Improving the Cartographic Quality and Design of Greenmaps

by

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Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

Bachelor of Science

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 2005

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Acknowledgements

Cherie Abbanat

Wendy Brawer and Green Map System

Christy Bressem

Kathy Cacciola and the National Wildlife Federation Campus Ecology Program

David Laws

Judith Layzer

Dara O'Rourke

William Shutkin

Jason Smith

William van Schalkwyk and MIT Environment, Health & Safety

1. Introduction

> *Basic maps of most cities show streets, landmark structures, elevations, parks, churches, and large museums -- but not dangerous intersections, impoverished neighborhoods, high-crime areas, and other zones of danger and misery that could be accommodated without sacrificing information about infrastructure and terrain. By omitting politically threatening or aesthetically unattractive aspects of geographic reality, and by focusing on the interests of civil engineers, geologists public administrators, and land developers, our topographic "base maps" are hardly basic to the concerns of public health and safety officials, social workers, and citizens rightfully concerned about the well-being of themselves and others. In this sense, cartographic silences are indeed a form of geographic disinformation. (Monomonier, 1991, p. 122).*

Environmental education is the attempt to sway private and political decision making processes by increasing the public's knowledge of the natural environment. It is the hope of environmental advocates that this information will then enter into the calculus of daily life. However, education is only one of many avenues available to promote the environmental agenda; others include research, administrative policy, legislation and enforcement.

Many advocates feel that education is crucial to achieving an environmentally friendly, sustainable, society. For instance, New Ecology Inc. conducted an informal poll at their 2003 Regional Sustainability Development Forum in New England. The sole question, whose results are outlined in Table 1.1 on the next page, was: "With limited financial resources always an issue, in what area(s) would those resources have the greatest impact in advancing sustainable development solutions?" Education was listed as the top priority for further expenditures, with triple the response of conservation.

Table 1.1: *Results of Regional Sustainability Development Forum poll*

Selection	Responses	Percentage
Housing	23	10.00
Transportation	40	17.39
Brownfields	25	10.87
Renewable Energy	35	15.22
Land Conservation	19	8.26
Economic Development	27	11.74
Education	56	24.35
Other	5	2.17
Total	230	100.00

Note: M.F. Cook, personal communication, November 17, 2003.

An innovative form of environmental education which is becoming increasing popular is the greenmap[1]. Greenmaps are a form of community based environmental advocacy invented by artist Wendy Brawer of the eco-design consultants Modern World Design. In the early 1990's Wendy was concerned that while many aspects of New York City were celebrated daily life remained disconnected from the natural environment. While attending a United Nations Earth Summit meeting in 1992 the concept of the greenmap formed (Green Map System [GMS], 2004a, p. G1).

Greenmaps are locally produced surveys of environmental risks and resources within a community distributed to its citizens in order to promote environmental awareness and sustainability. Since the inception of the first project in 1992, the Green Apple Map of New York City (GMS, 2004a, p. iv), approximately 250 greenmap projects have been initiated worldwide, of which two-fifths have published maps (GMS, 2004b). The interest in greenmaps has led to the creation of numerous organizations. For example, the non-profit

1. The official, trademarked, name is Green Map however in this thesis I have instead elected to use the term greenmap. First, I find the capitalized term too distracting for judicious use. Second, I feel the single word form places additional emphasis on the concept as opposed to the disjointed adjective plus noun. When describing greenmaps to laity, who do not necessarily associate "green" with "environment," I am often asked "Why green?"

Green Map System (GMS) was quickly formed to support greenmapping efforts world-wide and regional off-shoots have been founded in Japan and South America.

Maps are potent tools which can succinctly convey large amounts of information. Furthermore greenmaps are several steps beyond the conventional “hound the public to recycle”/”chastise them for not doing so” campaigns. Instead, greenmaps actually locate and present recycling centers, toxic waste sites, public art, dumps, community gardens, socially conscious businesses, and other features in an easily digestible visual format. The inclusion of less conventional urban resources such as public art as well as the more commonplace--mass transit stops--serve as hooks to increase the utility of a greenmap and integrate the public into their surroundings. The power of a greenmap, it’s *raison d’être,* is perhaps then best exemplified by the following: The first thing most people will do when they pick up a map of a familiar region is look for a reference spot such as their current location or that of their home or office. It is here that the user will be surprised to learn of the myriad points-of-interest available just around the corner and subsequently begin to make use of these resources and confront or avoid the risks.

This, at least, is the theory. Unfortunately, it remains unclear precisely how and to what degree readers are influenced by greenmaps. There is some indirect evidence of an effect on greenmap users though, as indicated by the interest in individual projects. Specifically several projects experience such demand for greenmaps that they seem scarcely able to keep up, even by issuing new editions and large print runs (GMS, 2004c, p. B4, G2). It is also known that greenmaps have the ability to influence activists. The Director of Milwaukee's River Revitalization Foundation has noted that she used the Milwaukee Greenmap, “when I first started my position . . . as an essential resource to increase my background knowledge of the Milwaukee River Basin and identify priority areas to focus on" (GMS, 2004c, p. I6). However there are no concrete data about changes in behavior, knowledge, or perceptions of the general public attributable to greenmap use.

On the other hand it seems clear from the writings of Maeve Lydon and others that participants benefit from the process of creating a greenmap (2002; GMS, 2004c). This is not surprising considering that the greenmap fits into a larger spectrum--the established arena of community mapping[1]. The potential for community driven development of greenmaps is an interesting aspect of the concept. In many fields involving public participation, ownership of the process is considered essential to encourage adoption of the results. Juliana Maantay paraphrases Doug Aberley in her evaluation of computerized mapping in environmental justice and states: "Perhaps the most important benefit of neighborhood-scale analysis is the potential for direct involvement of the affected people and their knowledge of their surroundings they bring to the project, along with the sense of ownership that their involvement brings to them" (2002, p. 169). In fact, many greenmap projects benefit from the grassroot nature of community mapping. While some greenmapping efforts are undertaken by municipalities and existing organizations, others are pursued as classroom projects or by ad hoc citizen groups. Seven of the ten successful projects described in the Green Map Atlas featured strong community involvement (GMS, 2004a). Further evidence of the effectiveness of greenmap creation in educating participants can be seen in the interest of using greenmaps in the classroom. Several articles have been published and republished in periodicals for educators, numerous educational websites link to the Green Map System homepage, and the former director of the Center for

1. A cousin of the greenmap is public participation geographic information systems (PPGIS) or more simply, computerized community mapping. David Tulloch notes that "interestingly enough, as GMS has evolved it has taken on many of the characteristics attributed to PPGIS projects" (2004, p. 3). PPGIS is a hot research topic (Sieber, 2003), and has also been shown as an effective form of community mapping for educating participants (Schroeder, 2001; Blackford & Mueller, 2002).

