nonprofits for their support and participation. She also would like to thank Barbara Poore for her helpful comments.

References

Aberely, D. (Ed.), 1993, *Boundaries of Home: Mapping for Local Empowerment* (Philadelphia, PA: New Society Publishers).

Antenucci, J.C., K. Brown, P.L. Croswell, M. J. Kevany, with H. Archer, 1991, *Geographic Information Systems: A Guide to the Technology* (New York: Van Nostrand Reinhold).

Azad, B., 1998, *Management of Enterprise-wide GIS Implementation: Lessons from Exploration of Five Case Studies*, Doctoral Dissertation, MIT.

Azad, B., 1993, Organizational Aspects of GIS Implementation: Preliminary Results from a Dozen Cases, Paper presented at the *Urban and Regional Information Systems Association Conference*, Atlanta, Georgia.

Barbeito, C.L., Bowman, J.P. and Applied Research and Development Institute International, Inc., 1998, *Nonprofit Compensation and Benefits Practices* (New York: Wiley).

Barndt, M., 1998, A Model for Evaluating Public Participation GIS Programs, *NCGIA Special Meeting: Empowerment, Marginalization and Public Participation GIS*, Santa Barbara, California, http://www.nciga.ucsb.edu/varenius/ppgis/papers/index.html.

Benenson, B., 1990, In the Cradle of Environmentalism, the Political Fight Is Hot, *Congressional Weekly Quarterly Report*, 48(3) (January 20), 189-191.

Brown, P. and D. Friedley, 1988, Assessing Organizational Preparedness for a Comprehensive, Distributed LIS/GIS, *Proceedings of the Urban and Regional Information Systems Association*, 3: 22-36.

Budic, Z.D., 1997, GIS Technology and Organizational Context: Interaction and Adaptation, In Massimo Craglia and Helen Couclelis (Eds.), *Geographic Information Research—Bridging the Atlantic* (London: Taylor and Francis), 165-184.

Budic, Z.D., 1994, Effectiveness of Geographic Information Systems in Local Planning, *Journal of the American Planning Association,* 60(2), 244-263.

Budic, Z.D. and David R. Godschalk, 1996, Human Factors in Adoption of Geographic Information Systems (GIS): A Local Government Case Study. *Public Administration Review,* 56(6), 554-567.

Nevodic-Budic, Z. and J. Pinto, 1999, Understanding Interorganizational GIS Activities: A Conceptual Framework. *Journal of the Urban and Regional Information Systems Association,* 11(1), 53-64.

Campbell, H.J., 1996, A Social Interactionist Perspective on Computer Implementation. *Journal of the American Planning Association,* 62(1), 99-107.

Campbell, H.J., 1991, *Impact of Geographic Information Systems on Local Government,* TRP 101 (Sheffield, UK: The University of Sheffield, Department of Town and Regional Planning).

Cheney, P.H. and G.W. Dickson, 1982, Organizational Characteristics and Information Systems: An Exploratory Investigation. *Academy of Management Journal,* 35(1), 170-184.

Clifton, R.L. and A.M. Dahms, 1980, *Grassroots Administration: A Handbook for Staff and Directors of Small Community-based Social-service Agencies* (Monterey, CA: Brooks/Cole Publishing Co).

Clapp, J.L., J.D. McLaughlin, J.G. Sullivan, and A.P. Vonderohe, 1989, Toward a Method for the Evaluation of Multipurpose Land Information Systems. *Journal of the Urban and Regional Information Systems Association,* 1(1), 39-45.

Cohen, J.A. and R.A. Perrault, 1991, Nonprofits' Most Common Computer Pitfalls—and How to Avoid Them. *Nonprofit World,* 9(6), 8-10.

Conservation GIS Consortium, 1999, *Conservation GIS Starter Kit* (Portland, OR: Conservation GIS Consortium).

Conservation Technology Support Program, 1999, *Program Description* (August 1999), http://www.ctsp.org.

Coveny, S., 1992, Technology Isn't Entirely Evil: Geographic Information Systems in the Services of Wildlands, *Wild Earth* (Special Issue), 81-82.

Crain, I.K., 1990, Analysis of Some Management Issues in GIS Implementation. *Proceedings of the Urban and Regional Information Systems Association,* 2, 14-22.

Croswell, P., 1991, Obstacles to GIS Implementation and Guidelines to Increase the Opportunities for Success. *Journal of the Urban and Regional Information Systems Association,* 3(1), 43-56.

