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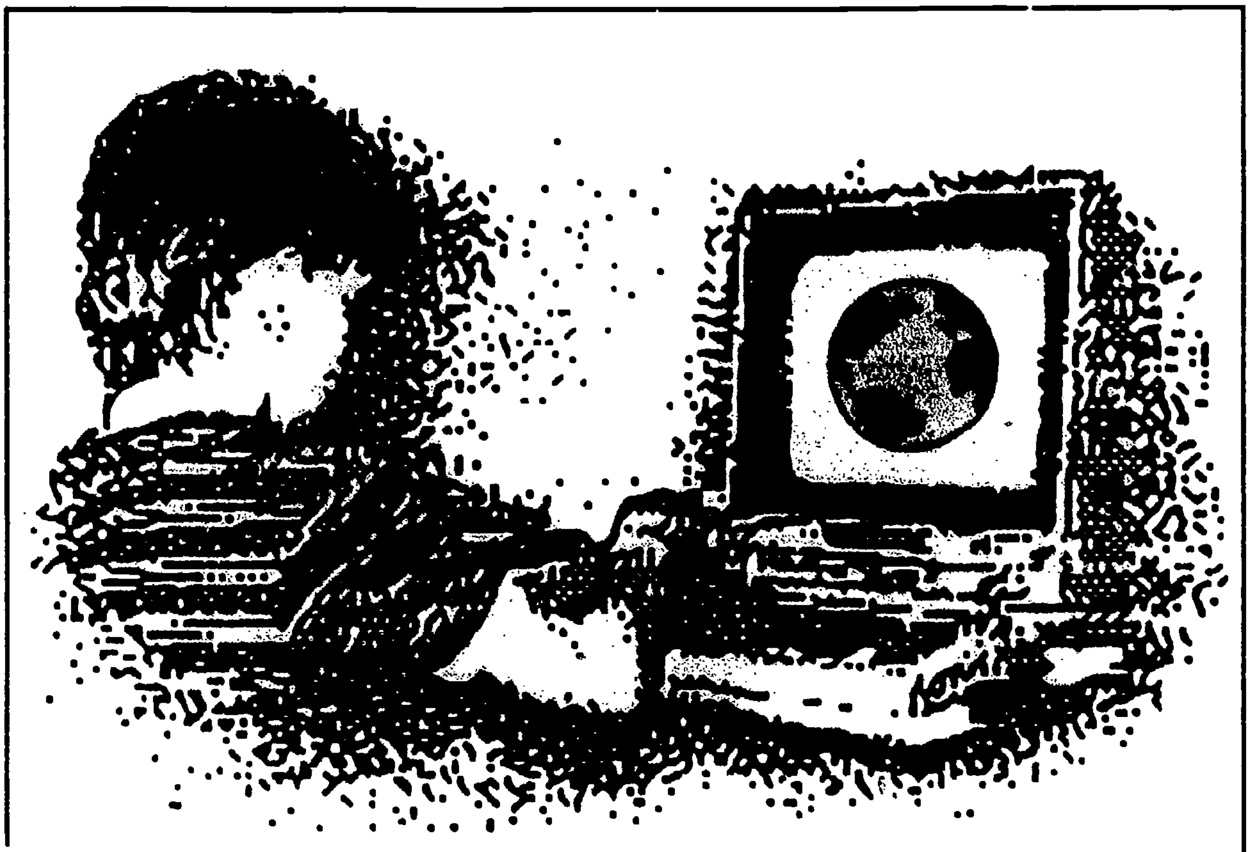
ABSTRACT

With creativity and innovation, environmental educators have begun wielding the ever increasing power of computers to promote and enhance environmental education. These pioneering programs and applications are the focus of this publication. This monograph is a sampling of the potential, problems and promises of this field. The four major content areas addressed in this publication are environmental hypermedia (including interactive videodiscs); environmental simulation/modeling; interactive software; and telecommunications. A list of additional resources which are not addressed in the articles is included. (KR)

COMPUTER-AIDED ENVIRONMENTAL EDUCATION



W.J. "Rocky" Rohwedder, Ph.D.
Editor

NAAEE
NORTH AMERICAN ASSOCIATION FOR ENVIRONMENTAL EDUCATION

COMPUTER-AIDED ENVIRONMENTAL EDUCATION

Edited by

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NORTH AMERICAN
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EDUCATION

Editor's Note:

With creativity and innovation, environmental educators have begun wielding the ever increasing power of computers to promote and enhance environmental education. These pioneering programs and applications are the focus of this publication. "Computer-Aided Environmental Education" is a sampling of the potential, problems and promises of this field.

To help set context, I've written an overview article which briefly describes the status of the field today and provides a summary of each of the four major content areas addressed in this publication:

- environmental hypermedia (including interactive videodiscs);
- environmental simulation/modeling;
- interactive software; and
- telecommunications.

The Table of Contents provides a listing of articles by area as well as a brief annotation describing the nature of each article. As you will see, the articles cover a very wide range of technologies, applications, and target audiences.

Because many new projects and programs were being created as this publication was under development, I've concluded with a list of additional resources which were not addressed in the articles. This is not a comprehensive listing, but it does represent many of the exciting new developments not covered by one of the contributing authors.

Finally, I would like to express my heartfelt thanks to the authors who took the time out of their busy schedules to share with us their insights and perspectives on this developing field.

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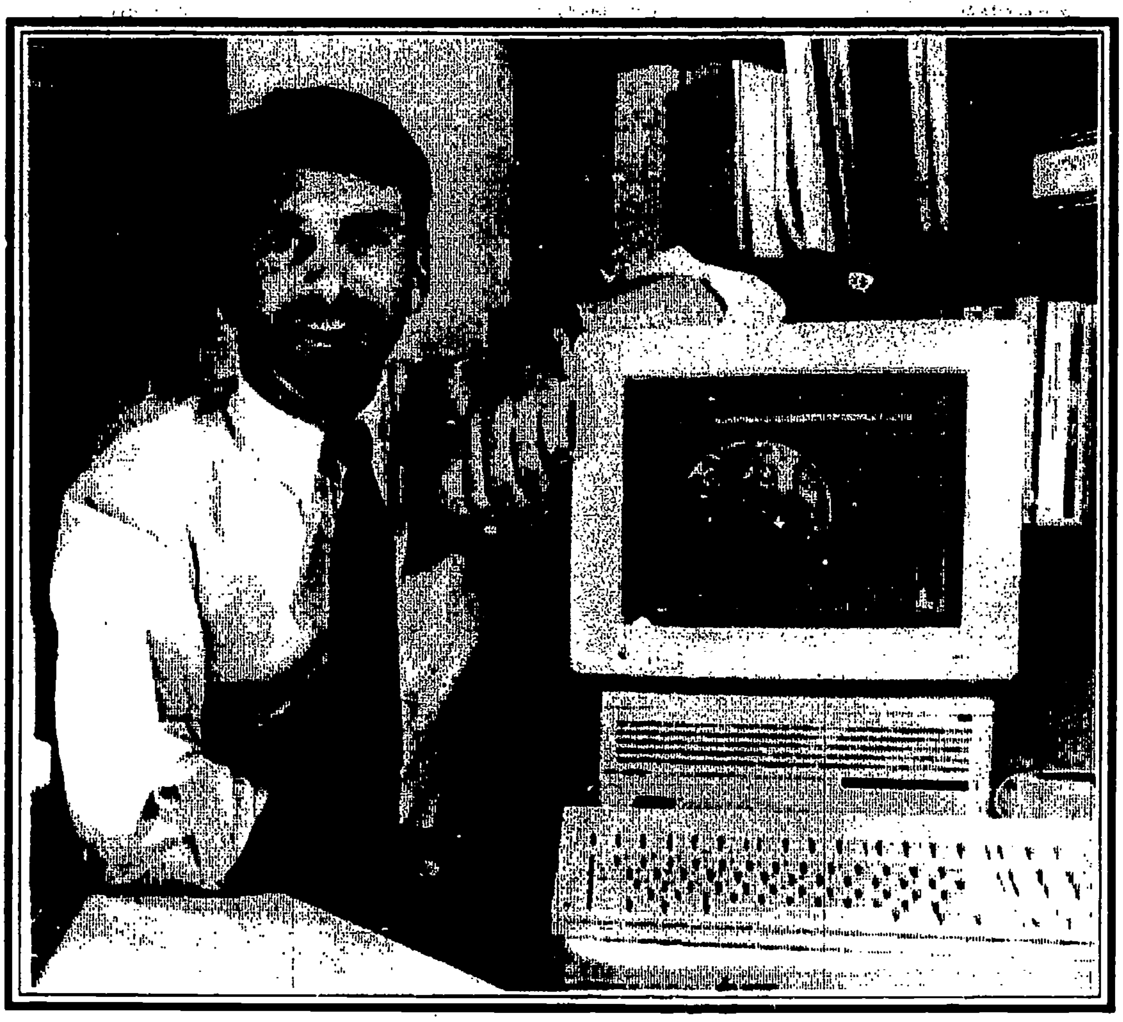

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A special thanks to Lori Mann for proof reading the final draft.

The North American Association for Environmental Education

The North American Association for Environmental Education (NAAEE) is a professional association established in 1971 to assist and support the work of individuals and groups in environmental education -- teaching, research, and service. NAAEE promotes the analysis and understanding of environmental issues and questions as the basis for effective education, problem-solving, policy-making, and management. It does not take formal positions on political or technical matters, except those relating directly to education.

NAAEE's geographic scope is international. The bulk of its membership is from the United States, but there is growing Canadian and Mexican membership, and additional membership from all continents (except Antarctica). Current total membership exceeds 1,000.

NAAEE is organized in three interactive sections, each conducting specialized activities responsive to its members. The sections are: Conservation Education (CES); Elementary and Secondary Education (ESES), Environmental Studies (ESS), and Nonformal (NFS). Professionals within these sections address the following audiences: the general citizenry, fellow educators at all levels, K-12 students, those who make or facilitate the making of major decisions affecting the environment (e.g., government officials, scientists, journalists, and environmental resource managers (e.g., water resource managers, park managers).

NAAEE is involved in two primary program thrusts: the annual conference and publications activities. The conferences have been recognized since the early 1970s for their quality and applicability to the field. They provide a rich mix of invited speakers, paper presentations, workshops, symposia, field excursions, film and video festival, resources fair, exhibits, and more. NAAEE publishes an annual conference Proceedings and is engaged in the occasional publication of Monographs, such as this one, dealing with topics of particular and timely interest. A compendium of Recent Graduate Studies in Environmental Education and Communications, containing abstracts of master's theses and doctoral dissertations in environmental education, is published every other year. A bimonthly newsletter, The Environmental Communicator, features Association-related and more general information.

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TABLE OF CONTENTS

COMPUTER SIMULATION/MODELING

INTERACTIVE SOFTWARE

TELECOMMUNICATIONS

TELECOMMUNICATIONS (Continued)

COMPUTER-AIDED ENVIRONMENTAL EDUCATION: PROBLEMS AND PROMISES

W.J. "Rocky" Rohwedder
Sonoma State University

Overview

It takes a while to become adept at utilizing any new technological tool. It takes *creativity and dedication* to seek the very best applications possible. It takes *practice* to become skillful. It takes *experience* to learn where it does and doesn't work.

Computer-aided environmental education, the utilization of computer technology to promote the goals and objectives of environmental education, has recently passed through an era of adolescence -- a time full of contradictions and mistakes born of inexperience. Today, while still in the early stages of development, computer-aided environmental education is moving forward with a new sophistication and depth. Given the progress to date and the possibilities for the very near future, computer-aided environmental education may prove to be our most powerful educational tool for promoting everything from environmental awareness to environmental action.

While environmental education as a whole has a significant history and acknowledged professional standards, *computer-aided* environmental education is truly an emerging field, still offering a vast expanse of uncharted territory filled with both problems and promises.

In the pages ahead I will highlight the current state of computer-aided environmental education. I will begin by discussing four fundamental problems which require our careful attention and mitigation. I will then present four areas of advancement in computer-aided environmental education which offer tremendous potential to significantly enhance the effectiveness and positive impact of our field.

Problems

There are numerous inherent and potential problems related to Computer Aided Instruction (CAI). These problems apply to all forms of CAI, including those which promote environmental education. A recent study by

the Office of Technology Assessment (OTA, 1988) entitled "Power ON! New Tools for Teaching and Learning," noted planning and preparation as fundamental roadblocks to increased utilization of CAI in the United States

Some of the most significant problems noted in the study were 1) lack of teacher and district planning and preparation, 2) limited teacher knowledge of recent developments and applications, and 3) inadequate training which focused on how to use computers as opposed to how to teach with computers.

Below are four additional problem areas which I feel are important to consider. The first two relate to computer aided instruction in general and the second two have particular relevance to environmental education

Some of these problems are inherent limitations of the medium. Others represent our tendency to let technology dictate our choices instead of first establishing our goals and then wielding our technologies to serve them. I've labeled these four problem areas as

- unfounded euphoria
- equity of access
- environmental substitution
- environmental impact.

Unfounded Euphoria

Give me a hammer and everything begins to look like a nail

Following the introduction of any new technological tool there is almost always a period of euphoria. Unfortunately, that euphoria soon fades as unrealistic expectations go unfounded, associated costs are discovered, and resistance to change is encountered. In our zeal to apply computer aided instruction and communication to promote environmental education, there have certainly been examples of "trying to fit a square peg into a round hole." We need to remind ourselves that we don't have to use the technology just because it exists. Just because it's on a floppy disk doesn't mean it's necessarily worth our time and attention

We need to replace overzealous computer euphoria, as well as computer phobia, with a more sophisticated understanding. This understanding includes knowledge of the diverse technical landscape, assessment of costs

and benefits of computer utilization, and careful attention to achieving the best match between technological tools and desired educational outcomes.

· **The best computer-aided environmental education is achieved when we do not allow the misapplication or inherent limits of computer technology to compromise what we know about how people think and learn.**

Equity of Access

The OTA study revealed that the average number of computers per 30 students has continually increased since 1983. However, in spite of that increase, in 1987 there was only slightly over one computer for every 30 students in high school and approximately 0.8 computer/30 students in elementary school. While this represents a national average, the ratios are even worse in areas where educational programs are poorly funded.

The utilization of computers in support of education therefore raises several important questions of equity. Who gets access to computers? What are the monetary costs associated with computer-aided educational tools? In light of those costs, who can afford to participate? Unless both the hardware and software are kept at reasonably low-cost, the utilization of computers will only be affordable to a few. The result could be an increasing gap in the quality of educational services accessible to learning populations of different economic status.

In order for computer-aided environmental education to be effective, it must also be affordable and accessible to all.

Environmental Substitution

Computer-aided environmental education could be viewed as a cost-effective, time saving and academically sound replacement for direct contact with the biophysical environment. Why not use an interactive software program on wetlands instead of taking a field trip to the wetlands? Why gather first-hand data on climate or water quality when you can get it through an on-line database? Why go bird watching when you can access a videodisc of 50,000 color slides of birds, cross referenced and selected at the push of a button?

The more time we spend at a computer, the less time we may spend with other people and/or the biophysical environment. Increasing

utilization of computers could promote an environmental substitution which limits the interaction between people and the natural world.

Computer-aided environmental education has positive potential only when used as a catalyst, and never as a substitute, for field based instruction or exploration.

Environmental Impact

It can be argued that computers are used in a variety of ways to benefit the environment. For example, they can be used to improve the efficiency of mechanical systems, thereby saving energy. Because telecommunications can increase communication between geographically distant individuals, it can help to reduce the need for regular face-to-face meetings, thereby saving the fossil fuel used in transportation.

On the other hand, numerous negative environmental impacts are by-products of computer utilization. The production of high technology components makes use of toxic gases, solvents, heavy metals and volatile organic compounds that can adversely impact workers, communities and the environment. Huge amounts of contaminated waste by-products are generated and must be handled and disposed of properly. Recent data from Silicon Valley reveals that the local industry disposed of more than 100,000 tons of hazardous waste off-site and discharged over 12 million pounds of toxic waste into the environment. In addition, the high tech industry is probably the world's largest single source of chlorofluorocarbons.

Add to this the increased electrical demand from computers, printers, and monitors. Throw in the the reams of paper used by computing and you've got a considerable set of waste and pollution problems associated with computer-aided EE.

Computer-aided environmental education must be held to the same environmental impact assessment we would give any technology. Only judicious use can result in a positive net impact on the biophysical environment.

Problems in Perspective

As documented in ancient Chinese philosophy, a situation filled with inherent danger is also a situation filled with inherent opportunity. The

articles in this monograph outline successful and effective computer-aided environmental programs and projects. They must all, however, be viewed in light of some fundamental questions around the impact of technology (La Porte 1974, Winner 1986, Berberet 1987). The basic questions asked of technologies during the past three hundred years (in both capitalist and socialist nations) have primarily been limited to concerns of economic gain or military clout (Toffler, 1980). Today's technologies, even when used to promote environmental education, must pass far stiffer tests, including ecological and social impacts as well as economic and strategic.

These questions of technological impact and choice lie at the heart of the emerging field of computer-aided environmental education. Technology is not value free. Technologies can shape values and values can shape technology. Different ideas of social and political life entail different technological tools for their realization (Winner, 1977 and 1986).

The coupling of computers and environmental education suggests that these technologies should be evaluated with criteria that range beyond cost, efficiency, and acceptability in the marketplace to include suitability to social contexts and consistency with desired goals (De Forest, 1980).

Promises

In spite of the fundamental problems outlined above, computer-aided environmental education presents a whole new set of extremely powerful tools for promoting, as perhaps never before, the goals and objectives of environmental education.

Computers now offer environmental educators an uncharted teaching and learning frontier. Four fundamental areas, which are described in the pages ahead, show tremendous promise for enhancing the effectiveness and positive impact of environmental education. They are:

* Environmental hypermedia with the associated utilization of laser videodiscs and CD-ROM

* Environmental simulation or modeling of complex systems

* Interactive environmental software

* Environmental distance learning/action projects supported by telecommunications.

Environmental Hypermedia, Videodiscs and CD-ROM

One of the most promising new frontiers for computer-aided environmental education is the development of Hypermedia and laser videodisc technology. Hypermedia (sometimes know as "interactive multimedia") combines several instructional technologies to form an extraordinarily powerful medium. Color video images, sound, text and searchable data all come together in a multisensory, highly dynamic learning frontier.

At the heart of this medium is the laser videodisc, an inexpensive, easy-to-use visual storage and retrieval technology. Vast amounts of audio and visual information can be stored on a single laser videodisc, thereby creating a visual database. As many an 54,000 images can be stored on each side of a 12-inch disc and these images can be programmed in any combination -- slides, graphics and motion clips. For comparison, a two-sided laser videodisc has the information equivalent of 5,000 double-density floppy diskettes! With a search command, any of the 54,000 images can be accessed in a few seconds. The stored sights and sounds are displayed on a color video monitor. "CD-ROM" technology offers storage capabilities similar to that of the laser videodisc.

The basic components of an interactive videodisc system are a laser videodisc, a videodisc player and a video monitor. Link to this basic system a microcomputer and you've entered the world of "hypermedia" -- an educational environment where learners have the opportunity to explore integrated graphics, animation, color, sound, randomly accessible video segments and text. The result is a completely new multi-sensory learning environment.

(To explore this further, see the additional resources section and the articles that follow by Lynch; Huning, Palmer and DiSilvestro; Hunter; Golden; and Cisler.)

Environmental Simulation/Modeling

Simulation and modeling programs can demonstrate in a visual, dynamic format, the complex interaction of environmental systems as well as the impacts of human activity. Computers allow us, as never before, to

simulate complex systems and to investigate the implications of our actions before we initiate them.

Systems which are familiar and of immediate interest can be simulated (within defined limits), providing the learner with new insights into their fundamental behavior. These new programs allow students to explore environmental systems in a new, mind-expanding way. Powerful lessons about entropy, rates of growth, and compounding feedback loops are brought from the level of abstract conceptualizations to a visual, quantitative reality.

We can all appreciate the self-regulating, balancing forces within natural systems as well as the importance of a "systems view" of the world around us. Communicating a clear understanding of this phenomenon, its complexity, and its importance in terms of human impact, is indeed a difficult task for any environmental educator. Now, with the aid of interactive, visually-oriented computer simulation or modeling programs, educators can demonstrate and students can explore, the complex interaction and interconnections of ecology and economy.

(To explore this further, see the articles that follow by Meadows and Fiddaman: and Odum and Odum.)

Interactive Environmental Software

Instructional software has made some major advances in the last few years. There is good news for those of us who explored the first-generation "environmental computer software" only to be bored stiff by lackluster programs with little or no supporting curriculum. Much of today's environmental education software is significantly differently than in the recent past. A new generation of graphic, interactive environmental software programs now enable self-paced, learner-centered environmental investigation and education.

There are several fundamental differences in this new generation of software. Animation, sound, color and pictures now enliven a software world which was previously occupied almost exclusively by words and numbers. In addition, "courseware" has replaced "software." The new generation of environmental software is part of a comprehensive courseware package which includes teachers' guides, student materials, and supporting visual aids Today, the better programs are part of a

comprehensive educational package, not just a floppy disk.

A whole new generation of "authoring programs" (such as *Hypercard* and *Course of Action*) can also be added to this more sophisticated approach to environmental computer software. This software provides the novice user with the power to generate customized programs tailored specifically to their educational context and objectives. The ability to undertake computer "programming" has rapidly moved from the limited domain of "technical specialists" to within the grasp of the "garden variety" environmental educator.

(To explore this further, see the additional resources section and the articles that follow by Wilson; McConnell; Kramer and Galo.)

Environmental Distance Learning and Telecommunications

Low-cost telecommunication tools allow us to dialogue and cooperate directly with students and educators around the world (or across your bioregion). Using readily available technologies, in a matter of seconds we can send and receive information from around the planet -- thereby shrinking the planet in time and space to the scale of a "global village."

For example, without leaving our desks or classrooms, environmental educators can network with like-minded educators around the world whom we have never met before, search a database for the best curriculum, discover currently available grant funding, look for a job in the environmental field, advertise our products or services, receive the latest environmental news stories, download environmental software, or receive on-line consulting from experts in a wide variety of fields (Newton and Rohwedder, 1990).

Our students, for example, can search comprehensive environmental data bases or instantaneously share field data and correspond with other classrooms across the nation or across the oceans.

Whether you're a teacher, a student, a resource specialist, or an advocate, the environmental distance learning opportunities made available by today's telecommunications technologies exhibit tremendous potential.

(To explore this further, see the articles that follow by Leland; Wals, Monroe and Stapp; O'Shea and Kimmel; Julyan; Robottom and Hart; Civille; McClaren; Hamilton-Pennell; Hodges; and Alm.)

A Look to the Future

Although we have only begun to explore the possibilities of this field, computer-aided environmental education clearly offers the opportunity of linking, interacting, experimenting and learning as never before. While there are indeed numerous impressive efforts to date (many of which are documented in the articles that follow), I must underscore that we are only beginning to understand the potential synergy between computers and environmental education.

Computer-aided environmental education has the potential to provide students with a rich, powerful, stimulating, and personal as well as global learning experience. This new learning frontier appears at the time in our planet's history when we may need it the most.

We can dismiss computer-aided environmental education because of the problems outlined above or we can explore, with care and creativity, how these new technological tools can be coupled with what we already know about effective environmental education.

I hope that in the pages ahead you will find an idea, an approach, or an actual project that will make good sense in your day-to-day context and encourage you to explore first hand the problems and promises of computer-aided environmental education.

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HYPERMEDIA FOR ENVIRONMENTAL EDUCATION AND THE LIFE SCIENCES

Patrick J. Lynch
Yale University School of Medicine

Nothing worth learning can ever be taught. (O. Wilde)
Experience is the best teacher. (Anonymous)

Acknowledging these aphorisms as valid ought to deflate complacency and inspire experimentation with new educational methods. Computer-aided instruction, appropriately applied in specific disciplines, may, in fact, have now achieved such power as to challenge such cynicism.

PC's (Personal Computers) as PLW's (Personal Learning Workstations)

Technical advances in personal computers (PC's) over the past few years offer educational opportunities undreamed of until recently. Early educational use of PCs focused primarily on their capacity to manage text and perform computation. Instructional design in that model created a succession of computer screens filled with text and numbers, presenting an austere, unexciting environment, little likely to sustain student attention or commitment. At best, that older teaching metaphor seemed to treat computers as if they were enhanced versions of books. On the other hand, current instruments, when combined with ancillary equipment (particularly videodisk players and CD-ROM storage devices) are capable of evolving into "personal learning workstations". (PLW's) These workstations offer a much enhanced educational environment since they can integrate graphics, animation, color, sound, randomly accessible video segments, and manual interaction (mouse and touch screen – "pointing and clicking") (Cook, 1988). The variety of sensory stimuli these instruments can support allows a totally novel instructional design in which images and "reality-simulation" play central roles. A key theme underlying the more advanced use of these tools is expressed by the recently coined term "hypermedia." Hypermedia (Nelson, 1987) implies a unique capacity to manage large collections of complex information including images, and thus permits educational applications not solely limited to text.

The term "hypermedia" should not be confused with "multimedia,"

which is merely a mix of audio-visual techniques. "Hypermedia," by contrast, connotes a highly integrated electronic environment allowing a user to interactively peruse a very large assembly of electronically linked information consisting of real-time moving color video images, sound, text and electronically searchable data. Implementation of the "hypermedia" concept as a distinct instrument-cluster has been promoted by several manufacturers. One well-known example is the Macintosh (Apple Computer Inc., Cupertino, CA) employing HyperCard software. Examples of other hypermedia software options on the same computer platform include SuperCard [Silicon Beach Software, Inc., San Diego, CA] and Course of Action [Authorware, Inc., Minneapolis, MN]). Hypermedia as an authoring activity has been assisted by the highly intuitive nature of the graphical user interface on which the Macintosh is based (Kay, 1984) and which seems ideally suited for instructional applications since it appropriately presumes minimal computer literacy on the part of the user (i.e., student). Alternative implementations of similar software environments are expected to be shortly forthcoming from other manufacturers (IBM, NeXT, Sun, DEC, and others).

The most important distinguishing feature of these hypermedia products, however, stems from the fact that they are constructed in a software authoring language which is modular and remarkably accessible to the non-programmer educator. The ease of authoring by non-programmers, and the modular properties of the software provide an ideal environment for educational development since the "domain experts" directly control the software (and thus the "look and feel" of the application) rather than being compelled to translate their needs to a professional programmer. Groups of educators working together can cooperatively construct a project in an iterative fashion since the software is so modular. Using hypermedia tools the author (or authors) can control the appearance of the user interface, the mechanism of the user interaction, display of data, display of video (sequences) and sound passages in a simple high level programming language that can be learned with minimal effort.

Don't Emulate Books

Intuitively, PLWs should have considerable advantages over books as conveyors of information. The most compelling reason is that a considerable portion of human learning arises from non-semantic, non-text, experiences

and must be conveyed to the mind through multiple senses. Images, in general, can never be reduced simply to words, no matter how eloquent. Books admit that fact by incorporating illustrations; but the physical limits of print media practically restrict the numbers of figures to a few hundred per printed volume, to say nothing of a book's complete inability to convey sound (unless the rustling of pages is considered pedagogically valuable). To the extent that efforts in computerized instruction are limited only to screens of text, societal acceptance will be understandably slow since little advantage over books would be evident and the value-added of electronic media debatable. Hypermedia, on the other hand, offers a greater educational opportunity by stimulating nearly all the human senses, often simultaneously. The attention-garnering capacity of that aspect of electronic media is indisputable, but caution must be exercised lest educators be accused of emulating video-games and other such lesser-valued aspects of modern culture.

One mechanism for determining which educational subjects might be most appropriate for "electronic authorship" is to consider those topics where print-based teaching runs into difficulties. Using that yardstick, one might defer efforts on ethics or reading and instead focus on subjects which traditionally have required the tutorial method or those that require field-work. From that perspective, the life sciences offer many attractive opportunities. These include many biologic topics where observations of animal forms, their sounds and motion are a critical part of learning. Another highly eligible field is professional-level instruction in medical diagnostic imaging where tutoring has always been the norm.

Greater Than the Sum of Its Parts

Though at first glance hypermedia might be examined as individual components, in actual use, computerized-integration creates an entity greater than the sum of its parts. This is particularly evident when the student must learn how a sound connects with a certain motion (say a bird call in a teaching module on animal behavior) or, for example, the advantage a computerized graphic-animation offers the medical student in simplifying complex organ motion. Only a computer, and no other tool – whether human-interaction or print-media – could offer the sequence control, user-adjustable speed of display, data logging, and continuous repetition available in computerized hypermedia.

Educators must realize, however, that this tool does not necessarily make the task of teaching easier but rather makes new forms of educational experience possible and more powerful. In fact, hypermedia inherently makes instructional design more complex. Conventional lectures and books are relatively forgiving media and require less planning on the part of the author. Linear progression of thought, neat compartmentalization of subject matter subdivisions, and minor forgivable digressions all are conveniently allowed in traditional lectures and publications. Hypermedia, however, places stringent demands on authors which in fact arise from the properties which give hypermedia its strength. Linear instruction when transformed into hypermedia makes the subject matter multi-pathed, or randomly addressable by the student, who can pursue any path motivated by curiosity rather than be restrained to a teacher-defined direction and pace. With hypermedia, the student is offered multifaceted connections placing him at the center of a lattice with dynamic links between subject segments defined on the fly. The material must now flow in a "student-centered" rather than "teacher-centered" manner, with each segment endowed with a rich, varied, and visually inviting form so that the student's interest is peaked and sustained. In hypermedia, nothing happens unless the student initiates it, and thus the media is more in concert with the conditions under which most natural learning proceeds.

Projects in the Life Sciences

Our hypermedia projects have focused on life sciences. The topics were chosen because they appeared most amenable to computer technology and lay in areas least well addressed by current teaching methods. The requirements for subject selection were that the topics inherently rely on moving video sequences as an essential feature, possess relevant sound materials, and have issues that could be enhanced by computer graphics. The choices were thus narrowed to the two fields of animal science and diagnostic medical imaging. Both areas had videodisks available for incorporation into the hypermedia modules. In the medical imaging subject we used a videodisk of our own devising but in the animal science we "repurposed" commercially available videodisks. "Repurposing" is the incorporation of preexisting videodisks made by other authors into a comprehensive hypermedia module of one's own construction. The only essential requirement is that the commercially available videodisk be

sufficiently indexed so that the position (frame numbers) of sequences and content of the videodisk be known to the new authors. Many videodisk publishers courteously provide a printed index but in the future it can be hoped that computer-coded indexes in a common file format might be included with published videodisks.

Two natural science modules developed by author are entitled "Bird Anatomy" and "Whales." The bird module uses a videodisc entitled "Encyclopedia of Animals, Vol IV, Birds 1 (Laser Disc Corporation of America Inc., 200 W. Grand Ave., Montvale, NJ 07645) and the whales module uses a disk entitled "Whales" (National Geographic, Washington, D.C. 20036). Both are CAV (constant angular velocity) videodisks. CAV disks permit computer controlled access and play of any single video-frame or sequence from 54,000 images on one side of the disc (1/2 hour of run-time video) with frame search times in the range of 1.5 seconds or less. Such control is called Level III operation and is usually achieved through serial connection from the microcomputer to the videodisk player.

Natural Science Modules

The bird module is authored in HyperCard. It is intended to comprehensively teach the anatomy, physiology and behavior of birds. As the application opens, a master menu screen (Figure 1) offers the student access to indices, videodisk directories, text discussion, graphics and sound, all navigated by pointing the mouse at various icons. As a requested path executes many of the common navigational icons (as well as an in-program help facility) remain visible on the screen and may be invoked in order to provide orientation. (Figure 2 shows a graphic that results from mouse-clicking the button "Head" on the master menu.) If the path taken by the student merits runtime video, digitized sound, "pop-up" text (Figure 3), or animation, these items are automatically evoked as the student clicks on a content icon; otherwise the item remains labeled and available as an option for the student to click electively. When videodisk sequences are invoked, they have their own video sound channel containing bird sounds, commentary or still-frame range maps, but only of sequences appropriately paired to the content of the adjacent computer screen. Digitized audio of bird sounds can be invoked and played as often as needed until they become comprehensible. The videodisk, professionally produced by the studio of a large corporation, contains high quality video including rare birds that would

be beyond the reach of the average educator. Yet this computer media offers a means by which such content can be personalized and integrated into the individual teaching curricula of a whole host of educators. In addition to the dynamics of the video, computer animated graphics, student-invoked by pressing and holding the mouse button over an appropriately labeled icon, offer explanations of complicated aspects of dynamic anatomy - particularly the operation of muscles and wings (Figure 4) but also of more abstract concepts such as the ventilation of the lung. Text commentary, electronic glossary searches and references are invoked by clicking on "text" icons or on body parts of the graphic figure.

The whale module is authored in SuperCard and thus employs a full-screen color-graphic interface on the Mac II. The icons are larger than the usual "mouse-click" size in order to allow for the cruder positional accuracy of touch-screen activation (MicroTouch Inc., Woburn, MA). Opening the application produces a dynamic color graphic of a breaching whale which dissolves into a directory with icons designated to take the student to segments on anatomy, social behavior, environment, etc. In keeping with the graphic metaphor, however, most features on the computer screen are sensitive to touch. Touching the whale's eye causes branching of the program to a discussion of eye anatomy and invokes a videodisk sequence, complete with sound commentary that deals at length with that organ. Other body parts such as the blow-hole, fins, etc., receive similar treatment.

Authoring Systems

The advent of any fundamentally new type of software inevitably brings with it the problem of describing the program meaningfully to those who have not yet used it. When VisiCalc, the first of the popular microcomputer spreadsheet programs appeared, writers struggled for metaphors to explain the advantages of the new program. Descriptions such as "sort of like a word-processor for numbers" were intriguing, but failed to communicate the nature of the program to most readers. Hypermedia authoring languages (such as HyperCard, SuperCard, Course of Action, Course Builder, etc. for the Apple Macintosh, Linkway [and perhaps InfoWindows] for the IBM) have suffered similarly in reviews because they do not easily fit into established categories of microcomputer software. HyperCard, for example, is part graphics program, part database, and includes a built-in programming language (Williams, 1987). HyperCard allows users with little or no previous

experience in traditional computer programming languages to integrate text, audio and video material, computer graphics and animation into educational and training applications that take full advantage of the Macintosh's easy-to-use graphic interface (Goodman, 1987). The central concept underlying HyperCard applications is hypertext.

In a hypertext application users browse through a system that is designed to extensively link and cross-reference text, graphics and audiovisual information in a non-linear, interactive format that responds to the user's requests for more information on a particular subject. For example, to get further information on a word or graphic the user would simply point at the area on the computer screen and click the mouse button. The program would then branch to another card, or play a video sequence, or call up new text from disk or CD-ROM, or in some other way bring a new set of related information to the user. Thus the user explores the program in a heuristic, self-paced manner that takes full advantage of the computer's ability to organize, correlate, store and retrieve information. While it is not a substitute for database management software, HyperCard shares some structural features with conventional database programs. Text is stored in fields on cards (cards are analogous to records in conventional database terminology), and can be searched and sorted rapidly. The program also incorporates a full range of paint graphics tools and a powerful English-like programming language, HyperTalk. The metaphor HyperCard files use is a stack of index cards, and HyperCard files (referred to as "stacks", as in a "stack of cards") are collections of cards containing screen buttons, text fields, paint graphics and other familiar components of the standard Macintosh user interface. The card is the fundamental unit within HyperCard stacks. Individual cards in a HyperCard stack occupy the full screen area of a Macintosh Plus or SE (342 by 512 pixels) in a black-and-white display. On a Macintosh II, cards occupy about half the area of a 13-inch monitor. HyperCard allows only one card to be visible at a time regardless of screen size. Recently released programs available from other vendors (e.g. SuperCard from Silicon Beach), functioning as "supersets" of the HyperCard syntax, offer authors the opportunity to work in color over the full area of high-resolution large-screen monitors with multiple windows. Users browse through HyperCard applications by moving between cards much as a stack of index cards can be flipped through, one at a time. Cards are composed of two independent layers, a transparent foreground layer

containing graphics, buttons and text fields unique to a particular card, and a background layer of graphics, buttons and text fields which may be shared by many cards.

Unlike most "procedural" programming languages HyperTalk is an object-oriented language tied to the various components (buttons, text fields, cards, backgrounds) which make up a HyperCard stack. Short pieces of HyperTalk code are attached to objects in a stack and do not execute until a specific event occurs — such as when a user of a HyperCard stack clicks the cursor on a screen button to initiate some action. All of the basic HyperCard objects can be created, moved, resized, and visually re-styled by choosing options from pull-down menus. It is this modularity in the programming language that allows multiple authors, working in concert on a common project, to be highly productive since it fosters individual responsibility for subsets of the project, with later easy integration into a single assembled program.

HyperTalk as an Authoring Language

The HyperTalk language interpreter within HyperCard is a simple object-oriented language (APDA 1987), as opposed to linear, procedural languages like BASIC, Pascal or C. In an object-oriented language nothing happens until the user actively initiates an action on the part of the program, usually by clicking on a screen button. "Mouse button down," "mouse button up," "new card" and "open stack" are all examples of common events occurring as a user navigates through a HyperCard application. Each of these events sends a message to HyperCard objects. An object with an event handler for that event takes action when the event message is received. Objects created within HyperCard exist in a hierarchy, and messages pass through that hierarchy seeking handlers aimed at controlling the event. If the user clicks down on a screen button that does not contain an instruction to act on the "mouse button is down" event, it passes the message to the card, the card background, the stack and finally to HyperCard itself. Any of the objects deeper in the hierarchy may be programmed to respond to "mouse button is down". Thus the foreground objects in the hierarchy (like buttons) can "inherit" capabilities from objects deeper along the chain (like card backgrounds), and large numbers of buttons on different cards can act on HyperTalk instructions attached to the card background (or stack) they all share. Scripts attached to the stack itself can control the actions of all

objects on all cards within the stack. This avoids the necessity of having to individually "tell" every object within a stack how to react to a specific action the user takes. Once the object-oriented structure of the language is understood writing scripts ("scripting" is the HyperCard parlance for programming) in HyperTalk is comparable to using a very forgiving, English-like implementation of BASIC. HyperTalk contains a wide array of basic programming constructs for repeat loops, if-then-else and Boolean true-false logic operators, mathematical functions and operators, text-handling routines and allows direct HyperTalk control over the properties of all HyperCard objects and painting tools. HyperTalk's handling of variables is particularly convenient, since local temporary variables may be created and used "on-the-fly", without prior declaration. Text may be imported from text-only (ASCII format) documents, conventional tab or comma-delimited database and spreadsheet files and HyperCard may be programmed by the user to accept and reformat other types of text files. Custom "Function" subroutines written in HyperTalk script (similar in concept to Pascal FUNCTIONs) are also possible. There are also extensive sound and visual effects commands available.

HyperCard allows the creation of five different classes of objects: buttons, text fields, cards, card backgrounds and stacks. Objects are created by choosing the appropriate command from pull-down menus ("New Button," "New Field," etc.). Once a button or text field has been created it can be moved around the screen and re-sized by "picking it up" and moving or stretching it with the mouse, much as objects are moved and stretched in an object-oriented drawing program like MacDraw (Apple Computer, Inc.). Double-clicking the mouse-button on an object brings up a dialog box that allows the user to choose names, visual styles, text styles, icons and other options appropriate to that class of objects. HyperTalk scripts are attached to objects by opening up a script editing window from the dialog box attached to every object HyperCard creates. Several features of the script editor allow easy "de-bugging" of defective scripting language. HyperCard automatically offers the option to edit a defective script (with a pointer showing where the language failed) when encountering problems executing the script of an object. When the user holds the mouse button down while the cursor is within the "Animation" button a short repeat loop cycles continually until the mouse button is released.

In addition to the programming possibilities offered by HyperTalk's

standard 250-word command vocabulary HyperCard's native capabilities may be extended and customized through the addition of HyperCard words to which special-purpose segments of Pascal or C-language code are attached. These so-called XCMD or XFCN resources allow the HyperTalk language to control virtually any device with a serial interface, such as videodisc players, CD-ROM drives and other audio-visual and computer equipment. Once installed into a HyperCard stack, the functions of a resource are typically operated with simple English-like commands such as Video Play, Video Step, Video Slow, etc.

The Apple Programmers and Development Association (APDA) offers a number of ready-to-use resource extensions to HyperTalk of particular interest to audiovisual application developers. The APDA video resource adds thirty-three English-like HyperTalk videodisc commands to HyperCard, allowing it to control five models of interactive videodisc players; the Sony 1500, the Pioneer LVP4200 and LDV6000A, the Hitachi 9550 and the Panasonic TQ2024F. Resources allow HyperCard stack authors to incorporate digitized audio sequences, color graphics and other capabilities not native to the standard out-of-the-box version of HyperCard. Resources are copied from one HyperCard stack to another in a simple cut-and-paste operation using the Apple resource editor ResEdit, available from APDA and most Macintosh User's Groups. Although fully-developed HyperCard stacks may look and act much like stand-alone application programs in compiled Pascal or C, HyperCard stacks can only be opened and run under the control of the HyperCard program. This dependence on the presence of HyperCard is a relatively minor drawback, since Apple includes the program with every new Macintosh sold.

Hardware Considerations

The minimum hardware necessary to run HyperCard is a Macintosh Plus with at least 1MB of RAM, a hard disk drive and Macintosh operating system version 4.2 or greater. SuperCard, which allows projects incorporating color, full screen and multi-windows, on the other hand requires 2MB of RAM memory and best shows its strength on a color Mac II system. Although HyperCard and application files can be run from systems equipped with two 800K floppy drives, HyperCard performs sluggishly due to the large size of the program and the application stacks. Complex HyperCard stacks dense with graphics and screen objects tend to be quite large, averaging

about 10K per card. In our experience the videodisc commands available from HyperCard have worked quite well with our Pioneer LDV6000A videodisc player. Although the HyperCard Video resource command set (see above) does not fully address all of the capabilities of the LDV6000A, we are using the "SendSerial" resource successfully to send hexadecimal command strings from HyperTalk scripts directly to the player to achieve "endless-loop" track jumps and other commands unsupported by the video resource. Currently it is not yet possible to develop a HyperCard-based interactive videodisc application running on a single monitor due to requirements of appropriate video display monitors and video overlay hardware which are not expected to be widely available until 1990. Thus, at least for the present year, HyperCard-generated interactive videodisc applications are likely to remain double-monitor configurations (computer screen and a separate laser disk video monitor).

Conclusions

Apple's HyperCard is just one of a number of microcomputer programs which implement interactive hypertext concepts for educational applications. The mouse-driven graphic user interface of the Macintosh operating system have gained wide acceptance by microcomputer users. The ease with which HyperCard allows the graphic "look-and-feel" of interactive videodisk programs to be redesigned make it an ideal tool for creating "shell" test programs in the course of designing complex projects involving iterative development by multiple authors. Hypermedia learning environments which incorporate videodisk image storage accessible by microcomputer control provide a powerful instructional tool which lets electronics substitute for much more time-consuming tutorial efforts.

The fundamental importance of object oriented programs for educational applications is that they not only offer opportunities to segment and compartmentalize portions of the subject material but that the programming code has the appearance of natural language. Because HyperCard scripts are generally not compiled, each item can be isolated and its code examined not only by the original author but by other potential authors seeking to modify it. This inaugurates a major opportunity for "groupware." Educators may desire to work in groups or have a lead player design the first sketch and allow other contributors to alter, customize or modify material to fit local student circumstances without changing the

overall look and feel of the program. It would be as if a textbook was published in looseleaf form with chapters or even pages resulting from the combined efforts of multiple educators or even end users. Thus, barring proprietary issues, authorship can become dynamic and evolutionary. Even complete programs could be viewed as a shell in which the end user can participate in modifying. Ideally a "good" teaching module could evolve over time into a "perfect" module by the gradual accretion of contributions from later users.

The modern educator must now cope with a number of novel circumstances. Without seeming to be overly anthropomorphic, it is essential that the educator think of the microcomputer as a partner in the control of the students' interaction. This metaphor is not intended to romanticize the instrument, but rather requires the author to recognize that some human machine interactions may directly appear to the student as if they were human-like. The educator must have the maturity to adapt and take advantage of this potential power; none the less recognizing the limits of electronic media. It is inconceivable that a successful learning interaction can occur without inviting student initiative as its core. Psychological experiments with passive, as opposed to active learning have confirmed this obvious point. It is essential therefore that the media in some way provoke and sustain student curiosity. Curiosity cannot be stimulated without a variegated experience which contains not only sound, texts, color graphics and animation, but also some manual interaction on the part of the student. The experience must include variable tempo, drama, humor, surprise and adapt to varying levels of student concentration. To date, considerable efforts have been made to employ electronic media to assist in analytic and rational processes, but the emotional portion cannot be neglected. For the moment, the novelty and complexity of controlling a multimedia environment may have distracted educators and resulted in over-emphasis of its entertainment capacity. But the burden of authorship has become more complicated because of the increased number of variables that can now be offered to the student.

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Authorware, Inc., [Course of Action software] 8500 Normandale Lake Blvd., Suite 1050, Minneapolis, MN 55437

Silicon Beach Software, Inc., [SuperCard software] 9770 Carroll Center Road. Suite J, San Diego, CA, 92126

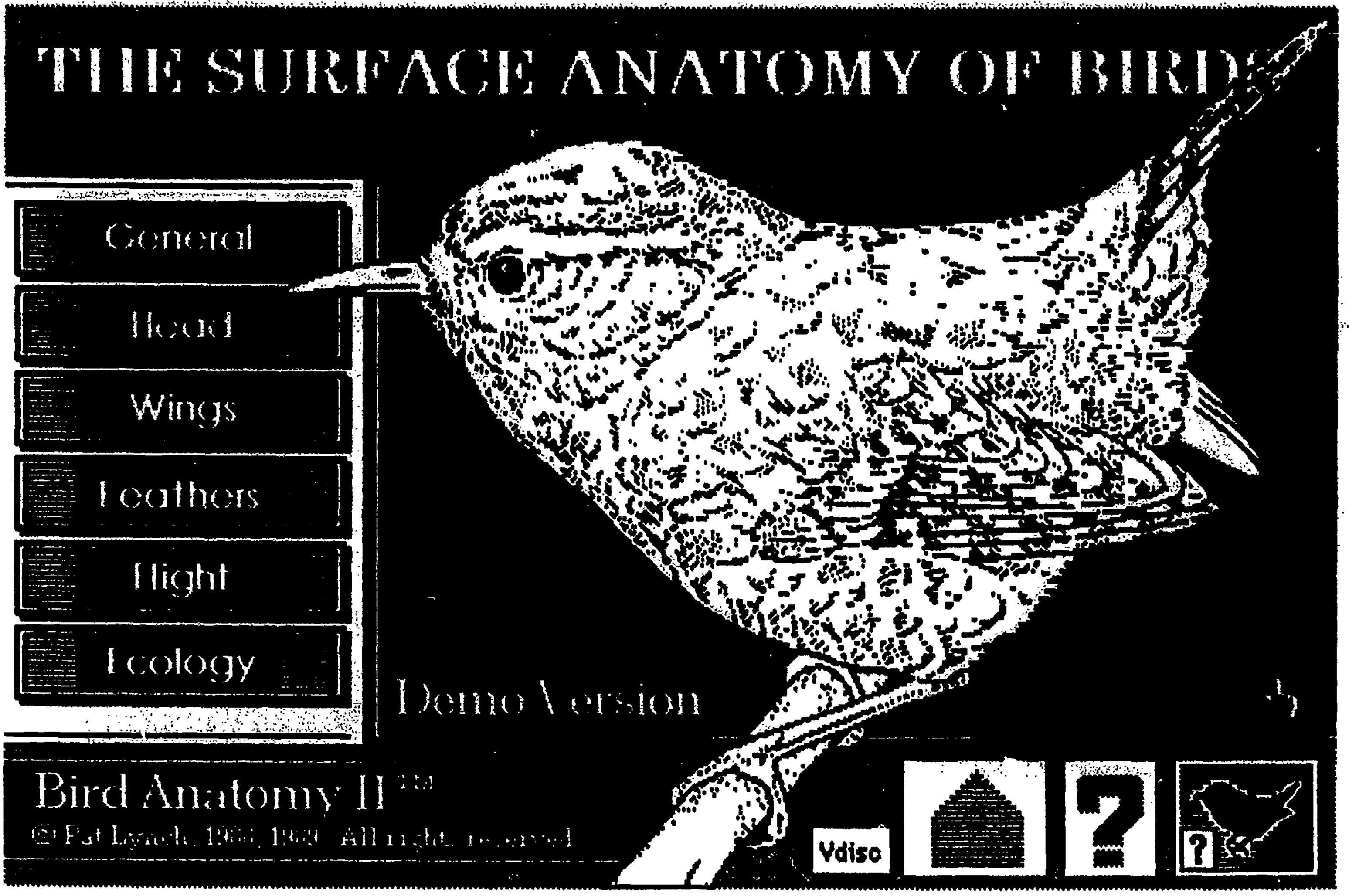

Figure 1 Master Menu Screen

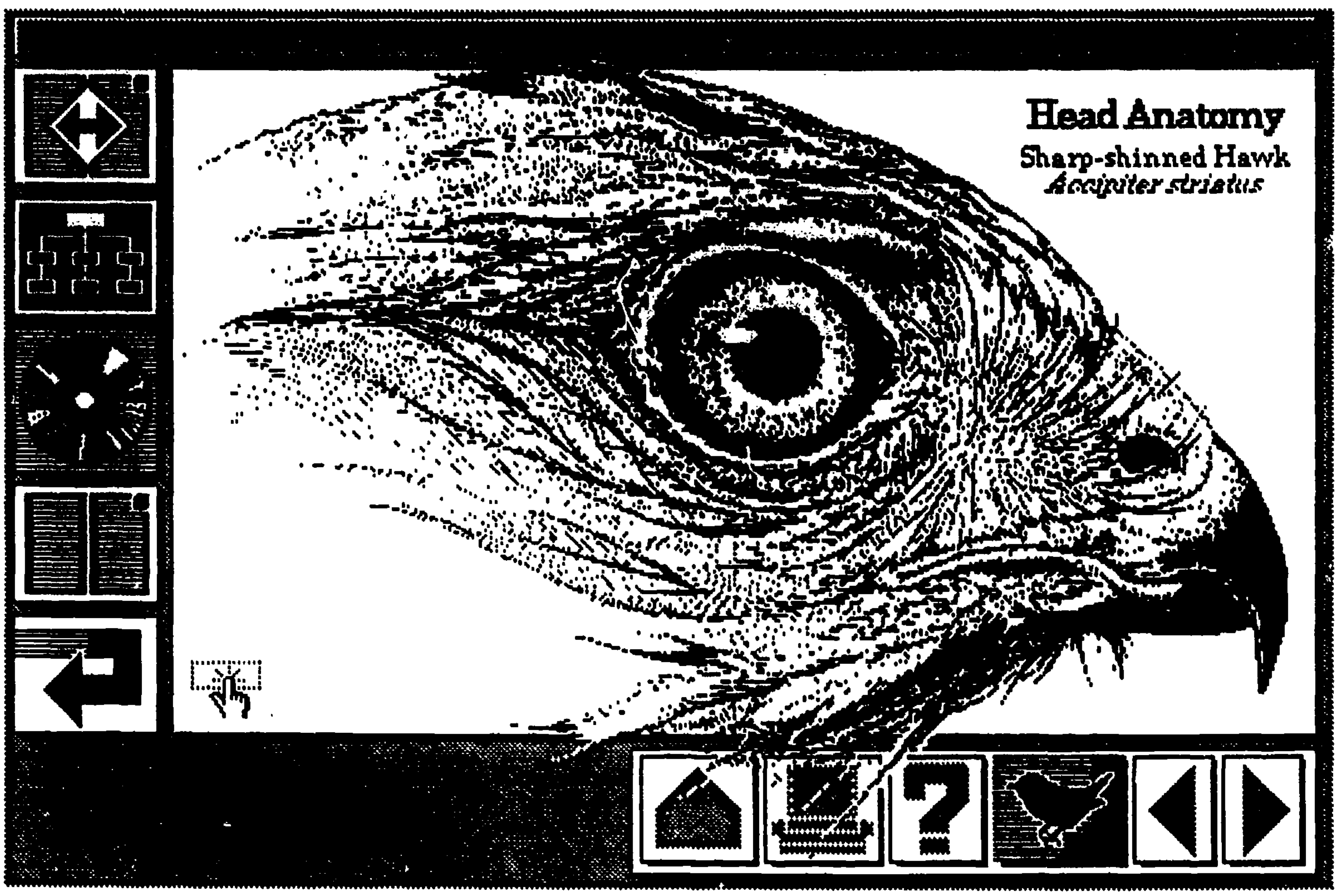

Figure 2 Head Anatomy (from Master Menu)

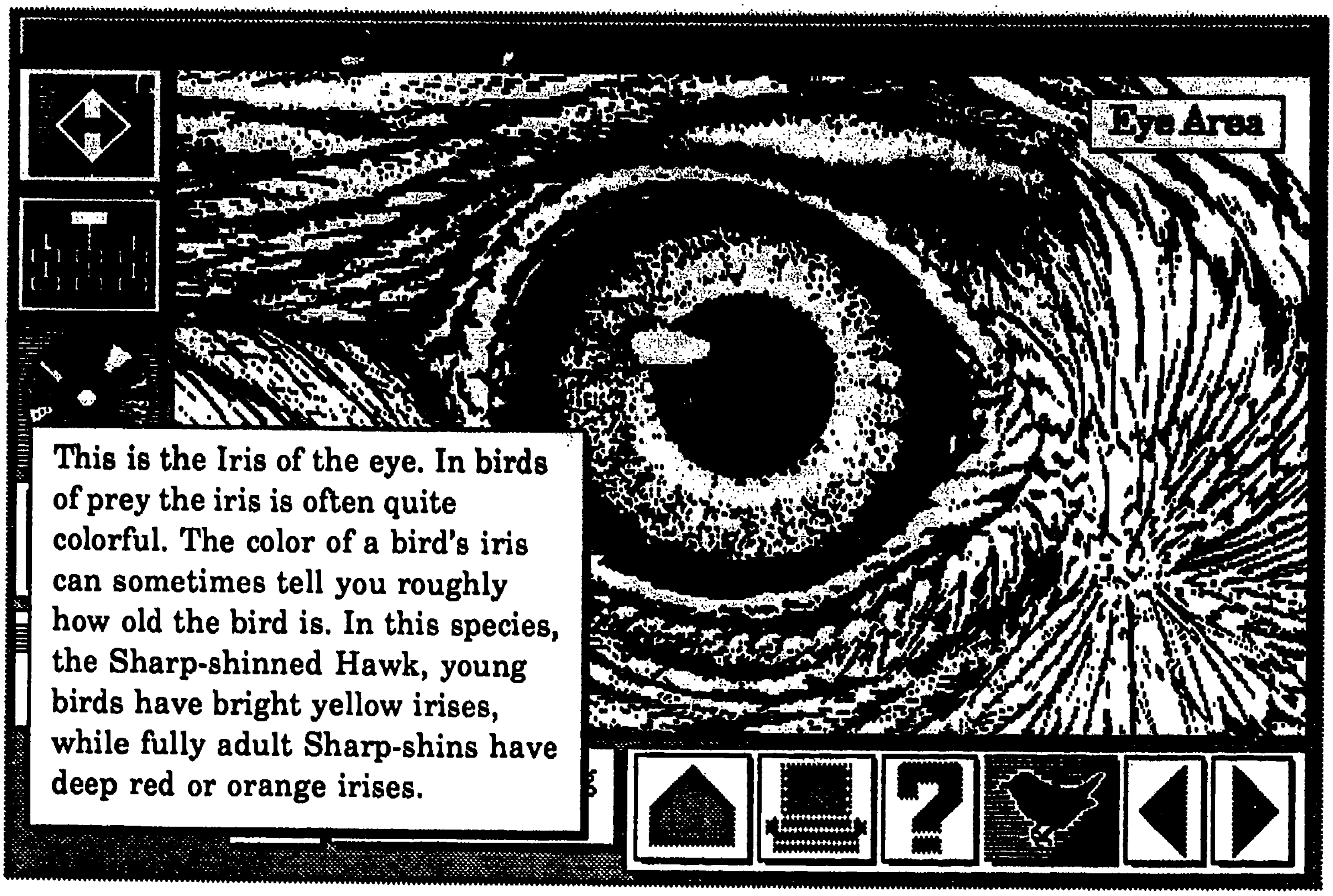

Figure 3 Sample of Pop-up Text

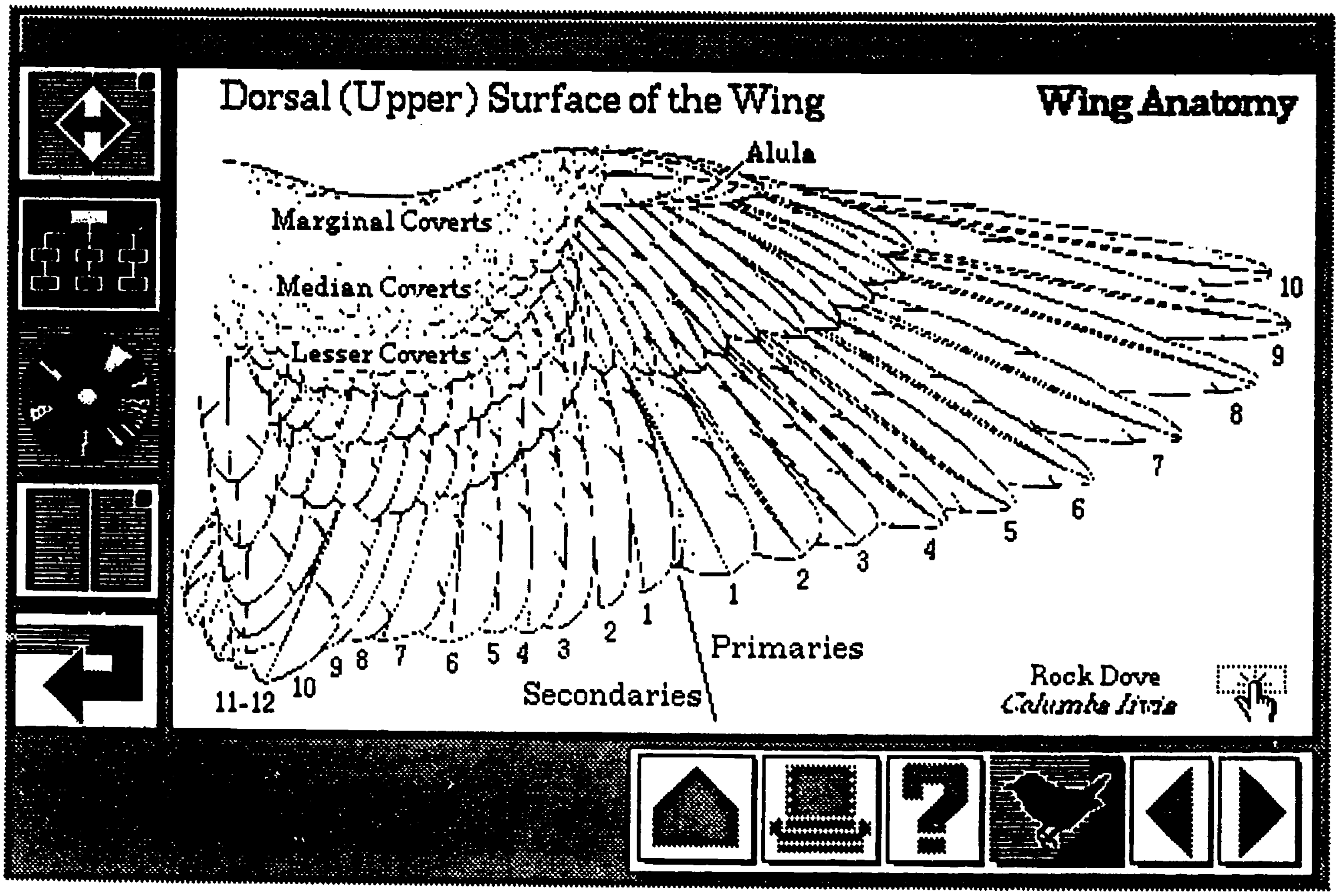

Figure 4 Sample Anatomy Card

THE MYSTERY OF THE DISAPPEARING DUCKS: AN INTERACTIVE MULTIMEDIA DESIGN EXAMPLE

Beth Huning, Christopher Palmer and Roger DiSilvestro
National Audubon Society

Overview

Environmental educators agree that every effort should be made to get students into the outdoors for field study, but field trips are sometimes impossible, and interactive multimedia offer the best substitute yet devised.

Just what is interactive multimedia? The term describes a free exchange of information among different types of media, in this case video equipment integrated with a computer program that provides access to a database. The operating equipment consists of a Macintosh computer, laser videodisc player, and a television or video monitor. These are interconnected to allow a HyperCard program to exchange information between the computer which drives the program and other equipment. In addition, the format is flexible enough to enhance any field experience and to provide an extension of that experience in the form of visuals of many subjects that may not be seen in the field.

Students love to use computers, and interactive multimedia is a very fluid format which puts them in control of their own learning process. For a creative teacher, it is a springboard from which to launch supplementary class activities. Many teachers are still intimidated by computers, but multimedia is so non-threatening, simple, and flexible that students can take charge. The teacher's role becomes that of a facilitator and not an expert. Given the number of curricular areas in which teachers are expected to have expertise, this role is very appealing to creative teachers.

One of the most sophisticated multimedia programs is the Paul Park Ranger Mystery, a new computer-based educational program that integrates film, text, graphics, voice, and music to create a single multimedia learning system. The program is a design example, or prototype, developed in 1988 as a co-venture of National Audubon Society, Lucasfilm Limited, and Apple Computer. It is a forerunner of future Audubon multimedia programs now in development. The prototype is unique in that it is the first multimedia program designed for classroom use that links moving video footage to an

informational computer program. It was designed and produce by representatives from the three partnership organizations, each bringing a different expertise to the overall product. The design ideas were inspired by a student team from Marin Academy in San Rafael, California.

Designed to demonstrate how this new technology may be used as a teaching tool for high school students, the prototype presents information about both declining natural wetland habitats and wildlife populations and the complexity of issues surrounding their loss. The program is developed in the form of a mystery and is designed to help students develop analytical and decision-making skills as well as enhance their sensitivity to environmental issues. To solve the mystery, students must uncover clues that are displayed pictorially on the computer screen.

Goals

When this project was launched in February 1988, the first step was to identify what the final product would be and to outline the process by which it would be completed in five months, and meet the design-team goals.

Each participant brought to the project specific expertise, among which were exceptional programming skills and facilitation of the design process. Being able to design a program that incorporated all of the goals of the participants was a major challenge in itself.

Initially, no one knew how the final product would look or how it would operate because this prototype was truly innovate. Some businesses, such as the aircraft industry, were using multimedia programs for activities such as flight simulation, and there were other programs in use by the medical industry or museums utilizing similar equipment to catalog volumes of photographs or illustrations. But a similar project had never been developed for educational purposes. Developing a new educational program, particularly one for environmental education, meant beginning with the basics of program design and developing the process before conceiving or envisioning a final product.

Audubon has been active in environmental education since the advent of the Audubon Junior Clubs more than fifty years ago. Audubon has published educational materials, operated nature centers, and conducted extensive teacher-training programs, among other activities. Integrating environmental education into wildlife-protection issues has always been a

focus of the society, and Audubon is always looking for new ways to produce educational materials using innovative technology to communicate to students the message of the need to protect wildlife habitat. Staff wanted assurance from the other partners that information would be presented accurately and that the program would be educationally valid. Audubon was also interested in presenting information to students about environmental concerns in a detailed, interesting way. Audubon educators were searching for a new format to reach the multitudes of high school students often excluded from environmental education because of an inability to go into the field due to class schedules or lack of interest or information on the part of the teacher. Audubon viewed this new technology as a way to achieve these goals and augment the already successful *Audubon Adventure* program for middle-elementary-grade students. Teaching classroom students about wetlands has always been a challenge. Attempts to address these complex natural habitats and the issues surrounding them in a classroom setting are relatively new. Audubon viewed multimedia as technology with potential to expand education activities to the more advanced school population and to create a citizenry informed about such complex issues.

Apple and Lucasfilm were interested in expanding the potential for educational interactive multimedia and in developing a product that used moving video footage in an interactive and interesting way. Hence the student design team from Marin Academy entered the picture. The involvement of the seven students and their teacher played a significant role in the outcome of the final product and were pivotal in achieving the goals set by Lucasfilm in particular. The two corporate partners also wanted to use the design process to find the most efficient, cost effective method of production for future programs.

All parties agreed that it was important to develop a program that empowered students to be responsible for their own learning, that emphasized long-term versus short-term decisions for the environment, that focused upon the reduction of critical wildlife habitat as an underlying theme, that presented material in a problem-solving context, that incorporated the viewpoints of various individuals concerned with protection or land use, and that avoided trying to tell students the "right" answer. This last goal was somewhat disturbing to students who are conditioned by right and wrong, clearcut answers to problems.

Methodology

Establishing the Design Team

Development of the multimedia projects was a long process. Months before the project commenced, Audubon Television producer Christopher Palmer was exploring various ways to use the Audubon television programs for educational purposes. He had been impressed with interactive multimedia and persuaded Apple to become involved. He then asked Audubon's West Coast education staff to participate in designing and writing the program content. Members of the Lucasfilm Games Division staff, in particular Craig Southard and David Lawrence, the senior designer, facilitated the design process. Participants included Beth Huning and Pamela Armstrong from Richardson Bay Audubon Center and Sanctuary, Margo Nanny from Apple's Multimedia Lab in San Francisco, Pat Roberts of Lucasfilm/Apple, and Christina Hooper, a biology and ecology instructor at Marin Academy High School.

Marin Academy was selected as the design and pilot school because of proximity to Lucasfilm's Skywalker Ranch, where the program was produced. Christina Hooper, an innovative instructor, was selected to coordinate the students and represent the school on the team. The selection of an exclusive private school was of concern because students in this particular school are not necessarily representative of the population as a whole. However, the positive advantages of working with this school outweighed any drawbacks. Students and teacher were able to be flexible in their scheduling to allow for participation in the meetings and field trips the project required, a complex scheduling problem that many public schools would be unable to accommodate.

Selecting the Student Design Team

Based upon their skills, students were selected to provide input into project design and content. Examples include artistic ability, creativity, group cooperation, leadership, and willingness to participate knowing that they would, on occasion, miss other classes and be required to make up work. They were selected from the student body as a whole. Many of them had not been Christina Hooper's students. A prerequisite was that they were

not avid Macintosh users. In fact, most did not have have computer skills whatsoever, and this initial lack of computer training ultimately contributed to a sympathetic team designing a program for other students who are not computer literate. Another prerequisite was that the students reflect no particular environmental ethical bias. In other words, these students initially were as likely to favor construction of a shopping mall in a marsh as to support marsh protection for birds, open space, and flood control. A total of seven students were selected for the team, a group small enough to work together efficiently, yet large enough to generate a multitude of ideas and allow for flowing group dynamics.

Developing the Conceptual Design

Initially the design team met weekly. These meetings included students as well as the professional design team. The first few meetings were to acquaint the design team and the students with each other, the participating organizations, and the conceptual idea for the program. Student assignments included learning to use Macintosh computers so they would be able to understand how programs might operate. They also watched the entire series of Audubon television programs. Students discussed the content of the programs in their meetings and brainstormed about how the information might be presented in an interesting way to others. Not surprisingly, the students were most impressed with the programs that focused on the larger, more visible forms of wildlife, such as whales, panthers, and cheetahs, rather than with the programs that dealt with environmental issues. However, the protection of wetlands and the challenge of finding a method to teach about the importance of wetlands was of primary concern to Audubon. Therefore, the theme of wetlands and their protection was ultimately selected as the concept for the initial program.

The Audubon film, *Ducks Under Seige*, and its 40 hours of unused video footage and numerous interviews of wildlife biologists, conservationists, hunters, farmers, and developers were selected to illustrate wetlands loss. At that point, students were assigned research projects and were required to watch the film more intently to learn about wetlands issues and the various complexities surrounding the issues.

Determining Methodology to Present Information

The next phase included a series of day-long meetings with the design team. In taped interviews, students were asked about their classroom experiences in an effort to determine the best and least effective instructional strategies.

The overwhelming consensus was that these students preferred to take responsibility for their own learning and wanted to be a part of the learning process rather than just having information delivered to them. They felt very strongly that all sides of an issue should be presented and that students be allowed to make up their own minds about values based upon the information presented and not be told how to view issues. They were not enthusiastic about a role-playing simulation that was not real and where they often were required to play adversarial roles contrary to their own developing values. This interview process validated what educators know but often ignore when designing programs. This feedback from students guided the entire design process.

Once this consensus was reached, the team discussed the most effective way to present information, and the mystery format was selected. The student team was reminded that this design must be appropriate for use in a variety of school settings including urban inner-city schools. Throughout the process they remained sensitive to other user populations.

However, the student's role in the design process was not yet finished. In fact, their creative imaginations had only begun to be tapped. The students brainstormed about how the story line of a mystery of disappearing wetlands would unfold and the writing and design team compiled their ideas and developed the educational concepts around them. The student team created and named the character of Paul Parkranger, developed the concept of the cabin as the "home" screen, and furnished the cabin with items that could ultimately contain information that would help users solve the mystery. The students even envisioned how these furnishings would appear, and those with artistic ability tried their hands at illustrations that were later transformed by Lucasfilm artists. The entire design team envisioned a presentation format that could become expandable should this program, or a similar one, be produced as a final product. In addition, the format could lend itself to other Paul Parkranger mysteries.

Having these detailed ideas from which to develop the program design,

the educators, writers, and programmers began interconnecting information into a visually inviting computer program. Student participation verified that pictures were worth more than many, many words and that linking pictures with sound held even more intrigue. The more the instructions could be presented by graphics, the easier the program would be for all users to operate.

Conceptual Design

The underlying goal in program development was that all content and program directions link together to be truly interactive with each other and with users. A combination of sound, visuals, graphics and text do not guarantee an interactive program. All of these must interact at some time but be randomly accessed by student commands. Students must be able to move freely to access information and shift freely among the screens.

The Mystery of the Disappearing Ducks uses a Hypercard stack operating on a Macintosh SE to drive a video-disc player (Figure 1). A Mac Plus does not provide the power or contain the memory required to drive such a complex program. The Hypercard program is standard issue with the SE computer. Hypercard, for those who are not familiar with the program, operates like stacks of cards on a desk. The user can dig deeper into one stack and continue to uncover additional information, then back out and skip around to other stacks. Hypercard seems to be especially suited for informational and educational purposes. The videodisc contains footage of interviews with ecologists, hunters, farmers, and others. View of migrating ducks and their wetland habitats as well as other footage illustrate the concepts in the program stack. Students navigate within the stack, moving from item to item, by placing the cursor on various items in the picture of Paul Parkranger's room (Figure 2) and clicking the mouse to command the computer to access specific information and action contained in the items. For example, clicking the cursor on Paul's diary allows students access items within it.

