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Introduction of using Geographic Information System(GIS) for Forest Recreation Planning[1]

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山林休養計劃을 위한 地理情報體系의 利用에 관한 紹介[1]

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ABSTRACT

Importance of forest recreation in the Korean forestry situation has recently been increased and will be even more rapidly in the future. For efficient planning and development for the national scale, computer-aided information techniques are urgently needed. Geographic information system(GIS) has been proven to organize and analyze data from various sources for large geographical areas. Unlike conventional data base management system (DBMS), GIS can handle spatially referrenced data and, thus, can be a good candidate for recreation planning support system. This paper introduces the concept and components of GIS and illustrates examples of GIS applications. A possibility of system integration with other data sources is also suggested.

Key words : forest recreation, recreation planning, GIS.

要 約

임업 내에서 山林休養의 중요성이 최근들어 인식되어지고 있고 앞으로도 빠른 속도로 고조되리라 예상된다. 국가차원에서 산림휴양 계획/개발의 효율성 증진을 위해 電算情報技術의 도입이 시급히 요구된다. 대단위 지역의 空間的 관련성이 부여된 다양한 자료를 관리 및 분석할 수 있는 地理情報體系(GIS)가 위의 요구를 충족할 대안으로 부각된다. 이 글은 GIS의 개념, 구성요소, 및 계획을 위한 예를 제시함으로 적용가능성을 보이고자 한다. 산림휴양 계획을 위한 적절한 정보체계의 개발에 응용가능한 GIS와 기타 관련 데이타베이스의 統合情報體系의 구조도 제안된다.

INTRODUCTION

Forest recreation has recently been recognized as a vital part of forestry business as well as a means to alleviate social problems providing outdoor recreation opportunities. The revision of forest law early this year partly reflects our society's concern for forest recreation. According to the revised law, new recreational development is allowed in publicly and privately owned forest lands, which has been prohibited for mainly preservation reasons.

Until July, 1990 when the new law becomes effective, The Korea Forestry Administration ought to make an official notice on nationwide recreational land classification scheme to guide proper development and administration. Unfortunately, the Forestry Administration has put little efforts on establishing the classification system

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and developing recreation related data base. The lack of conceptual and practical guideline tends to force decision makers to determine which part of land is to be developed only based on their subjective judgement.

The challenge to forest recreation planners is to accommodate the pressures which are to improve equitable provision of opportunities while at the same time to enhance the quality that makes the land attractive place in which to live and recreate. Most of our land is geographically complex, ecologically and socially dynamic. Successful solution to planning and development problems requires sensitivity, skill, and the application of advanced support technology available to the planner.

In many instances, simple access to the information is not the solution to the various problems related to the planning procedure. Planning in general has meant taking intelligent, rational action through generation of alternatives, evaluation, and choice based on that evaluation. However, what constitutes rational action is the subject of much argument, because the prescriptions of rational planning action are to evaluate all alternatives aganist all objectives pursued.

At least three problems can be raised in the context of rational planning. First, because many interest groups with conflicting interest become involved in the planning process, optimal output may not be guaranteed by the rational process. Rationality is a way of evaluating alternatives so clearly and demonstrably that the planner may decide a proposal is superior to the others (Gould, 1971). Very often proposals do not originate from a truly rational thought process, and the arguments advanced are for the purpose of communicating ideas in a way which will gain their acceptance. Motives behind such proposals occasionally imputed to the interest group lobbyists who usually favor on the extremes, for instance, the effects of economic growth with little consideration of environmental conservation. They implicitly wish to preserve their own privileged positions.

Second, an individual or organization has a limited capacity for handing information. The reason is simply that humans are limited (Miller, 1968). Within the context of the rational planning, There is a high demand for information processing within a short time frame. Unfortunately because of the limitation of the planners to process necessary information, many decisions are based on inadequate information and instinct thought. Though planning organizations may draw on the faculties of many individuals, and thus pool their ability to handle information, they still have limited capacity for simultaneously holding the mass of information required to fulfill a rational prescription (Faludi, 1973).