Crowfoot, J.E., and J.M. Wondolleck, 1990, *Environmental Disputes: Community Involvement in Conflict Resolution* (Washington, D.C.: Island Press).

Eason, K.D., 1993, Gaining User and Organisational Acceptance for Advanced Information Systems, In Ian Masser and Harlan Onsrud (Eds.), *Diffusion and Use of Geographic Information Systems* (London: Kluwer Academic Publishers), 27-44.

Edwards, M. and D. Hulme (Eds.), 1995, *Non-governmental Organizations: Performance and Accountability* (London: EarthScan Publications).

Er, M.C., 1989, A Critical Review of the Literature on the Organizational Impact of Information Technology, *IEEE Technology and Society* (June), 17-23.

Feldman, S.P., 1993, How Organizational Culture Affect Innovation. In Larry Hirchhorn and Carole K. Barnett (Eds.), *The Psychodynamics of Organizations* (Philadelphia, PA: Temple University Press), 85-98.

Ferber, D.L., 1992, *Geographic Information Systems Support for Environmental Groups: An Investigative Study* (Bellingham, WA: Greater Ecosystem Alliance).

Frans, D.J., 1993, Computer Diffusion and Worker Empowerment. *Computers in Human Services* ,10(1), 15-34.

Fulton, W., 1991, *Guide to California Planning* (Point Arena, CA: Solano Press Books).

Gittell, M., 1980, *Limits to Citizen Participation: The Decline of Community Organizations* (Beverly Hills, CA: Sage Publication).

Goldhaber, G.M., 1990, *Organizational Communication, 5th Edition* (Dubuque, IA: William C. Brown).

Gottlieb, R., 1993, *Forcing the Spring: The Transformation of the American Environmental Movement* (Washington, D.C.: Island Press).

Hall, B. and M.L. Kerr, 1991, *The 1991/1992 Green Index* (Washington, D.C.: Island Press).

Hays, S.P., 1987, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York: Cambridge University Press).

Huxhold, W.E., 1991, *An Introduction to Urban Geographic Information Systems* (New York: Oxford University Press).

Huxhold, W.E. and A.G. Levinsohn, 1995, *Managing Geographic Information System Projects* (New York: Oxford University Press).

Igbaria, M. and S.A. Nachman, 1990, Correlates of User Satisfaction with End User Computing: An Exploratory Study. *Information and Management,* 19, 73-82.

Kanter, R.M., 1983, *The Change Masters* (New York: Simon and Schuster).

Kwon, T.H. and R. W. Zmud, 1987, Unifying the Fragmented Models of Information System Implementation. In J. Boland, Jr. and R.A. Hirschheim (Eds.), *Critical Issues in Information System Research* (New York: John Wiley and Sons), 227-251.

Lee, A.S., 1989, A Scientific Methodology for MIS Case Studies. *MIS Quarterly* (March), 33-50.

Leitner, H., R. McMaster, S. Elwood, S. McMaster, and E. Sheppard, 1998, Models for Making GIS Available to Community Organization: Dimensions of Difference and Appropriateness, *NCGIA Special Meeting: Empowerment, Marginalization and Public Participation GIS*, Santa Barbara, California, http://www.nciga.ucsb.edu/varenius/ppgis/papers/index.html.

Manes, C., 1990, *Green Rage: Radical Environmentalism and the Unmaking of Civilization* (Boston, MA: Little, Brown and Company).

Markus M.L., 1983, Power, Politics, and MIS Implementation. *Communications of the ACM,* 26(6), 430-444.

McCullough, M.F., 1991, Democratic Questions for the Computer Age. *Computers in Human Services,* 8(1), 9-18.

Nam, K., S. Rajagopalan, H. Raghav Rao, and A. Chaudhury, 1996, A Two-level Investigation of Information Systems Outsourcing. *Communications of the ACM,* 39(1), 36-44.

Nonprofit World, 1994, Ten Secrets of Computer Wizardry. *Nonprofit World,* 12(3), 24-32.

Nonprofit World, 1990, Streamlining Nonprofits through Affordable Computer Resources, *Nonprofit World,* 8(2), 19-22.

Obermeyer, N.J., 1998, HUD's Community Connection for Local Empowerment, *NCGIA Special Meeting: Empowerment, Marginalization and Public Participation GIS*, Santa Barbara, California, http://www.nciga.ucsb.edu/varenius/ppgis/papers/index.html.