The program begins with a captivating visual introduction accompanied by sound effects that set the tone for the mystery and the action that follows. Digitized duck silhouettes on the Macintosh screen are suddenly mirrored by silhouettes on the video screen that turn into images of real, full-color

flying ducks. As students navigate the program to solve the mystery, the learn why waterfowl populations are declining and look at some possible alternatives that might enable both wildlife and people to coexist.

Content

During the developmental phases, a basic concern was that the program present a format by which students can access information to enable them to clarify values about environmental issues. One of the most difficult concepts for students to grasp and for teachers to present is that of long-term versus short-term environmental impacts.

Using disappearing wetland habitats as an underlying theme, learners are exposed to some of the natural and human-caused impacts on wildlife populations. They also learn why wildlife populations are declining. However, to gain such insight, students must search for the information location in pieces within the various parts of the program. By compiling the information, they learn about the complex issues affecting the health of wildlife populations and, ultimately, the integrity of human life. Wetland wildlife populations are declining because of habitat destruction, and students are introduced to various opinions as to where, why and how wetland conversion to other uses affects both wildlife and humans. They are also challenged to evaluate how important these wildlife losses really are. There are real characters within the interview file that express strong viewpoints about wetland conversion, pro and con. Students must them refer to other areas of the program to gain information about the value of wetlands as flood-control mechanisms, spawning areas for fish, natural filtration systems for pollutants, open space, or other values. They learn that not all agricultural development is essential for food but is economically driven. They gather information about how much wetland already has been converted to other uses and how much remains. They are even introduced to regulatory processes governing wetlands. Learners must look for ways to balance the needs of people with those of wildlife.

Truly interactive programs do not just deliver information, but also pose questions and provide ways for students to develop potential solutions to problems. The program design team wanted students to question and investigate the causes of change in their environment, not just accept information given to them by a program that functions like a sophisticated

version of a book, as some computer education programs do. The mystery format lends itself to this angle.

Three main concepts are buried within the program. These are the needs of wildlife, the needs of people, and the issues surrounding both as they affect the world's remaining wetlands. Several other themes are addressed within each of these conceptual areas and can be accessed through the on-line resource guide.

To illustrate the ability of interactive multimedia to teach informational content, a simple course in duck biology is introduced. By clicking the mouse on a picture of a duck (Figure 3), students are introduced to concepts about feathers (Figure 4), feet, beaks, and feeding. At key points, information within the stacks will automatically trigger a video segment to augment the computer program. Students can investigate waterfowl migration by clicking on a map on the wall in Paul's room. The map appears on the video screen, and pathways on the map actually shift to show migration patterns at selected times of the year. Pictures are automatically accompanied by a sound track that describes the life of waterfowl at that particular season. The visuals and sound help students to understand the need for wetlands preservation along a flyway. Students also learn why wetlands are important to wildlife and people by watching a "video tape." By clicking the mouse on the picture of a video, real video is triggered, and Paul Parkranger describes wetland values as different types of wetlands are defined.

The issue of human impact on wildlife is addressed in various locations within the program. Although a section illustrates the effects of salt water intrusion on fresh water marshes and includes corresponding scientific experiments, the most comprehensive information, as well as the most sophisticated ability to interact with the computer, is contained in the interview file. By accessing the file (in the picture of the file cabinet, of course), students are able to select from a menu of about a dozen different questions ranging from "What are the factors that determine the health of waterfowl populations?" to "Is all agricultural development necessary?" and "What are the prospects for the future?" Displayed on the computer screen are pictures of twelve individuals who can be selected to answer the questions. There are profiles on each person so that students know a bit more about the individuals they will be interviewing. The user clicks on a photo and the person appears on the video screen and gives a short

narrative describing their viewpoint on the question. (Figure 5) Students are able to access varying opinions and, by compiling information, synthesize their own answers to the complex questions that are presented. Combining these varying viewpoints with the information about wetlands and waterfowl, students are able to put together pieces of information that ultimately enable them to see the values of wetlands and people alike and, it is hoped, to formulate some suggestions as to how to protect remaining habitat. To assist with this ultimate goal, there are other areas within the program that inform students about wildlife laws and the regulatory process.

The interactive nature of the program is demonstrated in places where students and teachers can post current information about wetland issues within their own communities. Visual and auditory prompts throughout the program encourage students to investigate all areas of the program. These appear as telephone calls or messages from Paul Parkranger and are accompanied by interesting bits of natural history. There is a journal in which students can keep track of their progress and answer questions as well as make notes and do assignments. The design team intended the journal to operate on line and also be available in duplicate printed form.

Resource Information

Features useful to the teacher are contained in an extensive on-line reference section (Figure 6). These include activities, discussions, and background information that are extensions and applications of program content and a variety of useful and interesting resources and tools with which to convey the concepts and objectives. These flexible resources enable teachers to add their own information to the program and thus aid the next user. The resource guide also provides links to other curriculum areas and program objectives.

The Mystery of the Disappearing Ducks was designed with a flexible format. Ideally it can be used as an interactive program using the mystery to discuss and formulate solutions regarding environmental problems, but it can also serve as an illustrated lecture from which to present information. If used in presentation form, the class may focus on a particular area of study within the program, for instance duck biology or the political, social, and economic issues associated with declining habitat.

Opportunities and suggestions for class discussion and activities are

incorporated into the system and with the accompanying printed teacher guide. The discussions help broaden the scope of the program by asking the students to apply what they have learned to real-life situations and other issues of habitats. Suggested discussion questions may be asked and activities may be conducted both during and after the program. Many of the activities are designed especially for classroom and schoolyard uses, while others require community involvement and interaction. The on-line resource guide enables teachers and students to access information in the program from a different angle. Compared to the mystery process that randomly uncovers information, the resource guide outlines this information and directly links the user to the particular area of study that is desired.

The overall length of the program is also flexible, ranging from single class periods to entire units of study. Teachers select the amount of time they want to dedicate to the program based upon their individual needs and interests. For instance, classes may view much of the program, stopping at regular intervals for short discussions during a 50-minute class period. A second option is to view the program one day and spend the next class discussing the issues and related topics in greater detail. In addition, the program's flexibility allows it to be used as the center of an entire course consisting of research, design, and community involvement projects.

As originally conceived, the program was designed to include an extensive teacher reference manual that would instruct less confident teachers about how to use the computer program, provide detailed activities and discussions, and suggest detailed lesson plans illustrating ways to use the program.

The Paul Parkranger Mystery reaches beyond the subjects of science and biology to include other curriculum areas such as math, art, social science, geography, and language arts. Skills developed include those that enhance creative problem solving, values clarification, and decision making. Students develop techniques to assess situations, consider alternatives, confront complex issues, and weigh short-term versus long-term implications and learn to apply these skills to real-life situations.

The Future of the Program

As mentioned earlier, the Park Parkranger Mystery is a prototype developed to test several premises -- the technology as an instructional tool,

the most cost-effective way to design such a program, and the most effective instructional presentation. Since it is a prototype, it is currently not in a marketable format. Many of the program content areas are incomplete and lead to "dead ends." In fact, only 30% of the information that the design team envisioned has been programmed into the current form. For demonstration purposes, the program is quite suitable, though not yet completed for instruction with students.

Had this program been completed, the next phase of development would be to field test the current program in a variety of school settings, gaining feedback and insight as to how it should be modified for final publication. Before this could be done, however, a budget was developed for this second phase which also included completion of the first Paul Parkranger Mystery. To complete the program in its present format, Audubon would have to acquire substantial financial resources. A final version of a program as complex as this could easily escalate to $250,000. Audubon, a non-profit organization relying on contributions from individuals, foundations and corporations, found itself ready to move with a product and unable to do so as quickly as would be desirable given the lag time in raising money to finish the program with the initial partners. Apple, the source of funding for the original project, had recently reorganized their corporate structure and was unable to commit to completing the program at that point in time. Lucasfilm was a contractor on the project. In addition, a marketing and distribution plan would need to be developed. Several angles were investigated to expedite the development of a final product and keep it financially feasible.

A licensing agreement, a generous loan from an Audubon board member, and investment royalties provided a package for Audubon to begin development of a comparable program. This new program is expected to be completed, field tested, and on the market in about a year.

Interactive multimedia is rapidly becoming more available and affordable. Hypercard is enhancing the process, being one of the best and easiest programs for informational purposes. A question haunting the design team is whether schools will have the equipment to operate the program. Based upon research conducted by Apple, Optical Data, and others, Audubon believes they will. There is a reason that such companies are moving quickly and investing to develop products which use the equipment. Laser video players are becoming more available; 30,000 were sold in the US last year.

More than half of those were to schools. Apple provides educational discounts for equipment, and many students are growing up with Apple computers. Macintosh is one of the fastest growing personal computers on the market. Most of the newer television sets now have video input. All told, a school can equip itself for this media revolution for about $3,000. The design team envisions the program to be one of many that will be produced in the years ahead, and its flexible format lends itself to work stations within the classroom or a central media center or for transport of equipment from room to room. Obviously, not every class will have the equipment, nor do they need to. With advance planning, a set per school will bring students into the multimedia revolution.

With the high costs of programming and until the needed equipment becomes more commonplace, interactive multimedia is just now beginning to become a commercially viable venture. The future of this type of educational program is not assured, but if enthusiasm from teachers, students, and program developers is any indication, a whole new world is being unveiled to the educational community and environmental education is leading the way by being on the pioneering forefront.

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801 Pennsylvania Avenue, S.E.
Washington, D.C. 20003

202/547-9009

The Multimedia Environment

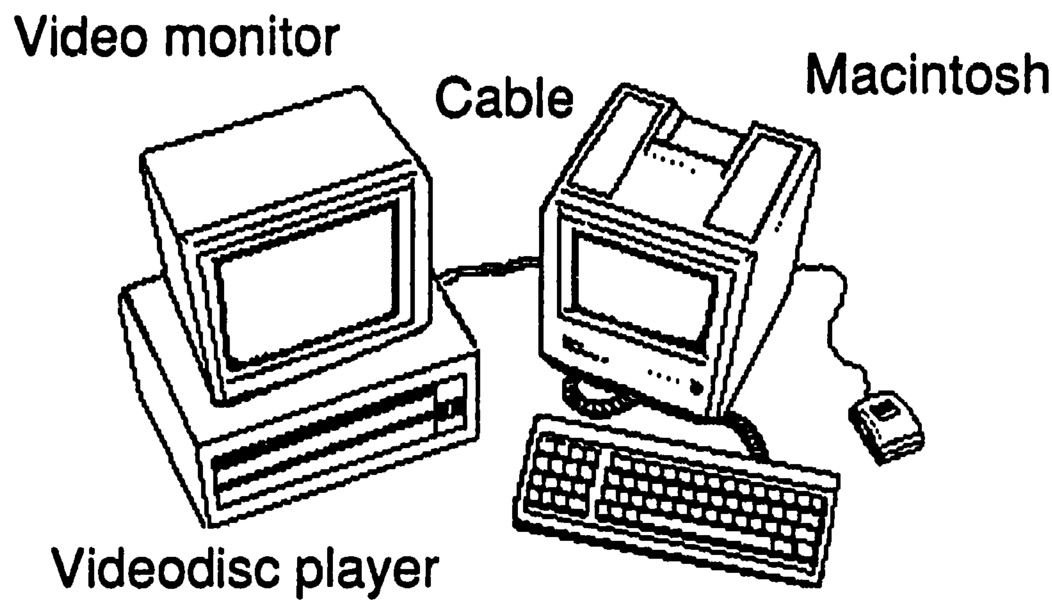


Figure 1 Macintosh SE with Hypercard, Videodisc Player and Video Monitor

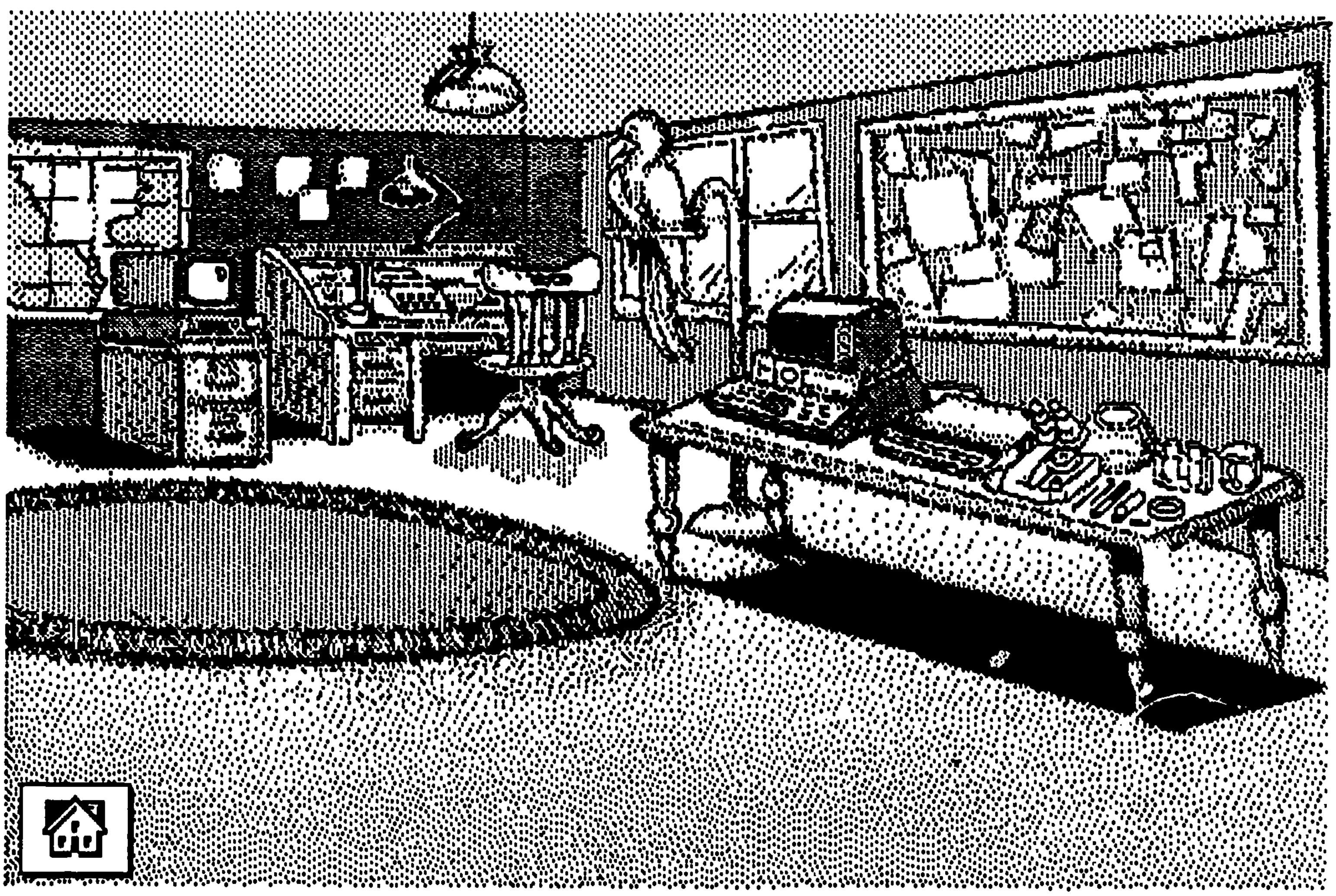
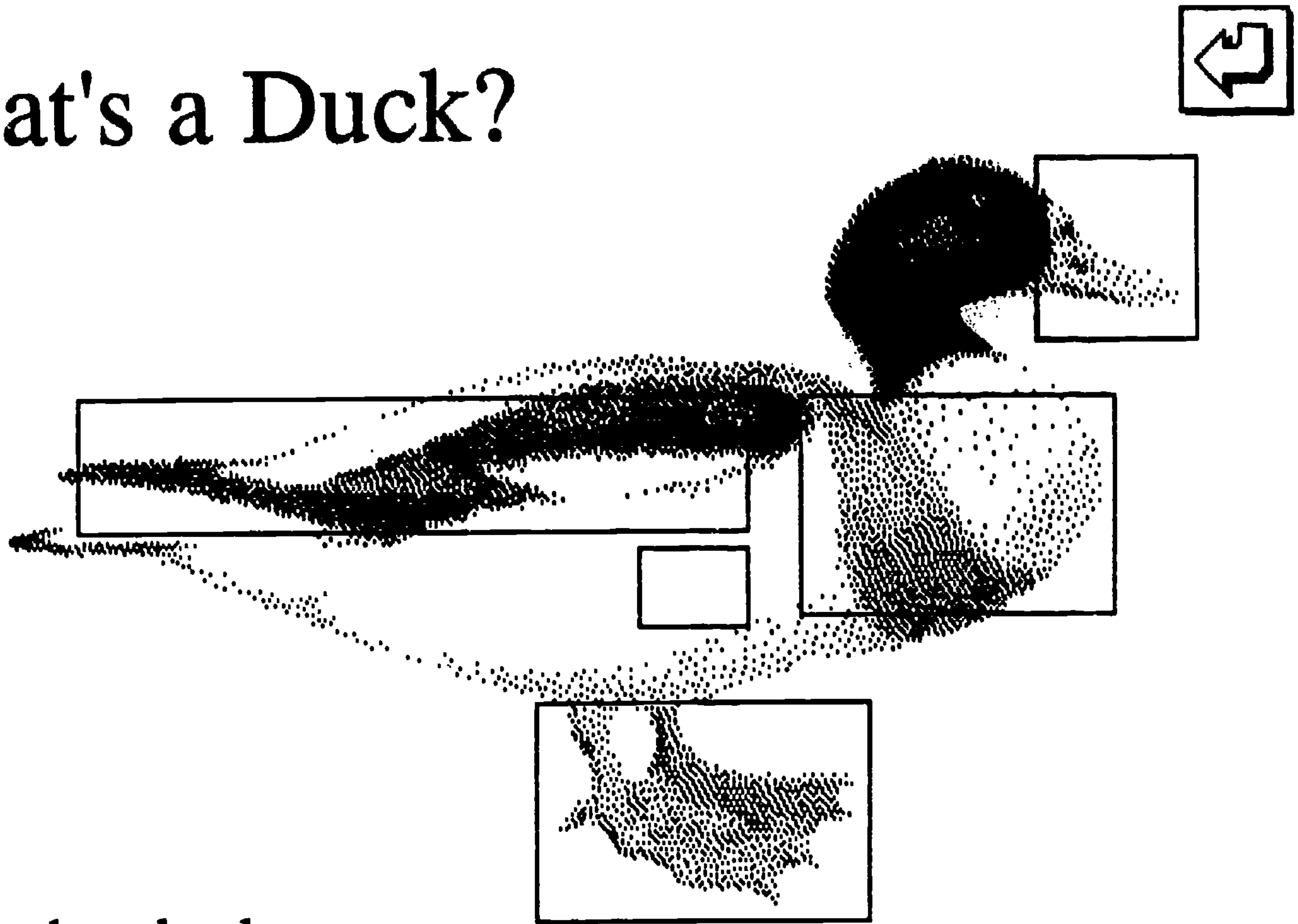


Figure 2 Paul Parkranger's Office

What's a Duck?

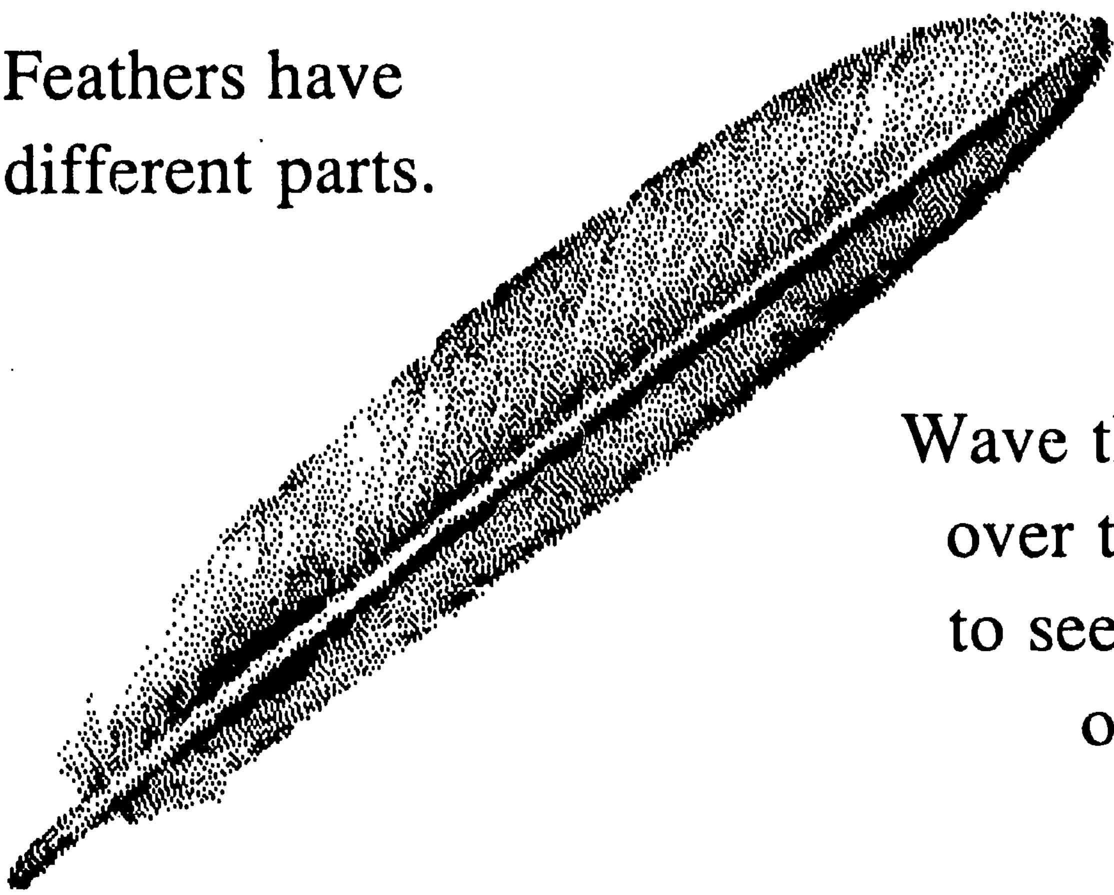


Click the duck parts.

Figure 3 Duck Anatomy (Click on Feathers for card shown below)

Feathers have different parts.

(more)



Quill

Wave the pointer over the feather to see the name of the part.

Click the feather to return.

Figure 4 Feather Anatomy

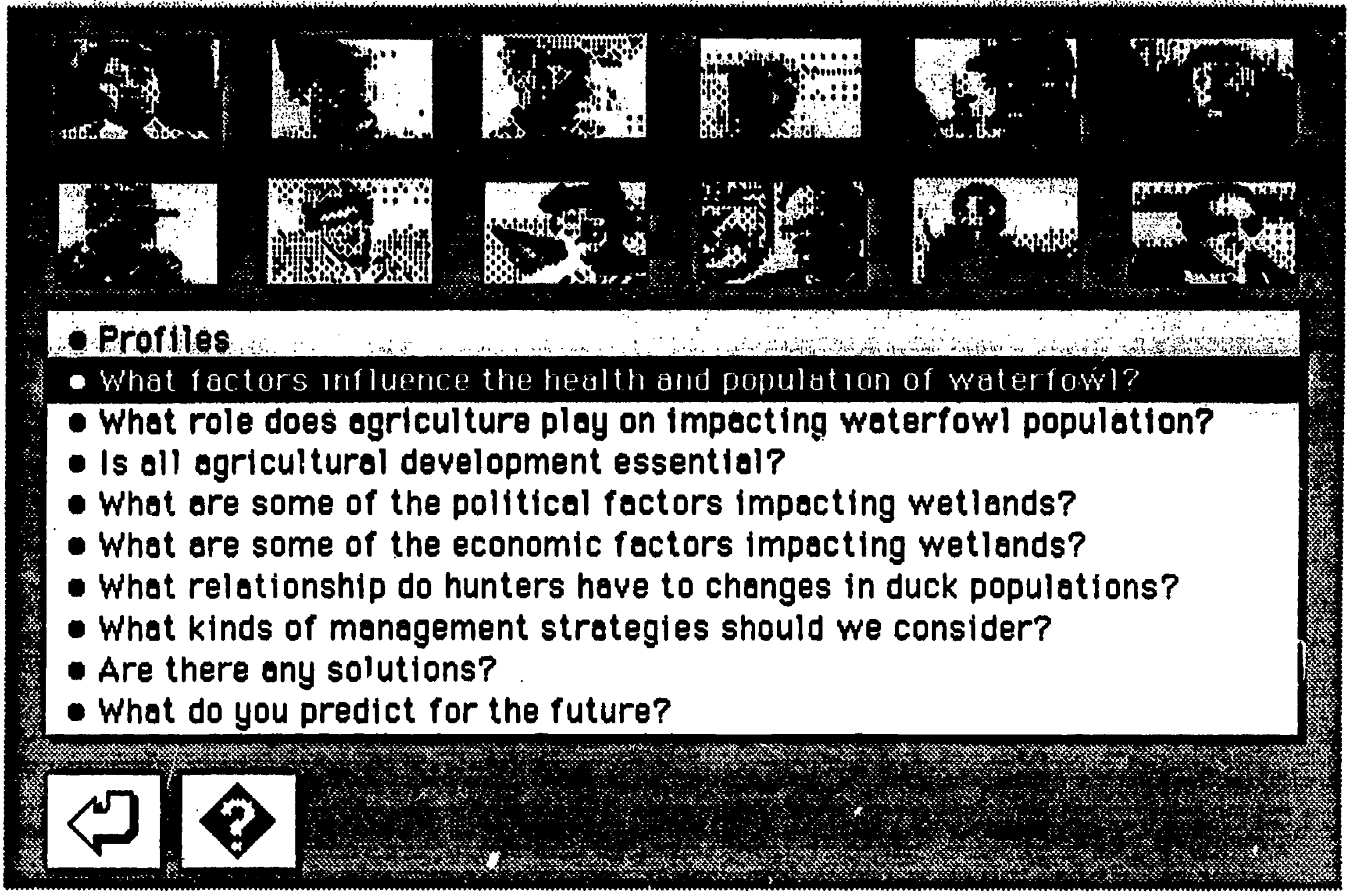


Figure 5 Profile Selection Card (Click on individual and question to run selected video segment)

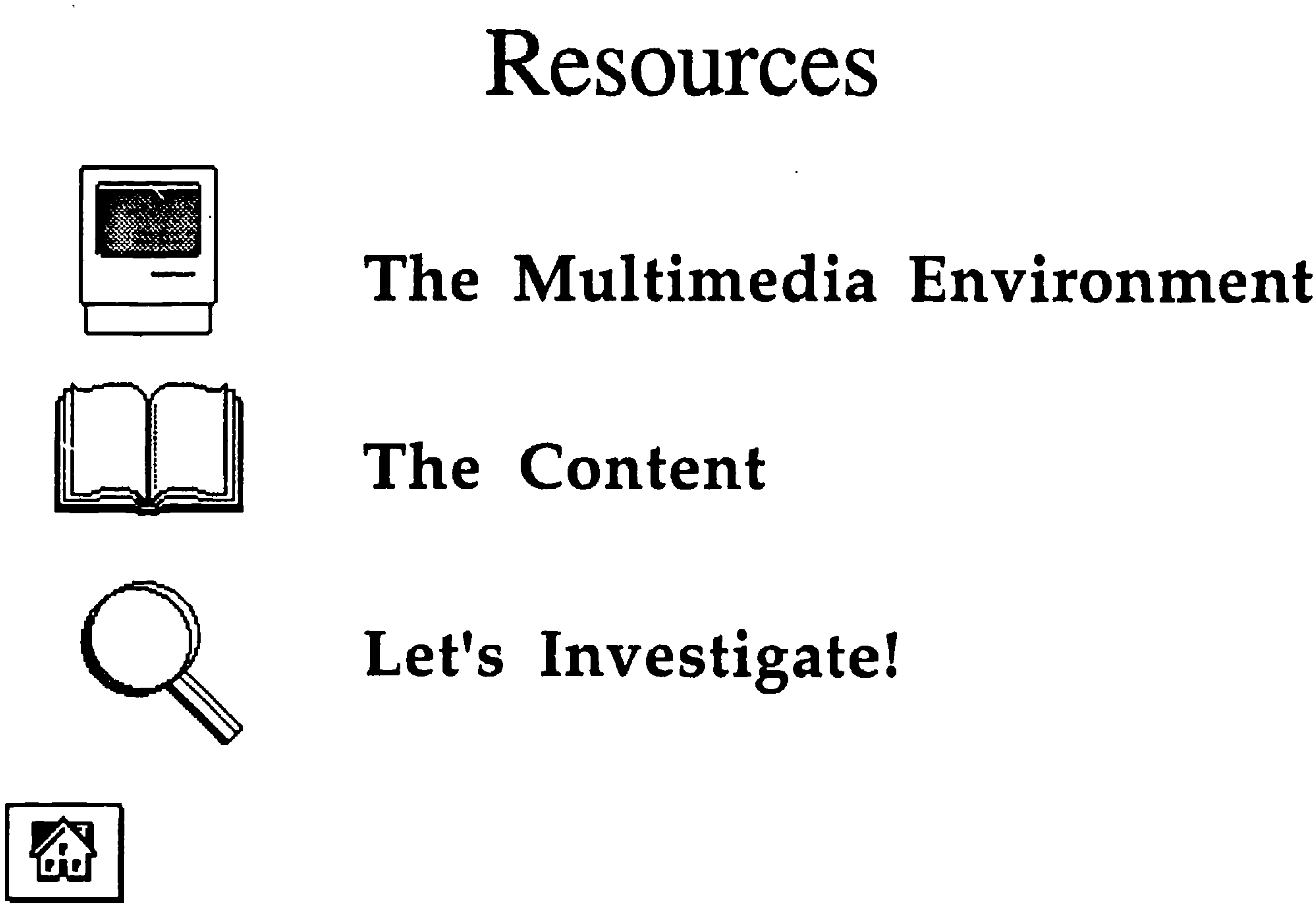


Figure 6 Resources Table of Contents

SCIENTISTS AT WORK: A BRIDGE BETWEEN CLASSROOM AND REAL WORLD ENVIRONMENTAL STUDIES

Beverly Hunter
National Science Foundation

Abstract

Scientists at Work provides students with an information-rich environment in which to conduct their own research studies. Students play the roles of research assistants at a nature center. They work in teams of two to four students, conducting projects that involve asking their own research questions, deciding what data are needed to answer the questions, selecting and organizing the information, analyzing and synthesizing, and preparing products related to their research.

Introduction

In the real world, environmental studies involve large amounts of data of different kinds from many sources. As a bridge between real-world complexity and (usually) oversimplified classroom studies, we developed a computer data base system that would give students the opportunity to work on projects of meaningful complexity and challenge with the support of a pedagogically designed interface and data base structure. *Scientists at Work* is designed to help students develop skills in handling information, conducting scientific research projects, and solving problems. The program was developed in 1988-89 by Beverly Hunter, then Director of Research for Targeted Learning Corporation, Richard McLeod of Michigan State University, Kris Morrissey, Curator of the Michigan State University Museum, Jim Harding, Naturalist for the MSU Museum, and programmer Glenn McPherson. The work was supported by the U.S. Department of Education and Apple Computer External Research. The program was tested by 600 seventh grade students and their teachers in environmental science classes in five schools in Northern Virginia. This article provides an overview of the program. More detail on design considerations is available in *Scientists at Work*.

Scientists at Work was developed using the HyperCard programming

system on a Macintosh computer. HyperCard enables the developer and user to integrate a wide range of different kinds of information -- pictures, sound, text, categorical data, and numeric data. In Hypercard, information is stored on "cards" which are arranged in "stacks," like a deck of cards in a stack. *Scientists at Work* has seven stacks: Nature Center, Animal Pictures, Animal Data, Dictionary, Nature Center Advisor, Notebook, Student Records.

The Nature Center

In *Scientists at Work*, students play the roles of research assistants at a nature center. They work in teams of two to four students, conducting projects that involve asking their own research questions, deciding what data are needed to answer the questions, selecting and organizing the information, analyzing and synthesizing, and preparing products related to their research. Figure 1 shows the nature center entrance, which is the opening screen of the program. On the opening screen, the learner or teacher can click the mouse on any of the six "buttons" on the screen: Science Advisor, Animal Data, Animals, Information, Quit, or the return arrow in the lower right hand corner.

Animal Pictures

Clicking the "Animals" button on the opening screen takes you to a stack of animal pictures, such as the elephant shown in Figure 2. The various buttons on this screen allow you to navigate through the pictures stack and travel to other places in the nature center. Clicking the little "RCA Doggie," for example, makes the elephant roar. Clicking the right arrow takes you to the next picture in the stack, while clicking on the "Rolodex" gives you an index of all the animal pictures in the stack.

Students enjoy the pictures, and use them in creative ways. A boy was looking at all the fish pictures and measuring their tails. He said he was using the relationship between length and width of tail fins to estimate speed of the fish. A girl held her live toad up to the toad on the screen and had them talking to each other. A team made a game of trying to find bird sounds they had heard in their own neighborhoods. Teams of students printed selected pictures, cut them out, colored them, and pasted them on food web posters along with data base printouts.

As shown in Figure 3, pulling down the Options menu allows you to do various things such as print the card you are looking at or go to the data screen for this animal.

Animal Data and Dictionary

Figure 4 shows the animal data base card. Data base field names such as **Class** and **Diet** are shown in bold type. If you need a definition of a field name, you just click the mouse on the word. Figure 5 shows the dictionary card for **Class**. In the dictionary, you can easily get information about related terms by simply clicking on them (e.g. **Amphibian**).

Students make frequent use of the dictionary because it is so accessible. Many students printed the dictionary pages and put them into their team folders. Students developed a substantial vocabulary of terms related to food chains and food webs during a two-week activity using *Scientists at Work*.

Tools for Working with Animal Data

Figure 6 shows the Options menu in the animal data base. These options provide a variety of tools for selecting, organizing, manipulating, analyzing and communicating information. One of the advantages of Hypercard as a programming system for developing computer applications is that it is relatively easy to build new tools into the system. Two of the most frequently used are the selection and graphing tools.

<u>Selection Tool</u>

In our work with students and data bases over the last several years, we have found that learners of all ages have many conceptual and skill difficulties in selecting a subset of data from a larger data base. Thus, we wanted to make the tools for selecting as easy to learn and use as possible so that the operation of the tools would not add further complexity to the learner's task. *Scientists at Work* helps you create an English-language sentence that tells what records you want to select from the data base. Figure 7 shows a user in the process of creating such a sentence to select mammals that live in a coniferous forest. The coniferous forest part of the sentence has already been created; the user is now specifying the **Class** of

animal to be selected, which (in the next step in the process of building the sentence) will be the class "mammal."

Graphing Tools

Two kinds of graphs can be drawn, using data from either all of the records in the data base or a selected subset of the data. Figure 8 shows the user choosing the bar chart tool. Figure 9 shows choices of bar charts, and the user choosing a chart showing number of animals by biome. Figure 10 shows the chart. Students find the bar charts to be very interesting and use them for many different purposes. For example, if you select all the animals that hibernate and then chart them by class, you quickly get some clues as to characteristics of hibernating animals.

Nature Center Advisor

The Nature Center Advisor is a kind of interactive coach who provides various kinds of support to the student research assistants. From any place in the program you can click on the Advisor icon to get advice about your research project. Figure 11 shows a pop-up window for the Advisor. If you go to her office (Figure 12), you have several kinds of assistance available to you. After students have spent some time exploring the nature center and trying out the tools, they come to the Advisor's office to sign up for a research project. Figure 13 lists the currently available research projects. Each project is described in an open-ended manner such that each student team will have a great deal of lattitude in its particular formulation of the research questions, methods, and products they develop.

The Advisor provides help with methods for doing the research. She has methods help for both data handling and science methods. An overview of the science methods is shown in Figure 14. Figure 15 shows the kinds of advice available concerning making hypotheses. The advisor provides this assistance in the context of the particular research project the student team is working on. For example, students working on the food chain project see examples of hypotheses related to food chains whereas students working on parental care see examples related to that project.

Our pedagogical philosophy requires that the learner be in charge of their own learning at all times. Thus, the students decide whether, when

and how often to interact with the Advisor. The Advisor only intervenes in one circumstance: if students try to sign up for a project but have not explored all the prerequisite places in the Nature Center, the Advisor insists they explore before signing up for a project. Some students were so incensed at this, they refused to consult with the Advisor afterwards.

Research Notebook

Each student team is registered with the Advisor, which keeps a record of their activities. At the time a team is registered, a notebook is automatically created for the team. The notebook is structured to correspond with the stages of research. Figure 16 shows an example page from the notebook. Notice that this particular page is designed to provide visual cues to the students to help them describe their methods. Other sections have different kinds of cues and structure. In the graphs section, for example, they simply click on a button that automatically copies their latest graph into their notebook. When students have completed their project and their notebook, they print out the entire notebook which then becomes their research report.

Time and equipment limitations in the classroom make it difficult for students to have enough time on the computer to take full advantage of the notebook. Our students were delighted to have the notebook but did not have enough time to learn how to incorporate its use into their daily activities.

Status of *Scientists at Work*

The program is not commercially available at this time. However, it is currently serving as a model for various Hypercard-based educational research and development efforts in the U.S. and Europe. A major zoo is tailoring the program to use with school children in its region. They are adding invertebrates and additional environmentally-related variables.

References

Scientists at Work Final Report. (1989) U.S. Department of Education Prepared by Education Turnkey Systems, 256 North Washington Street, Falls Church, VA 22046.

Kennedy, L. and Hunter, B. (in press) Scientists at Work: A Hypercard Based Learning Environment for Developing Skills in Science Inquiry and Information Handling. Submitted to *The Computing Teacher.*

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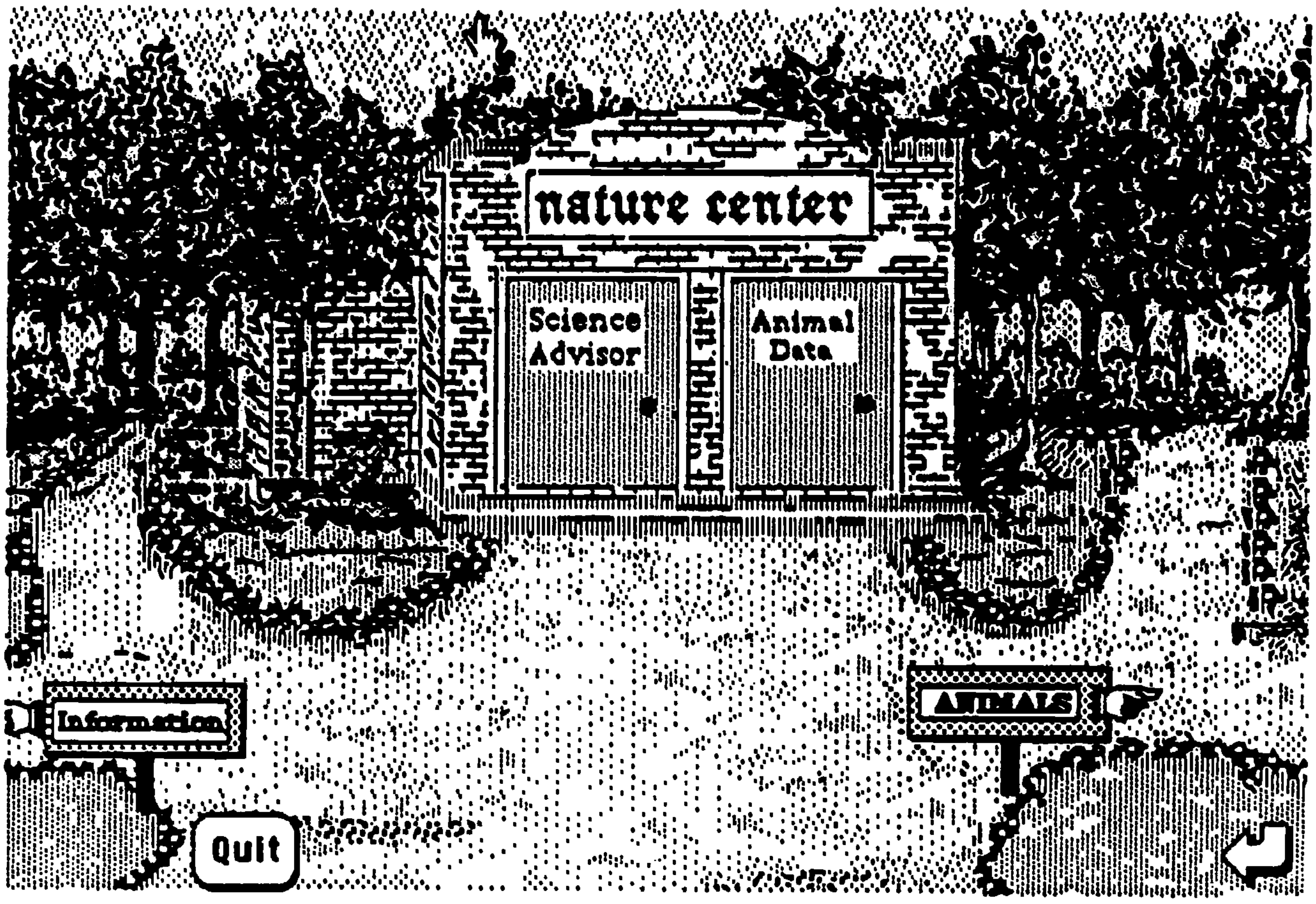


