# THE ROLE AND FUNCTION OF THE GEOGRAPHIC INFORMATION SYSTEM FOR THE MANAGEMENT OF NATURAL RESOURCES IN THE NATIONAL PARK SERVICE

Thesis in Landscape Architecture

by
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**Master's Thesis**

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## INTRODUCTION

The title of this thesis project features three broad, yet different, elements of study: a specific public agency (the National Park Service), an ecology-related procedure of manipulating the environment (management of natural resources) and in the center, a modern computerized planning and design tool (the Geographic Information System). This composition of elements, which can easily be paraphrased as a simple user-work-tool relationship, suggests a close and common ground shared by all individual parts. With some understanding of the character, functions and quality of each of these parts, and with some knowledge about National Parks, natural resources and the way computer technology can find its place within the first two components, few will seriously question the existence of a logical tie that links the individual parts together.

The title of this study might imply that an evaluation of the Geographical Information System's role in the National Park Service (NPS) would be mainly a technical task. However, several non-technical issues such as the historical and institutional situation of the Park Service, and different approaches towards the management of natural resources, increase the complexity of this topic's scope. The implementation of a Geographic Information System has a relatively short history in the resource management of the National Park Service and not all connections between the three components have been made yet.

In order to illustrate the character of recent developments, the metaphor of an unfinished construction site with intersecting routes which come from very distant places and sometimes from opposite directions can be used. The oldest route is long and winding and belongs to a bureaucratic apparatus. While still ascending to the highest and most glorious altitudes of American ideals, this route was also forced, in recent years, to descend to the shady lowlands of harsh critique and merciless accusations: the life road of the National Park Service.

Relatively late (some persons would say far too late), the ideas and principles of science based resource management began to modernize traditional methods of park management. Road construction for this intersection of management techniques is still underway and a number of sections (park units) have yet to be completed.

Only within the last few years has this development been joined and nearly overtaken by the emergence of traffic from the fast lane of computer technology -- the National Park Service (NPS) discovered the Geographic Information System (GIS).

As mentioned earlier, the author considers the GIS mainly as a tool for the user. In this sense, it will be important to find out whether this tool can fill the empty spaces on the wide screen of resource management and whether it can help to draw the very fine lines which are necessary to accurately capture the outside world. In order to effectively achieve this goal, the work also has to take a thoughtful look at the painting itself, it will have to deal with the ecosystem goals in parks and wilderness areas. Hence, the role and function of the NPS for the future management of natural resources in America, as it appears in NPS's own formulated view, in the eyes of the public, and to other external (qualified) observers, is of major interest.

The study's major objectives will be the technical and institutional phenomena of the GIS implementation as well as its role within the specific park goals and the general management philosophy of the National Park units.

Drawing upon literature, material from the existing NPS experiences, and data gathered from a telephone survey among 21 GIS-using park units, this study will examine the intersection between National Park Service policies, resource management strategies, and the computer technology. The analytical part will be followed by recommendations for the improved performance of functional aspects of natural resource management in the Park System.

# CHAPTER 1: AN EVALUATION STUDY

## 1.1 STATEMENT OF PROBLEM

A thesis which deals with a multifaceted topic like this one will necessarily have to focus on only certain aspects of the general subject. The decision to study the National Park Service has several bases:

- the long history of this agency in the preservation of natural areas,
- the worldwide reputation of this agency for the high quality of their achievements within the conservation movement,
- the value and size of wilderness areas which are administered by the NPS,
- the function and qualities of the protected areas for global ecological systems (e.g. wildlife, air, water, soils),
- the amount of data which must be dealt with for advanced resource management in National Parks, and,
- the actual experience of the Park Service in using the GIS for these goals.

By concentrating on the management of natural resources, rather than looking at all (including cultural based) park units, the study intends to focus on only a special aspect of the general topic and to respond to the following underlying characteristics :

- the management of natural resources requires the handling of large data bases (inherent to GIS),
- the management of ecologically relevant data can exceed administrative boundaries,

- the management of ecologically relevant data needs to be combinable and transferable to adjacent data management units (both NPS units and other land managing agencies)
- a solution for the urgent problems of our environment justifies highest priority when selecting strategies and assessing their appropriateness and success.

The decision to concentrate on parks with mainly natural resources was confirmed by the results of a recent study among GIS users in the Eastern part of the United States (North Atlantic Region Study, 1988) which found that the GIS is less appropriate for small and culture oriented park units.

Traditionally, the management of natural resources was based on spatial data collected by navigators, geographers, botanists, and surveyors, and rendered into pictorial form by map makers or cartographers (Burrough, 1986). While these maps were very helpful for general purposes like the topographical interpretation of the earth's surface, modern resource management ventures on more complex and detailed operations. The spatial manipulation of various interrelated data layers within one geographic unit, the advanced accuracy and quantity of aerial photography and remotely sensed data, and the sophistication of research methods for land studies, make computer applications an almost imperative objective for the management of natural resources .

The Geographic Information System (GIS) is an advanced computer technology for the performance of sophisticated resource management. It allows the collection, storage, retrieval, transformation, and display of various forms of geographical data.

This study will examine the intersection between National Park Service policies, resource management strategies and the computer technology. What appears as an integrated system of highly advanced technology into the organization of a modern
administration, will also have to deal with controversial questions like: Who will make the decisions in the future? How will those decisions be made? What will they be based on? An encounter between John Muir's adherents and the "McIntosh" generation of the Eighties might lead to some fearful thoughts, such as : Will the future of the National Parks will have to rely on the capability of a computer program and on experts who talk and think in the language of a FORTRAN or PASCAL program, but who might not be able to differentiate a spruce from a hemlock tree.? Or will the ranger, who "literally never has seen any aerial photograph" (Frank Westerlund, 1989) still base his or her management decisions on the loudest complaints of last year's most disturbed visitor? Although these questions certainly exaggerate the topic's character, they sketch a tendency which can easily be sensed when entering the discussion with experts from both sides, the GIS technology and the NPS.

## 1.2 PURPOSE OF THE STUDY

The purpose of this study is to evaluate the appropriateness and efficacy of a GIS for the planning and management of natural resources in the National Park Service. Drawing upon literature, material from the existing NPS experiences, and data gathered from a telephone survey, this study will give recommendations for the performance of technical and functional aspects of the management of natural resources, rather than looking at all (including cultural-based) park units. The study is designed to focus on the following four main categories of interest:

1. technical phenomena of the GIS implementation (hardware/ software),
2. institutional phenomena of the GIS implementation (staff training/decision making),
3. expectations of the NPS and its units towards the benefitsfor the specific management goals and future tasks, and,
4. function of the GIS within the management philosophy of the NPS (how much of a tool?)

Due to the scale and frame of a thesis, this approach will limit the analysis and description of only indirectly related subjects (like the history of the NPS and the GIS, technical details of computer science, and concepts of ecosystem management) to Chapter 2 and will be interwoven among the summarizing paragraphs.

Major analytical parts of this study, however, are based on data gathered in telephone interviews which directly sampled facts, opinions and attitudes held by National Park units with actual GIS experience in resource management.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. RESOURCE MANAGEMENT

### 2.1.1. History of Resource Management

The history of resource management in the United States is very much intertwined with the early history of the nation. While the "Era of Abundance" seemed to promise limitless resources for the never ending waves of incoming European settlers, the following "Era of Exploitation" ended in 1890 with the shocking realization that there was "no frontier line remaining" (Fazio/Gilbert, 1982, p. 17).

Around 1880, men like George Catlin, John Muir, Frederic Law Olmsted, Charles W. Eliot, Stephan Mathers, and others expressed their concern for America's land resources which were being exploited at an alarming rate through overgrazing, overcutting, and general misuse (Miller, 1985). During the "Era of Preservation" (1890 - 1930), the Congress responded by passing the Lacey Act (1900, regulated hunting), the Antiquities Act (1906, protection of wilderness areas), by establishing the National Park Service (1912), by passing the National Park Service Organic Act (1916), and by founding the Bureau of Biological Survey (1905). The Forest Reserve Act from 1891 was the basis of a national forest system and forestry became the first and for most natural resource profession. Pinchot had formed a cadre of foresters that was model for all other resource disciplines (Shanks, 1984). Especially during the presidency of Franklin D. Roosevelt in 1930, the federal role in land management expanded as a reaction to the Great Depression. Roosevelt alone set aside 150 million acres of public domain.

Many years later, the major political and social changes of the 1960s produced another wave of environmental consciousness. As a result the Congress passed in 1960 the Multiple Use - Sustained Yield Act and in 1964 the National Wilderness System was created as a major instrument for the preservation of federal land.

Today, approximately 42% of the total land of the U.S.A. is owned by the nation's citizens (see Figure 2.1) and is managed for them by federal, state and local governments. Federal public landholdings are distributed among several departments and agencies (see Table 2.1).

Table 2.1.: Land Areas Owned and Administered by by Federal Agencies in the United States in 1982 (Miller, 1985, p.169)

| Agency | Name of Landholding | Percentage of All U S Land |
|---|---|---|
| Bureau of Land Management of the Department of the Interior (DOI) | National Resource Lands | 15 |
| U S Forest Service of the Department of Agriculture | National Forests | 8 |
| Fish and Wildlife Service of the DOI | National Wildlife Refuges | 4 |
| National Park Service of the DOI | National Park System | 3 |
| Department of Defense | — | 1 |
| Other agencies | -- | 3 |

Although the public agency does not apply the management of natural resources to the larger part of the country (56% in private ownership, 2% in ownership of native American Indians) the remaining 1,235,000 square miles

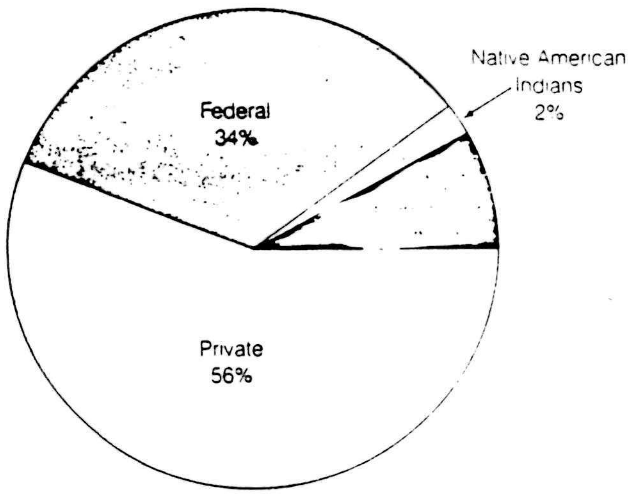


Figure 2.1: Land ownership in the United States (Source: U.S. Dept. of the Interior, Bureau of Land Management; in: Miller, 1985, p.167)

still represent an enormous contingent of natural resources and feature some of the most valuable natural areas of the world.

> "The publicly owned lands are the ideal lands of America, the pristine continent from which the nation rose with greatness. ...They are the spiritual heart of this nation, and because of the forces of history and geography, they are also the most evocative territories in the country."
> (Shanks, 1984, p. 26)

The sixties, fueled by publications like Rachel Carson's "Silent Spring", widened the scope of environmental awareness. The National Environmental Policy Act (NEPA) of 1969, the Forest and Rangelands Renewable Resources Planning Act (1974), the National Forest Management Act, and the Federal Land Policy and Management Act (1976)
strengthened public involvement in resource management decisions. At the same time, the prognosis of the Club of Rome (1972), later of the "Report to the

President - Global 2000" (1976), and the first Red Data Book from the Survival Service Commission (part of the International Union for the Conservation of Nature and Natural Resources, 1966), and the first world energy crisis (1974), set the stage for a dramatic reinterpretation of the notion of "Spaceship Earth".

### 2.1.2. New Directions in Resource Management

The growing understanding of a world that functions like a complicated organism and is based on the principle of a complex ecosystem with multiple, interrelated subsystems found its way into the public mind. The realization of how human activities can effect ecosystems in an irreversible way and can cause substantial negative impacts on the quality of human life essentials (water, air, food) gave rise to the conviction that it is necessary but not sufficient to establish National Parks, "... dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people" (Congress about Yellowstone NP in 1872, NPS, 1985 a, p. 6). The idea of creating a preservation area which from then on would continuously provide the public with reliable benefits turned out to be a heavy misconception of the reality. "All conservatism is based upon the idea that if you leave things alone you leave them as they are. But you do not. If you leave a thing alone you leave it to a torrent of change."( G.K. Chesterton, in: Chase, 1986, p.9) Hence, the necessity for active management of natural resources in order to enhance, mitigate, and correct, became a widely accepted practice - sometimes, however, with highly questionable results as in Yellowstone NP (Chase, 1986). Hickey (1974) expressed fear about the "management" idea because it consequently implies human decision making and manipulation within a field that is supposed to be in its optimal condition due to of the lack of human involvement.

Reasons for failed management efforts of the past were largely based on insufficient knowledge about the character and distribution of natural resources (Wright, 1986) and their significance in an overall context. However the situation has begun to improve.

> "Resource management in the past two decades has become increasingly sophisticated. Computers for handling data, modeling complex situations to help with decisions, and for communication, have become more important than the Jacob's staff compass or tally sheet. Stereoscope views have been supplemented with remote sensing devises in satellites that can pinpoint disease problems or aid in the planning of land use decisions. Biometrics, telemetry, wildlife behavior and nutrition, and biochemistry are bywords of today's natural resource manager. Slowly, human behavior, cultural norms, networking, and the monitoring of public opinion are also finding their way into the working vocabulary of the modern resource manager." (Fazio/Gilbert, 1986, p. 22)

The realization that an interdisciplinary approach to problem-solving must be considered as a crucial goal changed the role of resource management in a revolutionary way. The international scientific program of "Man and the Biosphere"( UNESCO, 1984) represents an effort to give life to a holistic vision which looks at the world as one ecosystem. This ambitious task can only lead to successful results when the management of natural resources is being used on a qualitatively and quantitatively high level of performance. Inventory, monitoring, access, retrieval and transformation of data are the essential elements of the effective and responsible management of natural resources. The quality of the results will strongly depend on the ability of the users (research institutes, universities and public agencies) to make the best use of all existing instruments and on their ability to cooperate with each other.

## 2.2 GEOGRAPHIC INFORMATION SYSTEM

### 2.2.1 General Aspects of Cartography

The importance of data when interpreting the spatial distribution of properties on the earth's surface has a long tradition reaching back to the early civilizations (Mesopotania, Egypt,etc.). During the last 200 years, beginning with the scientific revolution of the 18th century, the development of highly sophisticated cartographic standards became one major distinguishing quality of modern, powerful, and well organized societies (Burrough,1986). Scientific progress in general and specifically new ways of gathering and measuring spatial data (e.g.. aerial photography, seismographic instruments) allowed for continuous improvement in the quality of the final product. The medium on which these data have been presented, however, has remained the same: a map made of paper or film.

With the rapid development of resource management, the hand drawn paper map revealed various shortcomings for the needs and expectations of its new users. Peter Burrough, whose textbook "Principles of Geographic Information Systems for Land Resource Assessment" covers the essential GIS topics with comprehensiveness and objectivity, states:

1. the original data had to be greatly reduced in volume in order to adjust to a representable standard (often at the expense of accuracy)
2. the maps had to be drawn very accurately, which was a very time consuming and cost intensive procedure,

3. large areas could only be represented by the use of a large number of map sheets or scale reduction,
4. later it was not cheap or easy to retrieve data in order to combine them with other spatial information, and,
5. the printed map is a static, qualitative document, resulting in difficulties in changing and updating (Burrough, 1986).

Hence, a paper map represents a, "snapshot of a situation seen through a particular filter of a given surveyor in a given discipline at a certain moment in time" (Burrough, 1986).

As noted previously, these paper map "snapshots" are often not sufficient to produce desired results. The speed in which present data bases are growing due to additional thematic layers and improved resolution,the increased rates of changes in the landscape, the higher frequency and accuracy of data collection, and the much wider range of operations with which users need to manipulate their data sets, clearly demonstrate limits of the paper map. Advances in the field of aerial photography, and even more in satellite imagery, have made it possible to observe how landscapes change over time. Natural processes like desertification, erosion activities of rivers or melting glaciers, and forest fires, could only fairly or not at all be detected with traditional cartographic methods. Consequently, the introduction of computer- assisted cartography turned out to be partly a response to a cartography problem (Bie, 1984)

### 2.2.2. Computer-Assisted Cartography

In the United States, first computer-assisted mapping occurred almost simultaneously with the development of the GIS. In 1961, August Hills from the Ontario Department of Lands and Forests made the first approaches to define a unique and recognizable "natural unit" which had the character of a "correlative complex" (Vink, 1981). In 1977 Lewis Hopkins referred to this integrated procedure for resource surveys by using the term "gestalt method". The principle of working with transparent map overlays (Mc Harg,1969) from several monodisciplinary resources (soil, geology, vegetation, hydrology, etc.) was adapted in the mapping programs GRID and IMGRID which were developed out of SYMAP, a computer program designed by the American city planner Howard T. Fisher.

> "Because the management of the land involves a balance between diverse factors of the natural environment and competing human interests, landscape planning must integrate information from diverse sources"(Chrisman, 1986a, p. 427).

Before the introduction of the computer technology, map overlays were only subjected to visual analysis (though some attempts to quantify them by "photographic composition" have been made). All cited studies were efforts to create spatial models to express relationships in terms of their physical structure and in terms of chronological changes.

In spite of the positive results of some earlier projects (like the Honey Hill project where the explicit coding of each combination was much more specific than most of the comparable manual approaches), the new technology remained to be only experimental for quite a long time. In the late seventies, however, the advantages of computer technology in planning and design got more and more obvious.

Rhind (1977) summarized the benefits of digital cartography as follows:

1. to make existing maps more quickly,
2. to make existing maps more cheaply,
3. to make maps for specific user needs,
4. to make map production possible in situations where skilled staff is unavailable,
5. to allow experimentation with different graphical representations of the same data,
6. to facilitate map making and updating when the data is already in digital form,
7. to facilitate analysis of data that demand interaction between statistical analysis and mapping,
8. to minimize the use of the printed map as a database store and thereby to minimize the effects of classification and generalization on the quality of the data,
9. to create maps that are difficult to make by hand, e.g. 3-D maps or stereoscopic maps,generalization procedures are explicitly definedand consistently executed,
11. Introduction of automation can lead to a review of he whole map making process, which can also lead to savings and improvements.

2.2.3. The Appearance of Geographic Information System

Whereas the analyzing and manipulating capabilities of the computer-assisted cartography were still limited, the development of a Geographic Information System substantially improved the fusion between technical and conceptual achievements of various disciplines (see Fig. 2.2).

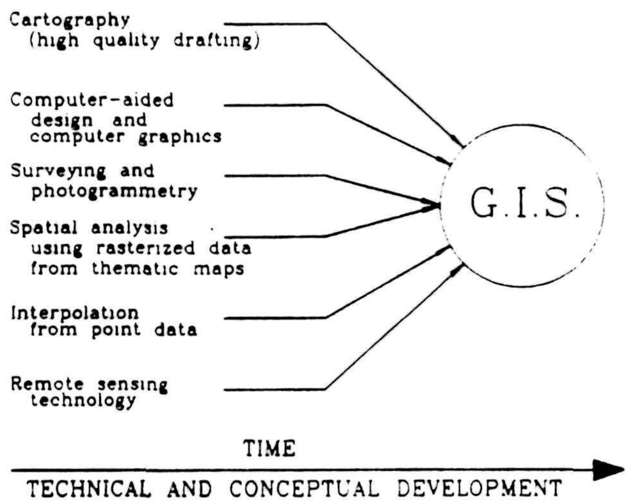


**Figure 2.2** : Geographical Information Systems as the Result of Linking Parallel Developments in Many Separate Spatial Data Processing Disciplines (Burrough, 1986, p.6)

The crucial advantage of a GIS lies in its ability to operate far beyond the coding, storage and retrieval of data. Dana Tomlin (now Ohio State) made an important step towards developing a useful interactive system when he designed the program Map Analysis Package (MAP) . Tomlin developed his ideas together with J.K. Berry of Yale and Carl Steinitz of Harvard. David Sinton who had written the mapping program IMGRID provided the appropriate training. The MAP program is based on the idea of cartographic modelling and defined a method called "map algebra", where data manipulation and analysis is performed by using neighborhood, combination, reclassification functions and interpolation methods.

Following the definition of Marble (1984), a Geographic Information System can be characterized by the presence of the following components:

1. a data input subsystem which collects and/or processes spatial data derived from existing maps, remote sensors, etc.,
2. a data storage and retrieval subsystem which organizes the spatial data in a form which permits it to be quickly retrieved by the user for subsequent analysis, as well as permitting rapid and accurate updates and corrections to be made to the spatial database,
3. a data manipulation and analysis subsystem which performs a variety of tasks such as changing the form of the data through user-defined aggregation rules or producing estimates of parameters and constraints for various space-time optimization or simulation models,
4. a data reporting subsystem which is capable of displaying all or part of the original database as well as manipulated data and the output from spatial models in tabular or map forms.

Hence, the typical software package for a GIS consists of the five basic technical modules which are subsystems for:

a. Data input and verification

b. Data storage and database management

c. Data output and presentation

d. Data transformation

e. Interaction with the user

Further elements of the terms and principles of Geographic Information Systems are explained in introductory paragraphs to the specific research topics in Chapter 4 (Findings & Discussion).

2.2.4. Critical Aspects of the GIS Technology

Despite the mentioned powerful potentials and the wide scope of its technical capabilities, the Geographic Information Systems still has to stand the crucial test of the day-to-day application. Like many other new technologies, GIS caused various laborpains which derived from initial financial, technological, institutional, and social problems. Information technology in general, however, is perhaps one of the most aggressive technologies of the current age, generating progress, change, and turbulence in many branches of industry, and in the lives of organizations and individuals. Drawing upon the GIS literature, the following list features some of the most common critical difficulties of a GIS implementation:

I. Technological Problems

a) problem of data accuracy

- the process of map production from remote sensing sources shows that accuracy is not easy to achieve (Hay 1979, Turk 1979)

b) problems of data-input, output, and storage

- often the data has to be prepared in a time consuming and tedious way to be transferable to the computer data base, the start of a running system might be delayed for a long period (up to 12 months and more, Niemann, 1988)
- especially with large areas, the storage capacity can be a serious problem , "disk space became a daily concern", especially a cost concern. (Niemann, 1988)
- (before the invention of the laser printer) the graphic standards of the mapping institutions are still much higher than what computer generated maps can offer (Bie, 1984)

c) errors through data processing

- problems with the cartographic modelling where integer numbers can lead to some misconceptions about the final results, especially after numerous operations (Burrough, 1986)
- polygon operations are sometimes extremely error-prone, especially when operating with high detail maps and different scales (Burrough, 1986)
- errors which occur through transfer from vector to raster and vise versa

d) hardware

- technology development, particularly in the computer hardware, continued so fast that it outstripped the abilities of managers to keep up with it (Burrough, 1986)
- different brands of hardware can require changes in programming to make them compatible (Niemann, 1988)

e) use of remote sensing data / raster technology

- display of raster maps are considerably less aesthetically (in a traditional sense) pleasing than maps drawn with lines
- in raster technology the use of large cells to reduce data volumes means that phenomenolgically recognizable structures can get lost, which can result in a serious loss of information
- in raster the intuitively visible data tends to be less recognizable disappeared (T.C. Waugh, 1986)

II. Institutional Problems

a) staff training

- often there is a shortage of trained staff (Huxold, 1982)

b) various other problems

- introduction into organization needs, and structural changes in work flow and practices
- many uncertainties about what the new tools were supposed to do
- the use of GIS is often limited due to the parallel use for administration and general data processing needs (Niemann, 1988)

III. General Management Problems

- evaluation of the capabilities of GIS can be very difficult when assigning benefits to new, unexpected products

- generally the benefits are hard to quantify due to integrated results from different disciplines (forestry, wildlife biology, landscape architecture) (Niemann, 1988)
- encoded information is easily considered (and sometimes falsely) to be absolutely correct and to not contain any errors (Burrough, 1986)

IV. Financial Problems

- the acquisition and development of the new tools are oftenextremely expensive (Burrough, 1980); costs are large upfront, and, if taken out of the context, they even seem overwhelming (Niemann, 1988)

Summarizing what can occur when a Geographic Information System is implemented, this list of "turbulences" appears to be very extensive. However, we have to realize that this contemplation may lead to a distortion of the major issues in resource management: for example,a list about the potential technical, social and financial disadvantages when purchasing a car could be even much longer. But nobody would therefore seriously propose to walk from Seattle to Denver, or even to walk more than 10 blocks within the city -- especially not in America.

"If one agrees that GIS is part of a paradigm suggesting that 'better decisions will result from better information', the GIS is fraught with the same basic social issues as information technology in general." (Niemann, Ventura,1988, p.2).

The question whether the Geographic Information System is mature enough to be accessible to the decision makers (Sullivan/Niemann 1986) will be one of the major topics of this evaluation study.

## 2.3 THE NATIONAL PARK SERVICE

### 2.3.1. Brief Summary of the Historical Background

"The conservation movement, like a river, had many beginnings," (Shanks,1984) In this context, the National Park Service certainly has to be considered as one of the major exponents of this movement, if not its most important and driving force.

