
Geographic Information Systems in the Environmental Movement

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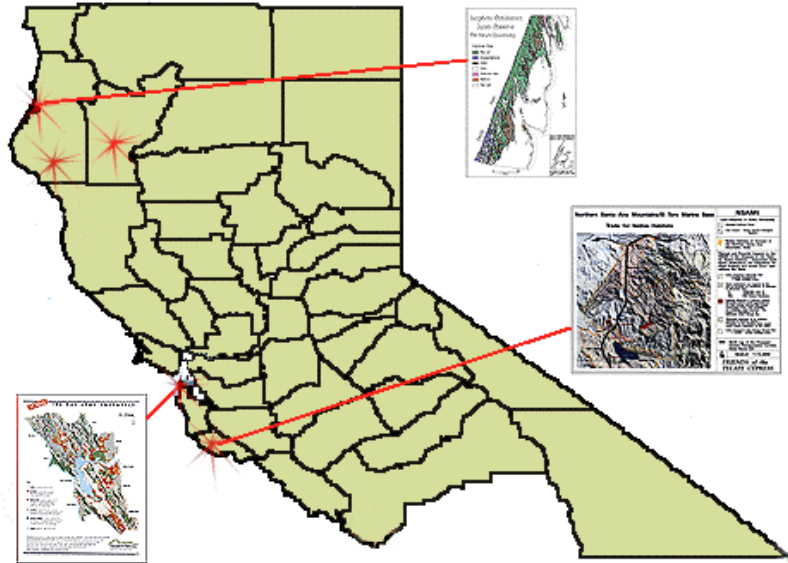
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Introduction

Geographic Information Systems (GISs) and related spatial technologies have become important tools for land management agencies to administer resources and protect the environment. Increasingly environmental nonprofits use GIS in their own activities to better understand and advocate for their communities. Current applications range from inventories of spotted owl locations, thematic comparisons of toxic lead and poverty, and models of sustainable forest harvesting, to scenarios of urban sprawl/growth control. GIS, like many computing applications, holds great promise for environmentalists to maximize their traditionally limited resource base. Just as the word processor and desktop publishing have helped to publicize causes, and the Internet has provided the avenue for mass mobilizations, GIS enables groups to present a visually compelling image of an issue and quickly analyze data from disparate sources. Improvements in the technology make GIS increasingly affordable and easy to use. Coupled with expanding amounts of spatial digital data, GIS could provide a critical implement to groups struggling to impact politics and empower environmentalist for social change.

Given the fragile resource base of these groups, however, they may struggle with system adoption and data acquisition. The GIS literature identifies inadequate resources as an impediment to successful implementation (Croswell 1991). At the same time it presupposes that the basic GIS-related hardware and software has been purchased and are located in-house; data entry and maintenance are largely conducted by paid personnel, frequently also in-house. Environmental nonprofits are far removed from the municipalities and agencies that form the base for the GIS implementation literature. Many survive on hand-to-mouth existence of one-time grants, volunteers, and paid staff/student interns who could demand better money with newly found GIS skills. The technology can be onerous to use: GIS exhibits a high learning curve and requires extensive data entry and database management skills. To some environmentalists these are technical details that expose GIS as the manifestation of capitalist-induced rationality and the antithesis of passionate activism. Overall, activists may find their time better spent understanding politics or acquiring new funding sources.

My research attempts to find a path between the promises and the perils by tracking the use and value of GIS in the environmental movement. As part of this research, I pose several questions. What are the actual applications of GIS and computing technology by environmentalists? How does their usage compare to the literature on GIS diffusion, implementation, spatial data acquisition and sharing? How are groups applying GIS to their goals and missions? What role does the technology play in impacting public policy? Is, as often purported, GIS delivering on its promises or does it trap activists in a rational and capitalist-induced technology? Finally, what is the role for policy makers in enabling (or disabling) groups' effective adoption? Of all social movement or community-based organizations, the environmental movement may be uniquely positioned to take advantage of GIS capabilities and consequently may provide an appropriate base of study. The environmental movement has long been engaged in data collection, computer usage, scientific analysis, and cartography production. Their experiences with GIS could inform and assist in the further diffusion of GIS to other social movement groups.