Figure 1 Nature Center Home Screen

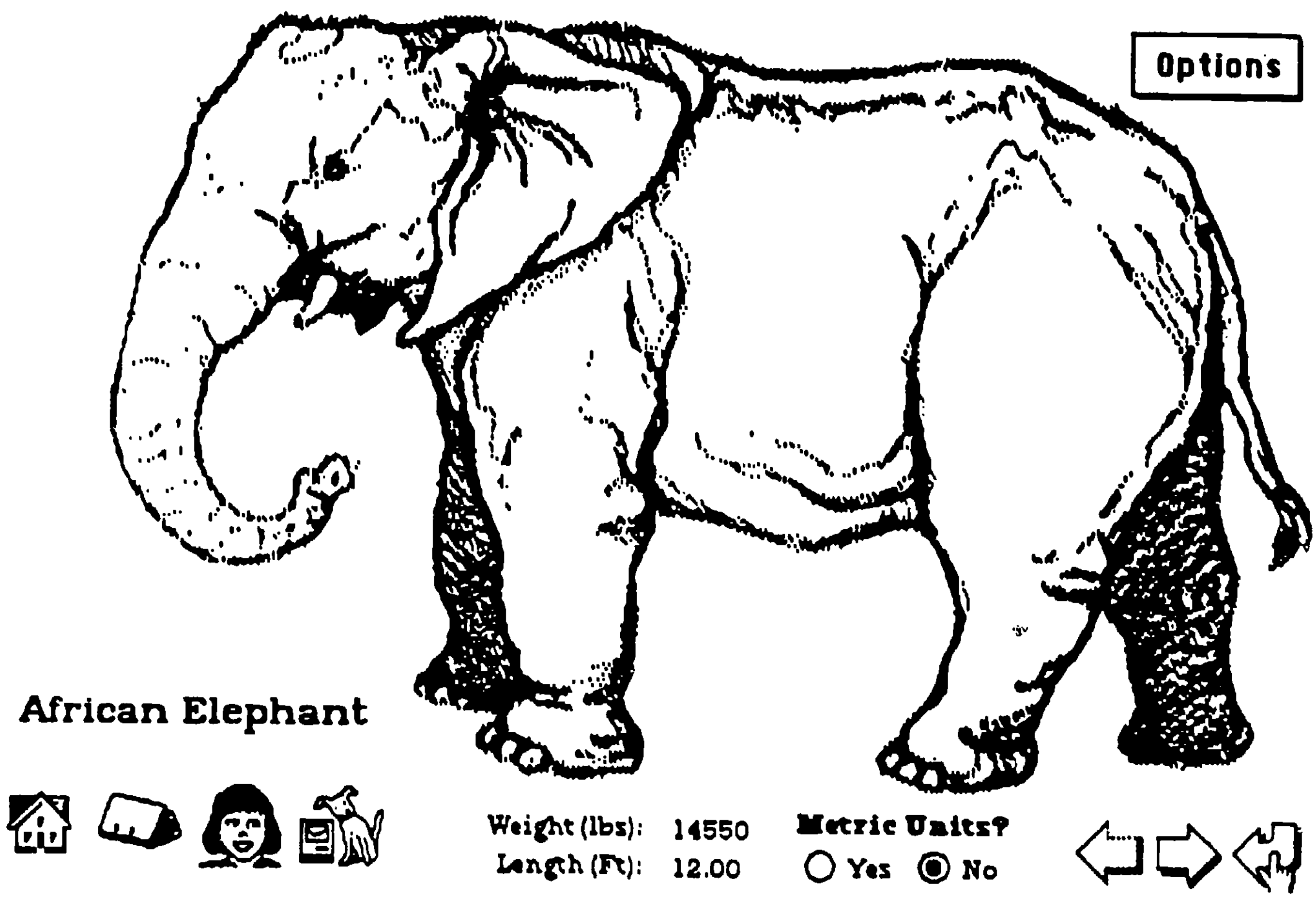


Figure 2 Animal Pictures Stack

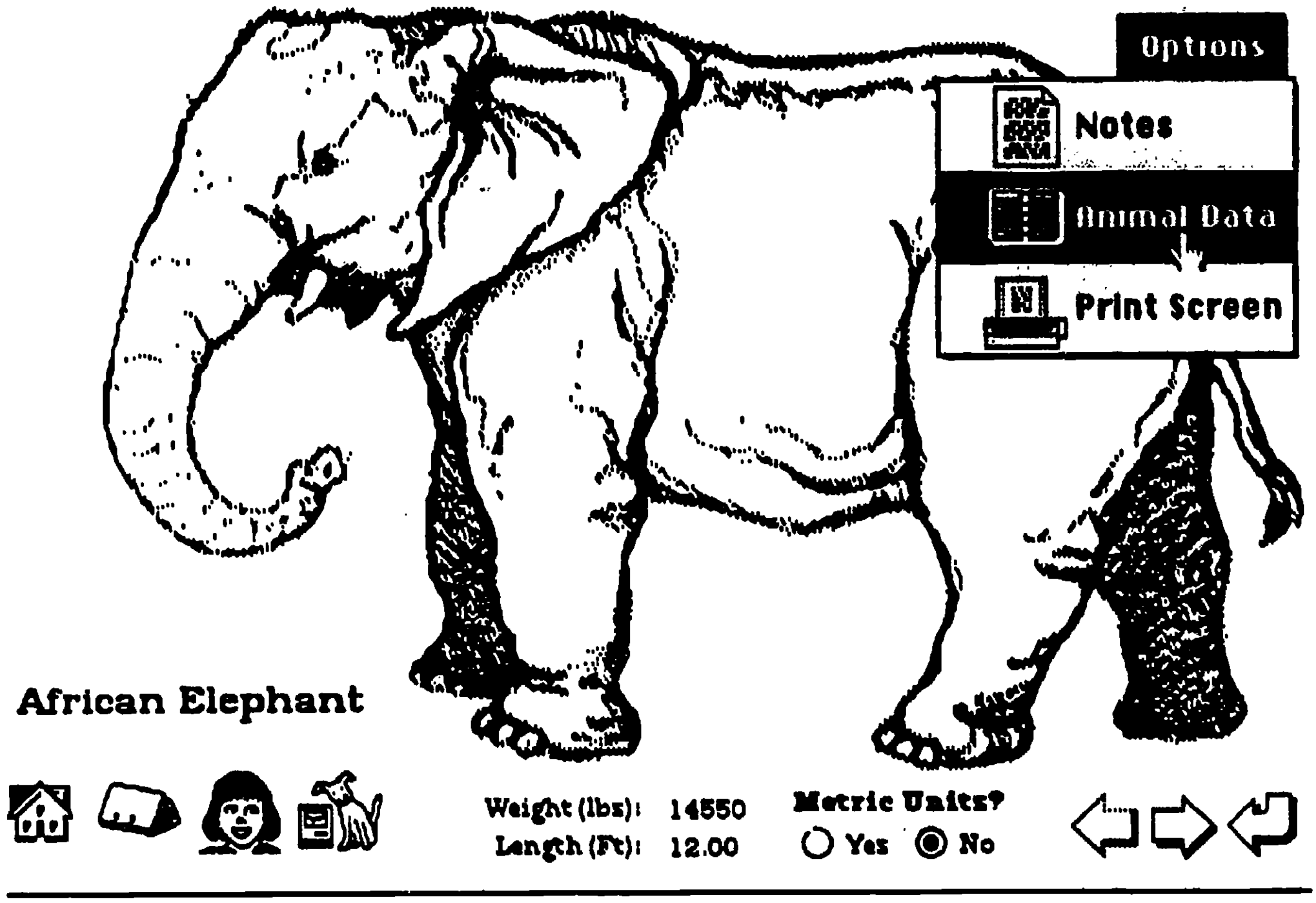


Figure 3 Card Illustrating Standard Buttons and Pull-Down Menu

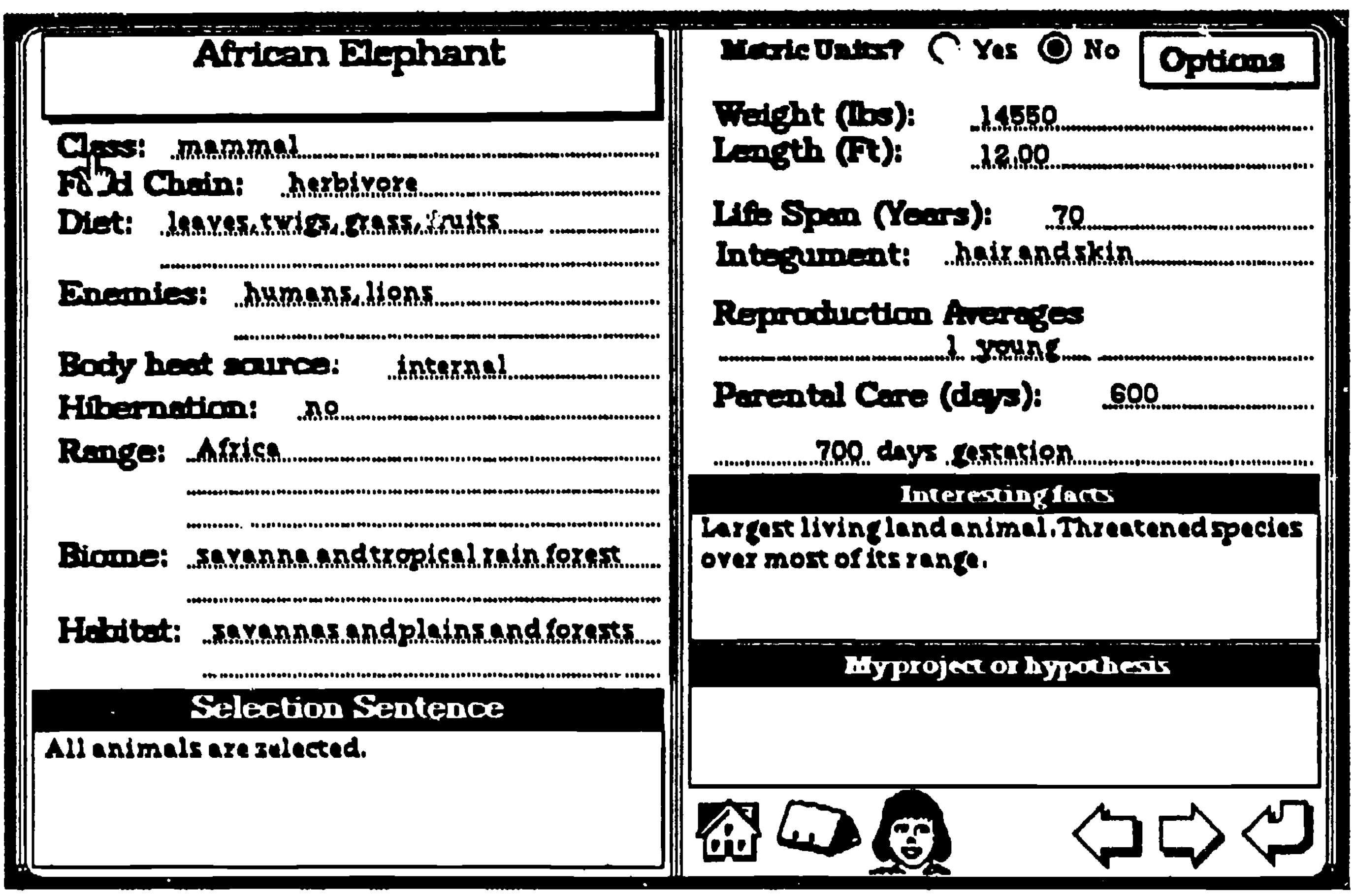


Figure 4 Animal Data Base

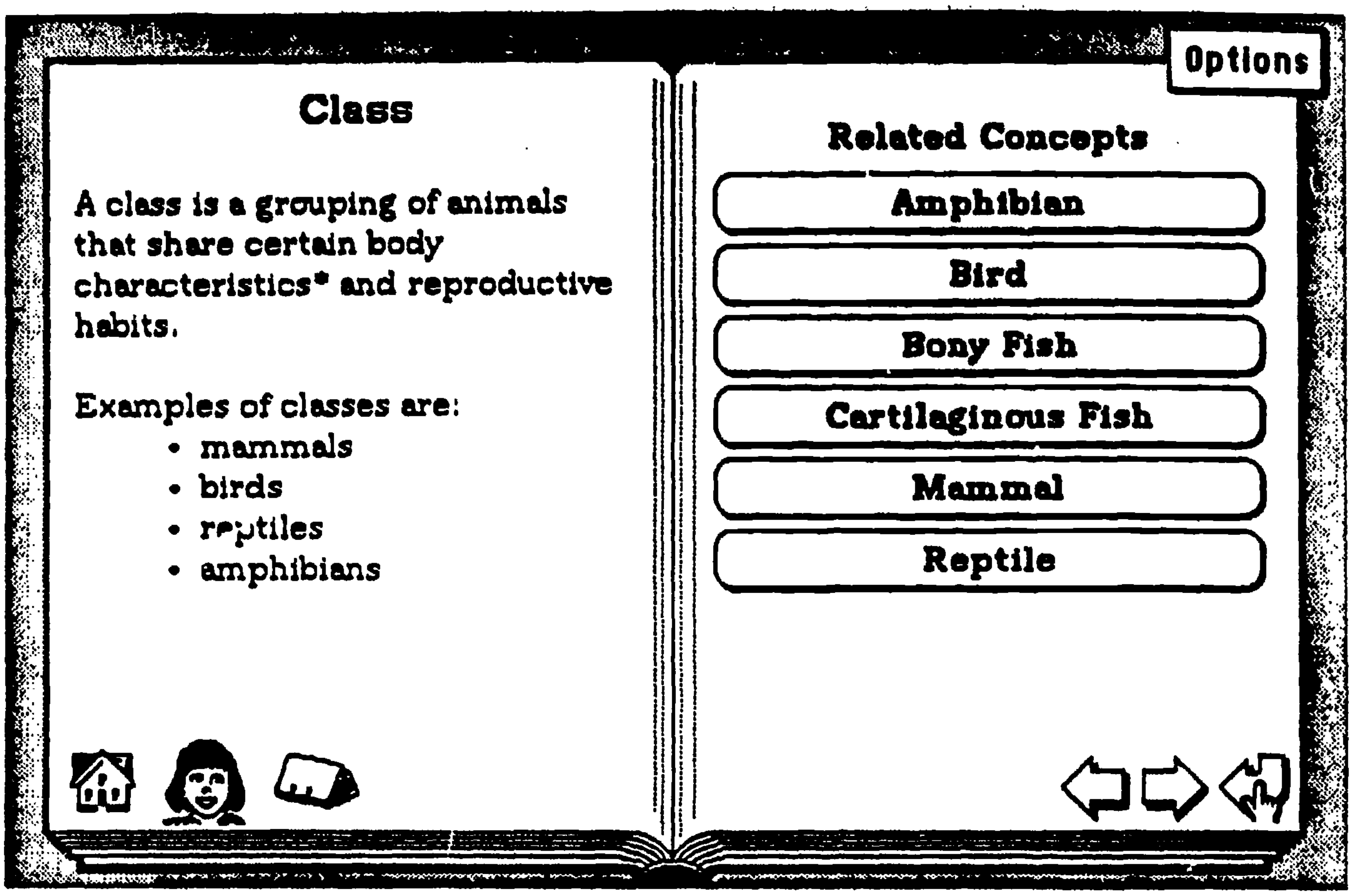


Figure 5 Card from Dictionary

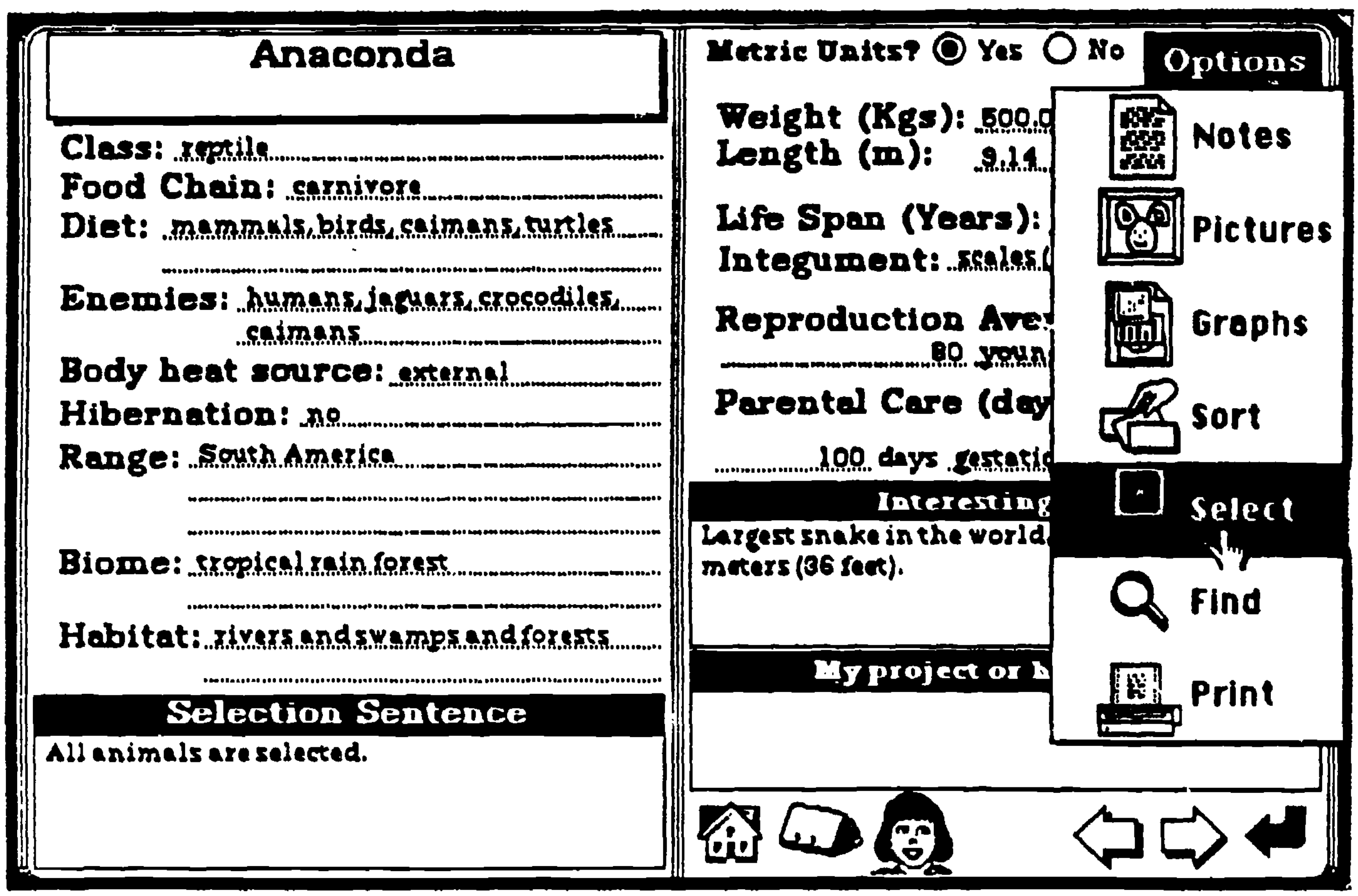


Figure 6 Animal Data Cards with Options Menu Pulled Down

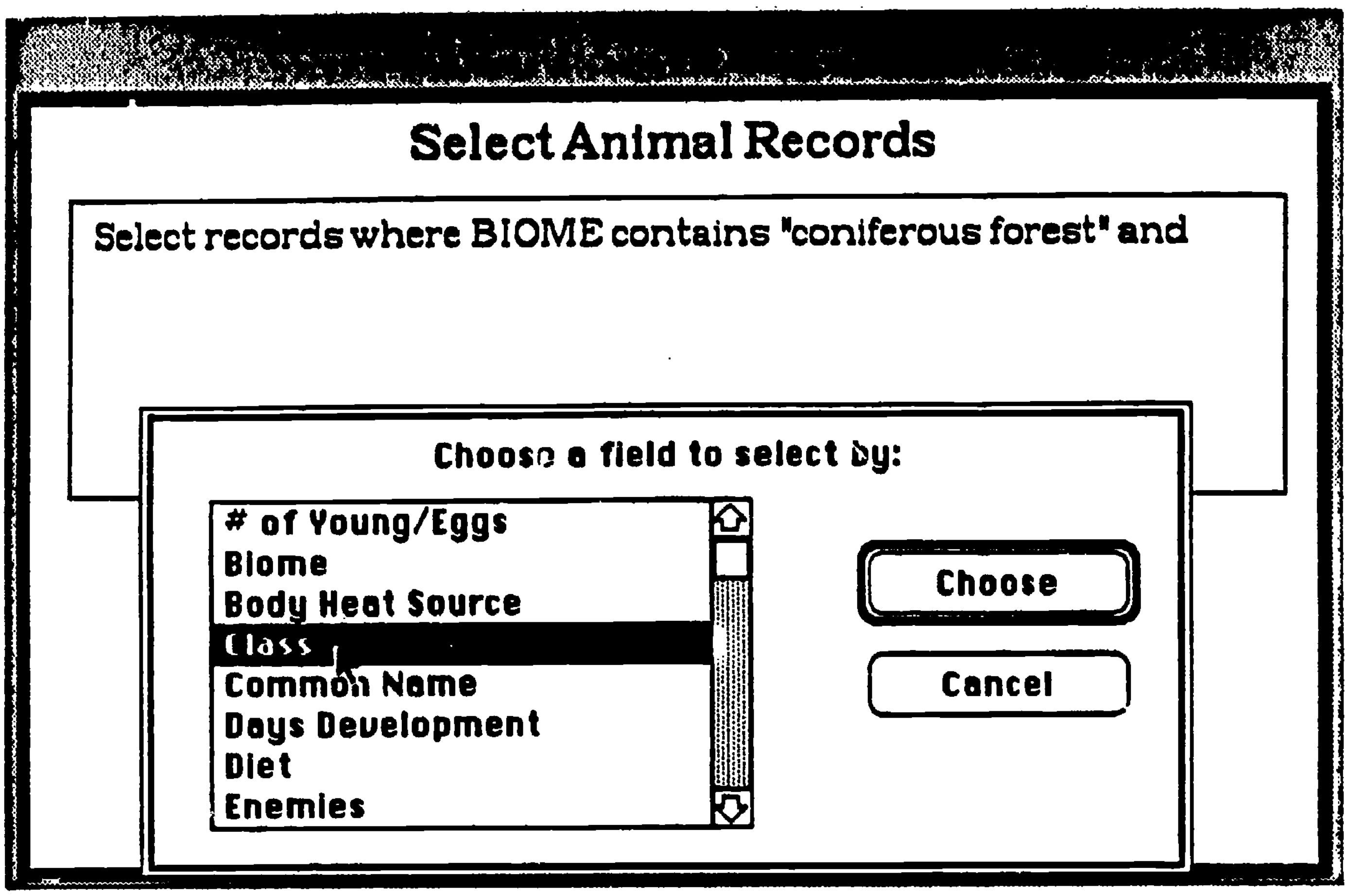


Figure 7 Selection Interface

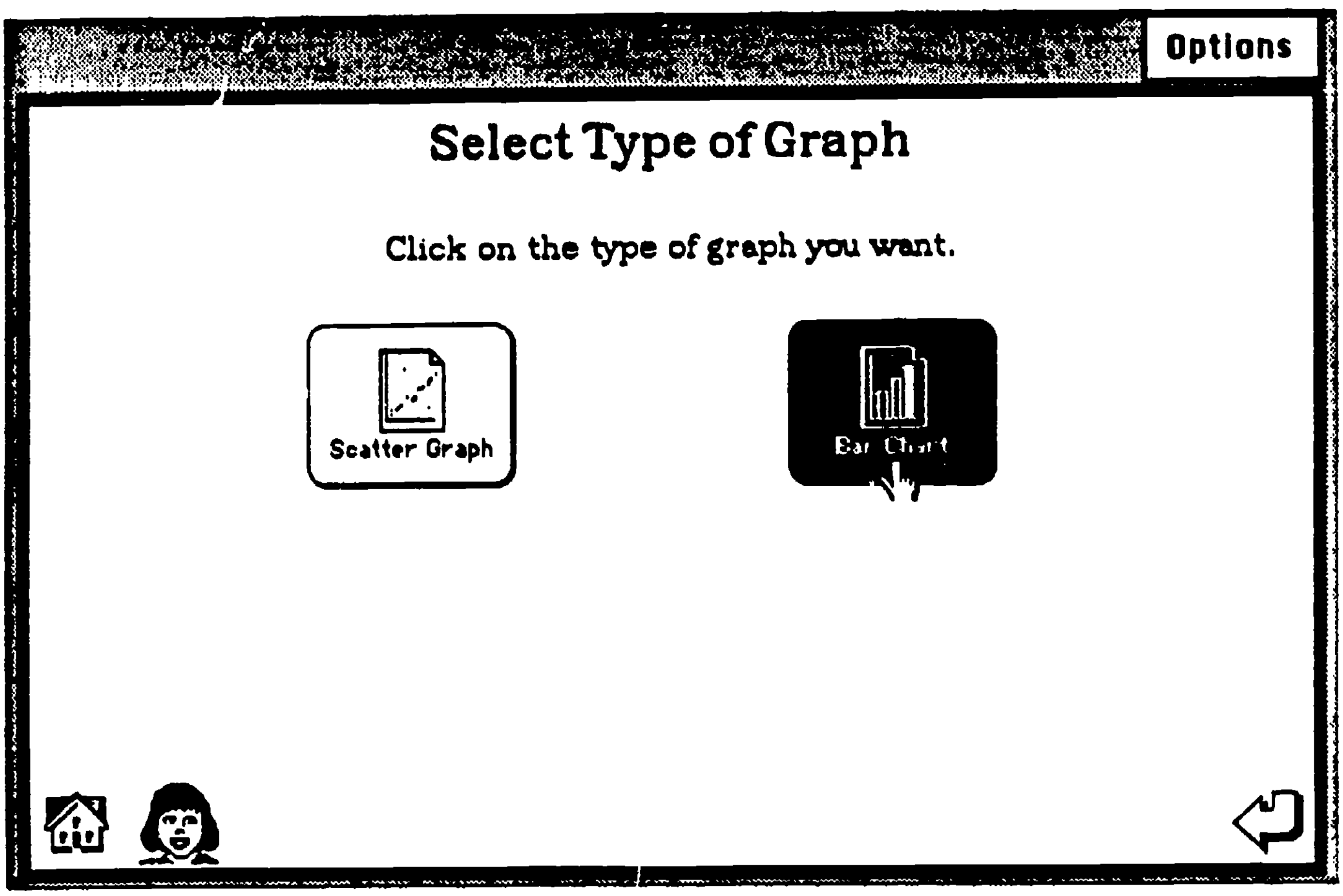


Figure 8 Choc ing the Bar Chart Tool

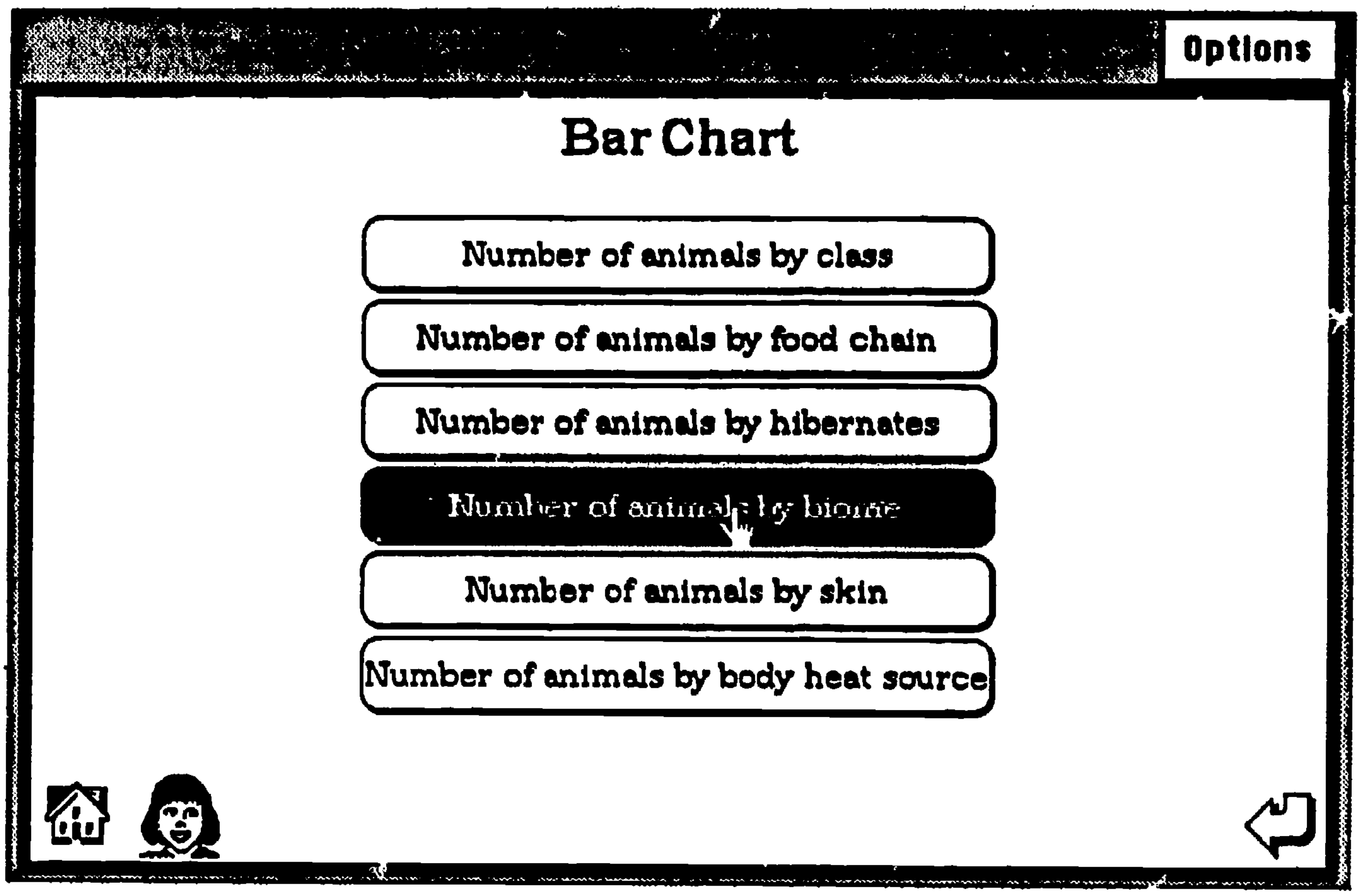


Figure 9 Choosing a Bar Chart

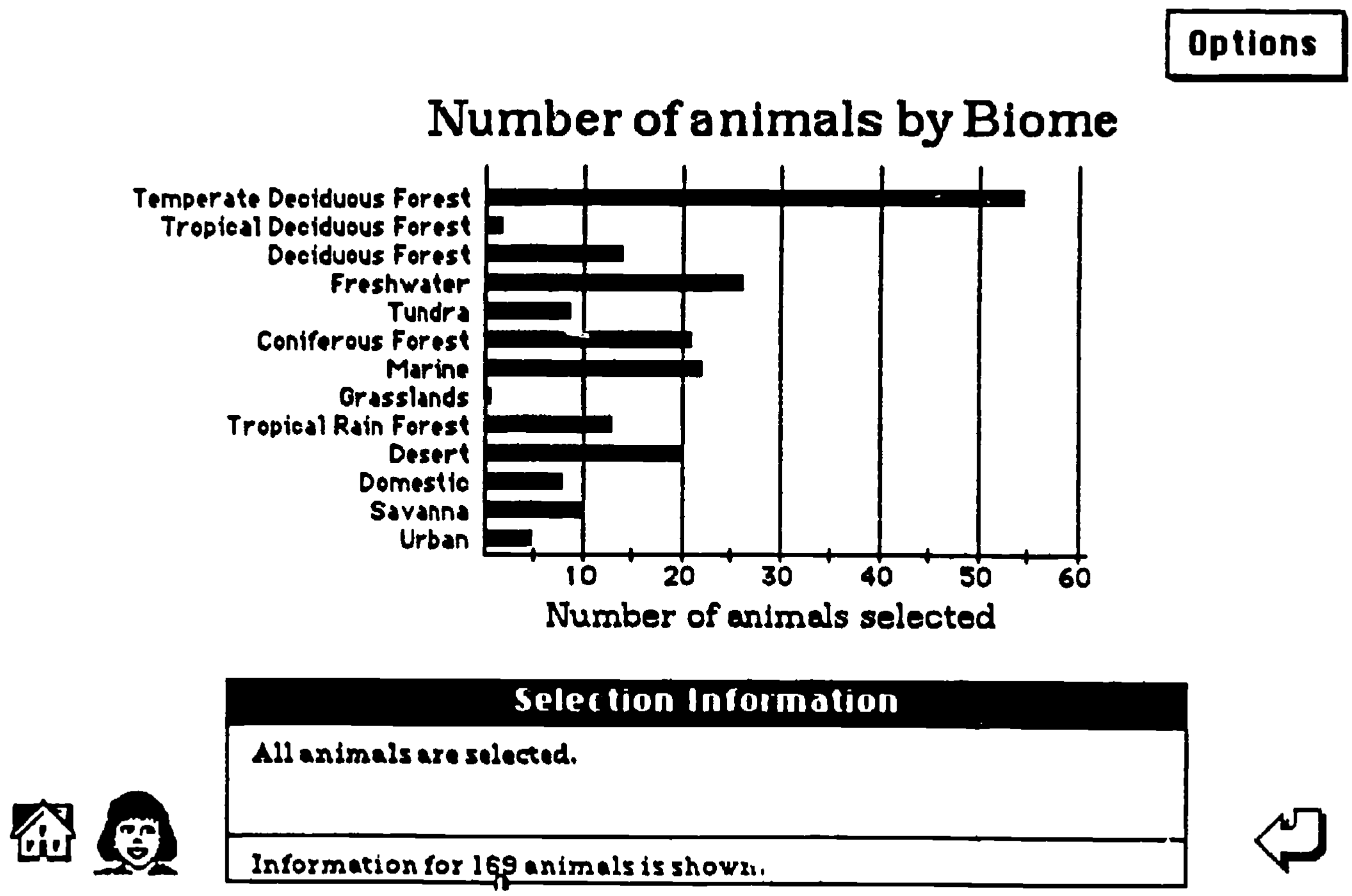


Figure 10 Bar Chart Showing Numer of Animals in Data Base by Biome

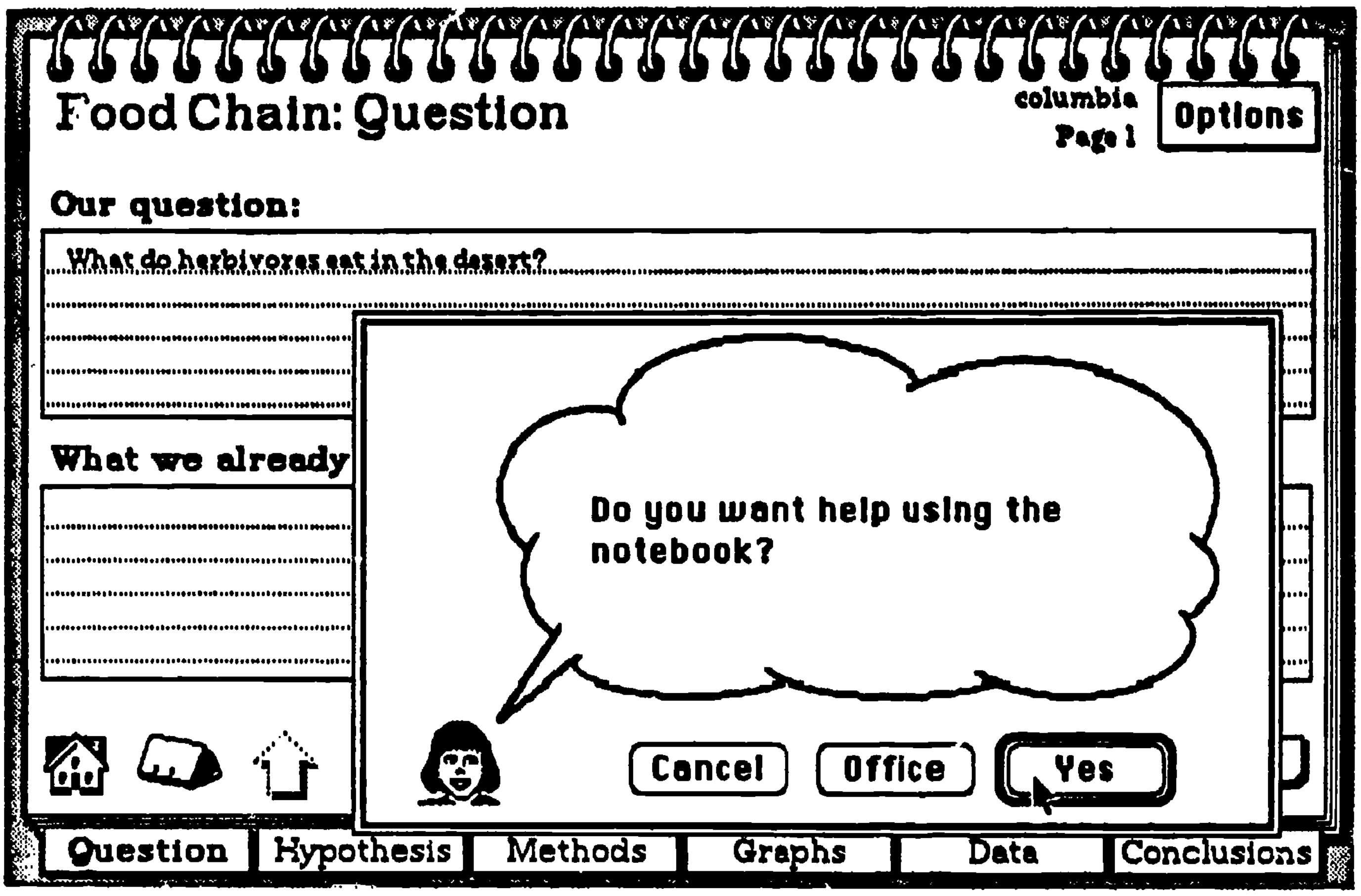


Figure 11 Pop-up Conversation Window

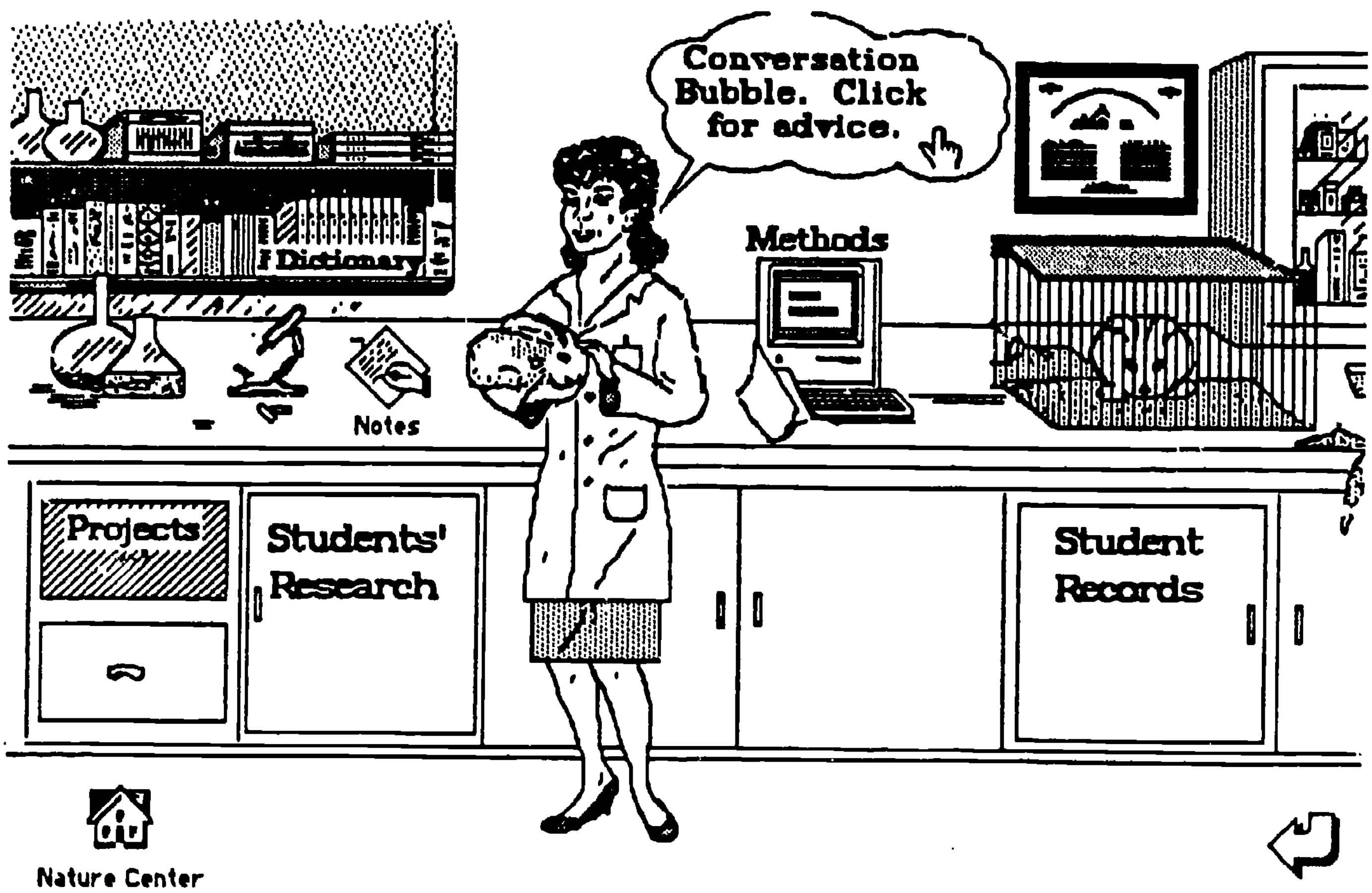


Figure 12 Nature Center Advisor's Office

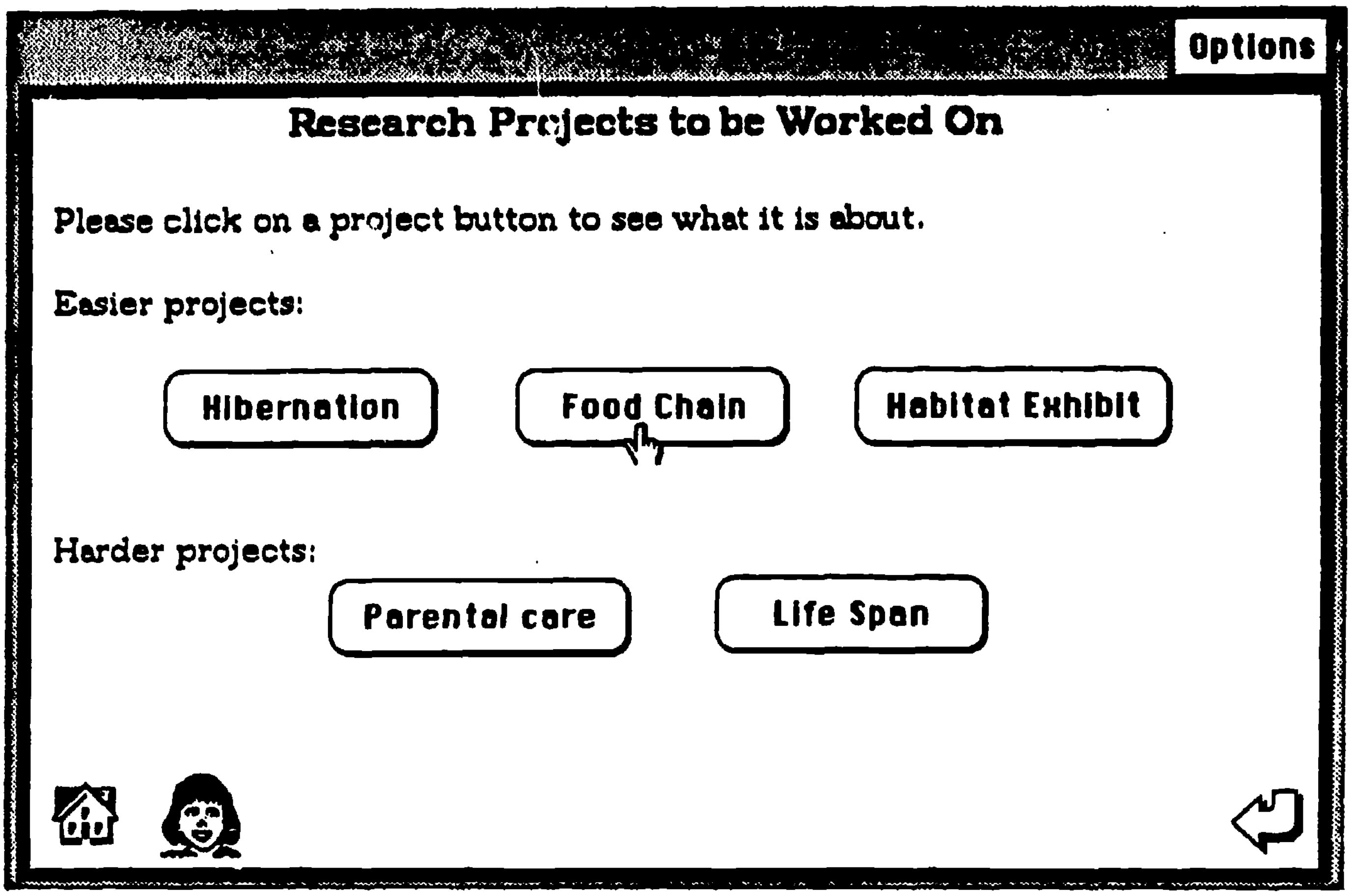


Figure 13 Choosing a Project Description

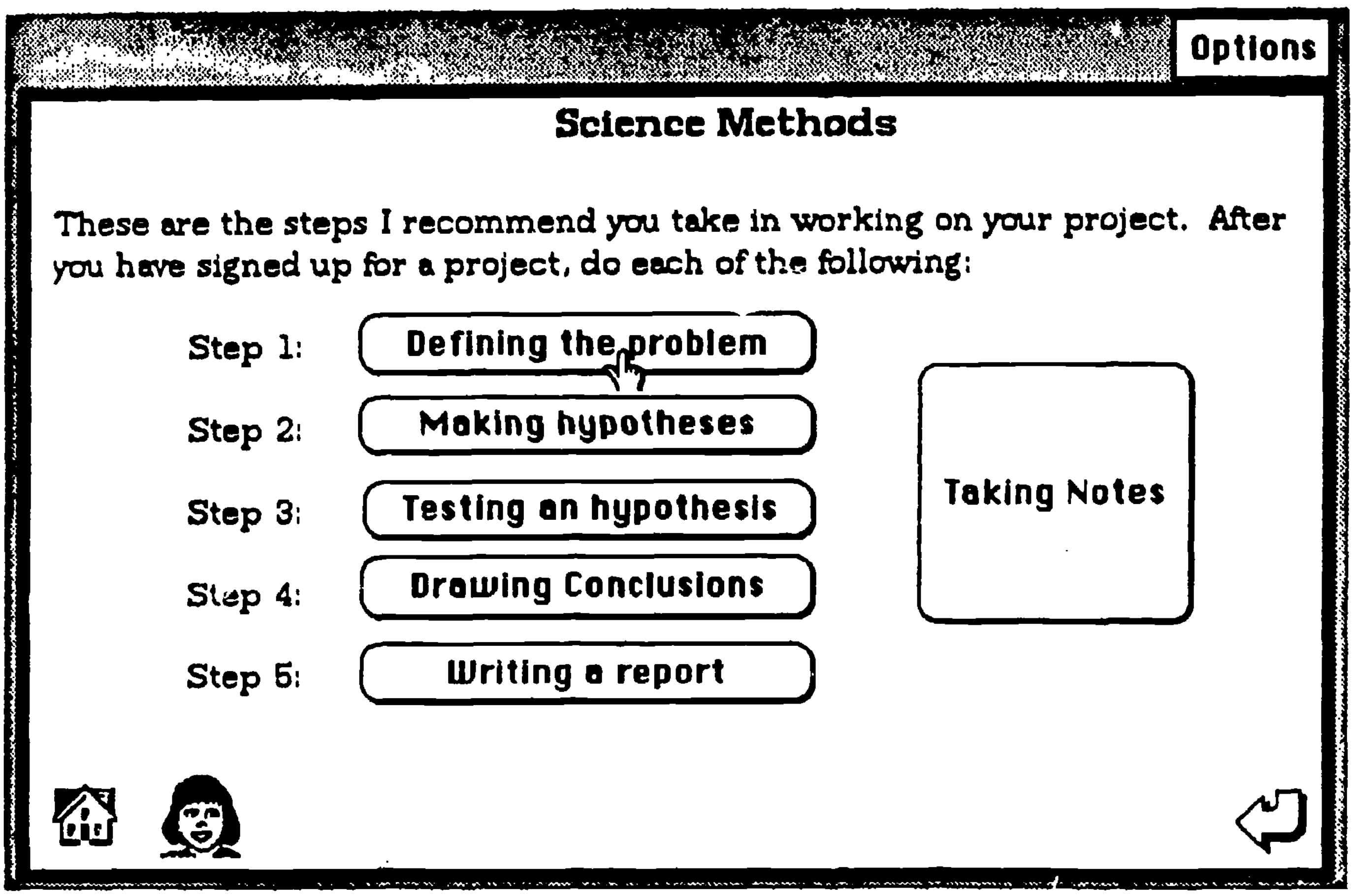


Figure 14 Science Methods Assistance Available to Learners

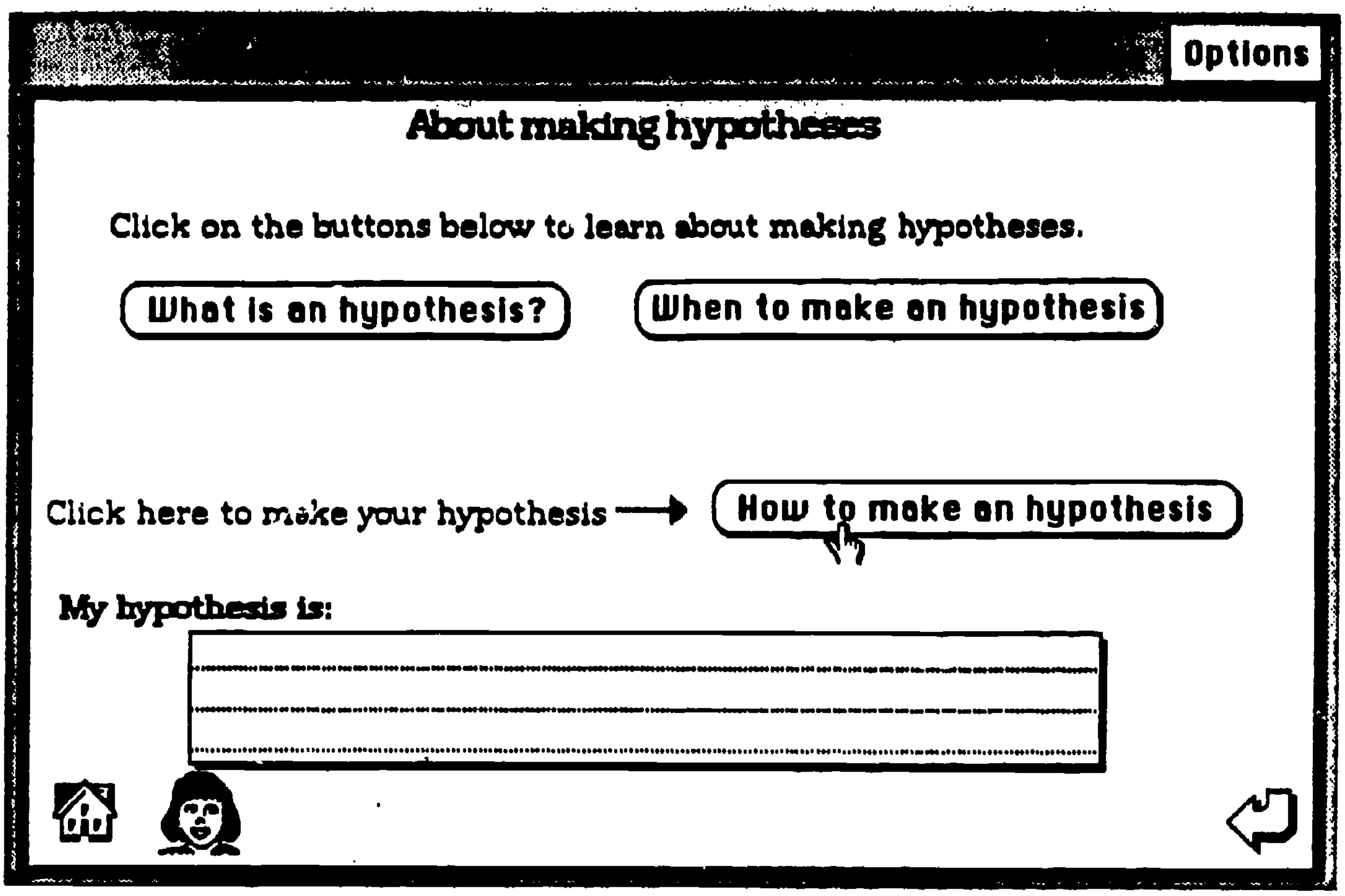


Figure 15 Instructions Available to Learners Making Hypotheses

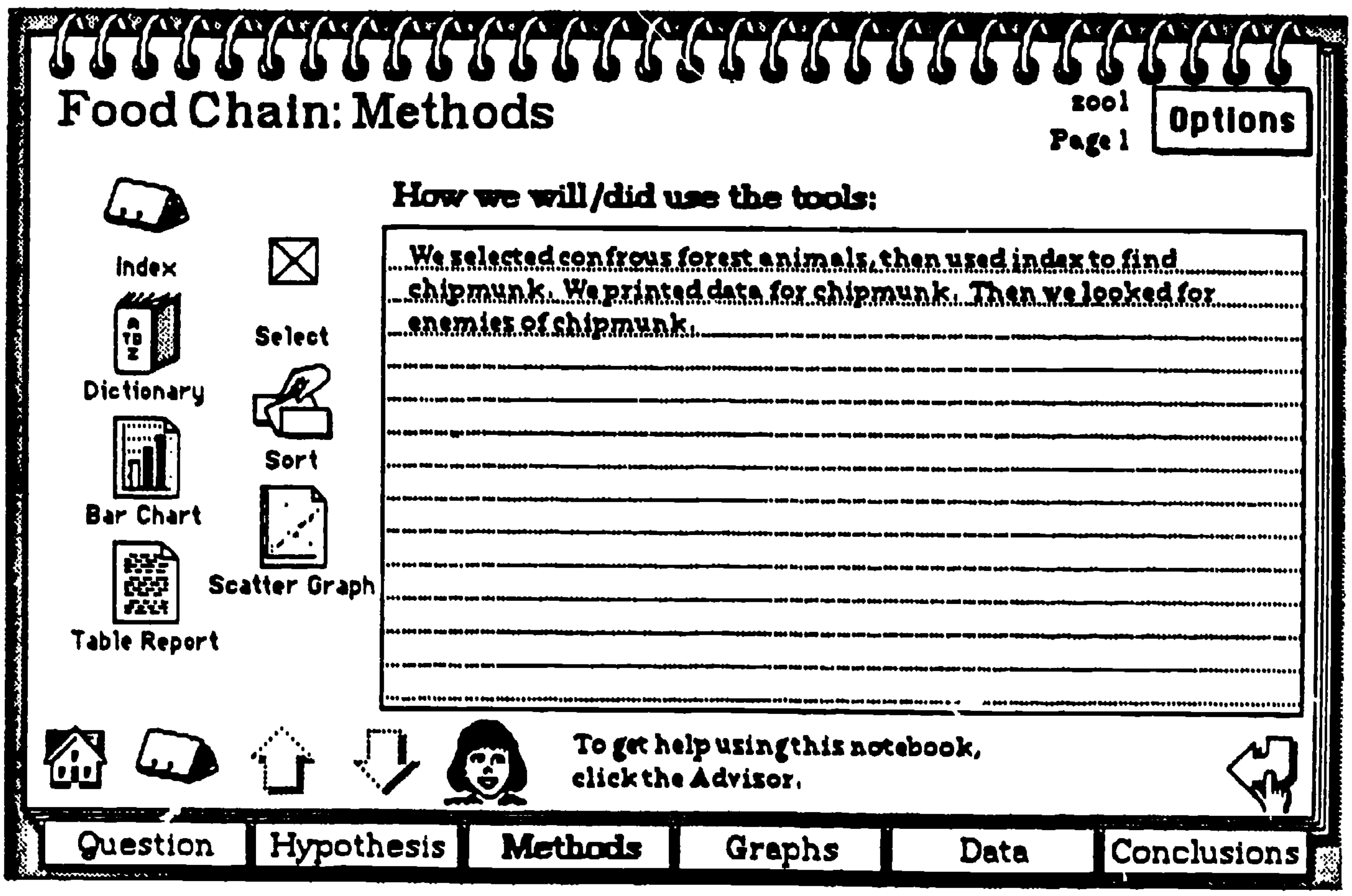


Figure 16 Methods Page in Student Notebook

KNOWLEDGE TREE ON GLOBAL CLIMATE CHANGE

Richard Golden
Climate Protection Institute

The *Knowledge Tree on Global Climate Change* is a computer information retrieval system that provides a student or teacher with a data base for the study of global climatic variations caused by the human-induced enhanced greenhouse effect (Figure 1). The target audiences are advanced high school students and educators who want an informational resource on global climate change.

The HyperCard system for the Macintosh computer is used. Physically the system consists of three 3.5 inch floppy diskettes. One diskette holds the HyperCard program and a stripped down version of the Macintosh operating system. The other two diskettes contain the data; one on the Physical Climate System the other on Global Climate Change. An introductory section supplies the first time user with directions on how to use HyperCard (Figure 2).

It was deemed insufficient simply to supply the student with information. To help the student to apply the information to the global climate system is the purpose of the program and therefore an Overview section is included. In that section, through a series of animated drawings, the student is introduced to various cycles that pertain to the global climate (Figures 3 and 4). The aim was to provide an overall conception of the operation of the interlocking systems whose details are displayed on the roughly 400 cards of information that are available.

From the Overview the student is directed to the Knowledge Tree card which gives a schematic view of the whole program. "Clicking" the mouse button on top of any of the words or phrases will open the stack of cards under the headings listed (Figure 5). The "Maps" referred to on the Introduction card are the displays of the topic headings. There are two of them, one related to each of the diskettes of information (Figure 6 and 7).

The student can access any of the 65 topics on the maps by a simple click of the computer mouse button. Under each topic there are "cards" -- computer screen views of information -- that contain text, graphics, and, in some cases, animations, photographs, diagrams, charts and sounds.

Reference words can be selected by the viewer that instantly bring

associated "cards" to the screen. In some cases, words requiring definition or more information are marked by an asterisk (*). Clicking on the word will cause the display of a temporary field of information which disappears at the next click. "Cards" displaying related information are linked to each other so that the student can follow any thread of connected concepts. A click of the mouse button when the cursor is on topic labeled buttons enables the student to navigate through the Knowledge Tree.

In addition, there are icons which when clicked will move the viewer from one portion of the Knowledge Tree to another. A changing listing of the topics of which the view card is a part is printed in the corner of the card. In this way the student always knows the more general area of which the current card is a part. It is easy to get "lost" in such a massive stack of information and therefore every card bears information relating it to the larger picture.

On the diskette "The Climate System," the subject is broken down into five components that contribute to climate formation: oceans, atmosphere, land features, energy flow, and cycles of interaction. The second diskette, "Global Climate Change," examines the way we affect the climate and divides its discussion into four broad areas: the study of climate change, human causes of climate change, the consequences of climate change, and possibilities for the prevention and mitigation of global warming and its effects.

The first version of the system was completed in December 1989 and was distributed to scientists at Lawrence Berkeley Laboratory for accuracy review. Classroom testing is underway. Revisions will be made and then the program will be made available to interested educators at a nominal cost.

For more information, contact:

Dr. Roland Otto, Director
Center for Science and Engineering Education
Lawrence Berkeley Laboratory, University of California
Berkeley, CA 94720;

The program was developed under the supervision of the Climate Protection Institute, 5833 Balmoral Drive, Oakland, CA 94619; Richard Golden, Director. Phone: 415/531-0100

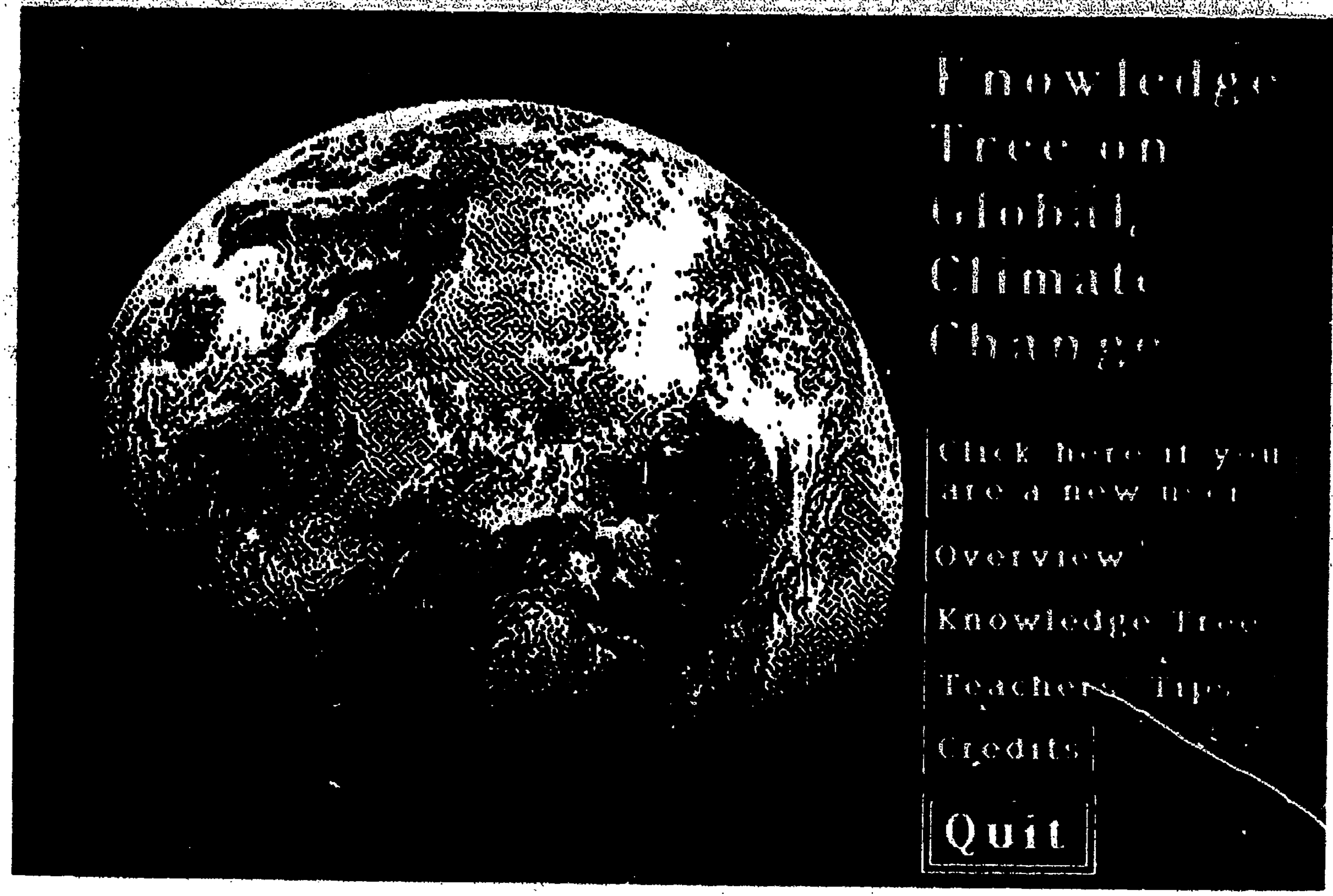


Figure 1 Intro Card to Knowledge Tree on Global Climate Change

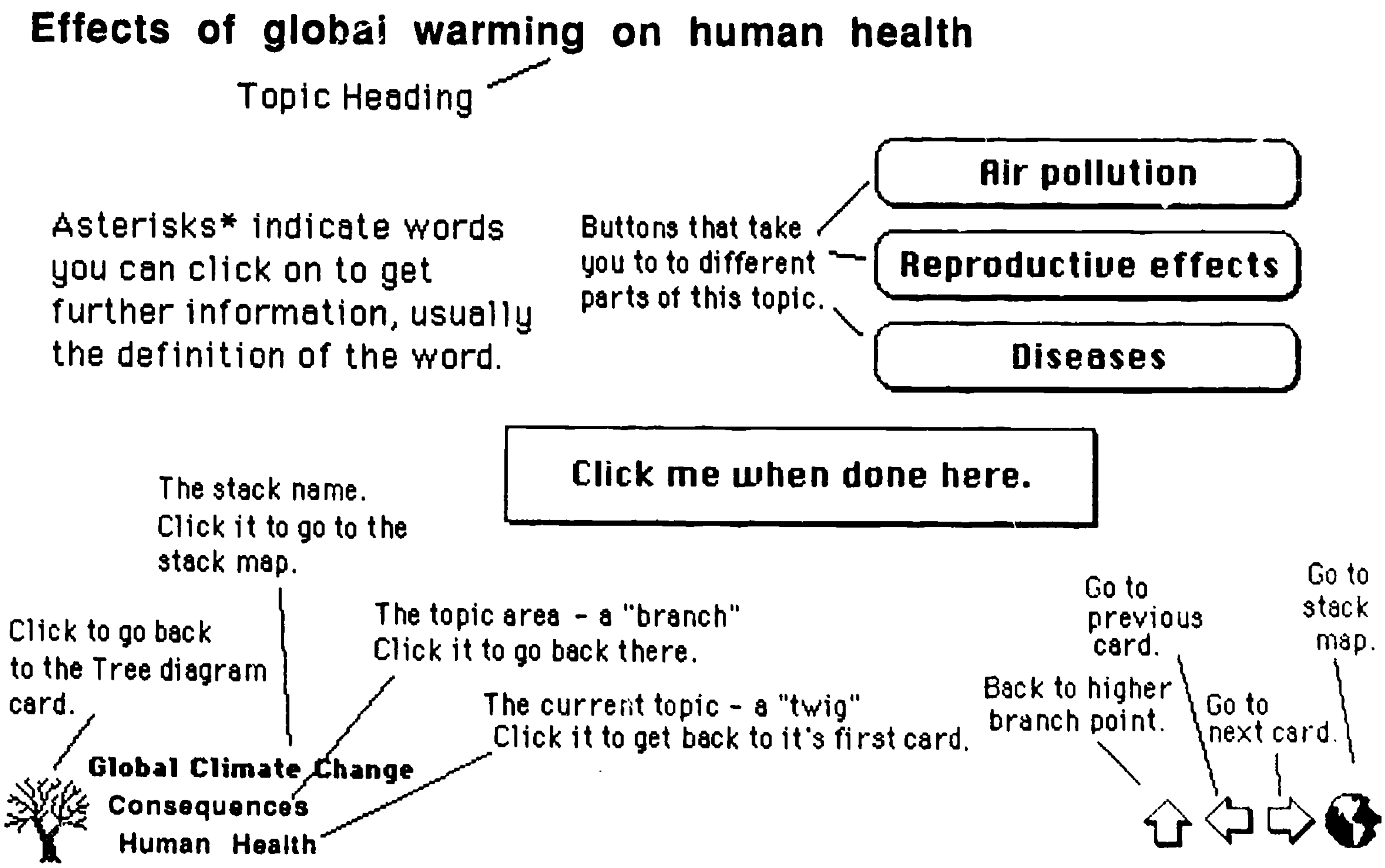


Figure 2 Explanation of HyperCard Features

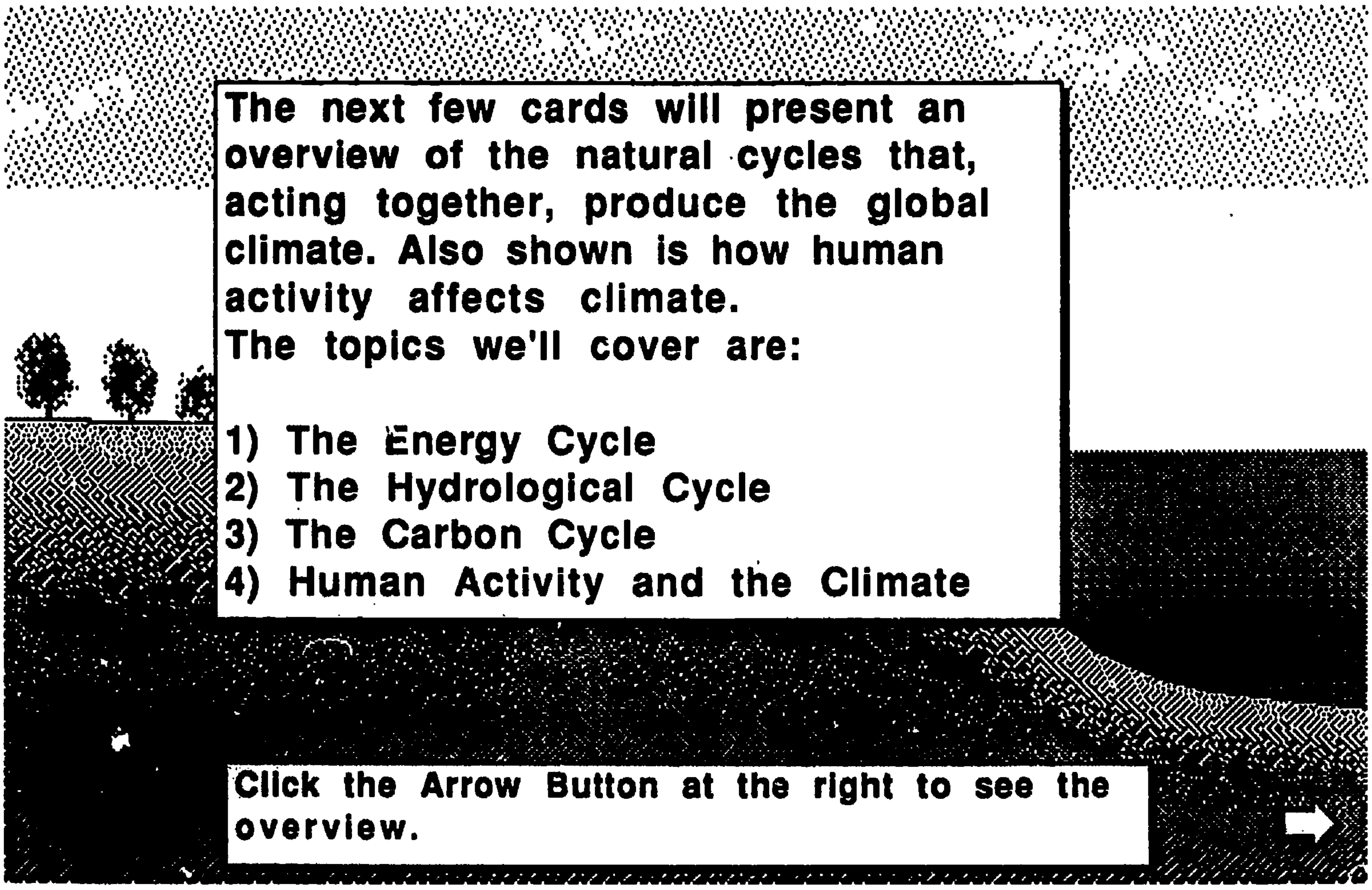


Figure 3 Cycles Introduction Card

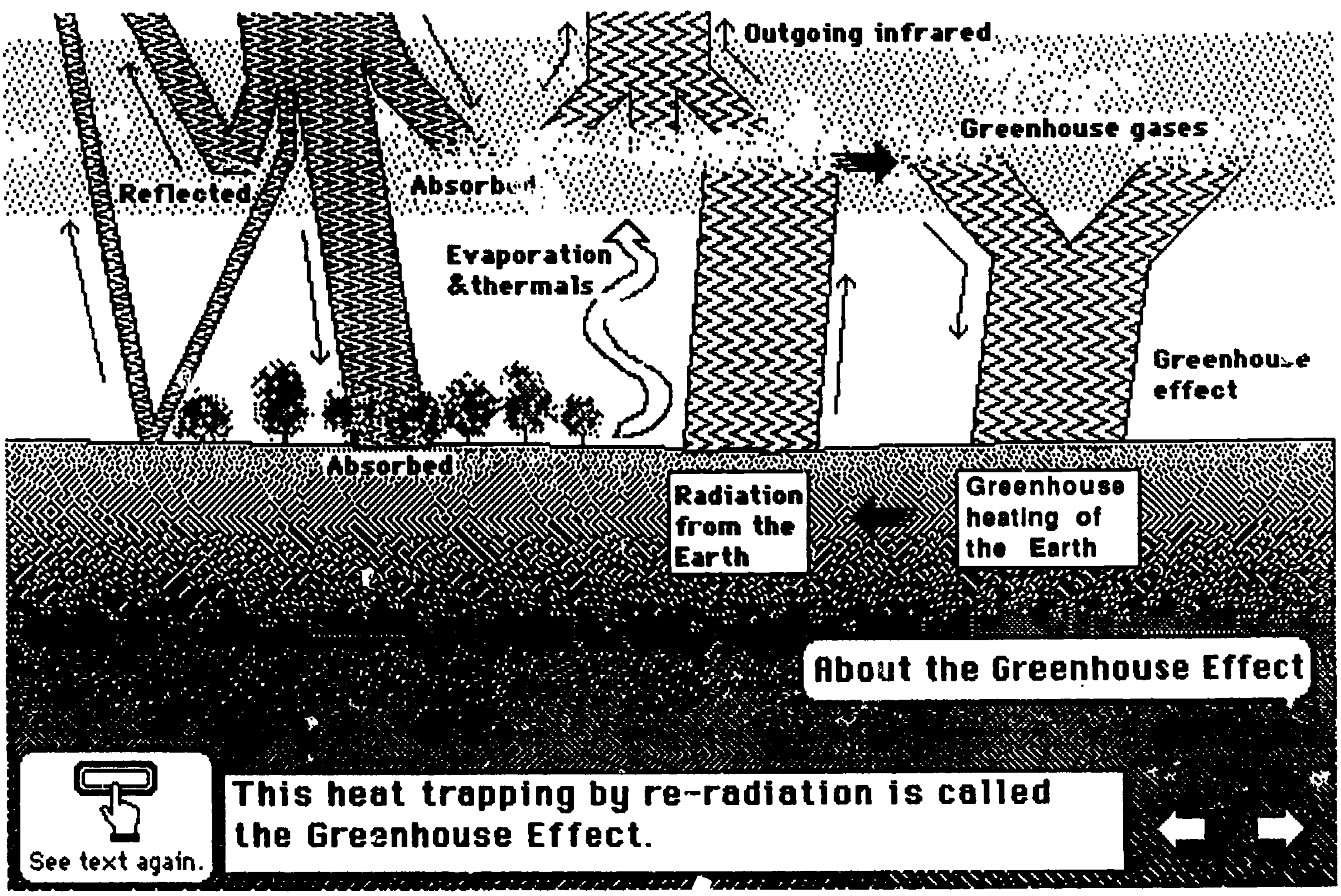


Figure 4 Sample Energy Cycle Card

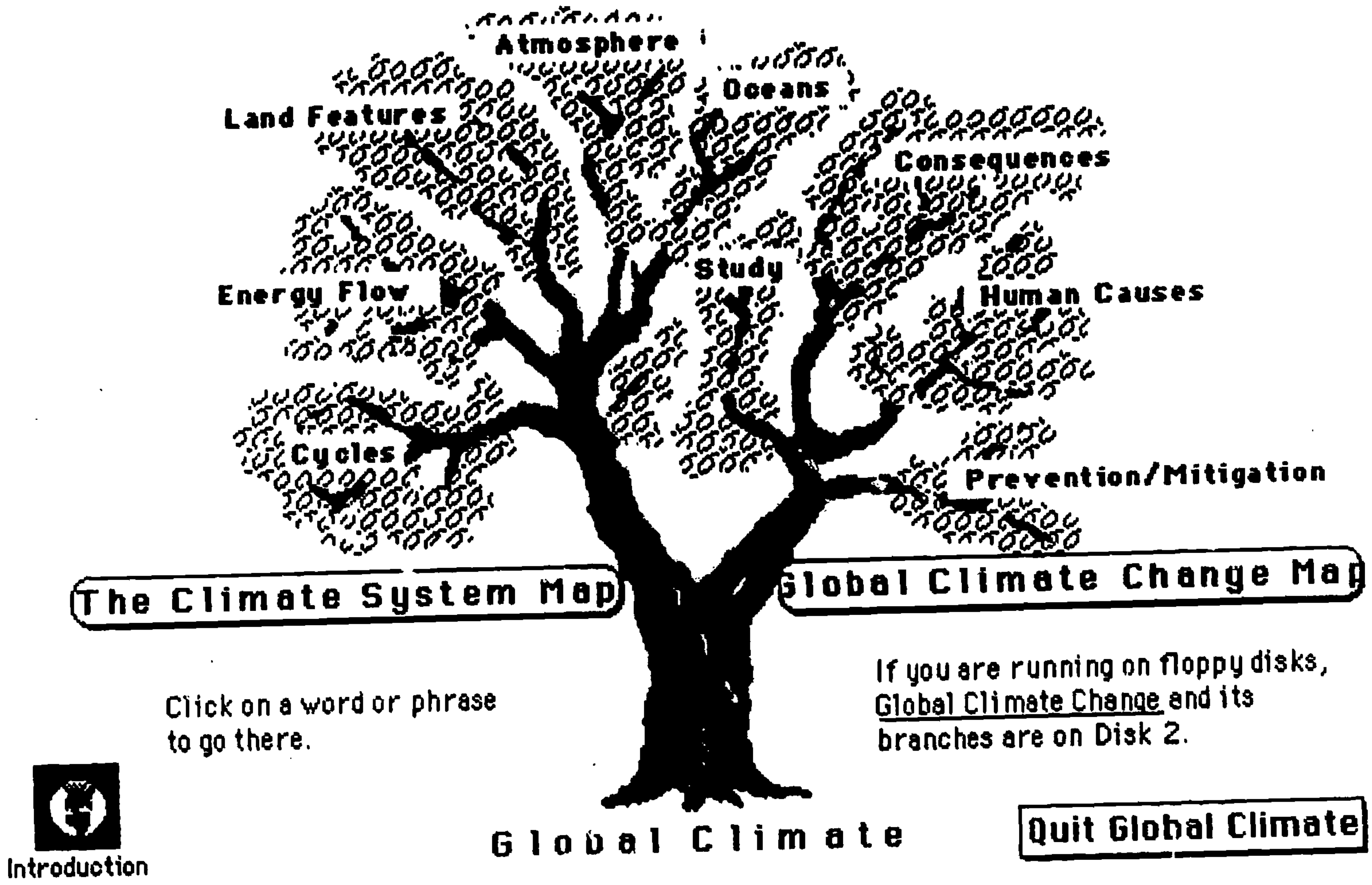


Figure 5 Knowledge Tree Card

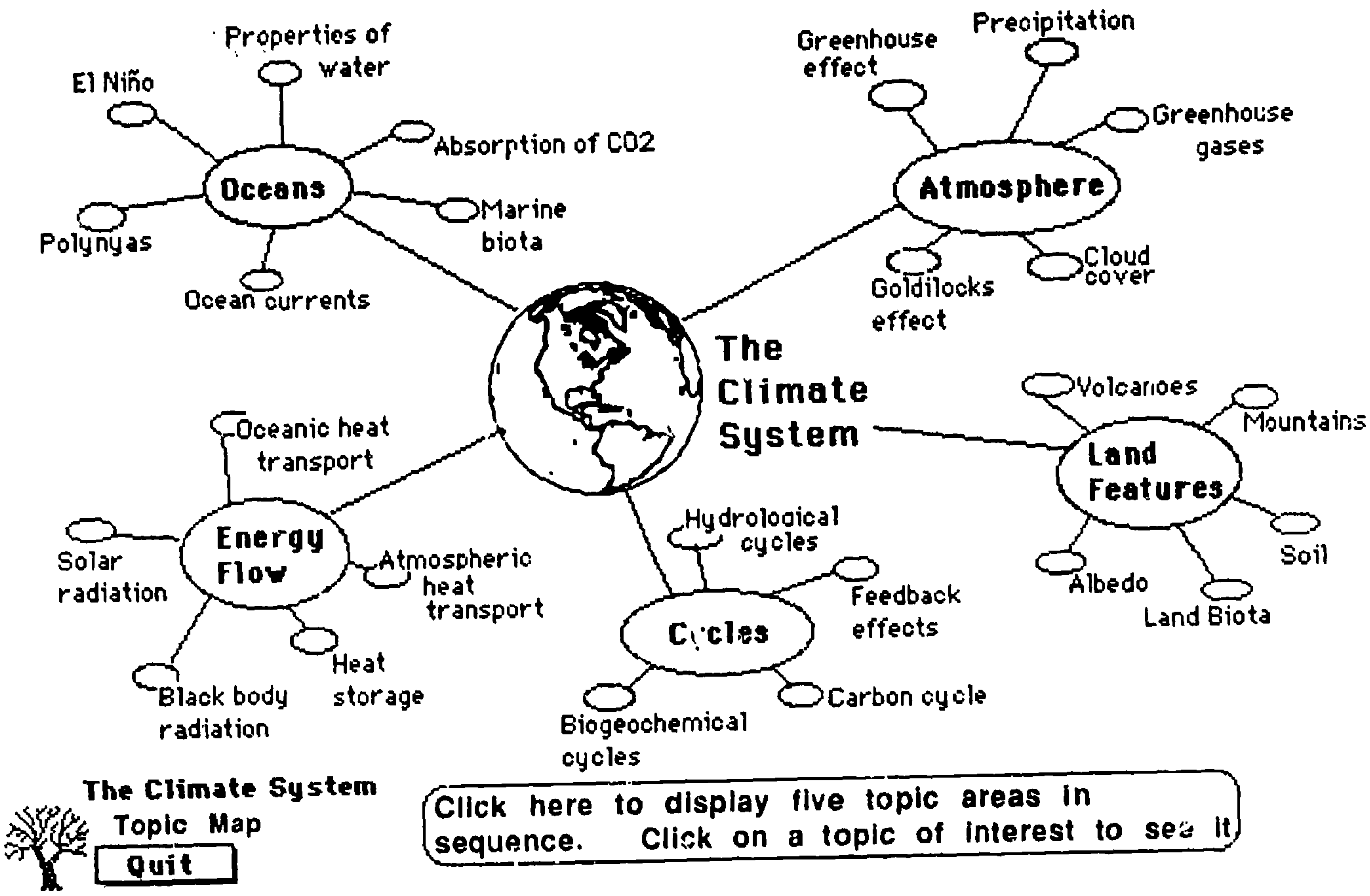


Figure 6 Global Climate System Map

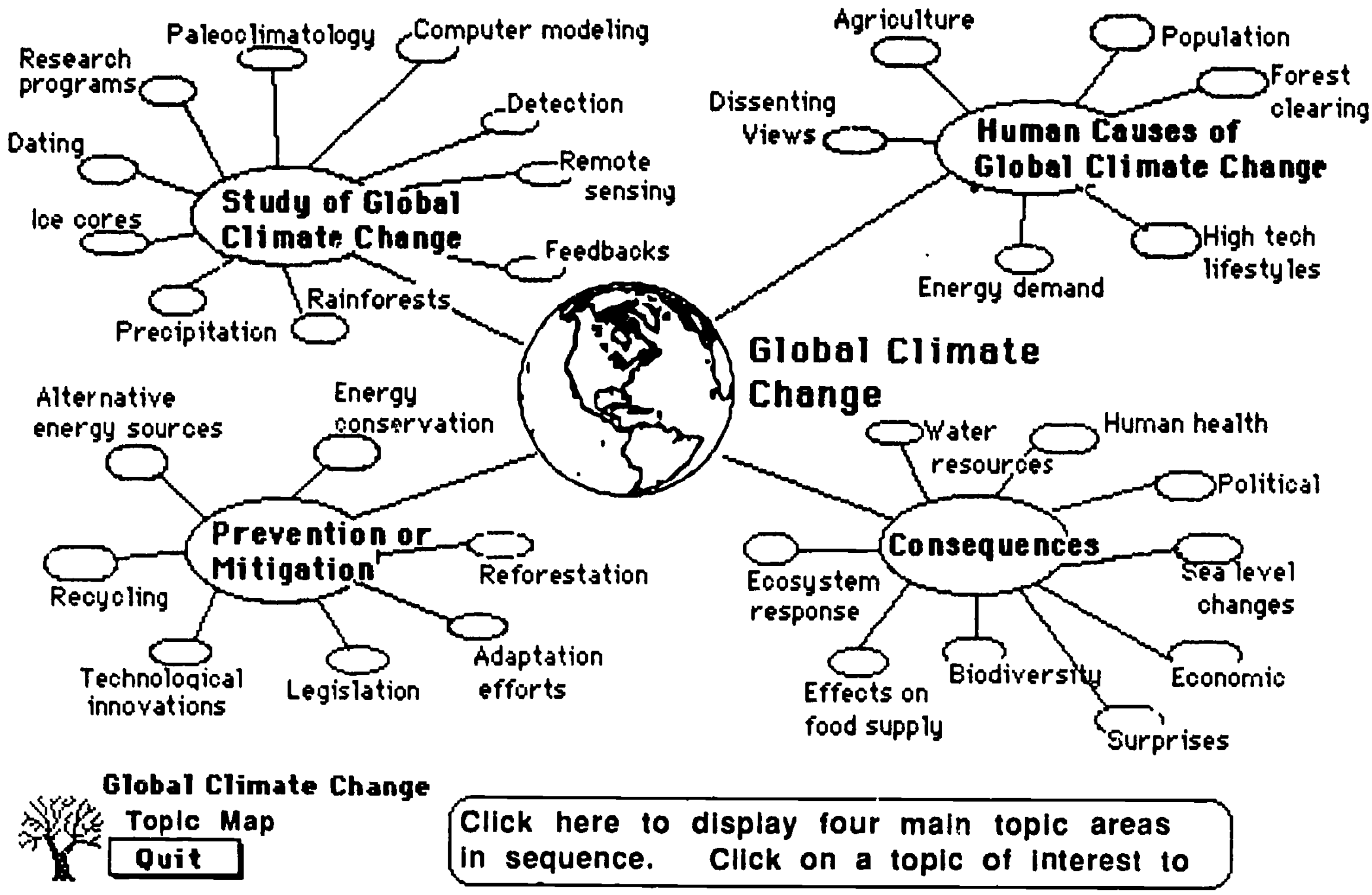


Figure 7 Global Climate Change Map

THE ELECTRONIC WHOLE EARTH CATALOG

Steve Cisler
Apple Computer

Outside of your professional career as an environmental educator, what were the three most influential reference books in your life? I would enjoy hearing your answers; in the meantime, here are mine.

In 1952 when I was nine, I received the first two books: The World Almanac and a 10-cent copy of the Johnson-Smith Catalog. The first one opened up other countries, world sports records, and the other news events in a way that television had not. The second was as thick as the almanac and promised me thousands of ways of getting control over my 9-year-old world: by making people laugh (dribbl glasses, magic tricks, ventriloquist dummies) or by amazing them (trick whips, giant bean seeds, sea monkeys, stamp collections).

Years passed before the third title made a similar impression on me. The year was 1968 and the book was the Whole Earth Catalog, a volume so revered that you may still find the tattered, oversize volume on a shelf in your public library. It was the compendium of tools for the new age, and books were one of the primary tools, as were solar devices, gardening equipment and construction equipment. Several editions came out over the years, all with Stewart Brand as editor or involved in some special way. A non-profit foundation was started to serve as an umbrella for various products. In 1984 they produced the Whole Earth Software Catalog, and their magazine, the Whole Earth Review, has been covering unusual developments in a wide variety of areas including the personal computer industry ever since. Kevin Kelly has been at the helm for many years, and his mark is also on the Electronic Whole Earth Catalog (EWEC), a CD-ROM product which is the subject of this article.

First, here is what the publishers say about their work:

> The Electronic Whole Earth Catalog is an evaluation and access device. It can help a user discover what is worth getting and how to get it. We're here to point, not to sell. Text and graphics excerpted here are provided for the reader to aid in evaluating what's being reviewed. We have no financial obligation or connection to any of the suppliers

listed. We only review stuff we think is great. Why waste your time with anything else? An entry is listed in this Catalog if it is deemed:

- Useful as a tool,
- Relevant to independent education,
- High quality or low cost,
- Easily available by mail.

This CD-ROM disk retails for just under $150 and only works on the Apple Macintosh. I have used it extensively on a Macintosh Plus and Macintosh II, but with less than 2 megabytes of RAM, you should use a system with fewer INIT files and fonts and desk accessories. There are 413.5 MB of files: approximately 29 MB of HyperCard stacks, 24 MB of inverted files for rapid searching, and over 360 MB of sound files. There are about 9,500 HyperCard cards, over 2,500 items with 4,000 pictures, 2,000 text excerpts, and 500 sounds.

Developing the Product

The advent of CD-ROM brought the Point Foundation, Apple Computer, and later, Broderbund Software together. In some ways CD-ROM is the perfect medium for the Catalog; the Macintosh is the platform that can utilize sound, graphics, and text on an optical disk; the electronic product allowed Broderbund to enter the CD-ROM market. The development of this product is a good example of why optical products generally cost more than print versions. Working with various supporters in Apple's Advanced Technology Group, the Point Foundation spent more that 12,500 hours developing this disk. The three partners put in more than $200,000, plus hardware and software. How did the development differ from the production of the text-based products?

At the start, they were using the unreleased version of HyperCard. Since HyperCard allows sound, graphics, and text links to be included, it was not just a matter of moving ASCII files and providing some sort of search engine for the text. A great deal of energy went into designing the interface. They used various scanning methods for screen backgrounds and for converting the sample illustrations and small pictures of the book

covers or record jackets. Displaying complex drawings and photographs in black and white with a resolution of 72 dots per inch is a compromise. It is an important first step, but it whets my appetite for high-resolution color images. This is possible when programs are used to extend the capabilities of HyperCard, but Broderbund and the Whole Earth crew wisely decided not to penalize the millions of Mac users who have a 9-inch black and white screen. So it is limited to the resolution of the Mac Plus screen.

Converting the text portion of the catalog was not as simple as they had hoped. Esthetically, they wanted the individual entries to wrap at the proper points on the screen, so it was often simpler to rekey the text, than to fiddle around with an imported text file that was full of odd line feeds. Because HyperCard can only display one font and style, book titles are not italicized. Most of the text is displayed in 12-point Geneva, again because that is the default font that every Macintosh user has. It is quite legible and the reader can print the article if reading on-screen is tiring.

How the Disk is Organized

EWEC is the ultimate browsing medium. Combining such disparate materials with HyperCard and Mark Zimmerman's Tex search engine, and putting everything on CD-ROM allows the user to graze everywhere in the database or hunt for specific items. The tools for narrow Boolean searches are not provided, just single words in context. When Bill Atkinson, the author of HyperCard, spent an evening with a copy of EWEC, he wound up buying $800 worth of books and tools that he ran across in the articles. Any item that is for sale includes an order form that inputs the item name and price; you add your name, address, and a check for the full amount and send it to a store that is not connected with the Point Foundation. Material and prices are accurate through the latter part of 1988.

The card pictured in Figure 1 shows the hierarchical pyramid consisting of the table of contents at the top, the domain cards below, followed by section, cluster, and article cards. The Table of Contents card (Figure 2) lists the domains: Introduction, Whole Systems, Community, Place, Household, Craft, Livelihood, Health, Nomadics, Communications, Media, Learning, Music, and Index. Click on the Whole Systems icon to reach the listing of all the items in that domain (Figure 3); jump to that item by pointing and clicking on the one line description. You can shift

domains by selecting one of the items in the vertical list in capital letters. If you click on the Whole Systems text shown in Figure 2, the program links you to the diagram (Figure 4) that shows the cluster of various whole systems: Space, Cybernetics, Civilization, Animals, Plants, Ecology, Evolution, and Gaia. Clicking on the Gaia button moves you to the section of subjects: Regional Maps, World Maps, and Gaia Hypothesis (Figure 5). Another level lower in the hierarchy (Figure 6) show the group of articles related to mapmaking. At the lower right part of each screen are two triangles for moving back and forth within the sections or clusters or cards that comprise each article. Figure 7 shows one of three cards of the review of Electronic Map Cabinet and Highlighted Data.

I found that moving between the cards and different areas can be confusing if you click too rapidly or too often. The commands are stacked up and carried out no more quickly than the CD-ROM drive can respond. Once you get used to this, navigation is quite simple.

The menu shows you where you are in the hierarchy and lets you move to a higher level or to the Index, the Table of Contents, or to Quick Search (Figure 8), based on Mark Zimmerman's Tex, a shareware retrieval system written for HyperCard. Since EWEC came out, Zimmerman has added proximity searching to his program and will be implementing full Boolean searching for text, and is working on ways of searching for graphic items as well. Although EWEC does not have these enhancements, I find Tex very useful when I don't want to browse through the hierarchy of cards.

Adding Value Through Sound

Where EWEC is vastly superior to the printed product is in the addition of sound. Over 500 digitized clips of less than a minute in duration to several minutes have been added. Each is marked by the music note icon in article cards. The quality of the sound is excellent, and I recommend that you attach headphones or supplemental speakers to bring out the full quality. I've used $15 imported speakers I picked up at a flea market as well as $200 Bose units for presentations. Either will enhance the listening experience.

Our experience at Apple Library has been that young people and adults really enjoy browsing through the text and sampling the music for hours at a time. Many people have remarked that the sound samples are extensive

enough to help them decide to buy a record or audio CD being featured.

Although EWEC is not meant as a sales catalog, I envision the day when retailers or mail order firms send out CD-ROMs with images and sounds and have transparent online links for pricing and ordering.

For more information, contact:

Broderbund Products 800/521-6263

The Point Foundation is located at 27 Gate Five Road, Sausalito, CA 94965. EWEC is also available through software retailers.

Communications to the author should be addressed to Steve Cisler, 4415 Tilbury Drive, San Jose, CA 95130; 408/974-3258; AppleLink -- Cisler1; Internet -- sac@apple.com; CompuServe -- 73240,1016.