By the Act of March 1, 1872, Congress established Yellowstone National Park in the Territories of Wyoming and Montana "as a public park or pleasuring ground for the benefit and enjoyment of the people," and placed it, "under exclusive control of the Secretary of the Interior". In an Act signed on August 25, 1916, Congress established the National Park Service in the Department of the Interior in order to,

> "...promote and regulate the use of the Federal areas known as national parks, monuments and reservations..."; "The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments and reservations ... by such means and measures as conform to the fundamental purpose of the said parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." ( NPS,1985, p.6).

In the General Authorities Act of 1970 Congress declared "that the National Park System ... has (since) grown to include superlative natural, historic, and recreation areas in every region ...".

Since 1872, the National Park System of the United States has grown to an agency which administers 337 areas covering about 79 million acres which make up 3.5% of the nation's total land (NPS, 1985, p. 10). These areas feature 48 major parks, and 289 national monuments, national reserves, national lakeshores and seashores, national rivers and wild and scenic riverways, national scenic trails, national historic sites, memorials and battlefields. However, it had been the large parks of the West like Yellowstone, Yosemite, and Grand Canyon, that gave birth to the myth of the National Park idea, and filled generations of visitors and travelers with exuberant enthusiasm. The scenery of its pristine and spectacular landscapes are reflected in the works and words of men like John Muir and Ansel Adams. Dr. Starker Leopold found that the "parks should represent the mood of wild America." Former National Park President Newton Drury called the national parks "America's crown jewels" and William Reillt, the former president of the Conservation Foundation, described them as "the cathedrals of the American civilization" and saw in them "the quintessential American idea"(Hartzog, 1988).

Using a less euphoric, but more technical, style, Joseph L. Sax (1980) defined the character and function of national parks this way:

1) the parks are places where recreation reflects the aspiration of a free and independent people,
2) the parks are are an object lesson for a world of limited resources,
3) the parks are great laboratories of successful natural communities,

4) the parks are living memorials of human history on the American continent.

The last big boost for the National Park System came on December 1, 1978, when President Jimmy Carter exercised his authority under the Antiquities Act of 1906 to proclaim 11 new national monuments as units of the National Park System and to add land to two existing monuments. Since the Alaska National Conservation Act became law on December 2, 1980, the National Park System has more than doubled the acreage from 31.3 million to 79 million acres (due to the additions in Alaska).

The president's actions in Alaska, however, can be seen as a striking example of the fact that the establishment of a park is relatively easy compared to the actual maintenance and management of its resources. Especially in Alaska, the execution of essential management tasks is now clearly limited (if not severely at stake) because the deficit of financial and personnel support (due to political opposition of an Alaskan Senator) is hindering the execution of necessary actions.

Alaska, this last true American frontier, still reminds the nation and the world of the past "Era of Abundance". However, now that there are fewer replacements to be found on this earth, the responsibility of handling its dwindling resources with care and wisdom, becomes the dictates of reason. There is no place for another Era of Exploitation and no forgiveness to repeat the mistakes of the past.

These mistakes occurred inside as well as outside of the park boundaries; and some were caused by active as well as by passive involvement of the Park Service itself.

2.3.2. A National Park Experience: The Pressures on the Resources

Since 1915, when Stephan T. Mather opened Yellowstone NP to cars, the rise of the National Parks' popularity as the tourist attraction on the American continent can be described by an exponentially ascending curve. One major boost for this development came during the Eisenhower Era, when in 1956 the landscape architect Conrad L. Wirth initiated the Mission 66 (Everhart, 1975). Explicitly designed to improve the recreational qualities of the parks, Mission 66 financed 130 new visitor centers. Between 1950 and 1984 the annual visitors to the national parks increased from 40 million to 335 million, including 18 million overnight stays (Miller, 1986).

Soon there was the need for carrying capacity studies in order to detect the locations and seasonal frequencies of the annual visitor -- the parks became a victim of their own success. "The only difference between Yosemite and Los Angeles was that Yosemite had trees and no traffic lights while Los Angeles had traffic lights and no trees" (Everhart, 1975). And Chase (1986) noted, that backpackers, due to their invasive pressures on very remote areas of the parks, were an even bigger problem than car tourists. And Hartzog, the former president of the NPS, cited Ansel Adams when summarizing his frustration the following way: "The pressures of a growing population, and shortness of vision are now the greatest enemies of the national park idea" (Hartzog, 1988, p.31)

But the impact of high visitor numbers is only one of numerous park problems. In some parks, especially in national monuments, profit oriented landuses such as logging, mining or farming are directly or indirectly competing for the park's natural resources. The times when a Stephan T. Mather could solve such problems with sheer determination (for instance when he exploded a lumber mill in Glacier NP in 1916) belong to the past (Connally, 1982).

Severe conflicts with landuses adjacent to national parks led to a controversial discussion of existing park boundaries. Already in 1933, the NPS report, "Fauna of the National Parks of the United States" by G.M. Wright, Ben H. Thompson and J.S. Dixon came to the conclusion that, "arbitrary boundaries laid out to protect some scenic feature" needed to be revised (Runte, 1984). Meanwhile, there have been various examples of park boundary related problems:

- the failure to protect oldgrowth trees and a watershed area next to Redwood NP resulted in the loss of highly valuable resources,
- the impacts of agricultural drainage near Everglades NP are a constant hazard to the park's ecosystem,
- the wildlife management problems due to overgrazing, migration, and feeding habits (grizzly bear) in Yellowstone NP.

"From Jackson Hole to the Everglades to the Redwoods, park boundaries were silent but firm testimony to the limitations long imposed on complete conservation" (Runte, 1986). However, the message for the management of natural resources was clear: it had to look beyond artificial boundaries, it had to look at the resources as "a biotic whole". Chase (1986) raised the question: "Was any park big enough to be a natural ecosystem for the species it contained?". Other major impacts came from the exclusion of fire from all national parks, from the introduction of exotic species, and from wildlife and plant pests.

In 1980 the National Park Service completed a study which revealed that, "scenic resources were threatened in 60% of the national parks," and, "visibility, air and water quality as well as wildlife were endangered in about 40% of the parks"(Miller, 1986, p. 177). Consequently, the resource management of national parks had to find more effective ways of responding to these accumulating and multifaceted challenges.

### 2.3.3. The Development of Science Based Resource Management in the National Park Service

A review of the early history of resource management in the NPS reveals that the lack of basic ecological research contributed to misconceptions and inadequate decision making.

> ...At this time (1930s) the first scientific unit within the the Park Service, the Wildlife Division, was established. It undertook a nationwide survey of the major ecological problems in each park, but the subsequent recommendations (Wright et al. 1933) were far too advanced for management to accept and traditional views prevailed for the next 25 to 30 years. Meanwhile, by 1939 the scientific staff of the Park Service had dwindled to nine, which was the total research complement at the end of World War II (Stottlemeyer, 1981, p.16).

In terms of training and education of the NPS's employees, other powerful agencies, like the U.S. Corps of Engineers and the U.S. Forest Service could claim to be more professionally organized (Shanks, 1984). And it was only after 1958 that the Park Service used official funds for scientific research (Chase, 1986). Five years later the report, "Wildlife Management in the National Parks," by A. Starker Leopold, a zoologist from the University of Berkley, called up to a "major policy change" because "the enormous complexity of ecologic communities... (required) a diversity of management procedures to preserve them" (Runte, 1984). But this goal was not easy to accomplish. As the biological researchers Fraser Darling and Noel D. Eichhorn put it in 1967,"We have the uncomfortable feeling that such members in the NPS as have a high ecological awareness are not taking a significant part in the formulation of policy" (Runte, 1986, p.153).

Finally, in 1975 the U.S. Department of the Interior adopted a crucial statement from the National Environmental Policy Act in 1969 which recognized the need to classify the natural resources of all NP units "possessing outstanding values" to be managed under the same objective, "regardless of whether they are in a natural, historical, or recreational park" (Stottlemeyer, 1982). Although starting belated, the reintroduction of fire and reduction programs for exotic species in various national parks were important consequences of the park management's consideration of science.

Since the late 1970s, the role of science and research gradually improved. The passage of the Clear Air Act Amendments (CAAA), of the Federal Water Pollution Control Act Amendments, and of the Endangered Species Act in 1980 provided the NPS with new responsibility and authority for analyzing and mitigating impacts. For instance, the "burden of proof for detecting both air deterioration and resultant ecological effects in national parks is placed by the act (CAAA) on the Park Service. The Service is staffing up and funding research for implementation of the act" (Stottlemeyer, 1981, p.19). The most progressive steps in this development can be seen in the establishment of new and large research centers as in Everglades NP or Redwood NP.

Yet many national parks are facing research related deficits and shortcomings. Again, Stottlemeyer comments that:

> "........From (the) preceding it is apparent that management can go on for decades, in the absence of any clearly defined policy, let alone an adequate ecological foundation. That this approach has been deleterious to park resources is demonstrated by the historic exclusion of fire, and the early management of barrier islands" (Stottlemeyer, 1981, p.20)

One of the remaining shortcomings is the process of data monitoring, data storage, and data analysis. Referring to this aspect of the general topic, Gerry Wright of the Cooperative Park Study Unit in the University of Idaho stated: "Finally, it should be realized that the resource data management problems faced by the National Parks are the result of years of inattention (Wright, 1984, p. 19). The sheer volume of research and monitoring data collected over many years accumulated to sometimes badly arranged files. Recent surveys confirmed this assessment and led to the conclusion that "most park files are poorly organized" (Wright, 1984, p. 2).

In February 1987 the General Accounting Office filed a report to Congress entitled, "Parks and Recreation: Limited Progress Made in Documenting and Mitigating Threats to Parks". The report stated followup omission of the 1980 State of the Parks report and blamed most of the failures on the, "lack of fundamental resource data (inventory) and any measure of change (monitoring)".

The NPS's need for a conceptual reorganization, restoration, and completion of many resource data files became more obvious. The present completion of a newly revised inventory analysis ("Inventorying and Monitoring Standards and Guidelines", "Natural Resources Inventory and Monitoring Initiative", NPS, July 1987 ) and the introduction of Geographic Information Systems are considered to be major efforts to tackle the pressing issues mentioned above.

2.3.4. The Implementation of a GIS in the National Park Service

The implementation of a Geographic Information Systems in the National Park System had a hesitant beginning primarily based on the initiatives of individual park units. With the progressive development of computer-assisted cartography, resource managers of parks got interested in the new technology and began to acquire their own systems or use the technical equipment of other agencies and universities. Smaller park units especially took advantage of Computer Aided Design (CAD) software programs running on micro-computers. But conceptually the Park Service refused to utilize proprietary software and based this decision for public domain software on the following reasons:

- it eliminates the significant costs of park-by-parkpurchase of appropriate software,
- it enables the NPS to retain very close and responsive control of the software's capabilities, and
- it allows the park units to invest more money into important hardware elements

An organized approach towards the implementation of a nationwide GIS, however, did not start until about ten years ago. At this time the NPS got involved in the development, utilization, and support of various public domain software packages (MOSS, ELAS, SAGIS) which requires large, powerful

On October 12-14, 1988, the National Park Service held its first national GIS conference in Luray, Virginia (see appendix). The participation of about one hundred park representatives and the presentation of a series of papers referring to GIS experience made the conference an encouraging event for the prospects of this new technology.

At the time when the conference took place, the participants could note a fast

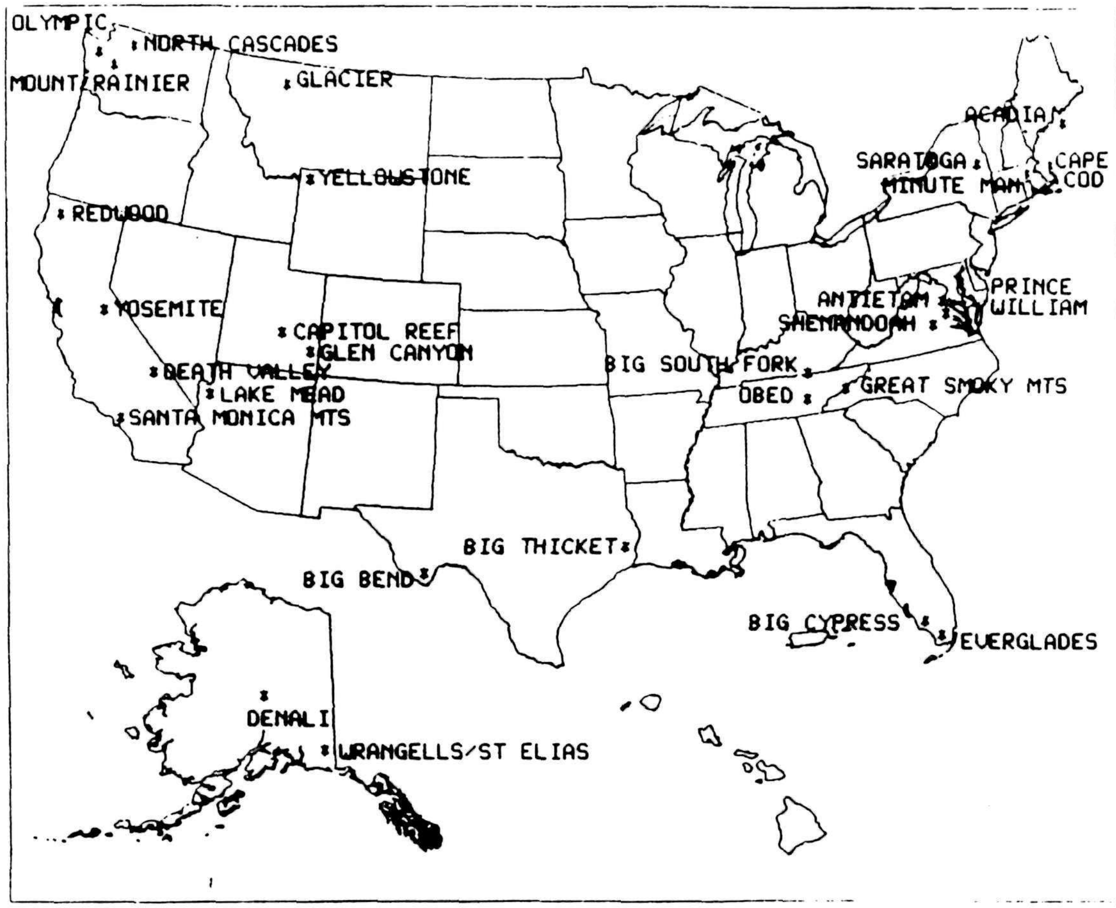


**Figure 2.3.**: NPS Areas With GIS Data Base Activities (Fleet, 1988)

increase of park units operating with GIS (see Figure 2.3.). Issues like GIS institutionalization, training, software, hardware, and the role of the GIS Division in Denver were topics of the discussions.(NPS, 1988d)

Today, approximately 40 park units are using GIS technology for the management of their resources or are in the process of setting up the system. Figure 2.4. gives an overview of the present state of GIS use in the National Park Service:

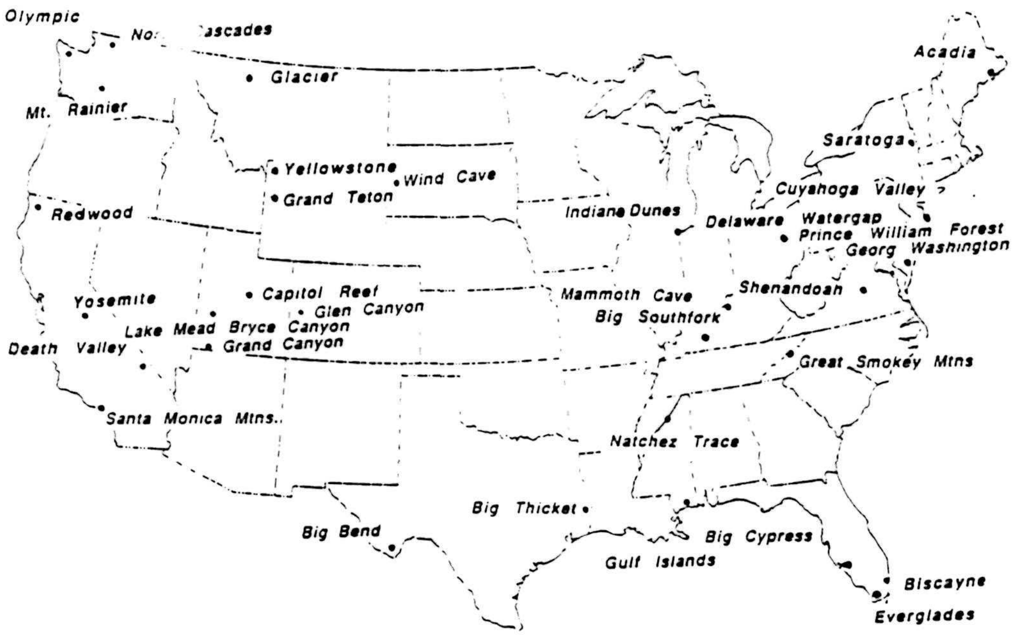


**Figure 2.4.**: Actual State of GIS Data Base Activities in the National Park Service (April, 1989)

In Autumn 1987, Harvey Fleet from the GIS Division in the Denver Service Center articulated the NPS's prospect of how GIS will develop in the parks, by saying:

> "It is expected that this number ( of parks with GIS; 1987: c. 24) will double or triple over the next year. Applications vary widely but typically include resources management, environmental assessment, and operations. It is still too early to know how effective--or cost effective--expenditures for GIS data bases, hardware, software, and operations are or will be. It is only over the long haul, perhaps five or ten years, that we can begin to assess this important question. Now that the technology is out in the parks, we will at long last begin a handle on this important question." (Fleet, 1987)

One purpose for this study is to provide some interim results of the GIS experience in the NPS. Support from the GIS Division in Denver, as well as from the Regional Office in Seattle, is evidence for the NPS's interest in this study.

Official NPS guidelines on Natural Resource Management are currently in preparation and are expected to be published by the second half of the year1989. (Fleet, 1989)

## CHAPTER 3: METHODOLOGY

### 3.1 THE OBJECTIVES OF THE ANALYSIS

This study will examine a user-tool-work relationship, while focusing specifically on the tool (Geographic Information System) that links the user (National Park Service) and the work (Resource Management) together. The underlying assumption of this approach is that a comprehensive and critical evaluation of the GIS will only be valid when its environment (the NPS) as well as the management of natural resources, is taken into account.

Such an intention makes it desirable to select a method of analysis that makes it possible to view the wide scale of the entire user-tool-work relationship as well as the small details. This concern was the basis for the decision to conduct a survey among a large number of GIS users in the Park System, rather than to investigate the use of GIS in depth in one park. A case study of one or two park units would have limited any reflections to only one special experience and would consequently have prevented the author to make any generalizations to other varied types of park units. However, as illustrated in Chapter 2 (Literature Review), the NPS views the successful implementation of the GIS as an essential condition needed to solve some of their most severe resource management problems in the parks.

The rapid increase of the GIS users in the National Park Service within the past three years makes a survey multivalent and timely.

This study is based on a questionnaire that seeks to investigate technical, institutional, park-goal oriented, and management-philosophy oriented aspects of the GIS implementation in the parks.

The questionnaire allows a separate analysis of each one of these four categories, an analysis of the relationship among them,and a summary of the entire situation. The interview contains numerous fact-oriented questions, but also emphasizes attitude and value related issues.

The major topics of all four categories and the inter-related issues are outlined as follows:

1. Individual Categories:

<u>Technical Phenomena</u>

- character and diversity of analytical GIS operations
- experience of the parks with different input devices (internal vs. external involvement)
- preferences and/or needs for various output devices
- experience with and attitude towards remote sensing data
- attitude towards the raster/vector question

<u>Institutional Phenomena</u>

- amount of active work on GIS
- training background and conference experience of the GIS staff members
- attitude towards the role of the GIS Division in Denver
- determination whether a user requirement analysis has been conducted or not

<u>Specific Park Goals</u>

- the role of research in the individual park unit

- number and character of long term, short term, and already completed GIS projects
- detection of the influence of GIS on park inventories

Management Philosophy

- investigation of whether the exposure to GIS technology created new management strategies and tasks
- detection of the influence of GIS on resource management plans
- role of GIS for new cooperative activities between NPS and other agencies

Inter-Related Aspects

- relation between the technical experience and the institutional situation in the parks
- interdependence between special park goals and technical/institutional results of the survey
- definition of ties that connect all four categories together
- relation of GIS experiences to the park's individual needs

For these questions, a survey was planned, samples were selected, and a questionnaire was designed.

## 3.2. PLANNING OF THE SURVEY

An evaluation study dealing with National Park units could be made in three basic steps:

1. Face-to-Face Interviews
2. Telephone Interviews
3. Mail Questionnaires

When selecting an adequate method to achieve the study's diverse objectives, the broad geographic distribution of the park units throughout the nation was an important consideration. Hence, face-to-face interviews, with their inherent constraints on time and finances was deemed impractical.

A comparison between the remaining two alternatives shows that the mail questionnaire features some shortcomings that can be summarized as follows:

- uncomfortable questions may not be answered ,
- a mail questionnaire lacks the opportunity to make additional comments on closely related issues is limited.

Another problem of a mailed questionnaire can be the decision to whom in the park unit to send the interview to:

> "The mail questionnaire is also at a disadvantage when the sampling unit is an organization or agency. This applies particularly to surveys in which is unsure of the appropriate respondent. For example, the desired respondent might be the "person in charge of hiring" or the "Dean of Students" whose name is unknown. To identify the right person, one or more contacts with the organization may be required. Such contacts can be made by telephone or in person with relative ease" (Dillmann, 1978, p.45).

Although featuring some limitation on the types and length of questions, the advantages of a telephone interview were clear at hand (Lavrakas, 1988):

- quality control
- cost efficiency
- speed of data collection

The NPS's offer to allow the author to conduct interviews with the park units by using their administrational phone network in the Regional Office in Seattle, further supported the decision to conduct a telephone interview.

## 3.3. THE SELECTION OF THE SAMPLES

Preparations for this study began with preliminary talks to the National Park Service's Regional Office of the Pacific Northwest Region in Seattlein Winter 1988/89. As a result of these dialogues, first contact to the GIS Division in Denver, Colorado, was initiated in January 1989, and Mr. Maurice Nyquist and Mr. Harvey Fleet were informed about the character and the goals of the forthcoming survey.

The selection of the samples was based on an annotated list of the GIS Division in Denver. The list was sent in response to a letter requesting such (date, see appendix) and classified the total of 339 park units into seven categories:

| | |
|---|---|
| (A) units which were established to serve the maintenance and preservation of natural resources, | 75 units |
| (B) units with such complex functions that the use of a GIS is strongly recommended in order to manage large spatial data | 75 unit (same) |

(C) units which have to improve their management of natural resources

(D) units where a "true" GIS has been established — 25 units

(E) units which currently use alternative computer systems (e.g. CAD), but in which the integration into the GRASS/SAGIS system is highly recommended — 11 units

(F) units with GIS results and applications which can be regarded as having "prototype" character . (identical with category (E) — 6 units

-----------------------------------------------------------------

(G) units with qualities that do not match one of the categories (A) - (F) — 264 units

Since the major objectives of this study focus on the analysis of park units with existing GIS experience, category (D) represents the appropriate sampling group. The other categories were considered to be mainly of statistical value and were objectives of some further investigations among GIS coordinators in the different regions (informal interviews).

From the 25 park units of category (D), only 22 units fulfilled the requirement of having been established for the maintenance and preservation of natural resources. Group interviews were completed with all but one of the category D units, leaving a list of the following 21 park units:

| NPS Region: | Park Unit: |
|---|---|
| **Mid Atlantic** | 1. SHENANDOAH NATIONAL PARK |
| | 2. GEORGE WASHINGTON MEMORIAL PARKWAY |
| | 3. DELAWARE WATERGAP NAT. RECREATION AREA |
| **South East** | 4. MAMMOTH CAVE NATIONAL PARK |
| | 5. GULF ISLANDS NATIONAL SEASHORE |
| | 6. EVERGLADES NATIONAL PARK |
| | 7. BIG CYPRESS NATIONAL PRESERVE |
| | 8. NATCHEZ TRACE PARKWAY |
| | 9. BIG SOUTH FORK NAT. RIVER AND RECR. AREA |
| **Mid West** | 10. INDIANA DUNES NATIONAL LAKESHORE |
| **Rocky Mtn.** | 11. YELLOWSTONE NATIONAL PARK |
| | 12. GRAND TETON NATIONAL PARK |
| | 13. GLEN CANYON NATIONAL PARK |
| | 14. GLACIER NATIONAL PARK |
| | 15. CAPITOL REEF NATIONAL PARK |
| | 16. BRYCE CANYON NATIONAL PARK |
| **Western** | 17. DEATH VALLEY NATIONAL MONUMENT |
| | 18. YOSEMITE NATIONAL PARK |
| | 19. SANTA MONICA MOUNTAINS NAT. RECR. AREA |
| | 20. REDWOOD NATIONAL PARK |
| **Pac. Northw.** | 21. MOUNT RAINIER NATIONAL PARK |

The names and addresses of the repondents and their park units can be found under Appendix B.

## 3.4. STRUCTURE AND IMPLEMENTATION OF THE QUSTIONNAIRE

After the sampling pool was generated and all tasks for the forthcoming analysis were identified, the next step was to decide by which means those tasks could be accomplished. The study's four main categories served also to provide structure for the questionnaire. After designing a first draft, and conducting two pilot tests (with North Cascades National Park and Mount Rainier National Park), a final, revised questionnaire (see appendix), with a total of 42 questions, was formulated.