The third problem is closely related to the lack of communication within a planning organization. Very often, many sections in a same organization work on the identical issue from various perspectives with little or no integration of information.

An approach to the solution of these problems lies in the development and utilization of computer aided spatial information systems that bring to planning objective decision rules with which planners can link informations and alternatives for addressing the problem of interest. In addition, the systems should not only be able to allow theory to be applied to reality but also be able to provide a channel of communication among individuals and organizations.

The purpose of this paper is, thus, to introduce computer aided spatial information systems through an explanation of the concepts, components, and applications of the system to the recreation planners. The potential benefits as well as problems are discussed.

SPATIAL INFORMATION SYSTEM

For many years, researchers and planners in many disciplines dealing with land resources have faced problems related to the analysis and manipulation of entities that exist within a specific spatial framework. While a map has been the most common medium for understanding simple spatial relationships, the task of processing information presented in a map is not easy. Similarly, experience has demonstrated that while it is easy to retrieve small amount of data manually, examination of complex relationships between different types of spatial data or simple retrieval of large amount of data is very laborious and slow.

A common question that planners frequently address relates to the possible interrelationships existing between two or more data sets. For instance, in attempting to assess the recreation potential of a specific study area, a planner may desire to know which water bodies of a certain size are located within a certain distance from several population centers. This simple measure of access is obtained by comparing two spatial data sets, one showing the size and distribution of water bodies and the other showing the similar information on population centers.

Though one can perform this query intuitively by making two transparent maps containing relevant information and overlaying on the light table to make a composite map, the task may cost more labor and time, and most importantly, substantially impact on the accuracy of the results. This problem becomes more severe when the query requires a series of complex decision rules which conventional McHarg-style map overlays can not handle (McHarg, 1971).

To solve the problems, a number of computerized systems, better known as geographic information systems (GIS), have grown up to automate the manipulation and integration of spatial data sets.

CONCEPTS

In general, spatial data have two components : a location and an attribute. The location component represents the values describing the spatial position of an object or event, while the attribute component describes its other non-spatial properties. Locational variables can be used to identify point location, line segments, or boundaries in a metric form, whereas attribute variables can be stored by means of either a qualitative or quantitative measurement scale. The spatial information system can be considered as a specialized data base management systems (DBMS) to integrate locational and attribute type data. In many respects, spatial information systems are similar to automated DBMS's in their capabilities of :

1. Collecting data, transforming them into the machine readable form and storing and organizing data within computer,
2. Editing and updating the data,
3. Manipulating, , analyzing, and retrieving entire data sets of selected portions,
4. Generating a variety of output products including maps, charts, and statistical reports.
5. Considering data back-up and system security.

Spatial information systems differ from DBMS in the sense that locational identifiers are attached to the data to form computerized maps. Thus each datum is so called georeferenced.

Once data are geo-referenced either by vector, TIN (triangulated irregular network), or grid units form (Schneider & Amanullah, 1979 ; McFarland, 1982 ; Deuker, 1987 ; Lee, 1990), they must be filed away and ready for the manipulation. The way spatial data are managed is illustrated in Figure 1 using examples of physical planning components for recreation development (Gunn, 1979). The filing of each component layers usually involves the assemblage of geometrically corrected data elements which are referenced by geographic coordinates. For any area or point on the component, the pertinent resource data can be examined, analyzed, and converted into information useful for decision-making.

Curran (1984) compiled the eight operations commonly found in a number of commercially available software packages designed specifically

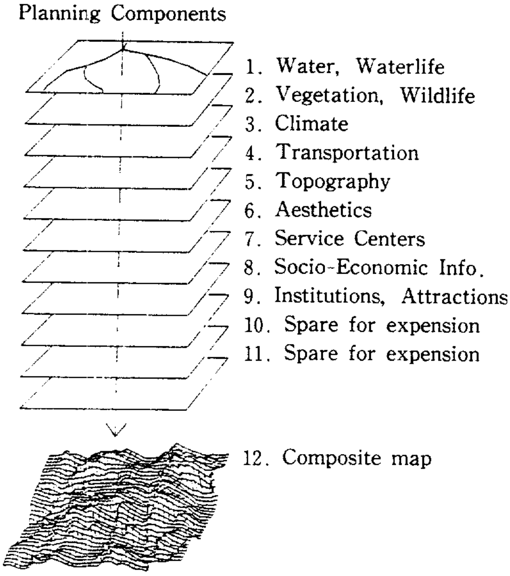

Fig. 1. Diagrammatic representation of a 12 level recreation development information system.