This paper summarizes research (Sieber 1997a) that constructed an infrastructure for necessary and sufficient characteristics of effective GIS usage by small environmental nonprofits. This infrastructure then suggested roles for interested external parties. It combined a review of literature on GIS implementation/data sharing and social movement issues with fieldwork. Fieldwork began with a mail survey of computer usage of 100 environmental groups. The survey included questions on software and applications, implementation issues, financial and organizational costs, future computer plans, data sources, and map and GIS "literacy." Seventy four mail survey responses and 25 expert interviews with vendors and conservation GIS leaders assisted in locating five cases for in-depth study of GIS usage. The case study research assessed GIS applications, implementation, spatial data acquisition and sharing, and the contribution of GIS to organizational goals and missions. Work was conducted in California and the Pacific Northwest over a two-year period.

Applications of GIS and Computing Technology

The mail survey found that groups are able to acquire and install GIS despite scarce or uneven resources. Twenty seven percent of respondents used GIS; 60 percent of those had no paid staff (number of paid staff was used as a surrogate for financial resources (Snow 1992)). They need not purchase in-house systems, employ staff, or train workers: they can amass the initial hardware and software through grants or utilize a member's computer. In general, the survey results suggest that the environmental movement has laid the foundation for GIS use. Most know of GIS functionality and have seen it demonstrated. GIS-using groups build upon a movement-wide base of computer use, map use/creation, digital data acquisition, and scientific analysis.

Case study research revealed the varied applications of GIS. Differences were observed in the applications of GIS but also in the objectives of GIS: visualization, analysis, or skill building. Below are key examples from the five cases

The Greenbelt Alliance, an open space preservation organization in San Francisco, has used GIS to capture the debate of where land is at risk and how it should be protected. So clearly does its widely disseminated "Open Space At Risk" GIS map express its goals that staff, members, and the press have labeled it the central metaphor of the organization. The 13 staff members believe GIS output provides them a powerful persuasion tool, allowing the organization to more easily attract members, funding, and support from many area elected officials. Three years ago the Alliance spun-off GIS skills to separate organization that already has used its skills, data, and linkages to build GIS capacity in more than 30 other grassroots groups in the region.

The Nature Conservancy at Lanphere Christensen Dunes Preserve, Arcata, is an small chapter of a national land trust organization, dedicated to preserving a 450 acre parcel of northern California coastal dunes. The two staff at the dunes preserve outsource for GIS services to the local university to track its mitigation of non-native vegetation. One application confirmed a long-held ecological growth model. Recently, with the creation of a bioregion-wide dunes

database, staff and students have discovered a new way—a "landscape level of analysis," according to its director—of comprehending the environment.

Trinity Community GIS, represents a community organizing effort in rural and poor Hayfork, in which 80 percent of the land is publicly owned. Trinity operates a GIS service center (or consortium) for area nonprofits but also contracts for projects with local public agencies. One such project tracked 8,000 individual pesticide sprays for the California Basket Weavers' Association. Internally, Trinity's GIS is used as an economic development tool: to train unemployed loggers in global positioning systems (GPSs) and in spatial data collection.

The San Andreas Land Conservancy (SALC) is a one-person all-volunteer land trust that ambitiously covers the length of the San Andreas Fault Line and is headquartered in the director's home just north of Santa Cruz. Previous to the creation of the trust, the director had developed GIS applications for two organizations in southern California. To date, his GIS analyses have been strategic in preventing hunting in a wildlife refuge and protecting a key landscape linkage for area mountain lions. That mountain lion map has been instrumental in attracting new members. In SALC, the director has directed GIS toward management of the land trust and the monitoring of conservation easements.

Located north of San Francisco in the Emerald Triangle, the Environmental Protection Information Center (EPIC) is dedicated to protecting the ecosystem of the old growth redwoods on both public and private lands. EPIC and its member organizations operate in highly reactive and litigious environment (members protect the trees with their bodies).¹ Its most dramatic GIS use was a courtroom demonstration that linked--and subsequently protected--a non-threatened species (redwoods) to an endangered species (the marbled murrelet). EPIC employs four staff, but its four tries at GIS have been outsourced to other nonprofits: two of which were all-volunteer.