Approximately 75% of all questionnaire were closended questions with ordered answer choices. The remaining 25% were open-ended question. Questions relating to all of the four evaluation categories were distributed as follows:

| | | |
|---|---|---|
| I. | Technical Phenomena | 16 questions |
| II. | Institutional Phenomena | 13 questions |
| III. | Specific Park Goals | 7 questions |
| IV. | Management Philosophy | 6 questions |

This distribution of questions seems to imply a higher emphasis on the first two categories. However, the character of the questions (higher number of open ended questions in categories III. and IV.) and the analysis technique (see next paragraph) are resulting in a survey, where all four categories are more in balance with each other, than the formal structure of the questionnaire suggests.

The introduction to the questionnaire states the interview will take 30 to 40 minutes. Due to the large number of questions and the character of the survey's topics, this time frame appeared to be rather conservative.. The anticipation that this time limit might be easily exceeded was confirmed throughout the interviewing process, and can be regarded as a typical characteristic of telephone surveys. Dillman commented:

> "The evidence clearly suggests, that once people are on the phone, the length of the interview does not appear to be a major problem." (Dillman, 1978, p.55)

In March 1989, each GIS staff representative (as they had been named on Denver's annotated list) of the 22 designated park units listed above received an initial introductory letter . This letter (see appendix) informed the repondents about the character of the study, described the four major categories as well as the time frame of the survey, announced the forthcoming steps to be taken, and included a letter of endorsement by Mr. Harvey Fleet from the GIS Division in Denver (see appendix).

The process of preparing and conducting the interviews was as follows:

1. Contact to the GIS Field Unit in Denver,
2. Reception of list of potential interview partners (GIS using park units),
3. Mailed introductory letter to the selected samples (22 park units),
4. First phone call with each sample to set up an interview appointment,
5. Conduction of the actual telephone interviews.

The scheduling of appointments for the final interviews was based on a preliminary phone call in the last week of March. All 21 interviews with the selected park units were conducted in the Regional Office of the NPS in Seattle between Monday, April 4 and Monday, April 10, 1989.

All interviews were recorded with a tape machine, plugged directly into a telephone adapter (no external microphone). Nevertheless, 21 separate versions of the final questionnaire had been prepared in order to guarantee an identical reference and interview procedure for each respondent. This way, the interview did not rely completely on the function of the recording machine and additional hand written notes were taken during each interview.

## 3.5. ANALYSIS OF SAMPLES

The questionnaire was designed to allow an analysis based on the coding and rating of its single factors. For each of the four main categories three issues of the complete questionnaire were selected to determine qualitative as well as quantitative differences of the park unit's GIS experience and management strategies. In addition, a fourth issue of closely related topics which do not necessarily indicate differences in high or low performance within the four categories, was assigned as a bonus score. Questions with bonus points character were designed to detect general attitude and believe issues rather than questions that elicit information on attributes. Answers to these questions could indicate a certain tendency in favor or against the results of the categorical analysis. Examples will be given in Chapter 4.0.

Since a maximum of 4 points was assigned to each issue, all 4 issues in the 4 categories could score to a total of 64 points (= 4 x 4 x 4), or, without the bonus issues, to a total of 48 points (= 4 x 4 x 3).

All 16 selected issues and all four categories were regarded to be of equal importance for the overall analysis. Hence, there was no ranking or weighting of special issues or categories. This decision is mainly based on the assumption that the selected issues can only indicate a tendency, rather than representing pure, absolute, and factual information about the GIS experience. Only a procedure where the combination of several indicating factors reduces the significance of its single components, is considered to be valid and interpretable. The avoidance of pre- conceptualized manipulations (weighting and rating) intends to follow same objectives and intends to "save raw data" for the sake of an analysis which is based on the inclusion of various, distinctive factors, rather than by an early exclusion of those factors.

The following table displays the coding and point scales for the 4 categories of the study:

## SCALE FOR INDEX 1 (TECHNICAL PERFORMANCE)

| | | | | |
|---|---|---|---|---|
| 1.04 | Ability to perform various GIS 0perations | want to do | 1 point | |
| | | some in use | 2 points | |
| | | moste in use | 3 points | |
| | | most incl. e) in use | 4 points | max. 4 points |
| 1.05 | Experience with diverse input devices | want to do | 1 point | |
| | | only externally | 2 points | |
| | | own involvement | 3 points | |
| | | strong concern | 4 points | max. 4 points |
| 1.06 | Preference & significance output devices | want to do | 1 point | |
| | | hardcopy maps | 2 points | |
| | | hardcopy + tabulations | 3 points | |
| | | more than 2 devices | 4 points | max. 4 points |
| | | | **1. total :** | **max.12 points** |

bonus points:

| | | | | |
|---|---|---|---|---|
| 1.12 | Use of remotely sensed data | one method in use | 1 point | |
| | | + see advantages | 2 points | |
| | | add. active groundproof. | 3 points | |
| | | active use of SPOT | 4 points | max. 4 points |
| | | | **2. total :** | **max.16 points** |

## SCALE FOR INDEX 2 (INSTITUTIONAL PERFORMANCE)

| | | | | |
|---|---|---|---|---|
| 2.02 | Active employee time used for GIS | 5 - 20 % | 1 point | |
| | | 21 - 50 % | 2 points | |
| | | 50 - 70 % | 3 points | |
| | | > 70 % | 4 points | max. 4 points |
| 2.05 | Average training background of employees | 0 - 39 hours | 1 point | |
| | | 40 - 60 hours | 2 points | |
| | | 61 - 120 hours | 3 points | |
| | | > 120 hours | 4 points | max. 4 points |
| 2.06 | Conference experience | occasionally attending | 1 point | |
| | | often attending | 2 points | |
| | | often + pres. paper | 3 points | |
| | | often + many papers | 4 points | max. 4 points |
| | | | **1. total :** | **max.12 points** |

bonus points

| | | | | |
|---|---|---|---|---|
| 2.09 | Need for cooperation with other agencies (1 - 2) additional ones | some (1 - 4) | 1 point | |
| | | many (4 - 8) | 2 point | |
| | | 3 points | | |
| | | ( > 2 ) additional ones | 4 points | max. 4 points |
| | | | **2. total:** | **max.16 points** |

## SCALE FOR INDEX 3 (SPECIFIC PARK GOALS)

| | | | | |
|---|---|---|---|---|
| 3.02 | Envisioned longterm projects for GIS applicat. | 1 project | 1 point | |
| | | 2 projects | 2 points | |
| | | 3 projects | 3 points | |
| | | 4 projects | 4 points | max. 4 points |
| 3.03 | Planned shortterm projects for GIS applicat. | 1 project | 1 point | |
| | | 2 projects | 2 points | |
| | | 3 projects | 3 points | |
| | | 4 projects | 4 points | max. 4 points |

| | | | | |
|---|---|---|---|---|
| 3.04 | Completed GIS projects | 1 project | 1 point | |
| | | 2 projects | 2 points | |
| | | 3 projects | 3 points | |
| | | 4 projects | 4 points | max. 4 points |
| | | | **1.total** | **max.:12 points** |

Bonus Points:

| | | | | |
|---|---|---|---|---|
| 3.07 | General issues | Res. Managm. Plan | 1 point | |
| | | assessing results | 1 point | |
| | | Role of research better | 1 point | |
| | | inventory improved | 1 point | max. 4 points |
| | | | **2.total** | **max.:16 points** |

SCALE FOR INDEX 4 (MANAGEMENT PHILOSOPHY)

| | | | | |
|---|---|---|---|---|
| 4.02 | dicovered new tasks due GIS experience | no | 0 points | |
| | | yes | 4 points | max. 4 points |
| 4.03 | New goals defined in Res. Managm. Plan | no | 0 points | |
| | | yes | 4 points | max. 4 points |
| 4.04 | New cooperation practice due to GIS | no | 0 points | |
| | | some | 2 points | |
| | | intense | 4 points | max. 4 points |
| | | | **1.total** | **max.:12 points** |
| 4.06 | Assessing significance of GIS for park | average | 1 point | |
| | | above average | 2 points | |
| | | high signifi. | 4 points | max. 4 points |
| | | | **2.total** | **max.:16 points** |

**TOTAL NET SCORE : 48 points**

**TOTAL GROSS SCORE : 64points**
**all 4 categories**

The analysis of these four index scales (for a seperate and correlative interpretation) wasgenerated with the help of graphical charts and supported by data and information of the accompanying literature, as well as further (informal) interviews with the NPS.

# CHAPTER 4: FINDINGS AND DISCUSSION

## 4.1. GENERAL DESCRIPTION OF THE SELECTED SAMPLES

### 4.1.1. Analysis of the Samples Within Their Regional Context

First a discussion of the distribution of GIS within the NPS will be discussed followed by the major results of the study. Drawing upon the annotated list from the NPS (Fleet, 1989), three of the seven different GIS related park attributes (see also chapter 3.3) were compared as to their geographical distribution.

As shown in Figure 4.1., the present distribution of active GIS use in the NPS is uneven and varies substantially from region to region. The 21 selected park units of this study cover almost all parks of the category "D" (units where a true GIS has been established) in six of the overall ten regions: Mid-Atlantic, Pacific Northwest, Western, Southeast, Rocky Mountain, and Midwest Region.

When comparing the occurrence of category "B" (units which were established to preserve natural resources and where a GIS is strongly recommended) with the actual number of GIS implementations in these six regions, the Mid-Atlantic Region, Southeast Region and Rocky Mountain Region turn out to feature the best current results. In the Mid-Atlantic and Southeast Regions, GIS or alternative computer systems cover about 50% of the potential parks with GIS suitability (category "B"); in the Rocky

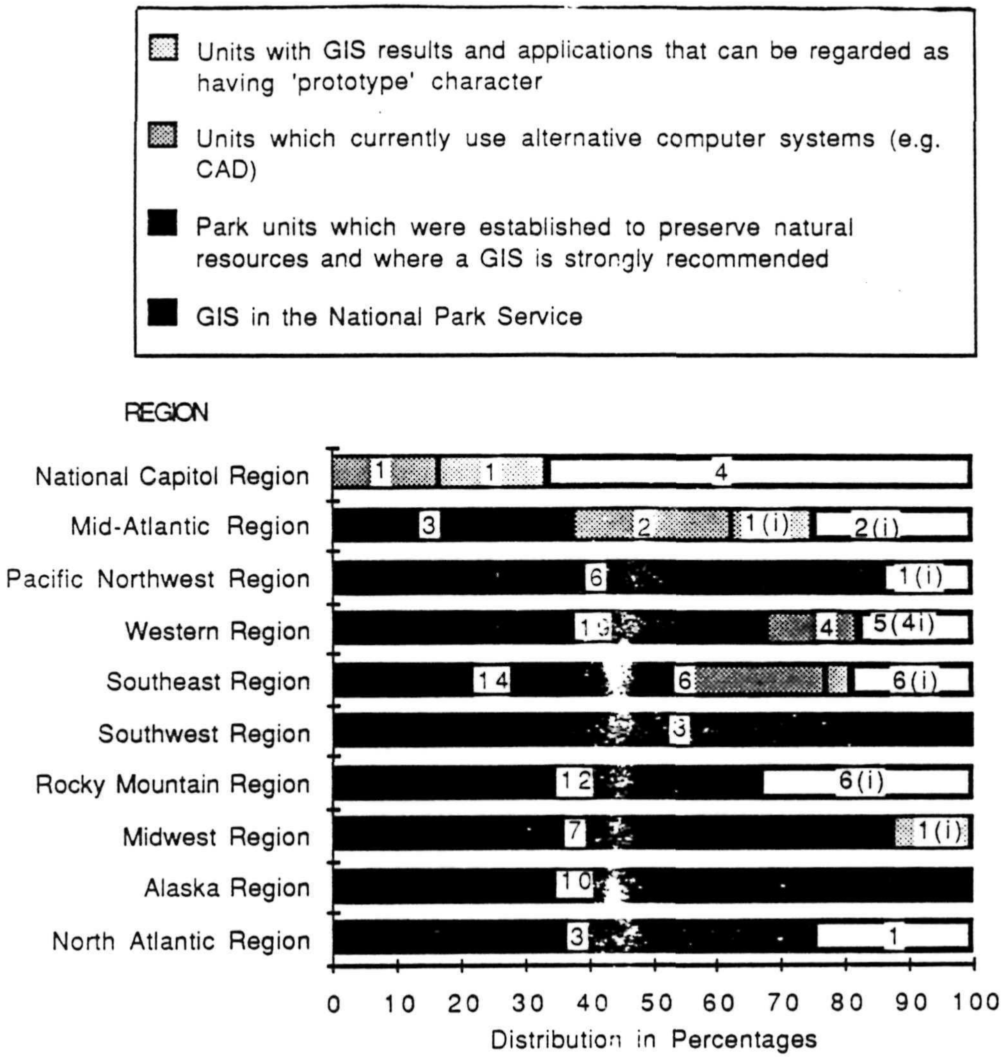


**Figure 4.1.:** Regional Comparison of the GIS Users Within the NPS (Numbers in chart-blocks represent absolute numbers of GIS-park units, (i) indicating the interview partners of this study)

Mountain Region, one third (6) of all potential parks with natural resources (18 park units) have been established a "true" GIS. These three regions are closely followed by the Western Region, where GIS and alternative systems are used in 8 out of 27, resulting in 29% of the whole.

Both the Pacific Northwest Region and the Midwest Region have established only one "true" GIS up to this date, leaving more than 80% of their potential park units uneffected by the new technology.

As noted in the NPS list (Fleet, 1989), the remaining four regions (in which no park unit participated in the interviews for this study) also feature a quite diverse distribution of GIS related attributes. The National Capitol Region (where non-natural resources clearly dominate) and the North Atlantic Region (where one out of the potential four park units has established a GIS) have the most advanced computer experience. The Southwest Region and especially the Alaska Region, where none of the ten extremely large parks has implemented a GIS, rank very low in this regional comparison.

Based on the interpretation of Figure 4.1. (which only describes natural resource parks), all NPS Regions are ranked in the order of 1 (highest number of GIS users) to 10 (no GIS in use):

| | |
|---|---|
| (Interviewed) | **1. SOUTHEAST REGION** |
| | **2. ROCKY MOUNTAIN REGION** |
| | **3. MID-ATLANTIC REGION** |
| | **4. WESTERN REGION** |
| | **5. PACIFIC NORTHWEST REGION** |
| | **6. MIDWEST REGION** |
| (Not interviewed) | 7. National Capitol Region |
| | 8. North Atlantic Region |
| | 9. Southwest Region |
| | 10. Alaska Region |

A comparison of the same three GIS-related categories on the background of the total park acreages as shown in Figure 4.2. illustrates even more dramatically the uneven geographic distribution of GIS activities in the National Park Service.

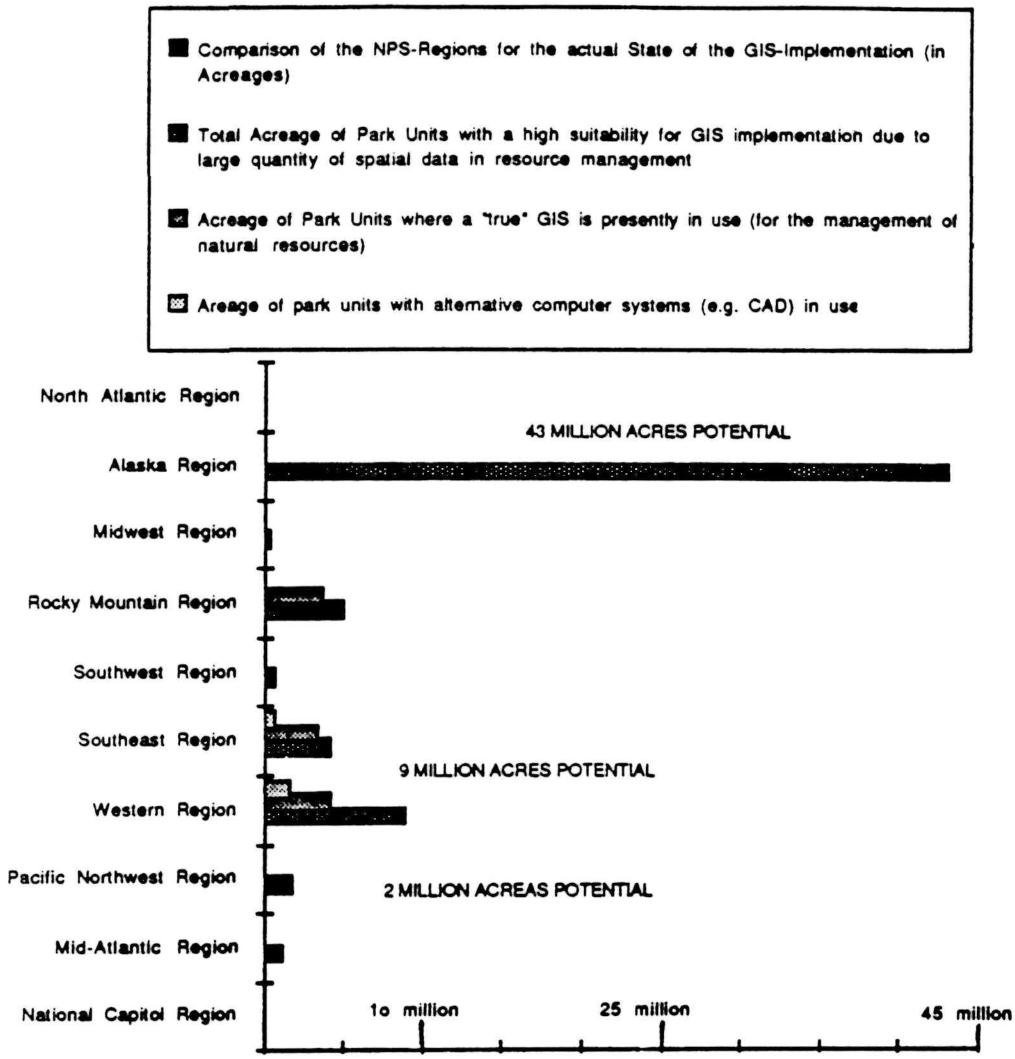


**Figure 4.2.**: Regional Comparison of the GIS Use in the NPS on the Base of Total Acreages

The graph demonstrates a high potential of large natural resource areas in the Mid-Atlantic Region, Pacific Northwest Region, and Alaska Region, which combined total to an area of approximately 45 million acres without any GIS applications in the management of natural resources. Hence, these three regions feature nearly 90% of all natural areas (about 51 million acres for all ten regions) in the National Park Service where a GIS is strongly recommended, but has not yet been implemented.

4.1.2. General Findings of the Telephone Interviews and Resulting Classification of the Samples

In the introduction to the questionnaire each respondent was informed that, "information provided in these interviews (will be) kept strictly confidential" and that the "final report will group data, and will therefore not make any references to individual park units or persons and their responses" (see Appendix B ). In order to meet these requirements, the study will refer to each of the 21 park units with an alphabetical letter from (A) to (U). Consequently, the order in the list of the 21 park units as it is given in Chapter 3.3., is not the same as the one the new alphabetical symbols are based on. In addition, a classification of the park units will introduce a second and more rational coding system.

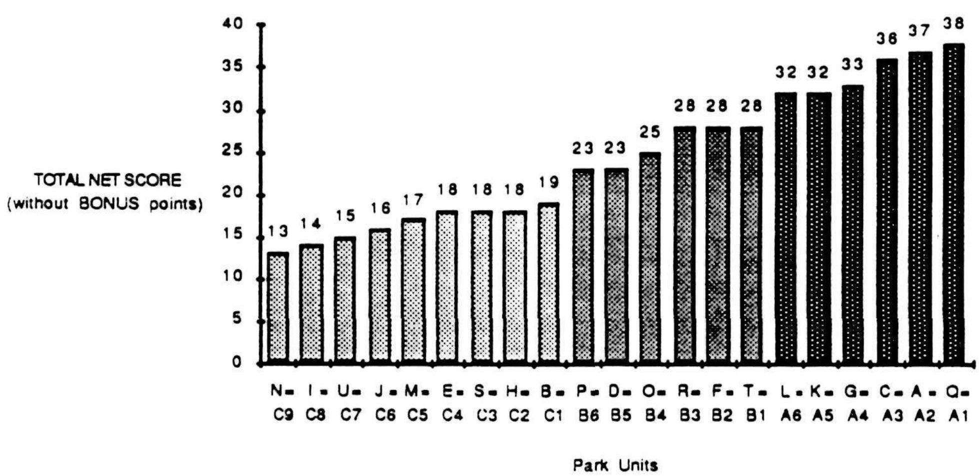


**Figure 4.3.**: Ranking of the Samples (Park Units) Based on the Total Net Score

The coding and evaluation method, as it is presented in Chapter 3.5., makes it possible to distinguish between the park units' GIS qualities for each one of the four main categories--namely for the technical phenomena, the institutional phenomena, the phenomena of the specific park goals, and the phenomena of the park's individual management philosophy.

Figure 4.3. depicts the results of all four categories for the 21 park units based on the Total Net Score of the evaluation method. This Total Net Score summarizes the individual results from each category without considering the "bonus" points. The Total Net Score represents the most complete scale for the park description by representing the park units' abilities and attitude or intention-related responses (marked as "bonus points"). This score is later used to cover the entire broad scope of the interview.

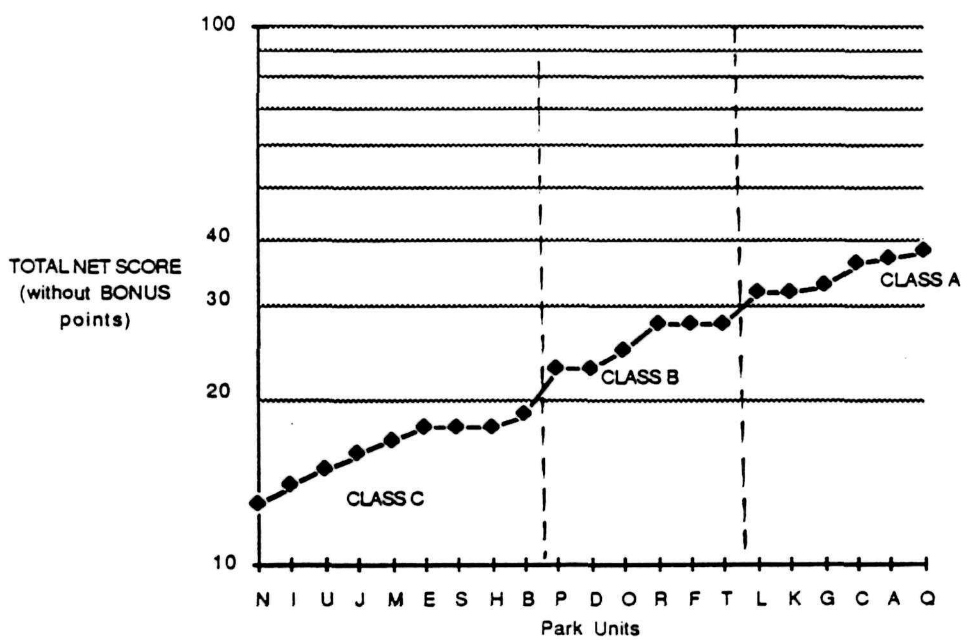


**Figure 4.4.**: Park Classification Based on the Total Net Score

In order to differentiate the essential GIS activity and GIS integration in each park unit, the Total Net Score is applied in Figure 4.3. The maximum number of points is 48 (3 sub-attributes x 4 max. points x 4 categories). The results of the 21 samples range from 38 points (Q) to 13 points (N). The forthcoming paragraphs of this chapter will investigate a) the character of, and, b) the reasons for, this difference (>50% of the overall scale).

In order to manage and interpret data gathered from the questionnaire, it was helpful and practical to group the 21 parks. As illustrated in Figure 4.4., the ascending curve which is formed by the total points of the 21 parks features two major leaps --four points between park B and P and four points between park T and L. Between all other park units the difference is less than four points. Hence, the data naturally forms three distinct groups --one in the range of 13 to 19 points, a second between 23 to 28 points, and a third one between 32 to 38 points. This configuration supported the designation of the following three major park classes:

1. **CLASS A**: high state of GIS performance (6 parks)
2. **CLASS B**: medium state of GIS performance (6 parks)
3. **CLASS C**: low state of GIS performance (9 parks)

These three park classes will continue to appear throughout the various analysis procedures of this study. However, in order to avoid unnecessary generalizations, each park unit's individual ranking position will be expressed in the ranking system which is directly based on the classification. This way, the preliminary character of an alphabetical order is either replaced or extended by a more rational approach, helping the reader to identify park units on their qualitative basis. Thus, the highest ranking park unit (Q) also carries the symbol (A1), while the symbol (C9) is assigned to the lowest ranking park unit (N).

## 4.2. TECHNICAL PHENOMENA

### 4.2.1. Interpreting the Data

Rather than presenting conclusions first, the Total Net Score chart will be used as an example to demonstrate three ways of using and interpreting the charts of this chapter. At the same time, the character and information of the Total Net Score chart will be explained.

(I). Basic Analysis : (defining and describing general tendencies and overall results)

Figure 4.5. shows the index numbers of all four categories as a sum for each park unit. The general tendency shows an increase of the Total Net Score from 13 points (C9) to 38 points (A1) which occurs as an equally distributed increase in each individual category. Consequently, in the

Technical Net Score or the Institutional Net Score, Class A park units score in the average 3 to 5 points higher than Class C park units. However, since all categories and park units do not follow this rule, the interesting exceptions will be identified.

