HYPERMEDIA: POTENTIAL FOR STORING, MANAGING AND COMMUNICATING NATURAL RESOURCE INFORMATION

by

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INTRODUCTION

Efficient management of natural resources requires the ability to utilize and integrate information. The challenge is to fully utilize this information base with its various degrees of accessibility, ever increasing volume and dispersed nature. The manager must be familiar with media types used to store, manage and communicate this information.

New technologies are constantly evolving which will be instrumental in helping us deal with the ever increasing amounts of information. Furthermore, these new technologies will aid in more effective application of information. For example, Geographic Information Systems (GIS) have been developed to input, store, manipulate, and output spatial data. Most GIS´s use Data Base Management Systems (DBMS) technology which enables storage and manipulation of very large data sets. Some packages even include statistical analysis capabilities which permit the analysis and comparison of large data sets.

Data regarding ecosystem components are input into these software/hardware systems and assist us in decision making. Analysis of these data results in facts, the building blocks of knowledge which in turn lead to increased insight and enhanced understanding of our ecosystems. This knowledge is usually embedded in text material which enforces and supports its identity. Historically, the storage mechanism for this knowledge and it´s attendant context has been linear text. The use of linear text as a storage medium hasn´t changed appreciably since Gutenberg developed the first printing press. However, print technology has allowed this information to be spatially dispersed on a large scale. Mass production has also allowed a larger segment of the population to be exposed to printed material . Since the turn of the century, information has proliferated in journals, textbooks and magazines. The sheer magnitude of this information effects its accessibility and usefulness to the general public. Information stored in full text form requires a very costly and inefficient use of space. Space has become expensive and will continue to be more expensive in the future. We must explore new alternatives in information storage which enable indefinite storage while increasing its accessibility. Diener (1990) points out that current systems are not adequate enough to allow dynamic, interactive, and real time communication of information. Although large steps have been taken which have alleviated much of the unwieldiness of information retrieval, much remains to be done.

Presently, data bases and information retrieval systems dealing with different disciplines are commonly used at most libraries. These include citation retrieval (author, date, title, publication, page numbers), in many cases including an abstract and in a few cases a full text retrieval capacity. These systems certainly represent an improvement over the card catalog, but still fall short of the need for future information retrieval. If desired, one should be able to extract the essence of a work rather than to page through related narrative to find relevant information. Of course the essence for one person may not be essence for another person and user requirements (context) is important in determining the essence of a work.

Neuralware

Future automated information systems will probably include the potential to mimic human information processing patterns. If one examines recent cognitive psychology theory, it is apparent that people input new information into short term memory, which is cross checked with each individual's existing knowledge structure (Jonassen, 1988). This input, if deemed accurate or useful by the person, is linked into the conceptual structure (long term memory), thereby enhancing the individual´s knowledge regarding the subject matter. This sequence of events is analogous to taking notes on index cards where new bits of information are added into a particular subject area (node/group of nodes). These cards (nodes) are linked by threads to other similar cards that share the common attributes of the category. The node/link pattern is used in the newer knowledge modeling technologies such as semantic networks. According to Bejar et al. (1991), in semantic networks concepts are represented by nodes which are connected by labeled arcs or pointers. The pointers represent the relation between the nodes. In this type of system, each concept is defined in relation to other concepts. In order for this organization (node/link) to function, a categorization process must take place. Lumping experiences, occurrences, etc., into like categories is critical if assimilation of information is to take place. Concepts or categories have an internal structure, being organized around prototypes that represent the central tendency of the category (Bejar et al. 1991).

Categories are very important in the management of any set of phenomena. In our example, the management of natural resources requires categorization, which allows us to deal with groups rather than individual instances or component instances. For example, we can deal with individual spotted owls (Strix occidentalis caurina) which represent unique genetic packages (instances of the class owl, subclass spotted) and which react to environmental descriptors (attributes) in a slightly different way than other instances of owl: spotted. In contrast, we can deal with owls as a group or groups of spotted owls. However, if we deal with the group (species) concept, we also accept, by default, the degree to which we can predict or infer how the owl: spotted, will react to environmental attributes or changes in attributes. We must accept the degree of freedom with which we can expect the category to behave in a certain way. Similarly, the matrix (environmental factors) in which we find the owl can also be categorized. However, groups of phenomena and groups of interactions are much more difficult to predict and manage for than single species or single instances. Landscape elements (plant species, topography, climate, soils, disturbance patterns, etc.) can, however, be grouped into meaningful categories. Hierarchical or network arrangements seem to work best when dealing with these categories.

Individual differences also exist in the way humans wish to view these environmental phenomena. Individual perceptions also differ among individuals due to the scale at which these entities are viewed and preferred scale of operation. Are we Reductionistic or Holistic in our view of the world? Most likely we are somewhere on the continuum between these two extremes. Of course, the position held on this continuum has a great deal to do with the entity being evaluated and the level of the understanding that an individual has of the entity. These differences have been attributed, at least in part, to brain structure and chemistry and, particularly, brain hemisphere dissimilarity. According to Riedl (1984) the left hemisphere of the brain operates from strengths in sequentiality, verbal and analytical capabilities. The right hemisphere, in contrast, operates more efficiently on tasks requiring spatial, synthetical and non-verbal skills. The two hemispheres work in unison on a problem, communicating continuously through the corpus callosum. Again, we operate on the continuum which exists between these extremes. Each individual is then unique and slightly different than other individuals due to combinations of the continua. These theories are constantly being refined and there is still considerable disagreement among researchers regarding these issues.

Software/Hardware

Development of computer technology has been heavily influenced by our perceptions of reality (sequential/simultaneous, verbal/graphic) described above. Software developers have historically worked through the linear or procedural paradigm. Recently there has been a trend towards balance of sequential and simultaneous philosophies. Currently these types of thinking are represented in personal computers through the DOS and Windows operating environments used by IBM compatible micro computers. DOS is much more geared to those who tend to be more analytical/sequential, whereas the Windows environment is more closely related to the graphic/spatial/simultaneous style.

Development of software has followed a path from the exclusively sequential pattern (procedural paradigm) to the open inclusive design of the object-oriented paradigm (OOPS). The OOPS pattern in characterized by 1) encapsulation, 2) message passing, 3) inheritance (Thomas, 1989)(Korson & McGregor, 1990). Encapsulation means that procedure and data access are contained within a module of code. This block of code can be reused in another program and is activated by passing a message to it. This is in contrast to the global nature of procedural languages. Inheritance is passing of characteristics from the class to each of its instances. OOPS has the general quality of modularity which is shared by more recent technologies such as hypermedia.

Hypermedia is a technology which developed partly out of the need to address large amounts of information, to connect (dynamically) disjointed (spatially and contextually) information, and the philosophical need to produce a cognitively comfortable information management system. Ted Nelson, the person credited with coining the term hypertext, envisioned a global system of linked data, information and knowledge (Nelson, 1974, 1978, 1981, as cited by Jonassen

(1988). These data could be accessed by anyone, with authors receiving royalties from each access.

Yankelovich et al. (1988), describes hypertext as "a system" which allows an author or groups of authors to link information together, create paths through a body of related information, annotate existing texts, and create nodes that direct readers to bibliographies, data, or the body of the referenced text." Hypermedia is the natural extension of the hypertext pattern to include graphics. These systems have been extended to include audio, animation and video. The concept of Hypermedia has often been used synonymously with multimedia. Some have suggested differentiating Hypermedia from multimedia by using the degree of interactivity possible. Multimedia would enable much more interactive processes than would hypermedia (Franklin and Kinnell, 1990).

Simply, hypermedia follows the non-sequential pattern by enabling the user to follow linkages within the information base without regard to how the information was/is structured (Fig. 1). This pattern is similar to that used in encyclopedias, i.e. "see also". The computer (software/hardware) has made the dynamic linking of information structure possible. The computer acts as an intermediary between the user, the information and the information media (CD Rom, video tape, audio, laser disk, etc). As was discussed earlier, this pattern tends to more closely resemble the current theory regarding human memory patterns. It seems reasonable to assume this link/node system would be more comfortable to work with than a strictly sequential system due to the increased compatibility. The passage of information from internal (brain) to external (society) to internal (brain) should be enhanced by using this model. Further, using an object-oriented approach should facilitate concept building. Modules can be interchanged or integrated into larger systems facilitating their

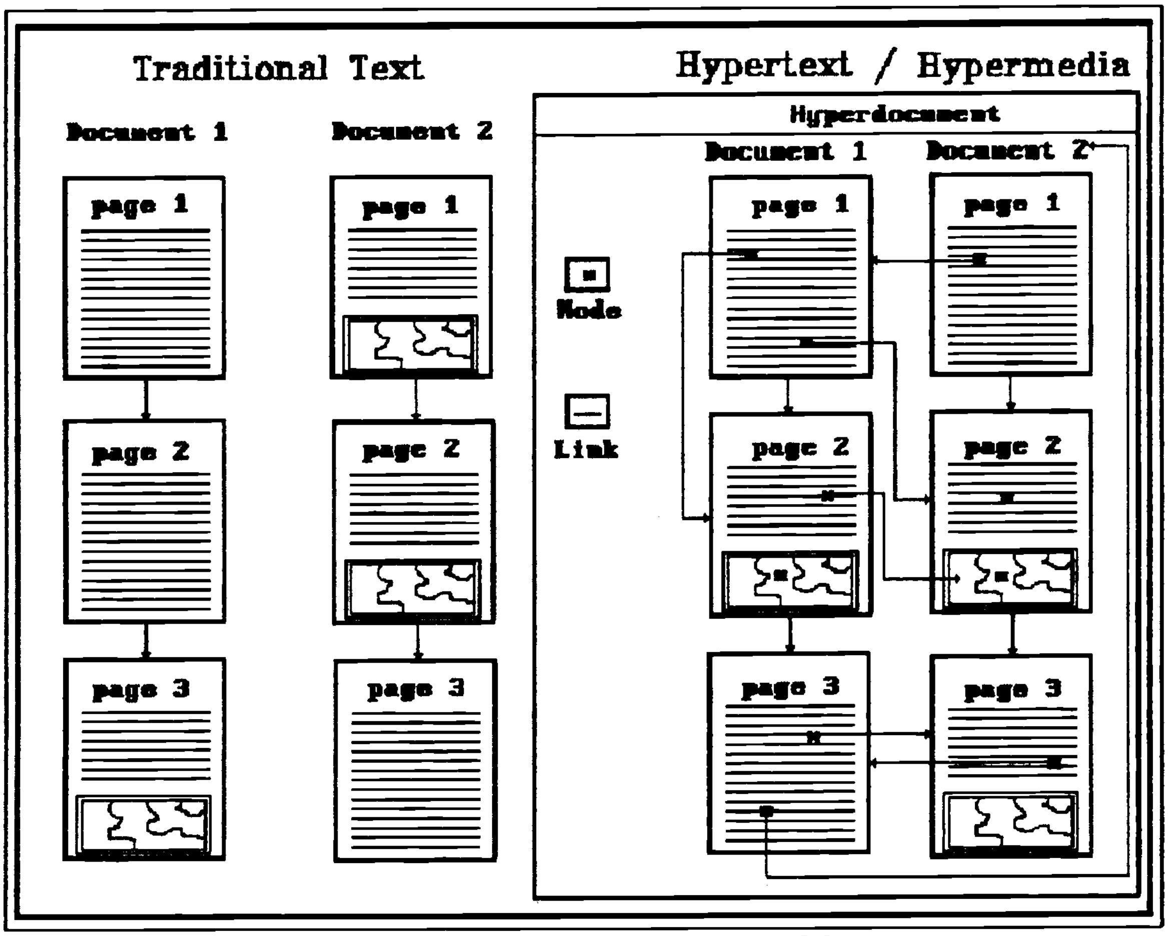

Figure 1. Differences between traditional text and hypertext.

usefulness to the user. According to Horn (1989), hypertext (hypermedia) can be used in six general modes.

1 - Browsing

2 - Training

3 - Briefing (presentation)

4 - Learning and analysis

5 - Help

6 - Referencing

Within each of these modes, users may implement one or a combination of several strategies (Jonassen, 1988). These include seeking information:

- of personal relevance
- which is dependent on the interest level
- for curiosity fulfillment
- based on experience level
- based on needs
- regarding a task.

Since these systems (Hypermedia) closely resemble functions of the human mind, as described by current theory, they should serve as an extension or augmentation to human thought (Franklin and Kinnell, 1990). The management of environmental information should be facilitated by using this neuralware/software/hardware/system which enables the node/link methodology. Natural systems are characterized by structural and functional components which can be represented by nodes (content) and links (structure). These components (nodes) are linked by processes and interactions which ultimately form ecosystems.

Importance of Context

A discussion of non-sequentiality would not be complete without mentioning the importance of context. Context as used in this paper is defined as material or settings which support the essence of facts presented. Context can be stated by either text or graphic means. Printed sequential text has evolved from a need to present information within a context. The importance of context is ultimately felt in the maintenance of language and the evolution of cultures. The challenge to any new knowledge management paradigm will come from the problems associated with the maintenance of this context. In order to fully understand the subject being related by the author, the reader must be exposed to context (Glover et al., 1990). Context may exist explicitly or implicitly. The efficiency with which individuals assimilate knowledge has a great deal to do with the context in which the knowledge was presented by the writer and the contextual filter of the reader.

Impetus for Change

In a typical management system (rangeland management) a manager is required to integrate information from different sources to reach management decisions. This information may include:

- Articles in professional journals
- Reference and text books
- Notes from previous experiences
- Expertise from co-workers or predecessors
- Tabular data - data bases, spreadsheets, etc.
- Legal documents
- Diagrams, charts, technical drawings
- Plant collections (herbarium)

In addition, she/he will probably be required to utilize maps which might describe:

- Soil type distribution
- Plant communities (present types)
- Habitat types (potential types)
- Wildlife distribution
- Topography (slope, aspect, elevation)
- Climate
- Land ownership patterns

- Hydrology
- Improvements (fences, water developments, etc.)
- Disturbance patterns (fires, erosion, plant species)

Recently these spatial entities and their attributes have been entered into Geographic Information Systems (GIS). These GIS manage the representation of spatial phenomena through data base technology. Digital representations of these spatial entities and their attributes (descriptors) are stored in formats accessible by other systems. Once this information is in digital form it can be accessed by other technologies such as hypermedia which extends the usefulness of the original data (information).

As mentioned earlier, a major key to management is the ability to group phenomena, both spatial and non spatial, into categories whose behavior can be "predicted" within an acceptable degree of accuracy. Technologies such as GIS and Hypermedia allow us to view these phenomena in new and unique ways permitting true integration of data and thought and allow us to dynamically "construct" categories in ways that were not possible before.

Although there are prototypes which best exemplify each of these categories, most instances of each class will be distributed on the continuum within each category. For example, instances of vegetation type A are alike only in degree with respect to composition, structure, function and spatial distribution and the degree to which they differ from instances in another type (B). Instances and groups of instances can have boundaries in space and time, although there may be gradients present in many cases. Individual plant species may be represented by several subspecies or ecotypes which can be further represented by different genetic material. These categories are based on

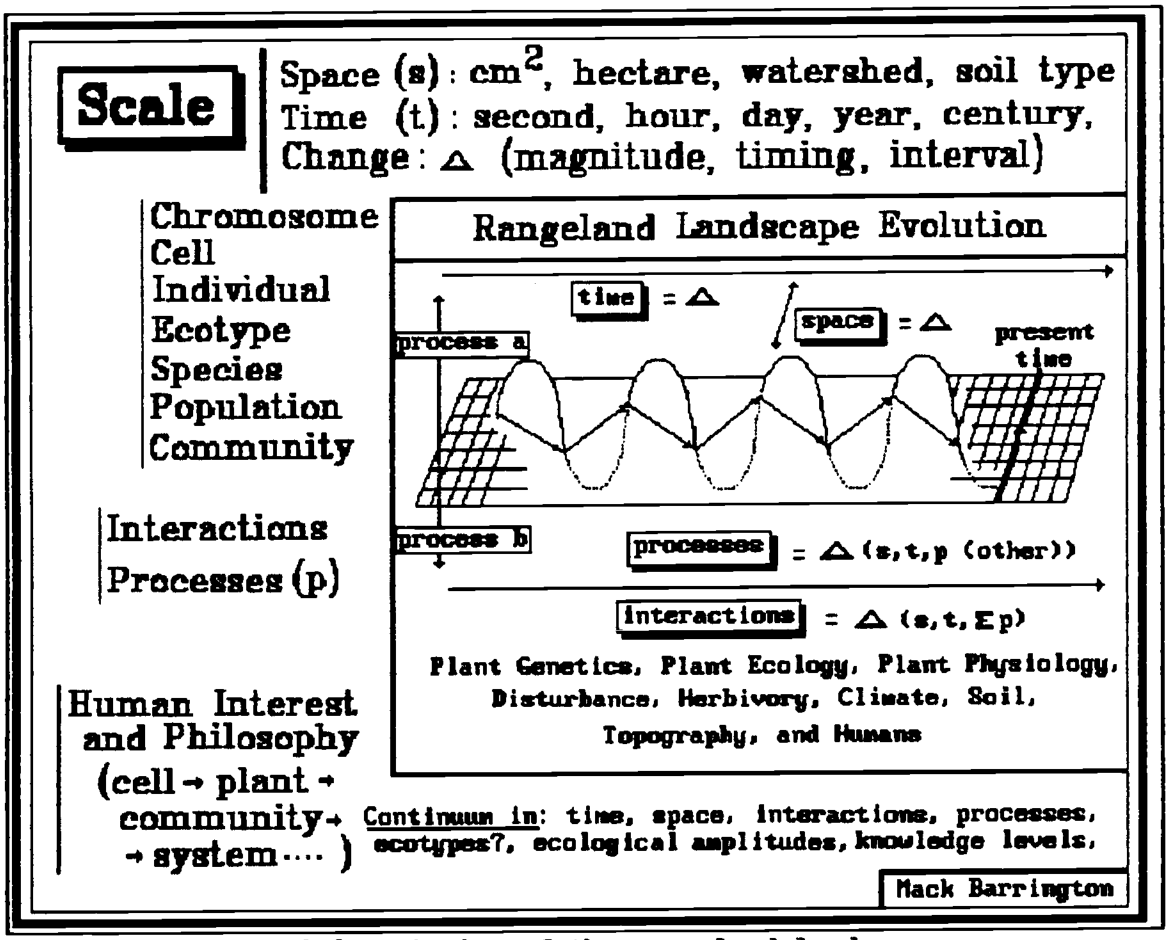

Figure 2. Scale and description of the rangeland landscape.

observable characters (macroscopic/microscopic) but also involve the human capability of concept formation (Lakoff, 1987). The attributes used to classify each instance will also undoubtedly fluctuate when viewed at different scales (Fig. 2). The manager must deal with these entities which have substance in time and space and which can be expected to change and interact in these dimensions. Entity structure, function, change (disturbance, replacement, etc.) and interaction must be dealt within a framework which allows transfer, commonality, communication and application of management actions. The application of these concepts may also require spatial and temporal uniformity.