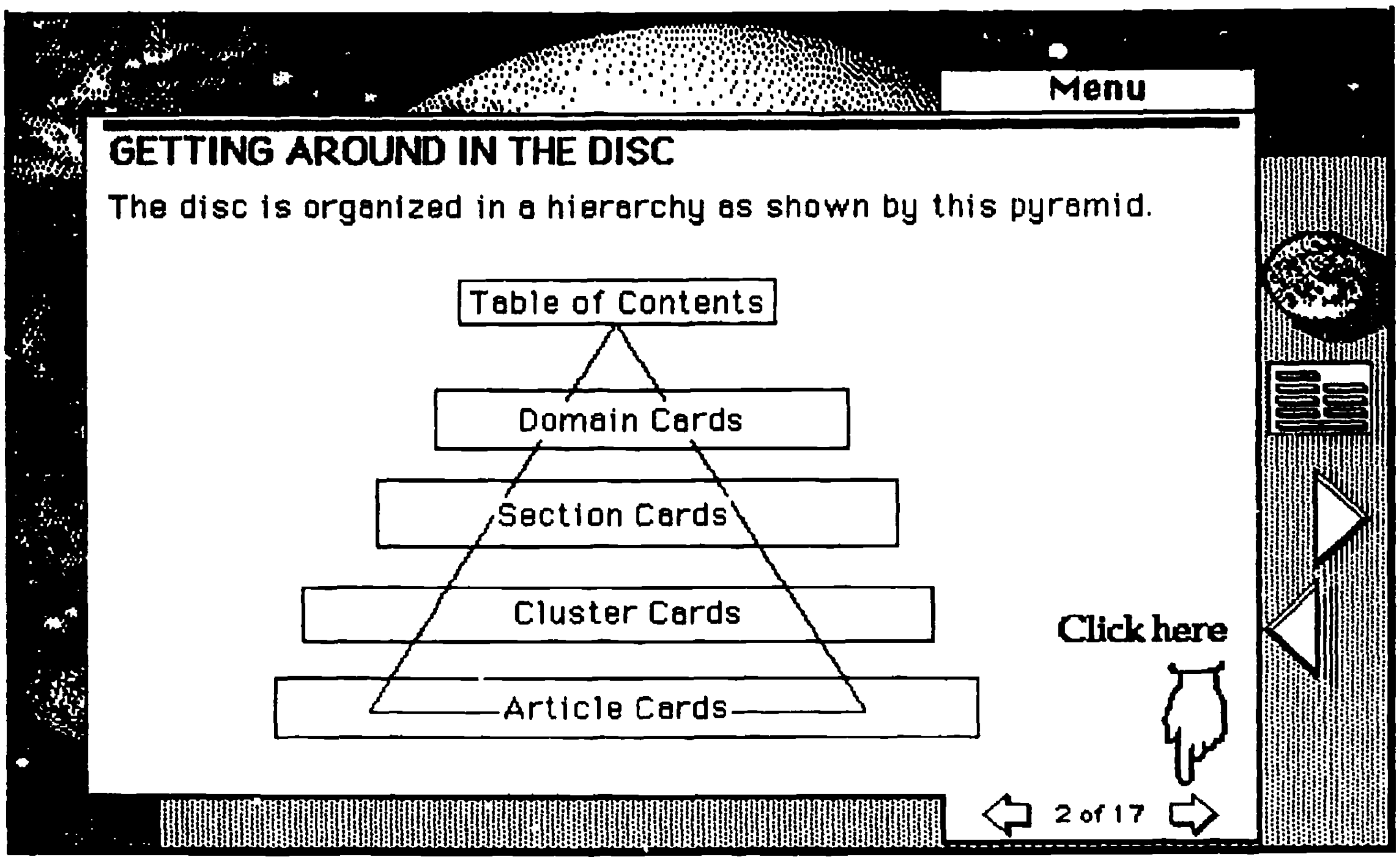


Figure 1 Getting Around the Disk

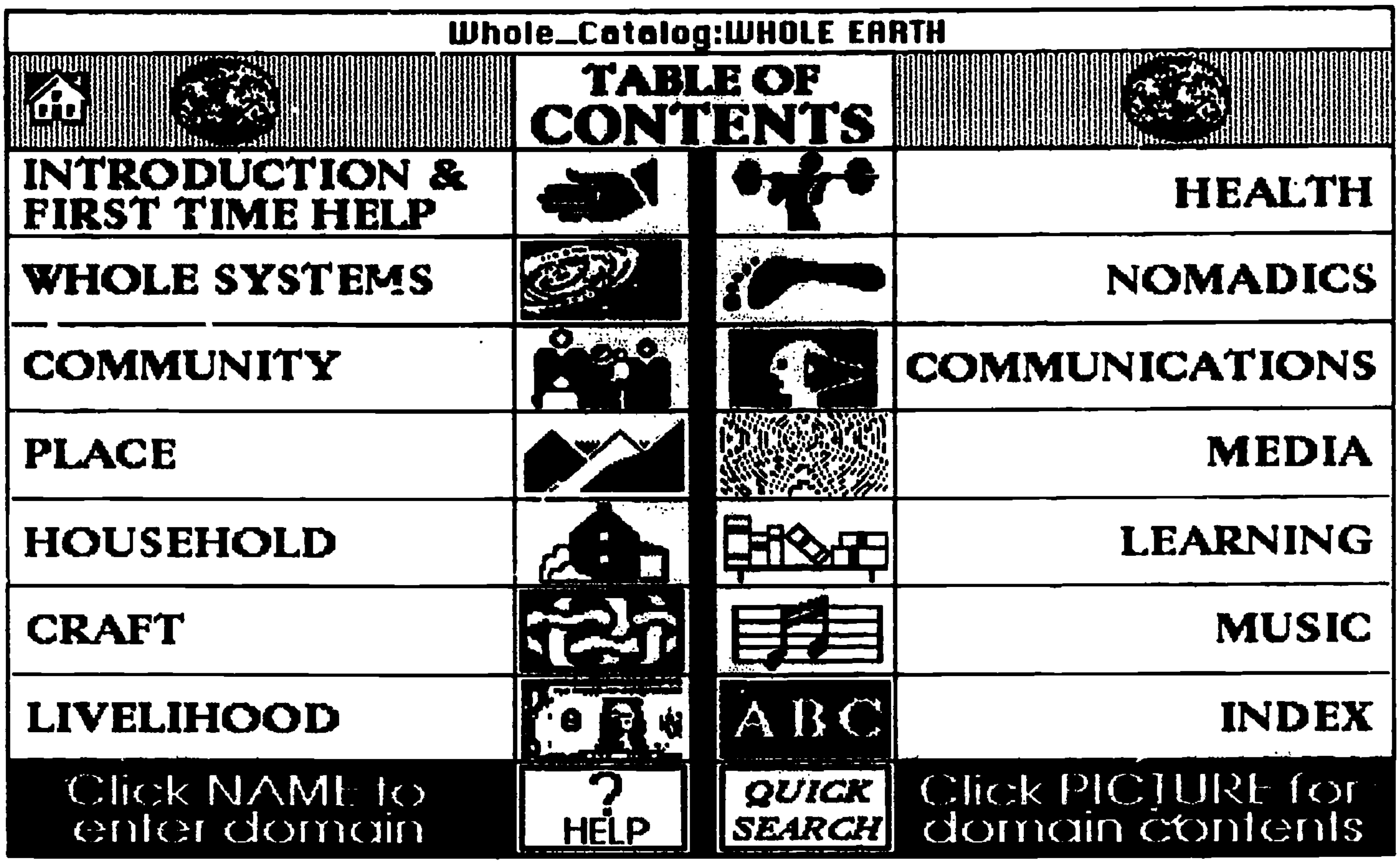


Figure 2 Table of Contents

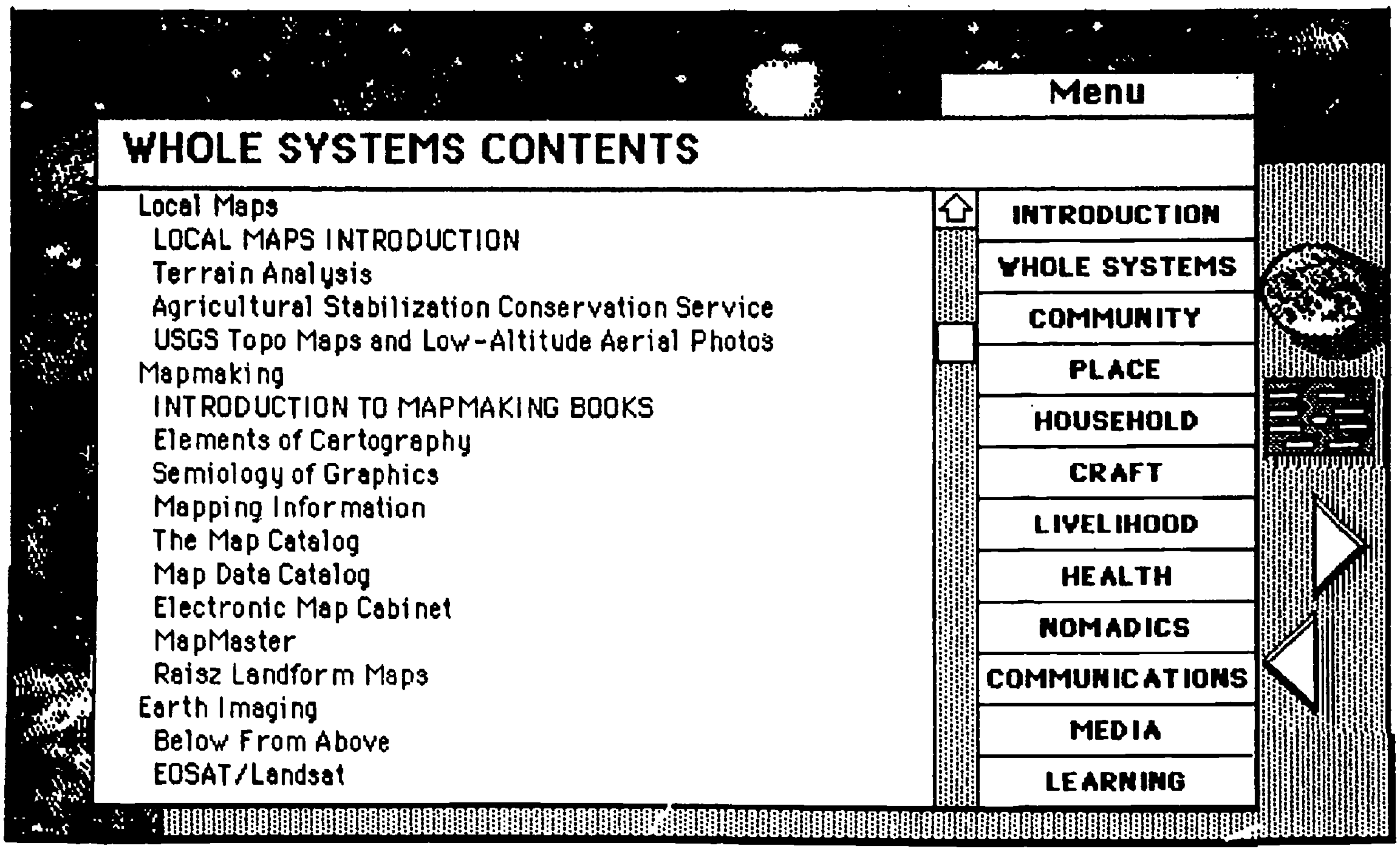


Figure 3 Whole Systems Contents

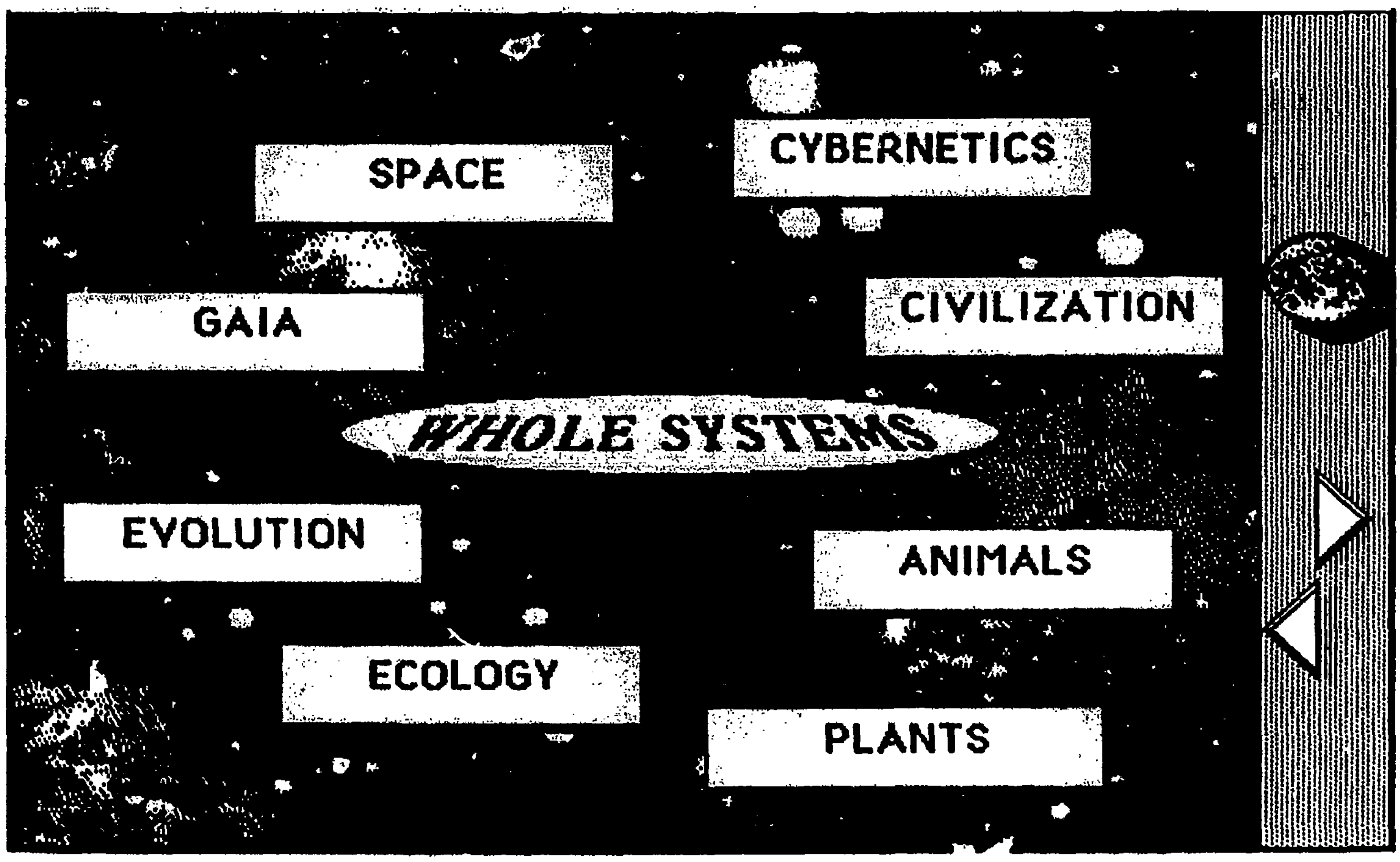


Figure 4 Whole Systems Cluster

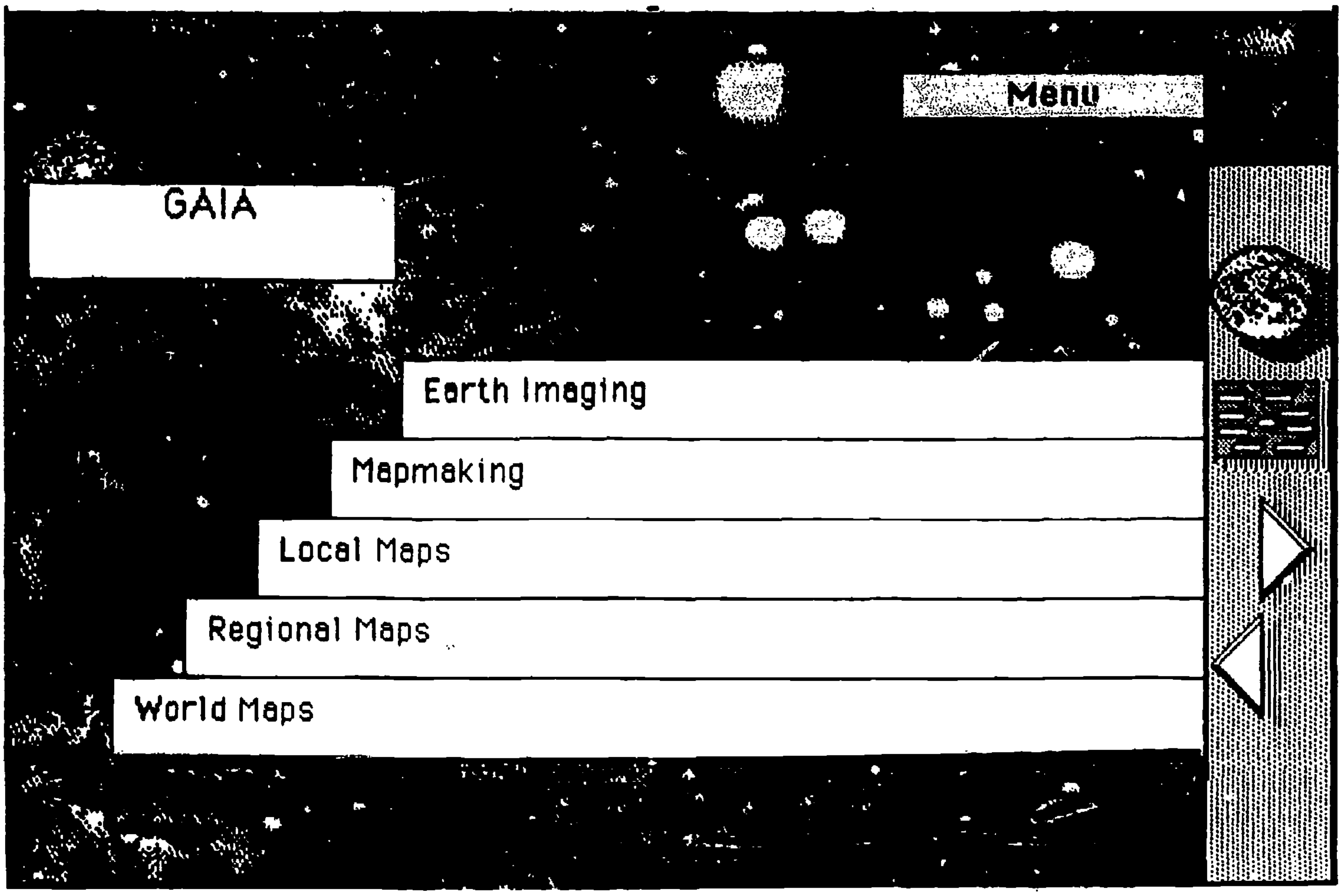


Figure 5 Gaia Subject Listing

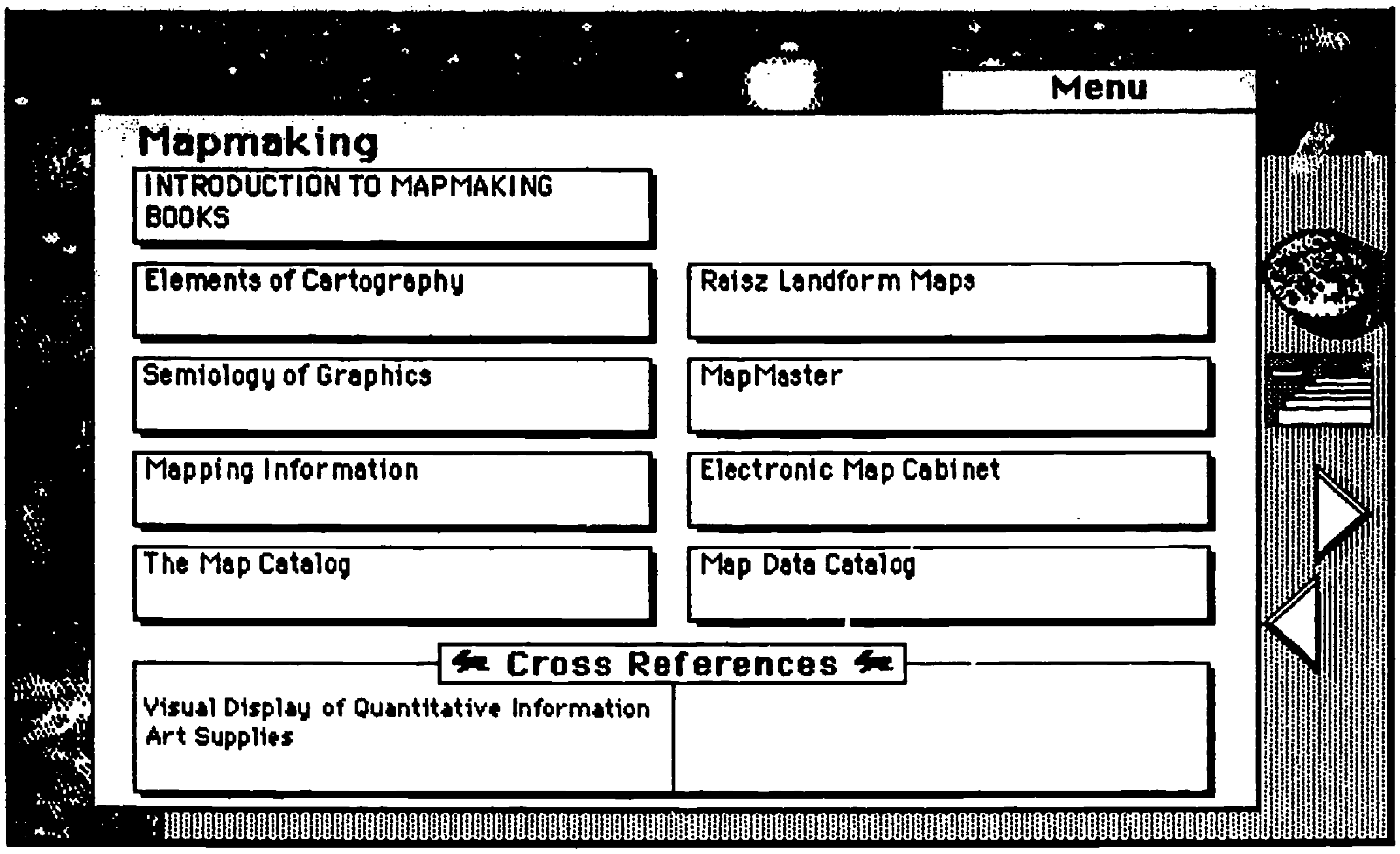


Figure 6 Mapmaking Articles

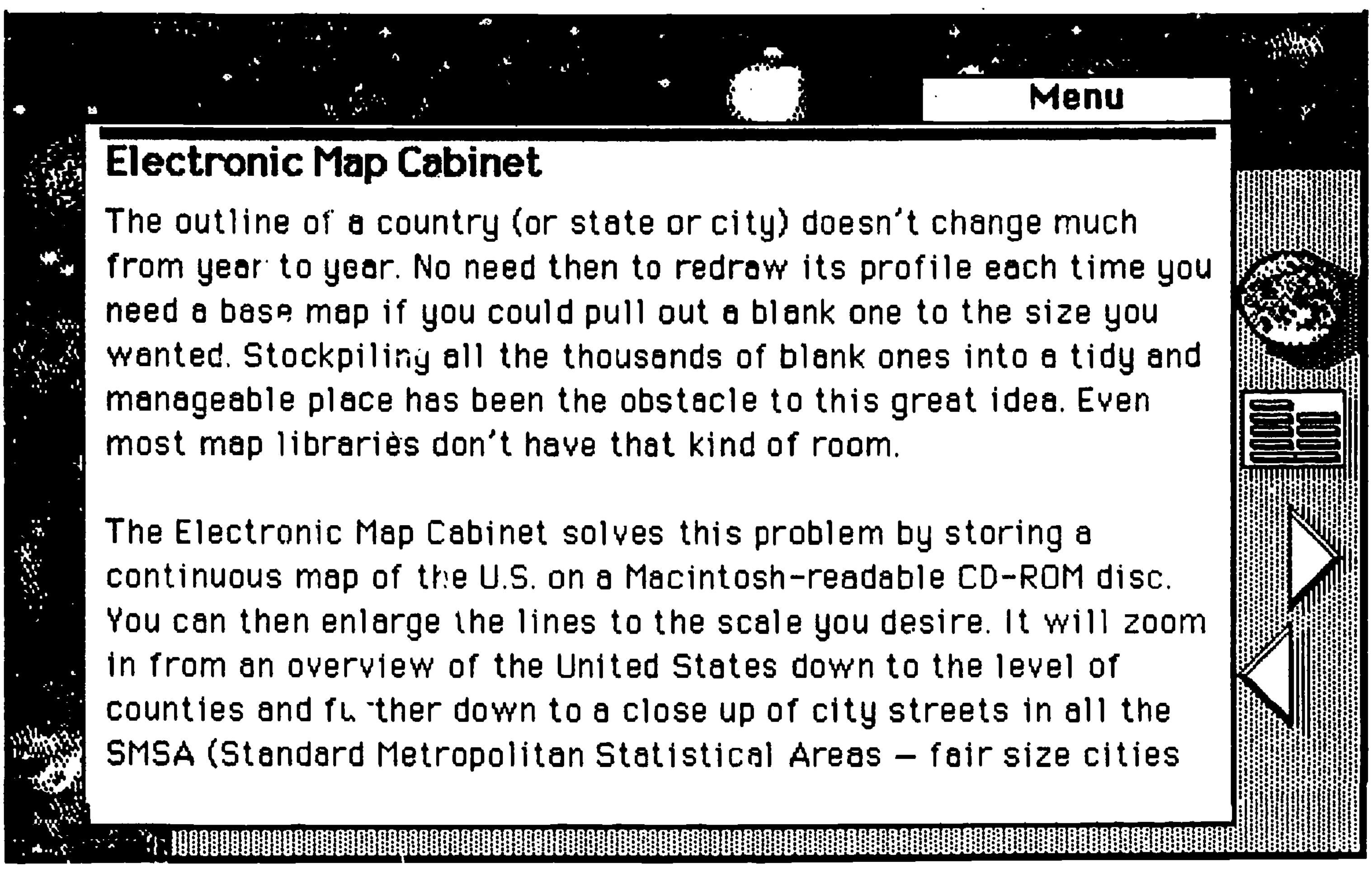


Figure 7 Electronic Map Cabnet

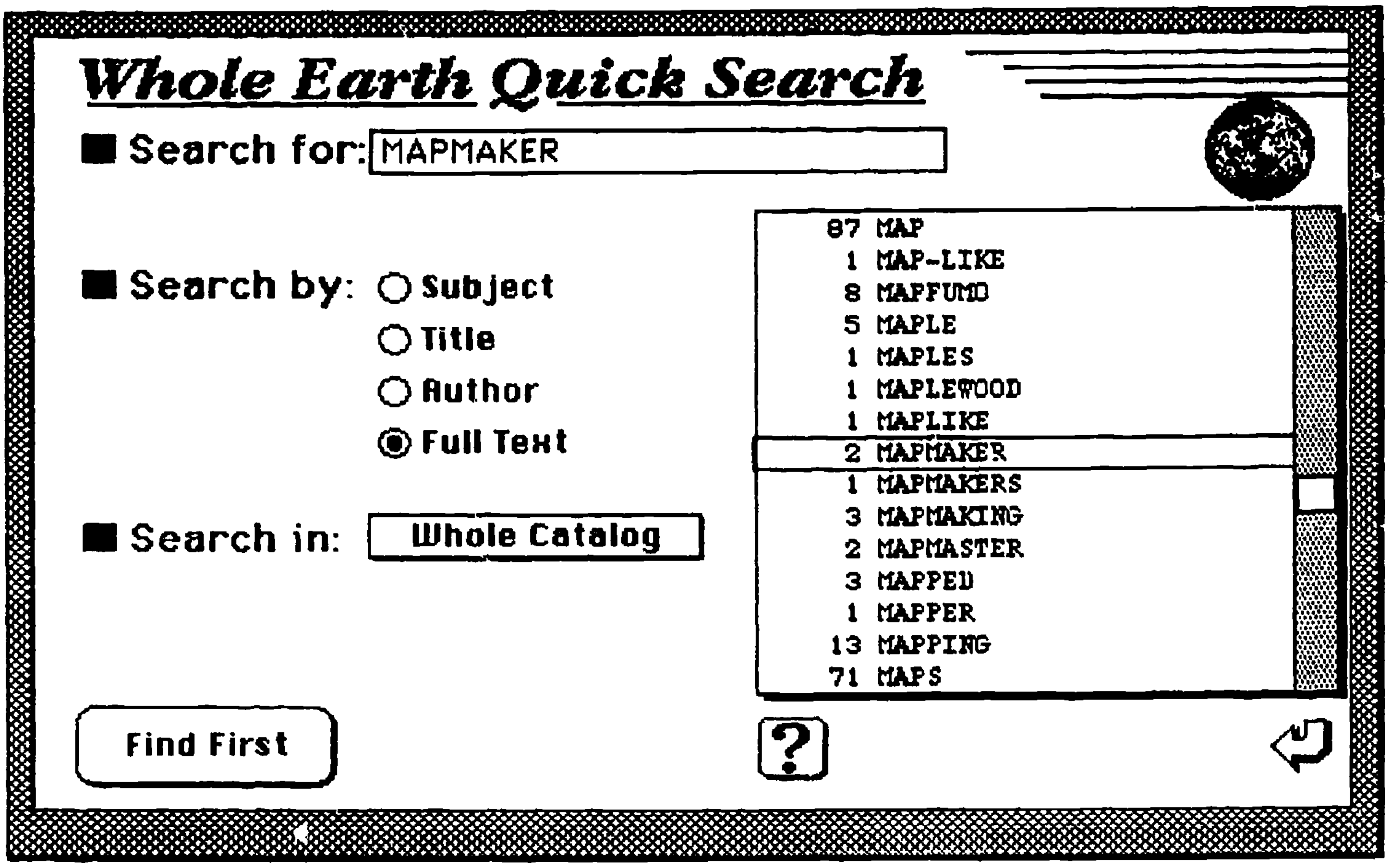


Figure 8 Quick Search

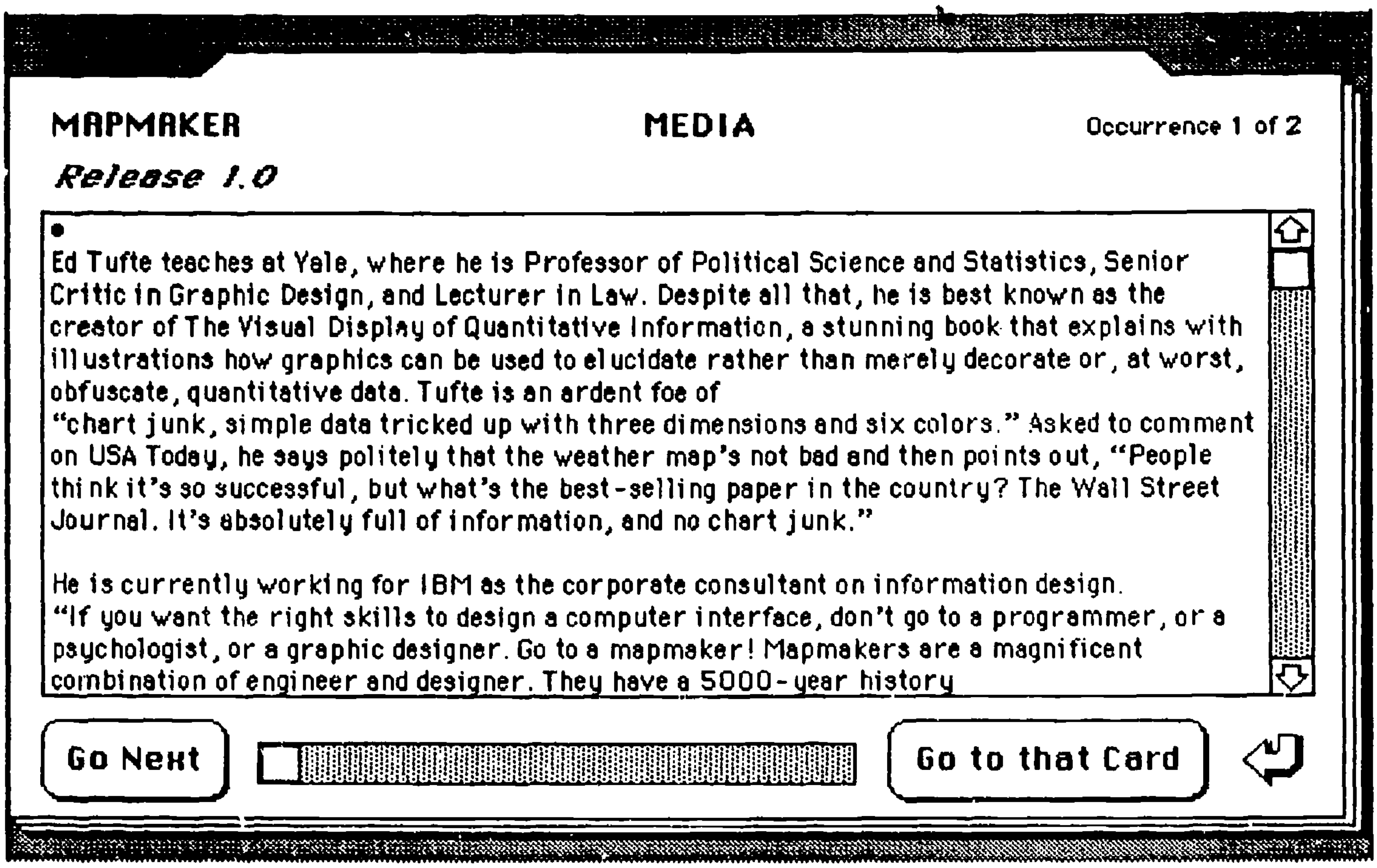


Figure 9 Map Maker Media

TEACHING SUSTAINABLE MANAGEMENT OF RENEWABLE RESOURCES

Dennis L. Meadows and Thomas S. Fiddaman
University of New Hampshire

Introduction

Since 1983 we have experimented with a variety of gaming formats in our effort to produce a powerful game-based teaching technology that will give senior public officials insights and principles, or heuristics, that will help them deal more effectively with a set of basic problems observed in resource and environmental systems of many countries. Our goal is to address the so-called universal problems, those that manifest themselves to some extent in most regions of the world and can be addressed locally. Examples would be soil erosion, inflation, deforestation, AIDS, and urban decay. These may be contrasted with the so-called global problems which are also observed in most regions of the world but which require concerted, international action for their solution. Marine pollution, the arms race, acid rain, and ozone depletion are examples.

In this paper we will explain the goals and methods of our application of simulation gaming to these problems. To illustrate our approach, we will describe the function, mechanics of play, and theoretical foundations of a simple game that teaches principles for sustainable management of renewable resources.

Gaming

Games may be designed to fulfill a variety of goals: creating a friendly and cooperative attitude among the participants, enhancing the players' communication or problem-solving skills, providing a set of metaphors and a meta language related to a group of phenomena represented by the game, providing pleasure, assessing the effectiveness of alternative decision strategies, or instilling a set of principles about the causes and

consequences of basic phenomena observed in a real system. These and other objectives are described usefully by Greenblat and Duke (1981).

The styles or modes of games used to achieve any of these goals may differ drastically - person-machine interactions, pure role-playing simulations, board games, physical exercises, and others. However, teaching principles for management of a real system generally requires the game to use a fairly sophisticated model of the underlying system. This model may be embedded entirely in the rules of the game, or be partially represented by a computer simulation.

There are several advantages to using a computer in a complex game. A computer can increase the realism and richness of information in the game, while at the same time freeing the players from performing tedious manual calculations. It is important that the computer be an unobtrusive part of the game, however, as the players' interpersonal relations are important to the processes of building cooperation in the group and of learning about the system.

Approach

Our approach has been to identify a set of cause-effect mechanisms that lie at the heart of a specific universal problem; these constitute a dynamic framework of the system represented by the game. Then we develop a game that conveys that set of causal interactions to an individual in a way that makes them relevant to many different regional settings and to a class of dynamically related problems. Rules structure the actions and relations of the players. The computer model represents a subset of the system and handles any accounting and scoring necessary. We create paraphernalia, such as game boards, to represent elements of the real system in order to allow visual thinking about the system and to facilitate communication and negotiation.

We develop the underlying structure of the game system and the accompanying computer model using the methods of a systems analysis technique called system dynamics (SD). SD is a comprehensive approach to the representation, diagnosis, and change of behavior patterns in complex, dynamic systems. The SD method is based on concepts of information

feedback, and it employs computer simulation of feedback models representing real world issues. The SD technique has roots extending back many decades into fields as diverse as operations research, social psychology, economics, and computer science. But the present philosophy and tools of the SD method originated in the 1960's with Professor J. W. Forrester and his associates at MIT in Cambridge, Massachusetts. It is now used throughout the world (Forrester 1961).

Normally SD models are closed; their behavior derives entirely from a set of rules embedded in computer equations. But in order to make a game one must open the model to influence from the players in each cycle of the game. Our fisheries game illustrates this approach.

Fish Banks, Ltd.

Fish Banks, Ltd. is a microcomputer-assisted simulation that teaches principles for the sustainable management of renewable resources. It was developed to serve as the introduction to a five-day workshop that conveys the fundamental insights required for corporate managers, public officials, and private citizens to use their regions' natural resources intensively without deteriorating the long-term productivity of their resource endowment.

The game also can be operated very effectively without the other workshop materials. Nevertheless, the game is influenced strongly by our goals for the workshop. That training session is intended principally for reproduction and wide-spread use by relatively unsophisticated instructors in Third World training centers. As a consequence, the game was specifically designed to fulfill eight requirements:

• The lessons instilled by the game should be interesting and relevant to participants from a wide variety of different regions that may be at different levels of technical, political, and economic development.

• The game should be suitable for use by groups of any size between 8 and 40 players.

• The game's computer program should be easily converted for use on any of the widely-available micro computers.

• A complete set of materials for the game should cost less than $50 to produce, preferably much less.

• One operator should be able simultaneously to run the computer and supervise the play of all participants in one game.

• The materials that are destroyed, lost, or used up in the course of a game should be easily and cheaply replaced with photocopies.

• It should be possible to start the play of the game without an extended introduction.

• A computer should be used to make it unnecessary for participants to make tedious calculations. But the machine should be unobtrusive - definitely the computer should not intrude on the social interactions that are at the heart of the game.

This last criterion was established for two reasons. First, an important goal of the game is to introduce the participants to each other; thus most of their time should be spent on interpersonal discussions, negotiations, and debates and not on person-machine dialogues and data entry. Second, most participants in our workshops have total ignorance, even apprehension, about computers. Therefore, the workshop materials must be designed so that participants can take part in early sessions of the workshop without being forced to learn how to operate any computer. One important goal of our resource management workshop is to give its participants some facility in the use of computers, and this is addressed later in the week. The opening sessions nevertheless must be designed to respond to the fact that computer-based systems and exercises are intimidating to many.

Through two years of testing and refining the game we achieved all eight goals for Fish Banks, Ltd.

Setup

Introducing, playing, and debriefing the exercise requires about three hours, with minimal setup time. The room used should be large enough to allow all the players to move freely about.

The principal materials required include the following items:

- Introduction and Debriefing Transparencies
- One copy of Role Description and Opening Scenario per player

- One Decision Sheet for each company
- Money
- Ships (100 units total in ships of three different colors:
  white = 1, red = 5, gold = 10)
- Game Board (2' x 2')
- Fish Banks, Ltd. program disk and any required system disks, tested in advance
- Overhead Projector
- Computer and printer with appropriate operator's manual

With the exception of the computer and overhead projector which are readily available in a normal school or conference facility, all materials are included in the game kit. Expendable materials may be reproduced by photocopying from the game manual.

Briefing

Players are divided up into teams of two to five members, each of which will operate its own fishing company in a common ocean. Each player is provided with a five-page role description which enumerates the team's goals and resources and describes the state of the fisheries system. A few samples of the text of a role description follow:

> Congratulations! You have just been hired to manage one of the principal fishing companies in your country. Together with the others in your company - captain and crew members - you will operate your fishing fleet each year according to policies you design to accumulate the greatest assets. The rules and information required for your success are provided below.
>
> Your bank balance is increased by income from fish and ship sales, and decreased by expenditures for ship purchases and operation. Additionally, your account is subject to interest earnings and charges. Your total assets equal the sum of your bank balance plus the salvage value of your ships at the end of the game ($250 per ship).
>
> You may change the size of your fleet by buying ships at auction, negotiating to buy or sell ships from another company, and ordering new ships from the shipyard.
>
> Two fishing areas are available to you: a large deep-sea fishery (#1), and a smaller coastal fishery (#2). Biologists have estimated

that area #1 could potentially support between 2000 and 4000 fish, while area #2 could support between 1000 and 2000 fish. The fish population is increased by natural births; it is decreased by natural deaths and by harvesting. The fertility of the fish and their lifetime are both influenced by the density of fish. Your total fish catch is influenced by the number of ships you send to sea, the fishing area chosen, and ship effectiveness.

The information in the role descriptions is supplemented by a brief introduction provided by the game operator. A set of overhead transparencies is provided for this function (Figure 1).

Play

The players proceed through six to eight one-year rounds of the game. In each round, there is an auction, in which the players have the opportunity to acquire new boats, and a trading session, in which players may buy or sell boats to or from other teams. The players then allocate their ships among the two fishing areas and the harbor. Their decisions are recorded on a sheet provided for that purpose and passed to the operator. The operator enters the decisions into the computer, which simulates the outcome of the year's activities. It calculates the fish harvest based on the allocation of ships and determines the regeneration of the fish population. The computer then generates for each team a report of their year's catch, income, and expenditures, and their current bank balance and fleet size.

In a typical game the players will realize quickly that a large fleet can earn more money than a small one. They will then compete to expand their fleets far beyond the level that can be sustained by the two fishing areas. The following is a typical team strategy: purchase many boats until average fish productivity starts to decline. When fish productivity goes down, fish other areas.

After a few more rounds, the fish population will be severely depleted, and the teams' catches will decline quite suddenly. This "crash" of the fisheries is the most powerful part of the game experience. After it has occurred, the game is halted for a discussion of its outcome.

Debriefing

To realize the full potential of Fish Banks as a learning tool, it is essential to discuss the game thoroughly at the end of play. The debriefing

allows the players to vent their emotions from the game and understand its outcome. More importantly, it relates the elements of the game system and its behavior to real fishery systems (Figure 2).

> The collapse of this anchovy fishery, once the world's largest, has been costly. Peru lost two export commodities – the fish meal and the guano from sea birds that depend on anchovy – that once dominated its foreign-exchange earnings. When this fishery was at its peak in 1970, exports of its products earned Peru $340 million, roughly a third of its foreign exchange. The disappearance of this vitally needed source of hard currency contributed to the growth of Peru's external debt; in the mid-eighties over 40 percent of the nation's exports are required merely to service its outstanding loans. And the world has lost a major protein supplement, once used in rations of hogs and poultry. (Brown, 1985)

The simple interactions shown in the causal loop diagram (Figure 3) that is the basis of the game model provide a conceptual framework for understanding the behavior of fisheries and other renewable resources, such as groundwater, timber, soil, and ozone.

Finally, the game provides a metaphor for discussing solutions to the problem of resource depletion. Because they have directly experienced the collapse of a resource, entirely due to their own behavior, the players feel a greater sense of responsibility for finding solutions to the real-world problems.

The Fisheries System

The basic theory of fish banks overexploitation used in the game is obviously not original to the authors of Fish Banks, Ltd. SD models of interactions between ship and fish populations were developed already in the early days of the field, in the late 1960's. These system dynamics models were based on even earlier work by resource economists and mathematical ecologists.

The causal structure of the model is shown in Figure 3. It is crucial to note, when examining the figure, that the structure portrayed there has an extremely wide applicability. If "Trees" were substituted for "Fish" and

"Sawmills" were substituted for "Ships," the model would provide the foundation for explaining the widely-observed phenomenon of forest overcutting. Similarly, substituting "Groundwater Level" and "Irrigation Pumps" would give one a start on a good model that explains depletion of groundwater resources. Any structure that has this level of generality is called a generic structure. System dynamics provides a set of theoretical and graphical tools for identifying and analyzing such structures.

This approach has one important strength. Although generic structures can be developed in infinite numbers and varieties to represent causes of behavior within elements of any system – economic, psychological, biological, political, industrial – the essential elements of any generic structure are very few in number. They consist of individual causal links, delays, and the feedback loops (closed chains of causal links) that govern the behavior of the whole system. In this game there are five causal loops (Figure 3).

This causal loop diagram shows the principal interactions governing the fisheries system. Arrows show influence or causality; a "+" indicates that the entities change in the same direction; a "-" indicates that the entities change in opposition. Delayed influences are indicated by "| |" on the arrow. Closed loops result in behavior which may be self-reinforcing (a positive loop) or self-correcting (a negative loop).

The first (Fish – Density – Regeneration – Fish) governs the regeneration in the fish population. When the fish population is large, it acts as a negative feedback loop, to maintain the fish population within the carrying capacity of the fishery. When the fish population is smaller it acts as a positive feedback loop, producing exponential growth of the fish population. Acting by itself, this loop would result in asymptotic growth until there was a stable fish population near the carrying capacity of the fishery.

The second loop (Total Catch – Income – Profit – Investment – Ships – Total Catch) is a positive loop, which produces exponential growth of the ship fleet. As the total catch of fish increases, income and profits increase, reinvestment of profits increases the ship fleet, and the total catch increases even more. This loop is accelerated by a third loop (Total Catch – Income – Profit – Desired Growth – Investment – Ships – Total Catch) which results from the players' competition. Because the profit from a

season of fishing is nearly equal to the cost of a boat, the delay in constructing a new boat is short, and the players typically reinvest most of their profits, the ship fleet grows very rapidly. Though the initial boat fleet is less than half the sustainable limit, the fleet typically doubles three times in five rounds of the game.

A fourth loop (Total Catch - Fish - Density - Catch per Ship - Total Catch) acts to reduce the harvest as the fish population becomes depleted. As the total catch exceeds the regeneration of fish, the fish population declines. As the population declines, the density of fish in the bank decreases, and ships are less effective at catching fish. This reduces the total catch.

Finally, as the catch declines, the fifth loop (Ships - Operating Costs - Profit - Investment) becomes active. This is a negative loop which acts to restrain growth of the fish fleet when profits decrease. As the catch per ship declines, operating costs remain constant, and the income and profit from fishing are reduced. Reinvestment in ships quickly drops to zero, and the fleet size stabilizes. However, by the time this occurs, the fish population is already severely depleted.

Conclusion

> For the past twenty years I have taught formal courses on system dynamics for groups ranging from high school students to senior corporate and public officials. I have used the traditional forms of lectures, created one person-one machine simulations, and assigned pen and paper homework exercises to convey understanding about the causes of phenomena such as overfishing. None of these approaches has generated as many insights for my students as the exercise of working through this simple game.

References

Forrester, J.W. (1961) Industrial Dynamics, Cambridge, MA, MIT Press.

Greenblat, Cathy and Duke, Richard. (1981) Principles and Practices of Gaming SImulation, Beverly Hills, CA, Sage Publications.

Availability

A kit for operating Fish Banks, Ltd. may be obtained for $100, which includes the cost of shipping from:

Prof. Dennis Meadows, Director

Institute for Policy and Social Science Research

Hood House, University of New Hampshire

Durham, NH 03824, USA.

The kit includes a 113 page teacher's manual, players' materials, small wooden ships, game board, money, and program disks. In the package are also 48 masters for creating overhead projection slides; with these you can quickly learn to introduce and debrief the game. Please send cash or check and indicate whether you want a Macintosh or a 5 1/4" IBM-PC compatible disk.

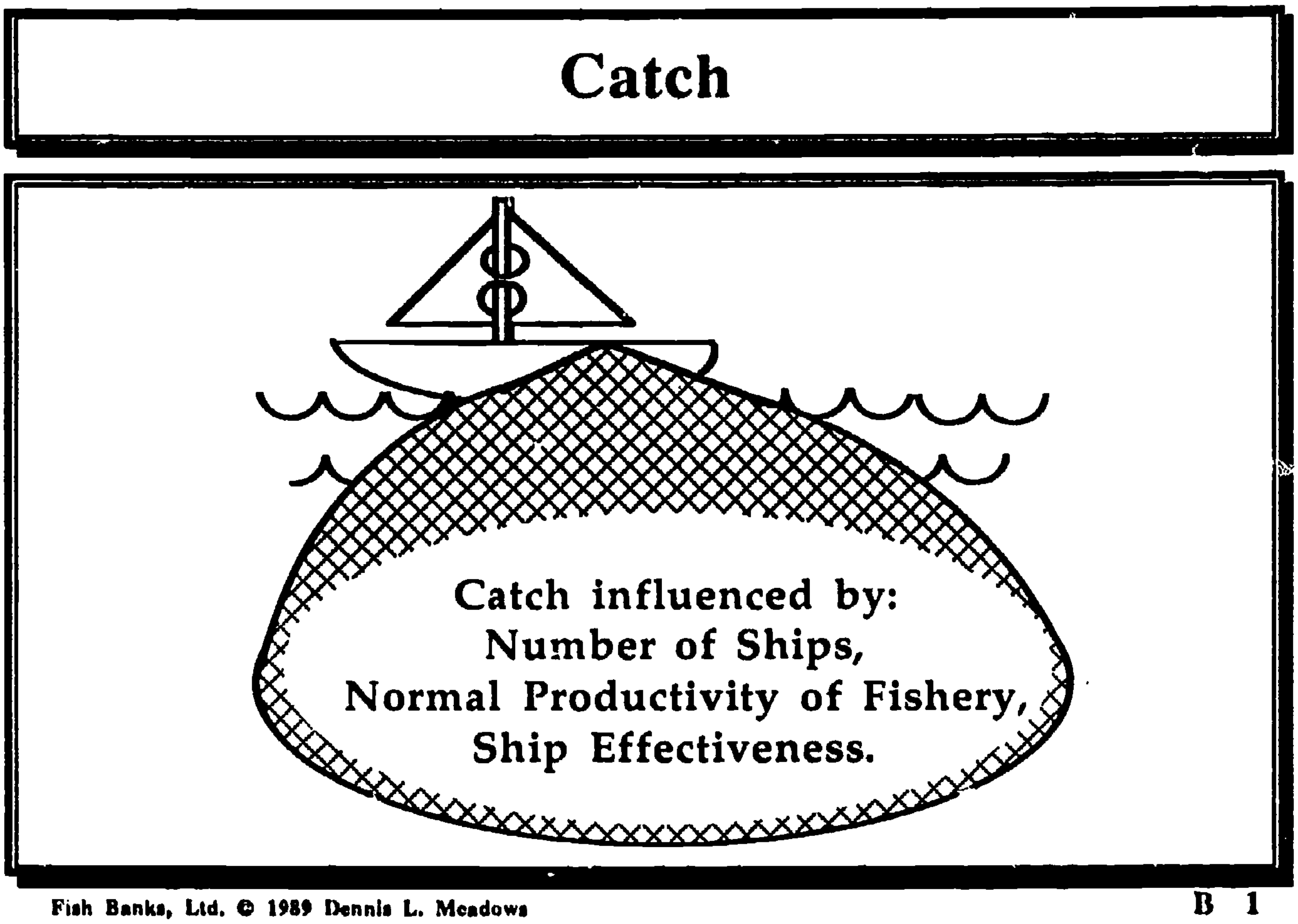


Figure 1. Sample Introduction Transparency.

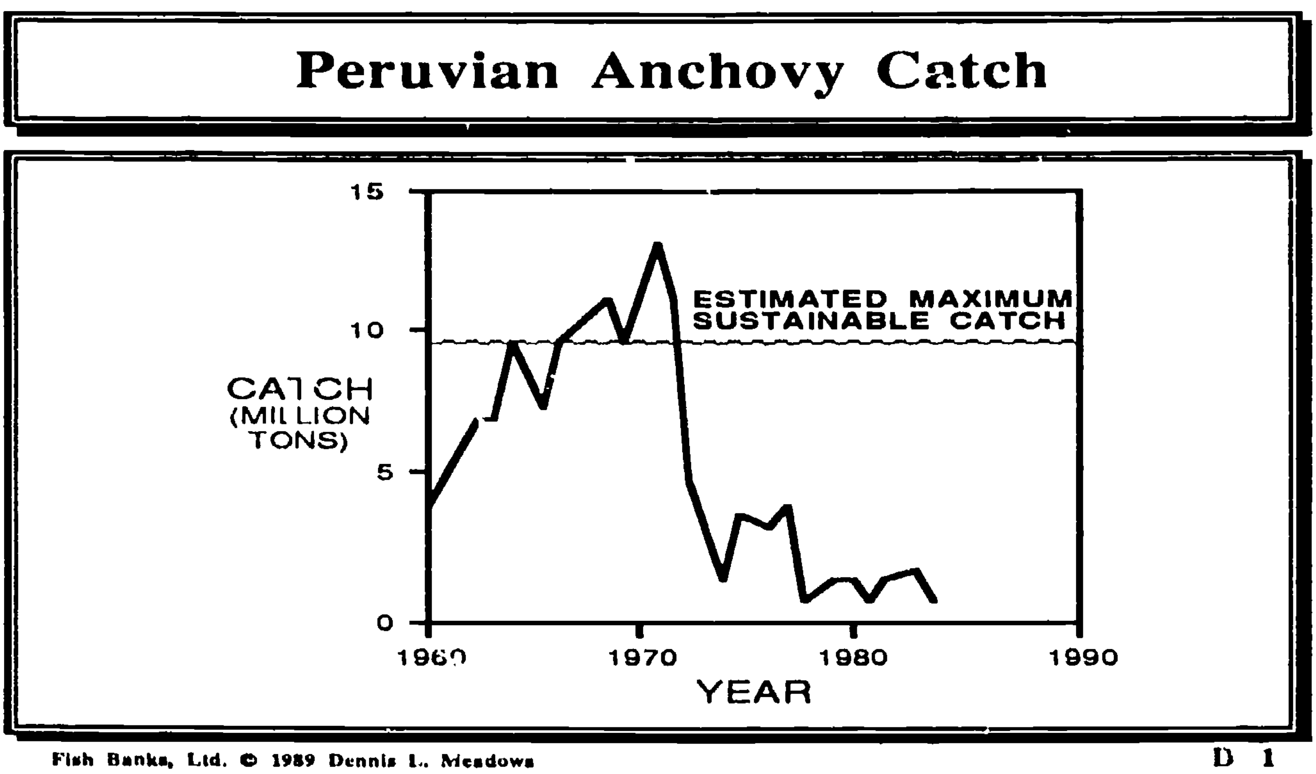


Figure 2. Sample Debriefing Transparency.

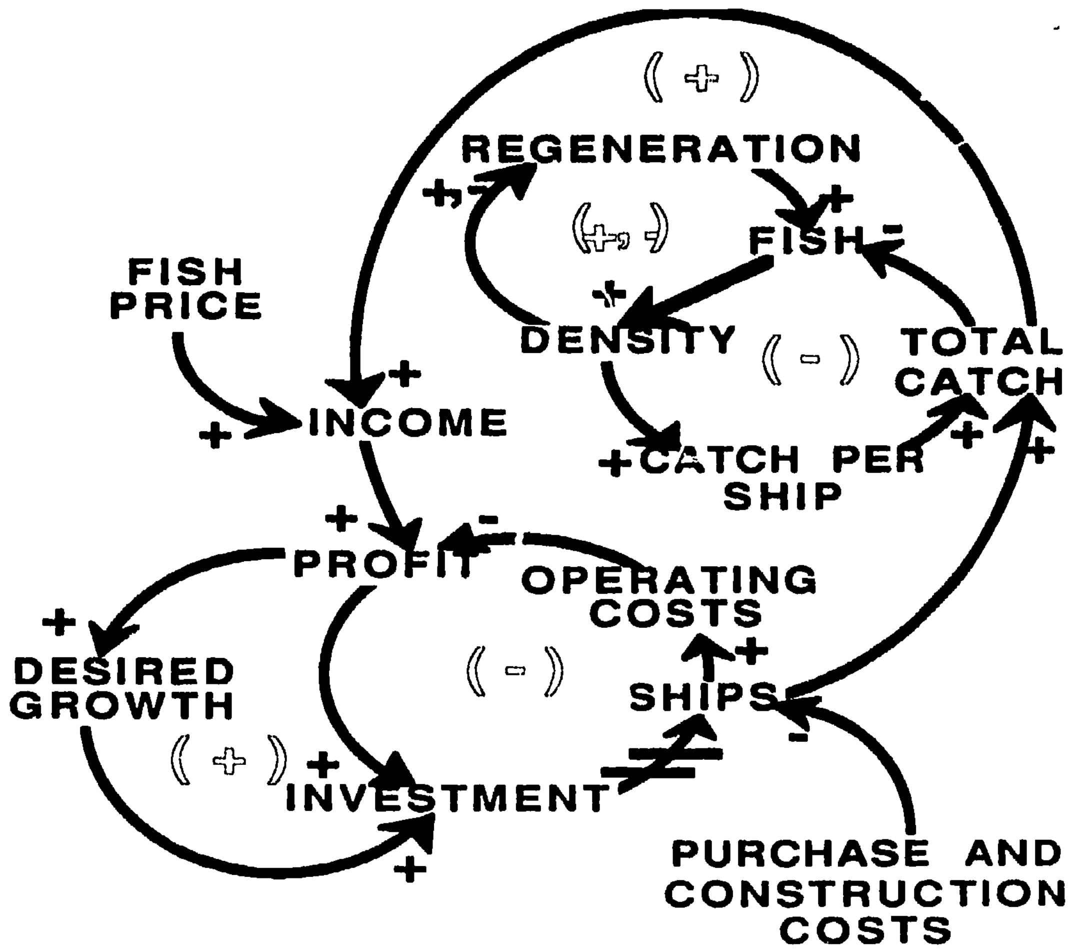


Figure 3. The Fisheries System Structure.

TEACHING SCIENCE WITH A SYSTEMS APPROACH TO ENVIRONMENT, ECONOMY AND PUBLIC POLICY

Howard T. Odum
University of Florida

Elisabeth C. Odum
Santa Fe Community College

Introduction

A fundamental need in science education is the study of whole systems simplified by grouping components rather than taking them apart to study one at a time. We need the whole approach to the new world theme developing a symbiotic partnership between humanity and the life-support system.

Diagramming with symbols and simulating with computers teaches how basic system designs perform, allowing students to understand the consequences of changes. Study ought to include ecosystems and economic systems together. A new course may be needed to combine environment, economics, computer simulation, and education about public policy issues of the future. The synthesis approach should replace the "take-apart-and-study-smaller" approach of current science and social science with a mindset to "put-together, overview, and visualize consequences." We need more educators who will accept the challenge to teach students to comprehend complexity of their real world.

Towards these goals, the authors, their colleagues, and students have been developing a systems teaching package for two decades. This article describes an educational course package. It includes a textbook, two computer simulation instructional modules with disks, and materials for teachers. The materials are available for distribution to those experimenting with this systems approach to general education. See the list at the end of this article.

The package supports a course in three stages that:

(1) teaches a systems view of environment and economy as one system;

(2) introduces computer simulation of the basic designs and principles of ecology, economy, and global systems;

(3) uses vital issues of current and future public policy to make basic principles of knowledge timely and socially interesting.

Dissection, the Wrong Approach

An environmental system has flows of energy, materials, people, money, information, and control. Often the approach to environment is to study each of these isolated and by itself. This seems easier in the short run because you do not have to deal with real world complexity. Understanding parts is not enough for understanding what the larger system will do, because one part controls another.

For example, you could try to represent the carbon cycle by drawing only the pathways of carbon cycling in an area of environment, but this might leave out the living organisms, physical processes, and humans that control its rates of flow. Thus, you need to show the whole system with the main components, inputs, and outflows together. The same network of parts and pathways is then used not only to understand the carbon cycle but to show the way that chemical cycle interacts with everything else (energy, materials, people, money, information, and control). You learn to think wholes and parts together.

Most people in science were taught to be rigorous by studying one relationships at a time, the "take apart basic approach." This approach is always incomplete until the "put together basic approach" is also done.

Diagraming the Parts, Relationships, and Processes of Systems

Our way of teaching is to connect pictures with pathways, learning what the pictures and pathway lines represent. We then use computers to show how things grow and decrease, and finally consider how the system will respond to human management choices.

Almost all systems are connected to other systems, but it is convenient to define a boundary for a system to be diagrammed. For a lawn system, for example, you could define the system boundary as the edge of the lawn, three feet down in the soil and one foot up in the air above the lawn.

For diagramming, a square frame is drawn to represent the boundary that you have selected. Anything from outside the chosen boundary is a "source" that sends in energy, materials, and/or information. Things coming in from sources are represented by pathway lines from the source to the receiving items inside.

Connecting Recognizable Icons

We start with small pictures that are easily recognized as items of the environmental system. Small picture used as symbols are called icons. These can be made into rubber stamps at small cost. Then the symbols are connected together with lines representing known flow of energy, material, food, service, control, information, etc. The kind of flow can be written on the pathway. See the example of a lawn system in Figure 1.

Teaching Hierarchy Principle, Small-Fast to Slow-Large

An important feature of all systems is hierarchy. Many small components such as blades of grass that are replaced rapidly are drawn on the left. Small items are used and controlled by items with larger territory and slower turnover such as grazing animals. The larger ones are higher in hierarchy and are drawn on the paper to the right. These larger items generally control the smaller ones by their services, by their recycling of nutrients, and by their control of seeds and other information distribution.

Teaching Energy Principles

The diagramming should show all the sources of energy from outside and the fate of that energy within. The principle that all energy that comes in is either stored or flows out is called the first energy law. Some energy that flows out to other systems still has the potential to do work, but after supporting processes, most energy leaving the system is used energy, no longer capable of supporting more work. Used energy is shown by pathways that go down to the bottom of the diagram to a symbol called a heat sink.

The very important principle that energy cannot be transformed completely without degrading some of it is called the second energy law. Making sure that there is one pathway to the heat sink for every part and process in the system is a way of teaching the second energy law.

Teaching Process Principles

When a picture is drawn to represent some component, such as the grass of

the lawn, or the insects eating the grass, you are also representing the processes that are characteristic of that unit. Grass for example, is a producer combining several raw materials to make organic matter of plants. Insects are consumers and tend to reproduce, making more individuals that also reproduce so that the population grows faster and faster so long as there is food. The processes characteristic of each component can be taught while also considering how processes of one unit affect the other units connected to it.

More Advanced Generalized Symbols

After learning to diagram and represent systems using the pictorial icons, a group may be ready to use a general set of symbols (Figure 2) that represent categories. There is a plant producer symbol to represent whatever green plants are predominant; a consumer symbol is used for each consumer population that is important, etc. Using the general symbols makes it easy to compare one system with another learning how they are all similarly organized. For example, the lawn system in Figure 1 is represented again using the general symbols in Figure 3.

With the computer simulation exercises below, the behavior of the main symbols in simple relationships to sources and other units is taught. With the simulations, ways of connecting units are associated with patterns over time.

Simulating Basic Principles and Systems Designs

One exciting way to show how environmental systems work is to program them on the computer. You can write programs for the systems and when they are run, graphs appear showing change over time. Exponential growth of populations, ecological succession, fire, and human intervention can all be easily programmed. For introductory work, finished programs are provided in text and on disk that the students can change.

After the first run, "what if" experiments use the students' creative critical numbering skills. For example, if an insect population is increasing faster and faster, what will happen if its food source is decreased. You can change one line on the program and run it again to see.

We have two approaches to computer simulating, one using the traditional BASIC programming language and another using a more pictorial way of

setting up programs for simulation with a new Macintosh program called EXTEND.

Simulating Environmental Systems with BASIC

Any system can be drawn with systems symbols, equivalent lines written to insert into a computer program written in BASIC, and then experimented with by running with changes made between runs. For example, Figure 4 is a simple ecosystem with producers, consumers, and recycling of nutrient materials (carbon, phosphorus, etc.). You can study the effect of increased light on productivity, consumption and recycling by running the program, making changes and running it again.

The fire model is a favorite. After learning how grassland and forest systems grow up and level off when they are using all their resources of sun and rain, the action of catastrophic consumption and recycling is shown (Figure 5).

In many parts of the country, fire is part of the grassland or forest system. When a certain amount of biomass builds up, fire burns it. In the fire model (Figure 6), the student can set the threshold amount of biomass for catching fire (Figure 7). Or, the student can set the number of years between controlled burns at a state park (Figure 8).

Environmental problems include economic questions as well as ecological ones. A solution to a problem may be ecologically sound, but not economically feasible. An example is the use of a forest to produce wood for the housing industry. The system of wood and the economic interface includes the market price and available dollars, the bank account of money on hand, and the goods and services available to purchase, cut and process the wood (Figure 9). The student can vary the price of wood and the price of goods and services. When economic conditions are favorable, more of the forest is cut. If left to the market control alone, the whole forest may be cut so that future production and profits are reduced.

Some students are taught to write their own programs for simple models that they diagram. These simple programs only contain a dozen or two lines. After students have practiced with elementary systems relationships provided in text materials, they can create their own models and programs for simulation.

Simulating with Extend

For those who use Macintosh computers there is a neat program called EXTEND (see the address at end of article) which you can use to simulate systems without having to look at the programs.

As we described earlier, using a mouse, pictorial icons for plants and animals are put on the screen as shown in Figure 10. Again, using the mouse, you connect the symbols with a line and this automatically sets the program up for simulation. Teachers and students never need to look at the hidden program; however, those interested in programming can change the existing program or make new symbol blocks with the help of the EXTEND manual. (This requires a more expensive version of the program than the one for student use.)

After the diagram is connected as shown in Figure 10, the mouse is double-clicked on each of the symbols which brings up dialog boxes to the screen. These have instructions about putting in your choices of values to start the program. See Figure 11 for an example.

Then you click on RUN and the screen gives you some questions about scales for the graphs -- time on the horizontal axis and biomass on the vertical axis. After these questions are answered, the program runs with the results in Figure 12. Notice that, in the run shown, plants grew biomass first, followed by consumers whose food comes from the plants.

Using Generalized Systems Symbols with Extend

We have provided a set of generalized system symbols for the EXTEND program which can be obtained from the source listed at the end of the article. Figure 13 shows the Macintosh screen with these symbols not connected to each other. You can compare these symbols to those used to draw on paper in Figure 2.

In Figure 14 the generalized symbols were used to represent the same production and consumption that was shown with pictorial icons in Figure 10. The generalized symbol icons have more flexibility in the values you can set. When you double-click on the generalized plant producer symbol, dialog box screen Figure 15 appears. Notice there are more boxes you can fill in than on the one for the grass picture in Figure 11. The results of simulating this model can be the same as the one shown in Figure 12 if the values typed into

the dialog boxes are the same as those built into the pictorial symbols.

Making Your Own Systems Models

The most fun is making your own systems models by calling up symbols from those available from Figure 13, connecting pathways to represent food chains, pathways of recycle, actions of humans etc. Each type of symbol can be used more than once. For example, to study biological competition, use two consumer symbols connecting them up to one plant producer. The growth of one consumer population will drive the other to a low level, in some cases causing its extinction.

Sources of Information on Simple Models

The text materials and the computer disks available to go with the texts provide already-set-up examples of basic configurations found in textbooks of biology, chemistry and economics. See the list at the end of the article.

Issues of Public Policy

One of the strengths of this course is to use important questions about environment and economy as examples for teaching principles of symbols, computers, economics and environment. Some of these questions of what happens when humans take action can be visualized by changing the simulation models and observing the effect. Once students have been through the basic instruction on systems and have done exercises using the symbols and simulation, they become able to visualize what happens to similar systems without simulating them.

To consider an environmental public policy question students should begin by diagramming the system in which the problem exists Here they must be careful not to simplify by looking at only one part at a time. Instead, they should simplify by grouping parts. For example, for some purposes representing ten species of grass with one producer symbol may be sufficient, as in a fire model.

Since most systems have controls and important influences from the next larger surrounding area, it may be a good idea to diagram a larger area first so

as to see all the ramifications involved with the problem. For example, in the case of fire, the larger system contains the sources of starting fire and the economic interfaces of the area such as the sale of wood or hay.

Some of the useful systems to diagram are given in Table 1, including the whole planet, whole countries, cities, farms, wilderness areas and smaller ecosystems. Diagraming together as a class or in smaller groups around tables is an effective social learning experience. One person does the diagramming, but everyone makes suggestions as to what to include and where it belongs on the paper. Remember that symbols have a position according to their hierarchy and their turnover time that we discussed in Part 1.

Always use pencil and have a big eraser as frequent erasures are necessary. For a group exercise where it is important that every student's input be recognized, a larger sheet of paper may be needed and the resulting diagram may be complex. Such complex diagrams are like an inventory of all the aspects of a problem. If the diagramming is done on the blackboard another student should be assigned to make a neat copy on paper.

After a complex diagram is done, the model should be simplified by grouping components so that a version of about a dozen symbols or less results. Remember not to leave anything out but to combine similar items in general categories. By making a simpler diagram but still retaining the overview, students can visualize what is causing what and perhaps see what kinds of graphs might result.

To simulate a system, beginning students probably should not have more than five symbols in their diagram. Therefore, further simplification by grouping is required before writing the simulation program.

Some of the public issues that should be covered in a course addressing environment, economics and public policy are listed in column 2 of Table 1. These can be the subject of group diagramming exercises, a teacher's lectures, or individual student work. The text material provides some guidance as well as samples of completed exercises.

The idea of approaching science through models generally applicable to various scales of view has been advocated by many. Many of the environmental science textbooks have some of the same aspirations but the tendency for these texts has been to divide up the environment in different segments like air pollution, water pollution, radioactivity, etc. without general systems considerations.

Summary of Goals for Environmental Education

There is a need for students to:

- understand what is happening to the world and how they fit into it. We need to teach how things work on a larger scale. Our viewpoint should be more concerned with the larger system of which we are the mechanisms and parts as well as with the mechanisms of smaller realms usually taught in education. We need to understand our environmental basis.

- be able to solve problems, to make a system do differently, to make a system change. Students need to be able to synthesize.

- make models of relationships. Students need to learn what happens over time given what what you see in the way of structure of a system.

- learn the basic principles that apply to things of different scales, the large and the small, and the principles they share.

- see how thinking about systems leads to understanding and applying mathematical concepts.

- let microcomputers carry out the steps of thinking that you believe represent the system--and then check what you get with what is observed

- realize there is a unified view of environment and economics--now called ecological economics. We need to understand the limitations of marketplace economics.

- do all this by learning with the systems diagramming and simulating methods. It helps us see how things work, the large and the small, how connections lead to process, and how to change a system to get a result.

This article describes the new approach but does not give enough detail to teach without more specifics. We have tried to supply these in the materials listed at the end of the article. Better yet, teachers can learn in short courses.

If all young students could learn their science using public policy examples, it might maintain their interest in science, computers, mathematics and creative thinking, while at the same time preparing them for the important issues their society will be facing in the years to come.

Table 1
Systems and Their Problems for Diagraming

System	Problems
Planet earth	CO2, global warming Fuel use and world economic growth Overpopulation
Nations	Resources and world markets Balance of trade Subsidy for agriculture Using up of forests, wetlands Allocation of resources to military Effects of illegal drug use
Cities	Waste recycling Sources of electricity Fuel conservation and transportation Air pollution and jobs
Landscape areas	Preservation of wilderness Endangered species Optimal development for economic prosperity Policies for water use Dispersal of waste waters and storm runoff

References on Energy Systems Education and Simulation

Items available for purchase:
(from Center for Wetlands, Phelps Laboratory, University of Florida, Gainesville, FL 32611).

Introductory Text:
Odum, H.T. E.C. Odum, M.T. Brown, D. Lahart, C. Bersok, J. Sendzimir, G.B. Scott, D. Scienceman, and N. Meith. (1987). Environmental Systems and Public Policy. Florida Supplement. Ecological Economics Program Phelps Lab, University of Florida, Gainesville, FL 32611.

Plastic template for drawing general symbols.

Introductory text for international use, examples from other countries:
Odum, H.T., E.C. Odum, M.T. Brown, D. Lahart, C. Bersok, J. Sendzimir, G.B. Scott, D. Scienceman, and N. Meith. (1988). H.T Odum: Energy, Environment and Public Policy, A Guide to the Analysis of Systems. United Nations Environmental Program, Nairobi, Kenya. UNEP Regional Seas Reports and Studies No. 95, 109 pp.

More examples using BASIC with program listings for Apple II, PC, & Macintosh:

Odum, H.T. and E.C. Odum. (1989). Computer Minimodels and Simulation Exercises. Center for Wetlands, Phelps Laboratory, University of Florida, Gainesville, FL. 319 pp.

Microcomputer disks with 46 simulation programs in BASIC including those in the text and the previously listed "Computer Minimodels and Simulation Exercises." Available for Apple II, PC, or Macintosh. The Macintosh disk also includes systems symbols for use with the program EXTEND.

Articles that describe the approach:

Odum, E.C. and H.T. Odum. (1980). "Energy Systems and Environmental Education". pp. 213-229 in Environmental Education, ed. by T.S. Bakshi and Z. Naveh, Plenum , NY.

Odum, H.T. (1986). Unifying Education with Environmental Systems Overviews. pp 181-199 in Environmental Science, Teaching and Practice. Proceedings of the 3rd International Conference on the Nature and teaching of Environmental Studies and Sciences in Higher Education held at Sunderland Polytechnic, England, September 1985.

Explanation written for engineers:

Odum, H.T. (1989). "Simulation Models of Ecological Economics Developed with Energy Language Methods". Simulation 1989 (August): 69--75.