Environmental Education, Robert Zuber, has created a greenmap toolkit for teachers (McRae, 1998; Paul, 1997; Student's Guide, 2000; Students Map, 2001; Zuber, 1999).

Whether or not users of greenmaps benefit as those making greenmaps it is certain that the quality of any map, green or otherwise, affects a reader's experience and ability to assimilate the information it contains (Monmonier, 1991). The body of this thesis then is focused on the quality of greenmaps, under the assumption that this affects their efficacy as tools for environmental education. First, in section two I inspect published greenmaps to determine how well they adhere to cartographic standards. There are fundamental parts of a map that affect map usability and I hope to determine if greenmap-makers are including them, thereby meeting a basic obligation to their readers. Next, section three contains a discussion of the mapping process as it relates to common problems in creating greenmaps, in particular the selection of features to map and a method to facilitate this. Finally, I also describe a novel method of including feature information on greenmaps.

2. Mapping Conventions

> *"A legend might make a bad map useful, but it can't make it efficient." (Monmonier, 1991, p. 22)*

The quality of a map's design affects its reader's ability to extract information, and consequently to learn from the map. Whereas Section 3 emphasizes the map design process and experimental layout, this section focuses on traditional map layout. I will first examine the utility of and justification for some mapping conventions and then describe a survey of published greenmaps' adherence to these standards.

Cartographic conventions have been developed in an effort to portray the world accurately and effectively convey information to the map reader. A legend, of course, explains the pictorial language of the map known as its symbology. The title generally indicates the region the map portrays, the map image portrays the region and so forth. Although every map element serves some purpose, convention only dictates inclusion of some elements while others are considered optional. A menu of map elements includes the neatline (border), compass rose or north arrow, reference grid (graticule or index grid), locator or overview map, scale or scale bar, projection, and information about the map sources, accuracy and publication.

The utilitarian logic of some map elements is suggested by Anne Godlewska:

> To some extent, you will look at a map in much the same way that you look at the countryside from atop a tall building. The landscape and map reader will immediately seek orientation, scale, familiar symbols or landmarks, recognition of location, and any connection with the experience or knowledge of the reader. (1997, p.35).

If users in fact read a map like a landscape, as Anne Godlewska claims, then it is all the more important to include the fundamental map elements.

When examining a landscape, scale can be intuited from trees, houses and cars. Not so with a map. Even such a simple thing as a north arrow is crucial. It may seem obvious that the top of a map should point north but this might not be the case. The supposition that "up" or "top" is automatically north is a cultural bias.[1] It is at least as reasonable to orient a map east with the rising sun; in fact this is the origin of the words orient and orientation (Harper, 2001). Furthermore, an oddly shaped or elongated region may be rotated to better fit onto a piece of paper, reducing coverage outside the region of interest. A map may be rotated for other reasons as well, perhaps to correspond with the intended audience's mental map of the world. The Buenos Aires map is oriented such that it is nearly "upside-down". The north arrow points to five o'clock. Finally, while something as innocuous as a reference grid might seem trivial and unnecessary, they can greatly enhance the usability of a map as related later in Section 3.

Methodology

While greenmaps are largely instances of amateur or folk cartography, one might expect them to still contain basic cartographic elements. For instance, as self-evident as the GMS icons are intended to be, a legend is still a crucial part of a greenmap particularly given the greenmap-maker's license to redefine individual symbols.[2] Since my introduction to greenmaps I've been repeatedly struck by the variety of designs and apparent lack of adherence to cartographic standards of greenmaps. In order to gauge the significance of this perceived trend I conducted a survey of thirty published greenmaps, one third of all those officially published (GMS, 2004b). I examined the maps to determine if they con-

1. See The Upsidedown Map Page at http://www.flourish.org/upsidedownmap/ Similarly, the classic classroom map uses a Mercator projection which preserves direction for maritime navigation at the expense of distorting land masses, particularly their size. For additional information see a proposed replacement, the Peters projection, at http://www.petersmap.com/
2. I have had one potential sponsor withdraw support for an early map because, among other reasons, the "secure bike parking" symbol was omitted from the legend and subsequently interpreted as a, non sequitur, clockface.

tain key map elements: reference grid, publication date, legend, north arrow, source citations, scale information.

The map elements I chose to focus on were determined largely by my own training in computer-based map-making and prior observations of greenmaps without consideration of the literature.[1] I included reference grids in the survey because I am interested in the manner greenmap-makers include the detailed information or metadata about features on their maps. As previously mentioned, reference grids are more thoroughly discussed in Section 3.

The sample of reviewed greenmaps contains equal numbers, fifteen each, of printed and electronic maps. The printed greenmaps were chosen at random; during a visit to the GMS office I received copies of all the duplicate greenmaps in their archives. The remainder of the assayed greenmaps were chosen from the list of electronic greenmaps on the GMS website (2004c). Greenmaps that bore a greater resemblance to traditional maps were favored over experimental web-based interfaces or other designs. Finally no map-maker was represented more than once to avoid double-counting the significance of their style and training. As such, certain projects which were initially selected had to be discarded.

The survey itself was largely of a binary nature and only recorded if a map element was used, with the exception of legends, and no systematic effort was made to rate the quality of these elements. While it is well established that graphic representations of scale including scale bars are superior to numeric ratios, I did not take note of such things in the

1. It is interesting to note however, the similarities between my choices and the elements emphasized by Ernst Spiess in graphic representations of map composition (2002, pp. 37-38) and the Canadian non-profit Common Ground Community Mapping Project. Common Ground advocates including a title, north arrow, legend, scale, and "production information" including publication date and source citations in greenmaps (2001, p. 19), whereas Speiss's focus was limited to a title, scale, legend, and sources (2002, pp. 37-38). The only difference in emphasis between Spiess, Common Ground and my survey then was my choice to include reference grids.

survey (Monmonier, 1991, p. 7). However, in some exceptional cases additional details were noted. For instance some maps placed key information in obscure places--the scale is difficult to locate on the Manhattan map--and on others the elements were obscured; the logo of Calgary's map is also ambiguously used as the compass rose. Finally, some maps with source citations did not include a complete list.