It seems reasonable to think that the natural resource manager's job could be supported by a system which managed pertinent information in an integrated digital environment, particularly if the system utilized existing digital data such as those produced by GIS analysis. Graphics such as plant drawings, plant photographs, technical diagrams such as those depicting water development specifications or ecosystem interactions could be easily integrated with other system components. The integrated neuralware/software/hardware system should provide the manager with increased power of insight, increased understanding and result in higher efficiency. Further, more comprehensive decisions should be made possible by using this system. This is all based upon a solid plan built on categorical frameworks.

APPROACH

The Setting

In order to explore the potential of hypermedia, categories and concept formation, I developed a fictitious prototypical example (Rangeland Hypermap) which depicts conditions found in rangeland environments of the Great Basin. This "place" (Rancho Generico), although non-existent in space and time is characterized by entities and attributes (descriptors) which have real meaning. This area portrays changes in topography, plant communities, soil types, management, land ownerships, and wildlife species which are commonly found in parts of the Great Basin. This example also includes "materials" (knowledge, data, examples) typically used by land managers in decision making activities. For example, information regarding plant species includes spatial distribution, taxonomic characters, associated species and their visual appearance. Similar information is included for other resources which might be found in these types of environments.

The Hardware Model

Development of this application took place on an IBM personal PS/2 computer (286) with 1 MB of RAM and a 20 MB hard drive. The display was a monochrome (B&W) VGA (all graphics were developed in the monochrome mode - MODE BW80). Primary interface with the system was accomplished with a mouse. Images were input to the system with a hard scanner or manually entered (mouse) using a paint program. Images were stored on the hard drive and archived onto 3.5" floppy disks.

The Software Model

The major component of this application is the KnowledgePro (**KP**) development system. KP was developed by Bev and Bill Thompson at Knowledge Garden, Setauket, N.Y. KP has three major attributes: 1) it is an object oriented environment; 2) it has expert system capabilities; and 3) it provides hypermedia facilities. This combination allows effective and dynamic communication of information.

Central to KP is the concept of topic (object). A topic in KP can store procedures, store variables, return functions, be assigned properties, inherit values, behave like system commands, be arranged hierarchically, or represent hypertext nodes (Thompson and Thompson, 1988). My project stresses the use of hypertext facilities in KP but other capabilities could be integrated as well. The KP system consists of many commands but has six main ones: 1) SAY - to display a message; 2) ASK - to ask a question of the user; 3) IF, THEN - to make decisions; 4) #M - to mark hypertext concepts (links); 5) WINDOW - to open a window; and 6) CLOSE-WINDOW - to close a window.

The DOS version (a windows version is also available) of KP integrates graphics and text through a software module called Picture.HKB that activates a graphics screen which in turn activates a topic that includes a screen image. This capability is used most often with a hypertext link from a text screen but can also be used to link two or more graphics screens.

Images for this project were created in two ways. First, pen and ink drawings (previously composed) were scanned into a paint package. Images were enhanced, annotated and saved as TIFF files. The paint software (PaintShow) included a file conversion utility which enabled image conversion to the PCX format needed by KP. However, most of the images were manually created in the paint program then converted from TIFF to PCX format. The mouse was used to manipulate the image construction process.

When portions of an image were to be used in more than one topic, e.g. base maps, templates were first constructed and saved. Templates provide three functions: 1) Consistency - each image constructed from a base template had the same base characters as others constructed from the same template, which provided simplicity (elegance); 2) Time - image construction in most cases was very time consuming, probably the most time consuming part of constructing the knowledge base. Time required to construct images ranged from 15 minutes for the base map (Fig. 3) to 20 hours for the shaded relief map (Fig. 4); and 3) Continuity for the user - images with common attributes can be mentally arranged more easily than sets with no continuity (Figs. 5 and 6),. Communication of more complex concepts can be accomplished by using pointers from one image to another. Research indicates that more information is mentally retrievable if this continuity is observed (Kulhavy et al., 1992, Larkin and Simon,1987). Iconic representations are also helpful in depicting these relationships.

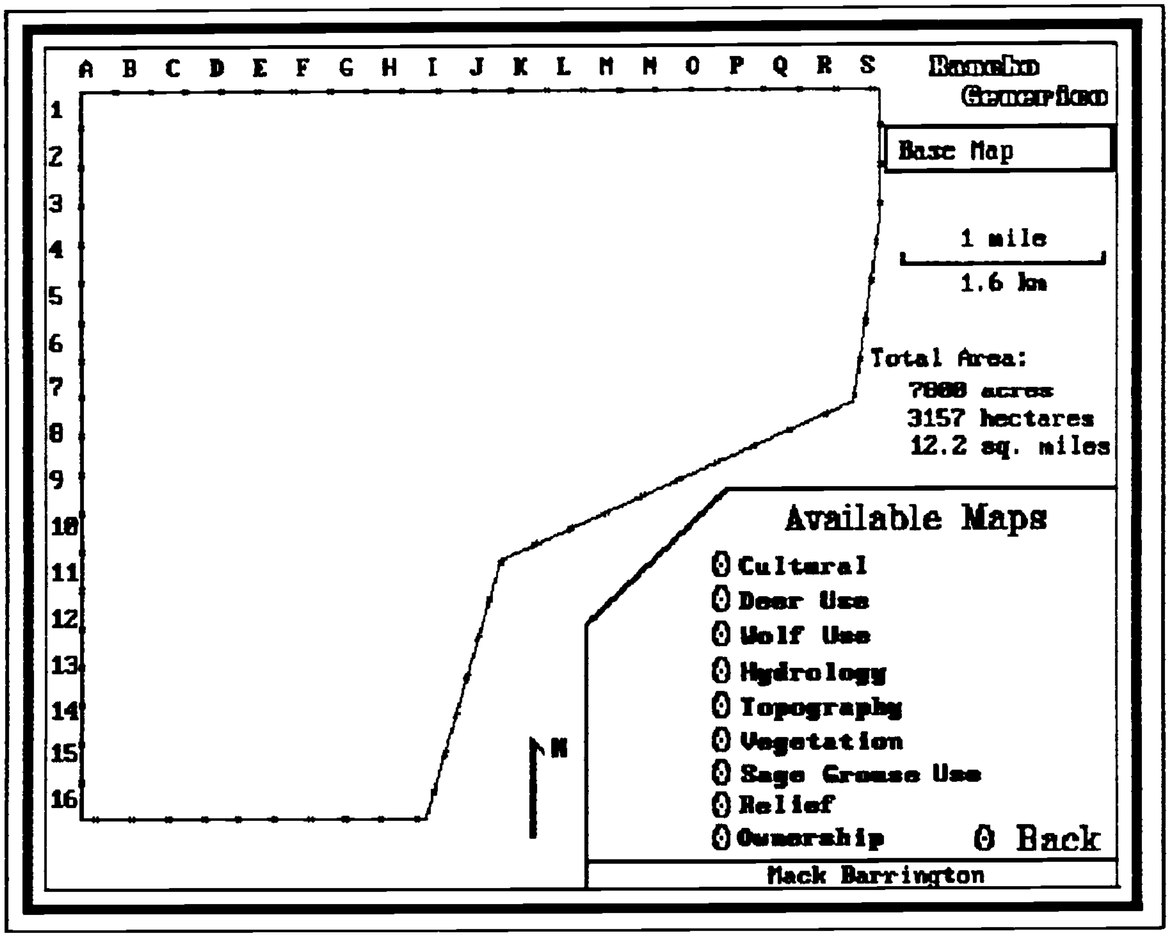

Figure 3. The Rancho Generico base map template.

The System Model

My objective was to create a prototypical enriched learning/reference environment (ELE) where the user could be exposed to the "ecosystem" (a rangeland system) and to the components (plant species, management actions, disturbance patterns, animal species, etc.) of that "ecosystem". The ELE is needed to empower the user with powers of integration, extrapolation, contemplation, exploration, imagination and interrogation. The ELE needed to be flexible enough to allow for individual level of understanding, perspective and interest levels. The ELE needed to be technically accurate and to convey a sense of reality even though it was based on a fictitious point in time and space. The graphics developed needed to be accurate and thought provoking leading users to "read between the lines" and enhance their own mental model of the subject matter. Incorporation of scale (information, space, time, change) was also important. Of course, the scope of these demands goes well beyond this paper and even beyond one application. Therefore I had to restrict the knowledge base and keep it as simple as possible.

Overall, KP was chosen for this project for its ability in dealing with comprehensive information and it´s ability to compartmentalize information. It was also selected because it offered facilities to deal with conceptual structure in an ordered way.

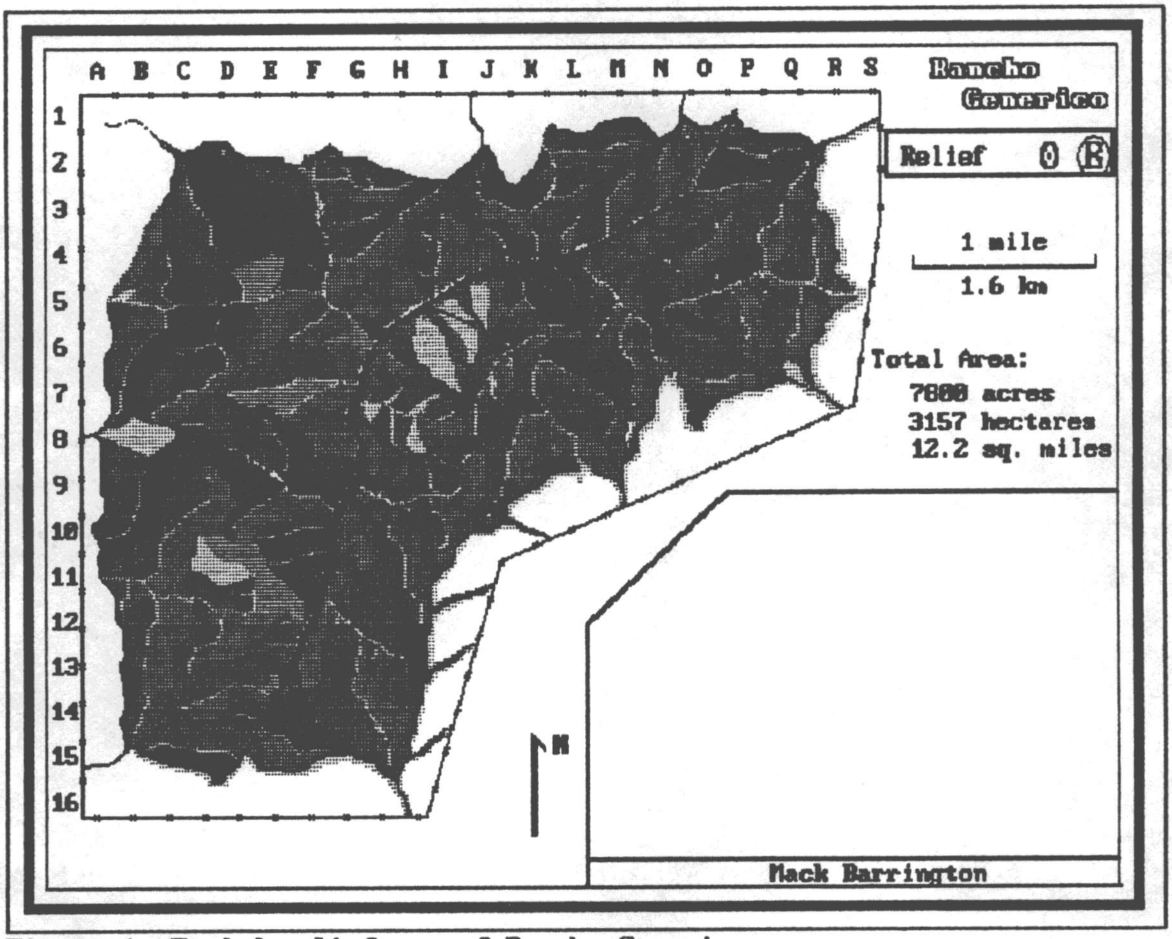

Figure 4. Shaded relief map of Rancho Generico.

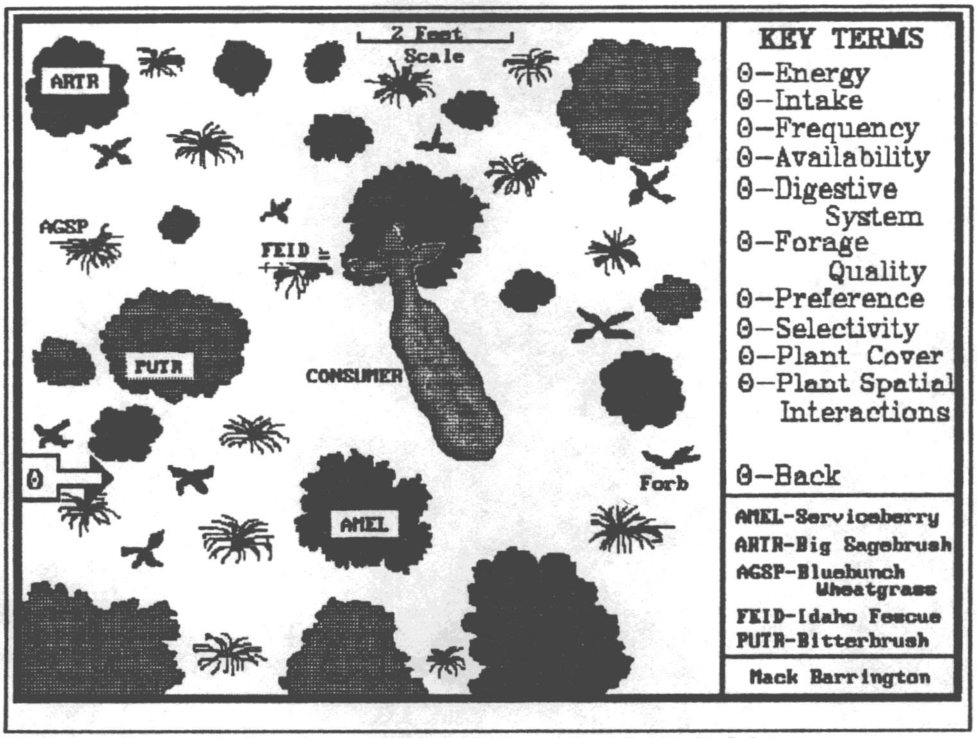

Figure 5. Aerial view of typical mule deer habitat.

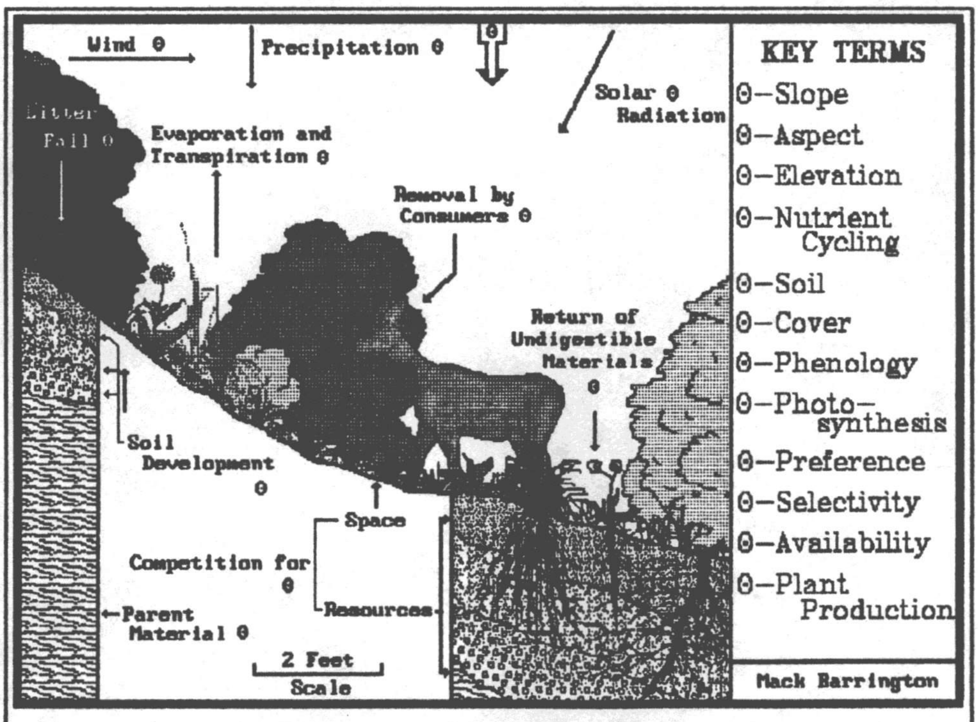

Figure 6. Profile view of typical mule deer habitat.

RESULTS AND DISCUSSION

The Rangeland Hypermap (RH) knowledge base was developed using the Developers version of KnowledgePro which means that a runtime version of KP can be distributed with this application without further royalty.