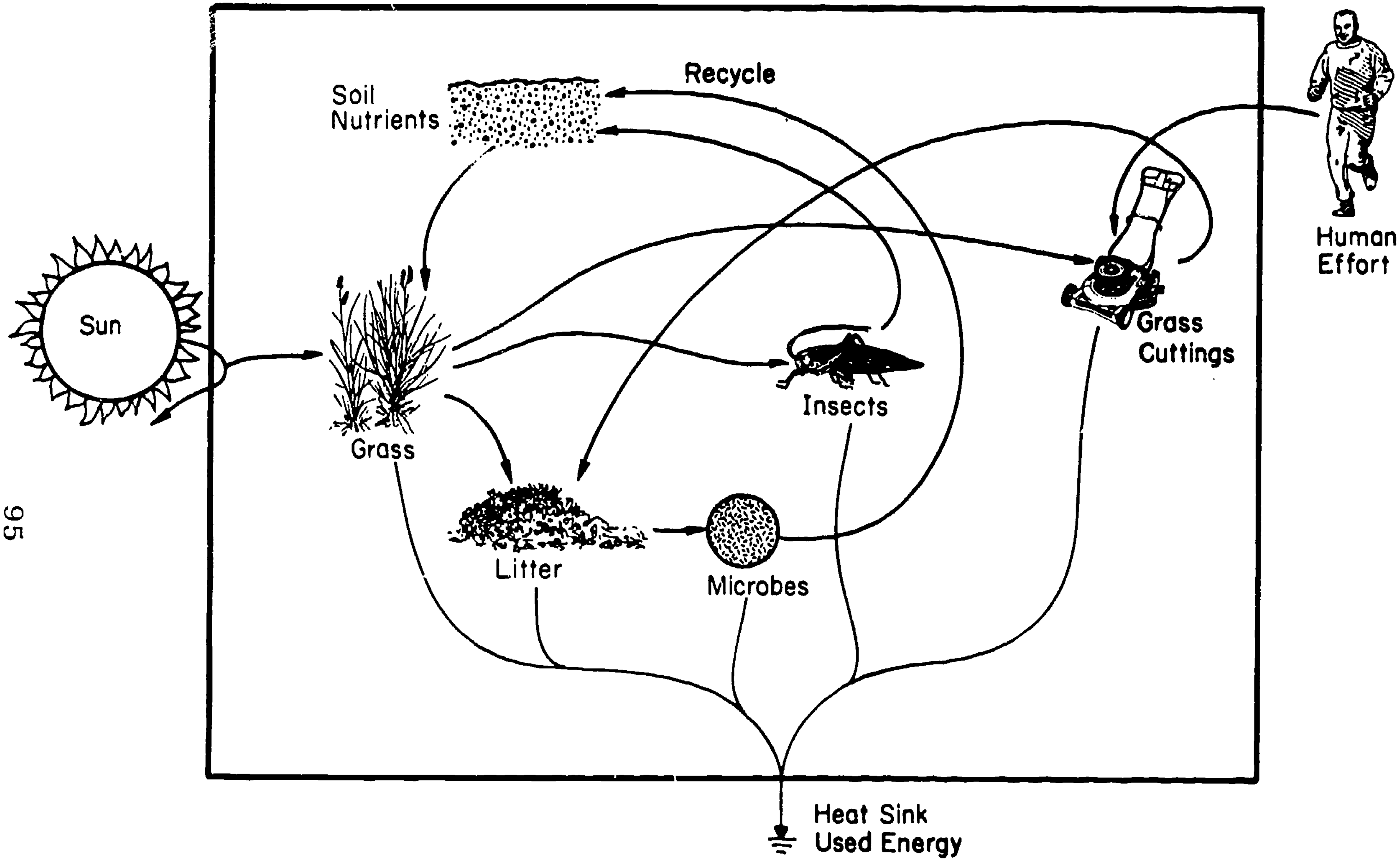
College Texts:

Odum, H.T. (1971). Environment Power and Society. John Wiley, NY. 331 pp.

Odum, H.T. and E.C. Odum. (1976, 1982). Energy Basis for Man and Nature. McGraw Hill, NY. 2nd ed., 330 pp.

Advanced text, graduate level:

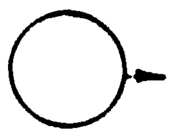
Odum, H.T. (1983). Systems Ecology, an Introduction. J. Wiley, NY. 644 pp.



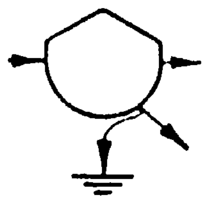
95

Figure 1 Using pictorial icons to start systems thinking

ENERGY PATHWAY - a flow of energy often with a flow of materials.

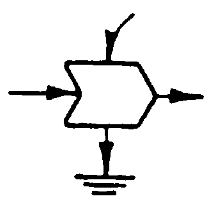


ENERGY SOURCE - energy which accompanies each of the resources used by the ecosystems such as sun, winds, tidal exchanges, waves on the beaches, rains, seeds brought in by wind and birds.

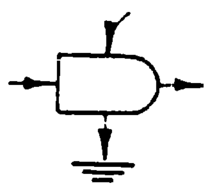


STORAGE TANK - a place where energy is stored. Examples are resources such as forest biomass, soil, organic matter, groundwater, and sands in beach dunes.

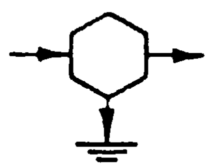
HEAT SINK - energy that is dispersed and no longer usable, such as the energy in sunlight after it is used in photosynthesis, or the metabolic heat passing out of animals. Heat sinks are attached to storage tanks, interactions, producers, consumers and switching symbols.



INTERACTION - process which combines different types of energy flows or flows of materials.

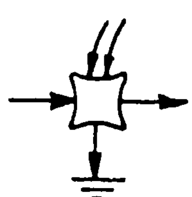


PRODUCER - unit which makes products from energy and raw materials, such as trees, grass, crops or factories.

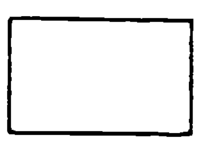


CONSUMER - unit that uses the products from producers, like insects, cattle, micro-organisms, humans and cities.

TRANSACTION - business exchange of money for energy, materials or services.



SWITCH - process which turns on and off, such as starting and stopping fire, pollination of flowers, and closing of fishing season.



BOX - miscellaneous symbol for subsystems such as soil subsystems in a diagram of a forest, or a fishing business in a diagram of an estuary.

Figure 2 Symbols for representing system components and processes

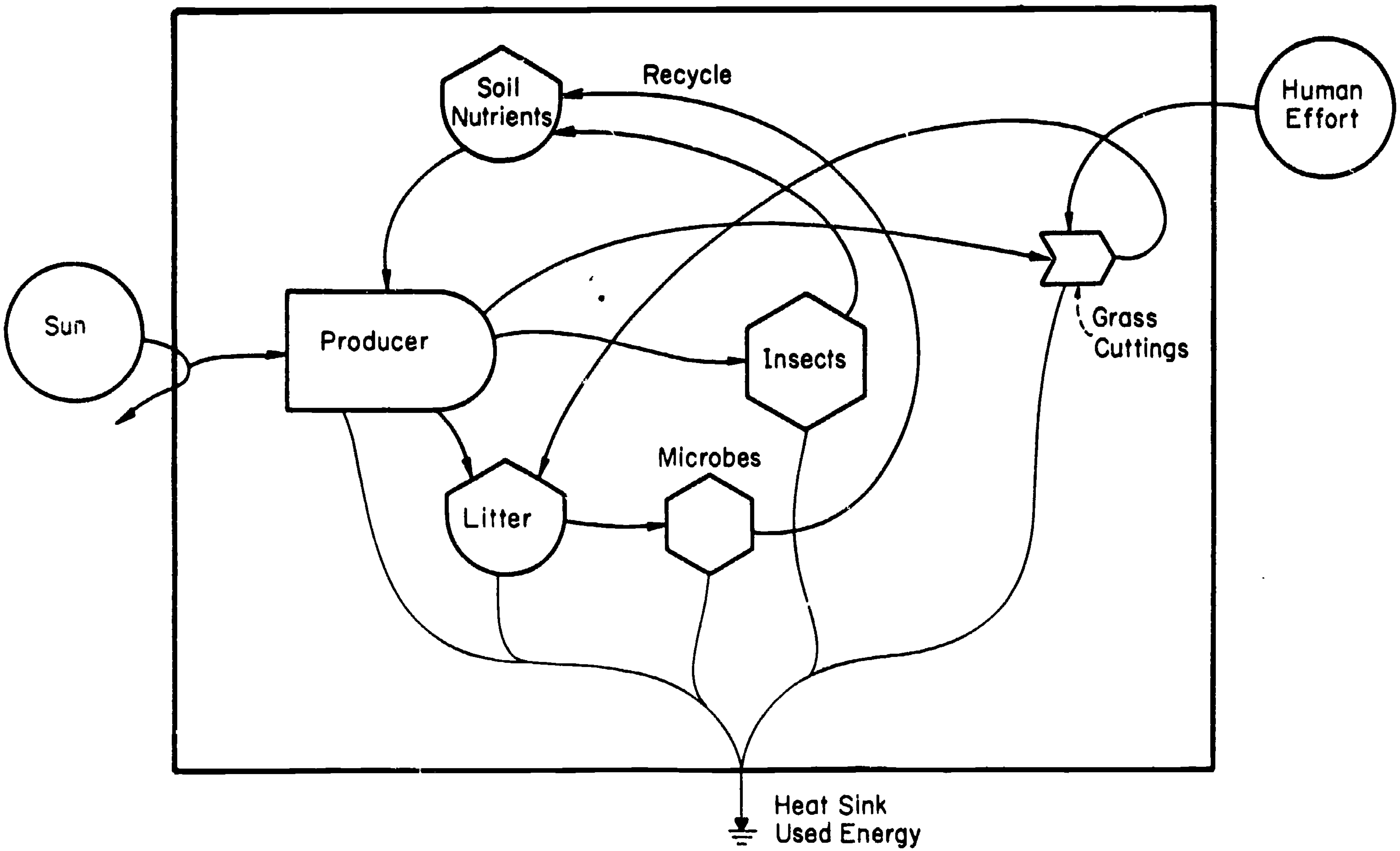


Figure 3 Lawn System of Figure 1 (Redrawn Symbols)

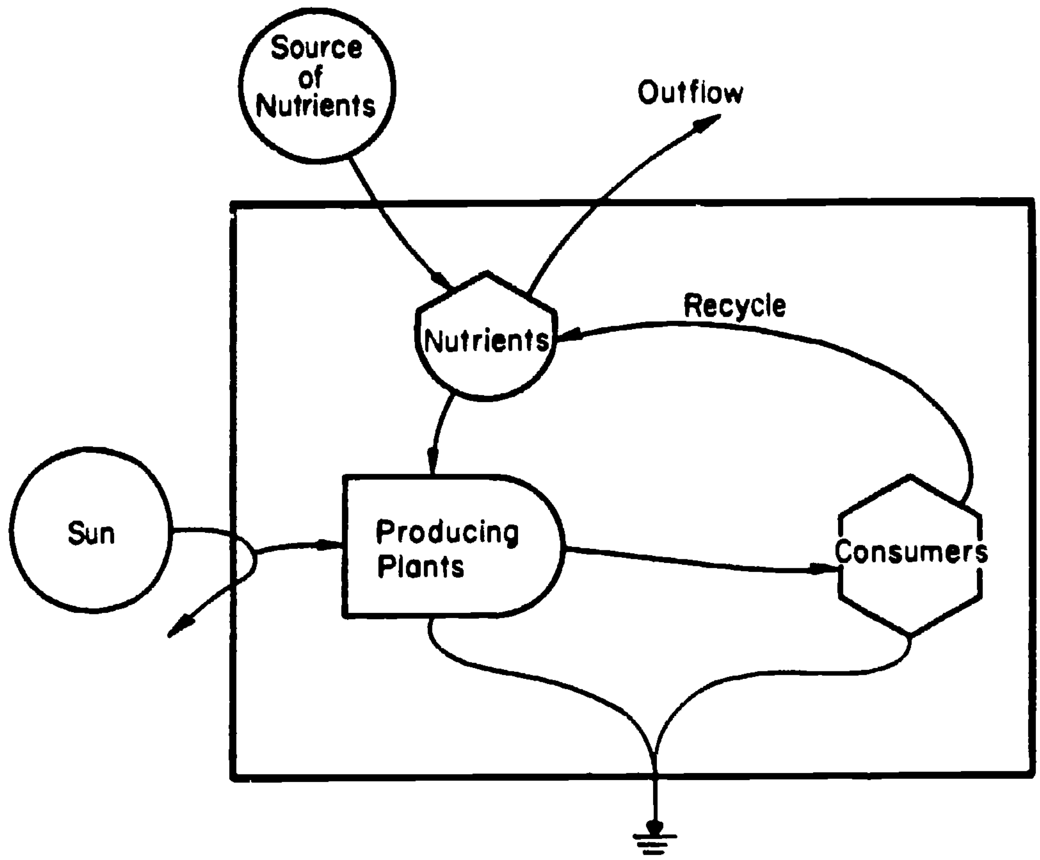


Figure 4 An ecosystem of producing plants and consumers (animals and microorganisms)

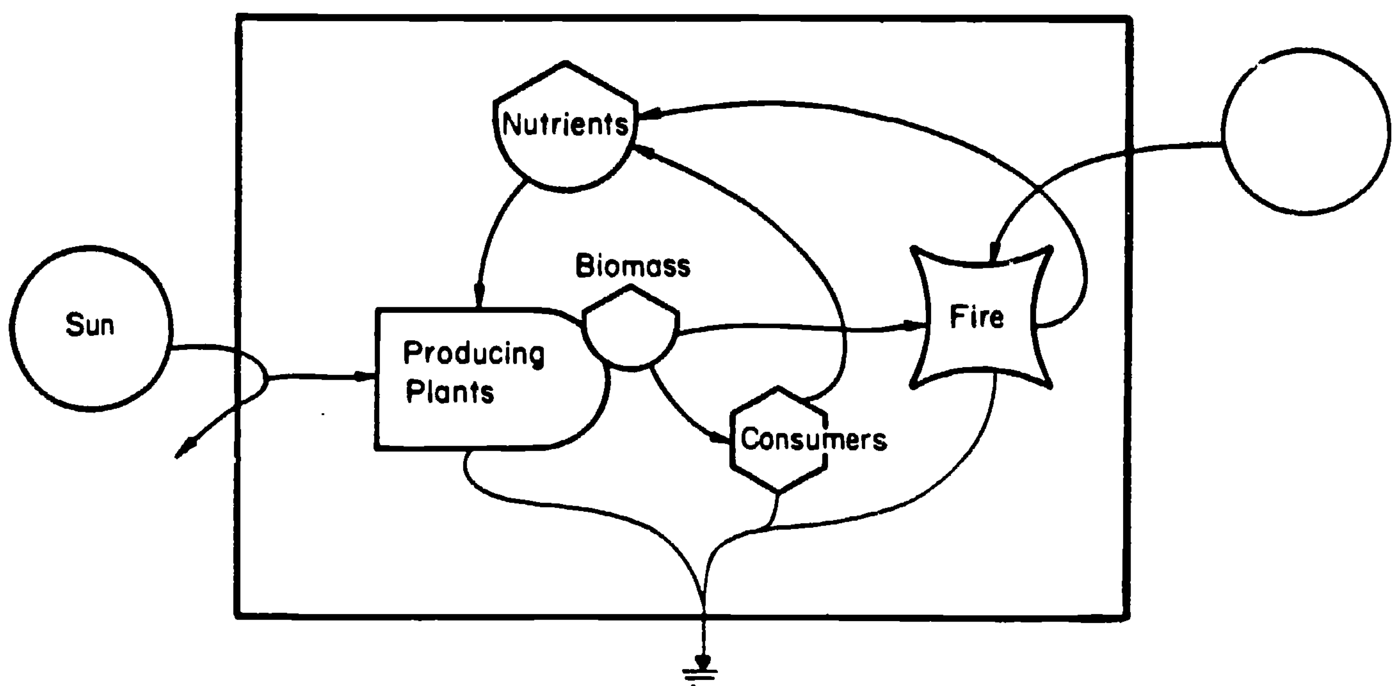


Figure 5 Systems diagrams of a grassland ecosystem with a fire symbol

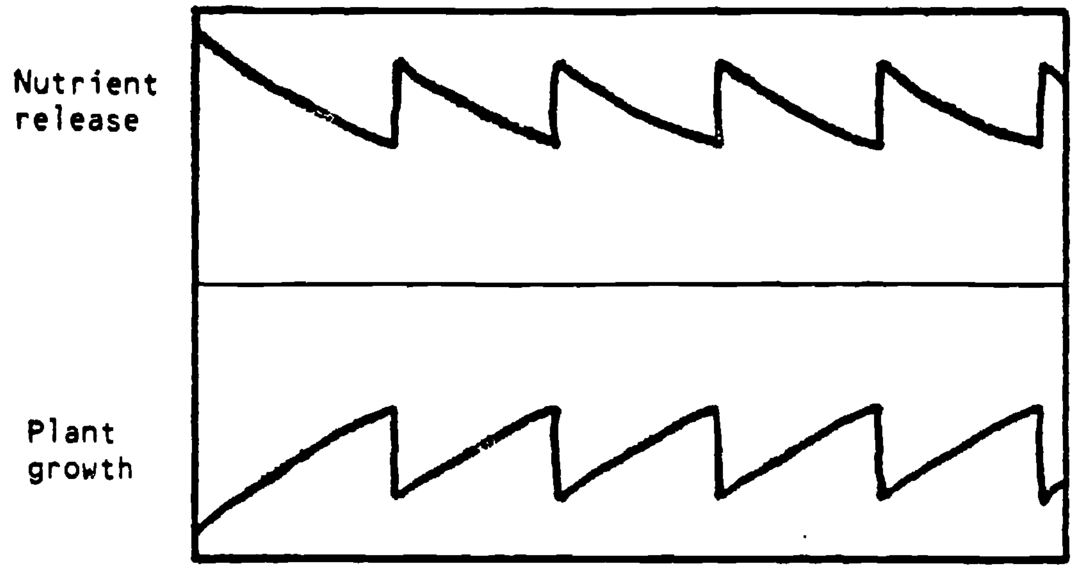


Figure 6 Results of simulating the model of growth and burn in Figure 5.

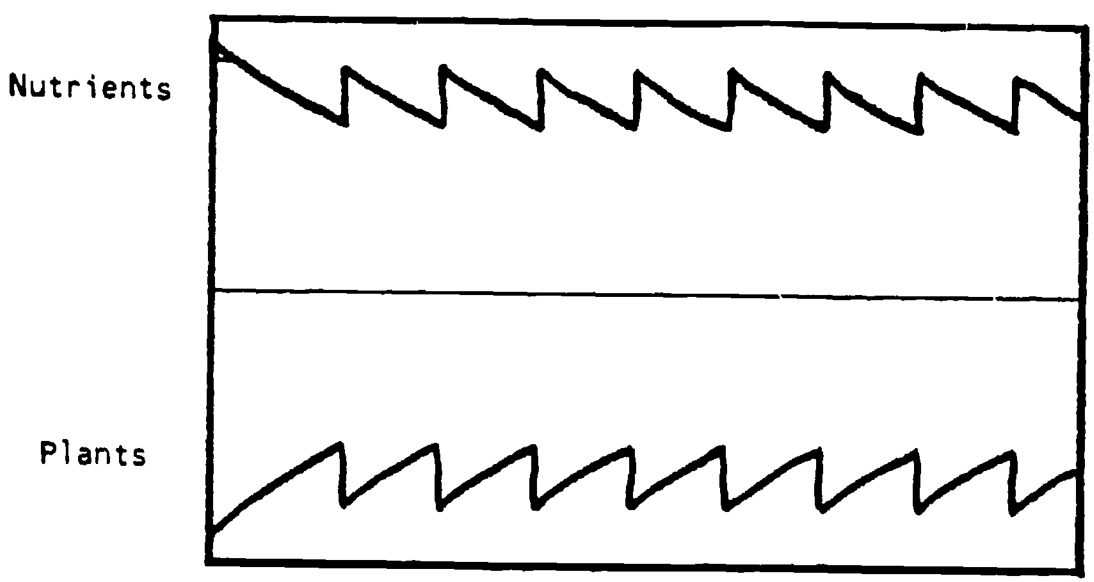


Figure 7 Results of lowering the threshold for burning, simulating the effect of drought. (Comparison with Figure 6)

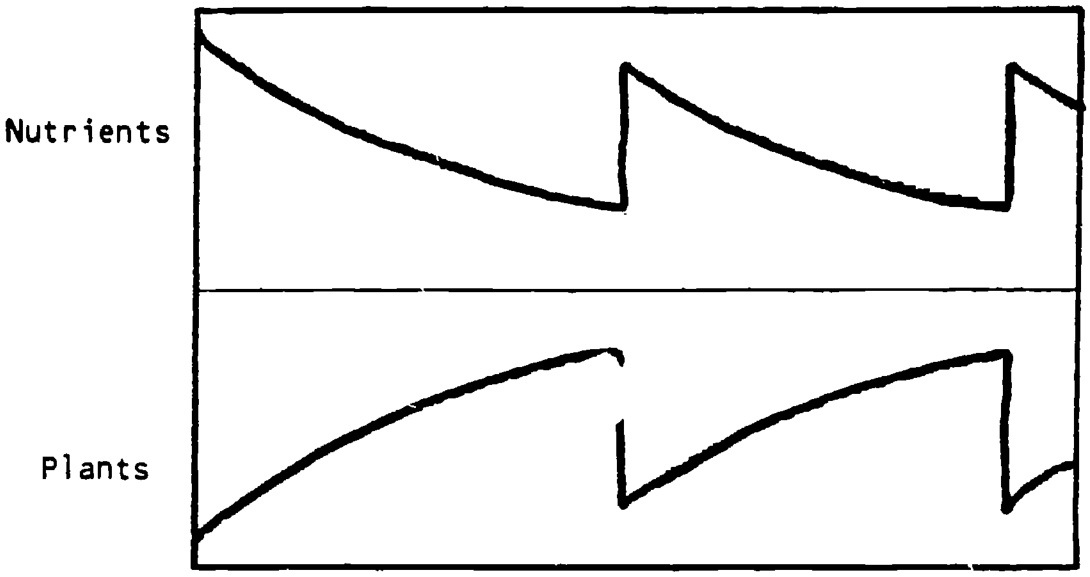


Figure 8 Result of increasing the time between fires

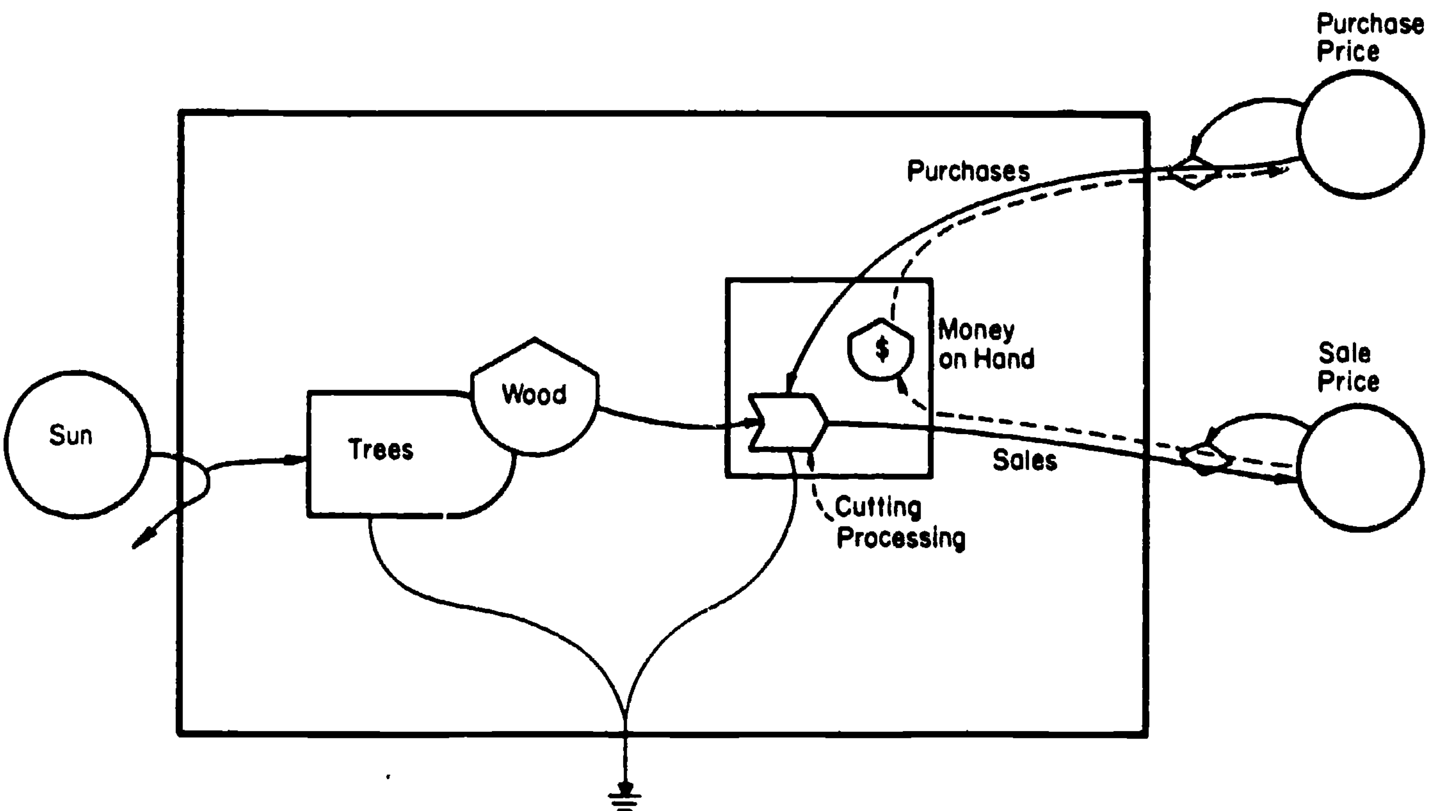


Figure 9 Systems diagram of a forest producing wood for sale, using money received to pay for necessary inputs to forest processing

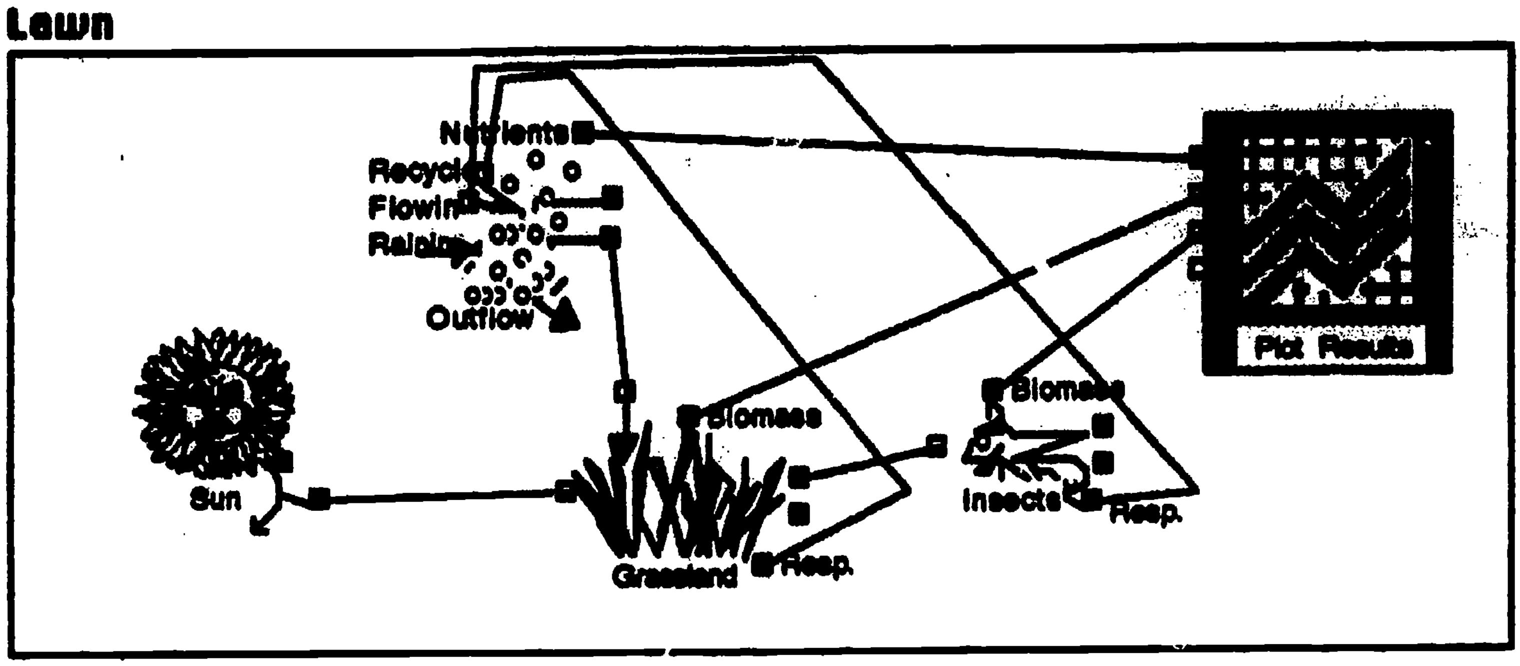


Figure 10 Macintosh screen w/dialog boxes for grass symbol

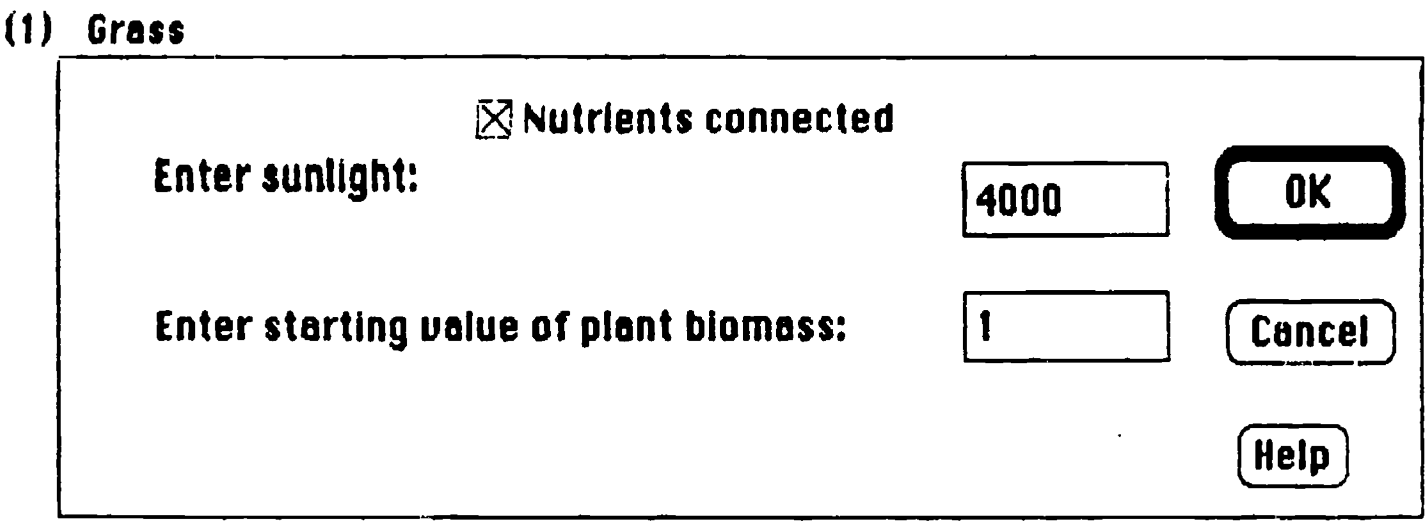


Figure 11 Macintosh screen showing a systems diagram that uses pictorial icons to represent a producer-consumer ecosystem

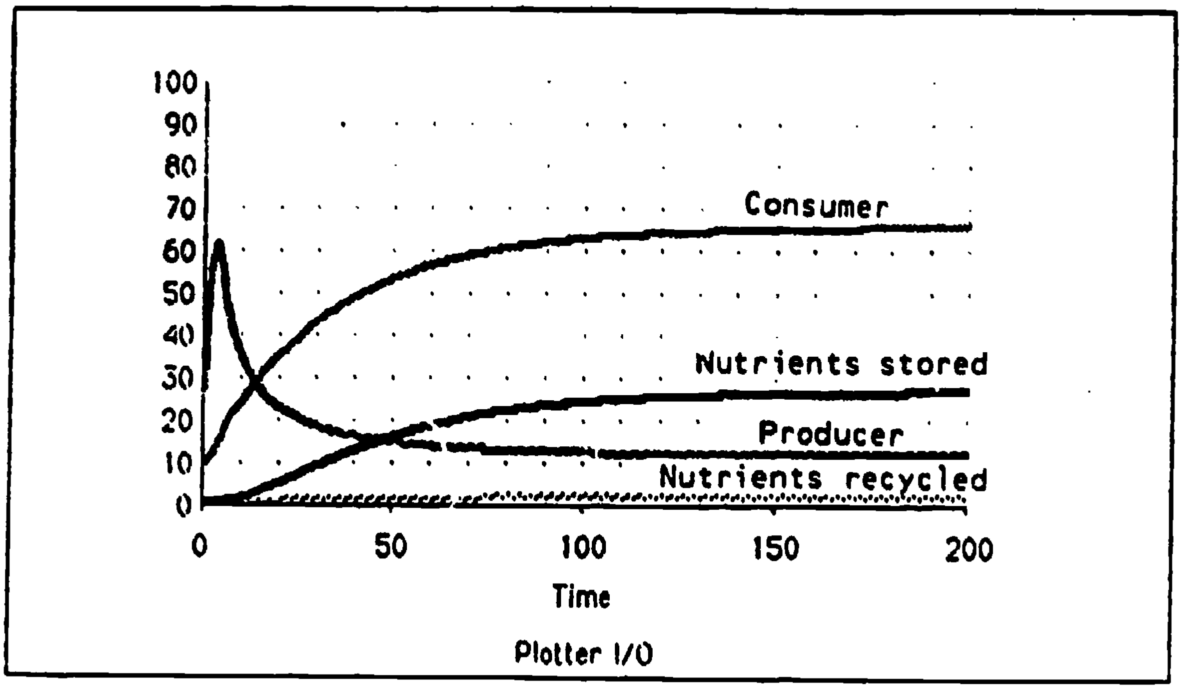


Figure 12 Graph of plants and animals with time resulting from simulation of the model in Figure 10

One connect picture icons

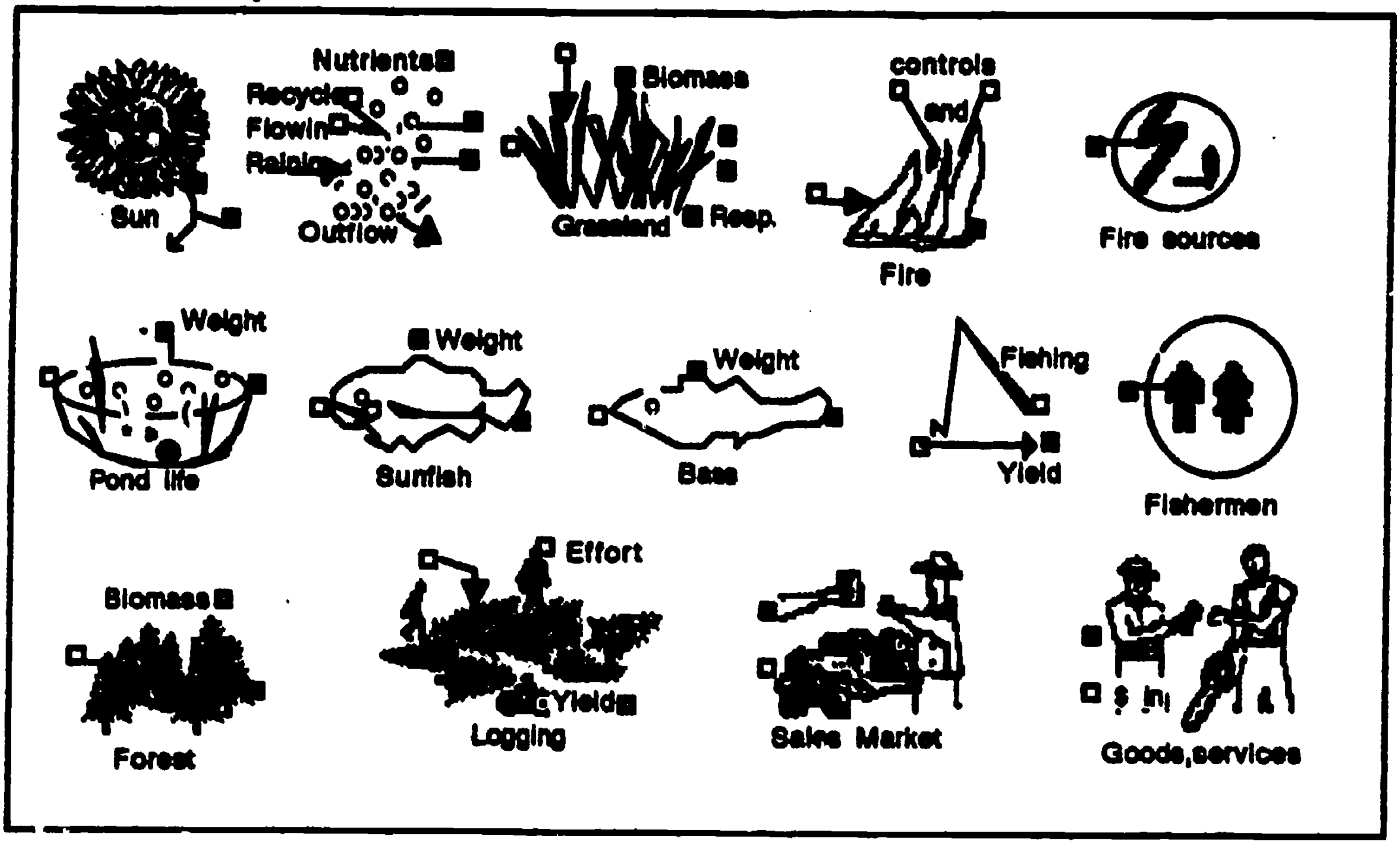


Figure 13 Macintosh screen with pictorial icons

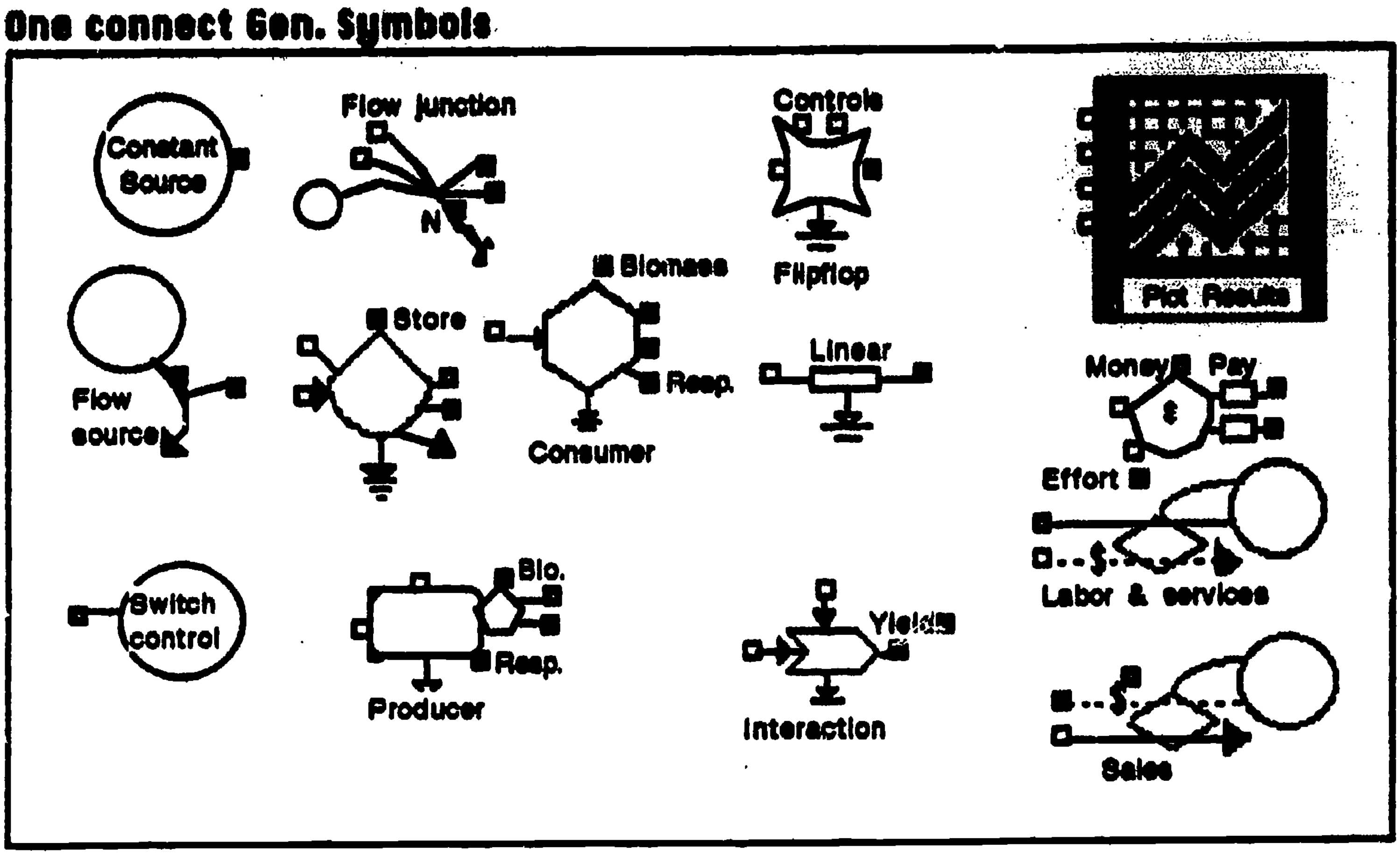


Figure 14 Macintosh screen with generalized system symbols

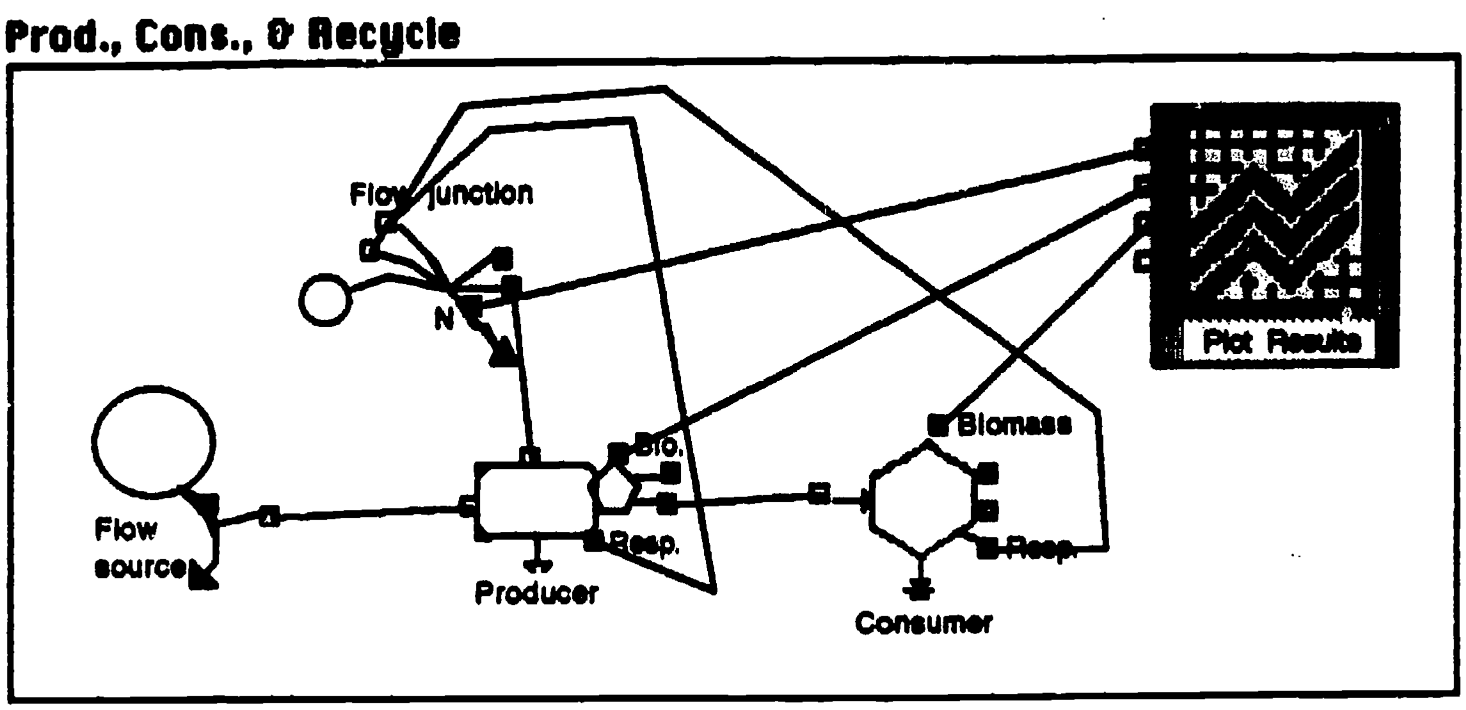


Figure 15 Macintosh screen showing production-consumption ecosystem using generalized symbol icons

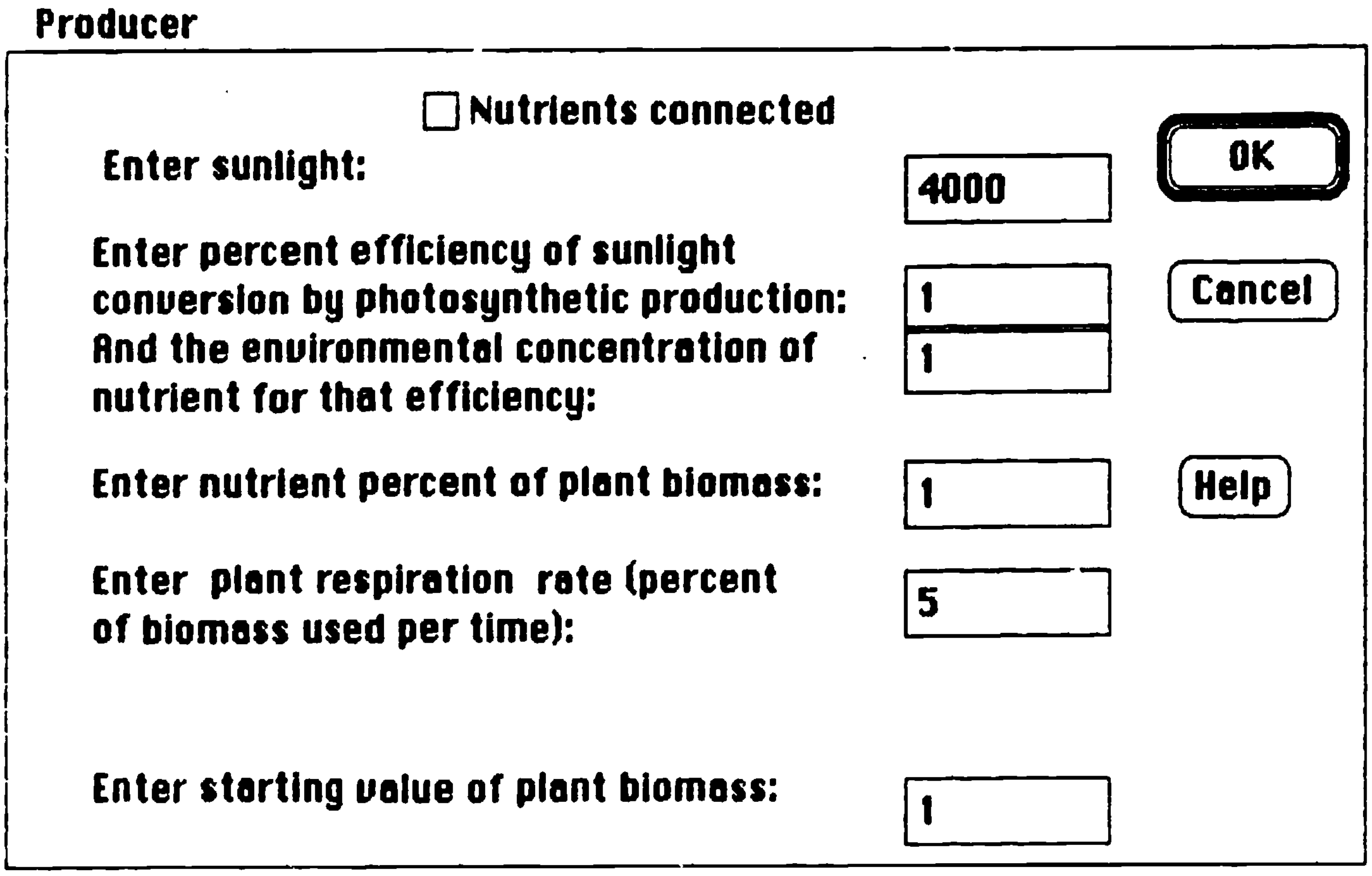


Figure 16 Macintosh screen with dialog boxes for the generalized plant producer icon shown in Figure 13

CRITERIA FOR EVALUATING ENVIRONMENTAL EDUCATION SOFTWARE

R.J. Wilson
Texas Wesleyan University

Historically, "environmental education" has been used as an umbrella term. Its meaning has been shaped to include a wide variety of attitudes, perceptions and behaviors. It has only been in the past few years that a general consensus of goals has been established for the field and operationalized for use (Hungerford, et.al., 1980). Recent research (Linke, 1985 and Volke, et.al., 1983) has indicated that there is a great need to investigate the wide range of topics, especially curriculum development. Many of the materials currently in use and some of those under development reflect the fragmented nature of the field. They have been developed to reflect personal or regional use without much attention being given to the new "goal focused" directions the field has taken. This has caused many problems for consumers of these materials. On one hand you have a wide range of materials and on the other there the "Goals of Environmental Education" (Hungerford, et.al., 1980). The evaluation of these materials using these goals is a time consumptive process. Very few individuals have the time and skills necessary to complete a thorough review.

In 1980, the National Commission on Environmental Education Research was established by the North American Association for Environmental Education (NAAEE) to aid individuals in the analysis and collation of environmental education research. (Iozzi, 1981) Since that time, the commission has expanded its role to include curricula materials. Dr. Ron Gardella (1986) developed an inventory scale for curricula which uses a "goal focused" approach. The commission has adopted the use of the tool as a bench mark for the project.

As the project progressed, it became obvious to the commission the instrument was not appropriate in structure for all types of materials. With the onset of technology in the last part of the 1980's, the field of environmental education has been overwhelmed by electronic curriculum materials. These materials need an instrument that is not only "goal focused" but also sensitive to their particular mode of presentation. Therefore, the commission decided to adopt the Gardella inventory to be used with these electronic media.

The result is the "Environmental Education Software Inventory (EESI).

The EESI, as with the original instrument, has been designed with the practitioner in mind. It was structured to require a minimum amount of time and skill for its use. Vast backgrounds in either environmental education or software evaluation are unnecessary. However, it does quickly indicate those environmental education goals which are being met and their context for use in particular settings. It consists of four parts. Part I consists of demographic information and hardware requirements. The second assesses the technical qualities of the software. Along with these, Part III reviews general education considerations. Finally, Part IV, which was adapted from Gardella's inventory, provides the user with information on the use of the "Goals of Environmental Education" (Hungerford, et.al., 1980).

In order to decide which components were to be used in the development of the EESI to make it useful with software, two separate procedures were used. First, a panel of seven computer specialists was assembled and asked to generate a list of demographic and hardware requirements that would be necessary to the operation of the programs. In Figure 1 the result of these discussions have been listed. While it is true this list is not exhaustive, it is a list of the most commonly identified items for use in educational settings. These items were placed into the EESI, Part I as fill-in the blank type responses.

The second part of the project was set up to determine what technical and educational qualities should be included in the EESI. A preliminary review of several software evaluation forms revealed that there is not a universal set of standards to assess software's quality. Thus it was decided to make a separate survey which determined the type and frequency of information used to evaluate a piece of software. The survey (Wilson and Shaw, 1989) began with a systematic search for varying types of software evaluation forms. Forms were solicited from local, regional, and state education offices, commercial software vendors, software evaluation organizations, and fugitive literature searches. A total of 163 separate forms were used in this analysis. As materials were collected, tallies were made of each type of data each form used. Individual items were separated into two groups which were arbitrarily defined as either technical or educational in nature. A technical characteristic was identified by its relationship to the structure and function of the software. Both of these are related to how the software was programmed. The programmer should have included the topic in the design or should have corrected a problem before the software was distributed. Figure 2 con-

tains a summary list of the most frequently asked technical questions on software evaluation forms. While there was a wide range of questions asked, there was a distinct difference in the frequencies between those that appear in the figure and those not used. Each of these items were placed in the EESI, Part II, using a "yes" or "no" format with exception of items f, g, and h. These three were placed on a five point Likert type scale which ranges from "Excellent" to "Adequate" to "Poor."

The educational qualities of the project were selected by defining them as those characteristics which are associated with some aspect of direct instruction. As was the prior case, there was a clear demarcation between those questions which were asked most frequently and those less seldom used. Those which had the highest frequencies appear in Figure 3. Each of these questions was placed into the EESI, Part III, using the same "yes" or "no" format as the prior section.

The final component, Part IV, of the EESI addresses the concept of "environmental literacy." Environmental literacy can be defined as those traits which allow individuals and groups to make sound environmental decisions and take environmental action which strikes a balance between man and his environment (Hungerford, et.al., 1980). This definition presupposes a set of environmental knowledge and skills which allow them to operationalize their decisions. Individuals must have a firm foundation in basic ecology to understand the ramifications of environmental issues. With this in hand, they need to be made aware of issues and the extent to which the issue impacts on the environment. This would include investigation and evaluation of all key positions involved in the issue including their own. These components will allow an environmental action to be taken to resolve the issue.

Environmental literacy then begins with ecological foundations and ends with environmental action. These are its goals (Hungerford, et.al., 1980). Dr. Ron Gardella in 1986 developed an *Environmental Education Curriculum Inventory, Form B* using the "Goals of Environmental Literacy" established by Hungerford, et.al. (1980). This instrument was adapted for use in this project and placed into the EESI (See Figures 4 5, 6, and 7). As with the EECI, this segment of Part IV assesses the software use of basic ecology. While it is hard to determine which ecological concepts are pertinent to a particular issue, an overview can be established. In Figure 4, the instrument assesses three major components of ecology. Individuals will be asked to determine whether basic principles of ecology are addressed. Then, if the response is

affirmative, a basic rating is given from one to three on how well the concepts were used. One is "Yes, but poorly," two is "Yes, fairly well," and three is "Yes, very well." This procedure is repeated for each of the three components.

As with the first segment of Part IV, the second deals primarily with information gathering. It is not enough just to know of an environmental issue. Rather, the larger parameters associated with the issue must be examined. One must be made aware of how individual cultures and behaviors impact on the environment and the issues as well. In addition, the individual must have knowledge of particular solutions applied to various issues and the impact of those solutions on the environment (Hungerford, et.al., 1980). In Figure 5 the ideas in this segment of Part IV are addressed. Like the prior segments, it is impossible to cover all possible topics in a short survey. Therefore a sample of some of the major components was included in the EESI. As with the prior segment, individuals are asked as to whether these topics are covered and then, if they do, how well they are covered. The same three point scale is used for each item.

Unlike the previous two segments, segment three Part IV goes beyond the acquisition of information. Here individuals are asked to examine the underlying components of each facet of an environmental issue. They must look at impact varying sets of values on the definition of the issue, its potential solutions, and results of the solution. During this process the individual should examine their own position regarding the issue. It must be subjected to the same type of analysis given to all other facets of the issue (Hungerford, et.al., 1980). Figure 6 contains the items which are designed to sample these types of efforts. Each item in this segment uses the same type of format as prior segments. A decision is made upon whether the item has been met and then rated on the three point scale from"very poorly" to "very well."

The final segment of Part IV deals with citizenship action. Once an individual has a basic grasp of ecology and people's role in the environment and can analyze the substructure of an issue, they are ready to begin an analysis of actions to remediate the issue. It begins with a basic knowledge of the varying type and levels of action available. With this available, varying solutions can be analyzed for their impact on the resolution of an issue, the culture, the individual and the environment. At this point the individual must make a decision whether action can or should be taken (Hungerford, et.al., 1980). As can be seen in the last segment of Part IV, Figure 7, the items it contains

try to assess citizenship action in the program. Each item follows the same pattern as prior segments. A decision is made regarding the inclusion of the concept in the software and rated on its degree of attainment of the item.

In the Fall of 1989, the EESI was subjected to both reliability and validity checks. A panel of five judges was selected and asked to compare the instrument with given sets of criteria. The panel voted unanimously to approve the EESI as meeting these criteria. The reliability was established using standard procedures. Five pieces of environmental software were selected and given to twenty-five teachers. Each was given the EESI and asked to evaluate each piece of software. After three months the same five pieces of software were given to the teachers to evaluate using the EESI. A comparison of the two sets of evaluation yielded a p=.91. Therefore the EESI was accepted a valid and reliable tool. Currently, the commission is in the process of generating a list of software which can be evaluated and potentially added to NAAEE's Environmental Software Collection. A variety of sources are being used to establish the list. These range widely from EPIE's The Educational Software Selector and ERIC to scatter citings in papers and fugitive literature. Once compiled, the individual programs will be assembled and evaluated. Each piece of software will be given to a panel of three judges. Each judge will be asked to evaluate the program using the EESI. In case of a conflict in the evaluation process, a majority decision will be used. It is hoped that the product of these efforts will provide both teachers and individuals with information on a particular software package to allow them to make informed choices in the curricula.

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Part I - Demographic Information and Hardware Requirements

Name ______________________________
Price ______ Version ________________
Author __________________ Publisher ________________
Subject _________________ Grade ___________________
Copyrighted ______ Shareware _____ Public Domain ______
Computer Type: Apple ____ IBM ____ Other ____________
Type of Software: Simulation ____ Tutorial ____ Drill ____ Game ____
Test ____ others ___________________
Memory _______ Drives number 1___ 2 ___
Drive type 5.25 ___ 3.25 ___ Hard disk ____
Monitor: mono ___ color___ hgd ___
joysticks ___ paddles ___ mouse ____
Printers: graphics _____ letter quality ____
modem: ___ Baud rate: ______
Other Hardware: ______________________
Documentation Available: Yes ___ No ___

Figure 1 Demographic Information and Hardware Requirements in the EESI

Part II - Technical Qualities of the Software

a. Is the Program Reliable Under Normal Use?
b. Is It Free of Grammatical and Spelling Errors?
c. Exist Capabilities?
d. ReEntry w/o Booting?
e. Are Help Screens Available?
f. Clarity of Screen Display?
g. Readability of the Screens?
h. Degree of User Control?

Figure 2 A Summary of the Technical Qualities Contained in the EESI

Part III - Educational Qualities of the Software

a. Are Clear Objectives Stated?
b. Is the Content Accurate?
c. Is the Content Appropriate?
d. Is Feedback Available and Appropriate?
e. Do Graphics, Sound, and Color Enhance Motivation?
f. Does the Program Allow for Differing Abilities?
g. Is an Appropriate Sequence and Logic of Material Used?
h. Are Directions Available?
i. Are Instructions Available?

Figure 3 A Summary of the Educational Qualities Contained in the EESI

Goal Level I -- Ecological Foundations

I. Know facts, concepts, principles of ECOLOGY such as: a. All living things, including people, affect each other (e.g. predator-prey, food chain, food web, competition, population behavior and distribution). b. Living things affect their non-living surroundings, and are in turn affected by these changes (e.g. water, mineral, pollutant cycles, destruction of animal habitat, plant succession, etc. c. Non-living things determine the kind of environment and in turn the variety and number of plants and animals (e.g. types of environments -- desert, forest, pond, etc., animal and plant adaptation).

Figure 4 Characteristics Used in the EESI for Environmental Education

Goal Level II -- Awareness of Issues

II. Knowledge and Awareness of Environmental Issues and Problems, such as: a. Defines, identifies, and discriminates between environmental problems and environmental issues (Environmental problems may be natural or human-made while issues are conflicts arising from how people view the problem). b. Explore case studies that identify environmental issues, causes and effects. c. Allow students to explore issues, identify costs and suggest solutions.

Figure 5 Characteristics Used in the EESI for Environmental Education

Goal Level III -- Investigation and Evaluation of Environmental Issues

III. Investigation and Evaluation of Environmental Issues, such as: a. Know that people use the environment differently and often cause problems because of their values and attitudes. b. Causes students to compare their values with the values necessary for maintaining a quality life for the environment and people as well. c. Enables students to analyze solutions to environmental issues in terms of the costs and/or benefits to the environment.

Figure 6 Characteristics Used in the EESI for Environmnental Education

Goal Level IV -- Environmental Action

IV. Know About and Practice of Environmental Action, such as: a. Define responsible environmental action, types, categories, and/or examples. b. Describes/presents models of responsible environmental action with a variety of action case studies. c. Allow students to suggest and/or take environmental action.

Figure 7 Characteristics used in the EESI for Environmental Education

SINKING TO NEW DEPTHS: CONFESSIONS OF A COMPUTING NATURALIST

Maureen McConnell
Boston Museum of Science

I didn't like computers.

After all, I was a zoology major whose love was the out-of-doors. I had worked at oceanography schools, both on and off boats. I had motored from zoos bringing live animals to kids in city schools. And now, in fair weather, I kayaked to work at the Boston Museum of Science where I developed "kits" of hands-on science materials for elementary schools.

Inabeth Miller, Director of Science Outreach, wanted computer programs in each of the museum's kits. She arranged for us to develop our own software with a local company called Learningways Inc. One of us was needed to work with them as a content person. When no hands were raised in eager enthusiasm to volunteer, I knew I would have to be the one to go.

Why shouldn't the consultant be someone who hated computers? I didn't want my students filling in the blanks of worksheets presented to them by a cathode ray tube. I would spring to their defense!

My first meeting with the staff at Learningways was something of a shock. Art Bardige, the owner of the company, was warm and enthusiastic. He had actually heard of children, and appeared to prefer them to computer hardware. Henry Olds, manager of applications development, had been seen stepping into classrooms on purpose. He spoke of open ended learning. Angela Faeth, head artist and animator, created rabbits that bounded to life as I moved them about the screen. Dinosaurs stomped across Cretaceous landscapes. Whales swam by and waved their flippers to me. I could be an oceanographer! I could steam out to sea! I could herd cows in a barnyard, or help caterpillars turn into butterflies! No one issued me a password. I was neither RAMed nor ROMed. There were no bitmaps, boot blocks, bundle bits. And, thank goodness, there were no worksheets.

I was enchanted. Surely, my students would be enchanted too.

The first project I helped with was ***Tyrannosaurus rex.*** In this program, users, cast as paleontologists, dig bones in the badlands of Idaho. Each screen is interactive. Using the mouse of an Apple II, the paleontologists

move rocks and sod to uncover bones. Back in the lab, they sort the finds from the field into the various body parts of the dinosaur. (If they need to learn some comparative anatomy to help them identify the bones of an extinct animal, they can consult a lion skeleton on another screen.) As the skeleton takes shape, they explore the relationship of muscle size to limb use, and color the dinosaur as they think it might have looked in life.

This was an exciting prospect. Students using this program could get a glimpse of a profession they might choose as their own one day. All the steps from the discovery of a dinosaur to modeling its look and possible behavior were represented in a program that invited learners to join in the adventure!

The reviews in computer educator magazines of ***T. rex*** were highly complimentary. But surely they were not to be trusted. Secretly I feared slipping into the persona of the computer nerd. Was I changing the world of computers? Or was it changing me? I checked my pockets for plastic pen protectors. I scoured my vocabulary for telltale phrases -- "Single In-line Memory Module," "RAM cache," "algorithm."

For the acid test, I signed on at the museum to teach a Saturday course to parents and kids using the software programs we had developed. At each meeting, my group first sat in a circle handling real artifacts: a saguaro boot from an Arizona cactus, the nest of a cactus wren, the seed pods of the yucca, fertilized by a yucca moth.

Then each student and parent team investigated the world of southwest deserts I had created for them in the ***Desert*** software. They opened up a saguaro cactus to discover a saguaro boot within. They opened the saguaro boot in turn, to discover inside the nest of an elf owl complete with eggs that hatched into owl nestlings. These were discoveries I could not have provided for them had we journeyed together to Arizona on that winter Saturday. Digging down through burrows in the desert pavement they found, all on their own, the kit fox and jumping mouse I had left sleeping for them there. Walking further, in the desert heat, they spotted a nest in the arms of a cholla that looked familiar -- and as the startled cactus wren flew away, they examined the nest of eggs she'd left behind.

While I watched, in startled silence, my families slipped into another world. They would call to each other across the room, as the stars rose in the desert sky -- "Look out for the bat!" "There's a scorpion under that rock!"

I suppose they could as easily have spent those Saturdays in a video-game parlor slamming quarters into slots for another round of Space Invaders. They might instead be scurrying Ms. Pac-man through a maze of hungry ghosts. Yet week after week they returned to the video-madness of my own making. They visited wolf pups in underground dens. They frolicked among whales on an open sea. They tracked rabbits across a frozen pond.

I had ventured into their world, and lured them into mine.

Ah, but all was not roses and laurels in this self-appointed journey. The published programs were prominently displayed by the Smithsonian's National Museum of Natural History gift shop long before we were able to convince our own store to sell them. The developer for the museum's dinosaur kit, no lover of computer technology, balked at putting ***T. rex*** in the museum's kits. And I recall one memorable afternoon at D.C. Heath arguing with an editor who felt that the bat should be removed from the cover of the Desert software package because it might denote satanism to Texas school committees. (The bat is still on the cover -- but greatly reduced, and no longer silhouetted against the moon.)

I can't be too harsh on those Texas censors -- hadn't my own prejudice against computers been as irrational as the fear of a bat winging its way across the moon?

Since that time I have changed jobs within the museum where I now work as an Exhibit Planner. With Learningways I've developed shortened versions of the computer programs to include in the museum's exhibits, as well as developing new applications using HyperCard and MacroMind Director. A new program, "Tidepools," once again created with Learningways but aimed at the junior high level, is now available from Disney Software.

I suppose the use of computers to teach environmental education is no more incongruous than a naturalist who paddles to work on a polluted river through the heart of an eastern city. "The river has its beauties," I muse, as a black-crowned night heron rises from the far shore.

And I have traveled a long way, for someone who didn't like computers.

Availability

Explore-a-Science series was jointly developed by Learningways, Inc. and the Boston Museum of Science.

The programs in the series are:

* Dinosaur Construction Kit: Tyrannosaurus rex
* A Closer Look: The Desert
* Animal Watch: Whales
* Animal Watch: Wolves
* Animal Watch: Tracks

The series is published by Collamore, D.C. Heath and Company and is available through:

William K. Bradford Publishing
P.O.Box 1355
Concord, MA 01742
(800) 421-2009

The program "Tidepools" is published by Disney Computer and is available through:

Sunburst Communication Inc.
39 Washington Ave.
Pleasantville, NY 10570-2898
(800) 431-1934

SAN FRANCISCO BAY-DELTA PUBLIC EDUCATION DISPLAY

Kathryn S. Kramer+ and Alisya Galo*

+ Aquatic Habitat Institute
* Oakland Museum

Introduction

The largest estuary on the West Coast of North America, the San Francisco Estuary is central to life in California. Northern Californians drink from its tributaries, eat its fish and shellfish, swim and sail in its waters, and use it to carry away treated sewage and stormwaters. In addition, great quantities of water are diverted from the Estuary for agricultural and urban uses outside of the watershed. As many of these uses are becoming increasingly incompatible, important and controversial public decisions regarding the future of the Estuary are inevitable. Many members of the general public, however, do not appreciate the myriad of resources that are part of this ecosystem, or the extent of human impacts upon the Estuary.

The Gulf of the Farallones National Marine Sanctuary encompasses 948 square nautical miles of water off the California coastline just north of San Francisco. Gusting winds, ocean currents, and the earth's rotation combine each spring and summer to produce an explosion of life in the Sanctuary. The nutrient rich water brought to the ocean's surface supports microscopic plant life that is the core of a rich marine food web. The diversity and number of living marine species supported by this plant life are nationally significant resources. In order to protect these resources, the region was designated as a Sanctuary in 1981, and is managed by the National Oceanic and Atmospheric Administration (NOAA).

Early in 1988 the San Francisco Bay-Delta Aquatic Habitat Institute (AHI) was contracted by the Environmental Protection Agency's San Francisco Estuary Project (SFEP) to create a computerized public education display about the San Francisco Bay and Delta. Designed as an exhibit for the Lawrence Hall of Science in Berkeley, California, the San Francisco Bay-Delta section of the project was funded by a grant from SFEP, donations of hardware and software from Apple Computer and Marvelin Corporation, and

in-kind donations from the Lawrence Hall of Science and the Oakland Museum. The decision to add the previously developed computer files on the Gulf of the Farallones to the Bay-Delta program was made in early 1990. The Gulf of the Farallones section of the program was funded and developed by the National Oceanic and Atmospheric Administration.

Project Description

The display is run by a Macintosh SE computer and the multilayered database and drawing software package *Business Filevision*. Viewed on a large (13") monitor, this interactive, portable public education display provides information about the ecology of the Bay-Delta, the impacts of people's activities on the estuarine ecosystem, and the resources within the Gulf of the Farallones Marine Sanctuary. This information is displayed on base maps that are enhanced with the addition of text and graphics that 'pop-up' on the monitor at the visitor's request. To obtain details on specific areas of interest, the visitor simply points the on-screen arrow and clicks a button located in the display panel.

The approximately three hundred screens of information contained within in the display are divided between the San Francisco Bay-Delta and the Gulf of the Farallones. The San Francisco Bay-Delta section of the program contains three major categories. These categories are; *Using the Bay*, *Life and the Bay*, and *Bay-Delta Issues*. *Using the Bay* contains specific information on industrial and municipal dischargers, salt production, shipping, and bayshore parks and refuges. *Life and the Bay* contains information on Bay-Delta hydrology, geology, biota, and habitats. *Bay-Delta Issues* presents information on the complex management questions concerning water diversion, dredging, pollutant loading, and bay fill. The Gulf of the Farallones section of the program contains information on the Sanctuary, marine mammals, and the Golden Gate National Recreation Area. This information and the software package take up 1,550 kilobytes of hard disk space. Details on the information included within each of these topic areas are outlined in Figure 1.

The display will be located at the Lawrence Hall of Science in Berkeley, California. The program is currently undergoing final development and testing at the Hall, and is due to be placed on the floor in the summer of 1990. In the museum setting, only the monitor and a track ball (for moving

the on-screen arrow) will be seen and accessed by the public. The computer and keyboard will be housed in the display case away from public view.

While initially designed as a museum exhibit, there has been considerable interest in utilizing this display as a teaching tool in classrooms. The Aquatic Habitat Institute is currently exploring possible use of this system in high schools and colleges, and will be developing curriculum designed to accompany the Display in the summer of 1990. A pilot program utilizing the display and curriculum in high school science classrooms is due to begin in the fall of 1990.

Software

The San Francisco Bay-Delta public education display was modeled after displays developed for NOAA's Santa Barbara Channel Islands and the Gulf of the Farallones National Marine Sanctuaries. The Channel Islands display has been running at the Sea Center in Santa Barbara, California, for over two years. The Gulf of the Farallones display is housed at the Golden Gate National Recreation Area visitor's center in San Francisco, California. Each of these displays has utilized the same hardware and software, allowing data to be easily exchanged. The files developed for the Sanctuaries and the San Francisco Bay-Delta display will be distributed to interested parties, thus providing a ready-made display on these three aquatic systems at a minimum cost.

As mentioned above, *Business Filevision* was selected in part because it had been utilized for the Santa Barbara and Gulf of the Farallones displays. A second advantage was *Filevision's* ability to display on a vertical 13" screen, a primary consideration for placement in a museum setting. A third advantage is that no programming experience is necessary to create or link files. As with any software package, *Filevision* has several disadvantages. One disadvantage is its inability to include sound as part of the program. Another is the inability to disable certain functions, such as scrolling. A third is the system's inability to automatically return to the opening screen after a certain amount of elapsed time, which means that visitors will most likely begin interacting with the display at a screen located somewhere within the body of the program.