GIS Implementation

Given the demonstrated use of the technology, how was it achieved? In general, organizations have discovered that GIS implementation encompasses far more than the purchasing and installation of hardware and software. In practice, the technical factors are equaled or surpassed by organizational factors because GIS tends to cross agency department lines, change job descriptions, and alter resource allocations. Empirical evidence from municipal, county, state governments suggests that successful implementation (from acquisition to the production of maps) depends upon accumulating an infrastructure of supporting factors. These include: (1) long-term upper management commitment to the project; (2) sufficient allocation of resources; (3) adequate staffing; (4) timely and sufficient training; (5) someone, called a GIS champion, who will shepherd the project from acquisition to use; and (6) organizational communication to smooth the transition to full utilization (Azad 1993; Budic 1994; Crosswell 1991; Onsrud and Pinto 1993). Ignoring these factors may multiply the costs of implementation

¹ A dozen activists were arranging for bail during my field visit. Recently (September, 1998), one activist was killed as a tree "accidentally" was felled on him (<http://www.headwatersforest.org/david.chain/index.html>).

and signal its ultimate failure. GIS consultants estimate that hardware and software account for only about fifteen percent of cost: data and organizational costs account for the rest (Parent 1989).

The case study research demonstrated that nonprofit implementation somewhat mirror the technical and organizational issues found in governmental agencies, most significantly the need for an in-house GIS champion. Certainly, it helps to have other factors such as sufficient training and upper management commitment. For example, Trinity ensures that all staffers are formally trained and it vigorously promotes GIS to consortium members. GIS receives considerable support in the Alliance because its former and current directors led the initial GIS efforts.

However, the chief difference is that these factors, while important, are largely unnecessary to an environmental nonprofit's successful implementation. The five cases were able to implement GIS because they improvised for a number of traditional resources, among them: (1) donations, primarily of GIS software (mostly from the ESRI Conservation Foundation); (2) universities (for hardware, software, data, and expertise); (3) volunteers/student interns; (4) a passionate "hyper-champion" who may even sacrifice personal comfort for GIS; and (5) informal connections rather than formal policies. Notwithstanding the innovativeness of the improvisations, the capricious nature of these factors also suggests that GIS remains a tenuous proposition for these organizations.²

SALC exemplifies this nonprofit implementation. Even though the director lives a meager life, he would rather work part-time than compromise his activist and GIS work. GIS equipment, a SUN Sparc, was purchased second-hand. He received donated software, software support, and training from ESRI. He travels to a nearby university or to ESRI in Redlands when he needs large-format maps. Implementation has been slow but successful. Organizational issues have been minimized since the trust is small and board members are selected based on their agreement with his vision.

Data Access and Sharing

Considering the increasing availability of digital data, it might be far more efficient for organizations to acquire or share data instead of collecting it themselves. Sharing of spatial data among multiple participants reveals a host of organizational issues similar to GIS implementation, including: (1) variations in priorities and goals among participants; (2) differences in GIS resources and skills; (3) differences in the character of each organization, such as the level of bureaucratization, whether the participant is public or private; (4) differences in data quality, format, and reach; and (5) differences in organizational power stability (Azad and Wiggins 1995; Budic 1995; Campbell 1991; Pinto and Onsrud 1995). Overall, data sharing is optimized under a stable environment, with a history of prior positive relations among participants. In this complex environment of resource exchange, the arrangement policies cement

² The Nature Conservancy recently sold the preserve to U.S. Fish and Wildlife as it transforms its role from landowner to land broker. The dunes preserve director, now an employee of USFW, hopes that another nonprofit will assume the GIS role, but little provisions have been made.

these relations. Policies must establish data standards, responsibility/ownership, frequency of exchange, costs, and incentives (Calkins and Weatherbe 1995).

Unlike implementation, the organizational issues of data sharing appears heightened for environmental groups. The dunes preserve benefits from the local university's immense (40 georegistered layers, at three scales, of ten million acres) spatial database of the region's natural resources. However, it must submit to the university regime: for example, differing priorities of professors, cycle of the semester system, and varying degrees of student interest/work quality. Should nonprofits acquire or share data with other institutions they can run risk of co-optation due to differences in power. Trinity inadvertently became a public service center for a state agency, which itself was limited in resources or upper management directives, and was only too happy to off-load public inquiries about its data. Indeed, power differentials appear so large that all but Trinity were unable to enter into formal data sharing arrangements. Consequently, they built strength through informal arrangements³ and interpersonal linkages.