Structure

The RH example first presents the user with a graphics screen (Fig. 7)

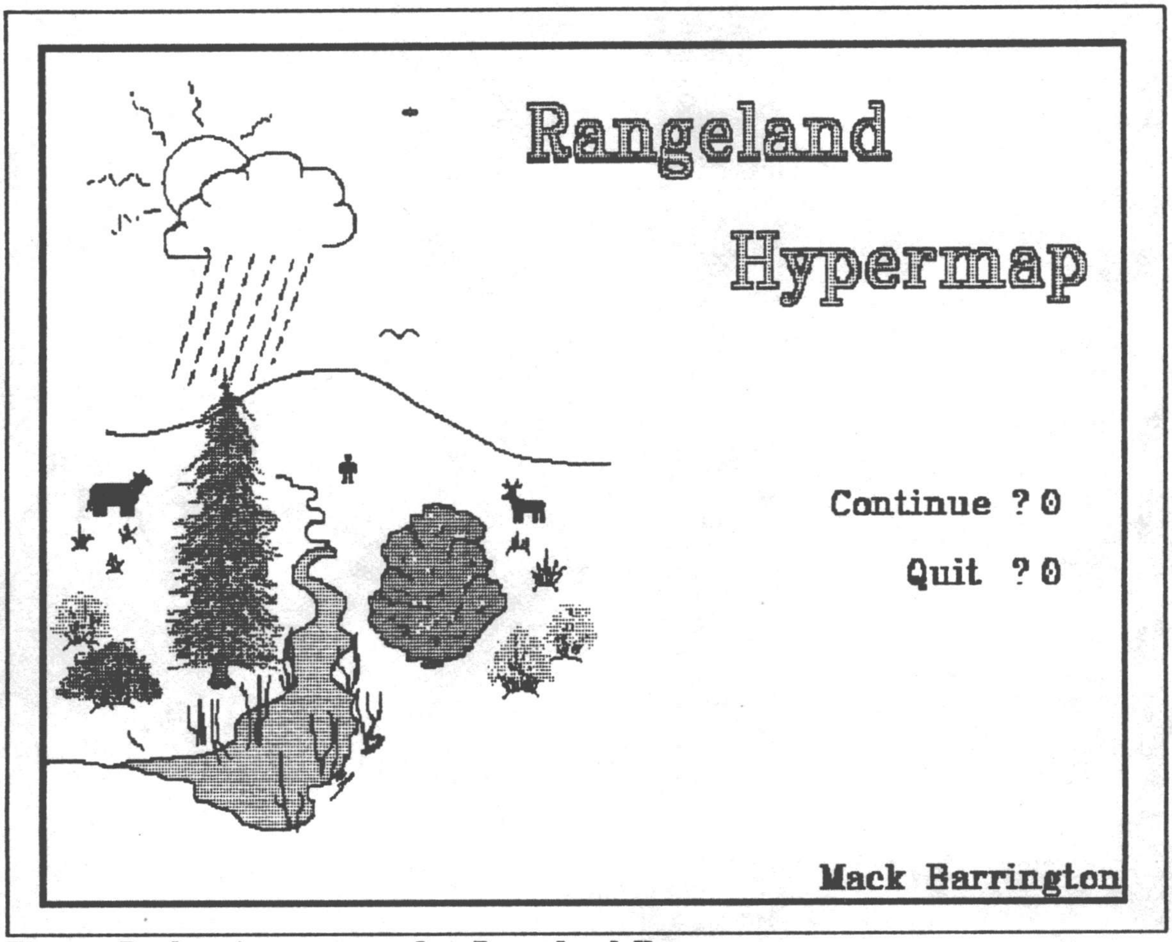

Figure 7. Opening screen for Rangeland Hypermap.

containing two hypertext nodes: 1) continue or 2) Quit and return to main KP menu. By using the left mouse button, the user can select either of these nodes. If the continue node is selected, then a text screen is presented which includes a table of contents where the user can select several paths which involve different components of the knowledge base. Some of these nodes involve graphics (maps) which include:

- Land ownership patterns
- Cultural improvements
- Topography
- Vegetation
- Mule deer distribution
- Sage grouse distribution
- Hydrology
- Soils

Other graphics include:

- Plant drawings
- Habitat diagrams
- Landscape views

Nodes can also be selected which describe management related text material regarding:

- Human Information Processing
- Automated information processing
- Scale and hierarchy
- Glossary of terms
- Calculations and conversions
- Plant species
- Wildlife management
- Rangelands
- Livestock management

All of these nodes have one to several sub-nodes that lead to additional information. At any point, the user can activate the right mouse button to reverse the node/link sequence. Additionally, F-10 on the keyboard can be used to exit from any point within the knowledge base.

Function

The RH knowledge base works reasonably well in the presentation of needed information. The computer system did present significant problems, however. Most of these problems revolved around processor speed (10 mhz) and hard disk access time (45 MS). I´m confident that a 486 (50 mhz) machine coupled with a large/fast SCSI hard drive and caching technology would produce excellent results. I found that speed of presentation was critical to get the full effect of hypermedia. A slow hypermedia system is not desirable in most cases.

The software (KP) presented another potential problem affecting speed. KP (DOS) uses a separate screen setting for text and graphics. Significant time was required to switch between text and graphics screen settings, a commonly required procedure in hypermedia.

I found that building a simple knowledge base such as RH required significant amounts of time. Decisions about content, information chunking, information structure required much background reading and planning. However, planning is critical to design of information extraction. This is particularly true when trying to emulate the environment of a resource manager. Since I was familiar with many of the concepts involved, significant time savings were realized. This probably indicates that the knowledge base builder be at least familiar with the subject matter even under the guidance of domain experts.

Development of the graphics was the other major time consuming task.

Accurate representation of ecosystem components took much trial and error work. Conveyance of conceptual material through graphics was much more difficult than I had originally thought. Perhaps I learned as much about what I didn't know as what I knew. Difficulties were also encountered when determining what material should be explicitly represented and that which could (should) be addressed in an implicit or intuitive way. I think one of the major benefits of hypermedia is the capacity to prompt the user to think between the lines, i.e. use intuition and insight to make inferences in the knowledge base.

Graphics development could have been made easier by using some of the more recent and extensive paint packages which enable importation and conversion of files created in other environments. Clip art and spatial products could easily be imported. Additionally, software with the capabilities of gradient fill and layer management would have been very useful. Newer technologies, such as still video, would have enabled even greater graphics flexibility. However, the costs of these technologies rendered them inaccessible for this project.

The spatial graphics were kept as simple as possible and were created using the mouse and the paint software. Templates were constructed for many of these graphics as was previously described. Map legends were also kept simple to control the number of legend links. In the future, imported map files will be used in the place of these simple maps. Many GIS packages enable the output of DXF format files which can be converted to PCX format needed in KP (Windows systems will be well suited to dealing with this problem). Using this procedure satisfies two major requirements of knowledge base development. First, it saves large blocks of time that would be needed to create the map files from scratch. Secondly, and probably more important, conversion of existing material serves as a bridge to other environments and extends the usefulness of the hypermedia concept. Undoubtedly, future GIS will include hypermedia capabilities (Anetuccii et al. 1991). Inclusion of hypermedia in GIS will result in vastly superior spatial products.

Development of the text material for this knowledge base was less time consuming than that needed for graphics development. However, large amounts of background information was sifted to present the relatively small amount of text material. This process was aided by a general plan of presentations. I knew before hand what I wanted to present and roughly how I wanted to present it. Therefore, it was generally a matter of outlining the material and filling in the voids. I should mention that there is the tendency to fill in too many voids, i.e. include too much information which results in too many choices for the user and further inhibits inference by the user. Incorporation of the Microworld Concept (Kommers, 1992) might aid in restricting the horizon where information overload might occur. Microworlds are self contained modules of interactive information.

I didn´t explore the use of cognitive tools such as SEMNET or Learning Tool for construction of the knowledge base (Beyerbach and Smith, 1990, Fisher, 1990, Kozma, 1987, Trochim, 1989). However, the use of these systems may greatly aid in the development of future knowledge bases. Neural networks, genetic algorithms, and concept clustering (Michalski and Stepp, 1983) technologies also show great promise in knowledge base development.

CONCLUSIONS

Although the RH knowledge base is effective in presenting information, it is still limited in its capability of communicating information needed by a manager. Speed and comprehensiveness will probably be key to the utility of information presented in this manner. The importance of knowledge base maintenance and continual building can´t be over emphasized. This is an ongoing process fed by new research (knowledge) and driven by the need to access this knowledge in a customized and rapid way. In my view, in order to construct a domain knowledge base, one must possess a certain understanding of that domain. Construction of interdisciplinary and transdisciplinary knowledge bases requires systems, philosophies, and technical expertise in holistic approaches.

Hypermedia is a key technology which will undoubtedly be central to future knowledge management. However, other approaches, models and technologies, such as cognitive tools, GIS, and telecommunication will amplify its power and make knowledge accessible to the masses much as Gutenberg did with the printing press.

In my estimation, knowledge bases built around the hypermedia model offer great potential in providing managers with timely and accurate information in customized form. Knowledge bases such as the one described in this paper should provide access to data stored in diverse media at dispersed locations. Perhaps central to this improvement is the concept of matching our own mental processes with technology to provide knowledge which can be easily assimilated. The Neuralware/Software/Hardware model should be a very durable mechanism for future knowledge management. This mechanism provides a learning environment for the user as well as for the developer.

In my view, the hypermedia pattern represents an evolutionary step in knowledge management. However, this step, although aided by technology, isn´t technology based but rather brain based. The human mind is the true integrator while the technology enables dynamic category formation and aggregation. Therefore, the shift toward hyper or meta technologies is as much a thinking change (paradigm shift) as it is a technology change.

In the future we must seek better conceptual structures based on more flexible categories. Construction of knowledge bases using these new conceptual structures will allow incorporation and integration of reductionistic and holistic philosophies into a dynamic scale environment. Furthermore, work can began on more comprehensive knowledge bases which are transdisciplinary.

Hypermedia combined with other technologies such as GIS will enable us to more clearly understand the earth and the ecosystems on it. Further, our increased understanding will allow us to manage natural resources in a more sustainable way.

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APPENDIX A

Code Listing for
the Rangeland Hypermap
Knowledge Base

```
(*THE RANGELAND HYPERMAP KNOWLEDGE BASE - Hypermedia: potential for
storing, managing, and communicating natural resource information*)


load ('picture.hkb').


do (cover).

  topic cover. (*opening screen*)
      select is element (picture ('RGCOVER',1,8,Y,
      [['continue',t,590,256],
      ['quit',t,591,292]]),2).

       if ?select <> ''
          then do (?select).

       topic  'quit'.
         say ('Activate F10 from the keyboard or with the mouse.').
         end.

       topic  'continue' .
         say ('                    Table of Contents

         #mLand Ownership Patterns#m          #mCultural Improvements#m

         #mSociety#m                          #mTopography#m

         #mVegetation#m                       #mMule Deer#m

         #mSage Grouse#m                      #mHydrology#m

         #mClimate#m                          #mSoils#m

         #mVegetation Type Key#m              #mPlant Species Key#m

         #mLivestock Management#m             #mWildlife Management#m

         #mGlossary Main#m                    #mBibliography#m

         #mGeographic Information Systems#m  #mRangelands#m

         #mInterdisciplinarity#m              #mScale and Hierarchy#m

         #mCalculations#m, #mConversions#m (stocking rates etc.)

         #mHuman Information Processing#m   #mAutomated Information Processing#m

         #mUseful Quotes#m').
```

```
topic 'land ownership patterns'.(*map of land ownerships*)
   select is element (picture ('RGOWNER',1,8,Y,
   [['lomback',t,592,76]]),2).

   if ?select <> ''
      then do (?select).

     topic  'lomback' .
            do (continue).
            end.
end.(*land ownership*)


topic 'cultural improvements'.(*map of improvements eg. roads etc.*)
   select is element (picture ('RGCULT',1,8,Y,
   [['riparian',g,247,237],
   ['pipeline',g,357,298],
   ['exclosure',t,358,398],
   ['cimback',t,564,72]]),2).

   if ?select <> ''
      then do (?select) and
                   do ('cultural improvements').

    topic 'riparian' .(*graphic (profile) of typical riparian zone*)

      select is element (picture ('RGRIPPRO',1,8,y,
      [['raerial',g,263,28]]),2).

      if ?select <> ''
         then do (?select) and
            do (riparian).
           topic 'raerial'.(*aerial view of typical riparian zone*)
            picture ('RGRIPARI').
             end.
   end.(*riparian*)

   topic  'pipeline' .(*graphic of water development*)
      picture ('RGPIPE').
      end.
   topic 'exclosure'.(*text describing exclosure*)
      say ('This exclosure is . . . .').
      end.
   topic  'cimback' .
      do (continue).
      end.
end.(*cultural improvements*)

topic 'Geographic Information Systems'.(*GIS Graphic*)
  picture ('phdgis').
```

```
end.

topic 'society'.
  say ('This topic is incomplete but will include information about
      the social structure, political system and ethnic groups of
      the Rancho Generico region').
  end.(*society*)

topic 'climate'.
  say ('This topic is incomplete but will include information
      (graphic, tabular and text) describing the climatic regime
      of Rancho Generico').
  end.(*climate*)

topic 'vegetation type key'.
  say ('This topic is incomplete but will include information which
      describes the plant community types (present groupings), and
      habitat types (potential groupings) represented on Rancho
      Generico').
  end.(*veg type key*)

topic 'livestock management'.
  say ('This topic is incomplete but will include information which
      describes the livestock management system used on Rancho
Generico').
  end.(*livestock management*)

topic 'interdisciplinarity'.
  say ('This topic is incomplete but will include information which
      describes the importance of teamwork and multi-perspectives
      in the formulations of natural resource policy').
  end.(*inter*)

topic 'scale and hierarchy'.
  say ('This topic is incomplete but will include information which
      details systems and system components and the relevance of
      viewing natural resources at different scales').
  end.(*scale*)

topic 'soils'.
  say ('This topic is incomplete but will include information which
      describes the soil types represented on Rancho Generico.  This
      information will be communicated through graphics, text, and
      tabular means').
  end.(*soils*)

topic 'wildlife management'.
  say ('This topic is incomplete but will include information which
      describes the wildlife management systems used on Rancho
      Generico').
  end.(*wildlife management*)
```

```
topic 'Useful Quotes'.
  say('
            "Upon this gifted age
             in its dark hour
             Rains from the sky a meteoric shower
             Of facts...they lie unquestioned,
             Uncombined.
             Wisdom enough to leech us of our ill
             is daily spun; but there exists no loom
             To weave it into fabric"

                        Edna St. Vincent Millay


"Ignorance is the necessary condition of life itself. If we knew
      everything, we could not endure existence for a single hour."

                        Anatole France


"Knowledge is of two kinds. We know a subject ourselves, or we know
      where we can find information upon it."

                        Samuel Johnson


"Crafty men condemn studies, simple men admire them and wise men use
      them."

                        Francis Bacon


"All change is a miracle to contemplate; but is a miracle which is
      taking place every instant."

                        Thoreau


"The human brain is a wonderful organ. It starts to work as soon as
      you are born and doesn t stop until you get up to deliver a
      speech."

                        George Jessel
            (as cited by McCarthy, M.J. 1991. Mastering
                  the information age. J.P. Tarcher. L.A., CA)
        ').
end.(*useful Quotes*)
```

```
topic 'topography'.(*topographic map of Rancho Generico*)
      select is element (picture ('RGTOPOG',1,8,Y,
      [['relshade',g,341,337],
      ['tmback',t,341,391],
      ['conshade',g,341,420]]),2).

      if ?select <> ''
         then do (?select).

           topic  'relshade' .(*shaded relief map of R.G.*)
               picture ('RGRELSHA').
               do (topography).
               end.
           topic  'tmback' .
               do (continue).
               end.
           topic  'conshade'.
               picture ('RGTOPOS2').
               do (topography).
               end.
end.(*topography*)

topic 'hydrology'.(*map of hydrologic features of R.G.*)
   picture ('RGHYDRO').
   end.(*hydrology*)

topic 'vegetation'.(*vegetation map of R.G.*)
     select is element (picture ('RGVEG',1,8,Y,
   [['vmback',t,595,77],
   ['plone',t,618,262],
   ['pltwo',t,618,283],
   ['plthree',t,618,303],
   ['plfour',t,618,324],
   ['plfive',t,618,343],
   ['plsix',t,618,363],
   ['plseven',t,618,384],
   ['pleight',t,618,406],
   ['plnine',t,618,428],
   ['vmback',t,346,280]]),2).

   if ?select <> ''
      then do (?select) and
        do (vegetation).

      topic  'vmback' .
         do (continue).
         end.
      topic  'plone' .
         say ('Plant species list for the Aspen type').
         end.
      topic  'pltwo' .
         say ('Plant species list for the Riparian type').
```

```
        end.
      topic  'plthree' .
        say ('Plant species list for the Greasewood/Rabbitbrush
             type').
        end.
      topic  'plfour' .
        say ('Plant species list for the Bitterbrush/Idaho
              fescue type
#mAntelope Bitterbrush#m              Purshia tridentata
#mArrowleaf Balsamroot#m              Balsamorhiza sagittata
#mIdaho Fescue#m                      Festuca idahoensis').


topic 'antelope bitterbrush'.(*graphic of bitterbrush*)
   select is element (picture ('RGPUTR',1,8,Y,
   [['plant',t,486,148],
   ['leaf',t,366,346],
   ['flower',t,483,302],
   ['glossary',t,476,390],
   ['abback',t,470,424]]),2).

   if ?select <> ''
      then do (?select) and
                  do ('antelope bitterbrush').

     topic  'plant' .(*text describing bitterbrush*)
       say ('Bitterbrush is .....').
       end.
     topic 'leaf' .(*text describing leaves of bitterbrush*)
       say ('Leaves are.......').
       end.
     topic 'flower' .(*text describing bitterbrush flowers*)
       say ('Flowers are.......').
       end.
     topic  'glossary' .
       window ('gw', white, green, blue, 1,5, 78, 10).
       do ('glossary main').
       close_window ().
       end.
     topic  'abback' .
       do (continue).
       end.
end.(*antelope bitterbrush*)


topic 'arrowleaf balsamroot'.
      select is element (picture ('RGBASA',1,8,Y,
      [['flower',t,328,86],
      ['leaf',t,316,220],
      ['roots',t,267,393],
      ['glossary',t,447,353],
```

```
        ['abback',t,443,401]]),2).

        if ?select <> ''
           then do (?select) and
                       do ('arrowleaf balsamroot').

            topic  'flower' .
              say ('Flowers are........').
              end.
            topic  'leaf' .
              say ('Leaves are........').
              end.
            topic  'roots' .
              say ('Roots are..........').
              end.
            topic  'glossary' .
              window ('gw' , white, green, blue, 1,5,78,10).
             do ('glossary main').
              close_window ().
              end.

            topic  'abback' .
              do (continue).
              end.
end.(*arrowleaf balsamroot*)

topic 'idaho fescue'.
        select is element (picture ('RGFEID',1,8,Y,
        [['flower',t,268,139],
        ['leaf',t,299,294],
        ['root',t,286,411],
        ['glossary',t,465,387],
        ['ifback',t,465,428]]),2).

        if ?select <> ''
           then do (?select) and
                       do ('idaho fescue').

        topic  'flower' .
          say ('#mFlowers#m are........').
            topic 'flowers'.
              picture ('RGGRASS').
            end.

          end.
        topic  'leaf' .
          say ('#mLeaves#m are ........').
          end.
            topic 'leaves'.
              picture ('RGGRASS').
              end.
        topic  'root' .
```

```
                say ('#mRoots#m are ..........').
                  topic 'roots'.
                    picture ('RGGRASS').
                    end.
                end.
              topic  'glossary' .
                window('gw', white, green, blue, 1, 5, 78, 10).
                do ('glossary main').
                close_window ().
                end.

              topic  'ifback' .
                do (continue).
                end.
        end.(*idaho fescue*)
      end.(*plfour*)

      topic 'plfive'.
        say ('Plant species list for the Ponderosa Pine/
              White Fir type').
        end.

      topic  'plsix' .
        say ('Plant species list for the Ponderosa Pine/
              Bitterbrush type').
        end.

      topic  'plseven' .
        say ('Plant species list for the Basin Big Sagebrush/
              Kentucky Bluegrass type').
        end.
      topic  'pleight' .
        say ('Plant species list for the Wyoming Big Sagebrush/
              Sandberg Bluegrass type').
        end.

      topic  'plnine' .
        say ('Plant species list for the Mountain Big Sagebrush/
              Bluebunch Wheatgrass type').
        end.

      topic  'vmback' .
        do (continue).
        end.
end.(*vegetation*)

topic 'Plant Species Key'.(*graphic of typical plant*)
  picture ('rggrass').

end.(*plant species key*)

topic 'mule deer'.(*map of mule deer distribution on R.G.*)
```

```
select is element (picture ('RGDEER',1,8,Y,
[['dmback',t,356,401],
['forage',g,357,346]]),2).

if ?select <> ''
   then do (?select) and
                  do ('mule deer').

      topic  'dmback' .
        do (continue).
        end.

      topic  'forage' .(*graphic of typical mule deer habitat*)
              select is element (picture ('RGFORPRO',1,8,Y,
        [['aerial',g,322,24],
        ['glossary',t,493,28],
        ['pfvback',t,501,417],
        ['solar',t,449,56],
        ['removal',t,352,134],
        ['evaporation',t,218,97],
        ['precip',t,279,22],
        ['wind',t,109,19],
        ['soil',t,176,319],
        ['competition',t,181,382]]),2).

        if ?select <> ''
           then do (?select) and
                         do (forage).

           topic  'aerial' .(*aerial view of habitat*)
             select is element (picture ('RGFORAGE',1,8,Y,
             [['afvback',t,499,309],
             ['glossary',t,490,21],
             ['profile',g,28,316],
             ['balsam',g,415,316],
             ['fescue',g,164,159]]),2).

             if ?select <> ''
                then do (?select) and
                              do (aerial) and
                              do (forage) and
                              do ('mule deer').

                topic  'afvback' .
                  do (continue).
                  end.
                topic  'glossary' .
                  window ('gw',black,yellow,white,1,5,78,10).
                  do ('glossary main').
                  close_window ().
                  end.
```

```
        topic  'profile' .
          picture ('RGFORPRO').
          end.

        topic  'balsam' .
          picture ('RGBASA').
          end.

        topic  'fescue' .
          picture ('RGFEID').
          end.
  end.(*aerial*)

  topic  'glossary' .
    window ('gw', white, green, blue, 1,5, 78,10).
    do ('glossary main').
    close_window ().
    end.

  topic  'pfvback' .
    do (continue).
    end.

  topic  'solar' .(*text describing solar energy*)
    say ('Solar energy .......').
    end.

  topic  'removal' .(*text describing herbivory*)
    say ('Herbage removed.......').
    end.

  topic  'evaporation' .(*text on evaporation*)
    say ('Evaporation is.........').
    end.

  topic  'precip' .(*text on moisture input*)
    say ('Precipitation is.........').
    end.

  topic  'wind' .(*text on wind*)
    say ('Wind is...................').
    end.

  topic  'soil' .(*text on soil*)
    say ('Soil is.....................').
    end.

  topic  'competition' .(*text on plant competition*)

    say ('Competition between..........').
    end.
end.(*forage*)
```

```
            end.(*mule deer*)

             topic 'sage grouse'.(*map of sage grouse distribution on R.G.*)
                select is element (picture ('RGSGROUS',1,8,Y,
                [['sgmback',t,604,78]]),2).

                if ?select <> ''
                      then do (?select) and
                               do ('sage grouse').

                                 topic  'sgmback' .
                                   do (continue).
                                   end.
            end.(*sage grouse*)

            topic 'plant species key'.
              say ('
This topic is incomplete but will utilize the KnowledgePro ASK command to
help distinguish plant species.
                       ').
            end.(*plant species key*)


            topic 'Human Information Processing'.
              say ('
 Since natural resources are managed by humans, human knowledge  level  and
perspective have a large bearing on how this management takes place. The pattern
(paradigm) with which this knowledge is applied varies over time and according
to individual differences.  These paradigm shifts are brain based and are a
result of increased insight gained through research and practical experience.
The facts developed through this research are grouped into unique categories or
concepts by each individual.  Conceptual structures differ with each individual
due to differences in experiences, beliefs, and #mbrain#m structure particularly
differences between brain #mhemispheres#m.  These differences have produced
#mdichotomies#m of perception and thought.  These dichotomies have led to
divergent viewpoints in ecology with regard to the description of ecosystem
components. Recently, educational institutions have recognized these differences
and the resultant #mlearning#m patterns.  Research has indicated that much of
the background to these patterns is chaotic or by chance due to individual
differences in development, motivation through time.  However, learning is
generally considered to involve assimilation of new facts into existing
#mconceptual#m space and is cross-checked against the resident information within
the knowledge (conceptual) structure.  The knowledge structure is either
strengthened by this new knowledge or the new information is rejected').
            end.(*human info proc.*)

              topic 'brain'.(*graphic of the brain*)
                picture ('brainsd').
              end.(*brain*)

              topic 'hemispheres'. (*graphic of the hemispheres of the brain*)
```

```
  picture ('braintp').
end.(*hemispheres*)

topic 'dichotomies'.(*graphic of thought dichotomies*)
  select is element (picture ('DICHOT',1,8,Y,
  [['ecologis',g,458,29]]),2).

   if ?select <> ''
     then do (?select) and
  do (dichotomies).

     topic  'ecologis' .(*graphic of prominent botanists*)
       picture ('ecologis').
     end.(*ecologis*)
end.(*dichotomies*)

topic 'learning'.(*graphic of learning styles*)
  picture ('learn').
end.(*learning*)

topic 'conceptual'.
  picture ('tessela').
end.(*conceptual*)
```