Results

As Table 2.1: "Map element survey" on page 14 shows, one third of the maps surveyed lacked a north arrow. Other, subtler, elements were used even less frequently: only one half of the maps indicated scale while sources and index grids were each found on only nine maps. The fact that so many green maps do not cite sources is problematic, not only is it dishonest to use a secondary source without credit, but proper citations lend credibility to a map and may serve as a buffer against criticism of a greenmap's content. While it is possible some mapmakers include sources in a list of acknowledgments on their maps, this is improper placement because it does not aid an inquisitive user. It is not obvious that a state agriculture department or local university provided data for the map when it is listed alongside a local bank or other donors and supporters.

Many greenmaps do not include a proper legend and instead rely upon the section headings of feature descriptions to inform the user of symbols' meaning, as in Figure 2.1. Still other maps include a legend with the entire suite of GMS icons, even though only a small subset is used. Not only does this waste space which might be used for other content or well-placed whitespace, but the clutter detracts from the map and can frustrate a map reader's efforts to ascertain the meaning of a symbol.

Nature - Flora : Community garden

HC001 G9 — **Kensington Community Garden** Westbourne Road, Kensington

Nature - Flora : Parklands / recreation area

HD001 U16 — **Alexandra Gardens** Melbourne

HD002 S10 — **Argyle Square** Carlton

Figure 2.1: *Mapped features detail headings*

Note: From “melbournegreenmap” (2001). Reproduced with permission

Table 2.1: ***Map element survey***

Location	Date	Grid	Legend	North	Scale	Sources
Beijing, CN	X		X			
Berlin, DE	X		X	X	X	
Boulder, CO, US	X	X	X	X	X	X
Buenos Aires, AR			X	X		
Calgary, CA	X		X	X	X	X
Chicago, IL, US	X		X			
Copenhagen, DK	X	X	X			X
Delaware County, IN, US			O	X	X	
District of Columbia, US	X		O			
Dublin, IE			X	X		X
Edmonton, CA	X		O	X	X	
Hackensack, NJ, US			X	X	X	X
Hamilton, NZ		X	X			
Manhattan, NY, US	X		X	X	X	X
Marugame, JP	X		X			
Melbourne, AU	X	X	X	X	X	
Milwaukee, MI, US	X					
New Haven, CT, US	X		O	X	X	
Oxford, GB			X			
Pittsburgh, PA, US			X	X	X	
Rotterdam, NL	X		X	X	X	
San Francisco, CA, US			O			
Santa Monica, CA, US	X	X	X	X	X	
Sheffield, GB						X
Singapore	X	X	X	X		
Somerset County, NJ, US		X	X	X	X	X
Tokyo, JP	X	X	X			
Toronto, CA	X		O	X		
Washtenaw County, MI, US	X	X	O		X	
Yarmouth, CA	X		X	X	X	X
Total	20	9	22(29)	18	15	9

Note: Legend entries marked with an O instead of an X include no proper legend but instead label each grouping of feature details with the designated symbol: See figure 2.1 on page 13. These maps are included in the total listed in parentheses.

3. Cambridge Greenmap - Experimental Design

As demonstrated in the previous section many greenmaps lack important elements, particularly a full and accurate accounting of sources but also indications of scale, direction, and age. Beyond remedying these shortcomings, and precluding formal training as professional cartographers: What else might be done by greenmap-makers to improve their product? The Cambridge greenmap project began as an inventory of recycling bins on the MIT campus but quickly expanded in scope and extent to include other features and the surrounding city. Eventually the project gained another goal, to serve as a proof of concept for several design ideas intended to improve greenmaps, outlined below. These ideas can be broadly described as the need of a greenmap-maker to keep the basic concepts of map design and the purpose of a greenmap in mind at all times.

The goal of a greenmap is to tell a story of place and of people--a story of an integrated and sustainable society--to convey an environmental world-view. Consider then that map-making is fundamentally a process of abstraction. A map simplifies the chaos of the world and brings order to the messiness of reality (Muehrcke & Muehrcke, 1998, p. 520). More specifically, map-making is differentiated into several sub-processes: selection and classification, simplification and exaggeration, and symbolization of features (Brassel & Weibel, 2002, p. 91; Muehrcke & Muehrcke, 1998, p. 55). As discussed in turn below, attention to these steps can allow for better informed decisions during greenmap design and, consequently, better story telling.

Selection and Classification

Selection and classification are closely related steps in mapping. Selection is the process of including or excluding individual features or a group of related features, also known as a feature class. Classification is the assignment of features to feature classes. For example, in the case of a greenmap one might choose to include stores (selection) that sell used goods and sort them into different groups based upon what they carry (classification): books, music, clothing, sporting goods or furniture. Simple though it may sound, selection is non-obvious. Muehrcke and Muehrcke note that: “Mapping purpose alone is often a misleading guide to information selection for mapping” (1998, p. 58). So even in the creation of a greenmap with its focus on the environment and its even narrower--though relatively broad--suite of icons, careful selection is necessary in order to convey a coherent message.

Including all 125 GMS icons, or even a large subset thereof, would yield an illegible map, to say nothing of including custom site-specific feature classes such as the habitat of a local endangered-species. When presented with the panoply of icons offered by the Green Map System, a greenmap-maker may be either daunted by the possibilities, or conversely tempted to cram an entire atlas into the greenmap; the latter being all the more likely if one has ready access to the necessary data. Complicating the matter, GMS recommends a transparent selection process--clear, open, and reviewable by anyone (W. Brawer, personal communication, July 31, 2003). Finally, classification enters the picture in a symbiotic manner. Good feature classes should be mutually exclusive but many GMS icons, like those for various transit modes, overlap with one another (Muehrcke & Muehrcke, 1998, p. 68). The decision to use some of these icons over others would be a combination of both selection and classification.

Before outlining the method used to manage the problem of selection-classification for the Cambridge greenmap, a note about the specific feature classes selected on greenmaps should be made. Few greenmaps seem to include negative features such as toxic sites, landfills or dangerous intersections. I believe this is a significant deficit in implementation as important as any cartographic flaw. This omission makes greenmaps without hazards examples of the same disinformation of which Monmonier writes and that greenmaps are purportedly intended to address (1991, p. 122). Including negative features provides some semblance of balance, hopefully providing readers exercising healthy skepticism with evidence that the map-maker is neither wearing rose-colored glasses nor attempting to greenwash the mapped area. I will admit however that the information required to include risks on greenmaps is often more difficult to acquire than that of beneficial resources. Although American greenmap-makers are blessed with the public records of the EPA, including the Toxics Release Inventory (TRI), this information is often out of date and difficult to interpret. In addition, there are potential political difficulties including cesspits on a map.[1] While GMS specifically indicates that greenmap-makers should not be unduly influenced[2] (W. Brawer, personal communication, July 31, 2003), including risks may be particularly difficult for greenmaps published by municipalities or organizations wishing to present their locale in the best possible light. Note that several greenmaps are specifically designed for tourists including The *Other* Map of Toronto. Nonetheless, efforts should be taken to incorporate less pleasant aspects of the landscape where possible.