These variations can worsen under unstable political climates and a history of contentious relations. Trinity and the dunes preserve have interacted well with local public agencies and find data acquisition easy; SALC and EPIC are confrontational and uncompromising. As a result, SALC's director enters much of his own data, so his data set has grown slowly and painfully. EPIC's outsourcer must enter its data since it is shutout even from county data. This makes GIS ill-suited to respond to the last minute reactionary environment in which EPIC operates.

Irrespective of the structure of data sharing, spatial data may not be designed to fit grassroots goals. Much computerized data may be available in a formats incompatible to requestors' systems. Forestry data sets of Trinity County tend to consist of aggregated features (e.g., ecological units); however, Trinity needs the actual species data. Some data can be physically inaccessible; it may be, for example, located in a distant site. EPIC's outsourcer often must travel hours north to Arcata for data. Rather than maximizing resources, nonprofit attempts to acquire government data actually may consume more resources than entering the data from the beginning.

Increasingly local and county governments recover the cost of expensive GIS hardware through the sale of their GIS data (Dando 1992). Often the non-digital version of this data is free or priced at the cost of its distribution medium; governments are selling the processed electronic version. For SALC, the high cost of accessing his county's cadaster presents a prohibitive obstacle to utilization.

Agencies may be disinclined to release data that can be privatized or, more importantly, regard as politically sensitive. The government retains the power to classify information as sensitive—for the protection of individual privacy or national security, or for its own protection in the uncertain status of liability for accuracy—or simply to withhold information it deems a threat to the status quo (Castells 1989; Epstein and Roitman 1987). The dunes preserve may

³ The most informal arrangement I have found was a secret meeting in a pub in which Friends of the Earth, UK (not involved in the original research) obtained the federal toxic release inventory.

easily obtain university data; however, the university was not always sanguine about distributing its database to environmentalists, since they include direct action groups. In another case, Orange County had refused to release to the SALC director the digital locations of a threatened species that were part of a voluntary conservation program between the government and the largest landowner. Refusal was based on the grounds that the director might do harm to the species. To obtain governmental computerized data, activists have engaged, and likely will continue to be forced to engage, in legal challenges (Archer and Crowell 1989). EPIC, for example, used a motion for discovery to access digital data.

Goals

So how will GIS contribute to advancing the many goals of the environmental movement? The literature provides a conflicting story on information technology (IT) (more fully detailed in Sieber 1997a) in which advocates and critics square off to paint IT alternately as political savior to a participatory democracy or as an electronic gilded knife in the heart of social activism. GIS can improve analysis (Dangermond 1991; Parent 1989) but it might be the wrong tool (Convis 1995). It could help groups compete better in the political environment (Goldman 1991; Klosterman 1987), drawing particularly on its double ability to exploit the perception of neutrality of computers and objectivity of maps (Monmonier 1991; Wood 1992). In so doing it may cripple groups' effective strategies and deny them their democratic foundation (Gittel 1980; Kweit and Kweit 1987; Piven and Cloward 1977; Rubinyi 1989). Environmental activists might gain methods to define meaning over their space (Castells 1989) because mapping technologies can harness the power of the image (Aberley, 1993; Wood 1992). Conversely groups simply may be adopting an instrument to hide corporate power (Curry 1995; Pickles 1995). Drama aside, environmental organizations already utilize GIS and other sophisticated computing technology; their use alone places value on the diffusion of technical innovation into the movement. If authors agree on nothing else, this varied literature is unequivocal that IT exerts a perceptible impact upon organizations.

Case study participants were clear that GIS enhanced their strategies for achieving existing goals. Many of these were directed internally. The Alliance has found the GIS invaluable to manage the hundreds of data sets from governmental units and developers. The dunes preserve found that the management of information confers greater clarification and identification of issues: "where it makes sense to advocate for preservation." Both groups are assisted by GIS's strong visualization functionality: a shorthand of complex environmental problems. Now the Alliance is using GIS to target new members; both groups use maps to acquire additional funding. In what the respondent at The Nature Conservancy's California office believes is a limited and highly competitive environmentalism "marketplace," GIS helps groups gain a larger piece of the public and foundation pie.⁴

I was surprised to observe that GIS was being used strategically as an "error detector" and a "layer dissector." The case participants have discovered, much to their dismay (or delight),

⁴ Several respondents also questioned the size of the pie.

numerous errors in secondary spatial data, some unintentional⁵ and some deliberate miscalculations. Three of five groups have found that GIS can be used to reveal those errors, omissions, or agendas in data collection/use. Groups also use GIS to dissect the resultant output and consequently understand the constituent data and decisions. Trinity checks and corrects data received from agencies to assist its clients. Conversely, the SALC director uses his GIS as a "guerrilla ground truthing tactic" to discredit opponents' information before information is concretized into policy.