topic 'automated information processing'.

say ('

Traditional computer programming methods have focused on linearity, sequentiality and mathematical logic (#mThomas, 1989#m). Other programming paradigms have emerged which deal with data and information in a modular or encapsulated way. This paradigm is generally known as object-oriented programming (#mOOPS#m). According to Thomas (1989) OOPS has four characteristics.

- Encapsulation
- Message Passing
- Inheritance
- Late Binding

OOPS programs process information by passing messages between objects which are analogs of entities in the real world. These objects can be categorized according to their shared attributes. These categories help us make sense of the world we live in (#mThompson and Thompson, 1991#m). Thompson and Thompson go on to state - Because of the fundamental connection that categories have with thought processes, a theory of categorization is central to our basic picture of reality.

The management of natural resources requires categorization of ecosystems and ecosystem components in order to apply management actions efficiently. For example, plant communities (present species composition) are composed of common qualities such as plant species present, quantities of (cover, density, etc.) these species, soil type, micro climate among others. With a certain degree of confidence we expect like communities to respond in a like way to a certain management action. This is similar to message passing in OOPS where object A and object B may respond in a similar manner to message 1 while responding in a dissimilar manner to message 2. OOPS should lend itself well to not only the management of environmental information but also to the communication of that information.

#mHypermedia#m is another software/hardware technology which enables to processing of information in a non-sequential way. Traditional information handling has centered around the linear and sequential model which has used printed text as the carrier of their information. No substantial alteration to this model has taken place since Guttenberg.

The non sequential model has been used however, by cartographers and artists for centuries. a map or a price of artwork can be viewed in different ways by the same person. Whereas text material or a mathematical equation must be processed in an organized, linear and ordered manner. Hypermedia allows nodes to be installed in text or graphic material which indexes, calls or links other related information similar to an encyclopedia entry indexed by a (see also) tag.

Combining Hypermedia with an OOPS programming environment offers considerable power in storing, manipulating and communicating natural resource information. Using this system allows for incorporation of scale, hierarchy, and connectedness found in natural systems. The description of these systems also requires the use of concrete and abstract perspectives which can be handled within a OOPS/Hypermedia environment.

```
                                         ´).
            end.(*auto info processing*)

              topic ´oops´.
               picture (´oops´).
              end.(*oops*)

              topic ´hypermedia´.
               picture (´hypertex´).
              end.(*hypermedia*)

              topic ´thomas, 1989´.
                 window (´op´, black, yellow, green,1,5,80,5).
                 say (´
Thomas, D. 1989. Whats in an object. Byte. March 1989:231-240.
                     ´).
                 close_window.
                 end.(*thomas*)

              topic ´thompson and thompson, 1991´.
                 window (´ca´, black, yellow, green,1,5,80,5).
                 say (´
Thompson, B. and B. Thompson. 1991. Overturning the category bucket. Byte.
     January:249-256.
                     ´).
                 close_window.
                 end.(*thompson*)
            topic ´conversions´.
                 say (´
```

```
English to Metric
     1 inch = 25.4 millimeters
     1 inch = 25,400 microns
     1 inch = 2.54 centimeters
     1 foot = 0.3048 meters
     1 yard = 0.9144 meters
     1 mile = 1.609 kilometers
          ').
     end.(*conversions*)

     topic 'calculations'.
          say ('
```

Approximate nuber of individuals per animal units based on ratios of metabolic weights ($Wt.^{0.75}$) for mature animals. (adapted from #mHeady, 1975#m).

	Aprox. Wt. lbs.	Kg	$K^{0.75}$	Number per Animal Unit
Cow/Horse	1000	455	98	1.0
Elk	600	272	67	1.5
Mule Deer	150	68	24	4.0
Sheep	120	55	20	5.0
Pronghorn	100	45	17	6.0
Black-tailed jackrabbit	5	2.8	2	50.0

```
          ').
     end.(*calculations*)
     topic 'Rangelands'.
       say ('
```

Rangelands are best described as those areas of the world where the potential vegetation is dominated by grasses, frasslike plants, forbs, and shrubs (SRM). These areas are usually characterized by low or erratic precipitation, rough topography and usually unsuited to cultivation (Stoddart, et al. 1975). Rangelands occupy approximately 47% of the earths land surface wheras farming occupies 10%, commercial forests are found on 28% and ice covers 15% (Williams, et al. 1968 as cited by Heady, 1975).

```
  ').
     end.(*rangelands*)


     topic 'glossary main'.

       say ('                         Glossary of Terms
```

Accuracy: The degree to which a measurement is known to approximate a given value: correctness: usually refers to computation.(#mRobinson#m et al., 1984)

Analog: The representation of a numerical quantity by a physical variable, e.g., graphic marks or electric voltages; contrasted with digital. (Robinson et al., 1984)

Anthesis -Gk. flowering: The stage during which the flower is fully expanded when pollination can occur. (#mSmith#m. 1977)

Assimilation: Piagets term for the incorporation of new information into existing conceptual structures. (#mS#m)

Attribute: descriptive characteristic or quality of a feature. An attribute.

Autecology: A subdivision of ecology that deals with the relationship of individuals of a species to their environment. (SRM) value is a measurement assigned to an attribute for a feature instance. (#mUSGS#m)

Autocorrelation, Autocovariance: Statistical concepts expressing the degree to which the value of an attribute at spatially adjacent points covaries with the distance separating the points. (#mB#m)

Automated Cartography: The process of drawing maps with the aid of computer driven display devices such as plotters and graphics screens. THe term does not imply any information processing. (B)

Blade: The flattened expanded portion of a leaf or petal. (Smith, 1977)

Caespitose: Occurring in tufts, mats or clumps. (Smith, 1977)

Carbohydrate: Any of the group of organic compounds composed of carbon, hydrogen, and oxygen, including sugars, starches, and celluloses. (#mP#m)

Cognition: The mental processes concerned with the acquisition and manipulation of knowledge, including perception and thinking. (S)

Concept: The mental representation of anything; arguably a concept has to be conscious. Many concepts are based on the sharing of common properties by items in a class (e.g. the concept of "robin" or "bird"). (S)

Concept Formation: The induction of concepts that divide items into classes (including highly abstract classes like "true") according to their shared properties. (S)

Concept Hierarchy: A structural taxonomy or arrangement of the associations that make up a concept. (#mM#m)

Concept Sorting: A psychological paradigm that can be used to tap the way in which a domain expert has organized key concepts. (M)

Connectivity: A measure of how connected of spatially continuous a corridor or matrix is. (#mF#m)

Continuum: A gradual change in species composition along an environmental gradient. (F)

Cordate: Heart-shaped. (Smith, 1977)

Culm: The jointed stem of a grass made up of a series of nodes and internodes. The internode can be either hollow or solid. (#mHitchcock, 1950#m)

Culm: The stem of a grass plant. (Smith, 1977)

Cuneate: Wedge-shaped as in the base of certain leaves. (Smith, 1977)

Defoliation: The removal of plant leaves, i.e. by grazing or browsing, cutting, chemical defoliant, or natural phenomena such as hail, fire, or frost. (#mSRM#m)

Digital: The representation of a quantity by a number code; contrasted with analog. (Robinson et al., 1984)

Digitizer: A device for entering the spatial coordinates of mapped features from a map or document to the computer. (B)

Disk: An outgrowth of the receptacle on the structure resulting from the fusion of nectaries or staminocles which develops around the gynoecium; the central part of the head in the Compositae. (Smith, 1977)

Ecological Amplitude: A species "ability" to deal with the environment through genetic and phenotypic plasticity as well as through regenerative flexibility (a function of the number of different regenerative strategies posessed by the species). (#mGrime#m et al., 1988).

Ecological Response Unit: A unit of land that is homogenous in character such that similar units will respond in the same way to disturbance or manipulation. (SRM)

Ecology: A study of the interrelationships which exist between organisms and their environment. (P)

Ecosystem: A functional system which includes the organisms of a natural community together with their environment. (P)

Ecotype: A subunit, race, or variety of a plant ecospecies that is restricted to one habitat; equivalent to a taxonomic subspecies. (P)

Entities: Items about which information is stored. May be tangible or Intangible. Are further defined by attributes.

Explicit: Expressed with clarity and precision; clearly defined or formulated. (#mAH#m)

Fibrous root system: A root system in which all of the roots are about the same size so that none is clearly dominant, as in many monocots. (Smith, 1977)

Floret: Very small flowers, particularly those which are found in dense inflorescences, as in Compositae; the flower, palea, and lemma of the grass spikelet. (Smith, 1977)

Function: The flow of mineral nutrients, water, energy, or species. (F)

Geographic Information System: The complete sequence of components for acquiring, processing, storing and managing spatial data. (S & E)

Glume: One of the two sterile bracts at the base of a typical grass spikelet. (Smith, 1977)

Graze: The consumption of standing forage by livestock or wildlife. (SRM)

Grazing Distribution: Dispersion of livestock grazing within a management unit or area. (SRM)

Grazing Preference: (1) selection of certain plants, or plant parts, over others by grazing animals. (2) in the administration of public lands, a basic upon which permits and licenses are issued for grazing use. (SRM)

Grazing System: A specialization of grazing management which defines the periods of grazing and non-grazing. (SRM)

Hastate: Having the general shape of an arrowhead, but without he basal lobes turned outward at right angles. (Smith, 1977)

Herbivore: An animal that subsists principally or entirely on plants or plant materials. (SRM)

Hydrology: The science that treats the occurrence, circulation, distribution and properties of the waters of the earth, and their reaction with the environment. (P)

Hypertext: An associative information management system (AIMS). (#mFranklin#m, 1989)

Implicit: Implied or understood although not directly expresses; contained in the nature of something although not readily apparent. (AH)

Landscape: A heterogeneous land area composed of a cluster of interacting eco-systems that are repeated in similar form throughout. Landscapes vary in size, down to a few kilometers in diameter. (F)

Landscape Development: Formation resulting from three mechanisms operating within a landscapes boundary; specific geomorphological processes taking place over a long time, colonization patterns of organisms (including humans), and local disturbances of individual ecosystems over a shorter time. (F)

Landscape Ecology: A study of the structure, and change in a heterogeneous land area composed of interacting ecosystems. (F)

Layers: Refers to the various "overlays" of data, each of which normally deals with one thematic topic. These overlays are registered to each other by the common coordinate system of the data base. (USGS)

Leaf: The leaves of grass are borne on the culm in two ranks, one at each node. The leaf consists of a sheath and a blade. (Hitchcock, 1950)

Lemma: One of two bracts of the grass floret, the other being the palea, which subtends the flower. (Smith, 1977)

Ligule: A strap-shaped organ; also the membranous projection at the junction of the sheath and lamina in grasses. (Smith, 1977)

Lodicule: One of the two or three minute hygroscopic scales of the grass flower; generally thought to be reduced calyx segments. (Smith, 1977)

Map: Cartography; a hand-drawn or printed document describing the spatial distribution of geographical features in terms of a recognizable and agreed symbolism. Digital; the collection of digital information about a part of the earths surface.(B)

Monocot: A semitechnical group name for those flowering plants which have a single cotyledon, parallel venation and flower parts in 3s or multiple thereof. (Smith, 1977)

Multiple Use: Use of range for more than one purpose, i.e., grazing of livestock, wildlife production, recreation, watershed and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output. (SRM)

Node: The point or region on a stem where one or more leaves are borne. (Smith, 1977)

Palatability: The relish with which a particular species or plant part in consumed by an animal. (SRM)

Palea: The bract which immediately subtends the flower in a grass spikelet; along with a lemma and flower, the palea is a component of the floret; also the scale-like calyx remmants in certain Compositae. (Smith, 1977)

Patch: A nonlinear surface area differing in appearance from its surroundings.