The selection process begins by striking out any feature classes from a list of the GMS icons and definitions that one does not want to use, perhaps because they are similar to others or deemed inappropriate for the greenmap's message. In the case of the Cambridge greenmap, I removed any classes that did not exist in the region of interest. I eliminated those icons which I deemed irrelevant culturally, geographically, or thematically. Examples are respectively: insect watching, bamboo forest, and alternative medicine.[3]

1. Some versions of the Cambridge greenmap, in particular the Primer referenced later in this thesis, lack these unpleasantries mainly due to space constraints but also in consideration of the audience and funding.
2. The prohibition is specifically about corporate sponsors. In letter GMS discourages corporate influence but the spirit is broader. It may be more acceptable to a greenmap-maker to make exceptions for individual features than entire feature classes.
3. The discarded icons were not actually removed, they remained throughout the rest of the process since an existing GMS poster, Appendix A, was used as a worksheet. This had the fortunate side-effect of the icons in questions acting as controls to determine if my judgements were correct.

The next step is to choose two dimensions in which to numerically rate the feature classes remaining in the revised list. For example a possible dimension is obscurity, chosen to emphasize the hidden jewels little known to the mapped region's residents. For the Cambridge greenmap, I selected "greenness" and public interest as the dimensions. I ranked each symbol from one to five (least to most) based on my opinion of its "greenness" or significance to the environment. Public interest was determined by conducting a survey where participants were asked to mark a dozen symbols they would like featured on a map of the local area on a copy of the GMS icon poster formatted as in Appendix A. I surveyed several acquaintances of varying political persuasions (N=3) and several passers-by in a town center and near the MIT campus (N=4). The marks for each class were tallied, and the range from minimum to maximum was divided into five parts (the same number of divisions as greenness).

With these valuations in hand, place the icon for each class in a grid using their values to graph each point. Finally, select those icons in the high-valued portion of the chart as the feature classes to include on the greenmap. If the graph was created with the origin in the upper left, then a line from the lower-left to upper-right would separate the icons to include (those below the line) from those to discard (above the line). However a dilemma arose: How to handle the icons in the grid cells crossed by the diagonal line? A greenmap-maker might simply make judgement calls for each of the icons in question, or review the ranking data for subtle differences lost in graphing.

After I placed the icon for each class into the corresponding cell of a 5x5 grid I drew a contour line following the general trend of the diagonal to select icons for use in the Cambridge greenmap. Deviations from the diagonal were made based on the importance and obscurity of local features represented by the icons. For instance, I felt it was important to indicate the presence of public squares and significant organizations like the Union of

Concerned Scientists. With few exceptions, the icons inside the contour have been included on preliminary maps. However, I hope to include the remainder and others near the contour such as fossil fuels, toxics, and dangerous intersections in future editions. The results are shown in “Selected feature classes for Cambridge, MA, US greenmap” on page 20. In the figure: the dark row and column contain icons discarded or otherwise ruled out, the hashed cells contain icons in limbo, and the grey cells holds icons selected for inclusion on the greenmap by the graphing process.

This systematic process for feature selection provides focus, and allows for a documented and justifiable process, as recommended by GMS in their new map-maker checklist (W. Brawer, personal communication, July 31, 2003). Additionally it can give insight into the utility of one’s map.

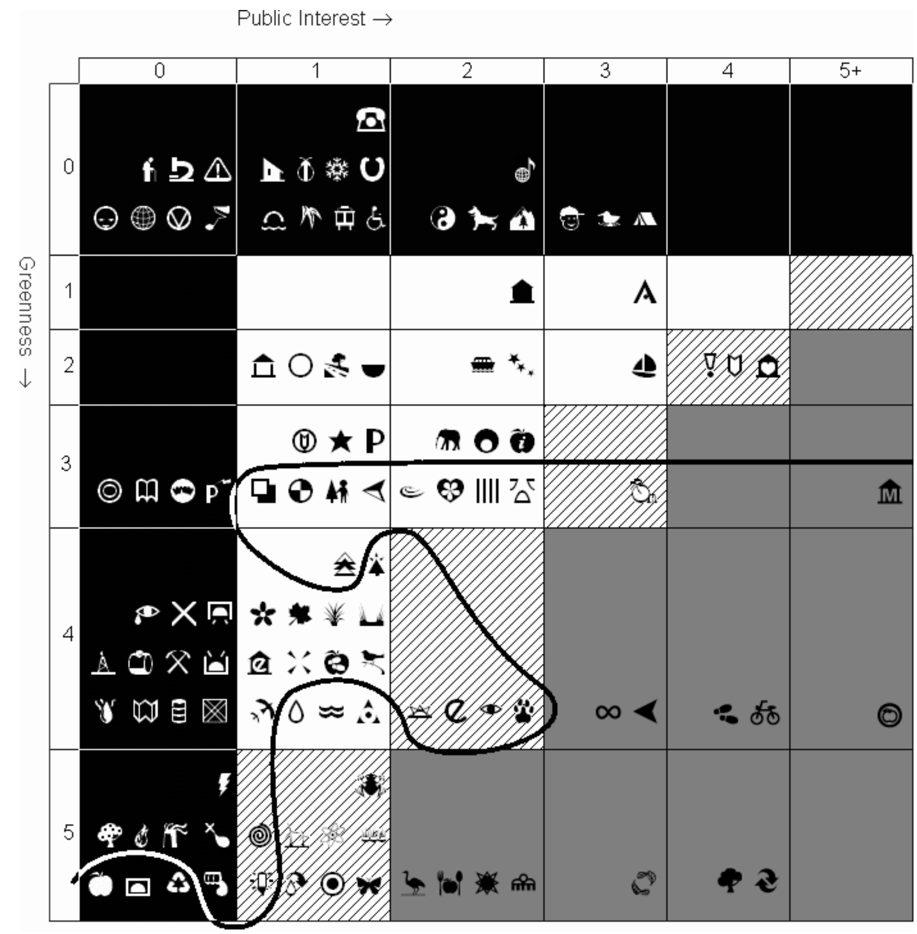

Figure 3.1: *Selected feature classes for Cambridge, MA, US greenmap*

Simplification and Exaggeration

Simplification and exaggeration are manipulations of a feature's size and shape. These modifications are done to improve map clarity as well as to influence the perceived importance of a feature or a feature's attribute. While a road may have minor curves removed to emphasize the gist of the route, a river may be drawn with additional squiggles to enhance its appearance. The "Greenmap of Cambridge, MA, US" on page 26 contains an example of aggregation, a form of simplification, where several vernal pools outside the city are represented by only the two frog icons in A3.[1] Clearly exaggeration and simplification are heavily reliant upon aesthetics and require judgement calls, making them more difficult to evaluate. In addition, these processes are most applicable to base maps and many greenmaps use pre-existing, often official, base maps. Nevertheless, Appendix B includes some discussion about simplifying linear features such as roads.