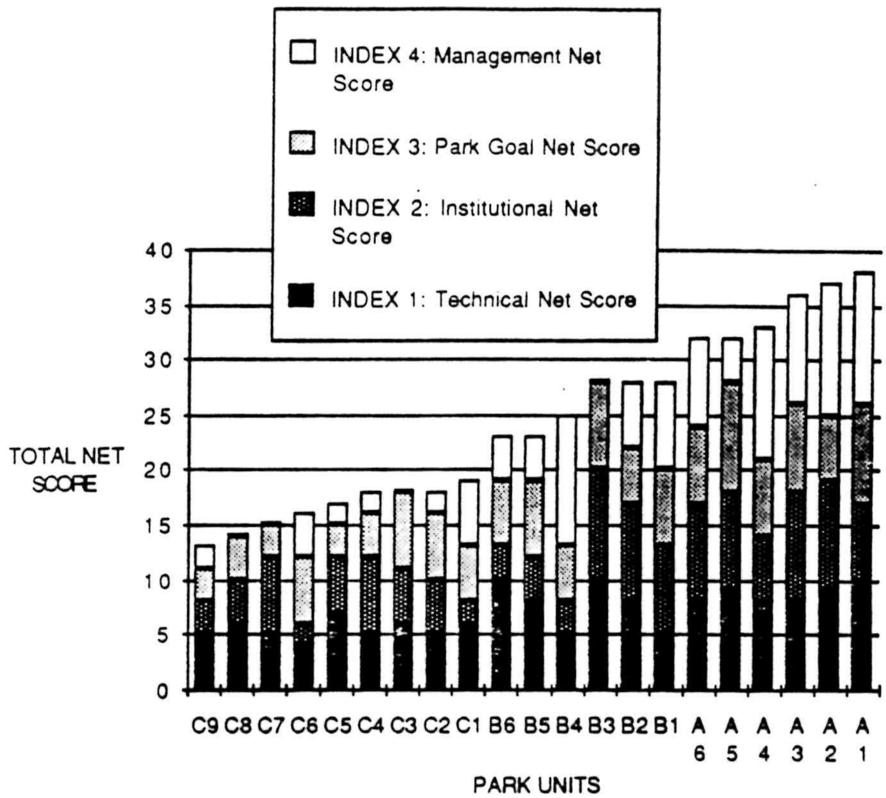


**Figure 4.5.:** The Total Net Score (All Four Categories Without Bonus Points)

The Management Net Score is an example of an irregular distribution pattern. A low score in this category implies the lack of a comprehensive management philosophy necessary to integrate the GIS on an higher level.

(II). Group Analysis: Interpretation of a tendency based on special group phenomena or class (A,B,C) phenomena

Figure 4.5. illustrates that one third of the Class C park units do not feature any points from the management score and that the remaining six Class-C-units score clearly lower in this index the first three categories (Index 1 to 3). This result is not very surprising, due to the following reasons:

1. In most cases, GIS implementation is initiated by an individual staff member on the resource management level, (see results of question1.04, Appendix C) and hence, the news of the GIS technology often is being carried up to the higher levels of the park management,
2. Many parks of Class C are in the very early beginning of the implementation process (see Fig. 4.1.6.), and hence, in many cases the GIS technology has not yet reached the higher park management levels, mentioned above.

(III). Individual Analysis:Interpretation of extremes or exceptions from a general tendency, based on single, separate park units and their phenomena

Figure 4.1.5. shows that park B1, a generally high ranking unit, scored relatively low with only 5 points in Index 1 (Technical Net Score). An examination of the park's responses to the technical phenomena questions explains this special situation:

1. the park operates presently with an extremely small data set,
2. the park's experience with some commercial vendors for the data input jobs (scanning) was not very satisfying,

3. the park is facing some serious problems with the software in use, (SAGIS), and,
4. the GIS staff states a lack of interest on the part of the upper park management, and a failure to adequately perceive the level which does not realize the data base problems.

The last two examples show particularly well the extreme importance of analyzing additional information from other parts of the survey for the interpretation of certain phenomena. In the case of the group or class analysis, charts of closely related topics or other chapters will be the main source of this information. For the interpretation of individual park units and their specific results, information will be garnered from direct answers and explanations which were given during the interview, but which do not appear at full length in the coded form of the data.

The following paragraphs and chapters will describe and discuss the findings of most analysis objectives by using the same conceptual approach as presented above:

1. Interpretation of the general tendency of the data image as it is generated in the chart (I),
2. Interpretation of the major group and/or class phenomena (II), and,
3. Interpretation of individual park units, featuring extreme or exceptional results (III).

In some cases, however, it will not be necessary to go through the entire process, and only one or two of the three interpretation models will be sufficient to meet the individual analysis objectives.

4.2.2. The Park Units in the Total Gross Score

The Total Gross Score describes the park units' overall GIS experience including bonus points, given for generally positive attitudes. These aspects, however, do not necessarily indicate differences in the quality of the park's

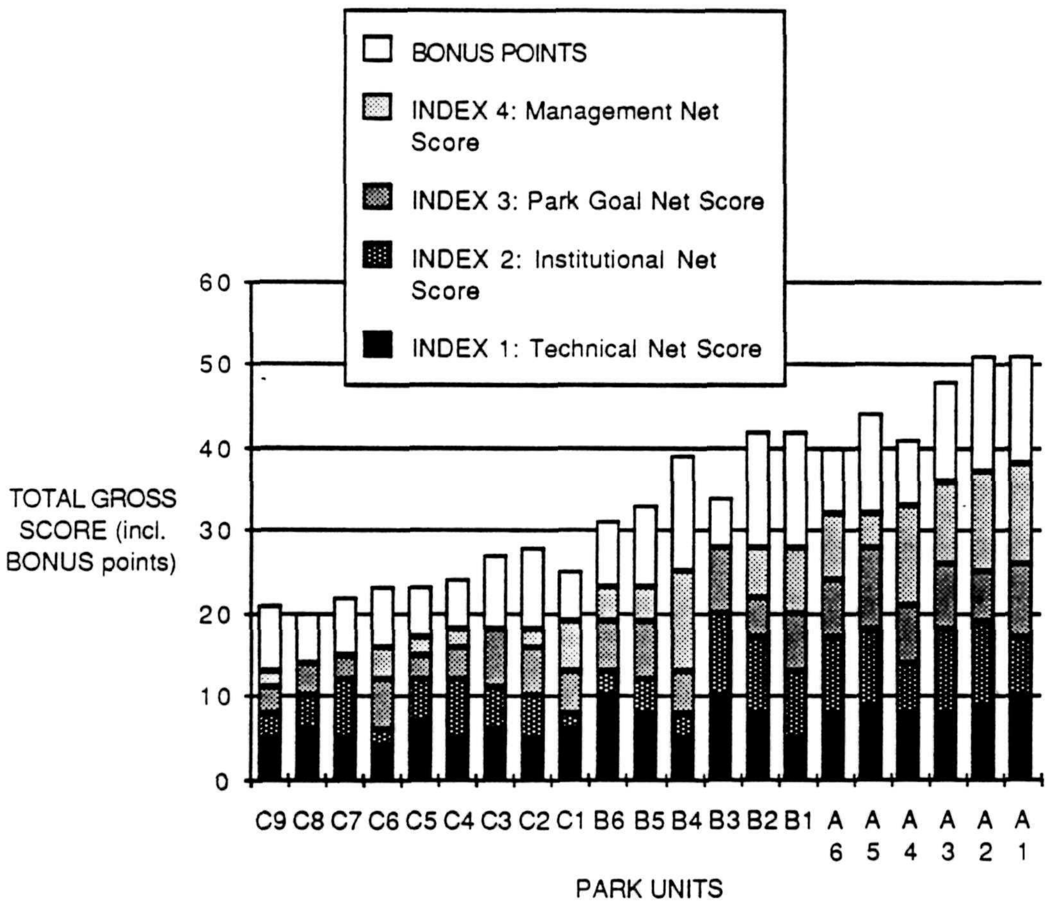


**Figure 4.6.**: The Total Gross Score (Including Attitude and Intention Bonus)

GIS performance (see Chapter 3.5.). The highest maximum possible Total Gross Score is 64 points (4 sub-attributes x 4 max. points x 4 categories).

(I). According to Figure 4.6. the park units (A1) and (A2) each score highest with 51 points, while park unit (C8) is lowest with 20 points. The general results of the first Total Net Score are basically confirmed and major shifts in the ranking order of the 21 park units (A1- C9) do not occur.

(II). The composition of the three classes remains generally the same. Only the ranking order within the classes is slightly altered. This proves that the attitude responses confirm the tendency of the results gathered in the "raw data" evaluation, as it is sammerized in the Total Net Score".

4.2.3. The Results of the Total Gross Score in the Context of the Park Units' Varying Years of GIS Experience

One obvious cause for the extensive variation in the park units' quality of GIS performance is seen in the time factor. As mentioned in Chapter 2.2.4., the implementation of a GIS needs organizational adaptations, structural changes in work flow and practices, meaningful training for unexperienced staff members, and general technical and/or personnel problems, can result in a relatively long phase of development. Consequently, one can assume that the quality of a park unit's GIS capabilities will strongly depend on the length of their individual experience with the new technology.

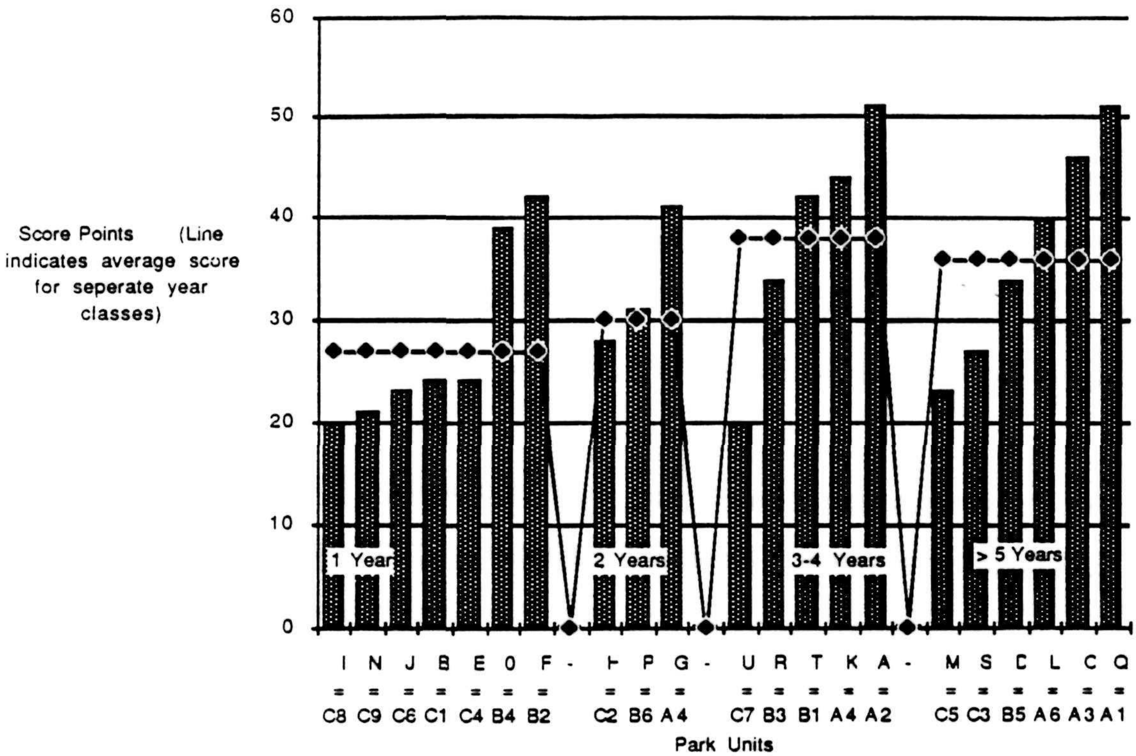


**Figure 4.7.**: Parks Grouped By Length of Experience (Year Groups) Versus Their Average Total Gross Score

The largest group of all samples (nearly 50%) started their GIS implementation only 1 or 2 years ago, in 1987/88. Five parks began 3 to 4 years ago (1985/86) and the remaining six park units have used computer technology for 5 years and longer (1984 and before).

(I). In Figure 4.1.7., these four year groups are projected against the Total Gross Score results for each park unit. The average score for each year class has been calculated and is expressed as a vertical line. A comparison of the two variables (time and score) confirms the general hypothesis, that park units with a longer GIS experience feature higher results than parks with short exposure to the new technology.

(II). One exception to this rule, however, is the average score (36 points) of the six parks with the longest GIS experience (5 years or longer), two points below the previous year group (3-4 years of experience). This unexpected result indicates, that:

1. the longest GIS experience does not guarantee the best GIS performance, and,
2. the best GIS performance is actually achieved by the group of parks which started 3 to 4 years ago (1985/56).

Two possible theories may explain this result:

1. The beginning of an organized strategy in the NPS (by GIS Division in Denver) to increase the use of SAGIS/GRASS software (see Chapter 2.3.4.) coincides with the initial phase of the high scoring third group (3 - 4 years of experience).
2. The "older" GIS-park units (more than 5 years of experience with computer technology) did not or could not profit as much from the new central GIS initiative of the NPS; perhaps because they:

   a) overestimated their own ability to take advantage of the new technology's wide scope and progressive trends, and/or,

   b) underestimated the significance of the upcoming GIS initiative in Denver, and/or,

   c) were not the main focus of Denver's GIS strategy, due to the expectation that their larger GIS experience justified a lower priority than the completely new and unexperienced GIS-parks.

These explanation models can only sketch some potential causes for the graph's deviation. However, the results of Figure 4.7. demonstrate a need for GIS-related improvements, particularly among the long time GIS users in the NPS.

(III). The park units A4, B2 and B4 reach exceptionally high scores and prove, that even short GIS experience can generate very positive overall results. All of these three units can be characterized by high scores (see Fig. 4.3.) in Index 4 (GIS Integration Into Management Philosophy). It is interesting to note that the low scores of the park units C3, C5, and C7 within the older GIS year groups (see again Fig. 4.7.) are accompanied by an obvious lack of management capabilities (Index 4). This implies, that the integration of GIS into upper management levels is also a problem of some parks with a long lasting GIS experience.

The Technical Score is derived from a combination of three primary parameters:

1. the quality of actual GIS operations,
2. the park's involvement in the input procedures for building up the data base, and,
3. the scope of the output devices in use.

A secondary parameter relates to the degree of the park's experience using remotely sensed data (since the use of remote sensing data is not a prerequisite for any GIS experience, it is only represented by bonus points).

General Results and Tendencies

(I). Figure 4.8. depicts the Technical Score for the 21 park units in the

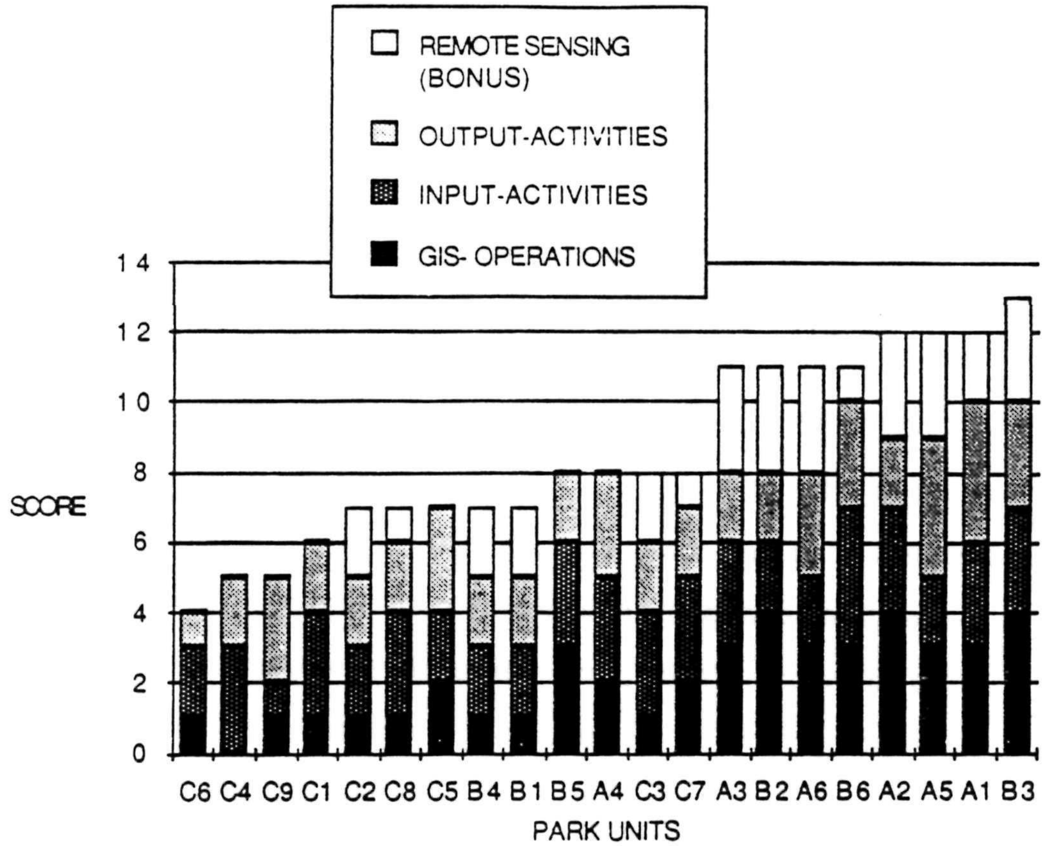


**Figure 4.8.**: Technical Score (Index 1)

three parameters and the bonus category in an ascending line. The highest score achieved by any park unit is 13 points which falls 3 points under the maximum number of points (16). Park C6 scored the lowest with 4 points. The ranking distribution of the three park classes (A = high, C= low) is generally maintained.

(III). There has been an obvious shift as some technically high ranking park units only ranked in a middle field (B3 and B6) in the Total Net Score. For example, a comparison with the other categories shows that park unit (B3) lost most of its points in Index 4 (see Fig. 4.21., Management Philosophy) and park unit (B6) scored very low in Index 2 (see Fig. 4.15., Institutional Phenomena).

A further analysis of the responses given by these park units (see appendix) leads to the following conclusions:

1. The high technical performance of park B3 can be seen within the context that a computer expert is leading the GIS staff of this park unit. The integration of the GIS into the broader management strategies appears to be a larger problem than the technical side.
2. In park B6, a very committed GIS staff member appears to have strong control over all technological aspects of the GIS. This individual is facing, however, some severe institutional problems (scepticism, isolation within the park) and feels he/she does not get the optimal support from the GIS Division in Denver.

These examples illustrate how some very specific elements of the overall picture can affect the final quality of a park unit's GIS performance.

## The GIS Operations

The level and character of the actual GIS operations is considered to be a valid scale for measuring how far the application is of the GIS is advanced. Since the crucial advantage of a GIS lies in its ability to operate far beyond the coding, storage and retrieval of data (see Chapter 2.2.3.), the questionnaire was deliberately structured to detect more advanced abilities of data manipulation. Hence, the highest number of points (4) in this score is reached when the park practices cartographic modelling which combines a whole series of GIS operations in a creative and complex way. As seen in Fig. 4.8., points out, only three park units (A2, B2, and B3) actually perform this most advanced way of manipulating spatial data. One of these units is a Biosphere Reserve and its large research center provides the opportunity to take advantage of the full scope of the technology.

More than 80% of the park units which use GIS for three years and longer have not performed any cartographic modelling operations at all.

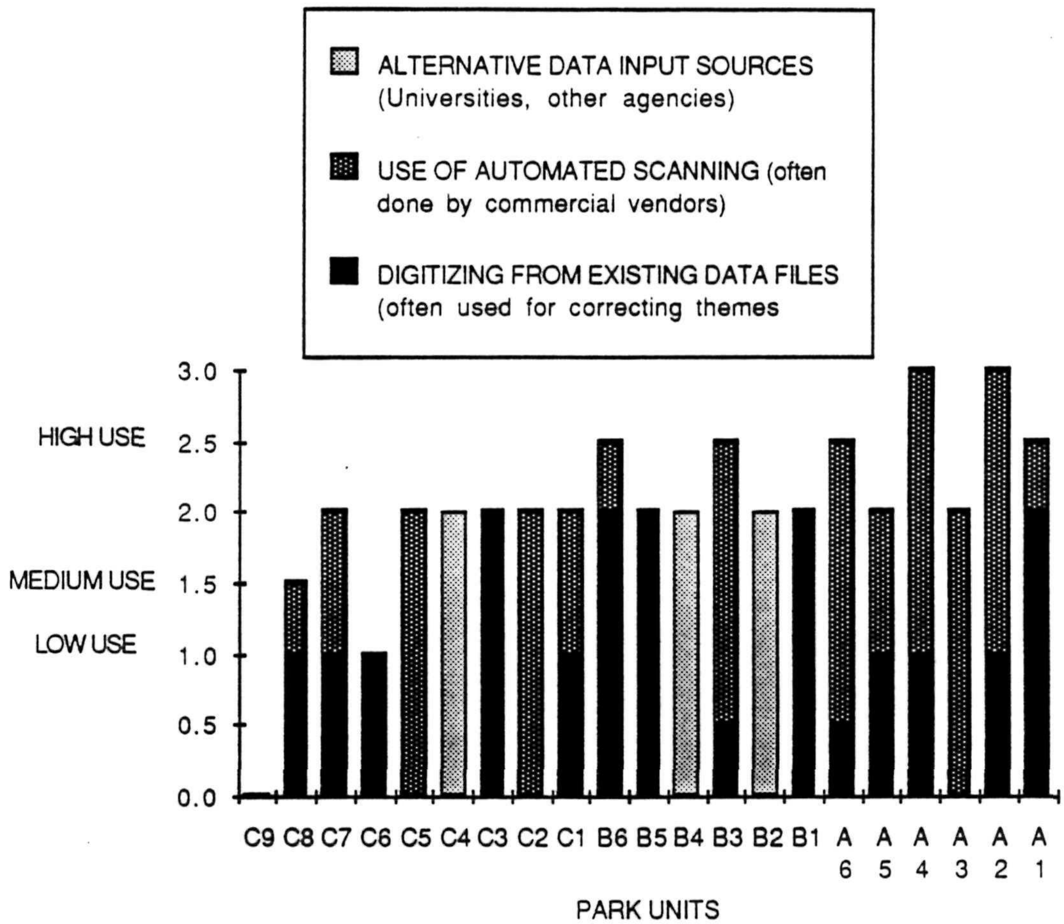


**Figure 4.9.**: Data Input Devices in Use

<u>The Input Devices</u>

The next parameter of the technical score is the level of input activities. Here the park's own involvement in capturing existing data sets, in controlling the set's quality and correcting mistakes, is the main matter of concern. Fig. 4.9. describes three major input devices which are presently in use. In only five parks (A1, B1, B5, B6, C3, and C6) does hand digitizing dominate the data input operations. Most of the park units, especially the higher ranking ones of Class A and Class B, strongly rely on automated scanning (often in combination with digitizing) which in many cases is done by commercial vendors. Park units B2 and B4 exclusively use already computerized satellite data.

Generally, the graph suggests that park units with a combination of both scanning and digitizing belong to the group of GIS users who received better scores in the overall performance.

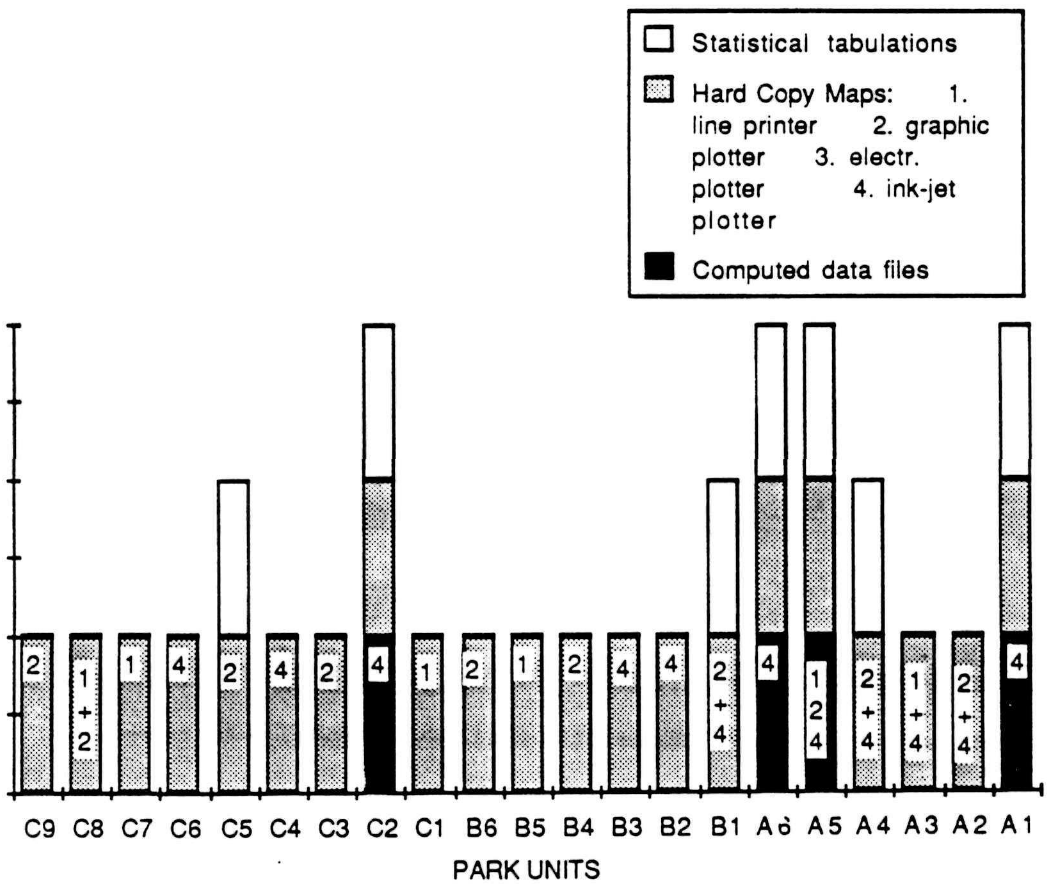


**Figure 4.10:** Data Output Devices in Use

The Output Devices

The third parameter for Index 1 ( see Fig. 4.8., Technical Sccre) is the examination of the output devices which are in use. The intention was to detect the park's ability and interest in taking advantage of the extended scope of output devices which are offered by a GIS. Potential output devices are hard copy maps, statistical tabulations, computed data files and digital elevation models. Besides the fact that the higher ranking park units also gained the highest points in this specific score, the general score for "output-activities" does not reveal many insights into the role of this parameter.