Perception: Recognition in response to sensory stimuli; the act or process by which the memory of certain qualities of an object is associated with other qualities impressing the senses, thereby making possible recognition of the object. (P)

Petal: A component part of the corolla. (Smith, 1977)

Phenology: The study of periodic biological phenomena which are recurrent such as flowering, seeding, etc., especially as related to climate. (SRM)

Photosynthesis: Synthesis of chemical compounds in light, especially the manufacture of organic compounds (primarily carbohydrates) from carbon dioxide and a hydrogen source (such as water), with simultaneous liberation of oxygen, by chlorophyll-containing plant cells. (P)

Physiology: The study of the basic activities that occur in cells and tissues of living organisms by using physical and chemical methods. (P)

Phytomer: One modular unit of a plant; consisting of the leaf, sheath (or petiole) and internode. (SRM)

Precision: The ability to distinguish small differences.

Rachilla: The axis bearing the floret of a grass plant. (Hitchcock, 1950)

Rachilla: The internal axis of the spikelet in the grasses and sedges. (Smith, 1977)

Range Improvement: (1) any structure or excavation to facilitate management of range or livestock. (2) any practice designed to improve range condition or facilitate more efficient utilization of the range. (3) an increase in grazing capacity of range, i.e., improvement of rangeland condition. (SRM)

Rangeland: Land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs. Includes lands revegetated naturally or artificially when routine management of that vegetation is accomplished mainly through manipulation of grazing. Rangelands include natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes and wet meadows. (SRM)

Range Management: A distinct discipline founded on ecological principles and dealing with the use of rangelands and range resources for a variety of purposes. These purposes include use as watersheds, wildlife habitat, grazing by livestock, recreation, and aesthetics, as well as other associated uses. (SRM)

Range Science: The organized body of knowledge upon which the practice of range management is based. (SRM)_

Ray: The outer or ligulate flowers of a composite head; the stalk which supports an unbellet of a compound umbel. (Smith, 1977)

Resource Base: An environments group of organic and inorganic resources upon which a population habitually depends for its subsistence. (Moran, 1982)

Restoration: A conservation measure involving the correction of past abuses that have impaired the productivity of the resource base. (P)

Rhizome: An underground horizontal stem which bears reduced scaly leaves. (Smith, 1977)

Riparian Zone: The banks and adjacent areas of water bodies, water courses, seeps and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of contiguous flood plains and uplands. (SRM)

Sagittate: Shaped generally like an arrow-head with the basal lobes pointed downward. (Smith, 1977)

Semantics: The study of meaning. (S)

Sensory Adaptation: The ability of people to adapt to environmental circumstances even under conditions of stress. (#mJackle#m, et al., 1976)

Social Structure: Principles according to which social features are organized. Includes kinship relation patterns, technoeconomic organization, belief systems, and political structure. (Moran, 1982)

Socialization: The process of learning a culture through a lifelong process of internalizing. May also be termed enculturation. Includes both institutional and informal learning processes. (Moran, 1982)

Soil: Freely divided rock-derived material containing an admixture of organic matter and capable of supporting vegetation. (P)

Spatial Behavior: Peoples cognition, choice and action as related to the use of places. (Jakle, et al., 1976)

Spatial Data: Data pertaining to the location of geographical entities together with their spatial dimensions. Spatial data are classified as point, line, area, or surface. (USGS)

Spatial Data Bases: Collections of spatial information related by a common fact or theme. (USGS)

Spatial Data Sets: Collection of similar and related spatial data records that are recorded for use by a computer. (USGS)

Species: A kind of plant or animal, its distinctness seen in morphological, anatomical, cytological, and chemical discontinuities presumable brought about by reproductive isolation; thought by some to be entities with biological reality and by others to be convenient concepts which exist only in the mind of the taxonomist. (Smith, 1977)

Species Concept: The idea that the diversity of nature is divisible into a finite number of definable species. (P)

Spikelet: The unit of the grass inflorescence which is nearly always aggregated in groups or clusters. The spikelet consists of a short axis (rachilla) with a reduced leaf (bract) at each node. The flowers are borne in the axils of the bracts. (Hitchcock, 1950)

Spikelet: A spicate arrangement of reduced flowers and associated bracts inserted alternately along an unbranched axis (the rachilla); a small spike; the basic unit of the inflorescence in the grasses and sedges. (Smith, 1977)

Stolon: A horizontal stem, usually above the surface of the ground, which roots at the nodes and produces new plants, particularly at its tip; also referred to as a runner or sucker. (Smith, 1977)

Structure: The distribution of energy, materials, and species in relation to the sizes, shapes, numbers, kinds, and configurations of ecosystems.(F)

Synecology: The study of environmental relations of groups of organisms, such as communities. (P)

Topological Relationships: Refers to how data elements relate to each other within the data base. In particular, how a change to one element affects other elements. (USGS)

Topological Space: A map that accurately represents the spatial ordering, but is not proportional to the distance and the length of time necessary to cover a route. Also, a geometry dealing with the continuous connectedness between the points of a figure. (F)

Topological Structuring: Process of organizing data topologically so that the relationships and reference linkages are specified.(USGS)

Topology: The way in which geographical elements are linked together. (B)

Topology: A branch of geometrical mathematics which is concerned with order, contiguity, and relative position, rather than actual linear dimensions. (USGS)

Type Line: The boundary line which separates two distinctive vegetation types on a map or photograph. (SRM)

Type Mapping: The process of delineating vegetation types on an aerial photograph or on a base map. (SRM)

Vector: A quantity having both magnitude and direction. (B)

Vector: Directed line segment, with magnitude commonly represented by the coordinates for the pair of end points. Vector data refers to data in the form of an array with one dimension. (USGS)

Vector Graphics Structure: A means of coding line and area information in the form of units of data expressing magnitude, direction, and connectivity. (B)

Vegetation Type: A kind of existing plant community with distinguishable characteristics described in terms of the present

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                vegetation that dominates the aspect or physiognomy of
                the area.  Syn., type. ct. range site. (SRM)
      ').


      end.(*glossary main*)

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behavior. Duxbury Press. Belmont, CA.
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   Continuum, N.Y.
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       #mZ699.A1.055#m
              ').
            close_window.
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              picture ('lib4').
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         topic 'Franklin, C.'.
          window ('', black, yellow, green,1,5,80,5).
          say ('
   I was tempted to put information here about Dr. Franklin.
     Of course we are aware that ETHICS do not permit me to
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                do this. We do know that don t we?
                     ').
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                   end.(**)
end.(**)
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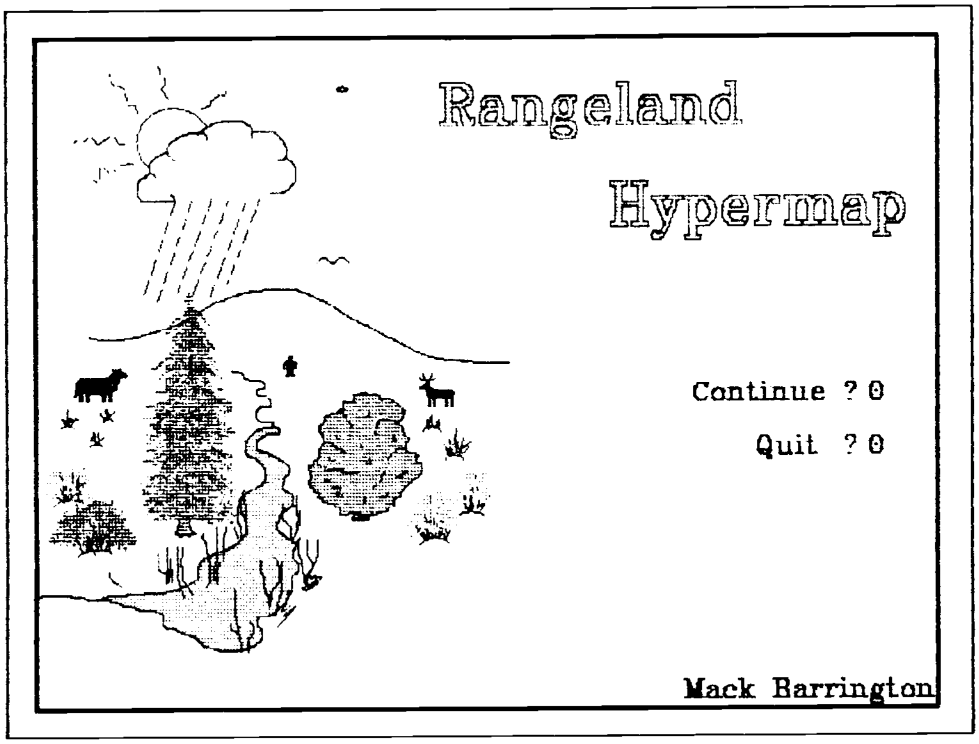
APPENDIX B

Rangeland Hypermap Images



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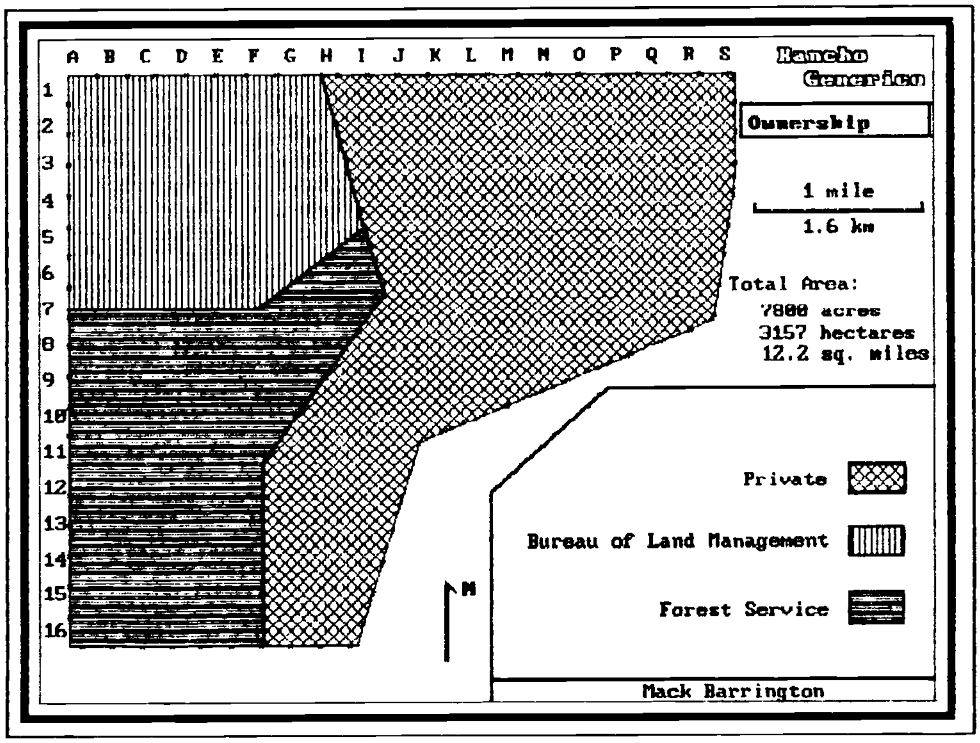

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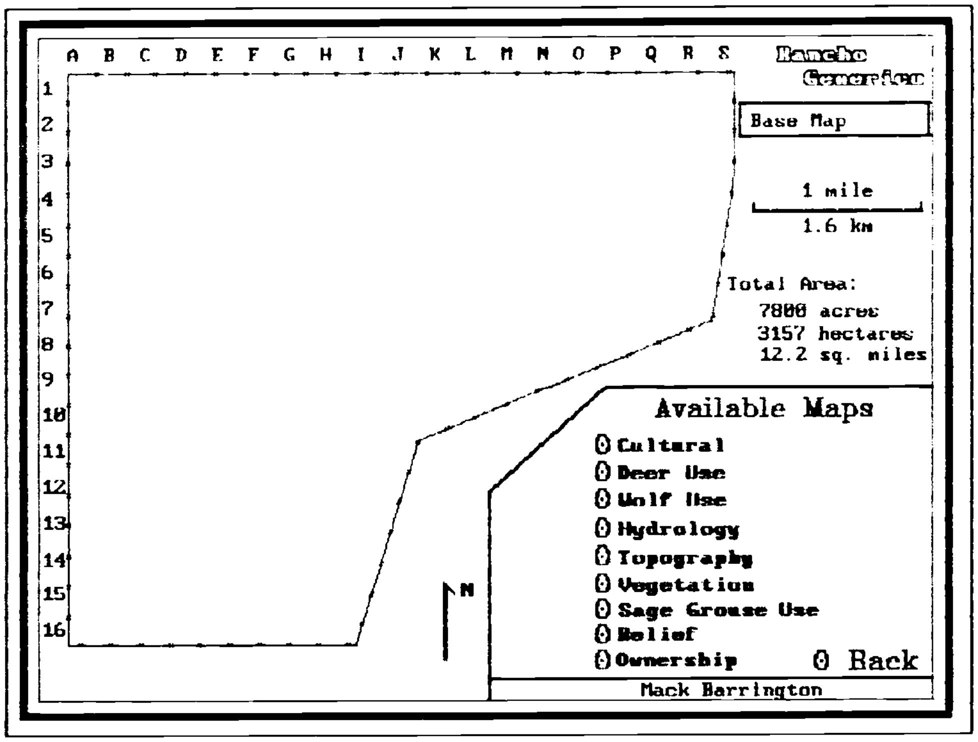

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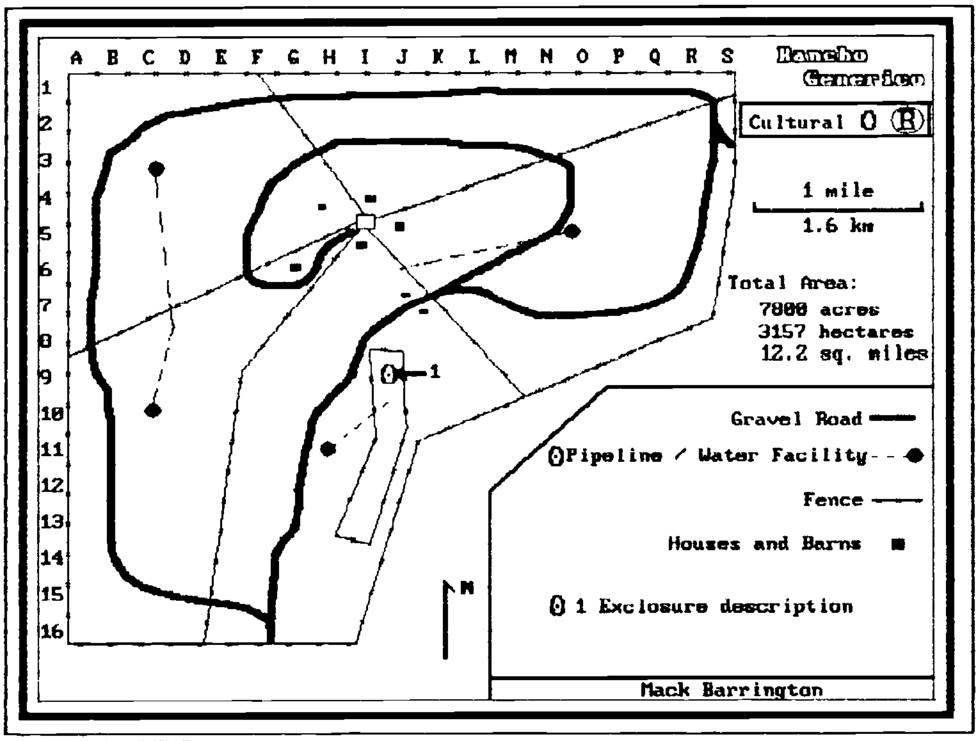

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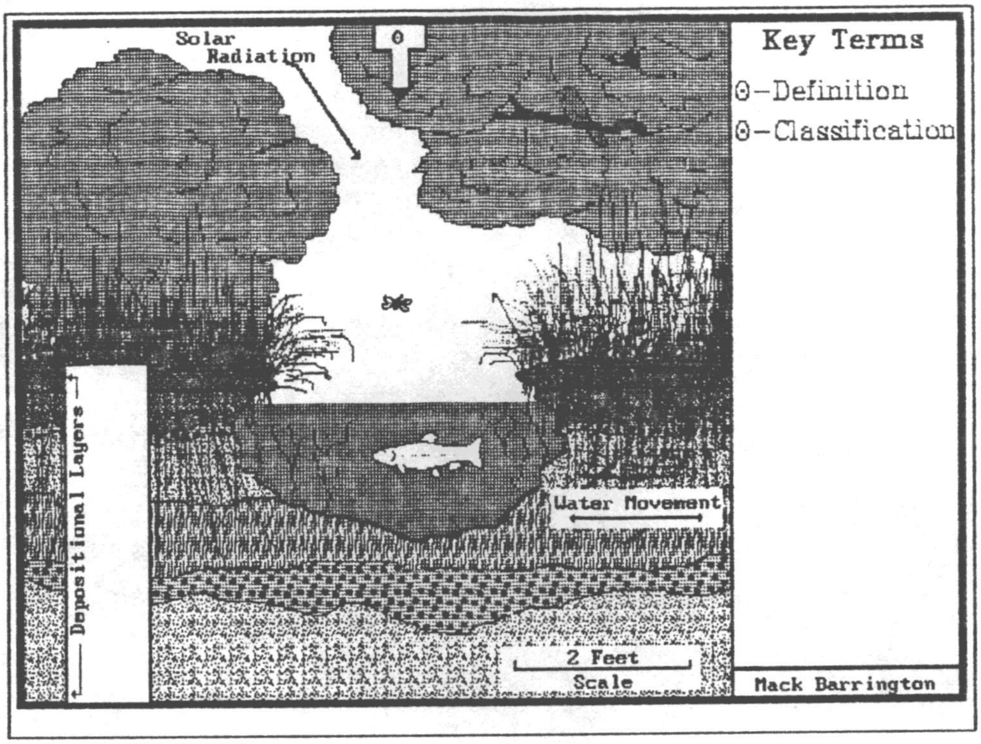