Goal enhancement exhibited an upper limit: groups would distance themselves from GIS rather than have it affect the organizational agenda. In fact, two groups (the Alliance and SALC's director's former organization) spun off their GIS capacity; a third, Trinity's umbrella nonprofit, created a separate organization. By outsourcing, the dunes preserve and EPIC stay true to their core goals. These GIS-only organizations choose the means and not the ends of GIS as its goals. This focus on means does not go uncriticized: the SALC director questions environmentalists' inordinate emphasis on GIS and the reification of the quantifiable to the exclusion of the qualitative.

In the larger scale, does GIS use exert an impact on policy and the environment (natural and man-made)? Most participants would agree; however, they are more guarded as to the isolation of impacts from accumulated political resources and external events. SALC's spatial analysis confirmed for policymakers that hunting in the region would prove detrimental to wildlife as well as humans. Trinity's efforts put unemployed loggers back to work, both in conducting GPS work and in sustainable harvesting of special forest products, although staffers are reflective about the optimal responses to the globalization of resource extraction. The At Risk Map has proved a powerful asset to influencing the political agenda, but it elevates the Alliance's already considerable status in the Bay Area.

EPIC would never argue that GIS was key to winning the court battle. Recently, thousands of acres of land were saved through a state buyout. Were these accomplished because of GIS or because of the unending tree-sitting, barricading, and "cat-and-mouse" games played with the chainsaws? Moreover, members are driven by a spiritual connection to the trees and many reject all forms of technology. They would rather chain themselves to trees instead of chaining themselves to a digitizing table.

Despite the argument on the direct impacts on a discrete policy GIS allows groups to express their own version of ground-truth, combining experience, science, passion, and people. The cases are able to show their intimate knowledge of their environment, demonstrate their scientific understanding, and bring people and skills together to protect the land they love. In Trinity's case, GPS also enables groups to exert a physical ground truth over their own area. Overall, GIS helps groups promote their vision in two ways. To the extent that public policy is based on science and the determination of accurate correlations, GIS helps activists by promoting the value of lay science and exposing weaknesses in institutional data. To the extent that policy in

⁵ Some would argue that information created in the context of power is never free from malign intent. By "unintentional," I mean misplacing a datapoint or decimal point or, at worst, sloppiness in positioning.

the political sphere is driven by other agendas, then GIS can be used to bypass policymakers and reach out to the public in the visual sphere.

The Role for Supporters

Elsewhere I have discussed the crucial role played by universities (Sieber 1997c), vendors, professionals, and nonprofits (Sieber 1997b) in diffusing GIS to the environmental movement. Every case depended upon these supportive institutions and individuals. Although it now has GIS in-house, GIS at the Alliance began by drawing land use patterns onto USGS quads and taking them to two local universities for digitizing and overlay analysis. The dunes preserve staff employ local university students who utilize university equipment and data. Trinity makes use of a university's SUN Sparcs for processing of large data sets, and tape drives for unusual tape formats (although the trip is eight hours). Local public agencies have responded by offering output devices. Through its spin-off the Alliance has created a GIS mentor program so that engineers and computer programmers can assist struggling nonprofits. Directors from Alliance and Trinity have participated in environmentalist technical assistant consortia, in which information about GIS is regularly exchanged among nonprofits.

As the reliance is tempered by the differing priorities of the institutions, so must the assistance. Supportive individuals can "shore-up" the fragile structure with resources (peripherals, students, and expertise), continuity, and act as an intermediary to acquire and massage data. Vendors can build on their tradition of donations and remove the initial hardware and software barriers. Technology transfer is tempting because it gives the groups the skills to tailor GIS to their own needs. However, too many diffusion attempts have failed because needs are so much more prosaic: groups may just want the maps. Similarly groups may lack the social, technical, organizational infrastructure for GIS diffusion. Supporters first must allow groups to discover their own resources and needs before attempting to push GIS.