Onsrud, H.J. and J.K. Pinto, 1993, Evaluating Correlates of GIS Adoption Success and the Decision Process of GIS Acquisition. *Journal of the Urban and Regional Information Systems Association,* 5(1), 18-39.

Onsrud, H.J., 1991, Diffusion of Geographic Information Innovations. *International Journal of Geographic Information Systems,* 5(4), 447-467.

Onsrud, H.J. and B. Azad, 1992, Case Study Research Methods for Geographic Information Systems. *Journal of the Urban and Regional Information Systems Association,* 4(1), 32-44.

Perkins, S., 1990, Down with Deja-vu: Making Changes Stick in your Organization, *Proceedings of Urban and Regional Information Systems Association,* 2, 1-13.

Pickles, J., (Ed.), 1995, *Ground Truth: The Social Implications of Geographic Information Systems* (New York: Guilford Press).

Pinto, J.K. and H.J. Onsrud, 1995, Sharing Geographic Information across Organization Boundaries: A Research Framework. In Harlan J. Onsrud. and Gerard Rushton (Eds.), *Sharing Geographic Information,* (New Brunswick, NJ: Center for Urban Policy Research (CUPR) Press), 44-64.

Rogers, E.M., 1995, *Diffusion of Innovations, 4th Edition* (New York: The Free Press).

Rogers, E., 1993, The Diffusion of Innovations Model. In Ian Masser and Harlan Onsrud (Eds.), *Diffusion and Use of Geographic Information Systems* (London: Kluwer Academic Publishers), 9-23.

Rubinyi, R.M., 1985, *The Effects of the Introduction of Microcomputers on the Communication and Information Behavior of Community-Based Nonprofit Organizations* (Ann Arbor, MI: University Microfilms).

Sawicki, D.S. and W.J. Craig, 1996, The Democratization of Data: Bridging the Gap for Community Groups. *Journal of the American Planning Association,* 62(4), 512-523.

Sawicki, D.S. and R. Peterman, 1998, Understanding the Breadth and Depth of PPGIS Supply. *NCGIA Special Meeting: Empowerment, Marginalization and Public Participation GIS*, Santa Barbara, California, http://www.nciga.ucsb.edu/varenius/ppgis/papers/index.html.

Schindler-Rainman, E. and R. Lippitt, 1975, *The Volunteer Community: Creative Use of Human Resources, 2nd Edition* (San Diego, CA: University Associates, Inc.).

Schoech, D., 1982, *Computer Use in Human Services: A Guide to Information Management* (New York: Human Sciences Press).

Sieber, R.E., 1997a, *Computers in the Grassroots: Environmentalists, GIS, and Public Policy*. Ph.D. Dissertation, Rutgers University.

Sieber, R.E., 1997b, Computers in the Grassroots: Environmentalists' Use of GIS and Information Technology, *CUPR Working Paper #121*, New Brunswick, NJ: Center for Urban Policy Research, 26 pp.

Sieber, R.E. 1997c, Geographic Information Systems in the Grassroots: The Role for Universities, *Paper presented at the University Consortium for Geographic Information Science*, Bar Harbor, Maine.

Slaughter, S. and S. Ang, 1996, Employment Outsourcing in Information Systems. *Communications of the ACM,* 39(7), 47-54.

Smith, M., 1991, Adventures in Dysfunctional Computerland. *Nonprofit World,* 9(4), 6-7, 30.

Snow, D., 1992, *Inside the Environmental Movement* (Covelo, CA: Island Press).

Specht, J., 1996, Mapping Earth's Endangered Biodiversity. *GIS World,* 9(3), 42-46.

Sprecher, M.H., 1994, ICMA Survey Dissects Local Government IT Use. *Journal of the Urban and Regional Information Systems Association,* 6(2), 92-95.

Walton, J., 1992, *Western Times and Water Wars: State, Culture, and Rebellion in California* (Berkeley: University of California Press).

Wikle, T.A., 1995, Geographical Patterns of Membership in U.S. Environmental Organizations. *Professional Geographer,* 47(1), 41-48.

Wolch, J.R., 1990, *The Shadow State: Government and Voluntary Sector in Transition* (New York: The Foundation Center).

Yin, R.K., 1989, *Case Study Research—Design and Methods, Revised Edition* (Beverly Hills, CA: Sage Publications).

Yin, R.K., P.G. Bateman, and G.B. Moore, 1985, Case Studies and Organizational Innovation, *Knowledge: Creation, Diffusion, Utilization,* 6(3), 249-260.