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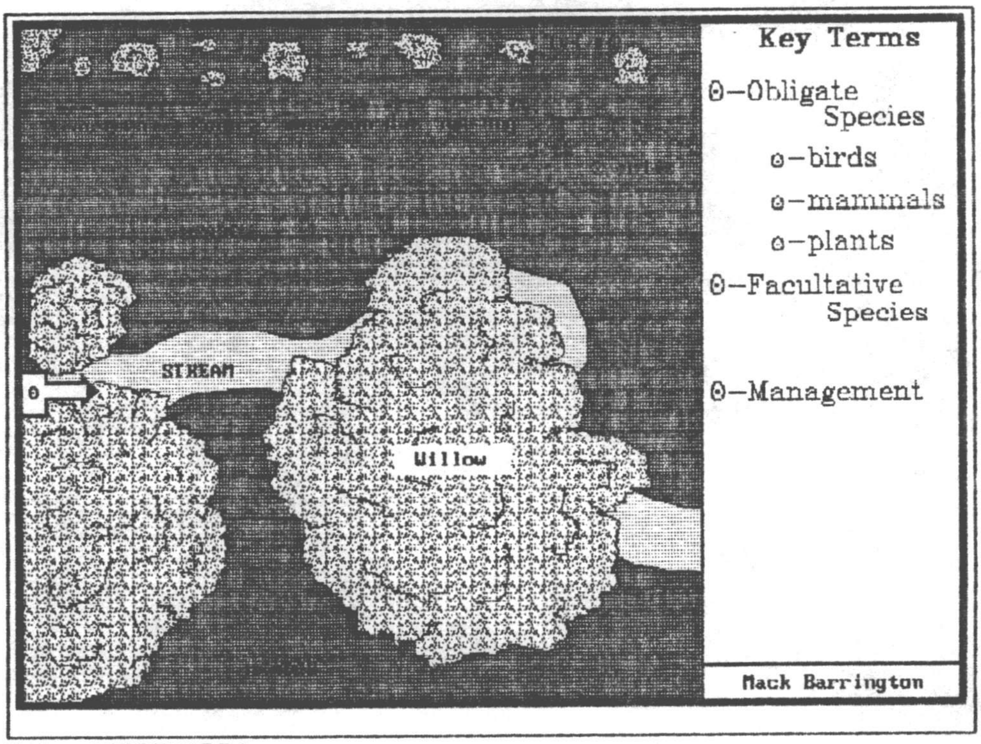

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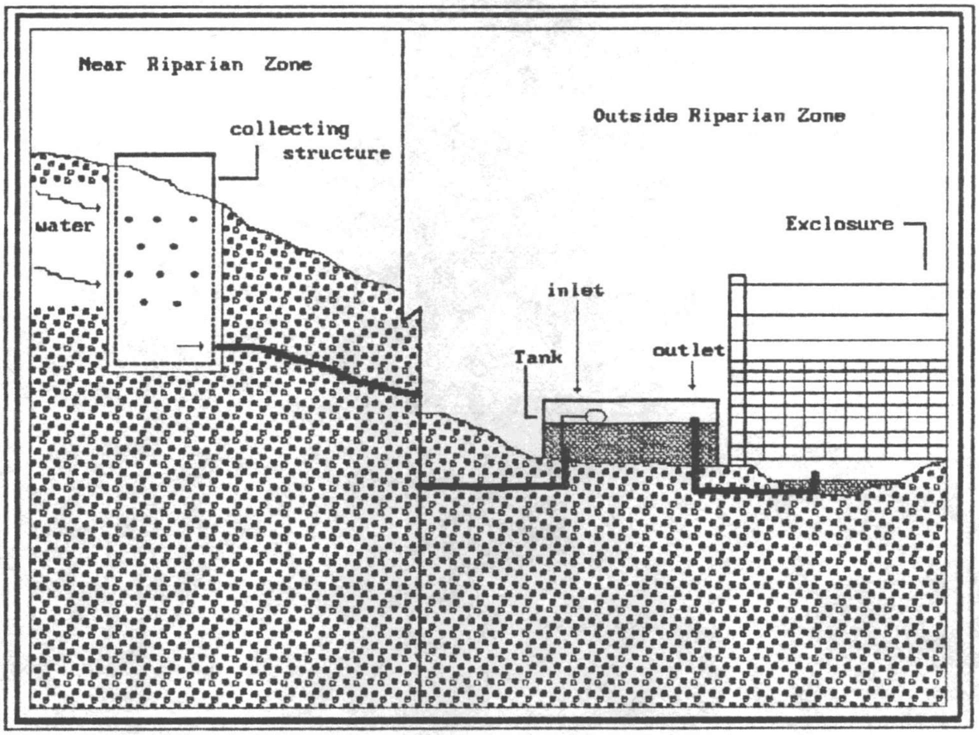

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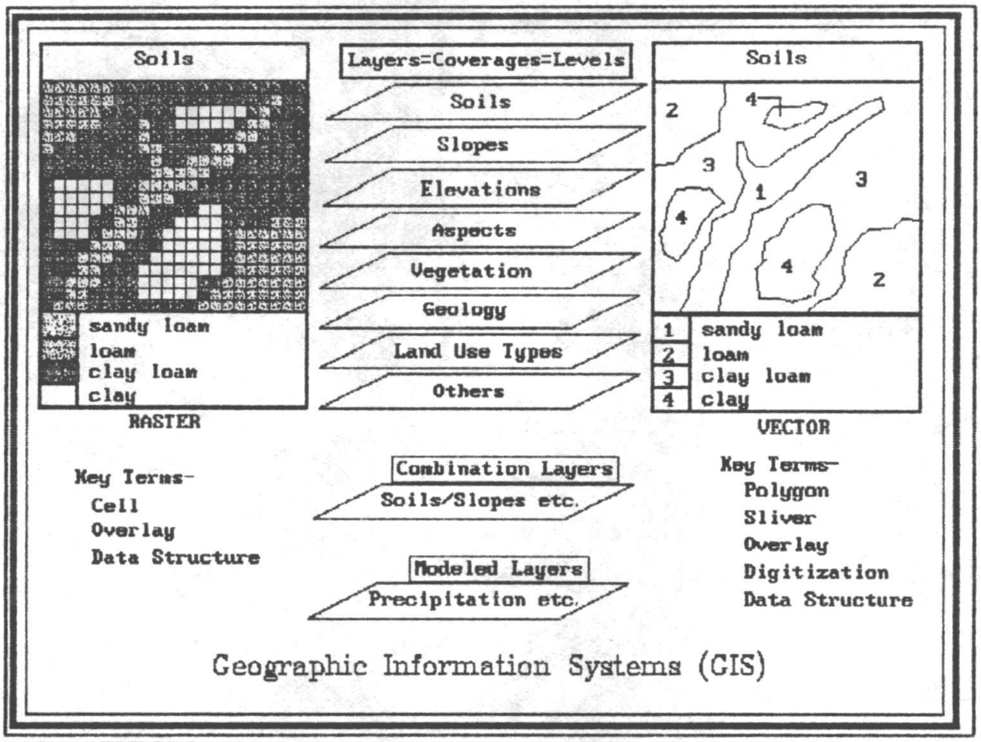

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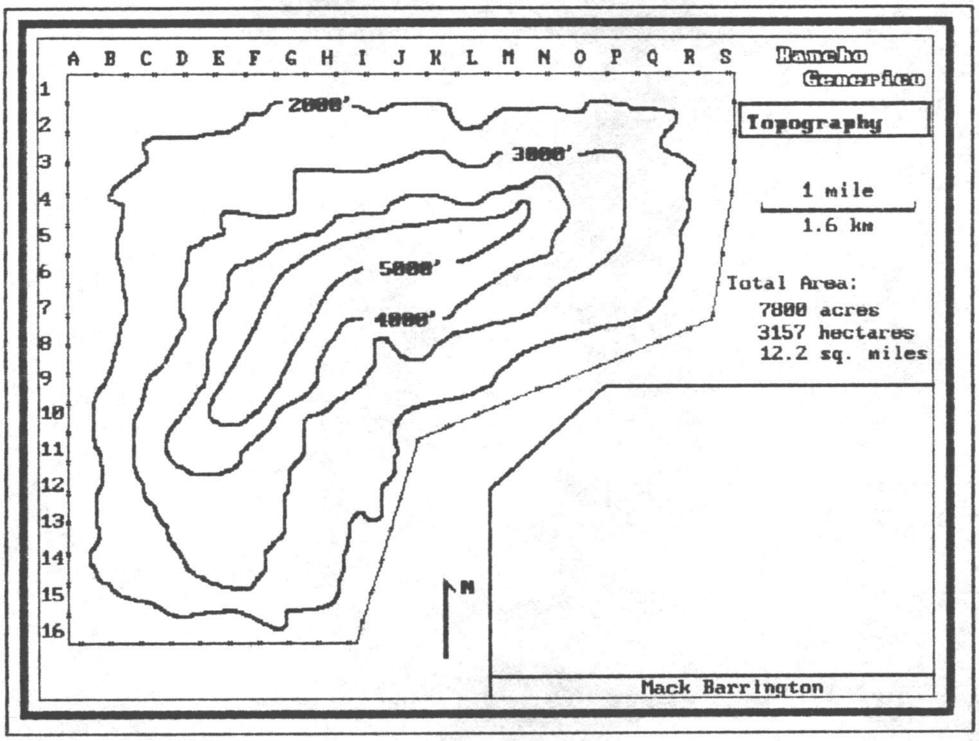

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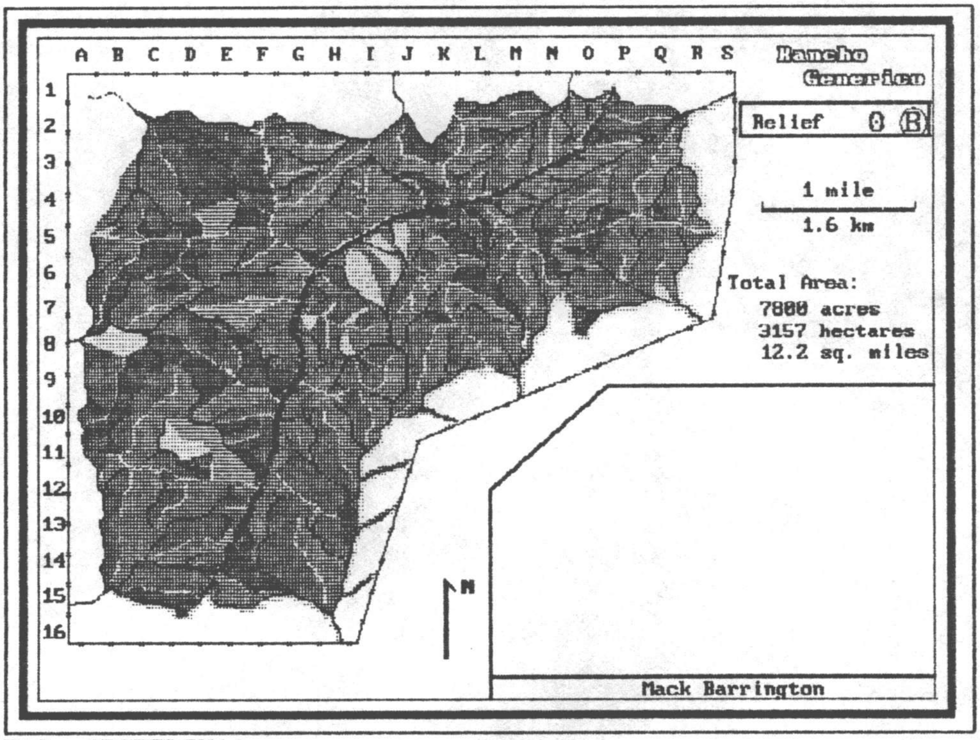

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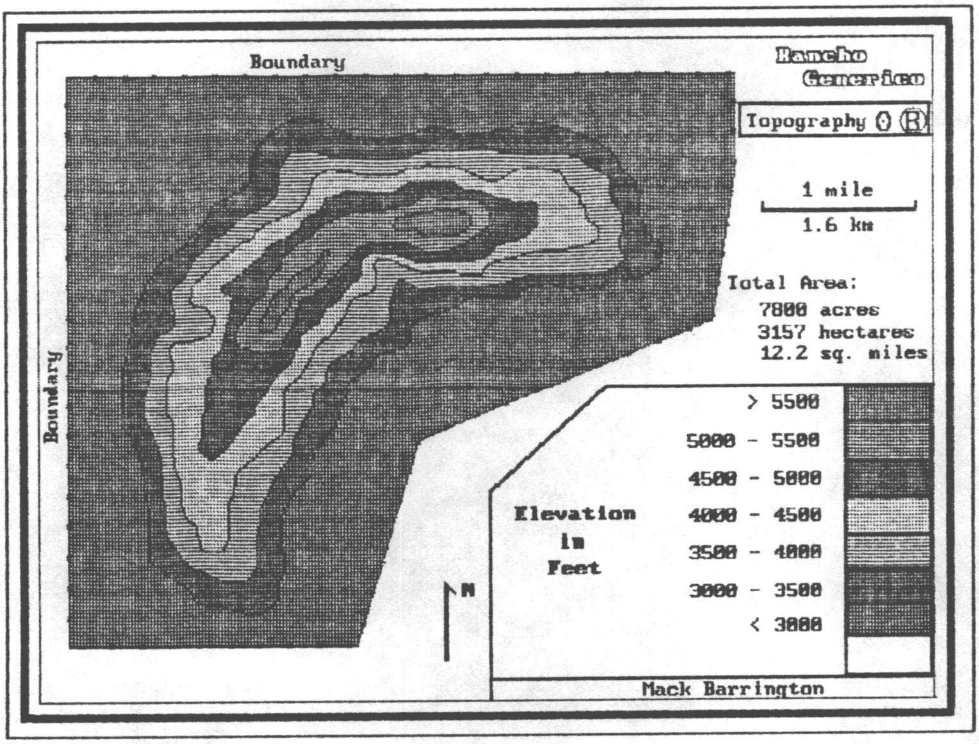

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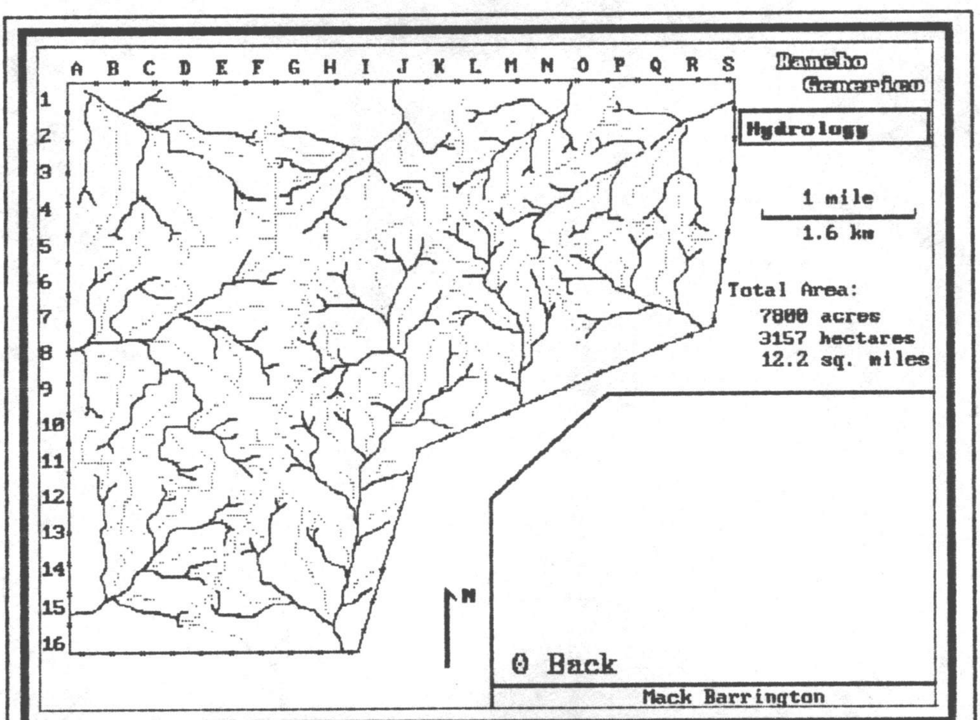

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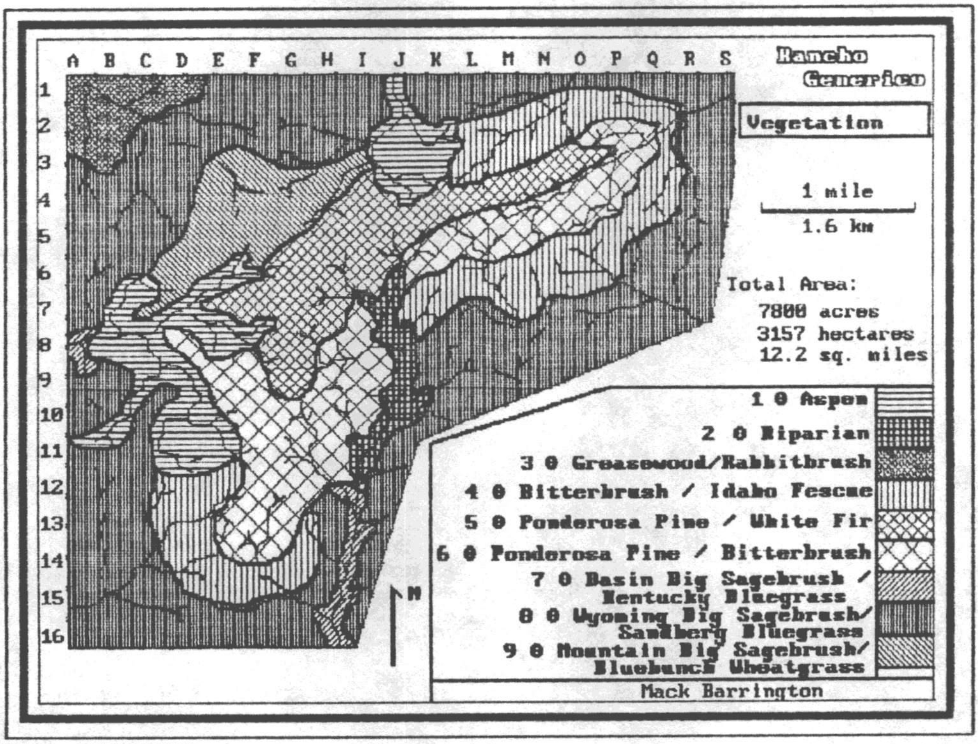