Findings from prospective and current GIS users in the mail survey and best practices cases reveal prerequisites that link GIS use to specific activities, applications, implementation/data sharing strategies, and attitudes. With the caveats posed throughout the research on the opportunity costs of GIS use, I propose a set of characteristics of groups that should and *should not* adopt the innovation. The two-by-two matrix presented in the figure shows skills that must be acquired, groups that are incompatible with required skills and conditions, and the broader implications for all groups interested in GIS technology. One axis shows characteristics of groups that do and do not have GIS; that axis is crossed with another that displays groups that should have and should not have GIS. The profile should not be construed as an exhaustive list of criteria, nor does it imply that groups cannot surmount obstacles to adoption. However, it synthesizes the experiences of studied groups that can frame discussion on the role of supportive institutions.

Who should or should not use GIS compared to who does and does not use GIS?

	SHOULD NOT USE GIS	SHOULD USE GIS
DOES NOT USE GIS	<p>OPERATION: Cannot spare resources to devote to GIS, Has largely computer-illiterate staff/board/volunteers</p> <p>Does not work with maps, Wants illustration only, May not know about GIS or have seen it demonstrated</p> <p>IMPLEMENTATION/DATA SHARING: Employs one or less staff or has no GIS champion, May be involved in science/data collection but does not want to invest in data computerization</p> <p>GOALS/MISSION: Is ideologically opposed to computing (and possibly nature's deconstruction)</p>	<p>OPERATION: Creates and/or analyzes maps, Is involved in scientific/public policy research and analysis</p> <p>Recognizes thematic as well as analytic functionality of GIS</p> <p>Shows interest in receiving technical support from other GIS-using institutions</p> <p>IMPLEMENTATION/DATA SHARING: GIS champion emerges, Can get value back/see results in one year (prototype), Utilizes at least one level of government data and or other nonprofits' data</p> <p>GOALS/MISSION: Is involved in habitat/open space issues, Engages in proactive, negotiation-oriented strategies</p>
DOES USE GIS	<p>OPERATION: Does not conduct analysis as activity or computer application</p> <p>Is not connected to the infrastructure of GIS users and resource substitution</p> <p>IMPLEMENTATION/DATA SHARING: Remains unaware of or unwilling to acknowledge GIS implementation/data access costs</p> <p>GOALS/MISSION: Goals and missions are better suited to non-GIS strategies</p> <p>Operates in crisis-oriented environment with a reactive and no compromise style</p>	<p>OPERATION: Is involved in scientific research, publications, media campaigns, Uses, creates, and/or analyzes maps,</p> <p>Uses CAD, graphics software, Creates analysis and graphics/presentation applications</p> <p>IMPLEMENTATION/DATA SHARING: Realizes implementation factors: commitment, computer literacy, grants of hardware and software, voluntarism; Has a GIS champion</p> <p>Recognizes costs of data collection, computer training</p> <p>Possesses good relations with institutional data providers</p> <p>GOALS/MISSION: Employs GIS in long-range and proactive vision</p> <p>Does not allow GIS to divert goals, mission</p> <p>Shows interest in offering technical assistance</p>

Conclusion

Research demonstrated that environmental groups use and value GIS. Differences can certainly be observed in the applications of GIS but also in the objectives of GIS: visualization, analysis, or skill-building. Implementation can also be quite varied, from traditional in-house implementation to complete outsourcing to resource-sharing within a consortium. Groups do, however, share an understanding of the complexities of and constant need for commitment to the technology. All groups exhibit an indigenous demand for GIS, backed by a history of scientific and technical knowledge. A leader committed to championing GIS innovation, so critical in government implementation, emerged in each of the cases. Improvisation demonstrated that resources did not represent a barrier to GIS implementation. This was not the case for acquiring digital data, however, which favored groups engaged in proactive and non-confrontational agendas. All five groups also use GIS with passion and for advocacy. Research also emphasized the pivotal role that universities and other professionals played in groups' successful utilization of GIS. This support must focus on the infrastructure of GIS environmentalism before it begins GIS diffusion.

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