Other software programs are now on the market that support a full page display and that have some features *Filevision* does not presently offer, such

as the ability to add sound, animation, or video images to the system. When the project was under development (in early 1989), no other suitable software programs that had the ability to run on a full-page display were on the market.

From the visitor's point of view, *Filevision* has three layers. The first layer is a base screen containing icons and 'buttons' (or boxes) that may be 'clicked' on. 'Clicking' (moving the arrow and pressing a button) on an icon or button results in a 'pop-up' (overlay) that contains graphics and text about that object. If further detailed information about the object is desired, the visitor can click on the 'INFO' button located at the bottom of the screen. Clicking on the 'INFO' button will bring up another screen of graphics and text (see Figure 2).

Filevision allows objects on the screen to be 'linked' directly to other *Filevision* files. 'Linking' closes the active file and opens a predetermined file. For example, if the visitor was viewing information on habitats and wished to learn more about salt marshes, she would click on the 'link' button. This action will close the Habitat file, and retrieve and open the Bay Fill file, which contains further information on salt marshes.

Design Considerations

A variety of factors were taken into account during project design. These factors included the visitor's expected computer literacy level, the need for on-screen instructions for navigating through the program, location and reference point information, directions for returning the program to the opening screen, and keyboard availability. Each of these factors is explained in further detail below.

Designed to be used by visitors with no prior computer experience, the display contains clear and ample on-screen directions. These directions appear either on the base screen, or in pop-ups (see Figure 2). Navigation through the system is achieved by utilizing the standard Macintosh point-and-click feature, and choices for navigating through the system are obvious and consistent throughout the display. Additional instructions on operating the track ball and navigating around the display will be provided on panels mounted on the display case.

In order to provide the visitor with information on where they "are", and to ensure continuity within the display, all of the base screens have the

same template (see Figure 3). Speckling in the buttons indicates where the visitor is in the system, and two speckled buttons are present on every screen. In Figure 3, for example, the visitor is in the San Francisco Bay and Delta, and is viewing the *Waste Disposal.* screen As a reference point, every screen also contains a Start Over button that allows the visitor to go to the beginning of the program. The asterisk near the Start Over button will allow users to clear pop-ups from the screen.

As mentioned previously, in the museum setting the keyboard will not be available for public use. The decision to remove the keyboard was made in order to prevent 'hacking' and general abuse of the relatively delicate keyboard. This means that the visitor will not have the ability to type in a question such as "What animals are found in salt marshes?" Visitors will make their choices and obtain information by clicking on the topics of interest to them.

Future Use

The display is encyclopaedic in content, although unlike an encyclopaedia, computerized information can be easily updated or changed. The information entered into the display is general enough to remain current for several years. Thus, public education facilities that purchase the hardware and software necessary to run the display (approximately $3,800 total) can expect to have a low-maintainance system in their visitors centers through the early 1990's. The ease with which information can be updated or added will enable non-programmers to keep the display current.

Public education facilities other than the Lawrence Hall of Science have expressed a keen interest in displaying the program. As the information contained within the display is public domain, the files will be distributed to interested facilities at a minimum (diskette replacement) charge.

Although designed initially as a museum exhibit, high school teachers and librarians have shown great interest at the prospect of utilizing the project as a teaching or reference tool in their schools. The Aquatic Habitat Institute is currently working with several Bay area high school teachers, and hopes to place several displays into schools in the fall of 1990. Possibilities for classroom use include environmental issue analysis and research projects for science and social studies classes. Conversion by students of the *Filevision* screens into other software programs such as

Hypercard and *Supercard* has also been discussed. Conversion into *Hypercard* would allow students to add information during their computer lab classes, which would give them the ability to customize the program for research project demonstration purposes. Conversion of the information into *Supercard* would allow the class to create a laser disc program by connecting video images to the existing database. Finally, to help teachers use the system more easily, curriculum materials designed to accompany the display will be developed in the summer of 1990, and a pilot teaching program will begin in the fall of 1990.

For further information on the display, please contact:

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San Francisco Bay and Delta: Life and the Bay

Last Ice Age
shoreline at 15,000, 10,000, 5,000, 125 years, and today
Habitats
salt and brackish marsh, tidal slough, mudflat, salt pannes, seasonal wetlands, urban and rural areas
Animals
species of animals occurring in each habitat of the estuary
Waterways
bathymetry, drainage, tides, null zone

San Francisco Bay and Delta: Using the Estuary

Waste Disposal
information on point source, municipal, and industrial dischargers, average daily flows from 30 dischargers located on the Bayshore
Salt Production
history of salt production, method by which salt is produced, location and number of acres of land actively used for salt production
Shipping
locations of ports, shipping channels, number of miles from the Golden Gate, number of vessels arriving at each port in 1988
Recreation
locations of 18 Bayshore parks and refuges, park description, activities and facilities available, directions, phone number

Figure 1 Description of information included in the San Francisco Bay-Delta Public Education Project **(continued on next page)**

Figure 1 (continued)

San Francisco Bay and Delta: Bay-Delta Issues

Water Diversion

management questions, explanation of water diversions, description of the mixing zone and how the zone is impacted by diversions, explanation of reverse flows and effects on biota, discussion of historical and present-day flows

Dredging

management questions, explanation for dredging, locations of dredge sites, locations of dredged material disposal sites, discussion of contaminants in dredged material

Pollutants

management questions, sources of pollutants, water quality and biological resource threats from pollutants, locations of 'hot spots', discussion of threats to human consumers of estuarine biota, and contaminant loads from dredging and dumping operations

Bay Fill

management questions, discussion of former and present-day shoreline, importance of wetlands habitat, types of wetlands, locations of remaining wetlands

Decline of Biological Resources

management questions, description of pristine Bay-Delta, commercial fisheries discussion, history of salmon fishery, waterfowl habitat requirements

Gulf of the Farallones: Coastal Resources

National Marine Sanctuary

depth, uses, jurisdiction, marine bird nesting areas, marine protected areas

Marine Mammals

estimated world populations, coloration, characteristics, size and general information on the humpback, blue, fin, and gray whales

Golden Gate National Recreation Area (GGNRA)

activities, accessibility, and general information on GGNRA districts at Muir Woods, Marin Headlands, Mt. Tamalpais, Bay, Ocean-South, and Ocean-North

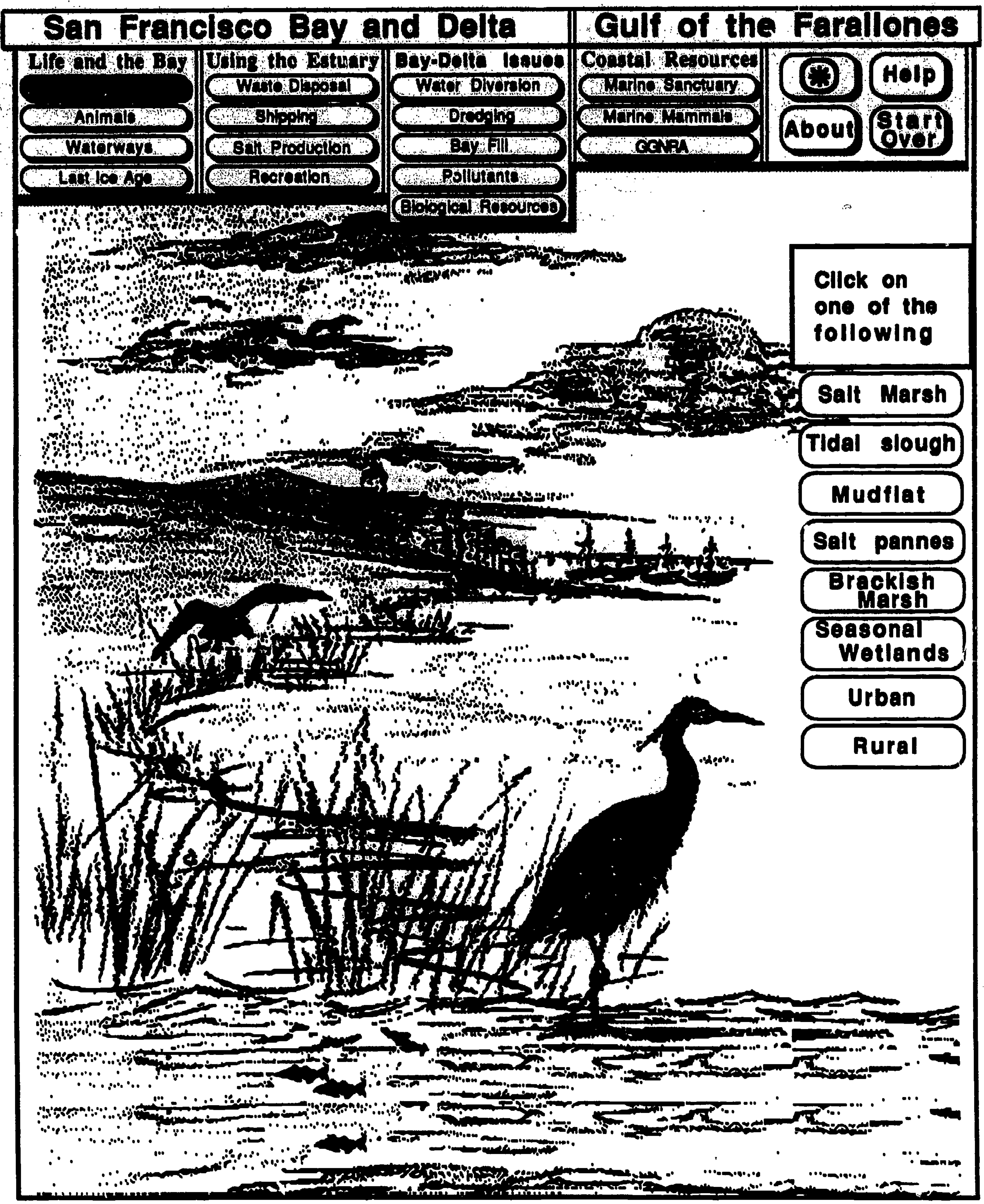


Figure 2 The Habitat screen lists habitats found in the San Francisco Bay and Delta. The visitor can either select any habitat, or they can change to another topic. See Figures 3 and 4 to follow the progression from base screen to pop-up to information screen.

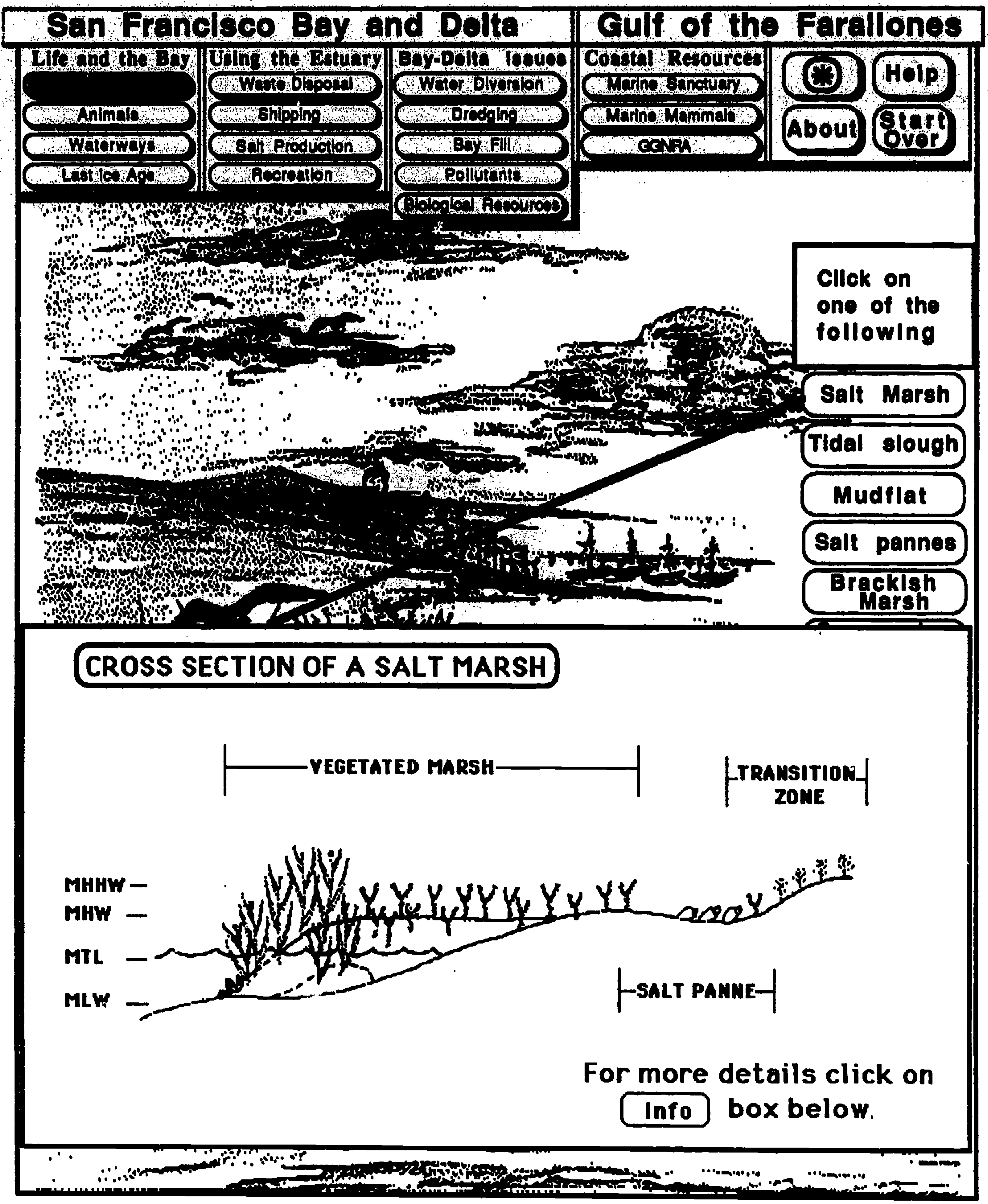
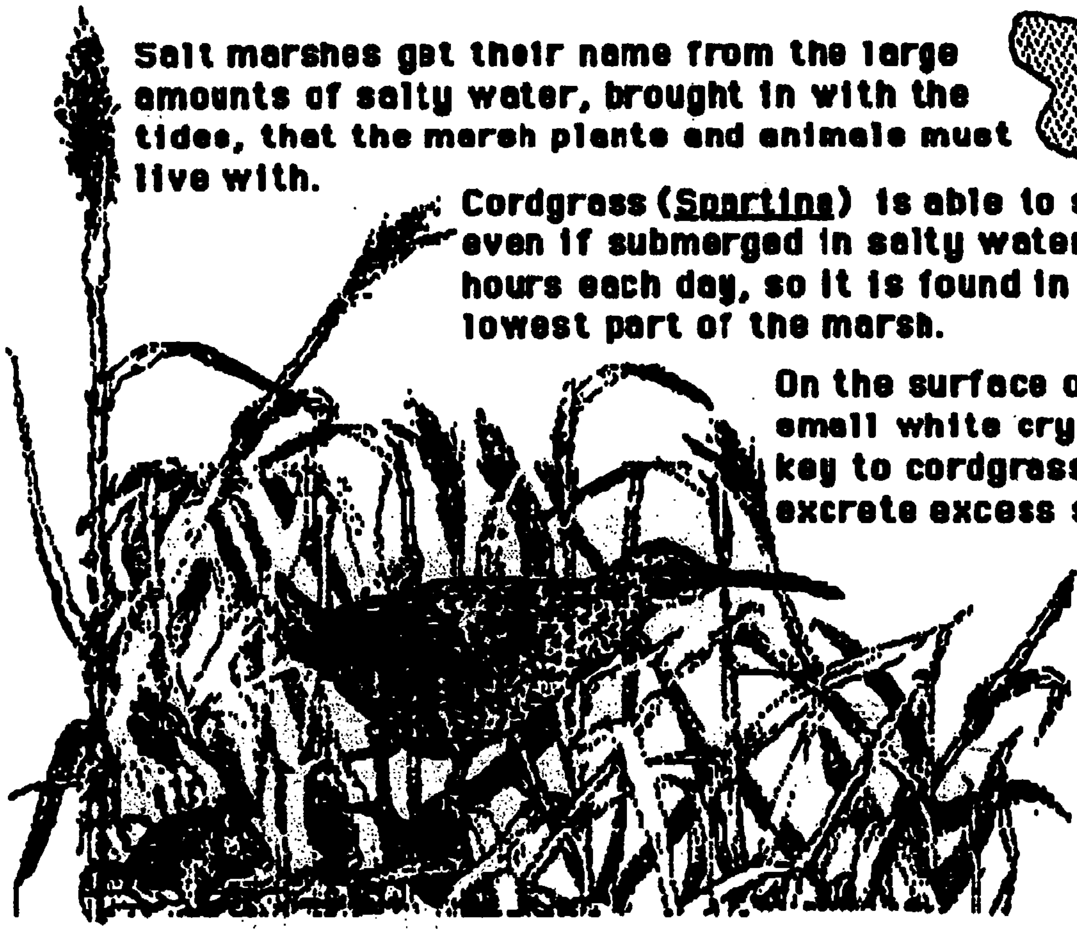


Figure 3 On this screen the visitor has selected the Salt Marsh habitat, and is viewing a cross section of the marsh. For further information, they click on the INFO box, (not seen on this print-out).



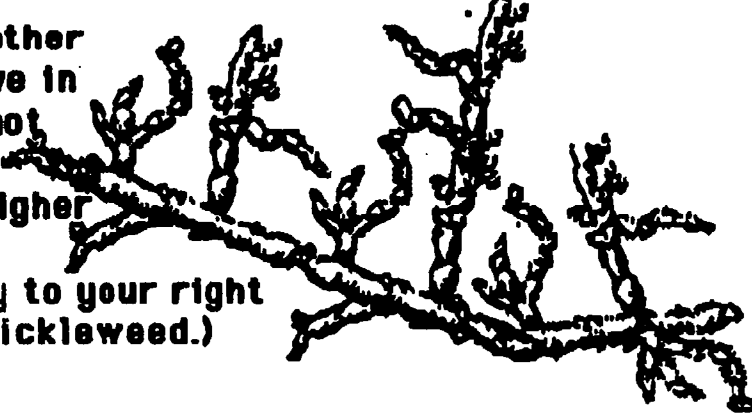
Salt marshes get their name from the large amounts of salty water, brought in with the tides, that the marsh plants and animals must live with.

Salt marshes are disappearing Click on [Link] to find out more.

Cordgrass (Spartina) is able to survive even if submerged in salty water for hours each day, so it is found in the lowest part of the marsh.

On the surface of it s leaves are small white crystals. This is a key to cordgrass' success, it can excrete excess salt.

Secretive animals such as the endangered clapper rail and salt marsh harvest mouse make their home in the salt marsh. When the high tides come in, they are flushed out.



Pickleweed (Salicornia) is another halophyte (a plant that can live in a salty environment.) It cannot live underwater as much as cordgrass and so it is found higher up the marsh.
(The harbor seal in the gallery to your right is "hauled out" on a patch of pickleweed.)

Higher up the marsh, above where the tide water reaches frequently, short eared owls and garter snakes search for mice and shrews to eat among the saltgrass (Disticlis) salt bush (Atriplex) and alkali heath (Frankenia).

To go to the main screen click on [Drawing] box

Figure 4 Additional details on the salt march habitat can be found on this INFO screen. An INFO screen is available for each of the habitats.

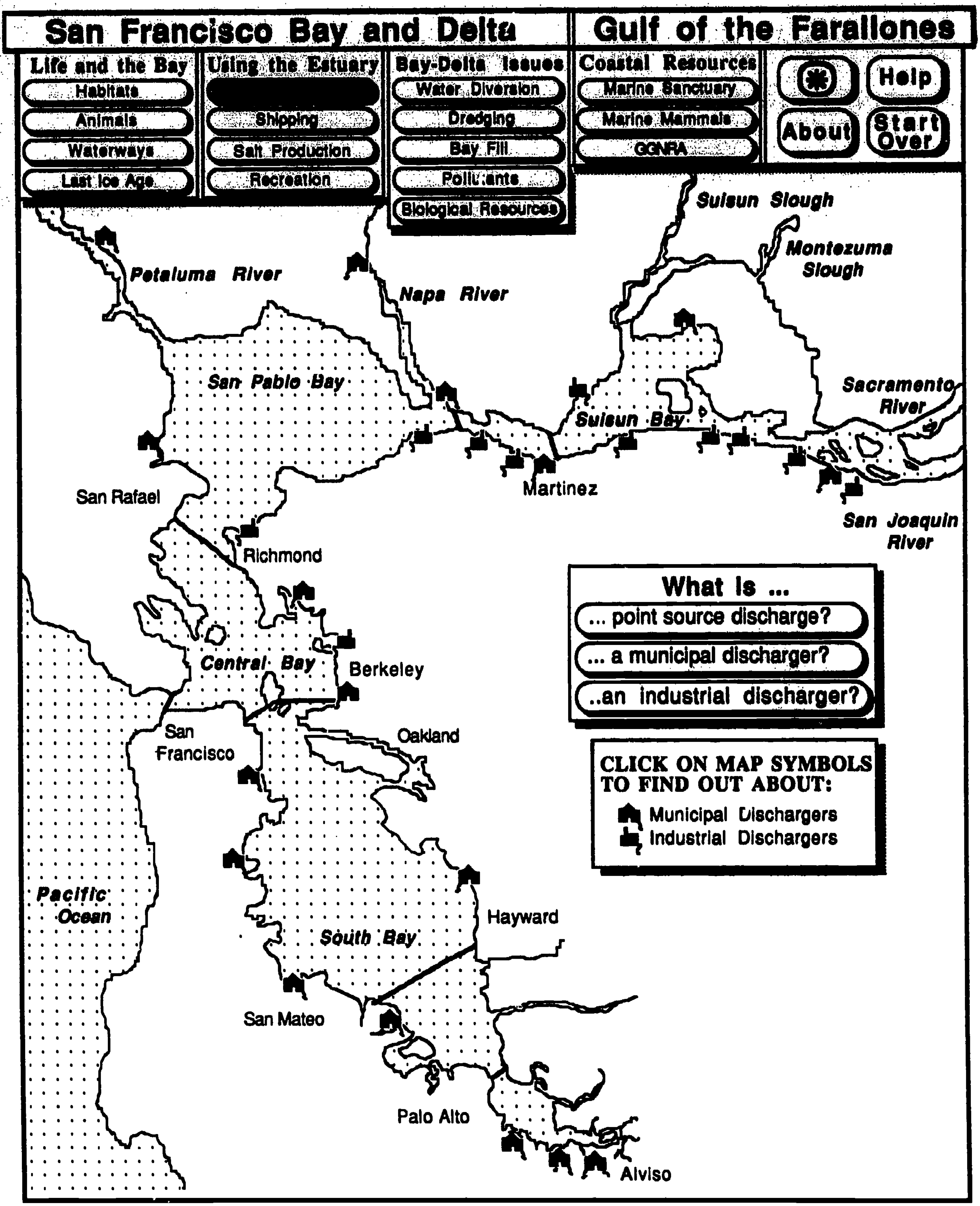


Figure 5 This is the Waste Disposal screen in the San Francisco Bay and Delta section of the program. Clicking on the icons will provide information about specific dischargers; clicking on the questions provides general information about point source discharge.

ENVIRONMENTAL EDUCATION AND COMPUTER-BASED TELECOMMUNICATIONS

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Overview

Computer-based telecommunications is one essential tool available to environmental educators. Computer-based telecommunication provides information resources as well as opportunities for enhanced interaction among the world's environmental community. Increased vitality is brought into environmental efforts by permitting organizations and individuals worldwide to work together to apply what is learned -- to support the relationship between learning and action.

EcoNet is an international environmental computer network which provides a window of access for environmental educators, offering an infrastructure which can be built upon and expanded. While much is already in place, the application of computer-based telecommunications is, relative to further developments of the technology, in its infancy. The environmental education community has already committed itself to using this tool -- the North American Association for Environmental Education (NAEE) and the Alliance for Environmental Education (AEE) are creating resources and interactive programs on EcoNet to serve environmental educators and students.

Telecommunications in its broadest definition can refer to a wide range of communications which in some way uses telephone technology. In this paper, I will use it to mean using telephone technology coupled with computer technology to permit individuals or organizations to communicate with each other throughout our planet. I will draw on my knowledge and experience with EcoNet to describe current applications of this technology along with some thoughts about where we are heading.

Computer-Based Telecommunications and EcoNet

EcoNet serves environmental educators as part of its broad mission to provide information services to the international environmental community. As a computer-based communication and information sharing system,

EcoNet facilitates collaboration among environmentally-concerned organizations and individuals throughout the world. EcoNet is a central program of the Institute for Global Communications (IGC). IGC is a division of The Tides Foundation, a California based non-profit corporation. Using computers linked over phone lines throughout the world, EcoNet facilitates interpersonal communication skills to help build effective relationships among people with common concerns and related activities. By making computer technology affordable and available to the worldwide environmental community, EcoNet enhances the effectiveness of that community and strengthens its impact by helping its members work together.

EcoNet users can send messages to another continent in a matter of seconds, gather the latest information on a wide variety of environmental topics, interact with other members of the environmental community around the world, look for a job in the environmental field, or find a foundation that might fund a project -- right from their desk! Through Sprintnet (an international service which links computers via phone lines), EcoNet is accessible with a local phone call to users in all 50 states and more than 80 countries. With a personal computer (or even just a computer terminal) and a modem, and a regular telephone line, anyone can use the electronic mail, conferencing, and database services at minimal cost.

EcoNet's telecommunications services compete favorably in sophistication and affordability with all of the other major telecommunication services. EcoNet users can exchange electronic mail through gateways with users on most of these other services, as well as send fax messages even if the fax receiver is not an EcoNet member. EcoNet has established a substantial base of environmental information and is becoming widely recognized as the network that is supporting extensive communication within the environmental community. Virtually all of the major national and international environmental organizations use EcoNet.

EcoNet thus provides appropriate and necessary worldwide communications links to respond to the many environmental issues which know no boundaries. We recognize the importance of communications technology and know at the same time that this technological tool will only realize its maximum utilization when we also address those human, social communication dynamics which can either inhibit or encourage people to

work together.

Here are few examples of the use of EcoNet to help illustrate the variety of ways in which the system works.

* Users respond to an on-line letter writing campaign request by immediately sending electronic mail, fax, and telex messages urging decision makers to help protect an area of rainforest that is about to be logged.

* Board members of an international environmental foundation who are located in 30 countries use EcoNet to circulate correspondence, review and comment on proposals, and vote on board business -- all without leaving their offices or using standard paper mail.

* Teachers throughout the Tennessee Valley use EcoNet to share ideas on environmental education in the classroom and the latest in outdoor environmental science curricula.

* Calling themselves "Campus Earth," university students around the country use EcoNet to organize on-campus activities to promote public awareness of global warming.

* While most of us are receiving the story of the Valdez oil spill through the mass media's eyes, EcoNet users nationwide simultaneously get first-hand accounts of the devastation from local Alaskans who are on-line.

* In order to help coordinate Earth Day's 20th anniversary, offices all over the world utilize EcoNet to gather information on regional events, post summaries of activities, send on-line newsletters, and coordinate media outreach.

* The editor of a small community newsletter downloads articles on recycling from an on-line EoNet environmental news service, placing them directly into a their local neighborhood newsletter on ways to reduce household waste.

These recent examples illustrate only a few of many effective and efficient ways in which the environmental community currently uses telecommunications. While the military and business communities have been at it for a long time, the environmental movement has only recently begun to grasp networking and communication opportunities born of the so-called "telecommunications revolution." Today's environmental computer networks represent an exciting and powerful tool to assist everyone from local activists to international foundations.

Linking for Learning and Action

Access to useful information is vitally important to people working at all levels, from small grassroots organizations to international foundations. Dedicated people in small grassroots organizations are working on a wide variety of local issues. Often these groups are the most in need of information about other local, state, or federal regulations and legislation, action which has been effective in other localities, and pertinent research and scientific measurements.

Communications technologies are already playing an important role in building the links necessary to tackle complex problems, but there is a much greater role for them. The telephone and telex have had a profound impact on international organizations and collaborations. Yet, it is still very difficult to get a geographically diverse group to work together on a sustained basis. Meetings are expensive and time-consuming. Telex and Fax are relatively expensive and are not interactive. Telephones demand the synchronous presence of both parties, are expensive, leave no record of decisions, and are not suitable for group interaction at an international level.

Networking for Sustainable Energy -- A Current Example

Further illumination regarding the use of this tool can be gained by looking at a current project regarding developing information resources and working for its implementation for sustainable energy systems. The materials created in this project will present a wealth of well-organized information along with clear choices that individuals and organizations can make to move towards realizing a sustainable energy future that serves humanity's needs on a global level. But, while a substantial and important task in itself, the creation of these materials is not enough. We all know of wonderful information resources which have been squandered for lack of implementation or application.

To maximize the impact of these materials, their creation and existence must empower individuals and organizations to act constructively, creatively, and effectively. To this end, the use of EcoNet presents exciting possibilities. In using EcoNet, we are using proven technology to bring together researchers, writers, educators, and activists in the energy field to

produce materials that will empower action. We stress here that a project of this type does not advocate a particular action, but supports informed choices and invites participation from experts and involved citizens representing a wide range of perspectives.

Metaphorically all of the necessary personnel are in the same room (EcoNet). However, the presence of these people does not ensure effectiveness in their communication. The success of such a project needs a nucleus of people who are energy experts along with people who are skilled communicators. These people, through the use of telecommunications and personal communications skills will catalyze all of the participants into highly effective action. In many ways the dynamics needed for successful telecommunications are the same as those needed for successful face-to-face meetings or conferences. When these human communication skills are skillfully applied, telecommunications presents exciting possibilities by adding the ability for people dispersed geographically around the planet to participate in projects when the time is appropriate for their work days.

As in face-to-face meetings a facilitator or co-facilitators continually summarize and coordinate information entered by participants. Because energy experts participate on EcoNet and because the facilitators have working and personal relations with them, these people are easily accessible when they need to be called on for additional information or critiques of existing information. EcoNet can include the widest constituency both for participation in the development of the materials and for its widest dissemination. As written materials are put into final form, they can be packaged in discrete units to be be downloaded by EcoNet users to disseminate through newsletters, periodicals, educational curricula, and other means. In this way, these products are immediately available for use and implementation. Furthermore, as they are used and critiqued, they can easily be modified and updated on EcoNet so that the latest version is always available.

We see from the above example that a wealth of information resources can be made accessible through EcoNet and that educators and activists can be directly involved with each other in the development, dissemination, and application of those materials. We see that the technology is necessary but not sufficient to produce a good product or to support its successful application -- interpersonal communications skills are at least as important

as with face-to-face communication.

The Human Dimension

Human factors in information processing must be present if we are to deal successfully with dynamics related to information overload. Computers have permitted accumulation of massive amounts of data that can be searched and displayed in a variety of ways. For some types of data and for some types of searches, use of computer power is entirely appropriate and can produce the desired results. However, there will always be some essential information and communication processes that are dependent upon the unique capacities of the human mind and its connection to the human spirit. We have seen in the above examples uses of the network where individuals and organizations have managed successful projects through appropriate application of the technology. Human information screens or filters are important in those examples and will continue to be so. As another example, using computers we can search millions of volumes housed in a consortium of university libraries. Once having that search result, we still need more information about the value and pertinence of what we have found. And, of course, we may not have asked the right question How we determine the right question, how we seek more information, how we decide what sources of information to trust, and how we sort through many other factors inevitably leads us to dynamics which are uniquely human. Within this broader perspective, we will use computer power and telecommunications when called for as an appropriate technology to augment other forms of communication.

A Look to the Future

With these observations in mind, environmental educators will continue to use EcoNet to develop a wide range of information resources and to create systems that will bring educators and students into dynamic communication with each other to work for further information development and its application. In this regard, telecommunications can add vitality and excitement to future educational processes. Students and educators see subjects come to life as they study, for example, about tropical timber resources and are, through telecommunications, in current

contact with those individuals and organizations who are addressing these issues on a day-to-day basis.

In this context, telecommunications has a wonderful egalitarian nature which has benefits for both educators and students. Furthermore, this egalitarian factor can change some of the normative patterns that are prevalent in the formal educational context. In electronic conferences, all EcoNet participants are "present" as equals. They will be observed/judged by their online peers only by the written word -- not by status, age, sex, or other factors which, by themselves, are irrelevant to the quality of their written contribution. Unless they are explicitly identified in some other way, they will be identified only by what they post online as a contribution to a specific topic -- the writer could be a tenured professor or a high school student.

Furthermore, all EcoNet participants can learn, as readers of online materials, in a completely non-threatening environment. They can be readers or observers of materials and discussions on the network and do additional "homework" as might be appropriate. When they determine that they are ready to participate by contributing a point of view or additional information, there are no barriers to their full participation. The network becomes an exciting "global classroom" both in its content focus and in its participation.

The next few years will see some very exciting applications of electronic conferencing in this global classroom. Up to this time on EcoNet, and even more so in the field of telecommunications generally, the majority of communications has been electronic mail. Electronic conferencing has lagged for both technological and interpersonal communications reasons. While there will continue to be new technological enhancements, new exploration and thinking in interpersonal communications in the telecommunications context will bring dramatic achievements in the next several years. As stated previously in this article, relatively speaking we are just at the beginning of this adventure. The technological enhancements will make telecommunications more easily accessible to the full range of computer users thereby increasing substantially the numbers of telecommunicators. The advancements in understanding interpersonal communications using telecommunications can augment other forms of communication, and perhaps stimulate new ways of thinking -- locally and globally.

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COMPUTERS IN INTERACTIVE ENVIRONMENTAL MONITORING PROJECTS: BRIDGING TROUBLED WATERS

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In 1984 a biology class at Huron High School in Ann Arbor, Michigan, became concerned about the water quality of the river their school was named after. The students knew that the Ann Arbor Parks and Recreation Department leased a windsurfing concession at one of the city parks bordering their school. Several students in the class as well as other area residents who used the river for windsurfing, however, had contracted hepatitis in the past few months. The group realized that the water quality formed a potential health threat and their concerns fueled a two week investigation of the Huron River. With the cooperation of university resource people, the biology class tested the water for the nine parameters designated by the National Sanitation Foundation as indicators for water quality. The investigations revealed that after heavy rains the fecal coliform count reached levels high enough to categorize the water unsafe for body contact. The question quickly became, "is wind-surfing a body contact sport?" Their findings and opinions were sent to the County Health Department, the City Parks and Recreation Department, and all City Council members, were published in the school newspaper, and appeared in the "letters to the editor" section of the local newspaper. As a result, the concerned City Council funded the University of Michigan's School of Public Health to test the water quality of the Huron River at regular intervals. It was soon learned that approximately 70 businesses and homes in the city had sanitary waste lines that were illegally connected to storm water lines which drained directly into the river. Raw sewage would accumulate in these lines and flush into the river after a rainfall which posed a health hazard to people using the river for recreational purposes. These findings triggered the development of a formula that could help predict when the river should not be used for windsurfing. The high school students then collaborated on the design of a sign which was posted on the river bank to warn windsurfers that following a rain the river water exceeded state water quality standards for body contact sports. Later, the city decided not to renew the lease of the windsurfing concession.

The interest in this high school water quality monitoring project on the part of the teacher, the students and the collaborators from the University of Michigan led to the involvement of two other high schools in different communities along the Huron River.

The Huron River project caught the attention of "Friends of the Rouge," a non-profit community organization in the Detroit metropolitan area which arose out of the realization that the Rouge River in southeastern Michigan had been abused and neglected too long. This group recognized that a water quality monitoring project for high school students would be an effective way to raise youth's awareness and concern towards the river, and to draw media attention to the Rouge and its problems.

The Friends of the Rouge funded students and educators from the University of Michigan's School of Natural Resources to establish a pilot project involving sixteen schools distributed throughout the watershed. With the assistance of teachers from the pilot schools and Friends of the Rouge, the university team developed an Interactive Water Quality Monitoring program for schools that is now widely known in environmental education circles as the "Rouge River model." Currently over 140 schools in twelve midwestern watersheds participate in Interactive Water Quality monitoring projects. Similar projects have also been implemented in other United States' watersheds; the Grand watershed, Canada; the Ganges watershed, India; the Rhine and Neckar watersheds, West Germany; and the Murray-Downes watershed, Australia.

A key element in these projects is the ability to share data, ideas, and questions between students and teachers throughout the watershed. Such information must be transferred quickly as many teachers have limited time to devote to the project. To meet these needs, an interactive computer network was selected as the medium for information exchange.

This article describes the role of computers in an Interactive Water Quality Monitoring Program. Special emphasis will be put on the use of computers in exchanging information with other schools and linking students to a variety of resource people.

Computers in Environmental Field Study?

When devising an educational experience that takes students outdoors to explore their environment, one does not always consider the role of

computers. Indeed, the Water Quality Monitoring Program did not start with this element. As the program grew to include a larger number of schools, computers became a very effective means to enable students and teachers to communicate with each other. As new schools join the project, an electronic message followed by the exchange of the data that were gathered while in the field may be their first contact with other schools. Questions raised by participants from other schools about some of the findings may motivate a class to decide to go back to its monitoring site to do additional testing.

Computers also generate an excitement of their own and help justify the program to teachers and administrators who hope that their students become computer literate. Because the water quality monitoring program focuses on a real-world issue that has relevance to many students and teachers, computers become a useful tool to enhance the program rather than an end in themselves. Many teachers see this program as the marriage between the benefits of modern technology and the traditional strengths of field work in science education.

Uses of Computers in the Rouge Model

Independent Personal Computers

Students and teachers can use computers to manipulate the data they have collected on water quality. All of the tests generate raw scores that are transformed into Q-values that provide a measure of "quality." The Q-value of each test can be multiplied by a weighting factor which is a measure of the importance of a particular test in contributing to the overall Water Quality Index (WQI). Any of the data may be graphed to visually compare the current information to last year's data, or to upstream and downstream data (Figure 1). This use of computers requires only that the teacher or resource person be familiar with the graphing software or computational programs used at the school. It does not require any additional hardware.

Personal Computers in a Network

Students and teachers also use the computer to share information--data, questions, concerns, and experiences -- with each other via a *computer conference*. School computers are linked through a telecommunication network to one central "host" that acts as a clearing house for the storing and

forwarding of communications and results (see Wolf, 1988).

Since the networking component is the primary use of the computers in the Water Quality Monitoring programs, the remainder of this article will be devoted to describing the technical terms used in computer networking, the hardware and materials used, the type of information that is exchanged. Furthermore, the merits and shortcomings of using computers in this fashion and opportunities for expanding the program to an international level will be discussed. Finally suggestions will be provided for starting your own project of this sort.

Equipment and Communication Structure

All participating schools in the Rouge and similar projects have personal computers (usually Apple IIe's or Apple II+'s; sometimes Radio Shack's, Commodore 64's, IBMpcjr's or Macintosh computers). One computer per school is linked to the mainframe computer of the University of Michigan through a *modem* and an outside phone line. The modem is a computer communication accessory that is operated by communication software. The modem converts digital data signals from a computer into analog tones that can be sent over telephone lines. By programming the modem to dial a local phone number, the school's computer will first reach a commercial or public network (e.g., AUTONET, TYMNET, TELENET, INTERNET and MERIT) and then the University of Michigan mainframe computer (IBM 3090-400 supercomputer). Several hundred access nodes allow people from all over the state, country and the world to join the university computer via a phone call. It should be noted that as a general rule, the farther away a participant is located from Ann Arbor, the more expensive the "on-line" and connecting charges become. Therefore, participants should be capable of "up and down loading" information in order to decrease costs.

Each school in the project is given a Computing Center Identification Number and a password which allows access to the University of Michigan's mainframe (after paying a $50.00 annual users fee). This mainframe operates a program called Confer II from Advertel Communication Systems, Inc. which allows groups and individuals to hold discussions and exchange information through various conferences. Participants in a conference enter their comments and data using their own personal computer which is connected to the central computer. The central computer stores and organizes the

comments and data, then presents them to each participant as items upon request. This process makes it possible for many people separated by time and space to have an in-depth discussion and to compare data.

Confer II provides a structure for participants to interact with one another in a number of different ways while "in" a conference that is based on: messages, items and responses to items. The system monitors usage, notifies one of new information, keeps track of what one has already seen and keeps a permanent written record of the Conference proceedings. Some vocabulary is perhaps helpful:

Conferencing allows groups to communicate. Text is entered as an "item," stored and organized so that every participant can read and comment on the discussion. Comments on items are called "responses."

Electronic Mail is a private message from one person to another. Confer II allows for private mail within the Conference through a "message."

Bulletin Board messages allow participants to post announcements that will be seen by all participants when they sign on, but do not allow for responses or for interaction to take place. Confer II also allows for each "participant" to enter a short description of who they are and the things they are interested in.

The advantage of Confer II is that it allows for all three forms of communications: public items and responses, private messages, and bulletins. The advantage of running the program on a large mainframe computer is that literally hundreds of users can make use of the system at the same time and that a mainframe environment provides much built in support. Figure 2 shows some of the commonly used commands in a Confer II conference. Participants are given sheets with the most basic commands prior to the project and can make use of the "Help" or "?" command if they need suggestions on how to proceed while using the program.

Confer II at Work

Confer II as a Database

When the raw data have been collected from the river, the students enter their test results into the computer network. They then analyze and

interpret the data and make comparisons with the findings of the other schools. The computer conference has a standardized data entry facility that makes it easy for students to enter the data by simply typing the command "REPORT."

Confer II will print out of an item in a water quality monitoring conference designated for data entry. Each test has its own weighting factor which is multiplied by the Q value in order to get the fraction that contributes to the overall WQI. Data entry follows a standard procedure which can be called up by participants by typing the "REPORT" command at the "Do Next?" prompt. (Figure 3)

All schools sample their river on the same day which makes the comparison of data obtained from various sites more meaningful. The database enables students to identify specific problem areas in the river and makes it possible for students to look at a subset of data or parameters. Once the specific data have been identified, any graphing program can be used to illustrate certain trends and developments. (Figure 4)

If a certain part of the river shows an anomaly in its water quality, students may decide to revisit that site to do some extra sampling or to look for causes that may explain it. Discussions that students might have within their watershed, or with students in other watersheds are made possible through the interactive capability of Confer II.

Confer II as a Network

Confer II participants may create either a public *item* visible to everyone on the system, or a private *message* intended for a specific participant. When a participant reads an item, she is given the option of adding her own comments to the discussion. (Figure 5)

Items have descriptive headings that enable participants to search for relevant information and respondents to keep the discussion focused. A conference organizer monitors the discussions and may reorganize items, edit items, index items, and if necessary, censor inappropriate items. Confer II keeps a record of the number of items and responses in the conference as well as the time and date they were entered.

Not only are schools involved in the Rouge conference, people from environmental protection agencies, community groups, universities, environmental organizations, industry and others with an interest or stake

in water quality issues are encouraged to access the conference as well. This maximizes the greatest advantage of computer conferencing -- involving many participants with diverse backgrounds and areas of expertise in one interactive network of resources.

How Teachers and Students Get Started

Although Confer II is user-friendly, teachers and students in the water monitoring projects need to be instructed. In the Rouge project, university facilitators as well as some of the high school teachers assist in Confer II instruction. Most schools in the Rouge watershed have computers, but the majority of science and social studies teachers have not used them for communication purposes. In the weeks prior to the annual Rouge project new teachers are invited to attend a workshop on using Confer II in the classroom. Furthermore, computer instruction sessions are held during a one day "introduction to the Rouge river project" workshop. At this particular workshop teachers from the participating schools and some of their students spend most of a Saturday becoming familiar with the nine tests, the use of benthic organisms as indicators of water quality, and computer conferencing. Simulation disks with a guided tour to Confer II are available for all participants to use.

Once the project starts in the classroom, the trained students usually help teach others the essentials of the water monitoring program, including using Confer II. Often linking the computer to an outside phone line by a modem (schools who do not have one are given one by the project) and dialing into the mainframe poses some technical problems that are school specific. University resource people are available to solve these and similar problems that arise in computer networking. Projects in other watersheds using the Confer II program all make some use of University of Michigan resource people (although not as much as most schools in the Rouge project).

The Rouge project presents only one way of using computers in an interactive network. Figure 6 gives some general suggestions for starting your own interactive environmental monitoring project.

If you are interested in finding out about the Interactive Water Monitoring network that uses the Confer II system, you should contact the Global Rivers Environmental Education Network (GREEN), School of Natural Resources,

University of Michigan, Ann Arbor, Michigan 48109-1115.

Advantages and Disadvantages to a Computer Network

Advantages:

* For many students using computers to communicate with people separated by time and space generates excitement. Since time and space are condensed, the interactions, regardless of geographical distance, have a low turn-around time.

* When a computer conference is properly used, there can eventually be rich discussions about a variety of water quality issues organized by the item headers. Students, through their investigations, discussions, and reflections come to recognize environmental challenges, and through the computer network have an opportunity to pose questions to a great number of people with different backgrounds and expertise. They also have an opportunity to respond to questions raised by other participants. The discussions can be printed so that everybody in the class can read them and use them as background information in environmental problem-solving.

* Since Confer II maintains a written chronological record of the discussions, new participants have a chance to go back in time and follow a discussion right from its beginning before adding their own thoughts.

* Computer conferences do not put people on the spot as in face to face discussions. Participants can take the time to look into a particular issue before responding.

* Since all participants enter a conference more or less anonymously, divisions based on class and/or race are minimized when discussing an issue of common concern through the impersonal computer screen. When the participants become aware that students and teachers in other parts of their watershed as well as elsewhere are doing similar investigations, a sense of community can be obtained. If combined with opportunities to meet students from other schools face-to-face, computer conferencing can be a powerful device to tackle prejudices and alter community perceptions.

* Teachers and even entire school districts can use computer conferences for announcing meetings, in-service training workshops, discussing problems that arise in the every day practice of schooling and the implementation of innovative approaches to education (for examples see Bull et al., 1988; Robottom, 1989).

* Computer networking also provides a rarely explored opportunity for helping in evaluating environmental education projects. Researchers,

be they teachers or outsiders, can use hard copies of discussion items and student responses in determining whether environmental perceptions, depth of discussion, level of understanding, and level of participation, for example, change during the course of the project.

Disadvantages:

* Although Confer II is user friendly there is much to learn before it becomes a useful communication and evaluation tool. One must first overcome any barrier regarding the use of computers, and then learn how to utilize the conference component. Students and teachers will have to learn how to use the modem software and how to enter a conference. This in itself is not difficult to teach when a student can sit down with an instructor and a sheet of paper that lists all the steps that are required and then has the opportunity to practice.

* Network access is a common problem with only one computer and modem available to over twenty students. Since it is impossible for the whole class to operate the interactive computer, printed copies of an item can help involve each student. Students can then prepare their responses on disk in a computer lab using a word processing program. The information on the disks can then be "up loaded" into the conference. This not only reduces "on line charges," it also gives the students time to think about their responses to questions raised in the conference. Ideally the teacher would create a rotation schedule that assures that every student has a chance to use the computer to assure that not just a few students become computer literate.

* Classrooms have not been designed for computer conferencing. It is difficult for some schools to designate an outside phone line for a computer, unless the modem hook up is in the principal's office, or a quiet corner of the library -- neither of which are ideal locations for classroom interaction on the network. Some schools have been innovative in resolving this problem by converting a closet in the lab into a computer work station. The phone company is then asked to install a new outside phone line.

* For some teachers working with computers generates anxiety. It should be emphasized that computer conferencing is only a tool that can be used in interactive environmental education projects and that the success of an environmental education project should not depend solely on the use of computers. The grass roots development at the school level of an environmental monitoring project under the guidance of committed teachers and motivated students that have the support of the school administration, the community and possibly some outsiders are far more crucial to the success of a project than the availability of a computer network.

Future Developments

The number of watershed computer conferences at the University of Michigan mainframe computer will continue to grow in the coming years. The international dimension of networking on water quality issues will be broadened through a new initiative called "GREEN" which is the latest product of the Rouge Model. The acronym stands for the Global Rivers Environmental Education Network. This network will provide teachers and students from around the world with the opportunities to reflect on the ways that land and water usage, cultural perception, and social structures influence their river system. Participants in GREEN are connected by the global nature of the water cycle, by the rivers that flow through their communities and across state and national borders, and by their common concern with water quality and its impact on the quality of their lives. By providing students and teachers with the opportunity to exchange their knowledge, ideas and experiences, the network will enable them to discuss the commonalties and differences between their communities and watersheds. Through networking participants may come to discover the local manifestation of global problems.

Besides organizing workshops on water quality monitoring and publishing a GREEN newsletter, the network will start a pilot computer conference for schools from around the world in the Spring of 1990. Participants from the various watershed conferences will be able to tap into an international conference under the code name "ICS:GREEN."

Conclusion

Computer networking is a tool that can help in making interactive environmental monitoring projects a success, but is by no means a goal in itself. The most crucial step is to develop a sustainable environmental monitoring project within and with the school community. Ultimately, this community should see the curricular relevance of such a project for students in order for it to be successful. Without some ownership of the program by teachers, students, parents and administrators, an interactive environmental monitoring project may come to rely on outsiders.

With this in mind, we feel that the Rouge Model provides a good example of how computers can be integrated into environmental monitoring projects

for secondary schools. In addition to a powerful tool in facilitating data interpretation, computers can become the core of an interactive network when connected by a telecommunications network to the Confer II program.

Computer networking can play a key role in facilitating the interaction between environmental monitoring projects separated by time and space, but bound by a common concern about the quality of the environment. In a rapidly changing world confronted with environmental problems that transcend national boundaries, computers seem an appropriate technology that can help interest young people in studying and improving their local environment.

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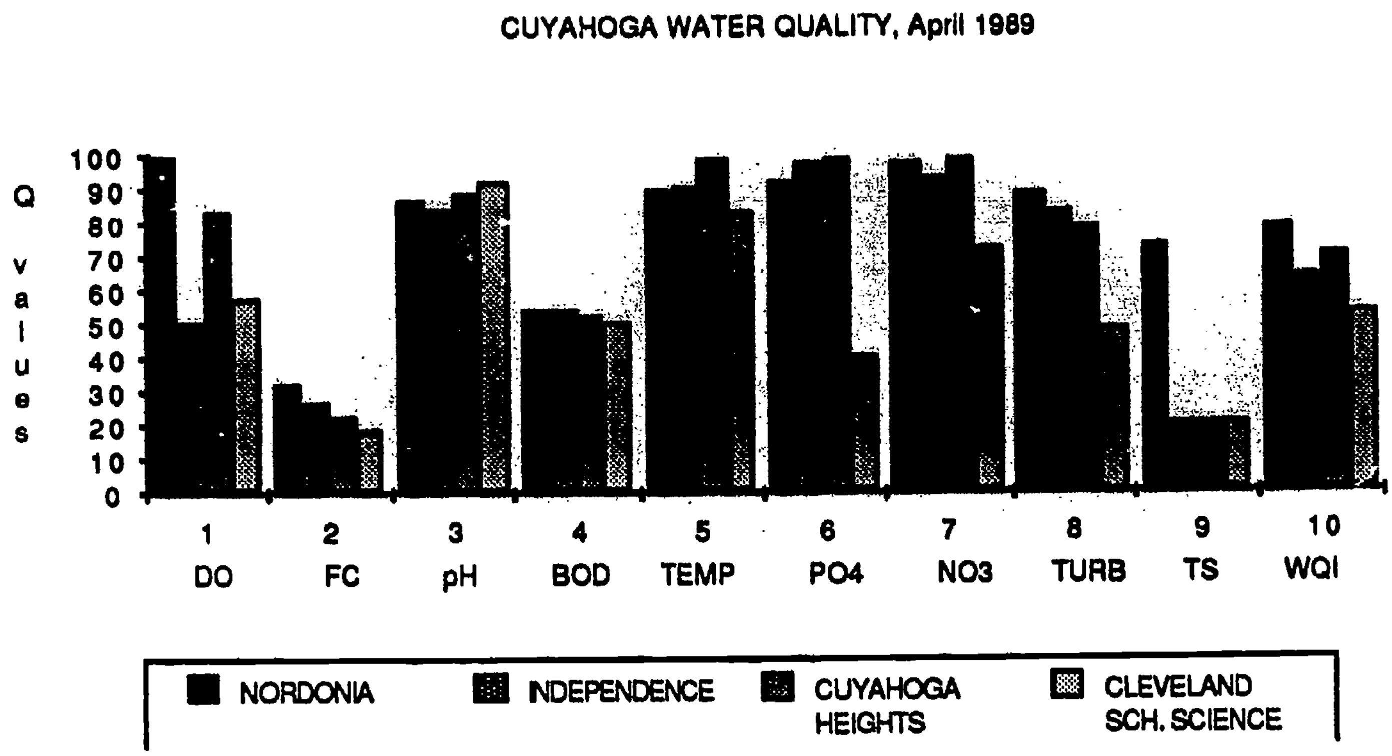


Figure 1 The Use of Computer Generated Graphs in Determining River Water Quality. (Schools are arranged upstream to downstream.)

1) Enter a question-mark ("?") whenever you want to know what options are available, or if you don't understand what's wanted.
2) Use the <BREAK> key whenever you don't want to see any remaining output; <control-e> is the "break" key for most terminals.
3) Use just <RETURN> at the start of a new line to terminate the entry of text, or to indicate "non-response" in order to go on.
4) The most common commands are:

"NEW" to view the new messages, responses, and items.
"ITEM nn" to view a specific item, where "nn" is a number.
"DES nn-nn" to see three-line descriptors of a range of items.
"MESSAGE" to read messages which have been sent to you.
"TRANSMIT" to send a message to another participant.
"ENTER" to insert an item for everyone to read.
"PARTICIPANT" to show a list of participants in this Conference.
"REPORT" to access the standardized data entry procedure for reporting test results
"BULLETIN" to post an announcement for all participants
"FIND w" to search for a specific word in the conference items, where "w" is a word
"QUIT" to exit Confer II and automatically signoff.

Figure 2 Some Basic Confer II Commands

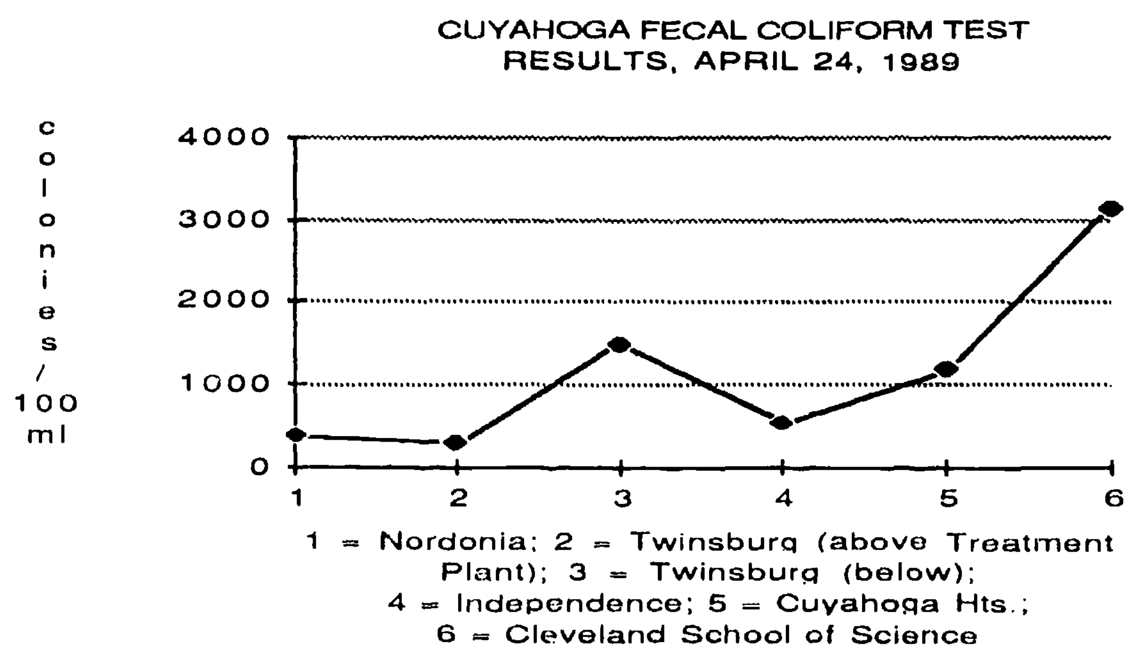
Item 2 12:06 Oct. 12/89 13 lines 1 response Mark Mitchell
Water Quality Monitoring data from specific schools around the world

This item will be used to collect the data from your school's tests. Please do not respond to this item itself, but start another item if you have questions that need to be answered or data that needs to be clarified. When reporting data. Confer II will automatically attach it to this item.

24 responses
May 9/88 13:34
2:1) Melvindale High School Weather: Cool and overcast
Location: Melvindale Ice Arena Time: 9:00AM

		Q-Value
1. Dissolved Oxygen:	92 % Sat	94.5
2. Fecal Coliform:	8500 colonies/100 ml	11
3. pH:	8 units	85
4. B.O.D.:	5 p.p.m.	56
5. Temperature:	-2 C change	90
6. Total Phosphorous:	0.16 mg/l	97
7. Nitrates:	0.54 mg/l	98
8. Turbidity:	5.5 feet	86
9. Total Solids:	83.4 mg/l	20
	Water Quality Index:	73.7

Figure 3 Sample Report



Fecal Coliform test results from the Cuyahoga River Study project in Ohio. Six high schools participated in this "Rouge based" model. Students from Twinsburg high school tested below and above the water treatment plant in their community and discovered for themselves that the plant violated EPA regulations. They publicized their findings and found out that the plant had already been cited by the EPA.

Figure 4 Sample Graph Item 154 20:42 May14/88 5 lines 2 responses

St Josephs College, Australia
High Total Solids readings.

In some tests we carried out the other day, we obtained values for Total Solids of 1960 mg/L and 1700 mg/L. These are considerably higher than those obtained in other parts of the world. Has any other school had values this high?

All the best from Geelong, Australia.

2 responses
May18/88 09:14
154:1) Randy Raymond, Detroit Country Day School, Michigan:
The readings that you obtained for total solids indicate that your river must have a great deal of sediment moving in the system. What is the turbidity of the water like? Do you have a great deal of erosion into the system? Has there been a recent rain or series of storms that could have effected the results of your testing? Generally, the tests that have been conducted in the Rouge River watershed have been done during periods when not much rain had occurred. However, I am certain that if samples were taken after a series of storms or a single large rain that we would find much higher results for total solids in our samples as well.

\- - - - -

May26/88 20:40
154:2) Lorne (Australia.):
From Lorne: we have values as high as 700 ppm. for our major water supply dam. We also tested the Yarra River on an excursion and found it to have a Total Solids reading of 4500 ppm! High values seem to be normal for this part of the world. Does anybody know what the reasons for this are? LORNE SCHOOL.

Figure 5 Confer II discussion about High Total Solids readings

Presuming you are interested in developing a network of schools and perhaps resource people to discuss an environmental concern, how might you get started?

1. Find a computer network. Ask a local university computer center or education department if they might support your project. Call any education or school support people (state or province, intermediate district, etc.) to see if similar projects already exist or what networks might be available. Computer sales people in your own town might be helpful as well. Some networks charge a fee to join. If this is the most desirable direction for you to take, you may wish to consider writing a grant proposal to fund the project for the first several years. An excellent overview of computer networks and conferencing systems worldwide can be found in "The Matrix" by John Quarterman (Quarterman, 1989).

2. Get the necessary hardware. Every school or resource person that you wish to involve will need a computer, modem, and phone line (ideally a line designated for computer networking). If they do not already have this equipment, you may need financial resources or a commitment to purchase these items before your network is operational. Obtain the needed software to operate the modem.

3. Develop the format for data collection (acid rain, land use surveys, Radon, weather, etc.) and the necessary materials or equipment for other schools and students to use.

4. Train the users--teachers, students, and resource people--in the collection of the data and the use of the computer. This may require several sessions and a facilitator on-site before everyone uses the system in comfort.

5. Designate and train a Conference Organizer to monitor, edit, index, and organize the information on the Conference. The people who help you with access to a network may have ideas on how to do this.

Figure 6 Steps To Take To Start a Similar Project

COMPUTER MEDIATED TELECOMMUNICATIONS AND ENVIRONMENTAL EDUCATION: LESSONS LEARNED

Mark R. O'Shea
Fairleigh Dickinson University

Howard Kimmel
New Jersey Institute of Technology

Extending Beyond the Limitations of the Classroom

Classroom walls are the single greatest barrier to successful environmental education at the elementary and secondary school levels. Only rarely do schools have environmental centers or natural habitat settings, and most of these facilities are under utilized. Typically, students study environmental science from textbooks and periodicals. Some class time may be allocated to visual aids about nature, but these resources are all substitutes for direct engagement of the student with the natural environment itself. On those occasions when students do have contact with nature they take the form of infrequent, sporadic field trips without meaningful continuity with classroom learning. Unless schools are restructured so that class scheduling and administrative functioning become secondary considerations, which at this point is unlikely, students will continue to be deprived of sufficient opportunities to investigate the environment through the application of scientific inquiry. In the meantime, those of us who wish to improve environmental education for the present generation of elementary and secondary school students will have to consider attainable alternatives to regularly scheduled investigations in natural settings.

Computer mediated telecommunications (CMT) is a recent technological advance that holds the promise of maximizing the instructional value of the infrequent occasions when students do come into direct contact with the environment. While the frequency and duration of forays into natural settings cannot be enhanced through this new technology, the value of these exercises for students can be extended beyond the classroom to the entire global community of students who are concerned with environmental issues. Specifically, electronic mail and electronic conferencing have achieved a level of facility that permits the

teacher and the student to include students of other schools and other nations in their investigations. The variety of CMT projects attempted so far suggests a need to review the progress made to date with the goal of suggesting some approaches that are shared by the more successful efforts. Before these projects can be considered more closely, an overview of relevant telecommunications utilities, electronic mail and electronic conferencing is in order.

Computer Mediated Telecommunications

The advent of microcomputers in the early 1980's led to quick acceptance of these machines by the business world, but elementary and secondary educators remained skeptical about their value in educational settings. Early efforts to produce computer aided instruction (CAI) software met with limited success. Teachers sensed a growing pressure from parent groups and administrators to use computers in instruction, but they failed to see why computers offered anything more efficient in the learning process than traditional print resources. This negative reception was mollified when a second generation of computers arrived in the schools.

By the middle of the 1980's, more powerful machines capable of operating applications software programs were marketed for school consumption. At the same time, consumer models of applications software such as "Appleworks" and "Bank Street Writer" became available to schools and many teachers began to realize that the microcomputer could be a valuable aid in the performance of traditional academic work, rather than just another curriculum item to be studied in its own right (O'Shea, Kimmel and Novemsky 1990).

The availability of spread sheet programs reinforced this more positive perception. Today, the use of applications software, more so than CAI, is justifying an inherent applicability of microcomputers to the learning process for more and more teachers. Word processing programs are now used as aids for the development of language arts skills. Spread sheet programs are lending themselves to the development of high quality math application exercises. Student group interaction during language arts and computation exercises is a logical next step for the school-level use of microcomputers. Telecommunications activities that link computers and students over large distances allow for collaboration and peer assistance

with these kinds of academic activities.

While students within the same classroom have been able to share the products of their microcomputing efforts through local area networks (LAN's), electronic mail has permitted students and teachers to share written work and computations with peers having similar computing resources anywhere else in the world. These resources are, minimally, a microcomputer, a modem, communications software, and access to a telephone line. On any occasion convenient to the teacher, a message can be typed at the keyboard of almost any microcomputer and sent through normal telephone lines to a larger computer at a host facility where the message will be "sorted" and held in computer memory for the recipient. At a later time the recipient of the message may turn on a microcomputer and communicate with the larger computer to see if there are any messages to be received. The larger computer, programmed for this kind of telecommunication, will inform the recipient that a message is in its memory and is ready to be received. The recipient can choose to accept the message or wait for a more convenient time. Typically, the larger computer is programmed to inform the sender if the message has been actually accepted by the recipient.

Electronic mail is not as intrusive as the telephone. The recipient does not have to be available to receive the message at the same time it is sent. This advantage is referred to as asynchronous communication. Telephone answering machines can be thought of as peripheral devices to telephone systems that also allow for asynchronous communication. Unfortunately, asynchronous communication by microcomputer has its drawbacks. Chief among them is the need for the recipient to check for electronic mail, for the microcomputer does not "ring" as a telephone does.

The advantage of asynchronous communication, the ability to receive a message when it is convenient to the recipient, is of particular importance to classroom teachers. Office workers are generally available to answer either the telephone or electronic mail whenever they please. Typically, a telephone is quite nearby in the normal office workplace. This is not so for teachers. Telephone calls to teachers usually reach the school principal's secretary who may be reluctant to take numerous messages while a teacher is in class. If a message is taken and put in the teacher's mail slot, there is no guarantee that the message will be accurate. Moreover, it is likely that the teacher will not get the message until the end of the school day and

perhaps as late as the next morning when the teacher checks in at the front office. A microcomputer in the teacher's classroom or department office that is connected to electronic mail overcomes these difficulties inherent in the rigid structure of the school day.

Electronic conferencing may be viewed as an enhancement to electronic mail. This facility permits individuals interested in a particular topic (or a group of people planning an activity) to communicate with one or more members of the group. Each member can send contributions to a chronologically ordered collection of messages and notices that all relate to a given topic or task. As an example, the New Jersey Science Supervisors Association, a group of curriculum specialists and science department chairs, operates an electronic conference on the Electronic Information and Exchange System (EIES) of the New Jersey Institute of Technology. They send their contributions and notices to a continuously recorded set of proceedings where such topics as the right-to-know-law, legislated mandates in the science curriculum, and text book evaluations can be reviewed by the membership of the organization. Science supervisors and department chairs who are interested in these topics need only subscribe to the telecommunications system that hosts this conference. While electronic mail facilitates communication between individuals and overcomes teacher isolation during the workday, electronic conferencing offers people with common interests or shared tasks the opportunity to work together even if they are clustered in groups that are separated by large distances. In effect, the electronic conference serves the same function as a symposium or professional meeting; individuals wanting to learn more about a topic or share their ideas with others "meet" to discuss their common interests. Moreover, a proceedings of an electronic conference are recorded continuously so that new participants can update themselves as they join the discussions. With electronic conferencing, individuals do not actually have to meet face-to-face in order to receive information or present their own ideas. They need only read incoming information on a computer screen or enter their own ideas at the computer keyboard. It is even possible for a teacher to print out a contribution from another conference member or save it on a computer disk for consideration at another time. Electronic mail and electronic conferencing now provide the opportunity for teachers and students to overcome the isolation inherent within schools due to scheduling and administrative concerns.

These utilities permit geographically dispersed students and teachers to communicate with each other as they perform shared tasks, present ideas to each other, request information from one another, and conduct experiments jointly.

Using Telecommunications to Further Environmental Studies

Many early efforts to use CMT in elementary and secondary school settings focused on environmental studies. While systematic evaluations of these activities were rarely undertaken, informal assessment and anecdotal records have begun to identify some general problems shared by the majority of these pioneering projects as well as some promising directions for future activity. As a few of these projects are reviewed, certain commonalties become evident. For the most part, colleges, universities, and foundations have provided the technical expertise and organizational support in bringing CMT to elementary and secondary school classrooms. Moreover, institutions of higher education get CMT projects under way by successfully applying for federal, state and foundation grant money to pay for long distance telephone calls, telephone line installation, and the purchase of modems and software incurred by schools that join the project.

An example of this kind of project is Western Carolina University's MicroNet project begun in 1981 with support from the North Carolina Department of Public Instruction (Perry 1984). The W.C.U. Micronet was installed as an electronic mail and computer conferencing system on a VAX 11/780 minicomputer. The electronic conferencing feature led to the establishment of dedicated "forums" for teacher support and interaction.

One forum was designed for what has become the most frequently undertaken CMT environmental project: acid rain data collection. In this particular effort students and teachers in different schools obtained stream and precipitation pH data near their school site. Usually, a small excursion could be made from the classroom to a nearby stream where data could be taken. The MicroNet forum permitted all participants to pool their data by entering findings in the forum for use by everyone. This allowed for site comparisons. Questions concerning changes in pH at different sites on the same stream could be explored as well as comparing data from different streams. While this activity was underway in one forum, another forum centered around comparative ecological studies undertaken by schools in

the various geographical and ecological environments that characterize North Carolina: coastline, tidewater region, piedmont and the Appalachian range. The evident diversity of flora and fauna in these regions of North Carolina provides an enormous source of data for students to reflect on how very different the environment can be from one part of the state to another. W.C.U. MicroNet is still active, having sustained itself beyond the early funding development period.

Conversations with MicroNet staff suggest that a number of problems had to be overcome to get the project going and sustainable. When these projects are started, a cohort of teachers is typically provided with training in how to use the system. Most people need a lot of support and practice with CMT before they feel confident enough to log on to a system and provide written contributions to the medium. One or two university experts with patience and caring can easily guide a group of fifteen or twenty new users on to a system. Problems develop after a project is underway and new participants are added. At these times individual tutoring and support are needed by the new participants. Visits by one or two teachers to a university for training represent a high cost of labor on the part of the teacher and the project trainers. The continual addition of one or two people to these projects over time can be a burden only supported with the help of outside funding. Most schools cannot afford the actual start-up and training costs of a CMT system when only one or two teachers choose to join an existing project. To save costs, CMT project coordinators need to gather cohorts of new participants for joint training to keep costs reasonable. Unfortunately, these administrative and organizational tasks also cost money. In most CMT project, the money needed is available through grant support. Problems develop as new participants express interest in joining after the initial funding is reduced or stops altogether.

Probably the best known CMT projects have been operated by TERC, the Technical Education Research Centers, Inc. With assistance from the National Geographic Society, TERC has developed curriculum units that go beyond acid rain data collection to include radon data collection and joint studies of weather phenomena. TERC has enjoyed the participation of more than 1,000 teachers in 43 states during these projects, and has even helped schools establish linkages with students in schools in the Soviet Union. Even with its considerable support from external funding, TERC's

projects have experienced problems as well (West 1990), and they seem to be similar to difficulties experienced by the W.C.U. MicroNet staff. Some teachers who have expressed enthusiasm and a willingness to have their students participate in TERC projects just can't seem to gain access to a telephone line. Moreover, the seemingly easy task of obtaining and installing a modem at a slight cost of approximately $100 to $150 becomes a frustrating experience when the teacher confronts the typical school district budgeting process. If the building principal or department chair has not anticipated the expense fully one year in advance, then the money for telephone line installation and modem purchase has to be borrowed from some other appropriation. Public school budget reviews are typically undertaken at various levels, starting at the principal's office and going through the superintendent's office to the Board of Education. Along the way, it is easy for an empowered individual to simply conclude that CMT projects are exotic undertakings only tangentially related to the local curriculum. The interested teacher rarely has an opportunity to explain or defend her request which therefore is denied. University or college personnel generally lack the time or the inclination to visit school administrators in order to explain the merit of a CMT project. Principals may balk at providing an interested teacher with a telephone line and modem fearing that every other teacher in the building will soon be requesting and expecting similar considerations. In the meantime, projects like those undertaken by TERC and the W.C.U. MicroNet must rely on the participation of those teachers who somehow manage to overcome local resistance to the procurement of equipment and services needed to log on a system. When grant money is available for initial start-up costs, few problems are experienced by persistent teachers who have university staff with financial resources backing them up. Problems often emerge at a later time when the funding ceases and the monthly cost of the telephone line and access charges to the CMT system must be picked up by the local district. At these times, some teachers are lost from the project as the school district or building principal fails to recognize the merits of a teacher's involvement in a telecommunications activity.