Symbolization

Symbolization is the assignment of symbols to feature classes where a symbol consists of shape, size, texture, orientation, and color (Asche & Herrmann, 1998, p. 137). Effective use of symbology continuously challenges map makers to balance many countervailing factors like clarity, specificity, legibility and simplicity. The symbology of greenmaps is no exception, even though the use of GMS icons sidesteps many of the design challenges in creating an effective symbology--the decisions have been made by GMS. The binary (yes/no) nature of its point symbols brings other challenges to the fore; the mismatch of zero-dimensional points and one-dimensional lines, and avoiding clutter when showing the overlap of polygons and other features.

The "there" or "not-there" implications of indiscriminately representing features as point symbols is a widespread problem in environmental mapping and was examined by Juliana Maantay in her paper "Mapping Environmental Injustices: Pitfalls and Potential of Geographic Information Systems in Assessing Environmental Health and Equity" (2002). As often used, point symbols give no indication of relative significance. In examining environmental justice maps a common error is to treat all pollution sources as equal, regardless of pollutant or amount (Maantay, 2002). A reasonable stopgap is to scale icons where appropriate, ideally based upon an intrinsic property such as scaling a park's icon based on acreage. This variation in size, a form of exaggeration, has an immediately obvi-

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1. Strictly speaking, almost any symbol on a map is an example of exaggeration if the symbol representing a feature is not shown at the scaled size of the actual feature. This is of course a major reason for marking features, they would escape notice otherwise.

ous meaning to the map user. Unfortunately, attribute weighting can be difficult to apply on smaller maps where everything is already minimalized due to space constraints.

The GMS icon set as symbology poses additional problems for the greenmap-maker, most notably in the representation of linear and polygonal features. It is either too difficult, or does not occur to many greenmap-makers to use the icons that represent various types of paths as linear symbology. The Melbourne greenmap represents bike paths with bold blue lines as in Figure 3.2: “City of Monee Valley” on page 24, even though the GMS icon set includes symbols for bicycle and mixed-use paths. Compare this to Figure 3.4: “Greenmap of Cambridge, MA, US” on page 26 which uses the provided icons. Appendix B includes information on how to duplicate this linear symbology.

In many ways, polygon symbology is a more difficult problem to tackle than linear symbology since any styling used to highlight a feature should not obscure the underlying geography. Two common symbologies intended to solve this problem are the use of an outline of the polygon or an overlay with partial fill. Unfortunately, borders seem to draw attention outward, away from the feature. Filling a polygon with a hash or stippling can work but if not used carefully they can make the map busy and cause printing problems. For an example, see the parks in Figure 3.4: “Greenmap of Cambridge, MA, US” on page 26.

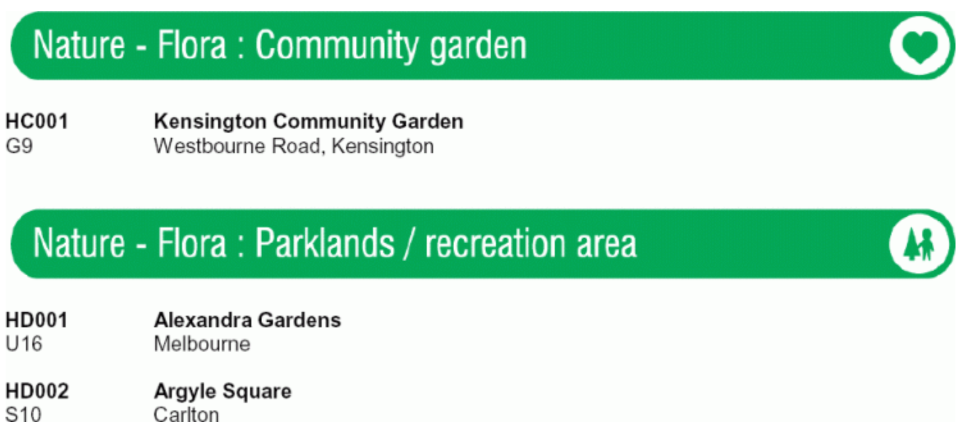
Feature Details

The strength of a greenmap lies in its aggregation of a wide variety of information in a single simple form. Therefore, I believe the detailed information about mapped features is best presented to the user in a continuation of the greenmap’s spatial context, rather than mimicking a collection of specialized datasets. However, many greenmaps use a system for listing the details of mapped features that denies this spatial context.

Most greenmaps use a system to present information about mapped features I have dubbed “indexed class lists”. The data is grouped into lists by feature class and one looks up the details of a site by locating the site's index in the corresponding class list (e.g.; In Figure 3.2: “City of Monee Valley” on page 24 the community garden is labeled with the unique identifier HC001. To learn more about this garden, one must locate HC001 in the details listing of the greenmap; in this case the small fraction in Figure 3.3: “Mapped features detail headings” on page 24). The indexing style varies amongst greenmaps though most number all features consecutively. Still other maps forego assigning their own numbers and use the street address of a site, requiring the user to have an intimate familiarity of the area.

The indexed class list system is particularly useful if a user is interested in many features of the same type. If a reader is searching for significant organizations in their area and is not concerned with the precise location, indexed class lists streamline this task. However in this case the map itself is superfluous and the greenmap has become little more than a kind of green phonebook. Indeed, unfortunately, some greenmap projects lack a map image altogether. And if, while perusing the greenmaps feature details a site piques one’s interest, it can be quite difficult to locate it on the map for a visit by this identifier e.g.; “Community Garden-Heart HC001.” The Melbourne map solves this by listing the coordinates from the index grid of the map in the feature details. An additional problem with this design is that readers are likely to be most interested in other features which are in the same space.