In order to achieve more detailed information about the output phenomena, Fig. 4.10. compares the different output procedures to the individual park unit's ranking position. A common characteristic of all park units is their interest in the production of hard copy maps. The parks were also asked whether they use a line printer, a graphic plotter, an electrostatic plotter, or an ink-jet plotter for this job. As it turns out, nearly all of the higher scoring park units (A1, A2, A3, A4, A5, A6, B1, B2, and B3) use an ink-jet plotter, while this tool is clearly underrepresented in the lower B- and entire C Class. Further more, the parks of Class A and park unit B1 distinctly represent the group with the most diverse output devices, by operating several printers and by seeking more than a hard copy map.

Main Data Error Sources in the GIS Application

The 21 park units were asked to select from the following choices the most common sources for data errors when operating a GIS in the park:

- Errors based on the data format
- Errors based on the age of the data

- Errors associated with digitizing
- Errors associated with combining overlays
- Errors based on other sources

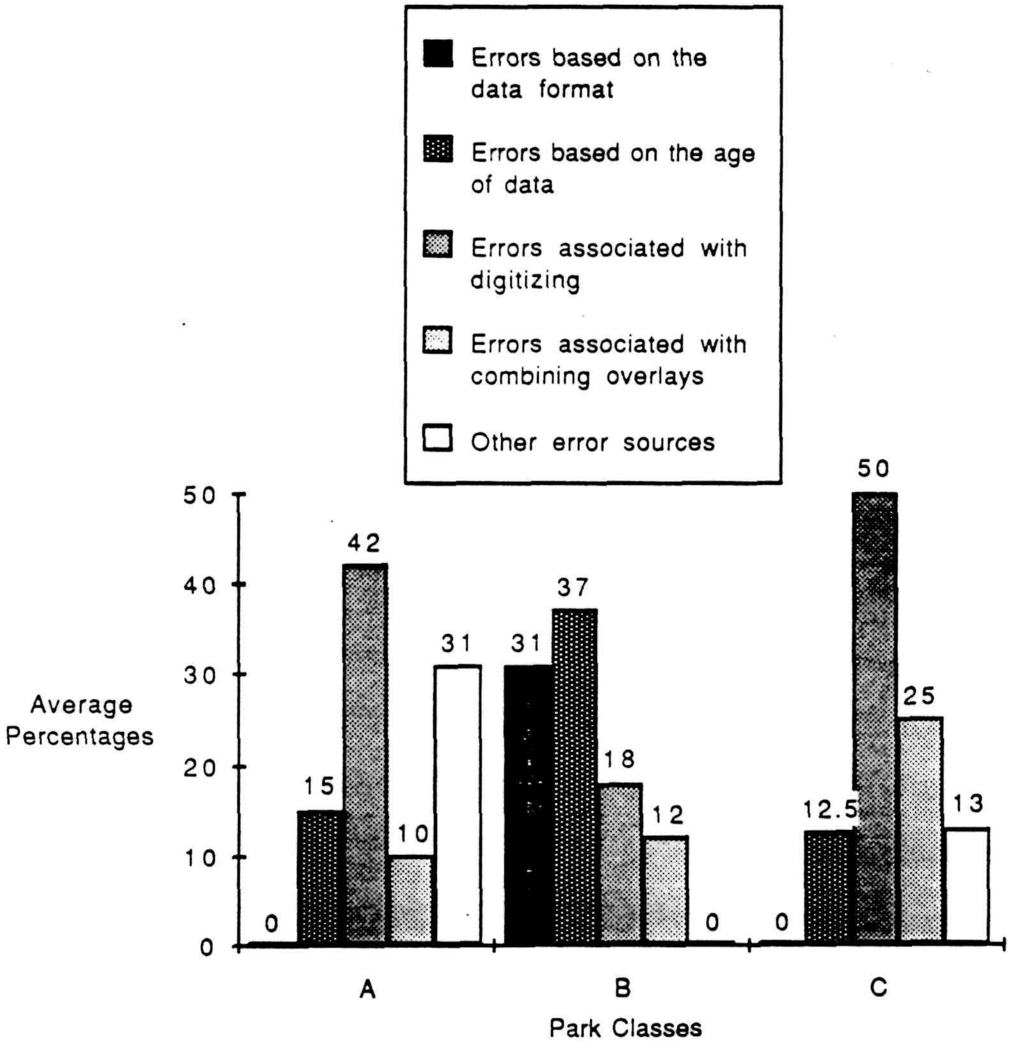


**Figure 4.11:** Main Sources of GIS Related Data Errors in a Comparison of the Three Park Classes (A, B, and C)

Figure 4.11 illustrates that errors associated with digitizing were deemed the most common error source for park classes A and C. Fifty percent of Class C claimed that digitizing operations are a primary error source while 25% stated that combining overlays created difficulties. In contrast, both of these categories rate relatively low in Class B, with18% and 12% respectively, while the error sources "age of data" and "format of data" clearly dominate.

Strikingly, the second largest error source in Class A is the one based on alternative issues. A selection of the responses relating to this category provides an idea of other important error sources:

- operating system errors,
- interfacing with UNIX,
- scanning results of contract firms,
- interpretation of field data,
- a problem specific to SAGIS: bringing quad-sheets, and, together and matching boundary lines,
- software is not "debugged".

This higher number of alternative error sources in Class A may indicate the higher sophistication of GIS operations in these parks and their advanced development of the technology. Hence, those examples (especially the ones that refer to the quality of the software) should be taken as a serious location of sources of GIS complications.

Remote Sensing Data

The bonus points for Index 1 are based on a series of questions which delve into the parks' commitment to the utilization of remote sensing data. Fig. 4.8. shows that five of the six park units in Class A and park B2 are deeply involved in the work with satellite data. This result indicates that the use of remote sensing data can be considered to be a typical attribute of successful GIS park units. However, the more-than-average number of especially large, research-oriented park units among the Class A parks leads to a higher representation of satellite data technology in these parks. The significance of the software for the overall GIS performance requires analysis.

### 4.2.4. Description of the Park Units' GIS Performance in the Context of a Raster/Vector Comparison

The decision of the National Park Service to implement SAGIS and GRASS as the major software components (see Chapter 2.3.4.) followed the intention to take advantage of both a vector and a raster-based method. The strength of vector based software lies in its compact data structure which allows precise operations, high quality output results, and a high degree of accuracy (Burrough, 1986). The NPS's strategy is to balance the disadvantages of vector technology (such as spatial limits of the polygon operations, complexity of data structure) with the advantages of the raster method. In raster, the data structure is simpler, spatial analysis is much easier, and, when combined with remotely sensed data (especially for large areas), is very practical. According to this plan, the simple use of raster-to-vector conversions and vector-to-raster conversions could generate an optimal composition of positive qualities for both methods, thereby hopefully generating the highest GIS results.

Although both systems, SAGIS (vector and raster) as well as GRASS (raster), are widely in use, most of the park units (16) expressed relatively clear preference for one or the other. Only five park units either could not decide on a preferred method or considered both of them to be of equal value.

It is interesting to note that all of these five parks (C1, C3, C5, C6, C9) belong to Class C. Possible explanations for this are:

1. Three of these parks are in a very early state of the GIS implementation and have yet not made a decision for one or the other method,
2. The other two parks (C3, C5) , however, belong to the long time GIS users. Their low average score implies that these parks are not able to take full advantage of both methods.

The distribution of the remaining park units from all three classes does not show any specific tendency between classes and preferences for raster or vector. Two-thirds of Class B prefer raster, which results in a slight advantage for the raster technology in the overall comparison (vector 7, raster 9).

Fig. 4.12. indicates that one reason for the differing preference of either raster or vector technology is related to the size of the park unit. The group preferring raster (9 parks) features park sizes with an average of about 1 million acres, whereas the "vector-group" consists of parks with significantly less acreage--an average of about 100,000 acres is standard. This result is partly predictable since the large parks are strongly dependent on the use of remotely sensed data which exclusively come as digital, hence, rasterized data sets. The extreme difference of a 1000% increase in acreage between the vector and the raster oriented group is still a surprising result. The third group which did not express any preference for either one of the two methods, with an average of 400,000 acres per park unit, ranges right in between the two other extremes. This implies that in the case of medium-sized park units,the advantages of both raster and vector methods, are more

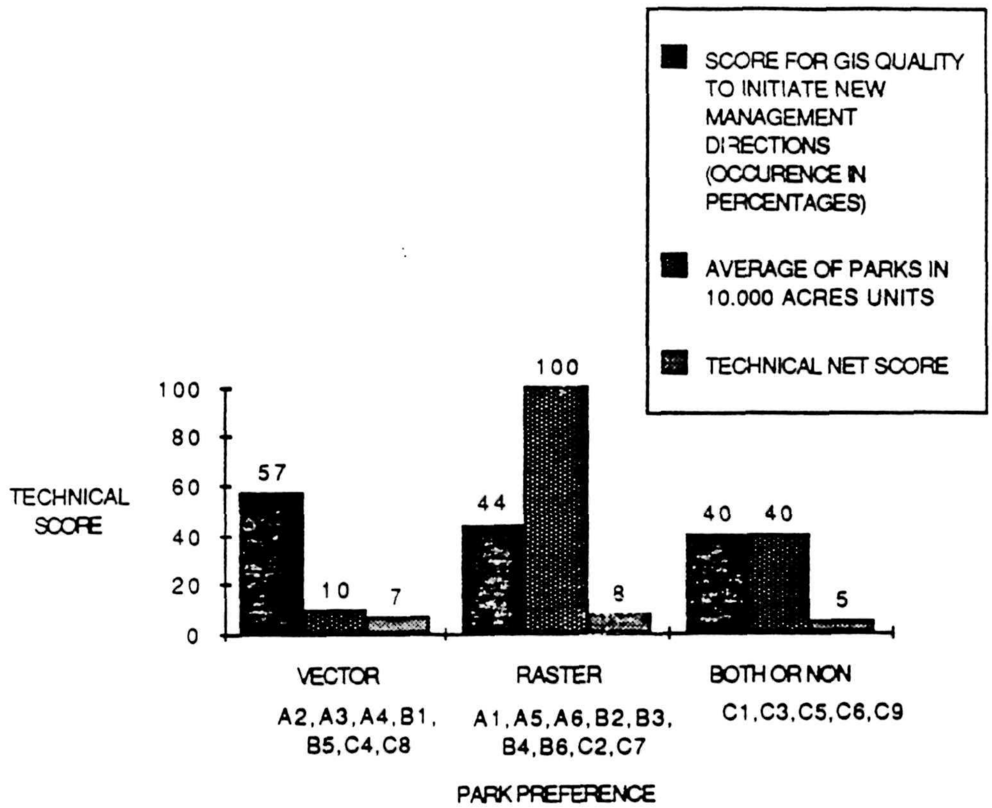


**Figure 4.12:** RASTER-oriented and VECTOR-oriented GIS Users in a Comparison of Specific Attributes (Management Creativity, Acreage, and Technical Net Score)

in balance with each other, although this is harder to determine than for the other two park types.

In further analyzing the software phenomena, Fig. 4.12. compares the three groups based on their average point numbers from the Technical Net Score. As mentioned above, Class C is strongly represented in the group without any preference, scoring lowest with 5 points. The vector-oriented park units feature a slightly better technical score than the parks with raster orientation (8 versus 7 points), though a difference of one point certainly does not allow far-reaching conclusions. The tendency of this result, however, supports the idea that vector operating park units, once the technology is under control, may develop higher skills and demonstrate more creativity in using the GIS's opportunities for data management.

Creativity is an important factor that must be considered when operating a GIS (Burrough, 1986). In order to achieve high standards in GIS performance, the user must not only possess a solid understanding of the software's capacity, but also a high level of creativity as well as the capability to develop abstract concepts and working models for a large variety of management tasks. Hence, it was interesting to investigate these capabilities in comparison between the vector-oriented parks versus the raster-oriented parks. Fig. 4.12 documents that vector operating park units were approximately 25% more successful in discovering and defining new management directions (based on their GIS experience), than the raster-oriented park units. This result is possibly an indication that the higher complexity of vector operations can result in positive feed-back to enhance the user's skills and creativity.

### 4.2.5. The Attitude of the Park Units Towards the Type of Software Supply

The response to the question of how the park units feel about the National Park Service's decision to implement a Service-wide GIS which exclusively utilizes SAGIS/GRASS software packages will be the topic of the following paragraphs. Fig. 4.13. shows that 14 parks are clearly in favor of this selection whereas 7 parks do not completely agree with the NPS 's software selection. This can be interpreted as a general acceptance of the SAGIS/GRASS direction. However, when one third of all respondents do not agree on such an essential topic, such a result should be considered as a matter of serious concern. The following list summarize the most frequently cited arguments against the recommended software combination:

- SAGIS does not handle neighborhood functions very well,
- the new version of GRASS is not always compatible with the old UNIX stations in the park (hardware problems),
- SAGIS is often very slow,
- SAGIS requires a lot of training,
- SAGIS is not very user friendly,
- the hardware is too complex for the funding and park size,
- GRASS/SAGIS is not applicable to unique park situations,
- new software limits data operation the the park boundaries,
- SAGIS appears to be a cryptic super-analytical tool,
- poor documentation for SAGIS,
- storage problems with the raster base, and,
- raster and vector is somewhat cumbersome.

Problems and frustrations as they were expressed in the interviews are not wholly new to the NPS GIS Division and in some cases the reason for the lack of success of the software might be more a matter of internal park problems than of software related insufficiencies. One indication for this thought is the projection of the Total Gross Score in Fig. 4.13. The comparison illustrates that the park units which disagreed on the NPS's software decision (with 30 average points) clearly score lower than the majority of

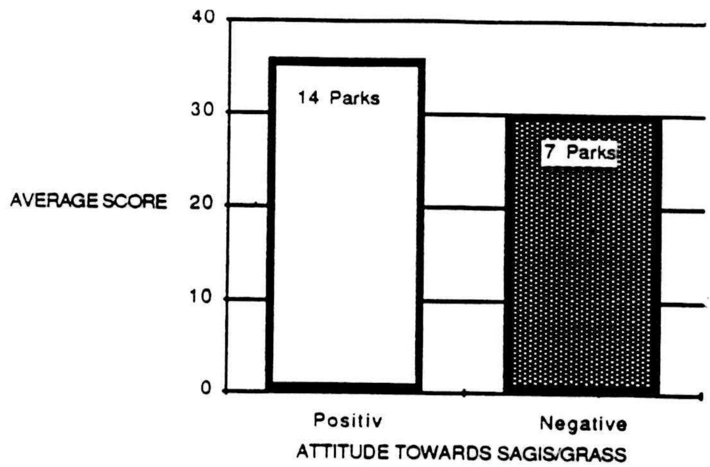


**Figure 4.13:** Parks Grouped By Their Acceptance for SAGIS/GRASS Versus The Groups' Average in Total Gross Score

SAGIS/GRASS supporters. However, with two higher ranking park units (A5 and B1), the opposition group also features some experienced and generally well performing members.

Despite this list of critical remarks the questionnaire also brought out many positive reactions to the selection of SAGIS/GRASS, even from many of the park units who also expressed the difficulties in using this software. A certain number of the critical statements, however, deserve the attention of the NPS GIS Division. Recommendations in Chapter 5 of this study will expand upon some of the above listed items.

The park units' interest in alternative software to the GRASS/SAGIS package are interpreted in Figure 4.14. More than 60% of all parks expressed an interest in other software systems. The highest interest rate is observed among the members of Class B, where 5 out of 6 park units showed alternative interests. In Class C and Class A, the distribution of pro-interest groups versus non-interest groups is nearly equal. A possible explanation for this phenomenon is the lack of experience among C-park units which results in a belief that any difficulties may be attributed to their own lack of experience rather than to any inherent problems with the softwares. Contrary to this, the Class B park units are further advanced but still lack the satisfaction of receiving optimal results. Hence, B-park units tend towards a stronger interest in external solutions (like a new software), rather than believing that the investment of more time and experience will eventually yield the expected results.

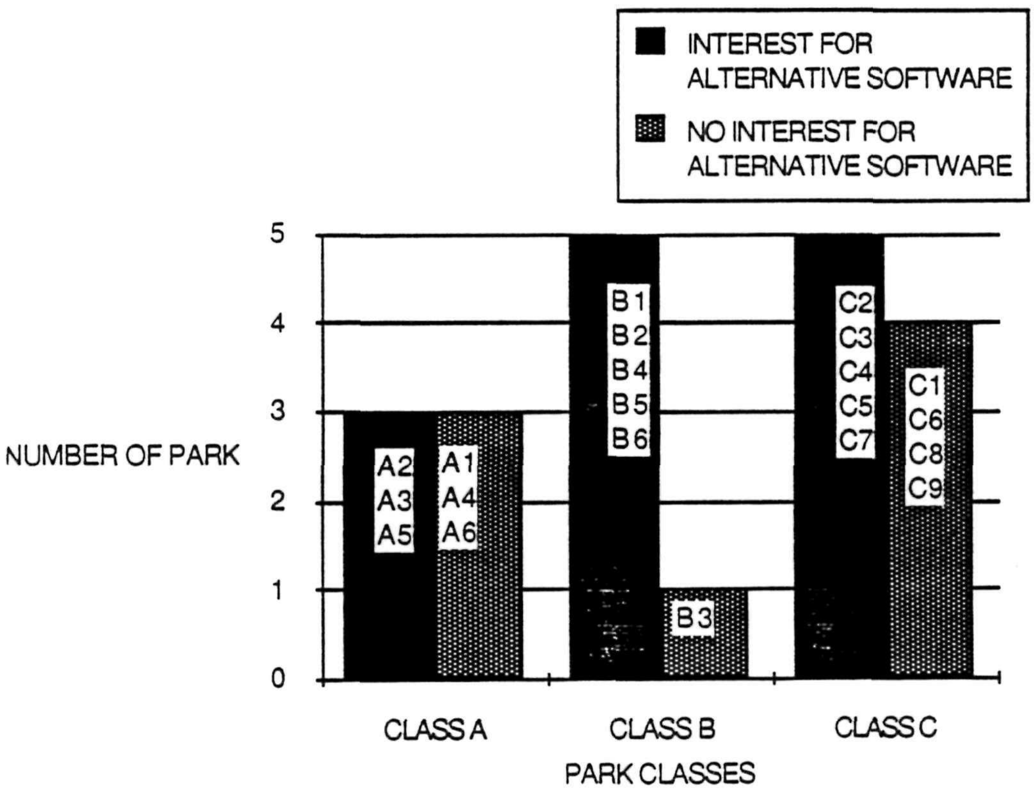


**Figure 4.14:** The Interest for Alternative Software Than SAGIS/GRASS in a Comparison of the Three Qualitative Park Classes (A, B, and C)

In Class A, three park units are interested in what benefits other software could provide them. Their responses focused on the following reasons:

1. In one park, the GIS expert is a very flexible person who is used to working with the different hardware systems of neighborhood agencies. These circumstances support a certain openness towards other alternatives.
2. The second park unit is basically disappointed from the speed and storage capabilities of the present SAGIS system.
3. The third park unit strongly regrets that GRASS limits the potential for cooperation with other land managing agencies which rely on different software. The park unit feels isolated from the surrounding "data-scape".

The last example, by touching the whole topic of agency cooperation, leads to the contemplation of how best to handle the software issue in the NPS. The recommendations in Chapter 5 will take up this subject in a more comprehensive manner.

When asked which alternative software would be of major interest, 90% of the parks in question named ARC/INFO as being the most attractive. According to a selection of the most often cited reasons for this attitude, ARC/INFO is regarded:

- to be cheap, easy to update and easy to edit,
- to have a very capable, fast built-in database,
- to offer, as a product of a commercial company, better perspectives,
- to be highly sophisticated for vector operations,

- to have better output results and to be very user friendly, and
- to be compatible with many other agencies which are using it (chance for greater cooperation).

Some of these opinions are certainly based on a very optimistic outlook which does not necessarily meet the reality of a hands-on experience with this popular software. It would be inappropriate, however, to ignore the parks' strong interest in this software or to deny some of the strength of ARC/INFO for certain aspects or park situations.

## 4.3. ANALYSIS OF THE INSTITUTIONAL PHENOMENA

In order to evaluate the institutional framework for the implementation of Geographic Information Systems in the 21 park units, three ascertainable parameters were selected from the questionnaire. These parameters are:

1. the staff's active working time devoted to GIS operations,
2. the degree of the GIS staff's training backgrounds, and,
3. the staff's exposure to GIS related conferences (including the presentation of GIS papers).

Besides these essential topics, the park units receive additional points (as a bonus) for the extent of their intention to pursue GIS based cooperative situations with other land managing agencies. Since this kind of information does not correlate directly with the parks' abilities to efficiently manage institutional GIS performance, this specific aspect is not part of the final Total Net Score.

General Results and Tendencies

(I). In the category of Index 2, park unit A2 scored highest with 14 points and park C6 scored lowest with 3 points. Figure 4.15. shows a distribution of all 21 samples that is not completely congruent with the overall results of the Total Net Score.

(II). Although most of the park units of each class are still in close proximity to each other, there is a moderate shift in the upper ranks of this chart. Three

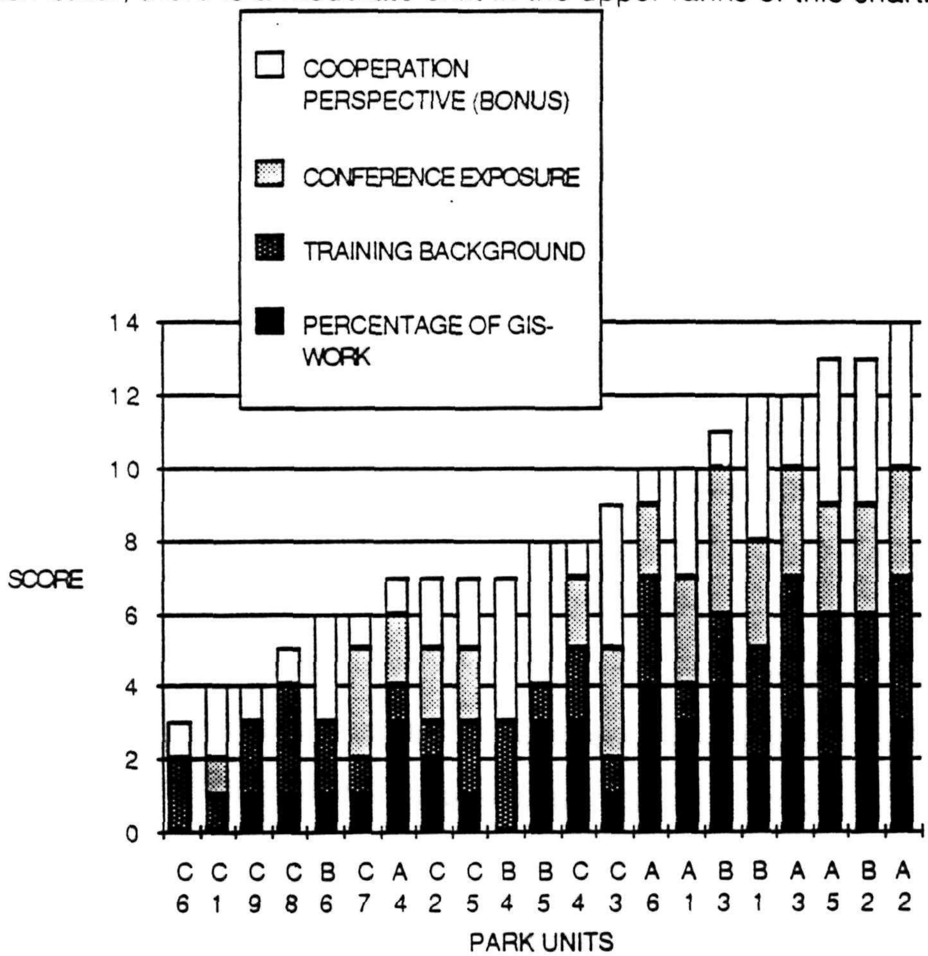


**Figure 4.15:** Institutional Score (Index 2)

Class B park units range among the six best in terms of the institutional score. This indicates that most of the B-parks can rely on positive institutional attributes, such as more than average training backgrounds and longer GIS working time.