for spatial information systems : retrieval, transformation, storage, searching, analysis, measurement, recombination and modeling. While the detailed explanations of each operation are available elsewhere (i.e., Dangermond, 1983), Table 1 explains briefly with examples which can be applied to recreation planning components in Figure 1.

In the context of the forest recreation planning, the following issues of spatial information systems deserve special attention :

1. Relevance of the systems view of information,
2. Possible use of statistical-econometric models,
3. Power of modern computer approaches,
4. Provision of better communication with comprehensive and coordinated data sets to other agencies or individual users.

PLANNING-ORIENTED SPATIAL INFORMATION

There are several broad guiding principles of planning on the land in what Gunn (1972) calls the art of creating satisfying environments for recreation. Such an approach places particular emphases on functionalism-structural, physical, and cultural/aesthetic in recreation landscape planning. Thus, the recreation environment must function physically with adequate capacity, space and equipment for desired activities. Equally importantly, the planning must be appropriate to the regional ecology and socio-economic settings.

To accomplish these goals, simple overlay of first-hand planning components illustrated in

Table 1. Eight operations performed by spatial information systems.

Objectives	Examples	Data components
1. Retrieval of one or more data elements	Vegetation	2. Vegetation
2. Transform, manipulation or combine new values of one or more data elements	Access	7. Service centers 4. Transportation
3. Store new data elements	Land ownership	10. Spare
4. Search and identify particular combination of data elements	Attractions within a certain transportation	4. Transportation 9. Attractions
5. Perform statistical analysis on one or more data elements	Correlation b/w wildlife and topography	2. Wildlife 5. Topography
6. Measure area and distance of one or more data elements	Area of water	1. Water
7. Produce composite images of several data elements	Image of climate and topography	3. Climate 5. Topography
8. Be capable of modeling using several data elements	If potential recreation development sites are a function of 9 physical factors combined, display an image of potential development	12. Composite

Figure 1 may not be sufficient. For instance, a planner may wish to solve a forest recreation facility location problem by minimizing the distance any nearby urban residents might travel to the facility (from cities 'A' and 'B' to park 'P' in Figure 2).

In order to accomplish this task, information on an appropriate inventory of existing recreation facilities in the study area must be provided. Second, as illustrated in Figure 1, potential facility locations can be searched with the criteria which meet the system constraints such as size, physical/ecological suitability, land price, and etc. Third, a distance matrix from each urban centroids in the study area to the existing and potential facilities must be developed. Measurement of the distance may take into account of the nature of road networks which affects the speed of movement. Since accessibility is a function of not only spatial separation but mobility of each urban residents, the variables determining mobility should also be considered. These could include socio-economic status and car ownership and public transportation availability to the location of interest.

Based on the above input, the next step would be to evaluate the changes of existing areal accessibility distribution pattern when each potential site is included in the system. Several proposed accessibility pattern can be developed depending on the number of potential sites (Figure 2). Final decision can be made after comparing several composite maps depicting accessibility patterns with different proposed park locations. To aid the decision, the system should be able to formulate the frequency tables of the accessibility for different urban areas as well as the variability in the accessibility.