An Effort to Integrate Traditional Methods with CMT

In September of 1984, Howard Kimmel, Elaine Kerr, and Lisa

Novemsky of the New Jersey Institute of Technology and Mark O'Shea of Fairleigh Dickinson University embarked on a CMT project with the intention of bringing a new middle school science curriculum into the hands of 20 middle school and junior high school science teachers. In the first two years of our project we focused on installing general hands-on investigative activities in selected schools. These activities were developed by science museums under the direction of the American Association for the Advancement of Science. Known as Science Resources for Schools, these activities were generally well received by students and teachers alike. A persisting problem that developed with the installation project stemmed from local curriculum control. In New Jersey, local school districts determine the scope and sequence of the science curriculum. It is therefore quite difficult to present a group of teachers from ten or more districts with curriculum materials that middle school and junior high school teachers typically teach general science, earth science, life science or physical science. While working with our mixed group of middle school/junior high school teachers, we realized that a cross disciplinary approach would be needed in order to make our investigative activities meaningful for all participants. With this new understanding in mind, we changed our focus to environmental education. We knew our problem of mutual interest had been solved when we dedicated our third year of activity to New Jersey's marine and coastal environmental problems. That theme provided each teacher with the opportunity to relate marine and coastal problems to facts and principles of each of the disciplines taught during the middle school years.

Curriculum relevance was only one of the problems we attempted to solve as we moved our attention from general science education improvement to environmental education. Our informal assessment of the first two years of activity identified problems that we shared with our counterparts at Harvard's Educational Technology Center (Katz, McSwiney and Stroud, 1987), and the W.C.U. MicroNet: our teachers had the same difficult time procuring equipment and services for participating in an electronic mail and electronic conferencing project. Additionally, we noted that many participants were willing to simply read contributions of others rather than share in the burden of typing something new into the conference (or forum) each time they logged on. In effect, we had one or two "silent partners" out there for each contributing participant. Project

directors at Harvard's Educational Technology Center had noticed this phenomenon when they linked several science teachers together from across Massachusetts.

A serious problem arises when a significant proportion of project participants fail to contribute items to a conference or forum. If few new entries appear in a conference over an extended period of time, or if new members don't find messages for them when they log on, they soon become discouraged and stop logging on altogether. In response to these early observations we developed a four part model for improving science curriculum, in our case environmental science, through the incorporation of traditional communication modalities and CMT.

Since the Fall of 1986, our middle school/junior high school teachers, the project staff, and faculty have conducted curriculum development workshops in environmental studies every sixth Saturday morning during the academic year. We find these face-to-face meetings invaluable for stimulating continuing activity on EIES, the CMT utility we have been using at the New Jersey Institute of Technology. These saturday sessions have become the centerpiece of our projects and the most important component of our model. At these meetings the teachers, not the staff, determine the direction of each year's curriculum project in environmental education. Typically, we use these sessions to help newcomers learn the techniques of logging on the system, sending and receiving electronic mail, and participating in an electronic conference. Because we meet at regular intervals, it is easy for new participants to "get on board," check in on the continuously developing proceedings in our electronic conference, and get support and training in the use of CMT. Those of us who are familiar with electronic conferencing and electronic mail participate in discussions where the teachers determine the kinds of investigations that will be conducted by students through the course of the academic year. The first two sessions of each academic year are generally dedicated to the selection of an environmental theme around which we develop curriculum materials. Our efforts in curriculum development are guided by the premise that effective environmental education is student centered, hands-on, and investigative in nature. We therefore spend a lot of our time exploring activities that engage students directly. After the central theme of the year has been clarified, we begin discussions concerning the fourth component of our four part model, the spring symposium. Moreover, the meetings

provide the teachers with the opportunity to renew their acquaintance in a way that only face-to-face meetings can offer. At the same time, we provide the teachers with a laboratory setting where they can try out hands-on investigative activities for later use in their own classrooms. Finally, these meetings are also used to establish the agenda and deadlines leading to important events of the academic year.

The second feature of our four part model for applying CMT to the improvement of environmental education is visits by faculty and staff of the college or university to schools of participants during the school year. This feature was adopted in order to address the issue of school resistance to the procurement of telecommunication services and equipment needed by teachers. During these visits, a number of activities take place. First and foremost is a visit to the principal's office to inform the school administration of the personal sacrifice and professional commitment made by the participant in attending our Saturday sessions without compensation of any kind. Moreover, we can provide school administrators with testimonials and persuasive arguments in support of the teacher's effort to obtain access to a telephone line, a modem, a computer, and software. Secondly, a visit to the classroom helps students develop a more concrete awareness of their teacher's involvement in the project. If telecommunications equipment is already in place in the classroom, university visitors can provide students and the teacher with instruction in logging on to EIES using the equipment and software available in the classroom. This function of the school site visits is typically the most lasting and valuable one from the perspective of the teacher.

When we provide telecommunications training to our project participants at one of our Saturday sessions at the University, the equipment, software, and system access procedures are somewhat different. When the teacher tries to log on the system back at their school using the school's equipment and software, they usually encounter stumbling blocks. It is at these times that we like to schedule a visit to the school in order to minimize early frustrations that can lead to disenchantment with our CMT projects.

The third function of our visits has been added only recently. We have recognized for some time that our teachers sustain their professional relationships within the group largely because of the Saturday morning workshops. Their students, on the other hand, do not have opportunities

to meet or see their peers in other schools. Therefore, we have begun the practice of making a "hello" videotape production with a camcorder. The visiting University faculty or staff member begins with a video segment where several students and the teacher of the school are waving "hello" outside of their building. Then, back in the classroom, the students introduce themselves individually and may illustrate some device, demonstration, or display related to the environmental theme of the year. Finally, a short segment may be made of a student operating the locally available CMT equipment. An entire school episode probably does not exceed four or five minutes. After a number of schools have been visited and recorded segments have been placed in sequence on videotape, copies are made for each of the participating schools so that they can see their own segment and those of other teachers and students they will be communicating with during the course of the academic year.

The third element of our model is the use of EIES, our CMT system, to keep the teachers connected between workshops and making progress toward the accomplishment of annual goals related to the theme selected for the year. Because EIES has both electronic mail and electronic conferencing features, teacher and student work on the system has flourished because students see each other via videotape segments and teachers communicate with each other at face-to-face meetings every sixth week. During the 1989-1990 academic year, the following kinds of entries were placed into the system through either electronic mail messages from teacher-to-teacher or student-to-student and through conference contributions:

* acid rain deposition data obtained and recorded on EIES for use by students at a number of schools;

* lesson plans that elicit student understanding of the difficulties inherent in solving environmental degradation studies;

* language arts exercises that have taken various forms including essays, poetry and journal keeping. These contributions by students that are shared over the system provide each class with the impetus to develop a positive affect toward the environment;

* information about textbooks, pamphlets, and other commercially available curriculum materials dealing with environmental issues;

* reviews of curriculum materials and activities conducted at the workshops

after they have been tried in the classroom with students;

* messages and reminders about upcoming events planned by the group as well as environmental education opportunities occurring in the New Jersey area of interest to all our teachers and students.

Probably the most important function of our EIES communications is to keep momentum going and to sustain relationships between the Saturday workshops. We have found that CMT in environmental education is effective and sustainable over a considerable period of time when it is used as a support for traditional means of communication related to shared goals and aspirations. We have several teachers in our CMT project who have contributed to the conference as a matter of habit and who have attended the workshop sessions regularly since 1984 with no salary, stipend, or academic credit. They state that they continue to be involved with the project because it makes their teaching so much more meaningful.

The last component of our four part model is the student symposium presented at the University in April or May of the academic year. This last component has been developed over the last two years and has stimulated activity in each of the other three parts of the model. At the symposium, students are expected to present a demonstration, investigation, or creative exercise related to the theme of the year. For 1989-1990, the theme was using technology to solve environmental problems. Students were called upon to prepare mechanical, chemical, or biological displays or devices that show the application of scientific principles or theory to the solution of an environmental problem. Typically, students constructed "Rube Goldberg" machines that were metaphors for environmental degradation of some kind. Other students demonstrated a technology that held promise for solving an environmental problem in an area such as source reduction or oil spill clean up.

During the symposium two kinds of activities were undertaken. In the first half of the morning activities groups of students (such as an entire class) would make a presentation of an investigation they had conducted during the academic year. These presentations were made at a plenary session of all participants for approximately twenty minutes each. Following the plenary session, small groups of students who had worked on projects displayed their efforts in an arena format while small groups of students made rounds visiting each station to interview presenters about their

projects. As time passed, interviewers became presenters of their own projects and students who had presented earlier then conducted interviews. Our teachers had prepared interview questions for their own students that would elicit a relationship between plenary sessions, student projects, and traditional curriculum work done back in the classroom. This was all followed by lunch and bus rides back to the school.

Our four part model for improving environmental education through the application of CMT rests on the premise that CMT in its own right does not supply sufficient numbers of teachers and students with the reinforcement necessary to keep them communicating. When computer conferencing and electronic mail are used to support traditional forms of communication like workshops and student symposia, then teachers and students persist in using this new medium of communication. Apparently, computer mediated telecommunications is much like computers themselves: they just don't provide much interest for most people when they are considered as an object of study in their own right. When these devices and utilities support traditional academic undertakings and make communication for academic purposes easier, then they are used frequently and enthusiastically. Successful school projects that use CMT all seem to have a curriculum goal or educational purpose that would probably be successful even if the telecommunications utilities were not available. Electronic conferencing and electronic mail become stimulating media for teachers as they are used to achieve academic goals that are by themselves perceived to be exciting and useful by teachers.

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TECHNOLOGY AND ENVIRONMENTAL EDUCATION: COLLECTING DATA LOCALLY--SHARING DATA GLOBALLY

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Many educators are skeptical of the appropriateness of technology in educational settings. Some fear that the computer encourages mindless activity in isolated learning environments; others debate the suitability of the available software. Often those who work with students in outdoor settings remain distant from these debates, assuming that technology has no relevance to their work. However, recent projects challenge these assumptions and suggest that outdoor explorations can be enhanced significantly by the addition of technology. While technology is certainly not essential to the educational enterprise, it can offer low cost, high quality instruments that can enhance students' ability to collect accurate, reliable data, to analyze the collected data, to explore models of ecological systems, and even to communicate with other scientists. The purpose of this paper is to suggest a new way to view the role of computers in environmental education--as a means for extending students' understanding and interests from their local surroundings to an expanded global awareness through telecommunications.

In recent years, an increasing number of curricula and educational products have provided opportunities for students and teachers to communicate with others in distant places. By connecting classroom computers to a modem and phone line students and teachers can make use of up-to-date scientific information stored in distant locations or exchange ideas and data with their peers around the world. Various projects, currently underway, demonstrate how this technology can be used in the classroom.

My colleagues and I at the Technical Education Research Centers are particularly interested in examining the various ways that human communication using computer networks enhances scientific studies. In 1986 we began our investigation into telecommunications curricula with the National Geographic Kids Network, a elementary grades science project funded by the National Science Foundation, National Geographic Society, and Apple Computers, Inc. The NGS Kids Network represents a partnership

between Technical Education Research Centers (TERC) and the National Geographic Society (NGS). TERC develops the curriculum and software for the project; NGS publishes and distributes the final product.

In 1987 we began the TERC Star Schools project, a high school level program funded by the Department of Education. While these projects both use computer networks to further classroom work, they differ in the extent to which the activities rely on these exchanges. The NGS Kids Network, is a telecommunications-dependent curriculum. Its curriculum activities require specific communications at specified times on a predetermined schedule. TERC Star Schools is a telecommunications-supported curriculum with classroom activities enhanced by but not requiring telecommunications. Both projects, however, are based on similar premises: that students of all ages and abilities can and should BE scientists, that they can and should converse with others about their work, and that computers can enhance this enterprise. Students involved with these curricula conduct experiments, analyze data, and share their results with other student colleagues using a simple computer-based telecommunications network. This collection and making sense of data gives these students an opportunity to experience the excitement of science that scientists feel.

In this paper I will focus primarily on the NGS Kids Network curricula as an example of the ways in which this use of technology enhances the work of environmental educators. Each unit provides students with a six-week investigation of an environmentally-oriented topic, such as acid rain, water quality, or weather. Students begin their study by examining the topic in the context of their local community and then explore it within the larger national picture. Each unit involves the collection of some type of data (survey or measurement), sharing those data through a telecommunications network with other classes collecting the same data, and finally making sense of those data. These data are examined by both student colleagues and a unit scientist, a professional with expertise in the unit topic.

The computer gives students a number of tools to help with the data collection and analysis: a word processor, a record-keeping data section, a graphing utility, a complete telecommunications package, and map software with data overlay (See Figure 1). This software component of the project is both simple and powerful.

The NGS Kids Network is more, however, than powerful software; it is a careful weaving of classroom activities and software tools. The following

outline of the ACID RAIN unit illustrates the connection that exists between these two components of the project.

Students begin this unit by learning to use pH paper and to build a rain collector. With this knowledge and equipment, they record the pH reading for each rainfall for the next several weeks. While waiting for the rain, they continue to explore pH through experiments that look at the effect of different pH solutions on a variety of non-living objects. They also keep a weekly log of odometer readings from the family car and roughly calculate the amount of nitrogen oxide that they have introduced into the atmosphere as a family and as a class. Through letters, classes can share the findings from all of these activities with others in the network. These letters are sent, not to the thousands of schools in the network, but to their "research team," a small group of ten to twelve geographically-dispersed classrooms. The content of the letters varies from concerns about the accuracy of the testing procedures to recent news reports:

....We have an important question to ask. The other day it rained just as school was getting out. We put our collectors out to catch the rainwater. The next morning when we got to school we found that the rainwater was frozen overnight. We checked the rainwater anyway and found the pH between 4.5 and 5.0. What we were wondering is if freezing the liquid would alter the acid or not? Also, would our reading be accurate if we had to wait until morning to test it? (from a class in Michigan)

...We enjoyed making our rain collectors. After our first test of the collectors, many of us had to make improvements--to make them heavier so they wouldn't blow over, to improve the design to keep all the pieces together, and to make them collect more rain.... They really received a test one weekend when the front that came through had 30 mph winds. Several were blown over in spite of the improvements. (from a class in Maine)

...We have wondered if the wind that comes with the spring rains might clear the air before we get the rain.... We discussed the problems that Europe and parts of Asia have had since the Chernobyl accident. We read an article that said many of the food sources are still unsafe because of radioactive rain after the accident--AND THAT WAS 2 YEARS AGO (stet). (from a class in Texas)

...Where we live we have to have our car exhaust tested for acid causing pollution. Do they do that where you live? Two days ago two people chained themselves on top of a tall smokestack in Chicago, near here, to protest the ash that goes into the air from burning garbage there. They said it caused acid rain... (from a class in Chicago Heights, Illinois)

After several weeks, during which time there has hopefully been some rain, classes share their findings to one another using a data form in the data entry feature of the software (see Figure 2).

While the network data are all quantitative, the letter exchanges among the classes in the research team often add important information to the data forms:

...We were not able to send any acid rain data because we had no rain. We did have one small snow storm, but it was accompanied by 60 mph winds. The collectors were blown over, funnels lost, and what water was left in the cups was contaminated with dirt, sand, and bugs. We measured the water in all the cups anyway and came up with the most common measurement of pH 5.5, but knew if we put it in the data file it would not be accurate and give false data to the network. (from a school in Colorado Springs, Colorado)

Within a week students receive the network data as well as a letter from the unit scientist. The data may come back as a data entry form or as a map file with color-coded data from each site displayed. The letter from the unit scientist, in this case Dr. John Miller from National Oceanic and Atmospheric Administration helps students put their data into the context of other data collected on acid rain:

... In the last few days, I have received all your pH values via the computer. .. Also I was able to get data from the National Trends Network (NTN) which is the official acid rain network in the United States. Though the NTN rain samples are collected in a somewhat different way than your data, they can be used for comparison. The first review of these two sets of data show that they compare very well. The general features show low pH in the Northeast with spotty lows elsewhere...

My initial conclusions are that you kids have done an outstanding scientific experiment and have helped in increasing not only your own, but others understanding of the acid rain problem... Please accept my congratulations on a job well done.

Next, students compare their readings with those of their fellow research team classes and to examine patterns in the network data. Again, a flurry of letters to fellow scientists takes place asking for clarification about surprises or validation of theories.

This unit ends with a look at the social significance of the data. Students examine two very different positions on what to do with the

information gathered. Each position, seemingly written by a student-colleague on the network, addresses the impact of decisions about acid rain on an individual's life, either a loss of coal mining jobs for parents or serious reduction of salamanders in a local pond. Students are encouraged to discuss these positions, take a class vote for no action without further research or immediate action as well as further research, and send the results to the network.

The results are particularly interesting for environmental educators. In a 1988 field test 2,088 students voted for immediate action; 820 students felt that they needed more information. It was interesting to find that all of the classes in New England or Canada voted for immediate action to resolve the acid rain problem. The following letters detail the various opinions that students voiced about the dilemma.

...We are a minority of students from Kendallvue who believe that we should research the acid rain problem more before we act on it. The reason we feel this way is that if we act now, we could spend billions of dollars on something we may not know enough about. If we spend this much money on stopping acid rain and it turns out that the culprit is something else, years and dollars would be down the drain.

There is no positive proof that acid rain is causing animals to die and buildings to be defaced. As soon as this is proven (if it is ever proven), we will agree with the position of acting on the problem. (from a school in Colorado)

...The whole class expressed sympathy for the boy who raises salamanders and almost no one was touched by the problems of the one whose dad is a miner. Maybe this is related to the fact that not one of my students has a father who's a miner. Each knows that his papa won't be laid off from work and each can say, "My papa wrestles for protecting nature." .... They have never seen an unemployed person. For this or some other reason, my students appeared to be unanimous. (from a school in Moscow, USSR)

...In our class there are 27 students. Eight of them chose a compromise. They said that already mankind can't make do with only a small quantity of energy; therefore, we must not reduce the mining of coal.... (T)he administration of mines must bear the expenses connected with protecting the environment....Part of this expense must be borne by the municipalities in those states in which these mines are located because they also make a profit and are responsible for the cleanliness of the environment.

Twelve people decided that pollution of the atmosphere has already reached such a level that we can't allow ourselves to continue to use traditional sources of energy. We must develop ecologically clean ways of obtaining energy... Probably even bringing humankind to begin to move toward cutting back on certain consumption of energy.

The remaining seven students are holding on to the opposite point of

view. They say that salamanders are not the most important things on Earth. People can't deny themselves a most necessary thing--energy. Moreover, it is not at all essential to breed salamanders.... (from another school in Moscow USSR)

The first reports about the effectiveness of the both of TERC's telecommunications curricula, the NGS Kids Network and TERC Star Schools, indicate that both generate considerable enthusiasm from students and teachers. Telecommunications appears to be an effective, exciting tool for helping students understand the larger environmental picture into which their experiments fit. Creating a network that revolves around the collection and analysis of data provides an important and engaging topic for conversation. Classroom exchanges can be fairly simple and do not require either fancy software or equipment. All that is required is a worthwhile set of data to collect and an interest in sharing those data among classes as close together as the same town or as far apart as different coasts or continents.

Telecommunications offers unique and powerful possibilities to classrooms. Julyan (1989) and Lenk (1989) suggest that this technology expands the work of the classroom in several ways: by expanding the amount of accessible information available to students, by promoting collaboration, by encouraging an interdisciplinary approach, and by extending students' work beyond the confines of the classroom walls to community and scientific groups. As one NGS Kids Network teacher explained, it "is an awesome concept, a truly revolutionary idea for education at a time when it is so badly needed" (O'Grady, personal communication).

Students participating in both projects demonstrated an eagerness to have a greater understanding of the environment and the topic of study. Teachers often reported that their students demonstrated communication skills that were unseen prior to participation in the program. Technology aided these advances in a number of ways. By using microcomputers for computations, students are able to manipulate their findings in more sophisticated ways than their computational skills might have permitted otherwise. Second, with the power of telecommunications, students are able to share data and ideas with others from all over the country and around the world. This extension of the classroom provides a powerful motivation for many students. Lastly, telecommunications offers a unique, manageable opportunity for scientists to communicate with science classrooms. The technology expands these classrooms by eliminating the limitations of time

and distance that would otherwise restrict communication.

By linking students' investigations to real environmental concerns, the students' work becomes valuable community information, not just an empty school assignment. In the fall of 1989, National Geographic Society began the sales of the NGS Kids Network to the general public. By December, 1989, over 2,000 schools had enrolled, including 66 foreign schools from 13 different countries. Students in fourth, fifth, and sixth grade classrooms around the world are developing a deeper understanding of the differences and similarities of various environments around the globe. While student investigations of local environmental issues are always worthwhile, the connection to identical studies around the country and the world makes real the environmental call to "think globally, act locally."

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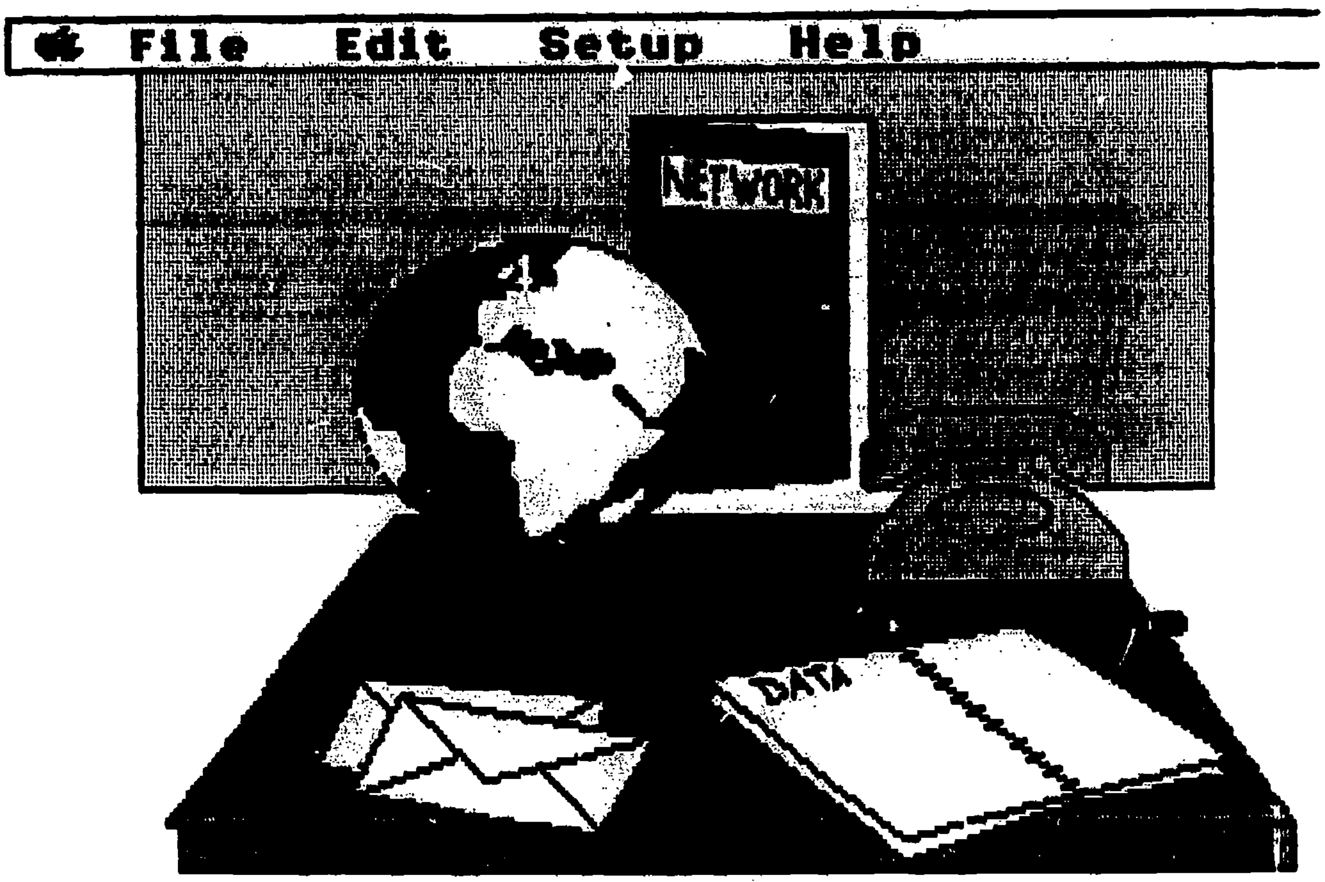
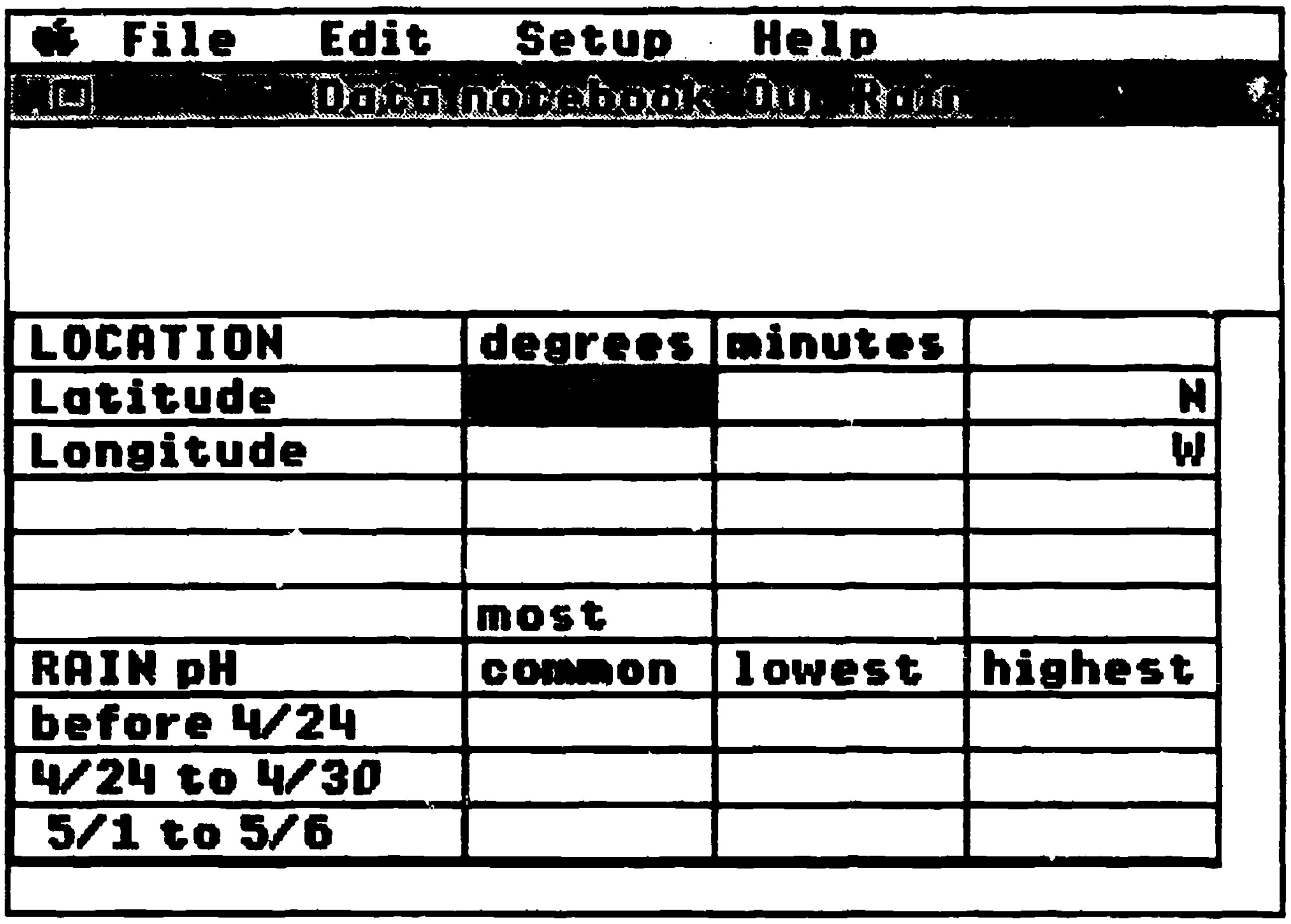


Figure 1 Opening Screen of NGS Kids Network



LOCATION	degrees	minutes	
Latitude			N
Longitude			W
	most		
RAIN pH	common	lowest	highest
before 4/24			
4/24 to 4/30			
5/1 to 5/6			

Figure 2 Data Notebook Sample

COMPUTER CONFERENCES IN ENVIRONMENTAL EDUCATION: CAN THEY HELP TRANSCEND THE 'DIVISION OF LABOR' IN EE?

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The "Division of Labor" in Environmental and Science Education

Many research projects involving environmental education uncritically assume a *division of labor* between researchers/theoreticians (the "academy"), and teachers/practitioners. Formulations like "What research says to the [environmental] educator" (Iozzi, 1989), ironically following the lead of science educational research "What research says to the science teacher," (Harms and Yager, 1981), are descriptively divisive. The very language in which the intentions of these publications are expressed indicates a perceived separation and, by implication, a hierarchy between two constituencies -- "educational researchers" on the one hand and "educational practitioners" on the other. The implied contribution of such publications to improved practice is to alleviate a perceived communication gap between researchers and practitioners, as if the solution to needed improvement in practice were simply a matter of presenting practitioners with the "findings" generated by the research academy. Following this line of reasoning, teachers are regarded as "deficient" or "defective" (see Russell, 1989) and the theory-practice gap is represented as a superficial communications gap.

There are other instances of research in science education (for example, see Penick, 1984) that contribute to a division of labor between researchers and practitioners by reinforcing a single preexisting conception of "excellence" legitimated by a panel of experts drawn from the science and science education academics. The approach in such research includes the following phases:

* development or legitimation of a set of "criteria of excellence" by a panel of experts in the disciplinary area;
* location of instances of science teaching that cohere with these criteria, and the development of case studies of these instances;

* celebration of these instances of science teaching, with consequent reinforcement of the "criteria for excellence" in terms of which they are described as "excellent;"

* starting with the "criteria for excellence," derivation of a set of behavioral (student) outcomes;

* instrumental evaluation of the extent to which program activities achieve the behavioral outcomes derived from the original "criteria for excellence."

Several methodological issues are associated with this approach. First, case study as a form of educational enquiry is being co-opted to an instrumental task for which it is epistemologically inappropriate. In essence, the use of case study methodology for purposes of justifying generalization, in this case about "excellence in science education," is simply not justifiable (see note 2). Second, the approach to research outlined above reinforces the division of labor between theoreticians and practitioners: in the event, the theoretical views of practitioners ultimately count for nothing in the representation of "excellence" and the research fails to contribute to an engagement of practitioners in the debate about what counts as excellence in science teaching. A third issue is the adequacy of top-down models of change: the notion of "defective teachers" embedded in science education in the '60's was realized to be unacceptably oppressive and coercive; the emphasis on "effectiveness" in the '80's has failed to confront the methodological inadequacies of existing models of change, simply replacing the negative connotations of "teacher defectiveness" with the seemingly more positive formulation of "effectiveness" embedded in a pragmatic notion of "what works."

There are similar instances in environmental education where researchers have separated the responsibilities of goalsetting and goal implementation by co-opting the language (goal statements) of environmental education and by using instrumental designs for "researching" environmental education programs by testing the extent to which program activities fit program goals. This process reinforces the environmental and educational values built into the goals by the academy, and preempts the opportunity for practitioners to conduct educational enquiries themselves into the meaning and significance of those values. Again, the approach here is for members of "the academy" to compose a set

of goals, argue for and actively defend these goals as the goals for environmental education (perhaps to use the scholarly journal of the field for this purpose, see Robottom, 1987), represent the problem of improvement of environmental education as one of changing student behavior in line with these goals, and then to conduct research concerned with determining the extent to which educational programs succeed in modifying students' behaviors and attaining the stated goals.

The relationship between goalsetters and practitioners reinforced by this perspective is a hierarchical one that disempowers practitioners: once the goals are accepted by the research community and treated as unproblematic, every instance of quantitative, instrumental, applied science research serves only to reinforce the goals, the environmental and educational values built into them, and the professional standing of the goalsetters. Practitioners, by definition, are reduced to a technical role within program implementation. Thus a hierarchical division of labor is implicit in this strategy: goalsetters live in the academy and control the language (and its institutional forms of discourse and policy), and resist attempts at interference with the power that this gives them to direct educational practice; practitioners who properly adapt curricula to their own educational contexts are made to feel as if they are improperly "subverting" the imposed curriculum. The perceived task for practitioners is to "get on with the task of implementation."

An Underlying Assumption: The Relationship Between Theory and Practice

The fundamental assumption embedded in the paradigm which generates these kinds of anomalies is the perceived relationship between theory and practice in education (expressed at a number of levels in professional and curriculum development). This fundamental assumption seems to be that educational theory can be produced by research conducted in theoretical and practical contexts separate from those within which it is supposed to apply. This supports a formulation of the "theory-practice gap" which assumes the "theory" to be that of the academy, and "practice" to be that of classroom teachers. Furthermore, it is assumed that this external theory in some sense drives practice, that implications for good practice can be derived from external, preexisting theory, and that the task for the practitioner is to bring his/her own practices into line with this inherited

theory. And so the problem of educational change becomes perceived as one of adequately communicating new theories to practitioners and "facilitating" them to make their practices more consistent with implications of these theories. This perception of the relationship between theory and practice is a one-way, non-interactive (non-dialectical) one: theory drives practice; theory is unproblematic to the extent that practical experience does not transform theory. The relationship is also divisive and hierarchical: it supports a division of labor between those responsible for generating the theory (the academy, the research community) on the one hand, and those responsible for implementing the theory (practitioners) on the other; and it ensures that the initiative for change resides with the former.

This view of the relationship between theory and practice informs an approach to curriculum development that exhibits a marked interest in:

* getting the goals right. There is the belief that what is required is a single set of goals accredited by "the academy" (academics, researchers, eminent members of the environmental education community) and expressed as specific learner behaviors and teacher competencies.

* getting the materials right. There is the belief that curriculum materials (if properly researched and developed, impressively packaged, and presented as finished, polished products) can embody universal solutions to effectively teaching the goals referred to above.

* getting the materials (and the educational ideas and values they contain) to practitioners: this is the need for "effective communication," which in turn is perceived as efficient knowledge transmission);

* getting teachers to implement the goals and materials. There is the belief that teachers need to be sold, persuaded, or even coerced through legislation to teach to these goals and materials.

* getting a measure of goals achievement. There is the belief that instrumental forms of program assessment -- those whose main interest lies in determining the extent to which the activities of the program achieve the program's goals -- is an adequate form of evaluation in environmental education.

There are other ways of approaching relationships between theory and practice in education. One promising approach recognizes the importance of teachers' personal theories of action as a basis for educational theorizing.

This approach draws on participatory research as a means of theorizing about education. The remainder of the paper explicates an alternative view of the place of teachers within educational research and development. From the outset, the project described in the balance of this paper sought to protect an authentic role for practitioners in decisions concerning the direction of professional and curriculum development. It endeavored to avoid a division of labor between the "academy" and practitioners. It also attempted to create the conditions for professional education to accompany curriculum development in an essentially interactive fashion.

Computer Conference and Environmental Education Project

Background

Seven schools in the state of Victoria in Australia are participating in an environmental education project which has three dimensions:

1. the teachers and students are engaged in an environmental education program that begins with studies of nearby freshwater and marine environments;
2. the teachers and students are participating in an international computer conference that enables interactions with some 100 schools in three countries, all of which are engaged in much the same kinds of environmental education program;
3. the teachers and university faculty are engaged in a form of participant research that focuses on educational issues that arise as efforts are made to develop the first two phases of the project.

Of the seven schools involved in the project, three are K-12 in structure; the others are secondary schools. Several of the schools are relatively isolated, with small class size. In each case, middle to upper secondary students are involved in the project. All participating schools are located near by or on the southeast coast of Australia. These schools were approached for a number of reasons, including their relative isolation, interest in computer-based telecommunications, and concern about the issue of water quality in their area. Each of these schools possessed a micro-computer, and each possessed or agreed to purchase a modem, dedicated telephone line and appropriate software. Support for the project

has also been forthcoming from the Victoria Ministry of Education through its regional School Support Centers.

In addition to the Australian schools, some ninety overseas schools, largely in the United States and West Germany, are participating in the project. All participating schools are engaged in activities based upon tests of water quality (including tests of dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature, total phosphorus, nitrates, turbidity, total solids) which form the substance of the schools' environmental education programs.

Deakin University provides the "gateway" to the overseas schools via its mainframe computer. The schools log-in to the Deakin mainframe and from there communicate via satellite to the University of Michigan, whose mainframe holds the actual database of the conference. This two-step process enables schools in any remote area in Australia to communicate directly about their environmental scientific studies with any of 90 overseas schools. This second dimension of the project enables students to do several things: to contribute technical water quality data; to obtain needed methodological advice; to gain assistance in the interpretation of technical data; to gain contextual (geographical, topographical, demographical) information about the sites where testing is being conducted at other locations; and to establish enduring personal/professional contacts. The turnaround time for messages and replies is a day or two, so the conference represents a rich and varied source of immediate support.

In addition to acting as a gateway, Deakin University provided a support structure to the Australian schools. For example, the university provided several schools with the latest field equipment for the testing of dissolved oxygen, nitrates, phosphates, and bacteria level, and also encouraged collaborative record-keeping for participatory educational research into the teaching and curriculum issues as the teachers themselves experienced them. Some of the specific sources of data are:

* personal professional diaries maintained by teachers;
* terminal log-books, in which all users make entries for each log-in;
* a monthly Project Newsletter;
* interviews of participants (teachers; pupils; principals ...)

* hard copy printouts of computer-conference discourse (messages; transmissions; responses; conference entries ...)

* observation (field notes and photography).

The Project as *Critical* Environmental Education

The environmental education engaged in by the schools has an interest in environmental accountability -- it is environmental education for environmental responsibility. An instance illustrates this point. One of the participating schools responded to mounting community concern about the pollution of the seawater along the nearby coast by developing an environmental education program based on the conduct of a series of bacteriological tests of samples of seawater taken from popular swimming and surfing beaches. The school discovered that coliform bacteria counts far in excess of EPA guidelines for safe body contact were common in the seawater where thousands of people swim and surf on a regular basis. The school attempted to take up the issue with the local Water Board, whose recently opened sewage treatment plant voids its effluent into the ocean via an outfall located offshore from these popular swimming and surfing beaches, and was rebuffed. The school then invoked the Freedom of Information act to gain access to the Water Board's own records of bacteria levels. The school "went public" with its own bacteria levels; these were published in the local press. The activities of the school have been partially responsible for mobilizing a general and sustained community interest in this issue: local, state and national media have visited the school to report its activities on television and in the press, public forums have been held for the purposes of debating the issue, and the Water Board has generally been required by the community to justify its environmental actions in respect to this matter (Robottom, 1989). Ultimately, the Water Board has been requested by the Victorian Environment Minister to undertake substantial improvements to their sewage treatment facility, at the likely cost of $5 million (*Geelong News*, 27/6/1989).

Some Substantive Issues

A number of issues have arisen in this study. They are outlined below

(and considered in more detail in Robottom and Muhlebach 1989, and Robottom, 1989).

1. Enquiry teaching -- the tension between teaching environmental education as enquiry and conventional didactic teaching styles.

In what sense does the availability to the student of almost immediate assistance from an enlarged community of fellow student inquirers through the use of the computer conference relieve the teacher of the need to act as "the authority" on the environmental issues being addressed, thereby enabling him/her to adhere more authentically to the principles of "enquiry teaching"?

2. The conference as an expansion of the community of inquirers.

In what sense does the availability of an expanded community of fellow inquirers improve the students' interest in exploiting the idea of a scientific community (by offering their findings for appraisal by others; by advertising methodological anomalies; by contributing to international databases on global environmental issues; by seeking information about the environmental and social settings of the research of others with a view to contextualizing research outcomes)?

3. The project as "Science, Technology and Society" (STS).

Given the rising interest in "Science, Technology and Society" in Australia and elsewhere, it is important for environmental education to consider its relationship with the STS movement. In what sense does the current project, by virtue of its necessary involvement of students in various forms of interaction with a substantial community of scientific inquirers, provide teachers and students with opportunities to explore and test the ways in which a scientific community mediates the scientific work of its participants?

4. Environmental, Scientific and Technological Literacy

In what sense is it possible for students and teachers to engage in debate about goals in environmental education and science education, and

those related to technological literacy (Fleming, 1987; Hart, 1987; McClaren, 1989)?

5. Kinds of use of the computer conference.

In what sense is it possible and desirable for students to be able to interact with the computer conference in a range of different ways? Some of these forms of interaction exercised in this study are cited below:

* initial introductions
* personal bonds between users
* exchange of geographical context information
* enhancing other aspects of the curriculum
* establishing new networks
* solving methodological problems
* accessing the data base
* interpretation of data
* classroom process considerations

Beyond the Division of Labor: An Interactive Relationship Between Professional Education and Curriculum Development

In our view, the above is an interesting example of critical, community-based, computer conference-mediated environmental education in its own right. It is also an informative example of an approach to environmental education that attempts to transcend the division of labor between the academy and the practitioner (between researchers and theoreticians on the one hand and teachers on the other). The project attempted to do this by avoiding the questionable but often unquestioned traditional elements of curriculum development listed earlier -- academic control over theory and knowledge mediated by external specification of behavioral objectives; central development of polished, complete, universally-applicable curriculum materials; efficient transmission of curriculum materials to teachers and students; external instrumentalist evaluation.

Considering students and teachers as curriculum developers and researchers has provided a new perspective on the relationship between educational theory and practice, one that is consistent with an image of teachers as "reflective" as opposed to "defective" or "effective" (Russell, 1987). Some of the ways in which this different approach has worked itself

out are discussed below:

The project is consistent with principles of participation and responsiveness.

In this project, teachers are involved in the study of the project itself. Through the use of several approaches to record-keeping, the project has enabled the participation of teachers in data collection and in processes of identification of technical, teaching and curriculum issues of interest and concern to themselves. Issues identified by participants for engagement by the project are technical matters like the escalating costs of telecommunications, and the problems of using a modem connected to a Commander-style telephone network; teaching issues like management of a classroom debate about a controversial environmental issue; and curriculum issues like the tension between a tightly organized discipline-based timetable and the need for extended fieldwork into environmental problems of an interdisciplinary character. The project has been required to respond at short notice and in an unpredictable variety of ways to these issues -- at times by organizing specific project workshops tapping into the expertise of different community groups, by the injection of funds to alleviate unexpected costs of computer conferencing, and by ensuring adequate communication of problems, issues and solutions among the disparate participants in the project.

The project embodies a range of structures for enhancing communication between participants.

As the project proceeded and teachers worked their way through a range of technical, teaching and curriculum issues, there was also development of a number of channels of communication between participants in the project -- teachers, students, university personnel, community groups and agencies, and the public at large. Essentially, there were five channels of support and communication:

1. *individual visits by university personnel:* university-based participants in the project visited schools perhaps once a month. The purposes of these visits was to discuss developments, provide assistance with record-keeping, and to address specific technical problems in particular schools;

2. *project newsletter:* newsletters compiled by university-based personnel from personal observations, inputs by teachers, and correspondence from

the Ministry of Education and other community agencies served the function of general distribution to participants of relevant new developments, such as technical problems and solutions, availability of grants, summaries of teaching and curriculum issues.

3. *computer conference:* there were four features of the computer conference: its relevant focus (specifically on water quality); its bulletin board that encouraged interactive, responsive use by students as well as teachers; its individual message function, which enabled teachers and others to communicate privately with each other; and the database function which enabled access by students and teachers to a developing bank of water quality information. Thus the computer conference served as a teachers' and students' forum for an enduring, developing discourse about the substantive aspects of the project;

4. *project workshops:* these were held at a regional school support center and focused mainly on technical (water testing or computer conference) matters of general concern for teachers and for which there was a need for an immediate solution. Two examples of the business of these workshops are the transferability of techniques of bacterial testing from freshwater to seawater, and techniques for minimizing computer conference costs by uploading and downloading of prepared textfiles. These workshops were organized on the initiative of the teachers, and participants collaborated in exploiting the expertise of visitors invited to the workshops in a face-to-face situation.

5. *articles in the daily press, visual media and professional journals:* To November 1989, over fifty newspaper articles, four television programs and four journal articles have described aspects of the project's activities. This has provided a forum for students, teachers and university personnel to make public the curriculum of the project in a way that perhaps occurs rarely in more conventional environmental education.

Each of these communication structures offers a different form of support to participants. The structures themselves and the substantive and procedural issues they tended to deal with, were developed practically -- as a response to imperatives that emerged during the practical work of project participants. It should be noted, however, that the locus of control over these forms of communication varies: the individual visits and project newsletter are largely organized by the university-based personnel and, it could be argued, reinforce external control over the project; the computer conference is an open forum for private and public communication between all participants (including, significantly, students), but technical problems tend to detract from its potential to serve as a medium for symmetrical communications; the workshops are organized at the request of teachers on the basis of issues identified by them, and constitute a powerful collaborative

means for influencing the direction of the study; and the press and visual media provide a means for participants in the project to interact with the wider community in relation to the activities of the project.

In short, the communication channels that are developing practically in this project offer differential control (by the respective constituencies in the project) over the discourse of the project. The experience of the project supports the views of Posch (1988, p.15) that in environmental education it is important to work towards "the improvement of teacher-teacher communication and the integration of a greater number of teachers/schools into this exchange of experiences, (and) the production of knowledge on environmental project instruction by the teachers themselves." It seems important to allow these communication structures to actually develop practically in response to the range of technical, pedagogical, curricular, political and social issues encountered by teachers as they attempt more critical, reconstructive forms of environmental education. To do otherwise is to ensure that these issues remain unaddressed by the only actors who are in a position to identify, address and resolve these issues, and thereby to contribute to environmental education as curriculum reproduction.

Significant Support from the Local Community

Many environmental education curriculum developments begin with significant external "project" funding that brings with it a commitment to a certain substantive or methodological philosophy, and often also to the development of a tangible, curriculum product -- some sort of new generally-applicable syllabus in textual form. The current project actually began with very few monetary resources, and with no commitment to the development of a curriculum product of a particular type. Its origins lay more with an interest in exploring a role for computer conferences in environmental education in a way that was open to different expressions in different educational contexts. As the schools developed their environmental education programs in response to perceived local environmental concerns, community interest and support was forthcoming from such agencies as: the Victorian Ministry of Education's regional office; the regional university; the State Minister for Education; the local Water Board; the local press and national television programs; the local medical

center; the local surfriders' association; the regional School Support Centers; the Ministry of Education's central office; a regional education/industry collaborative; and the Victorian Rural Water Commission.

Emerging Content

Conventionally, curriculum content is regarded by teachers and learners as knowledge to be gained or skills to be developed. It tends to be viewed by curriculum organizers as relating closely to a pre-ordinate set of specific objectives, and to be viewed (in principle at least) as applicable in a range of teaching/learning settings.

In this project, it can be argued that the curriculum content emerged from (was generated by) the activities of participants in the project. The curriculum content of this project can only be adequately defined with reference to the project activities and their outcomes. It is embodied in:

* research reports prepared by students;

* discourse engaged in by teachers and students in the computer conference (and available as a hard-copy printout);

* newsletter contributions by teachers and other project participants;

* conference presentations and journal articles prepared by students (e.g. Gumley, 1989), teachers (e.g. Shepherd, 1989), and university personnel (e.g. Robottom and Muhlebach, 1989); and

* newspaper articles describing outcomes of the project (published in the *Geelong Advertiser*, and the *Geelong News*).

The curriculum content of this community-based environmental education project is unquestionably idiosyncratic: it makes no claims to generalizability. It may be that this idiosyncrasy is actually a measure of the authenticity of community-based environmental education curriculum work. It is interesting that, informed by existing experiences such as the one described here, other projects that embody similar characteristics are emerging. One example is the "Student Scientific Community" project with a computer conference component initiated by a group of secondary school teachers in Regina, Canada.

Conclusion

The project described in this contribution attempted to avoid a division of labor between research, curriculum development, and teaching practice. Teachers, students and university personnel participated in a collaborative self-study of environmental education (a study of freshwater and marine environments) mediated in part by an international computer conference. A number of substantive and methodological issues are discussed. It is concluded that computer conferences have much to offer environmental education which is community-based, and which has an interest in offering continuing professional support for participating teachers.

NOTES

1. This account draws on a paper presented at the Annual National Conference of the North American Association for Environmental Education, Estes Park, Colorado, USA, 15-23 August, 1989: Robottom, I. "Educational Issues in International E.E Computer Conferences: An Australian Perspective."

2. Case study is concerned principally with the interpretive understanding of educational actions -- with explication of the subjective meanings in terms of which educational practitioners make their action intelligible. The notion of "subjective meaning" is crucial here. From the interpretive perspective, human actions, including educational actions, are intentional and can only be understood in reference to the assumptions, beliefs and purposes (the "subjective meaning") of the actor and the social context within which the actors' assumptions, beliefs and purposes for action make sense. The task of case study is to grasp those meanings and so contribute to the intelligibility of the actions. The educational meaning and significance of the educational work reported in case study resides in the interpretive categories of practitioners. Owing to their subjectivist epistemology, interpretive approaches like case study are unable to proffer any independent criteria for appraising alternative interpretive accounts. Such accounts seek to 'legitimate' actions solely in terms of the beliefs of the actors in the educational setting which the accounts purport to explicate. Interpretive accounts (different case studies) are not only different, they are incommensurable. So it seems to be a contradiction of subjectivist epistemology (consciously accepted in the decision to adopt case study methodology) to apply a pre-determined set of "criteria of excellence in science teaching" to appraise and make distinctions between certain interpretive accounts of science teaching. There seems little opportunity for the case study research to treat as problematic the pre-determined theory of the academy in the light of practical experience. The study serves to reinforce the academy as the "real" and lasting source of worthwhile theory in science education, and to reify the theory (represented in the statements of "criteria of excellence in science teaching") that the study actually began with. "Excellence" becomes seen as an objectively existing reality awaiting discovery, rather than a subjective construction designed by a panel of experts.

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COOPERATIVE DISTANCE LEARNING FOR ENVIRONMENTAL EDUCATION

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Introduction

> Two of the most important organizational trends in modern science are toward research by teams rather than solitary individuals and toward international co-operation rather than nationally isolated efforts. A third trend is now visible -- combining the other two -- that is, a trend toward joint research work by teams whose members are drawn from various countries (Dobrov et al, 1980).

The Greenhouse Effect, ozone holes and acid rain mandate global ecological management. This requires worldwide coordination of interdisciplinary, cross-cultural scientific teams. By being placed in the driver's seat of powerful global communication technologies at an early age, such skills can be acquired.

The federal government defines distance learning as a: "...teaching-learning arrangement in which the teacher and student are separated physically; in these applications, a portion or all of the learning interactions occur in real time" (U.S. Office of Technology Assessment, 1989). Cooperative learning is a model for helping teachers work with groups so students will "learn their subject matter, complete tasks, include all group members in their work, solve group problems with minimal teacher assistance, resolve differences among themselves [and] enjoy the process of working together" (Dishon and O'Leary 1984). Cooperative distance learning (CDL) is the facilitation of conversational learning activities among socially, culturally or geographically distant small groups of students or knowledge workers connected among three to five sites, using various communication modes, conducted over time.

Cooperative distance learning is a model for enhancing existing cooperative learning methods used in the classroom, and has broad implications for environmental education. CDL is based upon the simple observation that groups of people learn and get work done by speaking.

writing and making things happen together. It is feasible and cost effective to design CDL applications connecting small groups through the use of electronic mail and audio teleconferencing -- two highly complementary and widely available communication modes.

Cooperative distance learning activities can be distinguished by these features:

- A CDL production unit consists of three schools crossing multiple timezones at least one-half day away and a clear boundary (national, cultural or geographic); involving six student groups per school, with four to six members each, team grouped into parallel activities among the three schools over four to six weeks
- The use of various communication modes, not one, to enhance conversational activities
- Use of repetitious events connecting students around common tasks and activities; flexibility to take advantage of unplanned novel events to maintain an ongoing sense of purpose
- Use of field trips or community based activities to encourage students and teachers to view public schools as community, grass-roots support groups and resources
- Provide new facilitation roles in managing distance learning projects emphasizing peer communication among networked students.

This paper discusses the method and production techniques of the CDL model. Environmental science projects, methods and costs discussed focus on the utility of combining two modes of communication: real time oral and asynchronous written expression into a distance learning system supporting conversational learning activities among small groups.

Telematics in the Classroom

Using telematics may destine the classroom to become more a metaphor than a place. Telematics, from the French "telematique" is a word combining computers and telecommunications into a single concept. With small groups of students separated by time and space, the "telematic learning system" linking them must enable them to speak, write and make things happen together. The Office of Technology Assessment's recent report *Linking for Learning*, strongly emphasizes that:

> No one technology is best for all situations and applications. The quality and effectiveness of distance learning are determined by instructional design and technique, the selection of appropriate technologies, and

> the quality of interaction afforded to learners. Together, these technologies affect how interaction takes place, and how effective a distance learning system is likely to be. Each technology has capabilities and limitations that constrain the distance learning system, shaping the educational product.

Current telecommunication products being promoted to public schools -- Kids' Network, AT&T Long Distance Learning Network, FrED Mail, the McGraw Hill Information Exchange (out of business and reincarnated as Iris) use and promote a text-based mode of communication -- computer conferencing and electronic mail. For example, the Technology Education Resource Center (TERC) reports that "typically, when people talk about 'telecommunications in the classroom, they are referring to communicating by computer" (Lenk 1989). Communicating by computer in schools nowadays generally means text-based electronic mail or bulletin board activity. This suggests an underlying assumption that using *print media* is what is meant by telecommunications in the classroom.

If so, it is important to note that print media has less "social presence" and transmits less of the full bandwidth of human communication codes than do other communication modes. Electronic mail or computer conferencing is well suited for tasks "requiring lower levels of intimacy, conflict or socioemotional content," and less suitable for tasks involving "bargaining, persuading, or getting to know someone (Rice, 1984). Yet, audio teleconferences are "generally perceived as at least as 'rewarding,' 'friendly,' and 'enjoyable' as face-to-face meetings" (Christie, 1975). Moreover, audio teleconferencing enables "many more messages to be exchanged in a given time period than does typing" (Johansen et al. 1979). However, computer conferencing can "be used well as a preface and/or follow-up" to a meeting, either face-to-face or by audio teleconferencing (Valee and Wilson, 1976).

Establishing relationships and conducting learning tasks are both necessary for distance learning to work among remotely connected students. A researcher with the ATT Long Distance Learning network found that if "people in on-line situations knew each other but had no learning tasks, or did not know each other but had tasks they were equally doomed to failure." (Aumente 1990) Both relationship and task activity need to be present. However, electronic mail use in and of itself has been

shown to be weak in getting to know someone. The Kids' Network employs electronic mail as the only communication mode when linking classroom clusters as large as ten to 12 schools. Conversational learning opportunities among groups of students can become lost in such a structure. In reviewing the Kids' Network, Sache finds that "the telecommunication aspect is trendy, but the real action is in the classroom" (Sache 1989). Real relationships are sparked more readily in-class than over electronic mail. Moreover, electronic mail among a dozen schools could easily result in hundreds of messages a week, even among groups. This can become difficult to manage. The costs can be unpredictable. Moreover, limiting conversational interaction to a single communication mode (text based, asynchronous e-mail) among so many people makes it somewhat difficult for social distance to reduce enough to allow conversational intimacy to emerge among newly connected acquaintances.

With cooperative distance learning, the "real action" is *among* classrooms, and *among* socially, culturally and isolated groups of students. In describing the work at MIT's pioneering Architecture Machine Group, Bolt says: "Not only can input from several sources result in a richer central impression, but high levels of efficiency and accuracy can arise from the convergence of two or more modes that themselves provide incomplete or imperfect information" (Bolt 1984). This can be done by using telematics to help evoke and enable conversation by combining communication modes to help establish new working relationships within the online environment.

Conversation-Based Learning

> One difficulty that many existing telecommunications networks report is that these connections die if there is no reason to communicate (Julyan 1988).

Distance learning systems need to support conversation among networked groups in a manner approaching the quality available within the classroom. A good purpose to communicate (i.e. good activities) may not be adequate to spark new working relationships across a network. Cooperative distance learning relies on conversational learning activities. Conversation theory (Pask, Flores, et al.) suggests learning and problem solving is enabled through conversation. Cooperative learning in the classroom succeeds in

part because structuring good learning activities (a purpose to communicate) among small groups evokes lively conversation among attentive students.

PenQuest Pilot Project

What impact might students have on their local communities as a result of being linked globally through classwork at school with students far away? The PenQuest Pilot Project was designed to enable culturally and physically diverse youth around the world to make connections with each other, explore common problems and devise solutions specific to their regions. Students from three schools (nine schools in all connected for three projects) conducted a six week exercise with each other, comparing and contrasting water quality. On May 1, 1986, nearly 20 students from Scotland, West Germany and the United States were linked for an audio teleconference just days after the Chernobyl disaster -- an unplanned event. Students discussed weather, news stories, fall-out reports and local civil actions pertaining to Chernobyl. Afterwards, students exchanged messages by electronic mail. Each class then conducted a local field exercise to collect water samples. Students performed several chemistry experiments to test water quality and then met again via a second teleconference for a "planned event" to perform pH tests on water samples.

On May 20, student groups from three schools thousands of miles apart performed live pH tests on water samples collected during field exercises, described activities while conducting them, compared results and discussed implications. Deaf, indigenous and non-English students separated by thousands of miles, spanning six time zones from northern British Columbia to Hamburg, West Germany orally and physically conducted pH tests in this manner during this pilot project. The instantaneous and visually dramatic pH test powerfully focused student attention on broader topics under consideration because of the geographic context of the exchange.

During the teleconference, students at an Akwesasne Mohawk Reservation School in New York revealed problems with severe ground water contamination prompting a student in California to propose writing letters of concern. In a newspaper article, this student described this experience: "I was shocked. I thought we might be able to communicate how to conserve water. Now, because of this project, we could be saving

lives." Several months later, this student's teacher reported: "The change in Debbie as a result of this experience, and its ripple effect in our school has been dramatic. Telecommunications enables students who cannot relate to school to see an application of science that has meaning beyond the context of the school setting. Self-esteem of students rises when they realize people around the world are interested in their ideas. In addition, it is more important every day for students to feel comfortable with communication technologies. We need to empower students so they have the ability and confidence to work with each other on solving the many challenging problems society faces.

The Water Quest Electronic Field Trip

In 1987, ATT Western Canada, the Saanich School District near Victoria and the British Columbia Ministry of Education had been involved in a joint effort then ending its first year to examine long term requirements of educators to make effective use of networked computer and telecommunication technology in elementary and middle school classrooms. The Water Quest Electronic Field Trip was undertaken in three schools: Saanich Middle School near Victoria, BC, Gilbert Paterson Community School in Lethbridge, Alberta and Brookhaven Elementary School in Placentia, California. The purpose of the project was to demonstrate the instructional utility of the approach developed during the 1986 PenQuest pilot project.

The three schools are in west coast suburban communities with populations in the 30-50,000 range. This sharply contrasts to the diversity of communities connected during the 1986 pilot project. The demonstration project was conducted at the classroom level. Eighty-one students from three schools spent an average three hours a week, working in 12 teams for a total of 972 student hours in a one month investigation of local water conditions. The average class size for the three schools was 27. Student age range was 11-13 years. As the project was undertaken during the final months of the school year, it was not possible to evaluate its longitudinal impact over time.

Teacher and instructional aid participation averaged forty hours per school. About 120 total instructor hours were invested in the project. Instructors spent five weeks on the project averaging eight hours a week.

Time invested appeared evenly distributed. At the mid-point of the project, average instructor time spent was 23.6 hours. Average classroom hours were 10.67, about 25% of the total time invested, a little over 2.5 hours a week.

Saanich and Lethbridge worked with three study groups, with ten and seven students in each, respectively. Brookhaven worked with six study groups with five students each. All students participated in basic activities, including group work studying local water conditions, field exercises, collecting water samples and conducting tests. Eighteen students directly presented or conducted pH tests during teleconferences. About ten additional students asked and answered questions or made comments during teleconferences. Thirty-four students sent electronic mail messages.

Two audio teleconferences were conducted several weeks apart. Students were encouraged to use common amateur radio protocol and treat the exchange as if they were radio operators. Electronic mail was used to follow up questions asked during audio teleconferences. For example, during an audio teleconference, a student from Brookhaven asked students at Saanich what red tide was and why it glowed in the dark. Saanich students answered over the electronic mail system: "In answer to your question about phosphorescence, it is a substance in the water that lights up in summer nights. These are biological sea animals which are microscopic in size and can be seen only at or after twilight."

During the second teleconference, nine more students from the three schools conducted the pH test. In preparation, samples were placed in vials on the table with the speakerphone along with the universal indicator testing solution. The same "round-robin" amateur radio protocol used in the first exchange was employed. Students were requested by the moderator to perform the tests and at the same time, describe what they were actually doing to the students from the other schools. After the pH tests, results of tests previously conducted, such as bacteria and hardness were discussed.

The second teleconference was conducted two weeks after the first and several days after a field exercise, where students collected water samples. One teacher remarked that with the pH tests, students who were involved directly in the teleconference "achieved a greater understanding...students were more willing to be involved in discussion if they were directly involved in the testing and conferencing."

One teacher remarked: "I liked the idea of each site performing the

same types of tasks. It made it easier for my students to visualize what the other groups were doing." Visualization contributes to the reinforcement of learned material. Audio teleconferencing in CDL activities is used "as if" it were amateur radio. It has a strong similarity. Marshall McLuhan and others classify radio as a visual, not an aural medium. In the case of radio drama, imagined pictures may be more beautiful and powerful than real ones, the absence of the visual component in this form of drama may well be a considerable asset.

CDL activities appear to be more compelling as educational experiences in direct proportion to the cultural and geographic diversity of the schools involved. Increasing desire to communicate increases conversational motivation, learning reinforcement and the out-of-classroom "sense" of the project. The third site amplifies cultural, time zone and geographic factors tremendously without a dramatic increase in coordination over what two schools would entail. Students during the 1986 pilot project appeared to have a more powerful desire to converse than did students during the 1987 demonstration project. Deaf, Native American and European students were connected from four nations across six time zones. Affective change was reported. In contrast, the demonstration project crossed one time zone and one national boundary. Students were almost all from west coast suburban areas with far more cultural similarity than differences. No affective change was noted. During the 1987 demonstration project, one school was unable to participate in the first audio teleconference due to technical problems with a speakerphone. The second teleconference involved all three schools. As shown in Figure 1, the teachers all felt that the addition of the third site strongly contributed to the instructional value of the exchange.

The Urban Sleuth

The Urban Sleuth Electronic Field Trip links three classrooms from three cities around the country in a one month to six week investigation of energy consumption and waste management. The project was field tested briefly during the fall of 1988 with several schools linked through the McGraw Hill Information System (MIX). Nearly 100 students from three schools organize the source separation of up to six tons of household waste, creating a context for investigating recycling programs and development of

end-use markets for recycled materials.

First, student groups monitor household energy usage, reporting results to the other schools using electronic mail. Next, the three classrooms meet during a one hour audio teleconference to compare and contrast energy profiles of their locations: local demographics, climate and economics, where and how local power is generated and how it is delivered. Student groups follow-up the audio teleconference through brief reports sent through electronic mail. Each class then investigates components of the municipal solid waste stream. Students from each school work with families and neighborhood households in source separating household waste for one week.

The Urban Sleuth Electronic Field Trip works with a class size of 25-30 students directly impacting 75-100 students from three schools. Activities are structured around assignments given to six small groups of four to five students at each school, with "parallel" teams from the other two schools that they work closely with. There are eighteen small groups in total, from the three schools. Specific small group assignments greatly assist the management of electronic mailings and audio teleconferences.

Instructional Design and Production

Cooperative distance learning requires a production cycle management plan, like producing plays, newspapers, or radio shows. There are four phases in the production CDL activities: Design, Planning/Resource Acquisition, Production, and Follow-up.

The design phase is the longest phase: three months, corresponding to a normal curriculum development cycle taking place during the summer months between school sessions. Planning/resource acquisition will require between one and two months. This phase involves pulling together the pieces of technology, budgeting costs, identifying two other schools and conducting planning activities with the other teachers. Production of student activities itself will require four to six weeks.

A six step approach can be used to sequence activities encompassing small group tasks and different modes of communication. Conversations can be leveraged by switching among oral, written and visual expression by playing one communication mode off another in a strategic manner.

- First, start off with in-class discussions
- Second, break off into small group activities
- Third, have small groups send electronic mail messages about what they are discussing to other small groups at other schools who are discussing the same things
- Fourth, conduct a field exercise to focus student attention on local environment, culture and circumstances
- Fifth, hook up the groups through an audio teleconference so they can really talk about their shared experiences and become better acquainted
- Six, switch them back to electronic mail to follow-up points raised and questions asked during the teleconference.

This six step sequence (see Figure 2) could be called "Act I." The process can be repeated: small group meetings, e-mail, field exercise, audio teleconference -- "Act II." Cycling twice will fill four to six weeks of activities .

Resource Acquisition

The preliminary step to prepare for CDL activities is to assemble a Classroom Teleport. The Classroom Teleport is workstation consisting of a personal computer, modem, phone line, speakerphone and communication software set-up in a small group meeting space (see Figure 3). Ideally a Classroom Teleport occupies a corner of a classroom, arranged in such a way to provide space for a small group of students to work together. The set-up might include several acoustic wall dividers to dampen noise from the rest of the class. There should be sufficient wall space to pin maps, butcher paper and place three clocks (with time zones from each location). In practical terms however, audio teleconferences might be conducted in one place while the computer used for electronic mail might be located in a different place. For instance, student teleconferences might take place in the principal's office, and electronic mail exchanges might be done as an occasional quick job in the computer lab a few times a week.

Production

While we want every student to participate, the teacher is faced with managing both electronic mail exchanges and teleconferences. Doing this among three classrooms with upwards of one hundred students in all

requires a structure based on three teachers (from three schools) overseeing work of connected groups rather than individuals. Managing many individual electronic mail messages is unwieldy and tedious. It is better that single messages are exchanged between teamed groups. Each class establishes six small groups responsible for a specific topic. Of these five or six topics, there will be parallel or team groups at each school, investigating the same topic: three groups, one from each school are investigating the same topic.

Group messages should be kept to a paragraph or two, forcing brevity. This teaches good use of electronic mail. It is easier for a group to write together if the piece is very short—and more interesting for others to read. It is less expensive and time consuming. After an audio teleconference, students will likely have many points to raise or questions to ask. These comments and questions should be "batched" as single group messages. Individual students can make their own statements but the message should be sent from the group, supporting positive interdependence and group identity.

Each group sends and receives two messages a week for six weeks. In this manner, it is possible to predict volume, cost and time requirements for electronic mail activities:

- There are eighteen groups, six groups from three schools. Each message sent should be no longer than one page (two paragraphs). No more than two messages (two pages) a week per group should be sent -- one to each of the two parallel topic groups
- Messages sent are between groups, but the comments and questions within the messages can be delivered to other groups by individual group members in class
- In this way, group members distribute messages among themselves and to other groups, taking that burden off the teacher and encouraging self responsibility.

Using the following procedure will help keep the flow of electronic mail moving along among the groups, under their own responsibility:

- Students compose messages during group assignments
- One student types the message on a word processor; this responsibility rotates
- Another student or two collects all messages, puts them on one disk, goes off to the computer and does the message transaction, prints out incoming messages, photocopies them, returns to class, posts copies on a

classroom bulletin board under the group name sent to; this responsibility rotates.

Booting the computer and accessing the network will make each on-line session about a 10-15 minute task. Rewards can be given to students who can get the mail in and out faster than anyone else. Such incentive will reduce connect charges and telecommunication costs.

There are many ways to conduct audio teleconferences. The format outlined here will work for many different class situations. A one hour audio teleconference would be made up of six, eight minute segments with some time left in as a buffer. One segment would be composed of 12-18 students depending on class sizes from three schools; each local team would be composed of 4-6 students. This approach creates six segments, or "mini-conferences" among six working groups. Planning these segments is the key to both ensuring full participation and managing the audio teleconference within the school schedule. It is not necessary that the entire class be present during the entire audio teleconference. It is also quite possible to split the teleconference up into several separate exchanges managed by students at mutual convenience coordinated by electronic mail. What is necessary is that parallel topic teams from the three schools be present for their segment at the same time.

Students should be "on-call" about ten minutes before "air-time," giving the group time to assemble and gather their wits, before the previous segment is complete. The group then participates for eight minutes. They should also plan to be available for at about ten minutes after the end of the segment, in case of scheduling difficulties. In this way each student is responsible to her group for showing up on time. They will know in advance when to be expected. Also, if a student fails to show up, or is late, the group segment can continue without disruption.

It is important for students to use a protocol to manage their own meeting. Audio teleconferences linking several sites resembles an amateur radio ("ham") network. Ham networks consist of radio operators connecting on the same frequency for informal discussions or to coordinate emergency communications. The same protocol applies in either case. Imagine a group of people sitting around a table following a "Round Robin" format. The moderator opens discussion as participants raise hands for recognition. It is impossible to see hands raise over a ham network, or an audio

teleconference. Speakerphones work like a 2-way radio or a walkie talkie. The speakerphone is unable to provide a completely natural conversation because interruption is difficult. This makes the use of protocols more important.

Using amateur radio protocols such as "over to you," "break" and "go ahead," are quite effective. For example, when a student in San Francisco is done, and a student from Billings, Montana is next, the student in San Francisco says "Over to Billings." When general information has been aired and discussion becomes less structured, the "Break" technique can be used to support spontaneous conversation. The facilitator should frequently interject into the meeting a statement like: "I wonder if there are any comments at this point? I'm holding the network open for breakers." The facilitator pauses, leaving dead air. Anyone can step up to the speakerphone and briefly say "Break San Francisco." Someone else at about the same time might say: "Break Billings." The facilitator has just "seen" what amounts to a raise of hands. "Well, I heard Billings there and then San Francisco, so we'll go over first to Billings for their comment. Go ahead, Billings." The term "Go Ahead" means the speaker is finished and the party indicated may begin.