(III). Three individual park units feature some major shifts in the overall picture. An extreme alteration compared to the total score is observed for park unit A4 which ranks more than 10 positions lower, placing the park on a Class C level. And indeed, the comments of the GIS staff member in park A4 point out, "that the pressure within the bureaucracy is too high" and "that the GIS politics of the National Park Services are at a critical junction".

The second substantial alteration in position resulting in a lower institutional score is park unit A1. Here it is the relatively weak training background and a low work power percentage which result in the loss of points.

Park C1 lacks any experience with the new technology and has zero percentage working power committed to the GIS implementation. Training as well as conference exposure are also insufficient. The respondent of this park unit gave some interesting comments on the NPS phenomenon of the so-called "turn-over-rates" in the administrational hierarchy. When a new superintendent takes over, the continuity in pursuing certain projects (e.g. GIS implementation) may considerably change. In the case of park C1, the new superintendent lacks his predecessor's high interest in the GIS technology

### The Staff's Daily Work Time Devoted to GIS

A closer comparison of the three park classes proves that the percentage of daily work time that is spent actually working with GIS drastically decreases from Class A to Class C. Figure 4.16. assigns 60% "true" work power in exclusive support for GIS projects to Class A. Class B with 40% and Class C with only 21% confirm the trend as it is expressed in the overall institutional score. It should be added, however, that the average percentage for Class B was calculated by excluding the percentage number of park B3. Provided with a highly qualified research team, the staff of park B3 presently invests 285%, or nearly 3 full-time positions,

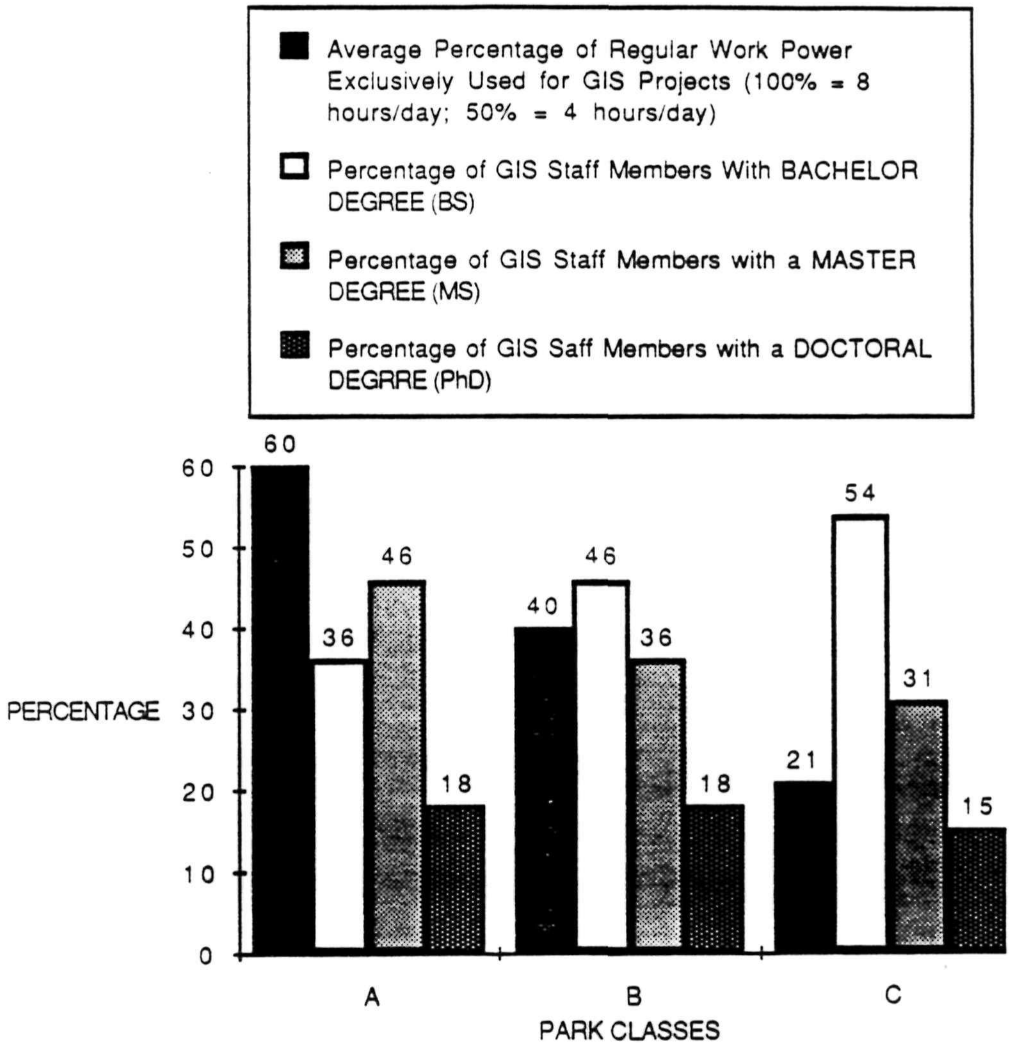


**Figure 4.16:** The Academic Qualifications and Manpower of the GIS Staffs in a Comparison of the Three Qualitative Park Classes (A, B, and C)

only for GIS. This uncharacteristic attribute, if included, would result in a strong distortion of the average. Hence, the decision to omit park B3 in the calculation appeared to be justifiable.

Up to this point, the comparison between the three park classes features the most extreme decline of qualities in the whole evaluation process. Hence, this result indicates that insufficient GIS work time can be seen as one major barrier on the way to a successful GIS performance.

A second part of Figure 4.16. depicts the comparison between the park classes A, B, and C, and the academic qualifications of their staff members. The chart illustrates a decrease of PhDs and Master degrees and an increase of Bachelor degrees from Class A to Class C. Again, it is the presence of an atypical class member (C3) which clouds an even clearer result. C3 also is a well equipped park unit (Biosphere Reserve) with a highly qualified research staff. However, their longtime difficulties in successfully establishing a GIS amount to a low ranked position in Class C. In the graph above, the numerous Master and PhD degrees of this park unit result in a significant distortion of the Class C statistic. Hence, given the omission of park C3, Class C would feature about 72% Bachelor degrees and less than 20% of Master degrees.

This finding suggests that the presence of higher academic degrees is a typical quality of successful GIS staffs.

The Cooperation With Other Agencies

As stressed in Chapter 2.1.2. the National Park Service's ability to cooperate with other land agencies is regarded as an important element of successful resource management. Figure 4.17. shows that Class C ranks lowest with 1.6 average points in this area. Class B, however, exceeds Class A by nearly 25%. One possible explanation is the perspective of the big research park units. The strong emphasis on independent research methods and the resulting self-confidence may lead to indifference towards the potential benefits of inter-agency cooperation.

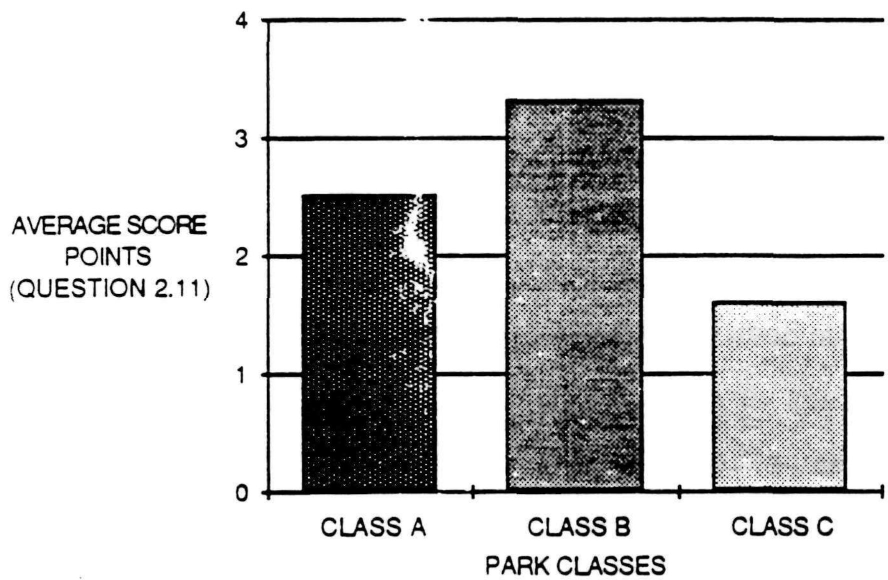


**Figure 4.17:** The Intention of the Park Units to Enhance the Cooperation With Other Agencies in a Comparison of the Three Park Classes

When investigating the park units' cooperation interests, their responses to this question can be summarized in the following list which ranks the agencies from highest priority to lowest priority. The percentage of the park units who expressed an interest in a cooperating with the agency in question, is noted brackets.

1. Department for Fish and Wildlife (85% of the parks)
2. Soil Conservation Service (71%)
3. Additional specific agencies of interest (67%)
   - state agencies
   - county agencies
   - water management agencies
   - NOAA
   - USGS
4. Forest Service (62%)
5. Army Corps of Engineers (57%)
6. Bureau of Land Management (52%)
7. Department of Transportation (38%)
8. Bureau of Indian Affairs (23%)

This list does not reflect the priorities of each individual park unit, since those needs vary according to the socio-geographical location of each park. The Bureau of Land Management, for instance,does not exist in the East Coast states. Hence, each individual need has to be defined and a specific park unit-oriented cooperation strategy has to be developed. Yet, the above listed agencies are certainly the most interesting potential GIS partners for the National Park Service.

Internal GIS Communication

When asked for their satisfaction regarding NPS internal communication, 81% of all park units (17 samples) responded that they feel the need for a substantial increase in the exchange of GIS information with other GIS-operating park units. Besides annual conferences and some super-regional meetings initiated by the GIS Division in Denver, the park units appear to be relatively isolated when interfacing with the new technology.

User Requirement Analysis

A user requirement analysis can be considered to be the most effective way of evaluating a park's suitability for a Geographic Information System. According to the responses of the 21 park units, one third started the implementation without any formal user requirement analysis. There are also indications that some of the other 14 parks conducted only a rudimentary evaluation. The fact, however, that three of the seven parks which implemented a GIS without have undertaken an official user requirement analysis are members of Class A, demonstrates that the significance of such a procedure should not be overestimated.

General Acceptance of the GIS Implementation

Nineteen or 90% of the park sampled stated that they do not see any problems with the acceptance of the GIS technology among other park divisions. Some respondents pointed out that the rangers especially show some skeptical attitudes or a certain passiveness in formulating application goals. In some cases, similar reactions could be noted for the interpretive staff. But the overall assessment is one of enthusiasm and support from all nearly all sides.

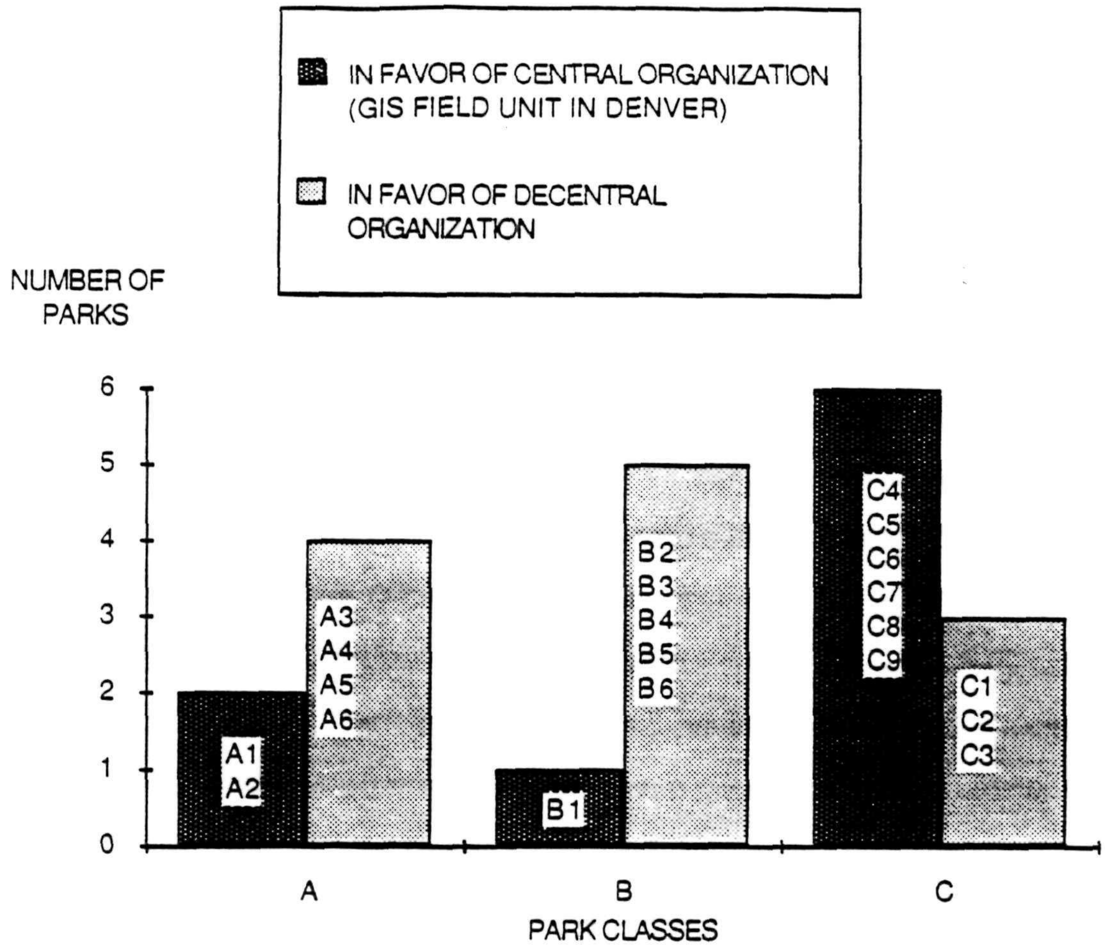


**Figure 4.18:** Preference for a Central Versus a Decentral GIS Organization in the NPS for Classes A, B, and C

Central Versus Decentral GIS Organization

The question whether GIS should be based on a central or a decentral approach in order to organize and control it, was investigated by comparing once again the three park classes. Figure 4.18. illustrates that the reactions to this subject matter are quite different. Both Class A and Class B are in favor of a decentral organization and emphasize the importance of operating GIS with a high degree of independence. Within both classes, the park units which differ from this attitude (A1,A2,B1) are the very high ranking park units. This could imply that these GIS-capable parks have already achieved an efficient self-determining way of working with the GIS, and that a central organization in Denver is considered to be a strong supportive element in the further institutionalization of GIS in the NPS, rather than as a threat to their own flexibility.

The underlying rationale of the results in Fig. 4.18. is amazingly consistent. Class C, consequently, strongly voted in favor of a central organization of GIS in the NPS. This is explained by the fact that the park units' insecurity in dealing with the new technology results in a dependency on a reliable and centrally operated "tutor". It is interesting to note that the Class C park units which favor a decentral organization are indeed the three highest ranking class representatives (C1,C2,C3). This fact further confirms the rationale just described.

## The Financial Situation for GIS in the NPS

More than 50% of all park units consider the present amount of financial support for their GIS to be clearly insufficient. As Figure 4.19. shows only in Class A is the situation different. Here, the majority (A3,A4,A5) is apparently satisfied with the financial situation and only two parks confirm the overall tendency. This result is not very surprising, since the big, successful science oriented national parks typically receive sufficient financial support from research funds and other sources.

Class B, with 5 parks, features the strongest group to demand increased

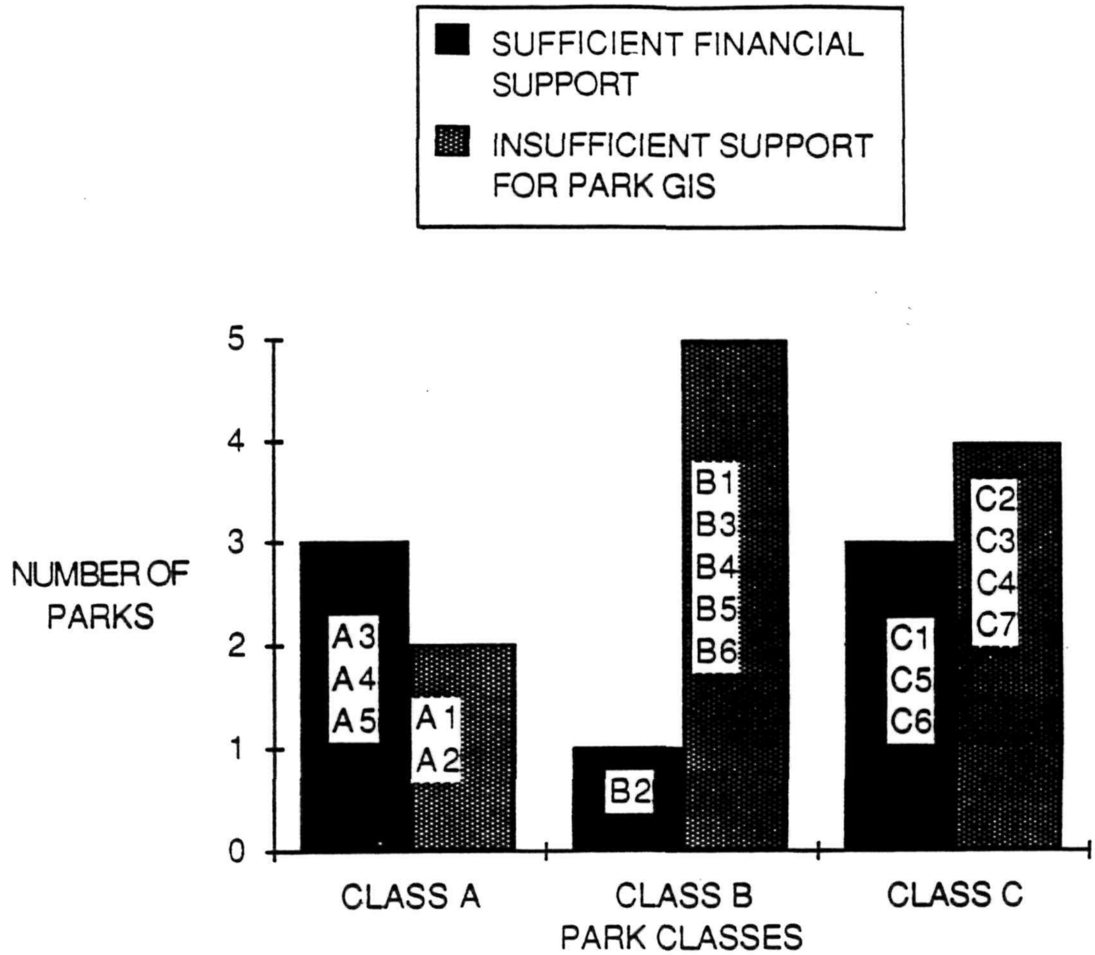


**Figure 4.19**: The Opinion About the Financial Situation of the GIS in the Park Units in a Comparison of the Three Classes (A, B, and C)

financial support. These parks do not have the same access to funds as do members of the Class A group, but they are highly motivated to improve their systems and update hardware components.

In Class C the situation is not quite as clear. Two of the park units of this class could not answer this question at all and 3 of the remaining 7 parks claim to be satisfied with the present funding of their GIS program. Since these parks do not score very high in the total scale, this result implies

1. that they indeed receive sufficient financial support, but are obviously not able to take full advantage of it, or,
2. that these units are simply underestimating the whole technical and personnel commitment which is necessary for an efficient GIS implementation.

Generally, it can be concluded that the amount of financial support appears to be a serious problem for many park units and that substantial efforts will be necessary to increase funding. A number of respondents argued that the lack of money hinders the realization of many of the National Park Service's management tasks --not only for the implementation and maintenance of GIS programs.

## 4.4. SPECIFIC PARK GOAL PHENOMENA

In order to explore how the GIS fits into the specific needs and management goals of the 21 park units, three parameters were selected to assess the existing and potential applications:

1. the park unit's prospect for using GIS to execute long-term projects,
2. the park unit's actual concepts to solve pressing problems by defining short-term projects, and,
3. the park unit's past and completed GIS projects.

These three fields of interest for the core of the Index 3 score (max. 12 points), while an additional four points could again be acquired in the "bonus" section of this category. This additional factor is formed by the coding of four questions which were designed to investigate the following issues related to specific management phenomena:

1. Will GIS significantly change the role of research and science in the individual park unit?
2. Is there a means of assessing the effectiveness of GIS results after projects have been completed?
3. Will GIS improve the quality and the quantity of the park unit's inventory?
4. Does the resource management plan mention explicitly the application of for certain management goals?

Each of these four questions are stimulating elements of the overall subject. However, their nature of examining mainly attitudes and opinions (with the exception of number 4), does not qualify them as true parameters when measuring the differences in the park's GIS performance.

General Results and Tendencies

(I). In the categories that form Index 3, the highest points were scored by parks A1 and A5 (13 points each) while park C4 scored lowest with 5 points. Figure 4.20. shows a distribution of the park units, where Class C is very congruent with the Total Net Score. Park Classes A and B, however, are partly intermixed with each other, resulting in a slight deviation.

(II). Class B scored higher than in other categories and 50% of this class is now represented among the top ranking park units. This result indicates that Class B parks feature some well developed concepts for the application of

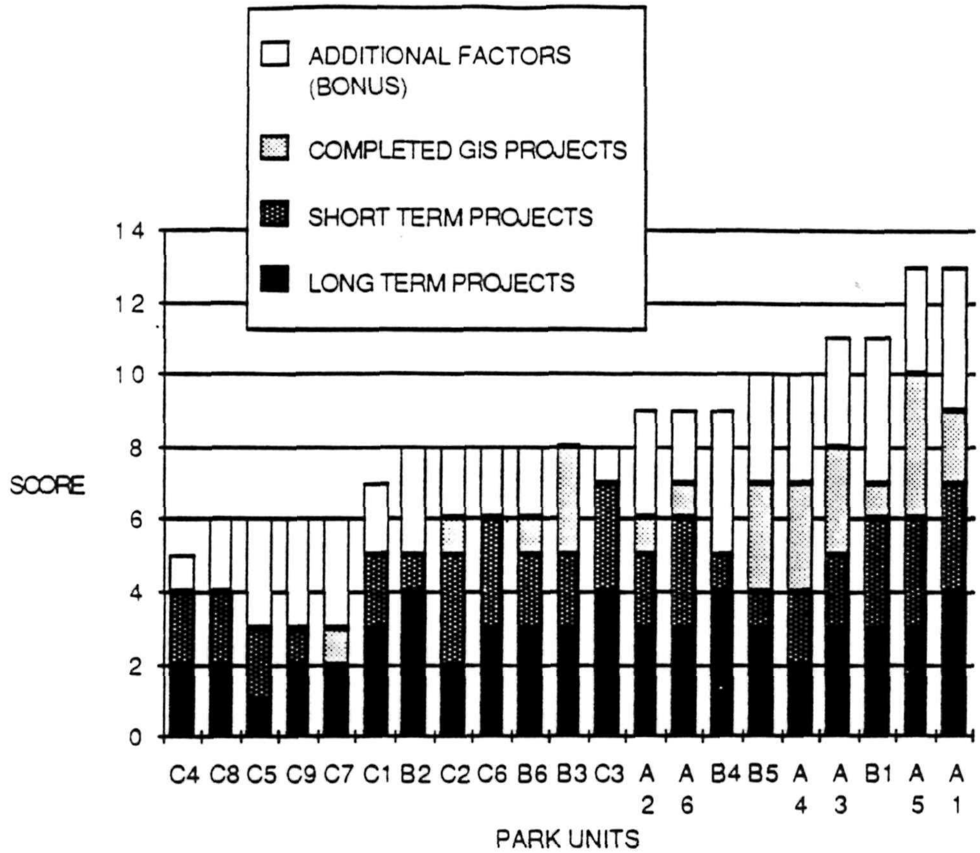


**Figure 4.20:** Specific Park Goals (Index 3)

GIS in specific management areas. In this quality, they clearly compete with the high scoring park units in Class A.

(III). An analysis of two individual park units reveals some interesting details. As Fig. 4.20. illustrates, park C3 scored much higher than its class position indicates. This park is a biosphere reserve with a strong research department which is highly interested in a long list of future applications and scientific objectives. Although this park has been exposed to the technology for quite a long time, the GIS staff faced a long phase of technical problems and frustrations. Hence, this park unit gained a relatively high number of points for Index 4, but lost points in all other categories.

Another interesting example is park unit B5 which ranks clearly higher then in the Total Net Score comparison. For 5 years, park B5 worked together with a university department and succeeded in completing a series of park goals within this time. While this experience certainly helped to develop some positive GIS results, this park features some shortcomings for the institutional aspects of the GIS implementation (see Fig. 4.3).

### 4.4.1. Definition of Categories for the Specific Management Goals

All projects which were named during the interviews with the park units form a long list of often greatly varying topics. In order to come to some quantitative and qualitative evaluations, all of these topics were typified and arranged in three separate and broad project categories. Each of these three project categories is composed of three sub-categories which feature a higher degree of differentiation. This evaluation system is presented below:

1. Project Category I: Comprehensive and research oriented monitoring projects

Sub-Categories :

a) General monitoring of change in natural environment (e.g. growth, hydrology, climate, ecological structures, etc.)
b) Monitoring the spatial distribution of natural environment (e.g. soils, vegetation, habitat types, etc.)

c) Science-oriented research programs (e.g. greenhouse effect, acid rain research, etc.)