This simplified illustration of planning procedure using a spatial information system gives several implications for practical implementation. First, the system should offer relatively sophisticated spatial analysis capabilities. Examples include the abilities to calculate a distance map, cost surface map, and to overlay several maps with mathematical operations. Second, unlike the natural resource planning schemes which need little information on human behavior, recreation planning requires information describing the underlying factor affecting people's recreation travel behavior. Finally, the system should be flexible enough to accomplish tasks which generally requires

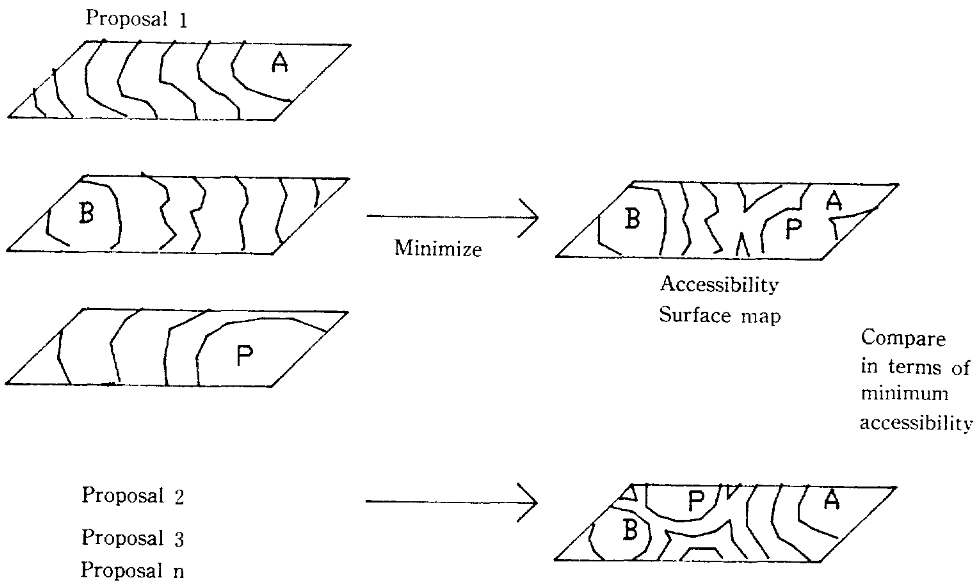

Fig. 2. Hypothetical planning procedure

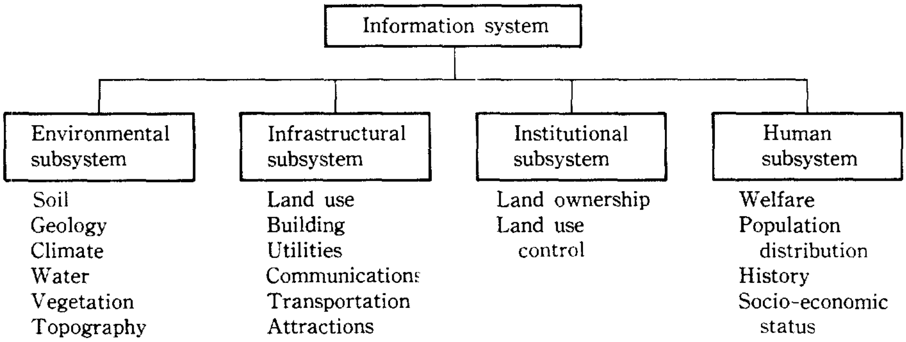

Fig. 3. Planning-oriented Information System

extensive data communication between several sectors of the organization.

Fortunately, today's computerized spatial information systems coupled with careful systems networking with other information sources are believed to handle the problems listed above. In this context, a planning-oriented information networks can be further defined as a combination of human and technical resources, together with a set of organizing procedures, which results in the collection, management, dissemination and use of planning-related information in a systematic fashion.

To be effective, four principal types of subsystems may be identified for this scheme (Figure 3).

1. Environmental systems which delimit environmental zones of a unique physiographical, biological nature,

2. Infrastructure systems which focus on man-made improvement to the land,

3. Institutional systems which are primarily concerned with political and administrative constraints on the land,

4. Human systems which are primarily concerned with socio-economic and behavioral aspects of human being.

INFORMATION SYSTEM NETWORKS

While a planning-oriented information network is a confederation of such four subsystems, each subsystem can also be considered as a specific goal oriented spatial information system or data base.

For instance, environmental subsystems are the main body of the most of the state or nationwide natural resource inventory information systems. In Texas, U.S., the Texas Natural Resources Information System (TNRIS) has been established to serve as a mechanism within the state for linking together the users of natural resources and related data with those agencies and institutions which collect and store such data (Wilson & Lancaster, 1979). Among its functions, automated spatial information system has got a special attention to guarantee a high degree of standardization for and access to natural resource related data.