Figure 3.2: *City of Monee Valley*



Nature - Flora : Community garden

HC001 G9	**Kensington Community Garden** Westbourne Road, Kensington

Nature - Flora : Parklands / recreation area

HD001 U16	**Alexandra Gardens** Melbourne
HD002 S10	**Argyle Square** Carlton

Figure 3.3: *Mapped features detail headings*

Note: Figures 3.2 and 3.3 from "melbournegreenmap" (2001). Reproduced with permission.

I have named the system I have used for Cambridge greenmaps, "battleship"[1] or detail grid. An example of this format is shown in Figure 3.5: "Details for greenmap of Cambridge, MA, US" on page 26. Battleship is an intuitive system that facilitates rapid lookup. Feature details are placed on a grid in a one-to-one correlation with the features repre-

1. Battleship is a game in which two players take turns calling out coordinates on a grid labeled with numbers on one axis and letters on the other. The purpose is to discover and "sink" a ship which stretches across multiple cells of the grid by successfully listing each coordinate.

sented on the map. Because the details are divided into many smaller lists, and the appropriate list can be found by simply looking in the same spot on another page, it is easy to locate the specifics of a given feature. It is also easy to read about features in the same area since they are adjacent in the detail grid as well. Finally, the detail grid may be embellished with a background image as in Figure 3.6: "Embellished details for Cambridge, MA, US greenmap" on page 27. This format is handsome, provides additional context and is a form of map in its own right.

While it is easier to glance over the gridded page of feature information in battleship, seeking out "apples" or another icon of interest than it is to scan the contents of indexed class lists for street names in the area of interest, my proposed system is not without warts. Producing this format is more involved than simple category lists. Battleship works best if it is possible to produce a layout with symmetry allotting the same amount of space for the detail grid as the map image. The detail grid should also be placed either adjacent to the map image, as in Figures 3.4 and 3.5 below, or on the opposite face of the map. There can also be difficulties producing a functional battleship layout for small or densely populated maps. In these cases, it may be possible to have the data spill over into an adjacent cell or it might be necessary to reconsider the value of some of the mapped features and remove them. Ordering of the feature details for a given grid cell might pose problems for the reader if there are multiple sites of the same type like C4 in Figure 3.4: organic groceries, subway stations and shared automobiles. My own, western, solution is to list details top-down as they occur reading the contents of the cell from left-to-right and top-to-bottom.

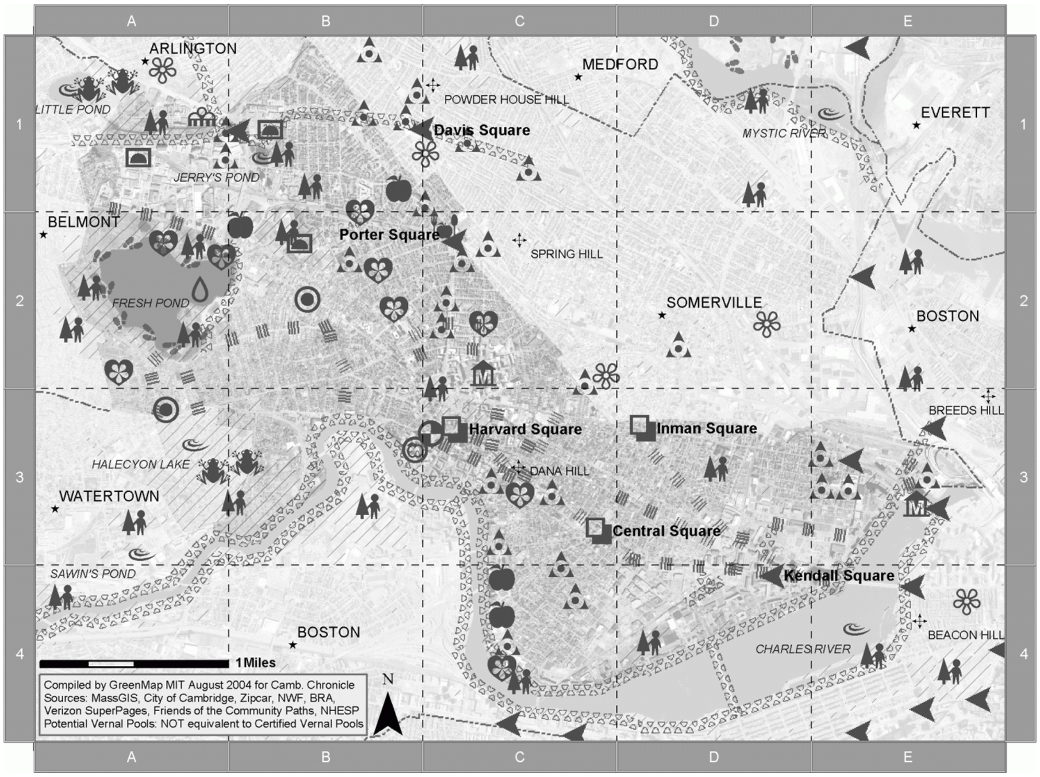
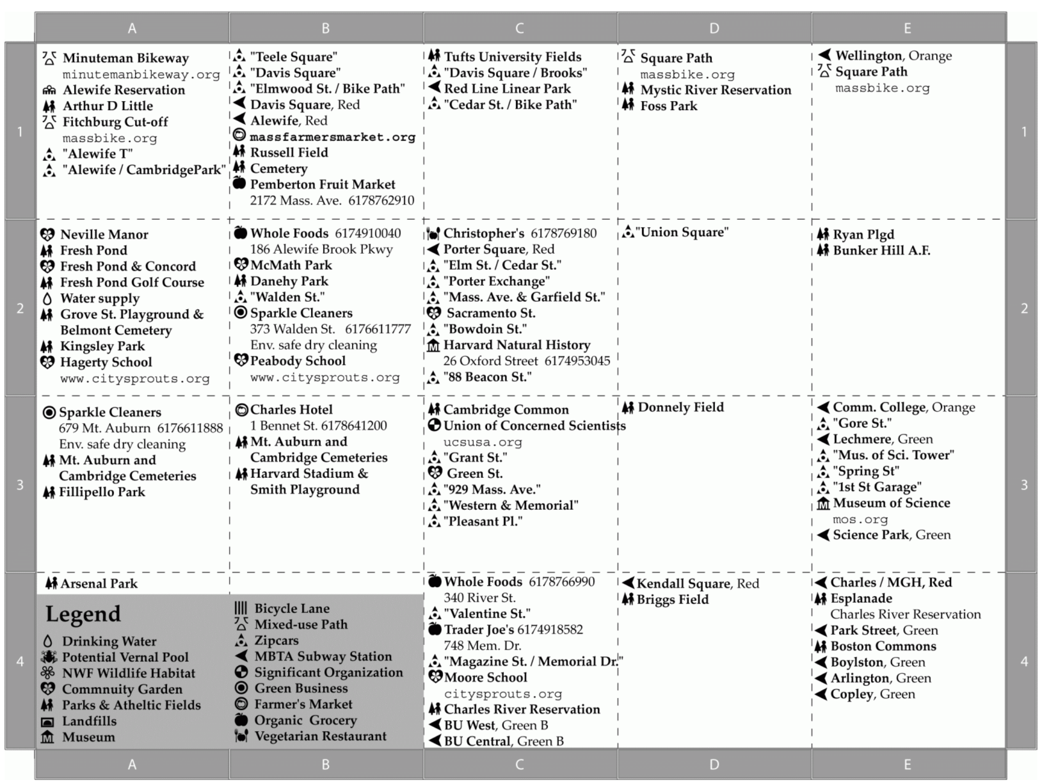