All of these terms should be practiced in class before the first audio teleconference. In-class groups can easily be used as separate "sites," and can practice "going over" to each other, "breaking" occasionally so the teacher or a student can practice facilitating. This protocol places much teleconference management responsibility with the students, encouraging use of group skills. It is not necessary for the teacher to facilitate. A student can do this as well. There are thousands of young ham operators around the world doing this every day. It is not a difficult skill to acquire.

Budgeting $160 for electronic mail and telephone use should be adequate for Phases II and III (Planning and Production). Electronic mail costs will be about $60 or less. Direct phone and audio teleconference costs will be well under $100. Acquiring a simple speakerphone, communication software and a modem can cost as little as $150. To calculate electronic mail costs, assume a group message is one page in length. Each group generates four pages a week, the total sent and received. At 1200 baud, that is well under two minutes of transmission time. Six groups at one school will send/receive about 24 pages a week, between six to seven minutes of transfer time. With an on-line overhead of

about 30% to log-in, enter commands to send and receive mail, and log-out, two sessions per week averaging about 12 pages of text plus the 30% overhead will require about five minutes connect time each, assuming a data transfer rate of 1200 baud.

Instructors will need at least two sessions per week to exchange brief messages among themselves. These sessions might require about 10-15 minutes of on-line time per week. Thus, in total, about 20 minutes a week will be spent on-line by students and teachers during the production phase. During the day, connect time will cost about $10 and hour plus about $10 a month for a standard service charge. In this manner, spending about two total hours on line over a six week period will cost about $40; two hours at $10 each and two months of service charges at $10 a month. Including another month for coordination with instructors from the two other schools during the planning phase would be perhaps another $20. With judicious use, perhaps sending messages to teachers in the evenings or over the weekends, and rewarding students for minimizing message length and transmission time, these costs can be further reduced. The total electronic mail bill should be easily kept at $60 or less on a per school basis.

The primary use and cost of the telephone will be for audio teleconferences. CDL activities described in this paper require two one-hour teleconferences plus a 50% overhead for unforseen needs, perhaps a total of three hours. This will cost $22.50 at current ATT cross-country daytime rates during the week. An inexpensive way to produce teleconferences is to use a "conferencing bridge" with a local university or junior college, a device connecting any number of phone lines for a conference. A bridging service will call sites into the conference, provide an operator on the side and send a single bill. Often, colleges have such services available for inter-campus needs. If one is available, they may well be willing to provide services for free, charging only the actual phone time used. Another inexpensive approach is to use "three-way calling" on private residential or business lines. First, one number is called, then the second number after which the lines are joined. Only one phone line and one phone are required to link three classrooms anywhere. This also works with an institutional phone system that has an internal two line conferencing capability.

Regardless of which options are used, it will cost about $22.50 per school for two audio teleconferences with perhaps $20 for coordination

calls among instructors. Telephone costs should be around $45. Budgeting $80 for telephone charges will be more than adequate. Thus it can be seen that the entire communication cost borne by one school, in a three school CDL production, can quite realistically be kept well under $200.

Conclusion

Cooperative distance learning activities are no more complex to produce in schools than plays. They follow very similar production cycles and can be easily understood as theater. It has been shown that interactive conversational activities can be provided to *all* students for less than $200 for a six week project. In a class of 25 students, that is $1.33 per student per week, or $8.00 for the six week undertaking. CDL activities are facilitated locally, by in-class instructors -- no remote teacher is delivering instruction to the class. The classroom teacher is important to the success of CDL, and concerns over remote instructors crossing certification jurisdictions do not apply. The teacher is empowered. Moreover, students manage their own activities with remote teams of students, involved in the same investigations directly, using oral and written means. Thus, students receive full benefits and full responsibility -- the stage is *theirs*, not the teacher's, and not some remote instructor. The students are empowered. Perhaps most importantly, this model show significant promise in two pressing areas of need. First, CDL can provide *compelling learning experiences*, to people who have never had them before. Secondly, CDL places students for the first time directly in the driver's seat of increasingly powerful and global communication technologies and gives them the *keys* to acquire necessary skills to deal with global ecological and economic management requirements of the future. CDL is direct, powerful, and adaptable to any good curriculum providing small group activities, field exercises, investigations and experiments. Finally, because CDL activities are locally controlled through the use of small, manageable production units (three schools), replicating them on a mass scale becomes very feasible. This is perhaps the most powerful potential of this approach -- coordinated activities conducted in this manner can make things happen very quickly on a large scale, whether it is source separated household waste or planted trees. This makes a difference, and this is what a student needs to *experience directly*, if we want them to grasp the importance of education.

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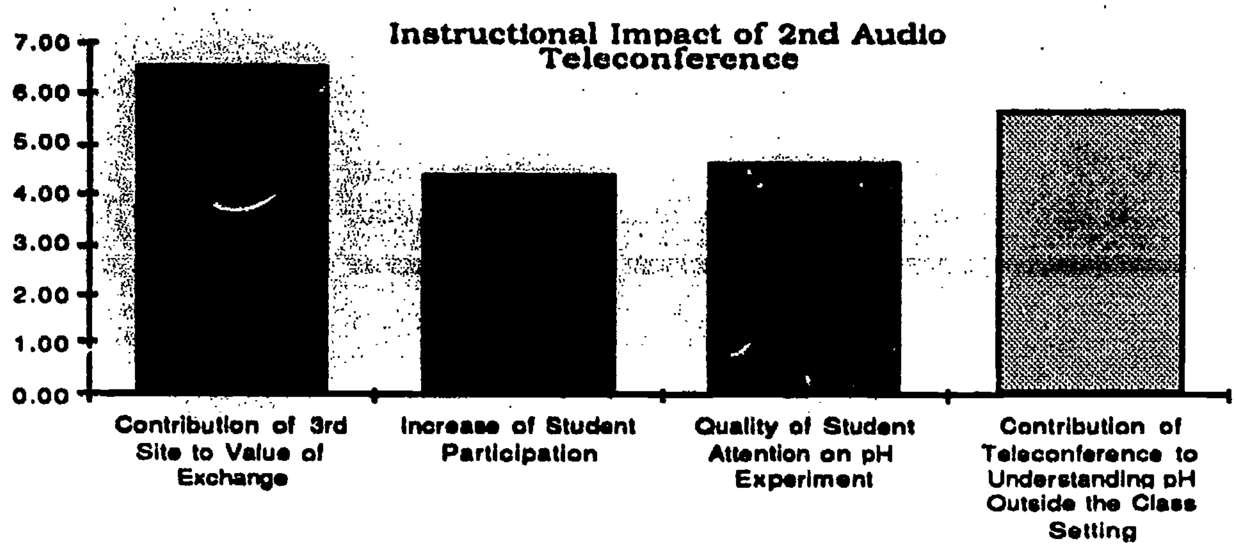

Figure 1 Instructional Impacts

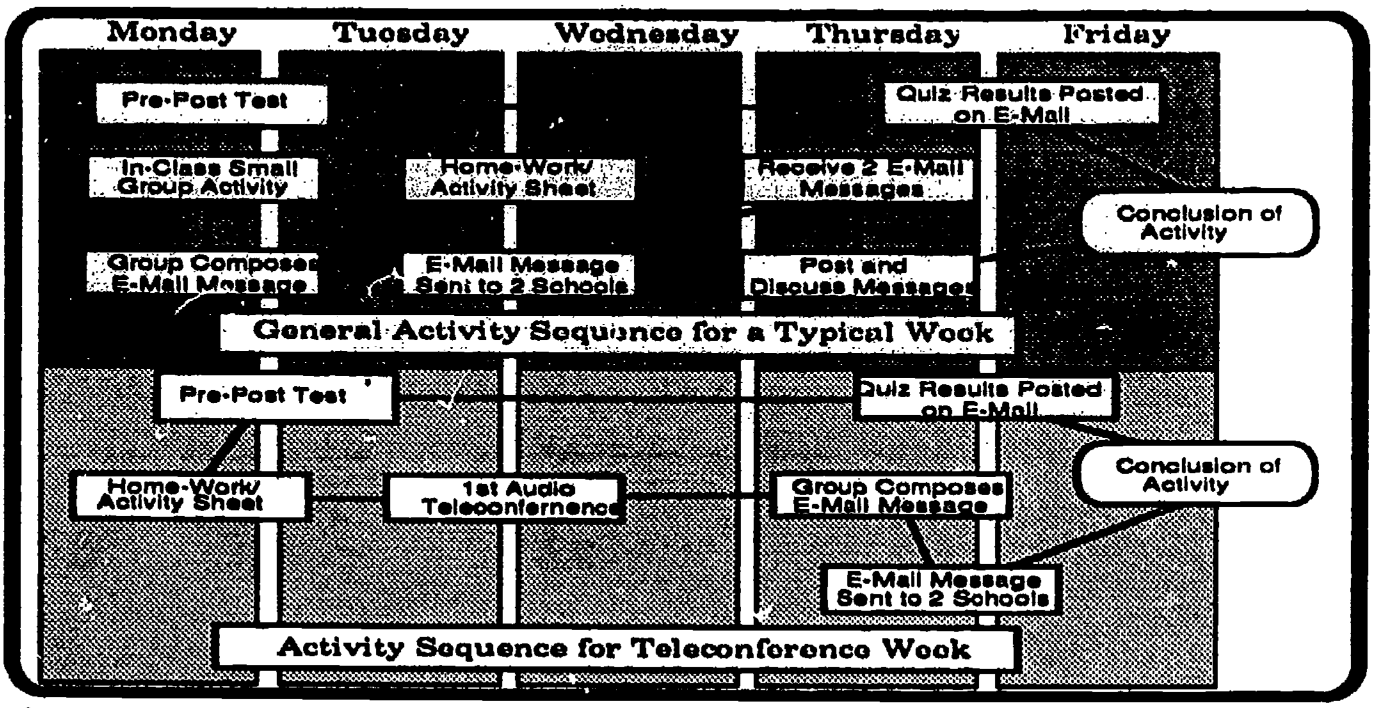

Figure 2 Activity Sequence for Typical Week

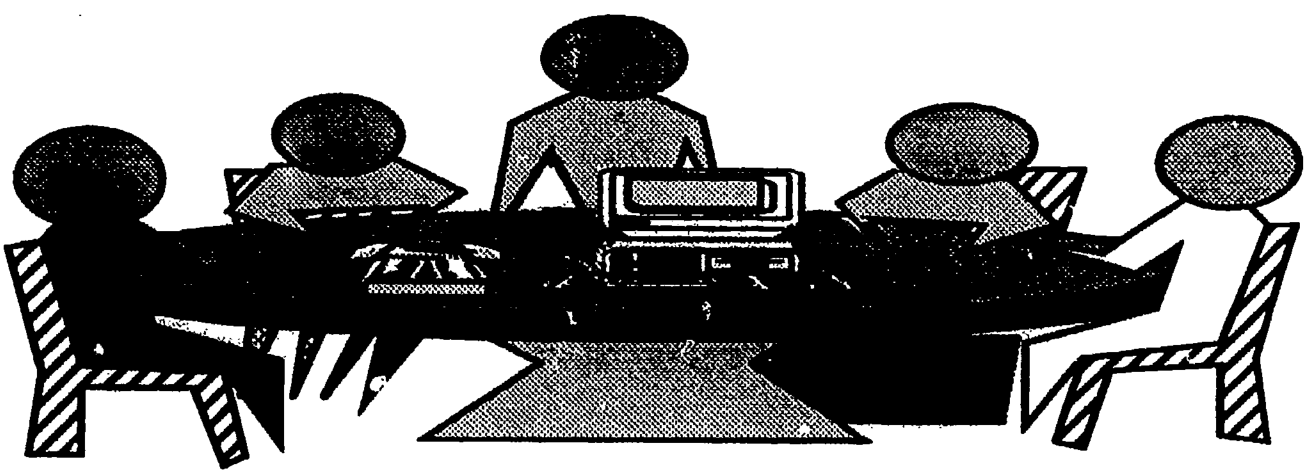

Figure 3 Classroom Teleport Workstation

THE EXCHANGE NETWORK: COMPUTER TELECOMMUNICATIONS AND ENVIRONMENTAL EDUCATION

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There are many people who are concerned that computer technology has a strong potential for the control, manipulation, and dehumanisation of people and for the centralisation of authority. It is appropriate for people to keep their critical faculties engaged concerning the application of any powerful new set of technologies. Computers and telecommunications represent a powerful combination, but whether or not their powers are engaged in the service of humankind will depend on people demanding that they be used appropriately, people who are knowledgeable concerning the capacities and limitations of these tools.

Environmental problems are often characterised as transcending national or regional boundaries and governmental jurisdictions. The solutions to environmental problems require the capacity to access up to date information from a wide variety of sources. They also require effective communications among stakeholders who are often widely separated from each other, or who find difficulty meeting face to face on any regular basis. Solving environmental problems often requires a multidisciplinary perspective and benefits by being viewed from the vantage points of different cultures, and of various age and socioeconomic groups. Computer telecommunications has the power to address many of these requirements. People interested in solving environmental problems will need to learn to use this medium of information and communication. Environmental educators will need to make certain that students also appreciate the powers, and the dangers of these technologies and learn to use their potential to address the environmental difficulties which we now face on many fronts.

Computer telecommunications is a new medium of information and communication. While some of the elements of the medium, telephone systems and computers, have been around separately for some time, their conjunction brings about new opportunities and creates new possibilities. Effective use of this medium requires a change in thinking. People who use electronic mail often have difficulty at first understanding that it does not

involve synchronous communication, unlike a conference call or live interactive television program. People who want to access on-line information data-banks soon learn that efficient use is essential both to get the needed information, and to make it economically feasible to do so. Those who participate in on-line forums and electronic conferences may be reticent to join in the discussions, fearing that they may make an embarrassing technical mistake in front of many people. Like any other innovation, people need the opportunity to explore, to tinker and play with the medium. They need to develop a new mental landscape concerning interaction and communication, as well as about the sources of information and advice.

The XChange Network

About five years ago the Faculty of Education at Simon Fraser University in British Columbia in Canada decided that teachers, and through them students, needed the opportunity to gain hands-on experience with computer telecommunications in education. To facilitate this the faculty decided to make the in-house university electronic mail and teleconferencing facilities available to as many teachers as possible so that they could start the exploration. We had no idea about the genii we were about to unleash.

Simon Fraser University is one of three provincial universities in British Columbia, the most western of Canada's ten provinces. The university's Faculty of Education has long been committed to providing services away from the main campus which is located in the heavily populated southwest corner in the greater Vancouver region. Given the size, rugged and variable geography of the province and the problems of winter travel, this commitment entails a major effort. The Education Faculty established regional centers in a number of areas of the provincial interior. These regional centers offer the professional year of teacher education, undergraduate courses for teachers, some graduate programs, and teacher continuing education. As a result of this dispersed style of operation, the advent of computer telecommunications seemed to offer a natural way of extending the faculty's existing commitment to extension services. Moreover, the faculty had adopted a general goal of developing a leadership capability in all aspects of the application of computers to education. The

move to make computer telecommunications available to schools throughout the province seemed consistent with this. As a consequence, the Simon Fraser University Faculty of Education XChange network was launched.

XChange offers teachers and other users access to electronic mail, on-line conferences, and some data-base services. The host computer is the university's large IBM mainframe, which the Faculty of Education shares with many other academic users. The core operating system software is the widely used MTS or Michigan Terminal System. In order to use the system any user must have a user ID and a password. Being issued an ID and password also means that the user is given an account on the system, with an initial $100 of computer time. At first the faculty's operations were mainly confined to its own staff and to some enthusiastic, technically-oriented teachers in schools near the main campus. But, as more and more teachers became interested in the instructional potential of telecommunications, the requests for accounts and for system access grew apace.

Our approach has been to provide accounts to educational users on a no-user-charge basis. In effect, the Faculty is providing a subsidy to support educational telecommunications. In Canada, users who are remote from the host computer may access the network via public access telephone Dataports, known as Datapac, a system operated by the telephone company. This system is analogous to Telenet or Tymnet in the United States. Of course, there is a charge for this access, but in our case the university is paying the datapac access charges. Unfortunately, not all small Canadian cities have local datapacs and so the users in those centres must often pay long distance charges to call the nearest network access number. Even so, given the size of the province, this charge is likely to be considerably less than a long distance call to the lower mainland region of B.C. Of course, we envisioned only a relatively small number of users, and a relatively slow growth of use. We were wrong on both counts.

Since 1984 use of the XChange system has grown from a few hundred to more than 4,000 education users. As a result, we now pay monthly datapac charges of about $7,000. To date, we are still committed to providing this service. Another surprise has been the extension of the system to users outside the school system and outside the province. At present we have active participants on the network from many parts of Canada and the U.S., and from outside North America in many other parts of the world, including Australia, Japan, and the middle east. It didn't take some teachers very long

to discover the powers of the Bitnet communications infrastructure. They began sending out rather open-ended messages to general Bitnet addresses at university and government agencies in other parts of the world. Before long teachers and students in Israel were exchanging messages with those in B.C. One highly successful project, the Global Teachers Network has now developed its own school based satellite communications facility and has essentially become independent of the university, an ideal example of the fulfilment of our intentions for this project.

The Faculty of Education at SFU has also been active in the field of environmental education since 1971. Thus, it was a natural extension to attempt to use the XChange network to facilitate communications among environmental educators all over North America. Thus, as a member of the U.S. Steering Committee of Project WILD, I have been able to give computer network access to all the Canadian and U.S. coordinators for the project. We have also facilitated on-line communications for the members of the UNESCO Man and the Biosphere programme's Network Committee in Canada. Working with the Canadian Wildlife Federation's Habitat 2000 project of grants for local habitat improvement projects based in schools, we have networked many of the grant recipients so they can access expert advice and share their projects with other participating schools in an on-line conference. In another on-line forum, called Ask-An-Expert, students and teachers often sign on to discussions with Dr. Spider or Dr. Hoot on wildlife, ecology, and habitat. Dr. Spider and Dr. Hoot are both experienced teachers with a wealth of experience in environmental and conservation education. They provide students with practical advice and assistance and with fine electronic mentorship as well. In the future we hope to be able to make on-line databases relevant to environmental education available to teachers and students. At this time the on-line databases in this system are still quite limited.

Environmental education is only one of the topics covered by the conference area of the X-Change system. Other conferences include the Universal Curriculum project, which has environmental stewardship as one of its themes, Cooperative Education, and PACRIM, a conference devoted to discussions about countries around the Pacific rim with whom schools might like to arrange student exchanges. In many of these forums environmental and global education topics are raised in discussions. In a conference called Law Forum, students and teachers interested in legal education can gain

access to mentors on issues in law and ethics. Here again, the potential importance for environmental education is evident.

When we began all this we were really making a probe, a reconnaissance into new territory. Little did we expect to become the operators of a network spanning the world and involving thousands of teachers and students. At first, conversations in the conferences and forums were often tentative. Many teachers had to be encouraged to find their way through the often user unfriendly vagaries of network software in order to send messages and join in on-line discussions. In the beginning some people remarked that this seemed a rather expensive way of having a high tech pen-pal exchange. Even after four years of operation I often feel that we are merely scratching the surface of what is possible from telecommunications as an educational medium. It has been said that all innovations progress through three stages: curiosity or diversion; improvement; and finally transformation. With the SFU Xchange system we are still generally in the stages of curiosity and diversion and improvement. Those of us who use Email to communicate know its power and value. Email has certainly improved our lives beyond the burdens of telephone tag. At times we catch, in the discussions in on-line forums, a glimpse of the real potential power of electronic networking and we sense the immediacy and intimacy which this supposedly remote and impersonal medium can foster.

What lies ahead for our system is uncertain. Clearly we are supporting use to the extent that the system now costs many thousands of dollars annually to operate. Like most other educational institutions our funding is always problematic. It is likely that in the next two years the provincial government will establish a more general network for educational telecommunications. Already the physical infrastructure for telecommunications and data transmission is being extensively upgraded with the installation of a fibre optic cables. It is possible that private sector businesses will enter the educational telecommunications field more than they have at present. But, we are convinced that we have played an important catalytic role in the early development of this medium in this region. In our view it is important that students and teachers alike begin to gain familiarity with telecommunications so that they can be participants in its development and directors of its uses rather than merely users or consumers of media services. Moreover, if the powers of this medium are to remain responsive to progressive, environmentally and personally

appropriate purposes, then networks such as ours may have to remain at least in part as alternatives to corporate private profit-motive systems. At Simon Fraser we hope that the Xchange system has been a facilitator of this new era in the development of human communicative power.

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DATABASE OF ENVIRONMENTAL EDUCATION RESOURCES: A COLORADO PROJECT

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Description

The Database of Environmental Education Resources (DEER) is a unique collaborative project of the Colorado Alliance for Environmental Education, the Colorado Department of Education, and the Colorado State Library. DEER is an online resource list of Colorado- and regional-based organizations, agencies, libraries, companies, and consultants who offer environmental education resources (interpreted broadly). DEER is the hub of an active Colorado network connecting providers of environmental education resources with users. The Database is available to educators, public policymakers, business and industry personnel, and the general public. It is mounted on a statewide automated library system, and is available free in 45 libraries, or by computer and modem for the cost of the phone call. There are three dial-up nodes across the state, with more planned in the near future.

Background

An environmental education summit was held at Governor Roy Romer's mansion in October 1988. The summit was initiated and facilitated by Colorado State Board of Education member Art Pansing and attended by over fifty environmental education leaders across the state. The participants identified and supported the need for a central clearinghouse of environmental education resources.

Also in 1988, a task force composed of representatives of the environmental community began meeting to consider how to promote environmental education in Colorado. This task force, which later organized as the Colorado Alliance for Environmental Education, hosted a statewide conference in February 1989. The more than 125 participants identified the need for a statewide environmental education center whose goal would be to raise the level and quality of environmental literacy in Colorado.

The Colorado Department of Education joined forces with the Colorado

Alliance for Environmental Education to develop an online environmental education database which would be available statewide. The proposed database was endorsed unanimously by participants at the February 1989 conference, many of whom volunteered to help with data collection and promotion. The project has also been endorsed by Governor Romer as well as the heads of several state and federal agencies, school districts, and private organizations. The Colorado State Library, through the Resource Center at the Department of Education, provided the means for mounting the database, and the personnel to develop and direct the project.

Development of DEER

The Colorado Alliance of Research Libraries, or CARL System, was chosen as the vehicle to carry the Database of Environmental Education Resources. CARL is an online library network which provides access to the catalogs of 29 member libraries, two regional library systems, and 20 information databases. CARL is available in 45 libraries or library systems. Gateways into CARL are also available through the statewide telecommunications network, Supernet, and through three other regional library online catalogs—IRVING (Denver Metro area), MARMOT (covering the Western Slope of Colorado), and Maggie (Covering the Pikes Peak Library District in Colorado Springs). CARL provides access to the latter two systems through its own direct gateway.

Several more libraries and library systems are slated to join CARL in the next couple of years, and more local dial access ports are planned. The dream of Nancy Bolt, Colorado Deputy State Librarian, is that any resident of Colorado can access all of the state's library resources through a local phone call. There are plans for legislation to be introduced in the 1990 session to fund this statewide access network. If funded, this network would allow free access to DEER for anyone in the state who lived near a CARL library or owned a personal computer and modem.

The Database of Environmental Education Resources was originally envisioned as a part of a larger environmental education center which would collect information resources, provide speakers, and offer reference and technical assistance. With current funding exigencies, DEER became the central focus of the environmental education community's efforts. The database includes current information about the organizations, agencies,

libraries, and businesses which have environmental education resources. These resources include curriculum guides, programs, field trips, brochures, speakers, courses, and other services or resources.

DEER is not a bibliographic database, i.e., it does not list individual items that might be held by area libraries or nature centers; rather, it is a directory to information sources in a variety of formats. Thus, it includes listings of libraries which have significant environmental collections, as well as agencies which produce curriculum guides, businesses which offer public education resources, schools which offer environmental education programs, and outdoor recreation or nature centers.

Methodology

The Colorado Alliance for Environmental Education developed a data collection questionnaire to send to all individuals, organizations, and groups on its mailing list. Before it was sent out, the questionnaire elements were compared with the database fields available through the CARL system, and modifications were made. A sample of 30 questionnaires was sent to a representative group from CAEE's mailing list and entered on the CARL system. This sample revealed additional changes which needed to be made to the questionnaire and raised various issues about subject control and access (see section below on problems and issues).

The revised questionnaire was sent out to approximately 700 individuals, groups, and organizations who were identified by members of CAEE as having possible environmental education resources to provide. As this paper is written, we are in the process of entering the data from the larger group of questionnaires into the CARL system. As other organizations, groups, companies, or centers are identified as potential information providers, additional questionnaires are sent out. Those who received questionnaires but did not respond will be contacted by telephone to make sure they are included in the database.

Problems Encountered

The main difficulty with the database is using the pre-determined CARL format, the MARC (MAchine Readable Cataloging) record. This bibliographic format was designed by the Library of Congress in 1969 to

describe various types of print and non-print materials. It is a standard for the library field, and MARC field tags refer to standard items in the description of a work. In adapting this format to an information database, one must substitute comparable or congruent data elements for the standard tags. For example, name of organization is entered into the author field; program name is entered into the title field; address is put into the series field; and information about scope of the organization is entered into the contents field. Both the ultimate format on the screen, and which MARC fields are indexed by the CARL system had to be kept in mind when the database was designed. Database searching may be somewhat confusing to our users because CARL search keys currently refer to bibliographic elements, e.g., "Title," "Series," and "Call Number." We hope a user search guide will address this problem.

A second issue which needed to be resolved was that of subject control. CARL provides free-text searching of its database. This feature makes it very user-friendly since no thesaurus need be used to access subject information (there is subject control in most of the bibliographic databases on the CARL system since most libraries use the Library of Congress Subject Headings). Users merely enter the word or words they wish to search, and CARL pulls up all records in which those words are indexed (see Figures 1-5). The questionnaire designed by CAEE listed broad subject categories for respondents to select so that there would be some consistency in responses. One such subject category is **Wildlife**. A person searching CARL for any resources about wildlife would be well served if they entered the term, **Wildlife**. On the other hand, a person who only desired information about raccoons might not think of searching under the term **Wildlife**. They might assume that no information about raccoons exists if they searched the term **Raccoons**, because all information about raccoons is listed under **Wildlife**. If the subject categories were made more specific, i.e., each animal or animal group was given its own name, the user with interest in specific animals would be well served, but the person wanting all resources about wildlife would have to look under each individual animal name.

There are two commonly-accepted solutions to this problem. One solution is to provide a searching guide (i.e., thesaurus) to use with the database. We are currently developing such a user guide. We are developing a thesaurus of descriptors for our database by comparing our list of terms with ERIC descriptors as well as the revised list of descriptors used by the

North American Commission on Environmental Education Research. Since the database is still under development, modification of our descriptor list is relatively easy at this point.

The second solution is to list entries under both general and specific terms, e.g., raccoons would be listed under both **Wildlife** and **Raccoons**. This approach is particularly useful since not all members of the public who use the database will have access to a thesaurus or searching guide. In addition to the descriptors, we have decided to add more specific terms which might also be logical access points. Most of these terms are gleaned from the organization or group's own literature.

A third problem is the time-consuming and cumbersome process of entering the data directly into the CARL system by remote terminal. The person entering the data must enter tag numbers and subfield indicators for each field and wait for them to be accepted before entering data into the field. The delays are significant. We are exploring using Pro-Cite Bibliographic Software for entering our database information, and then uploading our data to the CARL system. Pro-Cite uses MARC tags and runs on a personal computer. Entry time is significantly reduced using this software. We are currently in the process of doing a test run of this option.

Accessing DEER

DEER can be accessed through any one of 45 libraries statewide, or by computer and modem. The CARL system is menu-driven and aims to be user-friendly. A person who wishes to look at DEER selects the database from a numbered menu. An introductory paragraph introduces the database, explains its parameters, and directs the user to additional sources of help.

The following figures 2-4 are sample searches using actual CARL menus and data from DEER. The first search is a "Word" search using the words **Greenhouse Effect**. The second search is a "Name" search on the name **Michael Weissmann**. Figure 5 is a representative organization listing. (Please note: when the database becomes accessible to the public in the near future, an explanatory paragraph about DEER will appear on the screen when the database is selected).

Since the database is still under development, the final product may look slightly different than the examples shown, depending on how certain issues are resolved. The CARL office is also in the process of revising its

menu screens and adding new capabilities such as global searching (searching several databases at once) and name authority control (making available online the official and established name of persons, units of government, or organizations).

Future of DEER

We anticipate that DEER will be available to the public early in 1990. The initial feedback we have received has been overwhelmingly positive. We have received requests to provide everything from a listing of all Earth Day 1990 activities in Colorado to listing all the resources available on all sides of the issue for controversial projects with environmental impact. While some of these capabilities are not available at this time through the CARL system, we are making note of all the potential online functions our database might serve.

We are still waiting for the decision of the Colorado State Legislature on funding DEER. We are also pursuing funding through various federal, local, and private sources. The current funding base will allow for maintenance and continuation of the database at a very elemental level. Our dream is to have a much larger program. We envision a center which will include an 800 number to connect those with no access to a CARL library or computer and modem to professional librarians who can do a search for them. We would like to have staff who can promote and market the database to potential users. We would like to expand the database to include information on curriculum guides available commercially, model environmental education projects which could be replicated in Colorado settings, and resources on the pros and cons of proposed government projects with environmental impact, e.g., Two Forks Dam, solid waste disposal sites, Rocky Flats waste storage, etc. And finally, we would like to put together "Hot Topics" packets on various environmental issues and make them available to Colorado teachers, policymakers, and interested citizens.

The most important information about the future of DEER and its impact on environmental education in the state will come from our users. CARL is able to provide us with statistics as to how many users access our database, and where they are located geographically. We also plan to send out user surveys after a six-month and one-year period of time to determine how the database is being used; solicit suggestions for improvements; and

evaluate the level of satisfaction of our users. The ultimate test of the value of DEER, as of all environmental education efforts, is whether or not it contributes to an active citizenry who can make informed decisions about the environmental issues which affect us all.

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The following databases are currently available:

Member Library Catalogs:

1. Auraria
2. C.U. at Boulder
3. C.U. Health Sciences Center
4. C.U. Law Library
5. Denver Public Library
6. Denver University
7. Denver University Law School
8. School of Mines
9. University of Northern Colo.
10. University of Wyoming
11. Government Pubs—DPL & CU

Information Databases:

12. UnCover—Article Access
13. "Facts"
14. Encyclopedia
15. Metro Denver Facts
16. Info Colorado
17. Boston Library Consortium
18. Library News
19. Talent Bank
20. Environmental Education
21. More Library Catalogs

Enter the NUMBER of your choice, and press the <RETURN> key>>**20**

SELECTED DATABASE: Environ. Education

The computer can find items by NAME or by WORD

NAMES can be authors, editors, or names of persons or institutions written about in the book

WORDS can be words from the title, or subjects, concepts, ideas, dates, etc.

You may also BROWSE by TITLE, CALL NUMBER, or SERIES.

Enter
- N for NAME search
- W for WORD search
- B to BROWSE by title, call number, or series
- S to STOP or SWITCH to another database

Type the letter for the kind of search you want, and end each line you type by pressing <RETURN>

SELECTED DATABASE: Environ. Education

ENTER COMMAND>>**W**

Figure 1 Opening Screens

REMEMBER — WORDS can be words from the title, or can be subjects, concepts, ideas, dates, etc.

for example — GONE WITH THE WIND
SILVER MINING COLORADO
BEHAVIOR MODIFICATION

Enter word or words (no more than one line, please) separated by spaces and press <RETURN>.

>**GREENHOUSE EFFECT**

WORKING...
GREENHOUSE 00007 ITEMS
GREENHOUSE + EFFECT 00007 ITEMS

For the 00007 items that have
GREENHOUSE + EFFECT
Press <RETURN>, or type <Q>UIT for a new search.

You began with a WORD search on:

greenhouse effect

Type S to try your search in another database, or

R to repeat your search in Environ. Education or

<RETURN> for a new search:**<R>**

Figure 2 Sample Word Search

SELECTED DATABASE: Environ. Education

Enter N for NAME search
W for WORD search
B to BROWSE by title, call number, or series
S to STOP or SWITCH to another database

There is also a quick search — type QS for details

SELECTED DATABASE: Environ. Education

ENTER COMMAND>>**N**

REMEMBER — NAMES can be authors, editors, or names of persons or institutions.

for example	items	BY	WILLIAM FAULKNER
	items	BY	SALINGER, J.D.
or	items	ABOUT	JOHN KENNEDY
	items	ABOUT	EASTMAN KODAK

Enter NAMES (in any order) on one line, separated by spaces.
>**Weissmann**

WORKING...
WEISSMANN 00001 NAMES

Weissmann, michael 00001 ITEMS

PREPARING YOUR DISPLAY -- HOLD ON...
1 University of colorado
University of colorado museum bugmobile DEER00009

Enter <LINE NUMBER> to display full record, or <Q>UIT for new search
>**1**

Figure 3 Sample Name Search

WORKING...

------------------------Environ.Education------------------------

ORGANIZATION: University of Colorado Museum
PROGRAM: University of Colorado Museum BugMobile
Campus Box 218, Boulder, CO 80309-0218
303) 492-6270; (303) 492-3396
County: Boulder

Information updated 9/1/89

The goal of the University of Colorado Museum BugMobile is to bring arthropods into schools and lecture halls across Colorado. This educational program is designed for any age level (including adult groups), primarily to supplement existing classroom study of insects and their relatives.

SCOPE: Activities: Workshops or Seminars — Brochures or Pamphlets — Curriculum guides — Public speakers $ — Press releases — School programs.
Audience: Preschool — Elementary — Middle or Junior High — — High school — College or University — General public —Teachers — Elected officials — Mentally handicapped — Physically handicapped — Formal clubs (Boy Scouts, etc.)
Descriptors: Environmental protection — Pesticides or insecticides — Outdoor recreation opportunities — Wildlife —
Other terms: Arthropods — Insects — Arachnids — Crustaceans — Camouflage — Spiders — Predators — Prey — Life cycles —

CONTACT PEOPLE: Weissmann, Michael — Entomology Assistant
Phillips, Becky — Public Programs

<RETURN> to continue, <Q>UIT for new search, or <R> to REPEAT

Figure 4 Sample Name Search Results

1 The Logan School for Environmental Education Program DEER00004

2 Denver public school Balarat Outdoor Education Center DEER00008

3 University of Northe Environmental Studies Program DEER00010

4 Keystone center Keystone Science School DEER00011

5 Colorado state forest Project Learning tree DEER00005

ALL ITEMS HAVE BEEN DISPLAYED.
ENTER <LINE NUMBER(S)> TO DISPLAY FULL RECORDS
<Q>UIT FOR NEW SEARCH **1**

WORKING...
------------------------Environ. Education------------------------

ORGANIZATION: The Logan School for Creative Learning
PROGRAM: Environmental Education Program
1836 Logan St., Denver, CO 80203
(303) 830-0326 County: Denver

The environmental education program is interdisciplinary and is geared for gifted and creative students, kindergarten through eighth grade. The program is experiential in design and offers in-depth field experiences as part of the educational curricula.

Information updated 3/31/89

SCOPE: Non-profit Agency (School)
Activities: Newsletters — Curriculum guides — Grant programs — Field trips.
Audience: Preschool — Kindergarten — Elementary — Middle or Junior High.
Descriptors: Agriculture — Rangelands or Grasslands — Air resources — Water resources — Forests — Soils —Energy conservation — Historic resources — Cultural resources — Weather — Environmental protection — Pesticides or insecticides — Outdoor recreation opportunities — Outdoor survival — Fish — Wildlife — Wilderness or Parks — Quality of life — Greenhouse effect

CONTACT: Kowal, Dan Environmental Education Specialist

<RETURN> to continue, <Q>UIT for new search, <R> to REPEAT display

---

Figure 5 Sample Organization Search

TVA'S ENVIRONMENTAL EDUCATION BULLETIN BOARD

Lynn Hodges
Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a Federal agency with broad responsibilities for natural resource management, power production, economic development and related demonstrations. TVA serves parts of seven Southeastern states, Kentucky, Alabama, Georgia, North Carolina, Mississippi, Virginia, and Tennessee. Physically, the area is about one-half the size of Great Britain. In support of its environmental education program, TVA was an early user and provided a demonstration in the use of electronic bulletin boards.

TVA As An Experimental Agency

One of the "new deal" agencies in 1933, the Tennessee Valley Authority emerged as an experimental agency. For years, the Federal government established an agency with a singular natural resource mission (ie: Forestry, Agriculture, Wildlife) and assigned responsibility for nationwide management of that specific resource. The TVA experiment broke the pattern by having a Federal agency manage multiple resources in an integrated fashion, not nationwide, but within a specific geographic area. The geographic area was to be the watershed of a major river system in the U.S.

Responsibilities were to include flood control, power production, navigation, natural resource management, economic development, agriculture, and conservation. This new, integrated organization was to be "the great experiment" and projects were to be national demonstrations. The Tennessee River Watershed, inclusive of parts of seven southeastern states, was chosen and the Tennessee Valley Authority (TVA) Act passed by Congress.

Partners in Education

The need for better education in the TVA region was recognized early in

TVA's history. Partnerships evolved from efforts to meet this need. With its first construction project, Norris Dam in Norris, Tennessee, TVA established a community library, organized literacy programs for employees, and actually operated the community school until the late 1940's.

To improve agriculture and promote better farming practices, TVA aligned itself with land grant colleges and universities. Higher education became a key partner. Mobile libraries were organized to serve remote areas. Literature on various aspects of health, farming, land use, and forests were developed and distributed.

The prescription for TVA's efforts was simply stated by TVA's General Manager, Gordon Clapp, in 1954. He stated, "Resource development is achieved in a far reaching program of education and experimentation." This philosophy and earlier TVA projects set the stage for development of TVA's environmental education program.

TVA's Environmental Education Network

As the conservation and environmental education movement grew in the 50's, and matured in the 60's and 70's, the concept of integrated management (ie: Everything is connected to everything else!) was popularized. John McKay, in his article, "Why Environmental Education?" wrote,

> What's new about environmental education is that it pertains to more than the management of our natural resources as a practice to protect or enhance the growth of a given region; we are equally concerned with the maintenance of a sane human environment as well (MacKay,1980).

That TVA was organized around such an integrated philosophy, and the logical connection to the Agency's environmental education program, was recognized by some of the nation's most prestigious educators. Dr. John Disinger, Ohio State University, and Dr. Clay Schoenfeld, University of Wisconsin-Madison, made the following observations:

> But the Federal resource management agency with perhaps the most ambidextrous yet cohesive environmental education today is the Tennessee Valley Authority. From its very inception in 1933, TVA has what might be called an ecological orientation, and its modern environmental education activities reflect the inexorable

relationships of man and land (Schoenfeld and Disinger, 1977).

Once again, TVA established partnerships with regional colleges and universities. A network of University-based Centers for Environmental Education resulted. Each Center served its immediate geographic area and provided 4 functions: Teacher Training, Program Development, Community Outreach and Research. To cover the entire region, a network of seventeen Centers was planned.

Communication as a Function of Network Maintenance

By 1985, thirteen University-based Centers for Environmental Education existed in the Tennessee Valley. Extensive outreach to public schools, and citizen organizations was occurring. Production, field testing, and distribution of educational materials on topics such as water quality, natural resource management, groundwater, energy, and waste was being achieved. Colleges and universities outside the Tennessee Valley were looking to the TVA Network as a model.

Maintaining the Network required extensive communication. Traditional communication efforts such as quarterly meetings, monthly mailings to Centers, and newsletters published by each Center met many needs. However, in 1986, the TVA Environmental Education Bulletin Board was installed. This was TVA's first effort to use telecommunication as a tool to enhance communication among the various Centers, TVA and others.

TVA's Environmental Education Bulletin Board

"*...the new source of power is not money in the hands of a few, but information in the hands of many.*" (Naisbitt, MEGATRENDS)

In 1986, TVA installed the Remote Bulletin Board System developed by D. Thomas Mack. Although, TVA's Environmental Education Program can be credited with the application and use of the technology, credit for the development of the software and outstanding support documentation belongs to D. Thomas Mack and his colleagues who developed the Remote Bulletin Board System for the IBM personal computer (RBBS-PC).

According to D. Thomas Mack, the RBBS-PC had only two fundamental

purposes, ".....to foster the free exchange of information and to offer an educational example of what can be done with the BASIC programming language." In support of this philosophy, D. Thomas Mack provided a limited license for the RBBS-PC software at minimal costs, and distributed it through a group of users from Washington, D.C. called the Capital PC Users Group (CPCUG). Revenues were re-invested in and applied to the CPCUG's educational programs.

From a systematic search of Bulletin Board software, TVA found that the RBBS-PC was considered by many to be the industry standard. It had been refined significantly by users. Documentation was excellent. Training on its installation was available, and it was inexpensive.

The RBBS-PC software was implemented as a total package. Titles were added at appropriate places, a "logo" was created, and the operational parameters defined. The bulletin board was "hosted" by an IBM-XT. Since TVA decided to have the bulletin board operational 24-hours per day, 7-days per week, the IBM-XT was committed exclusively to this task. It is important to note that this was a TVA decision, and not an operational procedure demanded by the software. Connections to the telephone line via a Hayes modem and addition of a printer were the final steps to creating an operational bulletin board.

From the Users' Perspective

From the user's perspective, accessing the TVA-EE Bulletin Board was very easy. Users simply called the bulletin board and established a connection through their software and modem. They were prompted to provide their name and their password. New users were provided an opportunity to "sign in" and to establish their passwords. After providing their name and password, the user could access the electronic newsletter and electronic mail. All functions were made easy through the use of menus and single letter choices. "HELP" keys provided explanation at all levels. Users were not charged to use the TVA-EE Bulletin Board. The only user cost was their telephone charges for the time they were connected.

The Electronic Newsletter contained ten articles. Articles were added and deleted about every two weeks. Articles could only be put on the system by TVA. Users would send articles to TVA for inclusion in the electronic newsletter. Electronic mail allowed any users to send messages,

retrieve messages and communicate with any other user, including TVA. Electronic mail was instantaneous. The system would also accommodate file transfers.

Impact on Targeted Audience

The targeted audience was the TVA Network of University-based Centers for Environmental Education. Each Center had computers, modems, and software that would allow them to access the TVA-EE Bulletin Board. All thirteen Centers participated, some using the system extensively. Most used the electronic mail feature on a daily basis. Review of contracts, transmittal of text for publications, inquiries for specific materials, and critiques of projects were the most common mail communicated by the Centers.

Centers contributed articles and announcements for the Electronic Newsletter. Course offerings, announcements of grants, requests for proposals, reviews of new publications and evaluations of materials were submitted for use in the Electronic Newsletter. Articles were also selected from their quarterly newsletters as well as other publications dealing with environmental education.

The impact of the TVA-EE Bulletin Board on the Network was positive. Center directors communicated more with each other and with TVA. Ideas were aired in an electronic forum, and the structure of the forum added structure to the discussions without diminishing the creativity of the participants. "Turn-around times" for work was shortened, as documents received a faster review electronically.

During the second year of operation, the numbers of users increased substantially. Some of the universities conducted teacher training workshops and had provided teachers access to the TVA-EE Bulletin Board. Many of these teachers continued to use the system on a regular basis. The demonstration aspects of the TVA-EE Bulletin Board were presented at several national meetings, and many of the attendees at these meetings became regular users. Members of the media accessed the TVA-EE Bulletin Board for leads on educational projects and to request other detailed information from TVA or the universities. The growing numbers of users were perceived as simply more opportunities for cooperation, and the "open-door" policy for new users was maintained.

For the most part, a very successful demonstration, the TVA-EE Bulletin Board was not without some problems. The most common concern was that the system used a normal telephone number. Most calls were long distance, and although the use of the bulletin board was free, these telephone charges represented a sizable expense for some users. Some users wanted to provide articles to the Electronic Newsletter while on-line, without sending the articles to TVA. The system was configured to deny this capability. Very few instances of malicious "hacking" or abuse occurred. The system operator had the option of denying access to any user who abused the system, and generally, once "locked out" the user either never re-entered the system or re-entered and acted properly. Having a single telephone line created some problems. The most obvious was that two users could not use the TVA EE-Bulletin Board at the same time. This prevented "real-time" conferencing, although a user and TVA could be on the system simultaneously. Interestingly, few users reported getting a busy signal when accessing the system.

RBBS to ECONET: The Transition to Nationwide Linkages

As the work of the university Network expanded, and the TVA Network for Environmental Education became a model for several national initiatives, TVA identified a need for a more sophisticated telecommunications system. Having served its purposes for communication and demonstration, the TVA EE-Bulletin Board was discontinued in favor of a National system, ECONET, in 1988.

TVA's Environmental Education Program is a frequent contributor to ECONET, and can be reached "on-line" with the identifier "TVA."

COASTNET: AN ADVENTURE IN ELECTRONIC ACTIVISM

Andy Alm
Northcoast Environmental Center

The computer networking experiences of a group of environmental activists concerned with issues affecting the long California coastline provide an insightful case study of how grassroots organizations adapt -- or have trouble adapting -- to new communication technology. Almost by chance, the loose association called CoastNet found itself bearing high-tech computer communication tools when a major environmental crisis called. The story of that crisis follows, with some of the internal challenges and questions it posed concerning the role played by the use of computers to deal with very human problems.

Computing Gifts

In 1987, two clusters of organizations in California independently got the same idea: that computer networking among citizen groups concerned with coastal issues made sense. The fact that Apple Computer was giving away its Macintosh computers to help non-profit organizations take advantage of new telecommunication opportunities provided an extra incentive. A free computer and software was worth lots of promises. And after all, cooperative work on coastal issues was itself a worthy goal.

So it happened that Apple's Corporate Grants program received two different proposals each with the same name: "CoastNet." Each proposed expanding computer use by the organizations involved, including for the first time use of computer networking--sharing information between computers over existing phone lines and telecommunication services.

Apple's volunteer reviewers looked at the two proposals and, noting the coincidence of their extreme similarity, wondered if the ten groups represented shouldn't all be working together. The groups leaped at the opportunity.

The end result, with Apple's support, was an unusual -- perhaps even unnatural -- coalition brought together by technology, somewhat of a "back door" approach to organizing on coastal issues. Lumped together were general-interest clearinghouses and special-interest, single-issue

groups, organizations whose audiences ranged from small and well-to-do to large, grassroots and mostly volunteer.

The brave new experimenters (all located in California) were the American Oceans Campaign, a national organization headquartered in Santa Monica; the California Ocean Sanctuary Federation based in Willits; the Central Coast Conservation Center in Half Moon Bay; Earth Island Institute, an international organization based in San Francisco; the Environmental Defense Center, an environmentally oriented law firm in Santa Barbara; Friends of the Sea Otter in Carmel; the Mendocino Environmental Center in Ukiah; the Mountains Restoration Trust in Malibu; the Northcoast Environmental Center in Arcata; and the Surfrider Foundation in Huntington Beach.

Loads of Potential

CoastNet was thus launched as a network of experienced organizations sharing a cause and a potentially valuable new way to communicate--without much of a clue how to make it happen.

Electronic mail in theory would make sharing news, alerts and information requests nearly instantaneous, at a fraction of the cost of overnight mail or long-distance telephone calls. Computer conferencing could allow meetings to occur without the expense and time involved in traveling to span the distances that are inseparable from issues defined by thousands of miles of coastline.

Potential here is the key term. Other computer networks had formed around environmental issues, several helped with free equipment and software from Apple and others. But the human barriers to using the new technology had so far been greater than the idea. The time to learn how to use electronic mail and computer conferencing just didn't exist in groups whose days were filled with responding to environmental crises, and whose meager budgets kept staffing to a minimum that barely covered conventional correspondence and phone calls. Networks that had formed had, at best, trouble getting rolling; at worst, unused modems gathered dust as groups' interest in their computers centered on in-house chores such as word processing and list-keeping.

The underlying motives that caused the groups to believe that computers, and computer telecommunications, would help with their

mission are difficult to assess. Computers certainly have been touted as a modern panacea for managing the information glut of the late 20th century that threatens to overwhelm society rather than enlighten its members.

That we generally agree better communication is a worthy goal is largely a measure of our times. This view is strengthened by the public's expectations concerning information that came with the likes of the Vietnam War and a view of Earth from the moon, broadcast live on television in every home. Our society is still coming to grips with the promises of telecommunication and the new computer technology, and the opportunities they provide for mass access to information and power. Social activist Harry Boyte presents a vision that should be encouraging for grassroots efforts like CoastNet:

> In sum, elements of a democratic, populist sensibility grew through the 1970s: a renewed vision of direct democracy coupled with a mistrust of large institutions, both public and private. Such a democratic vision represented a rekindled faith in the citizenry itself, a conviction that, given the means and the information, people can make decisions about the course of their lives; a belief that people can develop a conception of the public interest that does not deny -- but rather is nourished by -- special interests. In turn, the building blocks of citizenship are to be found in the voluntary structures of all kinds at the base of American society (Boyte, 1980).

It seems reasonable to assume that having an expanded means of communication should help the communication process, but perceived need to communicate in specific situations is probably by far more important (Grunig 1968, 1975, 1976, 1977 and 1982). So far, this has been borne out by CoastNet's ups and downs.

Danger of Distraction

If entropy and lack of time aren't enough to make computer networking a difficult challenge, consider the pervasive theme in the environmental movement which ascribes evil attributes to computer technology itself. Because computers are expensive and complex, access and participation is seen as limited, even elitist. Computers are both products and precursors of wasteful consumerism -- causing some eco-activists to swear they

wouldn't be caught dead touching a computer, and others to complain that far from easing the workload of thinly stretched environmental groups, computers would generate their own needs and set their own distracting agendas.

Computers also pose an entirely new dimension in office management, one that is probably even more difficult to grasp and incorporate in underfunded organizations where volunteer work is a critical component. Planning for training, system development and maintenance of complex electronic systems is difficult even for sophisticated businesses or organizations with healthy budgets and adequate staffing; such planning and effort may too often be seen as a luxury or wholly removed from activist goals in small citizen groups.

A Roller-Coaster

Representatives of the ten coastal groups met for the first time at Apple's grantee training in Cupertino in early 1988. Some had met one-on-one before, some had worked together on the computer grant proposals and some were familiar with each other's work, but never had they all sat in a room together to work on a project. The grant proposals had spelled out some goals and timelines, but the reality of the network's function depended on the individuals and their level of commitment. Doubt and even fear over adopting the new technology was apparent from the outset.

The activists made several promises to each other at that meeting, among them that they would at least try to communicate with each other regularly via computer, and that they would also make efforts to share their work with others via the computer network. At first, this communication was to occur on Apple's own corporate computer network, AppleLink. Then, if it proved worthwhile, efforts would move to EcoNet, a public, non-profit computer network designed for the global environmental community.

It soon became apparent that only four of the original CoastNet groups were intent on using the computer to communicate, despite the time and costs involved in getting started. The others found that their needs, time, resources or abilities just weren't up to the extra effort.

Getting the ball rolling with just a sub-group of the original network was a fitful process, but by October of 1988, a new conference on coastal issues (en.coastal) was operating on EcoNet, and by the next month it started to

become a focal point for efforts to stop federal offshore oil exploration and leasing activities along the California coast. New groups and activists, notably Greenpeace via GreenNet in Great Britain, the Central Coast Regional Studies Program and California coastal community lobbyist Richard Charter, joined the fold.

Responding to Offshore Oil

All of the original CoastNet groups were in some way connected to the issues surrounding oil and gas exploration and development on the Outer Continental Shelf -- the ocean area within 200 miles of the coast claimed by the United States as its "Exclusive Economic Zone." Proposals for oil drilling along California's coast had come and gone over the years, but following early development off of southern California, federal lease sales were slowed by environmental concerns, largely fueled by public reaction to the impacts of massive oil spills off California and elsewhere.

> At the second annual National Ocean Protector's Conference, sponsored by Greenpeace Feb. 27-Mar 2, Ocean Sanctuary emerged as a goal and a vision of people from around our nation's coastal perimeter. To make permanent protection for the ocean from offshore oil development and other degrading activities a legislative actuality, co-authors from both the House of Representatives and Senate for a National Ocean Sanctuary Bill are needed now. ("Ocean Sanctuary lobbying ...Now," jharrington, en.coastal, 12:00 am, Apr. 2, 1989)

Nixon, Ford and Reagan administration proposals for massive oil and gas lease sales off of California had been stymied only by last-minute, year-by-year spending moratoriums imposed by Congress on the Interior Department's budget. In the oil politics of 1988, environmentalist jockeying for another moratorium was joined by a new concept, "ocean sanctuary," which would put areas with sensitive marine and coastal resources off-limits to exploitive energy and minerals development.

Both scenarios were documented in blow-by-blow accounts in the new en.coastal conference on EcoNet, supplemented by news reports by Greenpeace. Discussion was somewhat limited -- whether because of the new technology or shyness or a lack of vital information to convey is left to conjecture -- until dramatic events caused a sudden change in both the volume and content of EcoNet postings.

Alaska Oil Slick Hits EcoNet

The March 24, 1989, spill of 240,000 barrels of oil into the waters of Prince William Sound was the first time the fledgling CoastNet faced a coastal crisis that needed immediate communication and action.

A March 26 open letter to the president posted in the en.coastal conference marked the start of an avalanche of opinion and information concerning the spill on EcoNet.

> Dear President Bush, it began, We, the undersigned Alaskan environmental organizations, appeal to you in the wake of a national tragedy. Prince William Sound, one of the richest and most beautiful treasures of our state, has been marred by the largest oil spill in United States history. As the world watches our misfortune, one issue is immediately clear. This is a tragedy that could have been prevented... ("Valdez Oil Spill sparks angry," rblazer, en.coastal, 6:53 pm Mar 27, 1989)

It was signed by representatives of the Alaska Center for the Environment, Alaska Friends of the Earth, Alaska Wildlife Alliance, Denali Citizens Council, Juneau Group Sierra Club, Northern Alaska Environmental Center, Southeast Alaska Conservation Council, Alaska Chapter Sierra Club, Alaska Survival, Arctic Audubon, Greenpeace, Kodiak Audubon, Sitka Conservation Society, and Trustees for Alaska.

Another letter posted soon after advocated using public response to the Alaska spill to try to change Congress' mind about oil drilling in coastal waters and in Alaska.

> Please consider signing onto this letter, or using it as a model for an updated letter to your own Representative or Senator, as well as a letter to the editor of your local newspaper. This catastrophe may provide a pivot point upon which your Representative or Senator can shift his or her position to one favoring protection of the Arctic National Wildlife Refuge, to one limiting further offshore development in Alaska or other states, or to one favoring the creation of an Ocean Sanctuary.
>
> Note that this letter is signed by a broad coalition of concerned citizens. Fisherman, environmentalists, wives and students; all have common concerns in preventing another

> such catastrophe anywhere in the world. You will find it surprisingly easy to elicit support for a letter about the spill, if you act quickly, before it moves to the back pages of your newspaper... ("Letter to Congress re: AK Spill," nec, en.coastal, 10:13 am Apr. 1, 1989)

These initial forays into electronic activism stirred the pot, and the volume of offshore oil items in en.coastal soared. Alaskan groups and individual activists discovered in EcoNet a channel to the outside world, and first-hand accounts began to rival the wire service news reports in graphic description of the human-perpetrated disaster.

How effective this computerized agitation was may never be known, since little feedback was gathered, and none in any methodical way that could be called accurate. But the instantaneousness of electronic communication between citizen groups that were suddenly all tuned to the same focus, coastal impacts of oil development, drew information like a magnet.

Unlike the carefully mediated, edited versions of the Alaska spill that reached the public via conventional print, radio and TV news, the en.coastal conference was more like the oil slick itself -- expanding rapidly in unpredictable directions, uncontained by any human efforts.

The upshot of this raw, unexpurgated outpouring was an emotionally charged version of events as they unfolded. Unlike news stories that left only a feeling of distance and unease, en.coastal became a vital exchange that left a feeling of hope, the side of a disaster that shows what human beings can do when they work together as a community. This fits with veteran community organizer Saul Alinsky's view of what makes communication effective:

> People only understand things in terms of their own experience, which means you must get within their experience.
>
> You don't communicate with anyone purely on the rational facts or ethics of the issue.
>
> It is only when the other party is concerned or feels threatened that he will listen--in the arena of action, a threat or crisis becomes almost a precondition to communication (Alinsky, 1971).

> there, when we were putting out the FAX numbers for congresspersons and urging a strong last minute lobby, that was truly exciting and, I think, effective. But now the short lived crises of oil spill and moratorium are over, and CoastNet is sitting there idle, waiting for the next threat to appear. This is a shame, for now we have the time to do what really needs to be done, and instead, nothing is happening. We must move rapidly to change this state of affairs, or what's the point of maintaining CoastNet at all?

Jamie Newton's response also points to the need for keeping the communication channel alive between crises:

> Our overall evaluation is that CoastNet has been very valuable on special occasions, as in the aftermath of the Prince William Sound oil spill. In the low-use periods it has been a neglected resource that could have enhanced the work of all associated with it.
>
> The network will be increasingly useful as it gains members who have contributions to make and can benefit by exchanging information with others and working cooperatively, provided members stay active as network users. It seems that electronic networking needs to reach some sort of critical level of participation that makes it obviously, experientially worthwhile to users to remain regularly active.

Within the next five years, as computer and telephone begin to become synonymous, access to special-interest computer networks like CoastNet may be widespread. Pacific Bell, northern California's chief phone service supplier, has plans to sell a low-cost service to give its customers a "gateway" between various online services. And on the horizon, Pac Bell says it will introduce a phone-computer terminal at under $100.

> I think our telecommunication capabilities have been generally underused, but when used well they have been valuable, and the PWS spill illustrates that well, said Jamie Newton of the Central Coast Conservation Center. Even in that instance, we could have made much more of our communications opportunities. I think the time is ripe for a real expansion of CoastNet, to include people in Alaska, Florida, Louisiana, and other coastal states, as well as people in Washington, D.C. who are working at the national level for more beneficial policies.

The Central Coast Conservation Center, Greenpeace, Friends of the Sea Otter, Earth Island Institute and the Central Coast Counties Regional OCS Study Program used EcoNet to help organize an April 10 "Day of Mourning" for Prince William Sound, complete with major press conferences. Alaskan environmental groups, with the backing of Governor Cowper, declared April 23 "Prince William Sound Day," and used EcoNet to help organize a national observance, including suggestions for local activities that could be adopted by concerned citizens anywhere.

The volume of information continued to grow: first-hand reports and official statistics on dead wildlife, gripping personal accounts of the disaster, news of investigations into the cause of the tanker's grounding, stories of hush money and political dealing by those who would avoid responsibility for the spill...the stories continued to paint a graphic, multifaceted picture of the events.

In July, almost as a preordained response to the Alaska spill, Congress again imposed another one-year moratorium on offshore oil spending. By mid-July, just five months after what had been termed "the worst oil spill in history," the volume of information on the spill and offshore oil drilling started to decline as on-line postings became infrequent. New channels of communication were opened by the crisis, new contacts were made, but the en.coastal conference essentially went back to sleep.

The very nature of environmental crises as exemplified by offshore oil legislation and response to the spill--here one day, gone the next--poses some difficult questions about how to sustain interest in and education on the underlying issues that do not go away. Whether CoastNet or computer networking on environmental issues can rise to the challenge, or simply serve as extra channels when needed for crisis management, depends partly on the efforts of those involved, and partly on the way our society as a whole learns to deal with and use the new technology.

The Future of CoastNet

Both Gary Ball at the Mendocino Environmental Center and Jamie Newton at the Central Coast Conservation Center came to similar conclusions about the challenges that lie ahead. Said Gary:

> "Working for the last moratorium was an excellent example of what CoastNet can be and do. Especially at the end

CoastNet, even at its infant stage, provides several valuable opportunities that may be unique to its computerized telecommunication nature. As a mass-education medium, it now is available to some 1000 EcoNet subscribers. With a little extra effort, the same information could be broadcast and collected from all major colleges and universities in the United States that are part of the Bitnet intercomputer network, to or from public agencies and private organizations and industries via the Usenet network and other telecommunications systems.

The example of intense interactive communication as events unfolded around the Prince William Sound oil spill show that CoastNet, however it is accessed, has tremendous potential as a medium for experiential education. Those involved in discussion of vital issues via computer conferencing may choose to be passive observers, but they have at any time the option to interact with, comment on and affect real-life situations as they unfold.

Because information added to the CoastNet system is permanently archived, it essentially becomes a unique and historically significant library resource that is globally accessible. Ultimately, improvements in data storage on EcoNet may make any issue that has crossed the wires and satellite links, such as offshore oil development or oil spills, retrievable by searching for key words or specific criteria.

As a tool for citizen activism, CoastNet has only begun to realize its potential. Here it is treading on new ground, creating from scratch a model that has tremendous implications for democratic political systems at all social levels.

Some of the future tasks for CoastNet are clearly defined by the issues, their constituency and the realities of environmental politics and organizing, as Gary Ball notes:

> We should be electronically networking with the other coastal states and gaining their input and support for an ocean sanctuary bill that the whole nation would support, and even demand. We should be brainstorming ideas of how to reach out to environmental organizations, political action groups, educators and the public in general. And of course, we should stand always at the ready to deal with any crises that may arise, as they most certainly will arise until the world is finally able to stop messing around with massive quantities of the black goo.

But that's the easy part. The hard part is going to be coming to terms with our human limitations, reaching agreements on what CoastNet is or should be, and making the effort to see it happen. As Gary Ball writes:

> In short, en.coastal may be the right vehicle to accomplish great things, but right now the vehicle has no driver. CoastNet, as it is now, should not be called an organization, for we have failed to organize. Computers are great, but what is needed now is the painstaking human effort of deciding who we are and what we're doing.

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Notes

Andrew Alm coordinates monthly production of ECONEWS, the Newsletter of the Northcoast Environmental Center in Arcata, California, and volunteers as facilitator for the en.coastal conference on EcoNet.

Copies of "The Valdez File," the complete collection of postings in EcoNet's en.coastal conference on the Alaska oil spill of 1989, are available as a text file on computer diskette for $5 from the Northcoast Environmental Center, 879 9th St., Arcata, CA 95521. Specify Macintosh or DOS format. Inquiries concerning CoastNet should go to the same address, or to the following e-mail accounts:

EcoNet: nec or bball or jnewton
Bitnet: cdp!nec%labrea@stanford

ADDITIONAL RESOURCES

In addition to the resources noted in the preceding articles, the following resources may be of interest. This list represents computer-aided environmental education projects developed *by environmental educators* which reflect current and future trends in the field. It is not a comprehensive listing. I've only listed resources that are currently available, high in quality, and represent the current state-of-the-art. If you know of others that should be added to this listing, please send that information to:

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Rohnert Park, California 94928

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Internet/Bitnet: Rocky_Rohwedder@sonoma.edu
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Laser Videodiscs

"Our Environment" Videodisc Project

With support from the U.S. Department of Education, the "Our Environment" Videodisc Project will provide a single source for thousands of still images and motion sequences concerning environmental problems facing modern society. Aimed at grades 5-8, the videodisc will have four broad sections: global overviews of physical and human geography; human impacts on air, water, land and organisms; environmental problems (including acid rain, species extinction, soil erosion); and a visual glossary which defines and illustrates more than a thousand environmental concepts and terms. A caption frame will explain each video picture. Supporting print material (teacher and student guides) will facilitate using the disc and suggest activities for student learning.

For more information, contact:

Environment Videodisc Project
University of Wisconsin -- Stevens Point
Department of Geography and Geology
Stevens Point, WI 54481

715/346-4177

Macroscope Ecology Videodisc

The Macroscope Ecology Videodisc is a unique form of image database designed to document field sampling of plant communities throughout the San Jacinto Mountains of California and a range of samples from Venezuela. The visual database consists of 18,000 single-frame video images of subjects ranging form color air photography, ground-based oblique panoramic images from 11,000' to sea level at 1,000' intervals, close up images of herbarium records and museum specimens (vertebrate and invertebrates), and contributed photography from numerous natural history photographers. Also included are step zoom images of map resources, soil profiles, and unique ecological subjects. The first laserdisc volume is now available with a 4 megabyte Hypercard demonstration stack.

For more information, contact:

Michael Hamilton
San Jacinto Mountains Reserve
University of California, Riverside
P.O. BOX 1775
Idyllwild, CA 92349

714/659-3811

Distance Learning

Global Laboratory Project

A new, NSF-funded project, the Global Laboratory will involve secondary teachers, college faculty and students, developers and scientists in the use of computer-based communication to undertake studies that will be of scientific interest and will therefore contribute to better understanding of global environmental problems. Students will be involved in measurement, modeling, data analysis and experimentation activities on a variety of topics.

For more information, contact:

Robert F. Tinker
Technical Education Research Centers (TERC)
2067 Massachusetts Avenue
Cambridge, MA 02140

617/547-0430

Computer Courseware

National Geographic Society Computer Courseware

The National Geographic Society has been a leader in computer-aided environmental education. Courseware includes software, filmstrip, student booklets, and a Teacher's Guide with activity sheets. They have several offerings, including: Project Classify: Plants and Mammals; Project Zoo; and The Weather Machine. Designed for Apple II computers, this courseware is colorful, graphic and easy to use.

For more information, contact:

National Geographic Society
Educational Services
Washington, D.C. 20036 1-800-368-2728

Earthquest

Earthquest is an amazing stack with four "windows" to explore: natural systems, the human journey, the environment and fragile ecosystems, and continents of the world. It includes animated "movies", samples of language, maps, charts and tables, interactive games, and text.

Interdisciplinary in orientation, this program shows the amazing capabilities of HyperCard. It requires a Macintosh Plus with 1 MB or any more powerful Mac with a hard drive. $79.95

For more information, contact:

Earthquest
125 University Avenue
Berkeley, California 94301 415/321-5838

Balance of the Planet Software

Balance of the Planet is a computer simulation game where you act as the "High Commissioner of the Environment", levying taxes and granting subsidies in an effort to solve a variety of global environmental problems. Designed for adults, the program features 150 screens detailing environmental issues, simple "hypertext"-like browsing capabilities, a detailed reference manual, and user-changeable equations for direct control of the simulation. A Teacher's Guide is currently under development. Available in IBM PC (and compatibles) and Macintosh versions. $49.95

For more information, contact:

Accolade
550 W. Winchester Blvd., Suite 200
San Jose, California 95128 800/245-7744

Audubon Wildlife Adventures

Audubon Wildlife Adventures is a courseware series focusing on wildlife conservation issues. Current releases include grizzly bears and whales. sharks and "poacher patrol" are under development. The series features up-to-date scientific information, state-of-the-art graphics, computerized data bases and on-line guide books. The supporting guidebooks include instructions, questions and answers, activities and worksheets.

Computer requirements: IIe, IIc, IIc Plus, IIGS with at least 128K of RAM. A color monitor is recommended to fully appreciate the great color graphics. Cost $50-$60 (depending on your hardware). Additional $30 for School Edition which includes the support materials mentioned above.

For more information, contact:

Advanced Ideas Inc.
2902 San Pablo Avenue
Berkeley, CA 94702 415/526-9100

SimEarth

Based on the Gaia theory, as proposed by James Lovelock, this simulation game is a caricature of planetary ecosystems. The goal is to modify, manage and nurture a planet from creation, through the formation of life, to the development of technology. Once your planet is established you can watch and manipulate the influence of various factors. This company also wrote SimCity, a simulation game with the same flavor but based on urban systems. At press time, SimEarth was still being testing and refined. Both a Macintosh and PC version are under development.

For more information, contact:

Maxis
1042 Country Club Drive, Suite C
Moraga, CA 94556 415/376-6434

Wildways: Understanding Wildlife Conservation

This computer courseware combines information from the fields of biology, geology, and sociology in an effort to emphasize the need for wildlife conservation. It is designed for secondary and college students. Sections include: Earth and Life, Basic Necessities of Life, Importance of Wildlife, Population Ecology, Community Ecology, Extinction, Wildlife Management and Citizen Action. Designed for the Apple II series of computers.

For more information, contact:

Opportunities in Science, Inc.
P.O. BOX 1176
Bemidji, Minnesota 56601 218/751-1110

HyperCard Stacks

Interactive Energy Education Curriculum Library

This interactive HyperCard™ database is an annotated collection of over 100 current energy education materials. With a click of the "mouse" on the appropriate graphic symbol, users can search the database for materials in a specific energy area (solar, conservation, coal, wind, etc), in a specific grade level (K-3, 4-6, etc), or a specific discipline (math, biology, chemistry, physics, etc). Annotations include information on content, price, and availability.

Available only for the Macintosh, this database requires a hard drive and the HyperCard program. Cost: $12 (includes postage and handling)

For more information, contact:

Energy Education Curriculum Database
Energy Center -- Sonoma State University
Department of Environmental Studies and Planning
1801 E. Cotati Avenue
Rohnert Park, California 94928 707/664-2577

World Game Global Data Manager and Global Recall

The Global Data Manager is a dedicated spreadsheet computer program which displays over 180 variables for every country and continent in the world. Data on population, food, energy, education, natural resources, economics, etc. is stored, retrieved, added to, sorted, compared, changed, plotted on a map, and graphed.

MS-DOS and Macintosh versions available. Cost: $125 Additional data disks are available for $100.

Global Recall is a Hypercard-based geographical and statistical software product with over 200 scaled maps of the world, its continents and 165 countries, plus the most important statistics for each in areas such as agriculture, military, population, economics and environment. A supporting teacher's manual is also available.

Macintosh version only. Require Hypercard 1.2.2 or later. Cost: $85

For more information, contact:

World Game Institute
3508 Market Street
Philadelphia, PA 19104 215/ 387-0220

Global Warming: Impacts and Solutions

The International Foundation for the Survival and Development of Humanity (IFSDH), together with a group of volunteer computer experts from Apple Computer Inc., has developed a graphics-based, interactive software program focusing on the problem of global warming, its potential impacts, and mitigation strategies. The goal of the program is to graphically illustrate the perils of global warming and to highlight the role of energy efficiency and renewable energy in reducing the threat of global warming.

The program is divided into three sections:

- How Global Warming Can Affect Our Lives
- The Science of Global Warming
- What We Can Do About Global Warming

Computer requirements: Apple Macintosh Plus, SE, SE30 or Mac II with a hard drive or two floppy disk drives and Hypercard 1.2 or higher. The program is available for only $10. It is distributed by EcoNet.

For more information, contact:

EcoNet
3228 Sacramento Street
San Francisco, CA 94115

415/923-0900