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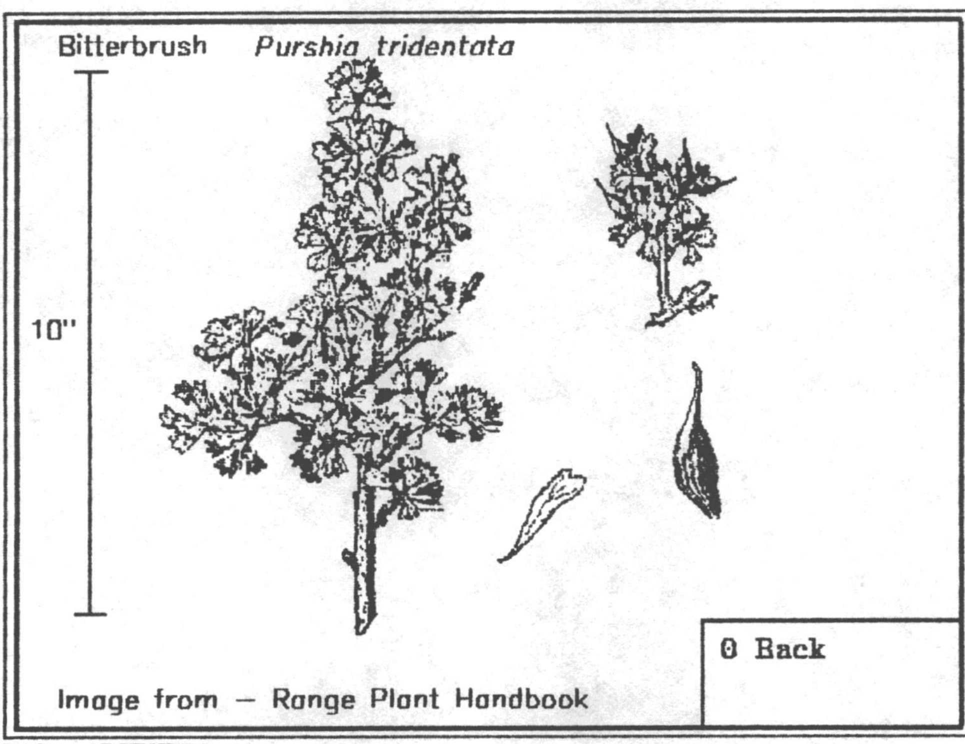

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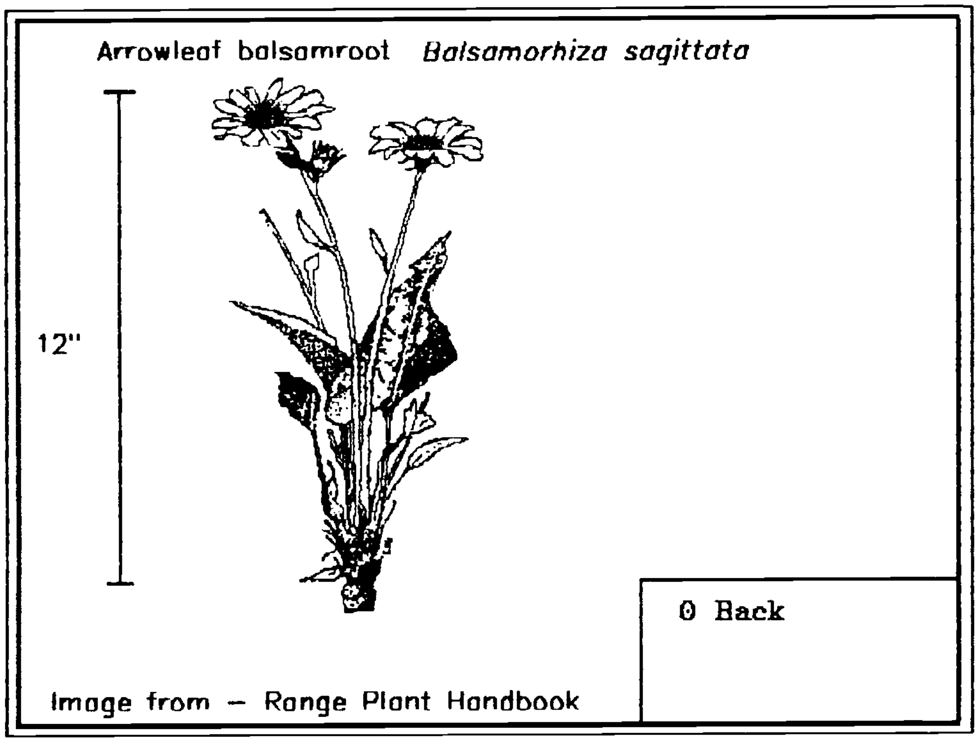

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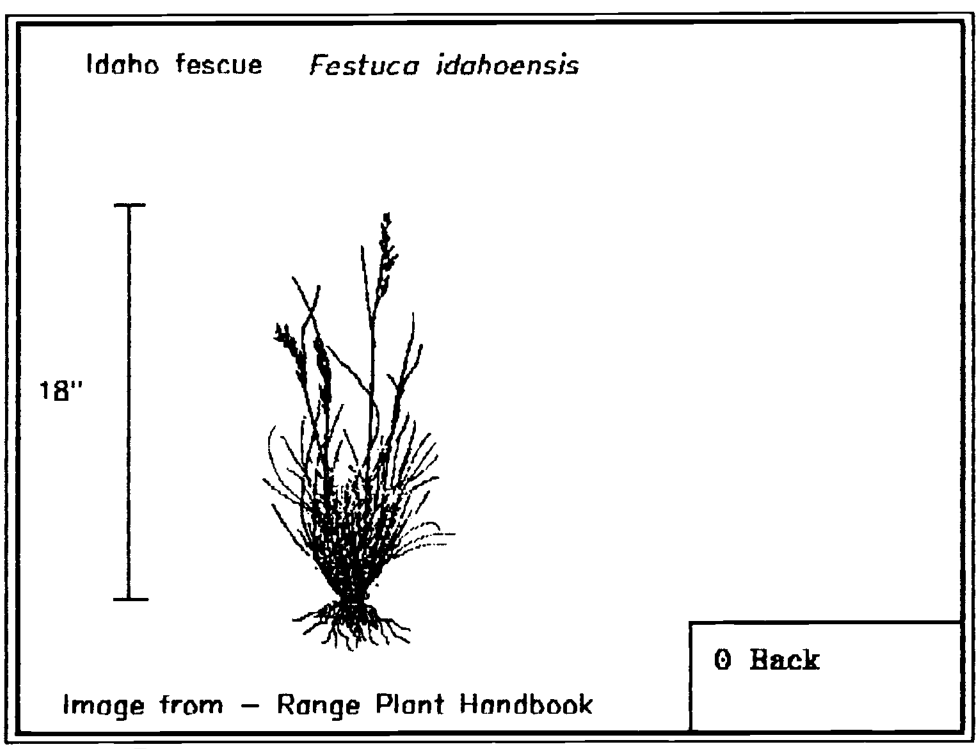

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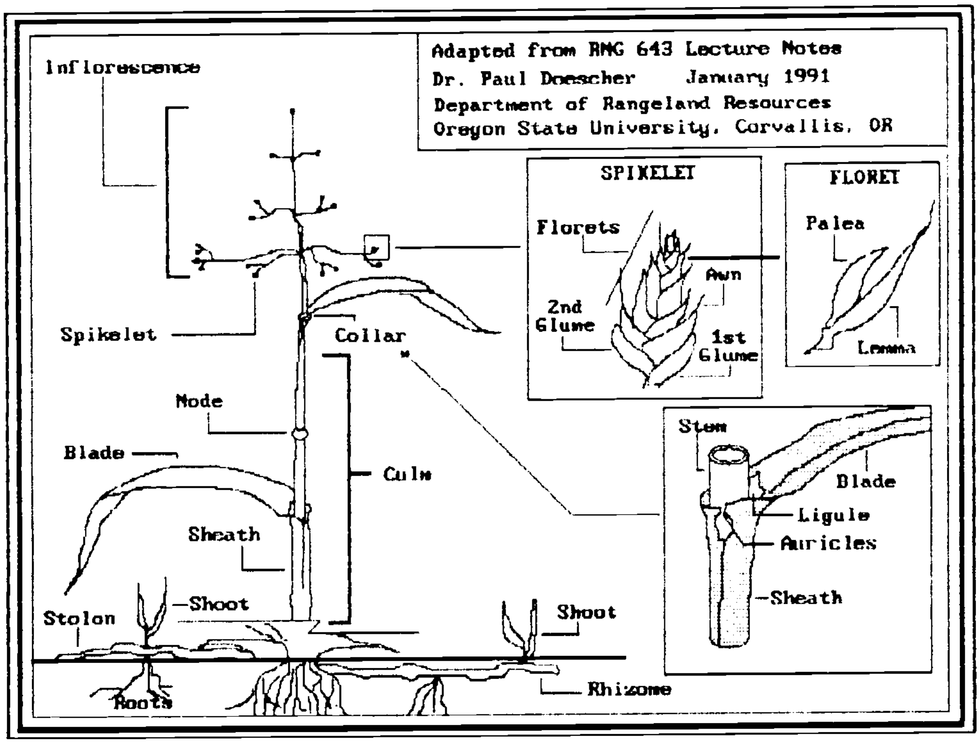

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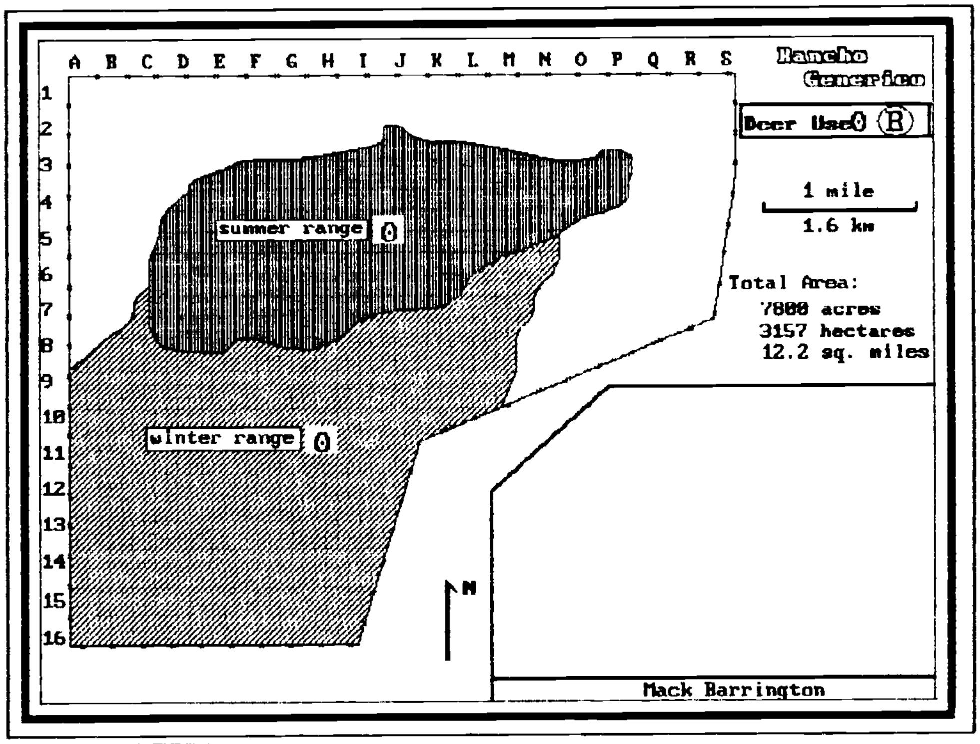

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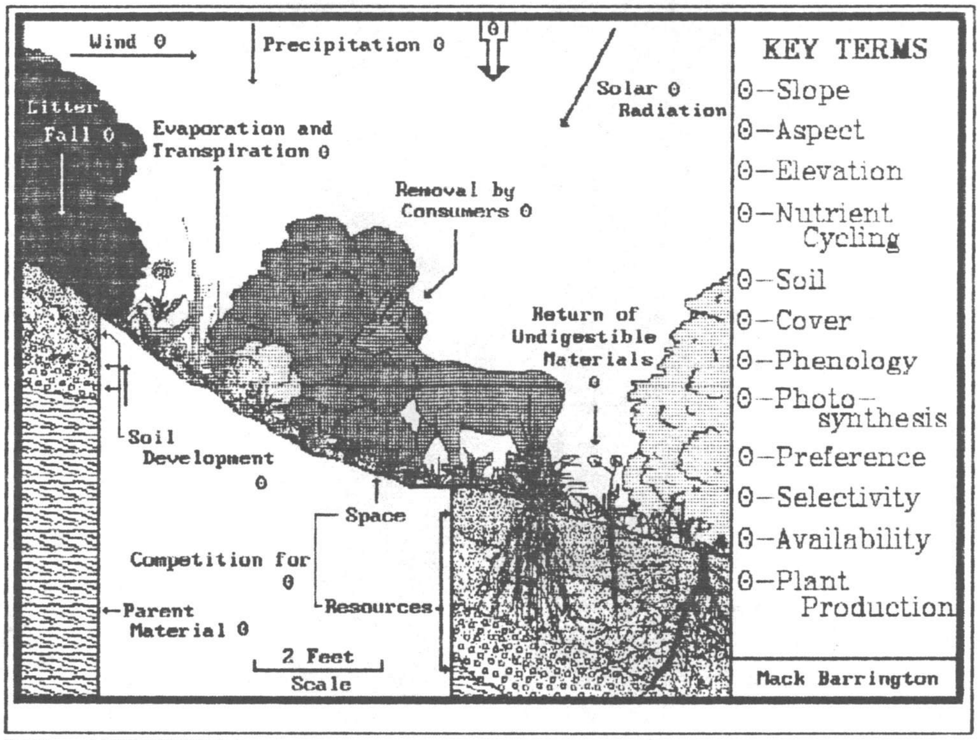

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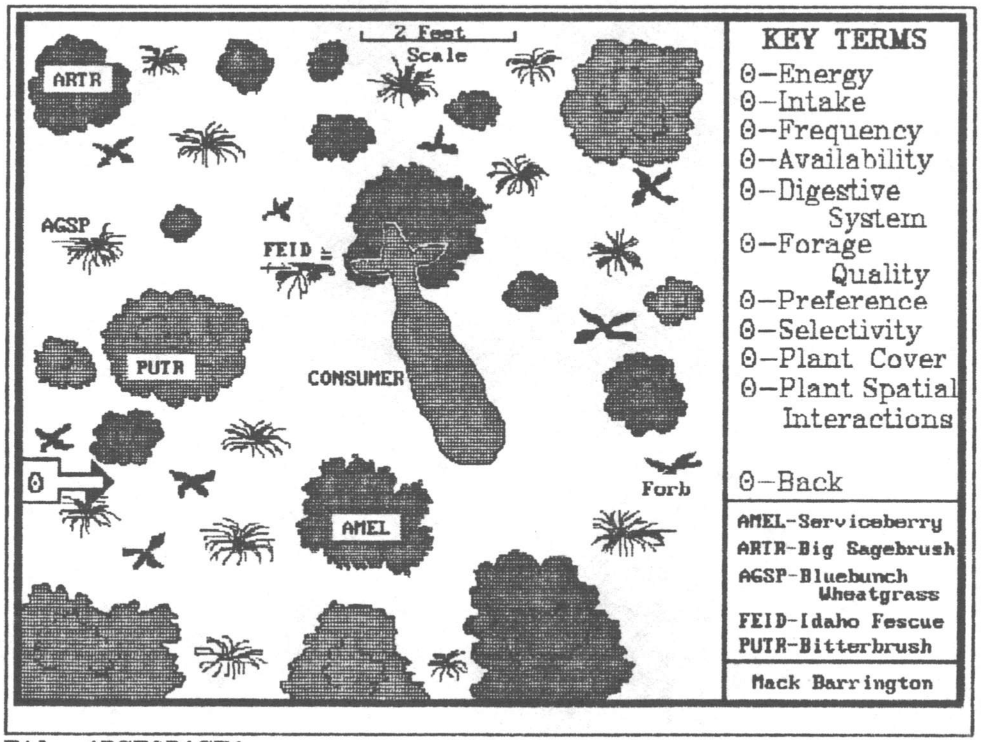

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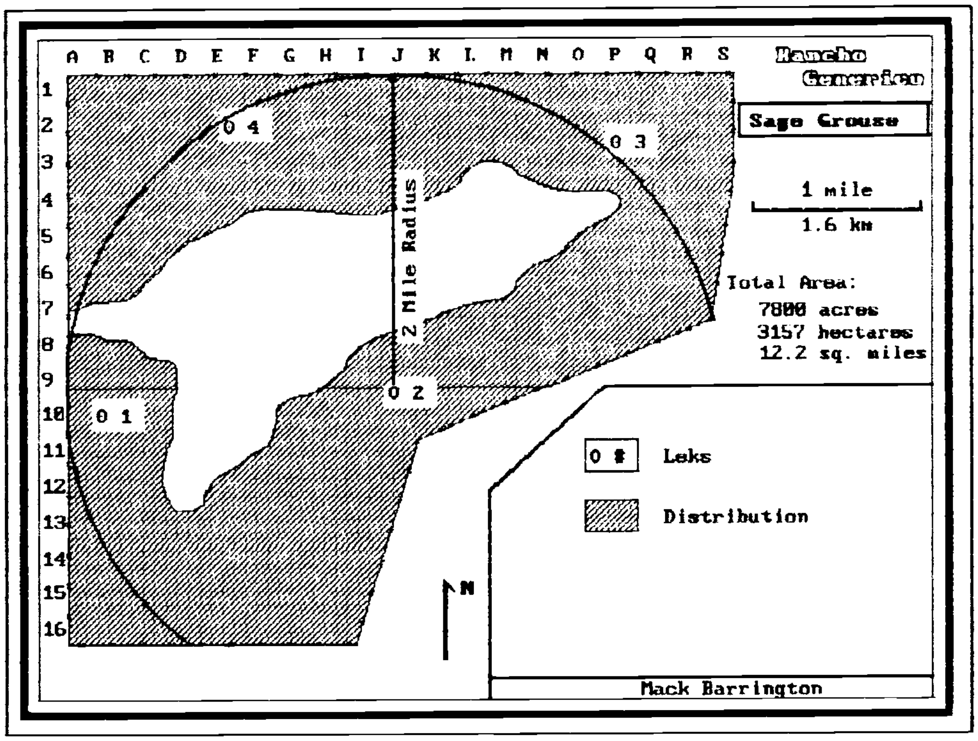