Figure 3.4: *Greenmap of Cambridge, MA, US*



	A	B	C	D	E
1	Minuteman Bikeway minutemanbikeway.org Alewife Reservation Arthur D Little Fitchburg Cut-off massbike.org "Alewife T" "Alewife / CambridgePark"	"Teele Square" "Davis Square" "Elmwood St. / Bike Path" Davis Square, Red Alewife, Red massfarmersmarket.org Russell Field Cemetery Pemberton Fruit Market 2172 Mass. Ave. 6178762910	Tufts University Fields "Davis Square / Brooks" Red Line Linear Park "Cedar St. / Bike Path"	Square Path massbike.org Mystic River Reservation Foss Park	Wellington, Orange Square Path massbike.org
2	Neville Manor Fresh Pond Fresh Pond & Concord Fresh Pond Golf Course Water supply Grove St. Playground & Belmont Cemetery Kingsley Park Hagerty School www.citysprouts.org	Whole Foods 6174910040 186 Alewife Brook Pkwy McMath Park Danehy Park "Walden St." Sparkle Cleaners 373 Walden St. 6176611777 Env. safe dry cleaning Peabody School www.citysprouts.org	Christopher's 6178769180 Porter Square, Red "Elm St. / Cedar St." "Porter Exchange" "Mass. Ave. & Garfield St." Sacramento St. "Bowdoin St." Harvard Natural History 26 Oxford Street 6174953045 "88 Beacon St."	"Union Square"	Ryan Plgd Bunker Hill A.F.
3	Sparkle Cleaners 679 Mt. Auburn 6176611888 Env. safe dry cleaning Mt. Auburn and Cambridge Cemeteries Fillipello Park	Charles Hotel 1 Bennet St. 6178641200 Mt. Auburn and Cambridge Cemeteries Harvard Stadium & Smith Playground	Cambridge Common Union of Concerned Scientists ucsusa.org "Grant St." Green St. "929 Mass. Ave." "Western & Memorial" "Pleasant Pl."	Donnely Field	Comm. College, Orange "Gore St." Lechmere, Green "Mus. of Sci. Tower" "Spring St" "1st St Garage" Museum of Science mos.org Science Park, Green
4	Arsenal Park **Legend** Drinking Water Potential Vernal Pool NWF Wildlife Habitat Comnnuity Garden Parks & Atheltic Fields Landfills Museum	Bicycle Lane Mixed-use Path Zipcars MBTA Subway Station Significant Organization Green Business Farmer's Market Organic Grocery Vegetarian Restaurant	Whole Foods 6178766990 340 River St. "Valentine St." Trader Joe's 6174918582 748 Mem. Dr. "Magazine St. / Memorial Dr." Moore School citysprouts.org Charles River Reservation BU West, Green B BU Central, Green B	Kendall Square, Red Briggs Field	Charles / MGH, Red Esplanade Charles River Reservation Park Street, Green Boston Commons Boylston, Green Arlington, Green Copley, Green

Figure 3.5: *Details for greenmap of Cambridge, MA, US*

Note: Figures 3.4 and 3.5 from "An Environmental Primer for New Students" (GreenMap MIT, 2004).