Institutional subsystems and human subsystems can be well covered by the Dual Independent Map Coding (DIME) developed by the U.S. Bureau of Census (Bureau of Census, 1970), which may be considered as one of the best geographical information data bases available. It is composed of segment records which are defined as a length of a street of features between two distinct vertices or nodes. The features may include imagery lines defining political or other boundaries; river, shoreline, railroad, etc. (Bureau of Census, 1970).

Given these segment records, DIME can be a bridge for cansus data and locally generated survey data to spatial information systems. Using one of the constituent programs of DIME called ADMATCH (for address matcher), and address

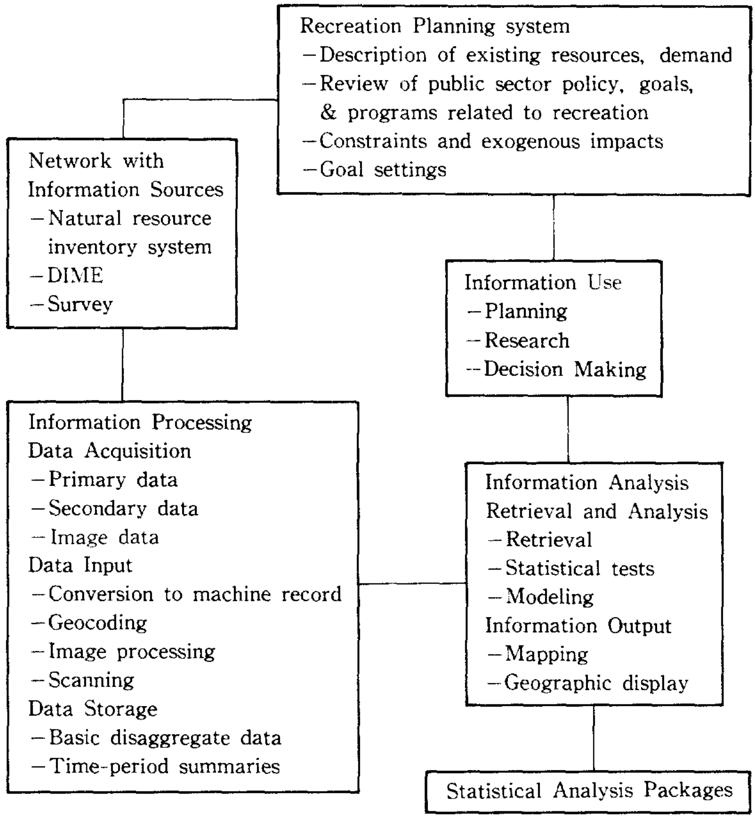

Fig. 4. Integrated Information System

that falls within the area covered can be matched to its proper census track or block which are already geo-referenced (Wills, 1986). For instance, questionnaire survey based data file which may include information on frequencies of recreation participation, awareness level for local parks, available leisure time, number of cars owned, etc. can be matched to the DIME file. This individual level data can be easily aggregated for the planning purposes.

At this stage, it is believed that several resource inventory information systems (i.e., TNRIS) and geographical data bases (i.e., DIME) can be agglomerated to form a powerful spatial information system for recreation planning. The interrelationships are illustrated in Figure 4.

OTHER APPLICATIONS OF GIS IN FORESTRY FIELD

Applications of computerized spatial information systems stem from the ability of the system to store, sort, merge, edit, update, and, most importantly, analyze the available information according to the set of decision rules (de Steiguer & Giles, 1981).

Considering the system is not an end but a means, possible applications are only limited by the advancement of problem definitions and research methodology which can take advantage of GIS. The followings are typical GIS applications in forestry research field which have reported in the related journals.