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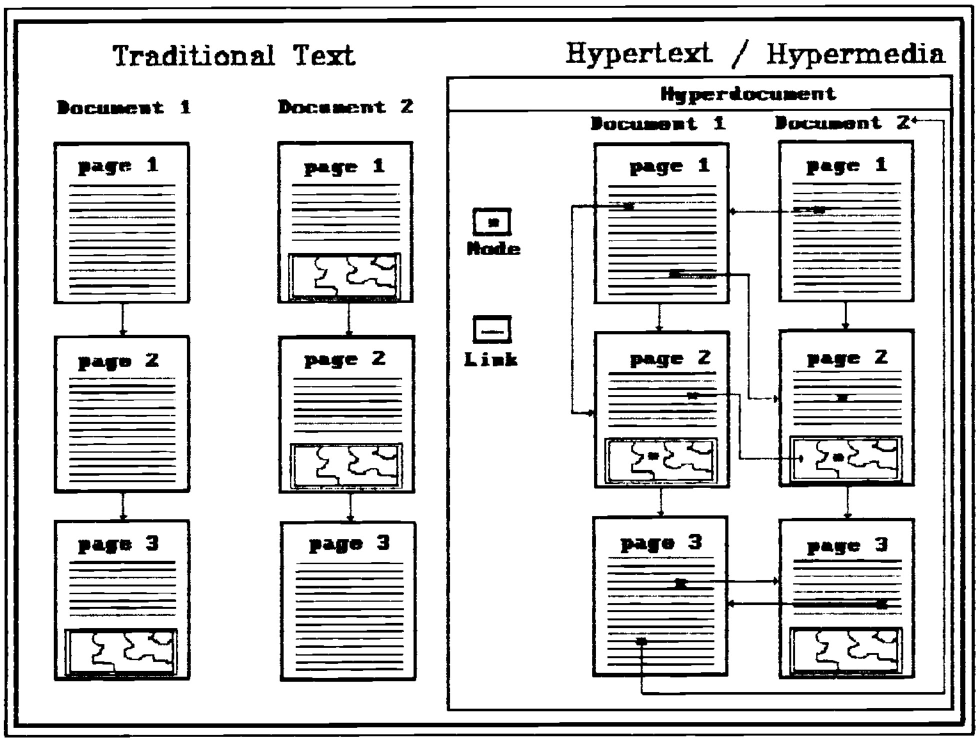

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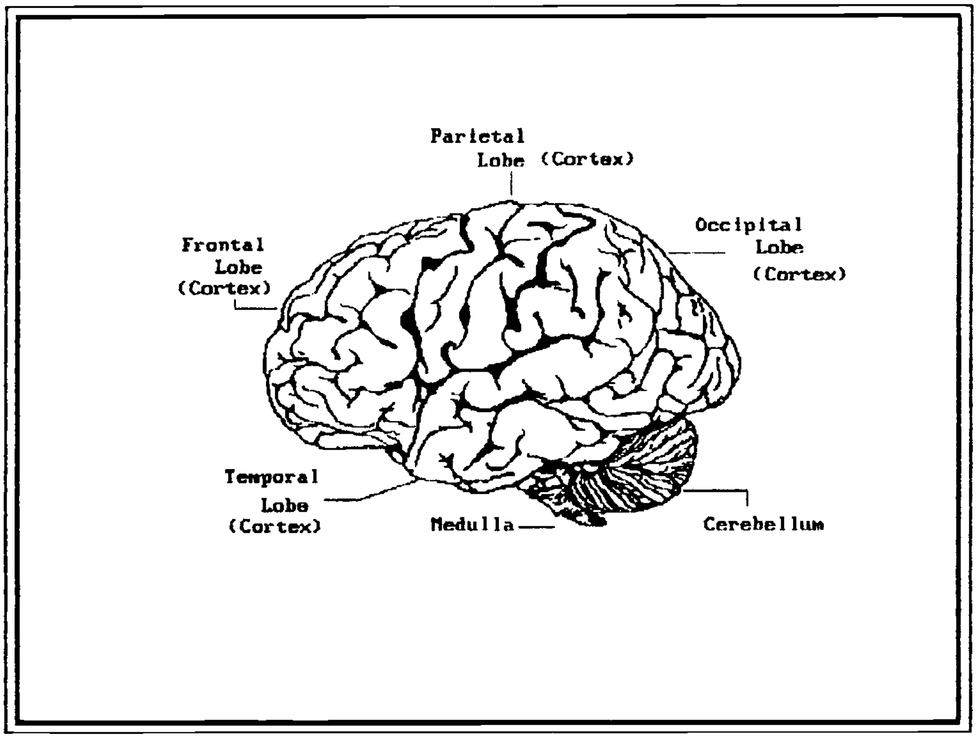

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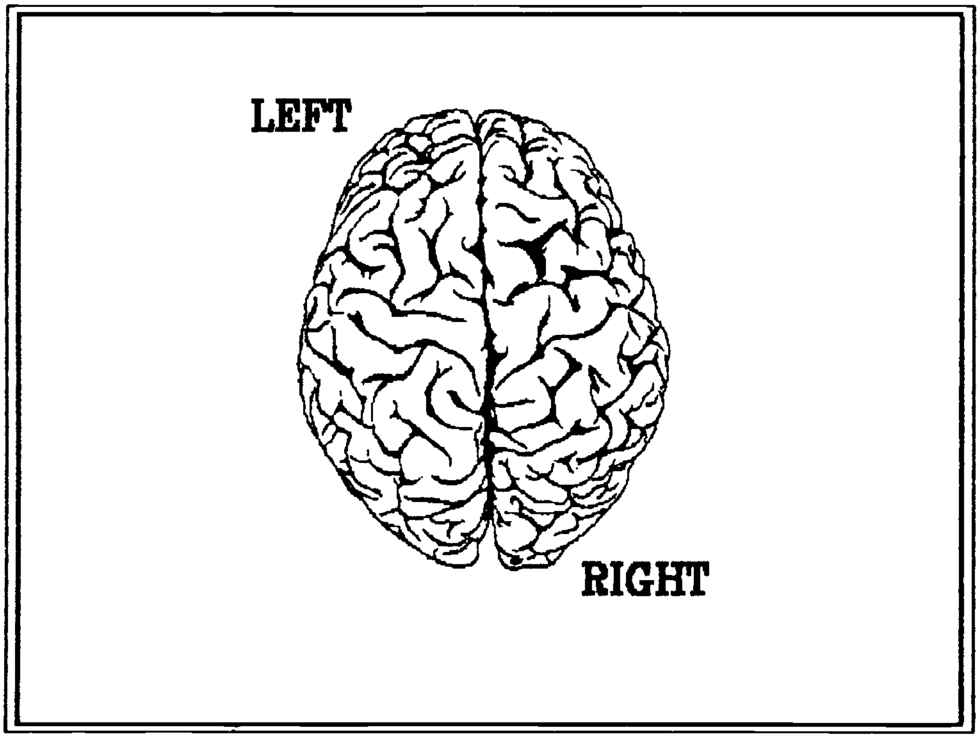


File 'BRAINTP'

Dichotomies

L. Hem.	R. Hem.
convergent	divergent
intellectual	sensuous
deductive	imaginative
rational	metaphorical
vertical	horizontal
discrete	continuous
abstract	concrete
realistic	impulsive
directed	free
differential	existential
sequential	multiple
historical	timeless
analytic	holistic
explicit	tacit
objective	subjective
successive	simultaneous

From: Springer, S.P. and G. Deutsch 1981. Left brain, right brain. W.H. Freeman. San Francisco, CA

R. Hem.	L. Hem.
Acceptance of Uncertainty	Thirst for Certainty
involvement	extrication
exploring new	rejecting new
opening	closing
yielding	stubborn
flexible	rigid
risk	security
floating self	unmoving self
learning to be	learning to be
larger	sharper
encompassing	finer
softer	harder
more absorbent	tougher

From: Elbow, P. 1981. Writing with power. Oxford Univ. Press.

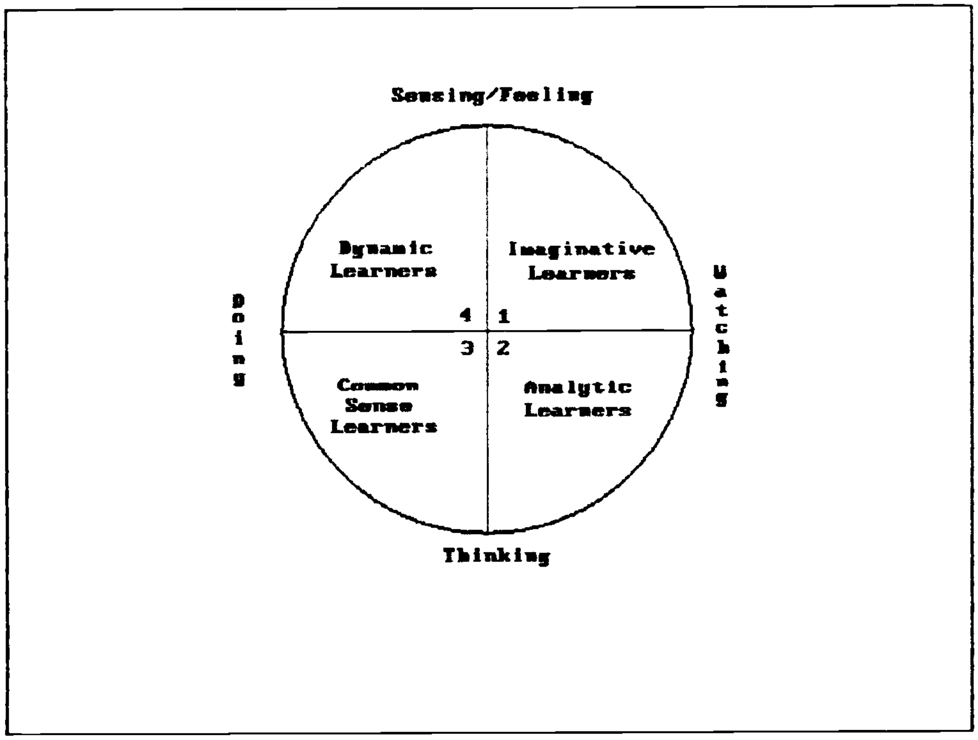
essence	words
receptive	skeptical
new ways	repetive

From: McCarthy, M.J. 1991. Ed. Lead.

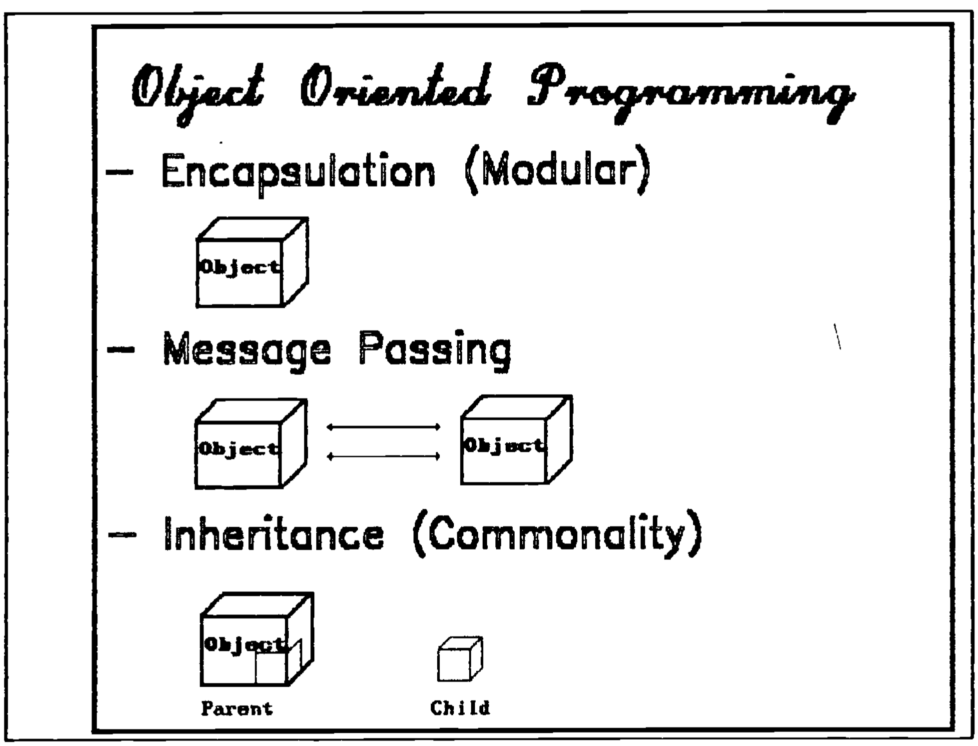
File 'DICHOT'

HUMANS	INFORMATION
Theophrastus	Plant Distribution
	Ecophysiology
von Humboldt	Species
Warming	Climate
Darwin	Succession
Cowles	Seral
Gleason	Climax
Clements	Gradients
Egler	Habitat Types
Piemeisel	Vegetation Dynamics
Whittaker	Space / Time
Daubenmire	Disturbance
Westoby	Genetics
	Competition

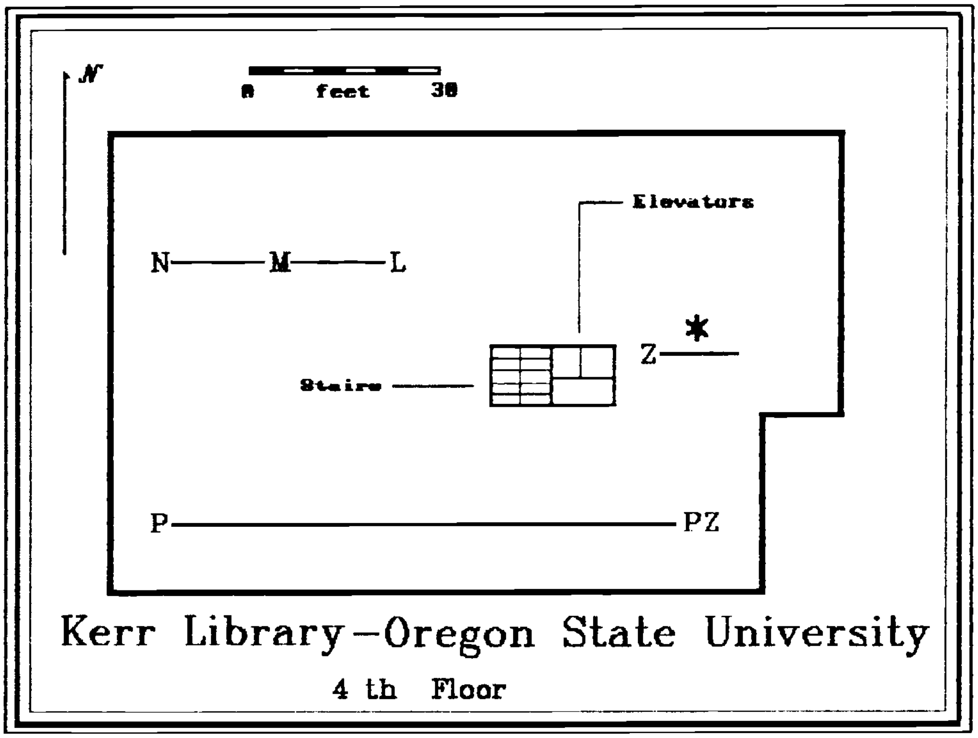
File 'ECOLOGIS'



File 'LEARN'



File 'OOPS'


N
0 feet 30
Elevators
N
M
L
Stairs
Z
P
PZ
Kerr Library–Oregon State University
4 th Floor

File 'LIB4'

APPENDIX C

Using the Knowledge Bases

Using the knowledge bases (RANCH.CKB and PAPER.CKB)

-You should have atleast:
- an IBM compatible computer with 640 Kb RAM
- a VGA display -if you have color- set to monochrome mode
  - i.e. MODE BW80 or else you will have blue deer eating pink shrubs or maps with bad color schemes (graphics were all constructed in monochrome mode)
- a Microsoft compatible mouse- helpful
- 4 Mb free space on your hard drive

-Installation Procedure

1. make a directory - your choice of name
2. change to that directory
3. insert the KP runtime disk and type INSTALL - follow directions copy the PCX.EXE program from the Graphics Toolkit
4. look at the READ.ME files on both of the above disks
5. copy the RANCH.CKB and PAPER.CKB files into that directory
6. copy all of the graphics (*.pcx) files into that directory
7. when using the system - change to the directory you created and then enter KP at the prompt - your screen should have a listing of the knowledge bases available to use - you can use the <u>left</u> mouse button or arrow keys and F3 to select the knowledge base of choice.
8. interaction is through the message window which is always below the main text window - you will use the <u>continue</u> command frequently - when problems are encountered use the F10 key to exit the knowledge base or use <u>help</u> to assist in solving the problem. The DEMO knowledge base probably should be consulted first for a short description of KnowledgePro capabilities.
9. when using the Main Glossary in the RANCH.KB please allow approximately 20 seconds for KP to partition the glossary into pages - you can page up (right mouse button) or page down (left mouse button) using the page command in the message window.
10. sometimes when using the <u>continue</u> command with multiple windows on the screen, an error window will appear- simply press <u>continue</u> again.
11. when in a graphics screen - to exit you have two choices-
    1. select a hypertext node (small square icon near a point of interest) linking to another graphics or text screen - left mouse button.
    2. use the right mouse button to reverse to previous node or screen - this can be done only if the cursor is inside the graphics screen.

12. Happy Navigating - Remember if all else fails use F10.