2. Project Category II: Projects with a particular focus on specific issues (often with an actual or individual goal definition)

Sub-categories:

a) Detection of the occurrence of specific and/or actual natural processes (e.g. fire, rain fall, impact assessments, etc.)

b) Detection and description of specific objects (e.g. endangered species, species management, habitat boundaries, etc.)

c) Analysis of cultural or historical issues (e.g. archaeology, artifacts of native Indians)

3. Project Category III: Projects that relate to the park's infrastructure and to data inventory issues

Sub-categories:

a) Anthropological aspects and scenic assessment as a park resource (e.g..: viewshed analysis)

b) management of visitor traffic and impacts (e.g. specific site planning, camp sites, trails, parking, etc.)

c) projects related to the implementation or optimization of the GIS itself (e.g. setting up the data base, storage, updating, etc.)

All three parameters of Index 3 score (namely the long-term projects, the short-term projects, and the completed GIS projects), as they are mentioned in the first paragraph,will be compared within the Project Categories I - III (including their 9 sub-categories). Again, this comparison will be based on the three qualitative park Classes A, B, and C.

The Long-Term GIS Projects

All park units were asked to list those projects which were developed to be of continuing interest for the individual park and which would involve GIS operations (e.g. baseline inventory, ecological scenarios and future predictions) for several years to come. The underlying assumption for this kind of project is that permanent record keeping and repetitive procedures of data manipulation contribute basic research materials for the long-term management of a park's natural resources.

The selection of the following projects (arranged according to the three Project Categories as described in the previous paragraph) gives an idea about the specific long-term goals of the current GIS users in the National Park Service:

Project Category I (Comprehensive research oriented topics):

a) fire management , development action, shoreline erosion, change detection, monitoring vegetation change, models for fire behavior prediction, shoreline processes. land use changes over time

b) vegetation management, watershed management, plant ecology and wildlife, watershed monitoring, fire ecology , agricultural work

c) weather, research information, simulation for research, scenarios ( nuclear winter), global warming, biosphere issues, air pollution monitoring

Project Category II ( specific issues of natural resource management)

a) water depth, hydrological pattern, grazing management

b) grizzly bear habitat, endangered species habitat modeling, wading birds, exotic plant species distribution, wildlife management, endangered species (panthers)

c) archaeological site survey, archaeological site studies, water quality, monitoring

Project Category III ( internal park organization and data inventory):

a) land use, scenic easement

b) trail planning, mineral leasing, roads and trails coal and gas permit processing, telephone line, water sewage,backcountry camp sites

c) general cartography , file to keep permanent map records, update boundary map, storage, general data base management.

Figure 4.21. shows a distribution (using average percentages) of the three Project Categories (I ,II, and III), within the long-term projects, in a comparison to all three qualitative park classes (A, B, and C).

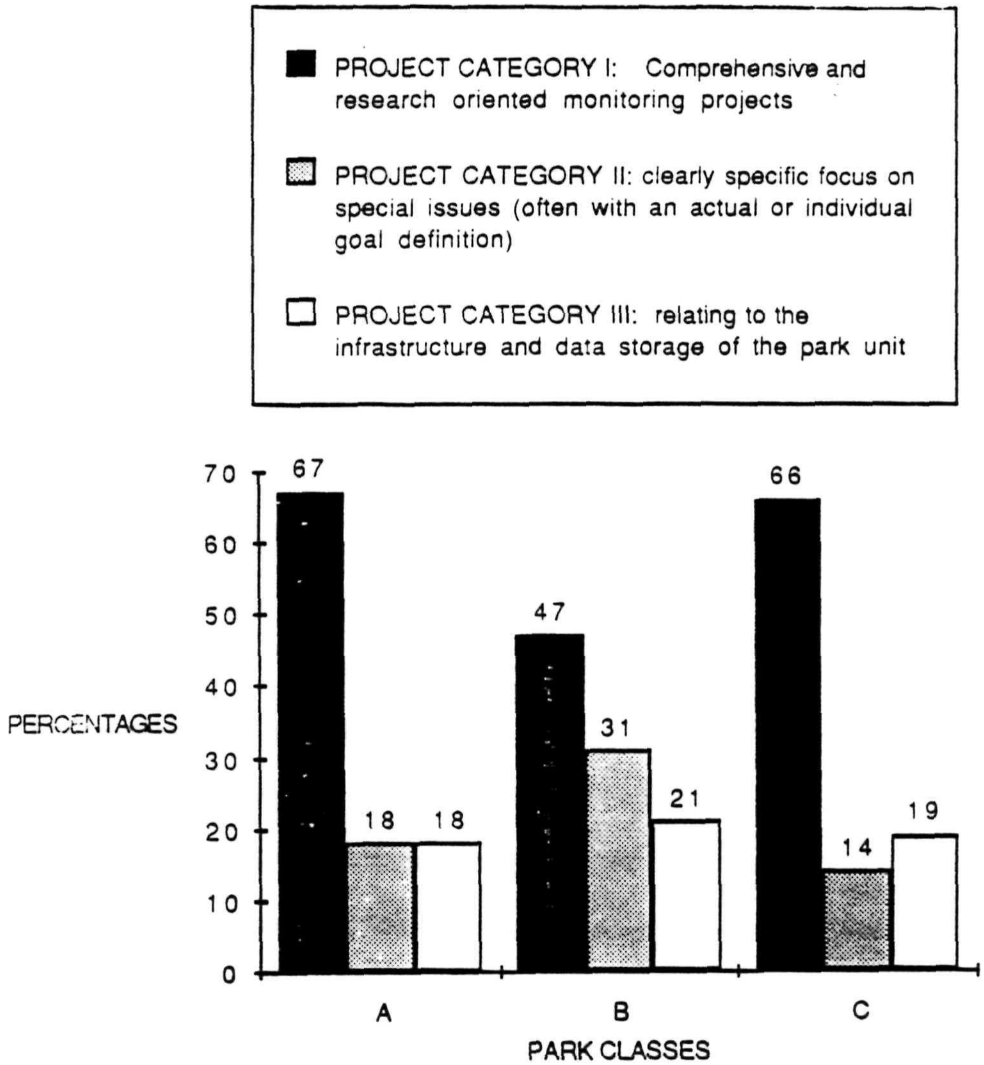


**Figure 4.21:** Long-Term GIS Projects in a Comparison for the Three Park Classes (A, B, and C)

For each park class the Project Category I is the dominant character of the long-term projects. In both Class A and Class C, more than two thirds of all long-term projects deal with comprehensive and research oriented monitoring tasks. Only Class B remains behind this strong trend and features less than 50% research oriented management goals for their long-term schedule. Hence, in Class B the other two types of projects, Project Categories II and III are represented stronger than in Classes A and C. At first glance, it is surprising that Class C appears to have the same emphasis on research oriented goals as Class A, where a high level of GIS performance is often based on the presence of strong research divisions within those park units. However, a closer examination of the individual park units in Class C, again underlines the distorting influence of park unit C3 (see foregoing section 4.4.1. in this chapter) on the overall picture. Park unit C3, due to its qualities as a Biosphere Reserve, plans to pursue several strongly science related objectives, yet this park was not able to perform well in the technical or institutional aspects of the GIS implementation.

With park unit C1, Class C includes another park which features some exceptional qualities that result in an above average percentage. Park C1 made a very comprehensive and thoughtful effort by completing an extensive feasibility study before undergoing the implemention of a GIS in their park. Therefore, this park is very aware of the essential GIS goals and was able to name a larger number than other parks of Class C.

When subtracting these two park units (C1 and C3) from the average score in Project Category I, the new percentage for Class C is 50%, which brings it close to the result of Class B (47%). Such a revised graph (see second Project Category I chart in Fig. 4.21. for Class C) corresponds much more to the real character of the three park classes.

The distribution of the other two Project Categories give a good impression of the general orientation of these park classes. Thus the overall results for the long-term projects, as they are illustrated in Fig. 4.21., can be characterized as follows:

1. Class A has a high interest in comprehensive and research oriented monitoring projects; applications for specific topics or topics which refer to the inner organization of the park rank equally low.
2. Class B still emphasizes the more comprehensive projects of Category I (although, less than in Class A), but rates specific management issues (Category II) much higher than park internal applications (Category III).
3. Class C, especially in its revised version, also considers research oriented topics as the major long-term commitment for the future. Category III, however, ranks slightly higher than Category II.

## The Short-Term GIS Projects

In the following part of the questionnaire, all park units were asked to name projects which are planned to be completed in the near future. In general, the topics of these projects are based on very concrete and sometimes pressing management problems of the individual park unit (certain endangered species, an actual impact (flood, fire), etc.). The Geographic Information System is supposed to generate the basic analytical models in order to set the stage for early management strategies to overcome present critical situations.

Again, the following selection of projects (arranged according to the three Project Categories) will give a quick overview of typical short-term goals, as they are viewed by the GIS staffs in the 21 park units:

Project Category I (comprehensive, research oriented topics):

a) large fire behavior,

b) vegetation map, aquatic vegetation map, land use, wetlands mapping

Project Category II (specific and/or actual management goals)

a)1988 fire analysis, rain fall input, monitoring the springs, measure sea level rise, gypsy moth management, drainage research, prescribed burning, evaluation of canals at park border,

b) wildlife habitat management, habitat association for wild life, homerange of bighorn sheep, habitat evaluation, evaluating bighorn sheep and peregrin falcon habitat, mapping T&E species,

c) archaeological sites,

Project Category III (internal park organization and data base issues)

a) digital elevation modeling,

b) viewshed analysis, camp ground planning, specific site survey properties, park site analysis for planning projects (roads and buildings), roads and trails, trail system, road system, management of hunting camps,

c) complete data base, acquire data base, completing input, completing a test area, completing boundary lines, inholding inventory.

Following the same analysis procedure as it was applied to the long-term projects, Figure 4.22. shows a distribution (using average percentages) of the three Project Categories (I ,II, and III) within the short-term projects in comparison to all three qualitative park classes (A, B, and C).

The results of this comparison indicate some significant differences between the three park classes. In Class A, the distribution of the Project Categories appears to build directly upon the results of the long-term project comparison, as it is described above. Typical for long-term goals, the Project Category I scores are consequently low (6%) in terms of short-term goals, in comparison to Class A, and Project Category II has the highest representation of all classes. In the other classes, Project Category I occupies relatively large places in the short-term program of the park units. One possible explanation for this phenomenon is that the B and C Classes might not have defined the character and time-schedule for their projects in the same quality as the Class A parks.

This assumption was confirmed during the interviews, when a series of park units repeatedly mentioned the same project in both or even all three categories. Given these conditions, the higher percentages in Category I of both park Classes B and C must consequently result in a lower percentage for the Category II.

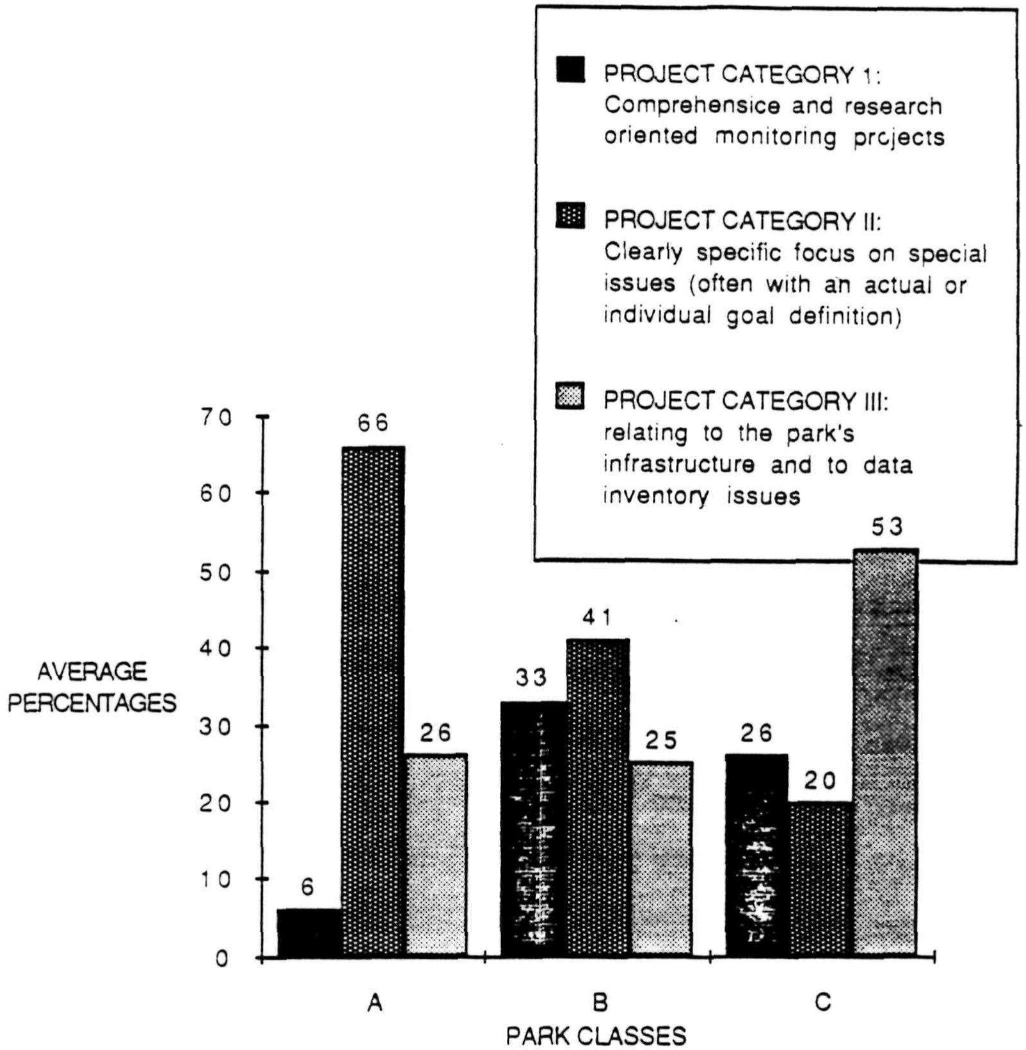


**Figure 4.22:** Short-Term GIS Projects in a Comparison of the Three Park Classes (A, B, and C)

Class C shows some conspicuous deviations from the general pattern of the higher ranking park classes. Here, the Project Category I (comprehensive research oriented issues) outnumber the Project Category II (specific management issues). This finding appears to be surprising, especially with regard to the presently lower performance capabilities of Class C. However, the results for Categories II and III simply indicate that the park units of Class C, other than in Class B, did not develop a very precise concept of how to approach specific GIS applications for current management goals. In Class C, a larger number of park units had only a general idea of the benefits of the GIS. Hence, Class C has a higher response rate for more general monitoring objectives.

For this reason, most short-term goals of Class C belong to the Project Category III (relating to the park's infrastructure and to data inventory issues). Since a high number of the "C-parks" are still on their way to overcoming initial technical problems of the GIS implementation and to setting up a data base, these parks frequently named goals which directly relate to the GIS implementation itself. Another important part of their major concerns for the near future relate to visitor and park infrastructure related topics. Presently, there is a tendency by Class C to view the GIS as a tool to improve the park's inventory and to pursue traditional and conventional management goals.

## The Completed GIS Projects

In the third part of this interview section, the park units were asked to list the names of their completed GIS projects. The projects in question had to be based on the application of a Geographic Information System. In some cases, early projects were completed with alternative computer systems (e.g. CAD). Since these examples are still considered to represent an early commitment to the GIS technology, all computer-based projects are listed without further differentiation regarding their specific origins.

Again, the projects were arranged according to the three Project Categories in order to compare their different characters. Following is a selection of the completed projects based on the application of a GIS:

Project Category I (comprehensive, research-oriented topics):

b) site selections for long time monitoring, mapping prairie systems, vegetation trend analysis,

Project Category II (specific management goals):

a) spring detection map, hydrological stations mapped for display, field models, statistical tables, shoreline trend analysis, fire analysis,
b) grizzly bear analysis along trails, mountain lion observation, hazard map for gypsy moth management, location of bear sightings in the parks, model for bighorn sheep, grizzly accumulation effects, identifying potential habitat for Great Grey Owl, locating abandoned coal mine openings (for wildlife),

Project Category III (internal park organization, inventory):

b) cemetery mapping, oil and gas site locations,
c) general site maps, location maps for different scales, measuring acreages in the park.

Figure 4.23. shows a distribution (using average percentages) of the three Project Categories (I ,II, and III) for the completed GIS projects compared to the three qualitative park classes (A, B, and C).

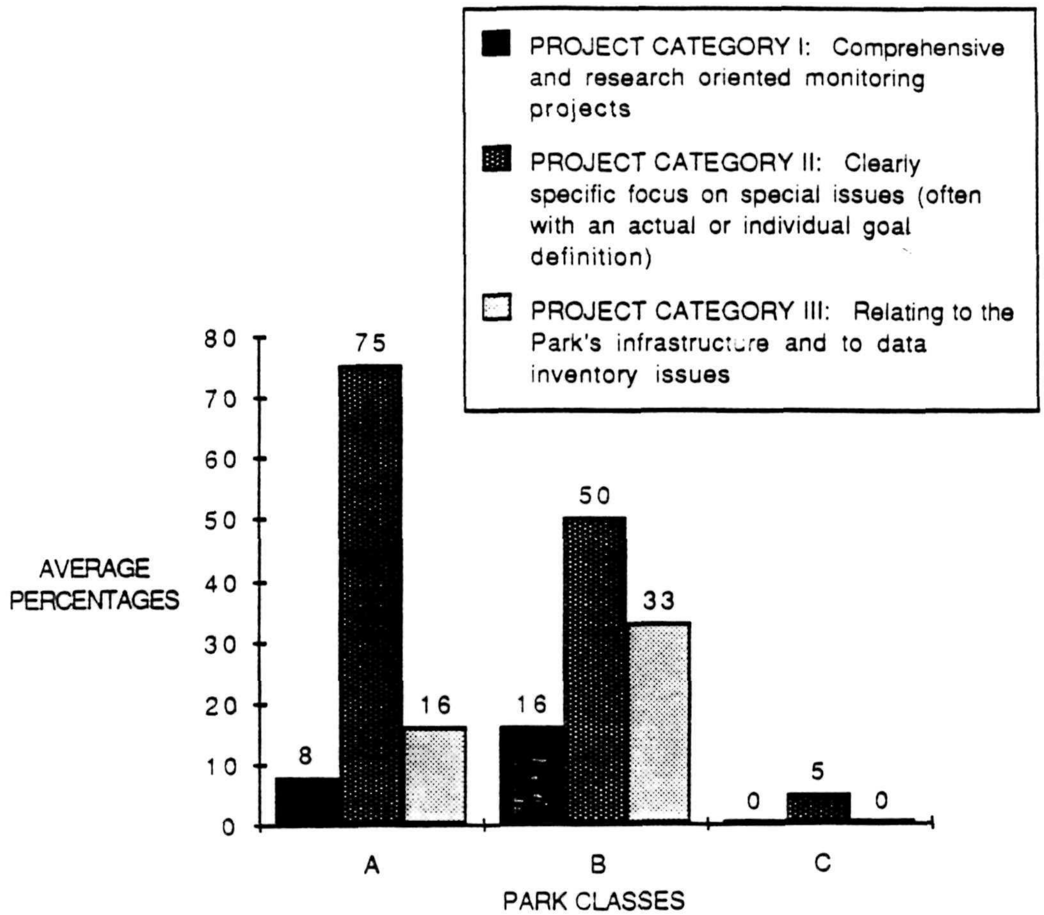


**Figure 4.23:** Completed GIS Projects in a Comparison of the Three Park Classes (A, B, and C)

In all three park classes, most of the completed projects belong to Category III. This indicates that for specific tasks, like the initial mapping and managing of threatened or endangered species, the GIS was applied first. This is especially true for Class A where 75% of the completed projects are from Category II. Naturally, the more comprehensive research projects from Category I are represented only in small percentages. The projects that relate to the internal organizational and infrastructural issues are more represented in Class B than in Class A. This could indicate that in Class A parks, the stronger emphasis on research issues weakens the role of Category III items. Besides this, it is supposed that Class A parks have already overcome initial tasks related to the data base construction.

Class C completed few to no GIS projects.

Additional Aspects of GIS Applications

The question whether GIS has influenced the role of science in the individual park units was answered affirmatively by 50% of the respondents. For most of these parks, the GIS is positively altering the significance of research and science based resource management. A comparison among the three park classes fails to find any specific class characteristics among the response sets. Some of the Class A parks, for instance, have long research tradition and the introduction of GIS did not really revolutionize the role of science in this individual unit.

The question of the impact of GIS on the park's data base brought an overwhelming result. All 21 park units (100%) are convinced that the implementation has improved or is improving the data inventory and retrieval capacities in a substantial way. This could be one of the most important phenomena of the GIS experience in the National Park Service.

Only 12 out of the 21 park units included the application of GIS for specific management goal in their individual Resource Management Plan. The Resource Management Plan (RMP) is considered to be the essential program for stating, defining, and scheduling the park's future tasks and responsibilities. Again, a comparison of the three park classes shows that there is no evidence of any correlation between park classes and the specific responses.

When investigating the park unit's capabilities of reassessing the results of GIS operations after the completion of a project, many answers turned out to be based on hypothetical approaches. Most of the respondents regarded field trips and ground proofing to be the appropriate way to reassess results. The complexity of this subject, however, does not allow a very sophisticated interpretation of this topic's role in GIS based management concepts.

## 4.5. THE ANALYSIS OF THE MANAGEMENT PHILOSOPHY PHENOMENA

Whereas the previous Chapter 4.4. investigated the specific management goals in the individual park units, this chapter is exclusively devoted to general aspects of the parks' management philosophy. This differentiation was considered to be extremely important for a look beyond the actual management commitment of each park unit. The questions of this category of the study were designed to examine the function of the Geographic Information System within the parks' own definition of the NPS's role in managing America's resources. Hence, in this part of the study the researcher was interested in park units' attitude to modern resource management strategies and in the actual involvement of GIS in parks' responses to these changes.

The three essential parameters for Index 4 (Management Philosophy) are based on the following issues:

1. Did GIS stimulate new management strategies and concepts in the park?
2. Did GIS induce the discovery or realization of new management goals which were not obvious before the implementation of the technology?
3. Does any kind of active GIS cooperation with other agencies already occur?

Besides these fact oriented questions the park units could again score some additional points in the "bonus" category by answering an attitude question. The parks were asked to rate the significance of the GIS for the management of natural resources on a scale from "1" (highly significant) to "5" (low significance), based on their individual experience or expectation. Another part of the interview explored the park units' ranking of general management objectives for the GIS applications.

General Results and Tendencies

(I) Figure 4.24. shows the park units' overall results in the fourth category. Four park units reached the highest possible score (16 points) and four park units scored lowest with 2 points. Hence, Category 4 features the strongest polarization with eight park units more than one third of all samples at both ends.

(II). The overall distribution of the three qualitative park classes (A,B, and C) is comparable to the results of the Total Net Score. In the middle range,

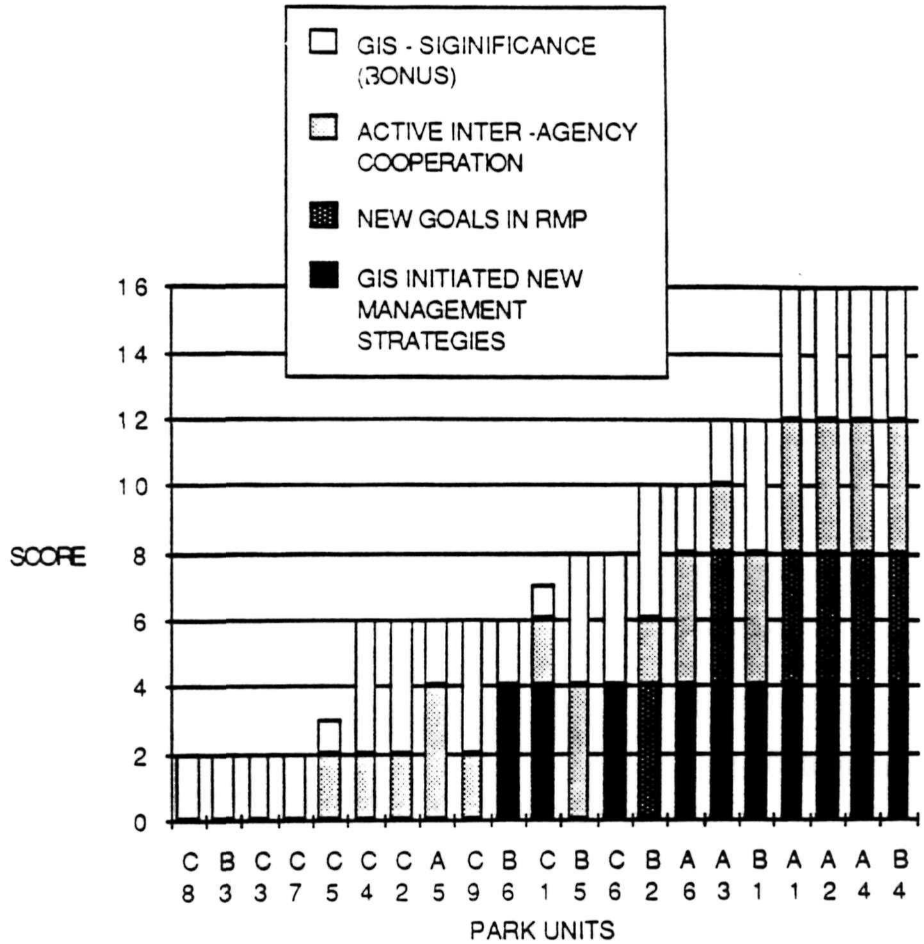


**Figure 4.24:** Management Philosophy (Index 4)

however, an interference between all three park classes points at various, class-independent shifts in this category.