1. Forest planning in general

Forest planning in U.S. is becoming more complicated as the public is becoming more involved in and knowledgeable of what they are doing. Bringing the technology of GIS with the existing databases has provided the Service can effectively implement forest decisions (Watry, 1989; White & Heasely, 1989; Prather, 1989). In particular, vegetation resource inventory (Steffenson, 1989), forest cover maps (Berry & Mansbach, 1981), forest pest management (Lee, 1989), and modelling growth and yield (Crookston & Stage, 1989) are few examples.

2. wildlife research

The primary application is to inventory records of wildlife habitat quality or quantity over space and time. These records can be used for habitat evaluation and potential habitat selection analysis. In general, the greater the diversity of plant species, age classes, and successional stages, the better the quality of the habitat for a variety of wildlife species. Wildlife managers can not evaluate a forest land in isolation because adjacent lands may be added to, or detracted from wildlife habitat values. Forest edge, open area in the forest, and underground cover are among many factors which should be considered. GIS capabilities such as measuring boundary configurations, the ratio of area to edge, frequency of interior gaps, coincidence, diversity, distance and connectivity, shortest paths, and view areas can be used for wildlife research (Tomlin, Berwich, & Tomlin, 1979; Dabney, 1980; Kopf & Cushwa, 1984; Haywood, 1989; Lyon, 1989)

3. timber supply analysis

Berry & Sailor (1981) developed cartographic model which can be served as a strategic planning tool to spatially characterize the harvest and transport cost for the timber supply surrounding an existing or proposed forest product facility. According to the model they can identify so-called 'timbershed' that characterizes which parts of forest lands should be harvested and hauled to certain product facilities using certain road systems to minimize the overall cost.

DISCUSSION

The gap between required and available information influences decision making, in that some decisions are either postponed or are made without an adequate rational foundation. To overcome this problem, GIS and planning-oriented information systems have been developed and are now becoming more widely used in some countries. With data provided from remote sensing and other survey sources, the systems has proven to organize and analyze them for large geographic areas. In order to be effective in natural resources and land use planning for the national scale, appropriate application of the system is urgently needed.

In terms of forest recreation, special emphasis has been put on spatial aspect of information system because activity participation inevitably implies spatial movements to the resources. Equally importantly, for recreation planners, reading statistical data from a map has clear advantages over having the same information listed in tables.

It has been shown that the system should be networked to utilize other available information and to accept survey-based information. The negative side of system integration is that it means possible problems in data communication between different organizations and systems. Automatic data transfer from one system to another has been always problematic. Incompatibility between the data can be resulted from different areal definition, temporal changes, as well as topical discrepancy to classify the same data (Cater, 1979). Efforts should be put in an attempt to further identify the commonality of information and to secure the data standardization.

Though implementation of the system is conceptually sound and practically feasible, it may be difficult to justify on the basis of a single or a few applications because of cost and time involved in development and management of a system. The maximum benefits would be obtained when the system is utilized repeatedly to solve the planning problems. Developing a customized information system is ideal, yet, use of commercial or public domain software is a good alternative particularly for those agencies or organizations who have little expertise in the system. Appendix lists some of the available GIS softwares for personal computer or workstation and developer's addresses from which one can get more information.

In sum, the spatial information system can provide a new approach to the conventional task of multi-resource inventory, evaluation, and decision-making for forest recreation planning. Hopefully, the advantages of the system would be recognized by the researchers and practitioners and will soon break the obstacles of planners imaginations and system availability. In so doing, the planners are one step further to achieve the ultimate goal ; better use of our land to live and recreate.

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APPENDIX

ARC/INFO
Environmental Systems Research Institute
380 New York Ave.
Redlands, California 92373

GRASS(Geographical Resources Analysis Support System)
U.S. army construction engineering research lab
P.O.Box 4005
Champaign, Illinois 61820

MOSS(Map Overlay and Statistical System)
Oregon Bureau of Land Management(BLM)
P.O.Box 2965
Portlans, Oregon 97208

MAP(Map Analysis Package)
Department of Geography
The Ohio State University
Columbus, Ohio

SAGIS(Systems Application Group Information System)
Branch of Digital Cartography
P.O.Box 25287
National Park Service
Denver, Colorado 80225-0287

u-GIS
Forest Science Department
Texas A&M University
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