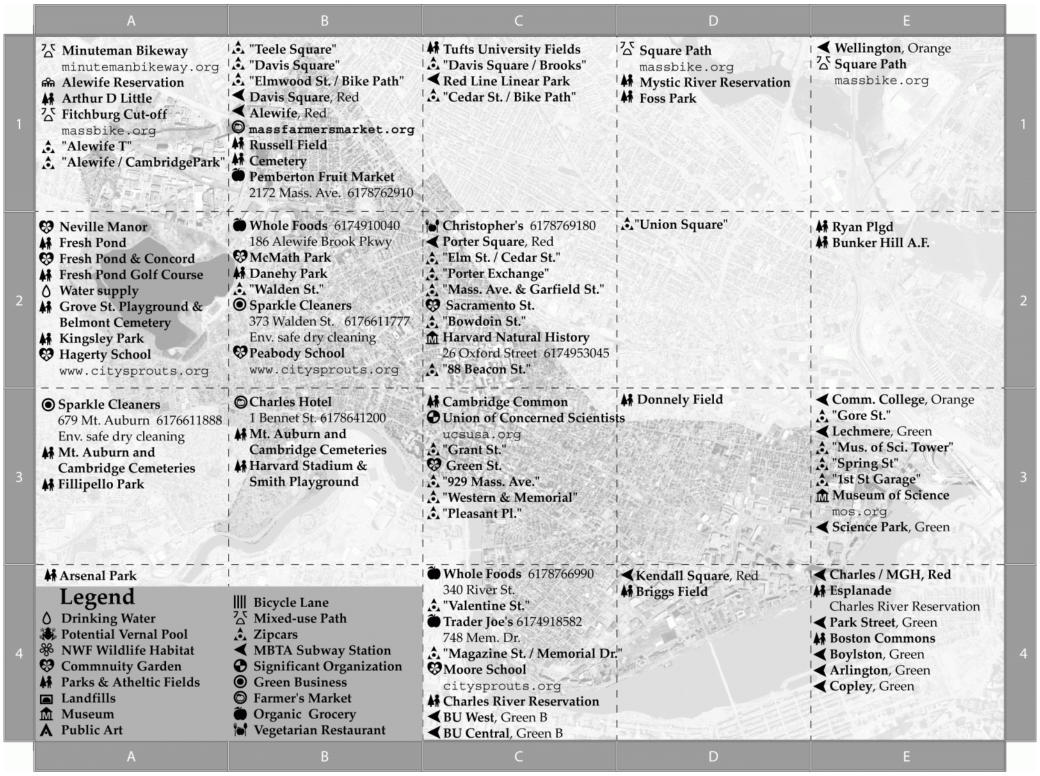


Figure 3.6: *Embellished details for Cambridge, MA, US greenmap*

4. Conclusion

It is a widely held belief among advocates that effective environmental education is vital to improving humanity's relationship with the natural environment. In pursuit of this goal, it is crucial that what limited political, human, and fiscal capital is available be applied as effectively as possible. Greenmaps have shown tremendous potential as a means of focusing grassroot efforts and educating participants; however, further research is required to evaluate claims of it being an effective tool for public education and determine if the model warrants further use and investment of effort for that goal. It is my belief that the greenmap model will indeed prove an effective means of educating the public. In order to maximize impact, though, greenmap-makers must pay particular attention to detail in constructing their maps.

It is my hope that future greenmap projects will show that attention since acquiring the data to map is only the first step towards a finished product. Careful selection is required to produce a consistently themed and useful map. I have given the example of a potentially effective, if imperfect, algorithm for selecting feature classes however similar attention should be given when selecting individual features. It is also necessary to convey the non-spatial content of a map--the feature details--as effectively as possible. Based on the interest expressed in my "battleship" method, by map users and readers of earlier drafts of this thesis, it appears to be a powerful tool for doing so.

Finally, existing greenmaps fare far better than I expected regarding their compliance with cartographic standards however there is room for improvement. While the glaring absence of some elements like a compass rose are what spurred my examination of the use of basic cartographic elements in greenmaps, it is the other, subtler, elements which are most lacking. Greenmap-makers must begin to include a publication date and a list of sources as well as the compass rose et al to be properly useful to more than the casual user.

Appendix A

Public Interest Worksheet

The Green Map System Icons Poster (GMS, 2003) was printed 2-up double-sided and used as the polling worksheet in a survey conducted to determine the public's interest of including feature classes on a greenmap of Cambridge, MA, US. Participants were asked to mark the icons for several types of features they would like featured on a map of the area.

Appendix B

Is there a more robust means of creating greenmaps?

There is a type of software known as Geographic Information System (GIS), specifically designed for handling spatial information like that which constitutes greenmaps. A GIS facilitates data sharing, organization, analysis and rapid prototyping. Many greenmaps are made without the benefit of a modern GIS (GMS, 2004a; D. Earle, personal communication, 2004, December 12); in the author's opinion too many, as the use of GIS could greatly benefit greenmap-makers. Two reasons for not using GIS to make a greenmap when adequate computing facilities are available are (1) the cost of software and (2) the learning curve, or lack of familiarity with the software, is too great. However both of these are specious claims, one of the more popular tools for creating greenmaps is Adobe Photoshop (GMS, 2004c), an arcane and expensive tool in its own right.

Commercial GIS packages are indeed expensive, however this does not mean GIS is beyond the reach of budget conscious greenmap makers. ESRI, the publisher of one of the leading GIS suites, offers grants to qualified groups making their software available at virtually no cost (Environmental Systems Research Institute, 2003). There are also numerous free GIS software packages available, some of them simplified and well suited to a beginners first foray into GIS. A good place to start is http://freegis.org/.

It is surprisingly easy to gain basic proficiency with most GIS software, particularly if new users are familiar with many other desktop applications. One might consider a GIS as a combination of a layer-based graphics program such as Adobe Photoshop, the user interface, and a database such as Microsoft Access. If this analogy is insufficient to place one at ease diving into a GIS, there are also many excellent tutorials available online such as ESRI's tutorial for the free GIS viewer ArcExplorer at http://www.esri.com/software/

arcexplorer/. Finally, as with most sophisticated programs, the effort put into familiarizing oneself with the application will be returned in greater productivity many fold.

As previously stated, GIS offers a map-maker many advantages over graphics software “data sharing, organization, analysis and rapid prototyping”. Many organizations and government agencies are likely to have data pertinent to a map-maker's project and this data is likely in a geospatial format. If one is using GIS to create a greenmap, this data can be used directly. Likewise, it is easier to share any information the map maker creates with interested officials if it is in a geospatial format. The GIS model of “Photoshop+Access” means that feature data can be tied to the graphic representation of the feature on the map, making it simple to keep all of the data for a greenmap neatly organized and in a single location. Additionally, it may be possible to (semi-)automatically create the list of map feature details depending upon the format used.

GIS allows rapid-prototyping of maps in two ways, through the ability to “write once read many” and by simplifying the map layout process. Because a GIS stores map features in a database, they may be selectively displayed. It is possible to use the associated data to filter feature classes, allowing for the creation of special map versions suited to different audiences or scales more readily than in a traditional graphics application. With a map easily containing scores if not hundreds of features, it can be difficult to create a clean, legible map. Fortunately, many GIS packages provide the ability to label features although this might normally be used to place text labelling roads. The genius here is that label positioning is not concrete; the application selects the most suitable location for the label so as to avoid overlap or another faux-pas. It is possible to use a GIS's labelling engine to automatically place features on a map handling such collisions in a user definable manner. removal of a feature from the map, displacement of a feature to avoid overlap, and aggregation of several adjacent symbols of the same class into a single feature on the map.

An additional advantage of using a GIS to create greenmaps is the potential to assign symbols to entire sets or layers of features at one time, instead of one-by-one as they are created with a graphics application. Because the GMS icons exist as a font, features must be added as text objects in graphics editors. Furthermore, this text entry requires the user to have memorize the symbol-key table or consult a reference. The most convenient reference is charmap or a similar tool however, they can only display the font and are ignorant of the symbol names and meanings. A GIS can make this process more convenient. For instance, I have a created a style for ArcMap--available at http://greenmap.mit.edu/ GMStyle.html-- that allows the user to choose symbols from a graphical menu with names. This ArcMap style has the added benefit of being configured to allow the use of several GMS icons as linear symbology.[1]

1. When using linear symbology it is important to simplify features for best results. Linear symbology is effected by repeating the chosen icon along segments of the line. However if there are too many closely spaced vertices on a line there will be gaps in the representation of the line on the map. For example, city-provided street data often includes a vertex at every intersection and very accurate representations of curved road segments but these extra vertices will cause a blotchy or disconnected appearance.

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