(III). As Figure 4.24. illustrates, park unit A5 made a clear shift into the range of Class C. This indicates, that despite the high score in the previous category (see Fig. 4.20., Specific Park Goals), park A5 did not develop new, GIS-related management strategies. Most of this park's GIS experience is based on the longtime cooperation with an adjacent U.S. Forest administration.

However, an explanation for this speciai phenomenon (low score in Index 4) is presently not at hand.

Encountering New Management Strategies Through the Use of GIS

Almost 50% of all park units came to the conclusion that new concepts and strategies for the park management have been developed, due to the implementation of a GIS. Most of these progressive discoveries relate to new possibilities in monitoring spatial distribution of physical factors and in locating and measuring changes over time. The following illustrates the most commonly cited for management innovations:

- locating monitoring plots from data base
- frequent production of fire maps
- trend analysis for vegetation
- overlays to land succession
- grizzly bear project
- detecting exotic species
- mapping deer habitats

The greatest advantage of the new technology appears to be its qualities to standardize locations with UTM coordinates, to produce maps of high quality in a fast and efficient way, and to use remotely sensed data to analyze large areas . Before the establishment of a GIS, sophisticated management operations of large-acreage-park units were simply not possible.

Active Inter-Agency Cooperation

Two thirds of all park units are actively involved in GIS related inter-agency cooperation. This relatively high result confirms the park units' positive attitude towards this topic, as it has already been expressed in the discussion of Index 2 (see Chapter 4.3., Institutional Phenomena). Other cooperating agencies include:

- Los Angeles County Fire Department
- U.S. Army Corps of Engineers (high degree of cooperation)
- Environmental Protection Agency
- NOAA
- USGS
- Forest Service (high degree of cooperation)
- Tennessee Valley Authority
- Soil Conservation Service

These existing contacts to other management agencies is an encouraging basis for the development of additional and more intense situations of inter-agency cooperation in the future.

Priorities for Future GIS Applications in Resource Management

In order to evaluate the park units' priorities for the future use of GIS in the Park Service, the 21 parks were asked to rank the following categories of applications and their sub-categories. Although dealing with similar objectives, the arrangement and typology of this part of the study do not relate to the earlier definition and differentiation of projects in Chapter 4.4. (the list of specific park goals was interpreted and classified after the collection of the data). This time, however, the questionnaire was designed to encourage the park units to make their own conscious decision about the definition and rank of priorities of future GIS applications.

The parks were asked to rank the following types of application and their sub-groups:

### 1. Research Projects

a) Conceptual Models (Ecology, Interaction)

b) Long-Term Studies

c) Baseline Inventory

### 2. Management, Planning, and Communication

a) Quantification of Indicators

b) Analysis of Risks, Trends and Potentials

c) Assessment of the Effectiveness of GIS after Application

### 3. Conflict Resolution and Cooperation

a) Inter-Agency Communication

b) Pursuit of a Super-Regional Computer Network

c) Expansion of Regional Responsibilities (not geographically !)

Figure 4.25. illustrates these types of GIS applications by comparing them with the three qualitative park classes (A, B, and C) in the form of a matrix. When being asked to rate the main types of GIS applications for the future, all park classes chose for the same line-up: at first place ranks "Management, Planning and Communication", at second place "Research Projects", and "Conflict Resolution and Cooperation" was rated third. For Class B and Class C, this result was to be expected (based on the findings in Chapter 4.4.). Based on the same information (Chapter 4.4.), Class A was supposed to have

its strongest emphasis on "Research Projects". However, Fig. 4.25. indicates that "Research Projects" actually rate only second in this comparison.

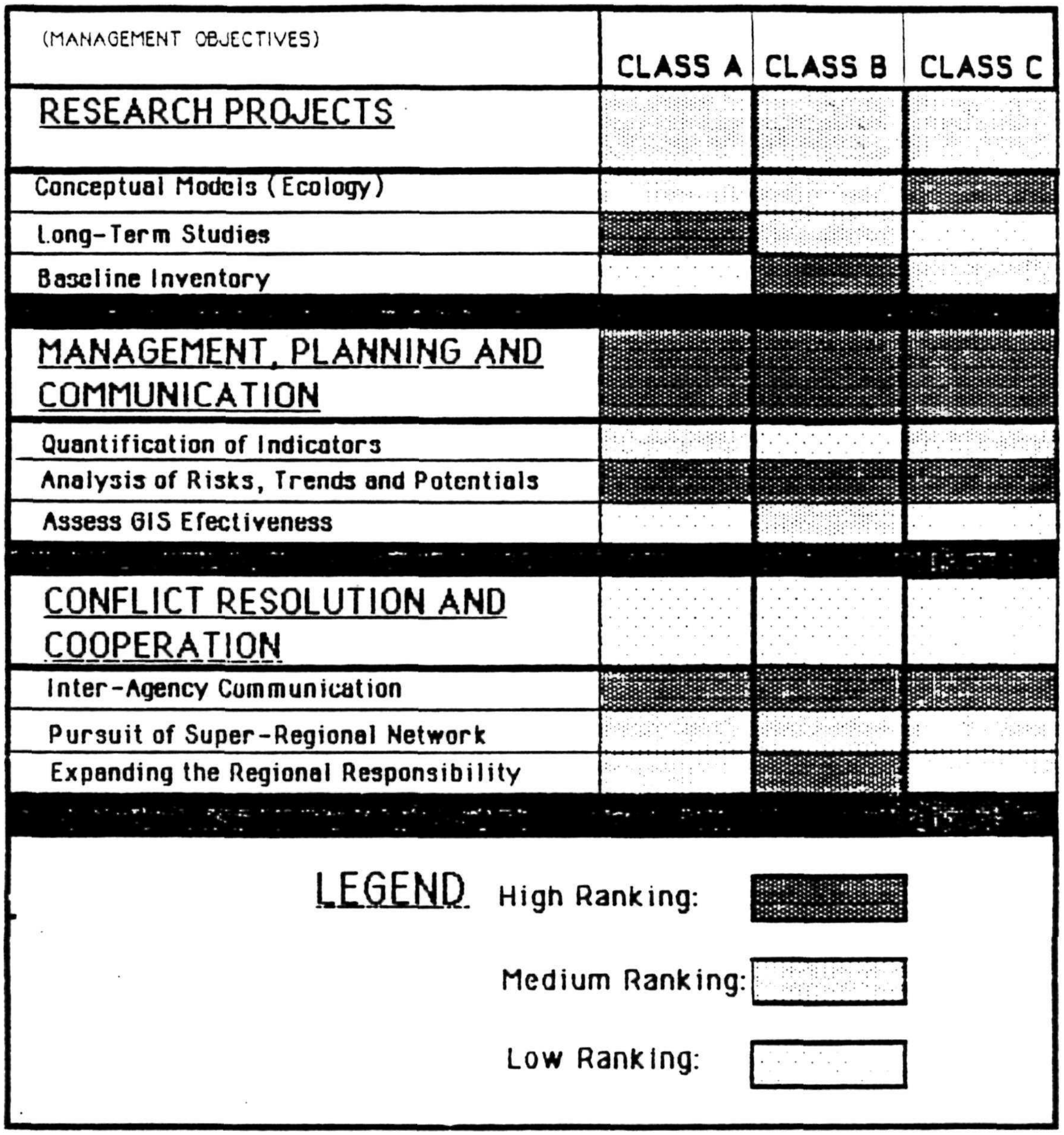


**Figure 4.25:** Ranking of Management Objectives for the GIS Applications in a Class Comparison

Research Projects

All three park classes gave the highest priority to a different sub-group of GIS applications. Class A favored "Long-Term Studies", Class B "Baseline Inventory", and Class C put "Conceptual Models" at first place in the "Research" category. Hence, this result features the highest diversity of opinions between all three park classes in all three parts of the comparison. The heterogeneity of responses in this point, might indicate a certain diversity of attitudes towards the general role of research in the National Park Service. It is interesting that Class C rates "Long-Term Studies" lowest within this comparison. This can be interpreted as a certain reservation against a long-time commitment for scientific applications of GIS, and confirms the results from the previous chapter (Chapter 4.4.) that park units of Class C presently seek to use GIS for traditional management goals.

Management, Planning and Communication

The sub-group "Analysis of Risks, Trends and Potential" was selected by all park classes to be the most important objective in this category. This type of possible GIS future applications feature offers the most interesting combination of management objectives for the majority of all park units. Potentially, this category includes the monitoring of change, the detection of negative impacts, and the creation of analytical models for specific park management strategies. With this result the park units proved that they are willing to use GIS beyond pure mapping and inventory targets. Hence, the "Quantification of Indicators", a category which describes the process of capturing data, was rated second by both Classes A and C.

The third sub-group in this part of the comparison, the"Assessment of GIS Effectiveness After Application", is rated lowest by Class A and C, and rated second by Class B. This trend confirms the results from the responses to the same issue in Chapter 4.4. This leads to the conclusion that, presently, most park units are not very interested in evaluating the products of the GIS application. Considering the fact that most GIS users in the National Park Service are still in the process of exploring the new technology, this result is not too surprising. In the long term, however, a critical reassessment of the parks' a GIS products appears to be a necessary requirement in order to assure the exactness and ultimately the success of the new tool's application.

Conflict Resolution And Cooperation

In this second main category of future GIS applications, all three park classes uniformly emphasize the subject "Inter-Agency Communication" as the most important objective. This can be considered to be a strong vote for inter-agency cooperation among all GIS users. Class B puts the same emphasis on the topic, "Expanding the Regional Responsibility".
During the interviews, the researcher presented this objective as a management philosophy which encompasses the entire natural region (beyond the park boundaries) of a park unit. The fact that Class B identifies so strongly with this objective, demonstrates a clear awareness of the impact of external pressures on the park's interior values. At the same time, this result can be interpreted as a sign of high commitment among Class B-parks, to think within a super-regional framework when asked to respond to these pressures.

# CHAPTER 5: IMPLICATIONS, RECOMMENDATIONS AND SUMMARY

## 5.1. THE INTERPRETATION OF THE FINDINGS

The purpose of this study was to evaluate the appropriateness and efficacy of a GIS for the planning and management of natural resources in the U.S. National Park Service. As mentioned earlier, the evaluation is mainly based on data gathered from the findings of telephone interviews as they are described in Chapter 4.0. Presently, twenty-two park units in the National Park Service are actively using a "true" GIS in order to manage their natural resources. By having interviewed twenty-one of them within the telephone survey, this study covers more than 95% of the GIS experience within this field.

As noted previously (Chapter 4.1.2.), the coding and evaluation method allowed the researcher to distinguish between different qualities of GIS performance in the NPS (see Figure 4.5.: Total Net Score; Figure 4.6.:Total Gross Score). This comparison of scores led to a ranking of all twenty-one park units and finally to a grouping of parks with high GIS performance (Class A), medium GIS performance (Class B), and low GIS performance (Class C).

This classification provided the first rudimentary results about the present state of the GIS performance in the National Park Service. However, these results are also a reflection of the scale which has been used in order to measure them. Hence, the results of the classification are a function of the coding and evaluation method and do not necessarily represent the reality of another scale or another perspective. Nevertheless, the overall findings (and most of the specific results, as they are discussed in the 4 categories of Chapter 4.0.) feature a rationale for the implications and conclusions.

The first general implication of the park classification (Chapter 4.1.2.) is that two groups (each with 6 park units) show a medium and a high GIS performance, while the largest group of the samples (9 park units) scores with low GIS performance. However, two thirds of the Class C-parks and two of the lower ranking Class B-parks implemented the new technology within the past 1 or 2 years. This proportion demonstrates that the relatively large number of low-performing GIS users results from the large number of GIS beginners within the sample group. Based on the prospect of progressive trends among presently low scoring park units (which may move up to higher classes of GIS performance), some major shifts in the parks' classification must be anticipated. The few exceptions in the scoring of the years-of-experience/classification comparison are discussed in Chapter 4.1.5., and will be taken up later.

The influence of GIS beginners on the overall results implies that the results of the park classification cannot be applied to examine the overall success of the GIS technology in the National Park Service. However, the survey generated enough data to allow a general assessment of the fundamental qualities of the Geographic Information System for the management of natural resources. These conclusions can only be drawn by comparing the advantages with the disadvantages of the Geographic Information System. Such a comparison has to take qualitative as well as quantitative aspects of the pros and cons into concern. This means that a mere numerical comparison of the positive and negative phenomena of the GIS implementation would be insufficient. In order to allow an objective and collective judgement, the various characters of the finding's major implications have to be defined and their specific role in the overall context has to be assigned .

## 5.2. GENERAL IMPLICATIONS OF THE FINDINGS

The main objective of this research was to analyze a user-work-tool relationship with special focus on the tool, the Geographic Information System. In order to evaluate how the GIS (technical tool) is embedded in its environment, the interviews probed into the situation of the users (institution = NPS), and asked for their specific needs (park goals) and for their basic intentions (management philosophy).

The findings allow the general conclusion that most disadvantages of the new management tool originate from various technical and institutional deficits. The advantages of the new technology are the obvious improvements of the quality of data inventory and data manipulation (as they are described in the third and fourth category--specific park goals/management philosophy). These improvements are impressive and show essential GIS-induced contributions to the park units' progress in resource management. The study concludes that these encouraging results justify further efforts to continue, facilitate, and support the technical and institutional implemention of GIS in the National Park System.

Before specific and detailed recommendations are given, the general implications for all four research categories can be summarized as follows:

Implications of the Technical Phenomena

Due to organizational and technical difficulties, the start of a running system causes frequently frustrations within the park management. This situation needs to be improved. The analysis of the character of GIS operations, input devices, and output devices points to shortcomings in the use of the system. The high occurrence of critical statements about the vector-based software SAGIS and interest in alternative software systems (e.g.ARC/INFO), deserve action by the NPS.

Many of the problems are directly or indirectly related to institutional shortcomings and/or a lack in GIS-oriented management strategies.

Implications of the Institutional Phenomena

The largest handicap for a successful GIS implementation appears to be the frequent lack of GIS-related work time in the individual park units. Another critical parameter for the quality of the GIS performance is the amount of GIS-related staff training and financial support for the new technology. The overall acceptance of GIS is generally good. Further results lead to proposals regarding future cooperation with other state agencies, concerning the future role of the GIS Division in Denver, and the lack communication among the GIS using park units in the NPS.In some cases, the GIS implementation is accompanied by changes and innovations on the institutional side of the parks' resource management (e.g. cooperation).

Implications of the Specific Park Goal Phenomena

One third of all GIS using park units could not give a precise program for GIS long-term and short-term projects. This inability is considered to be critical. The projects which have been listed feature a wide variety of topics and cover a large portion of the entire scope of resource management. Directly related to the initial technical difficulties in starting a GIS, most of the low ranking park units were not able to complete a project within the first one or two years. This result is dissatisfying and indicates a need for action.

Other results of this category were generally positive. The most encouraging result was the parks' uniform endorsement that the quality and quantity of the parks' inventory was tremendously improved due to the implementation of GIS. Regarding the earlier cited deficits in resource data management within the NPS (Wright, 1986), this finding certainly indicates a central beneficial achievement of the new technology.

Implications of the Management Philosophy Phenomena

The analysis of the findings in this evaluation category brought out several positive aspects of the future role of GIS within the management of natural resources. Fifty percent of all GIS users stated that they had discovered new management concepts and strategies while exploring the potential applications of the new technology. Many park units are already committed to more-than-average activity regarding their (active) cooperation with other land managing agencies.

While the interest in specific management objectives is generally well developed, the role and function of GIS for research-oriented projects still lacks a similar clarity in its overall definition within the parks' management philosophy.

The findings of this study define various critical aspects for each of the four evaluation categories. These aspects must be considered in order to optimize the system's value for successful resource management in the NPS, and in order to avoid misguided actions. Proposals and recommendations for these concerns will be given in the following chapter.

## 5.3. RECOMMENDATIONS

The questionnaire of this survey was exclusively designed to investigate the present state of GIS performance as an integral part of the management of natural resources in the sample park units. None of the interview questions asked the parks to make their own proposals concerning the type of improvements, or to otherwise indicate how they would like to solve a specific problem. The reason for an omission of these kind of questions was simply that the definition of problems is a very result of the interview analysis.

Hence, all recommendations are based on the researchers conclusions and do not necessarily represent the park units' view of the various critical issues. Some inspirations for these recommendations, however, were derived from discussions following some of the open-ended questions or at the end of the entire interview. Most recommendations are based on the literature review (Chapter 2.0.) and on the data analysis (Chapter 4.0.).

Since the National Park Service undertook an organized approach towards the implementation of a nationwide Geographic Information System, all recommendations of this study are mainly directed to the NPS's GIS Division in Denver. Although the study will also have to comment on the future role of the GIS Division itself (see under institutional recommendations), the success and the existing infrastructure of such a central organization features the best qualifications for responding adequately to the implications of the findings.

In order to maintain the structure of this study and to allow a fast and easy orientation the recommendations are again arranged according to the principle of the four evaluation categories.

I. Recommendations for the Technical Phenomena (6)

**a. GIS Operations**

As stated earlier in the study (Chapter 2.2.3.), one of the main advantages of a GIS lies in its ability to operate far beyond the coding, storage and retrieval of data. One essential strength of GIS is the principle of "cartographic modelling" in which a series of various GIS operations is designed in order to undergo comprehensive analysis procedures. Only 3 park units are presently taking advantage from this quality of the system (see Chapter 4.2.) This result implies that the lack of "cartographic modelling" operations is a general problem in the NPS.

**Recommendation:**

All GIS operating park units should be more exposed to analytical procedures which are based on the principles of "cartographic modelling". The process of the various analytical steps of this method should be documented. Practical or fictional examples of the application of "cartographic modelling" procedures should be gathered and distributed among actual and potential GIS users in the NPS.

**b. Input Devices** The use of automated scanning is considered to be a practical method for capturing existing map data and is fairly widespread among GIS users in the NPS. The findings indicate, however, that parks with own additional hand digitizing experience score higher in the overall GIS performance. Problems with the job quality of some commercial vendors (for scanning) and the advantages of the GIS staff's direct involvement when creating their own data base (better knowledge of local situations) suggest the importance of the digitizing input device.

**Recommendation:**

In spite of the frequently tedious aspects of the digitizing procedure and in spite of some technical problems when operating with polygons, the advantages of personal digitizing experience for data base construction should not be underestimated. Maps which feature a special suitability for hand digitizing operations (low quantity and quality of data) should be identified and prepared for digitizing the data. Passive data input procedures should not dominate in any park unit.

**c. Output Devices:** Nearly all of the high performing park units are using ink-jet plotter as their major output device.

Although expensive, the high quality of the final products meets the parks' needs for visually satisfying results in order to present their projects successfully to the public.

**Recommendation:**

Although there is no reason to make the ink-jet plotter a standard requirement for each GIS, the park units should not hesitate to express their need for improved output devices.

**d. Data Errors:** The most cited data error is related to digitizing operations. While in most cases there is probably no other way but improving the parks' individual capabilities in applying these operations, their frequent complain about weak digitizing qualities in SAGIS (especially: bringing quadsheets together and matching boundary lines) suggest some concern about these aspects of the software.

**Recommendation:**

The digitizing and polygon operation qualities of SAGIS should be reassessed and eventually improved. If SAGIS continuous to be disadvantageous within the near future, alternative software sources should be considered.

**e. Raster versus Vector:**

As the findings have shown (Chapter 4.2.1.), the occurrence of a preference for either one of the two methods (raster or vector) is fairly common among the GIS users, especially among higher ranking park units (Class A and B). The indication of a greater creativity when operating GIS (see Fig. 4.2.5.) among vector-oriented park units underlines the positive aspects of the vector method. Yet, the size of the area in question will always have a strong influence on the decision to choose which method (raster or vector) is the most adequate for the needs of each individual park unit.

**Recommendation:**

A preference for one or the other method (raster or vector) will strongly depend on individual park qualities and management objectives. It has to be emphasized, however, that no matter which method appears to be more practical, the predominance of one method should never result in an ignorance towards the advantages and strengths of the complimentary method. A successful GIS application will depend on the flexibility of the user to take advantage of <u>both</u> methods.

**f. Software**

The decision to offer the SAGIS/GRASS-package as a software combination, covers the vector as well as the raster method and puts a very powerful GIS tool into the hands of the users. Since many park units expressed their frustration about their experience with SAGIS (too complicated, poor documentation, insufficient neighborhood functions), this software should be analyzed and eventually adapted to the needs of the park units. Yet, the user-friendliness of a system should not have a priority over its actual capabilities to deliver an sophisticated GIS performance. Hence, the decision to promote the use of SAGIS and GRASS appears generally to be a step into the right direction.

However, the findings pointed at some irritations among some of the park units about the absoluteness of the SAGIS/GRASS program in the NPS. Especially in cases where already developed GIS activities were based on a fruitful cooperation with other--alternative software using--agencies, this irritation seems to be understandable. The researcher considers the significance of the cooperation between the Park Service and other agencies extremely high. Since productive cooperation can only take place when there is a mutual approach between the participating sides, the final results will ultimately depend on the readiness of these sides (agencies) to reach compromises on various levels of their relationship.

**Recommendation:**

The operational structures of the software program SAGIS should be analyzed and eventually adapted to more user-friendly requirements. Before implementing this software package in the park units, a user requirement analysis should examine all aspects of a forthcoming GIS implementation, including the option of supporting alternative software systems. The decision why SAGIS/GRASS has been selected for the NPS needs better documentation which should allow differentiating comparisons with other popular software systems (e.g. ARC/INFO).

II. Recommendations for the Institutional Phenomena (5)

**a. GIS Staff**

The findings confirm the expectation that a high exposure to GIS training and a substantial amount of active GIS-related work time (50 - 100%), are the basic pre-requirements for a high performance in the use of a GIS. In some parks, the GIS seems to be operated seasonally, following the outdoor-related work patterns of the resource management staffs. However, there should be a concern that a consistent project quality of the GIS work is guaranteed.

The specific number of members in a GIS staff does not seem to be crucial for positive results. Although certainly not a pre-requirement, there is an indication that high GIS performance coincides with higher academic qualification (Masters and PhDs) of the staff members.

A frequently cited problem of the institutionalization appears to be the so-called "turn-over-rate" within in park management administration. the periodical taking-overs of new superintendents (generally in a 4-years rhythm) can lead to inconsistencies in the organization and support of individual GIS programs.

**Recommendation:**

Sufficient technical training of the GIS staff and sufficient active GIS work time are the essential requirements for successful GIS performance. It should be guaranteed that the data base of the inventory is permanently accessible and that long-term projects are not substantially effected by seasonal work patterns (...GIS should not only be a winter job!). Personnel changes within the management levels of the parks should be accompanied and prepared by specific documentations about the role of GIS in the resource management of the individual park units.

**b. Cooperation**

The GIS offers the opportunity to an extended cooperation between the NPS and other land managing agencies. Many of the present GIS users are already actively involved in such cooperative communications or are determined to enter it. The following list names the five most important potential cooperation partner for GIS projects of the NPS:

1. Dept. of Fish & Wildlife,
2. Soil Conservation,
3. State agencies,
4. Forest Service, and,
5. Army Corps of Engineers.

The quality of resource management will strongly depend on the ability of the NPS to fuse existing powers and integrate external and adjacent land use data into their own analytical programs.

Within the National Park System itself (e.g. among neighboring national parks) a GIS cooperation should be obligatory. Unfortunately just the one national park with the highest expectations concerning new super-regional management approaches does not cooperate at all with his neighbor park unit.

**Recommendation:**

The NPS should make a central approach to prepare and facilitate the GIS-related cooperation (specific criteria): the sharing of common data bases and the type of software to be in use between the major agencies and the GIS using park units. Each park unit should be strongly encouraged to cooperate with adjacent agencies as well as with adjacent NPS units. High flexibility of how to achieve this, is an essential requirement for active GIS cooperation.

## c. Internal GIS Communication:

Most park units (85%) are not satisfied with the present state of internal communication between the GIS operating units. The periodic GIS conferences are obviously not sufficient to satisfy these needs for more communication.

**Recommendation:**

The GIS Division should initiate or support the initiation of a NPS internal GIS-newsletter. In such a publication each park unit could share actual information about GIS applications and experiences with other (often very distant located) GIS users in the Park Service.

## d. Decentral/Central Organization

The findings show that there is no real need to decide between one or the other way of GIS organization. All park units expressed their conviction that the GIS Division in Denver is an extremely important and helpful element in the overall context of the GIS organization in the NPS. Park units with more experience in the use of GIS and with better results in the overall performance tend to prefer a more independent organization of the GIS in the NPS, than GIS-beginners and low performing parks.

**Recommendation:**

The GIS Division should proceed to guide the implementation and organization in the NPS. Experienced, well performing park units will need less attention than new unexperienced park units. Experienced park units should participate in the decision making processes when defining future directions in the GIS implementations and policies. The contacts between the NPS's GIS Division and the ten Regional Offices are important and should be used to facilitate the institutionalization of the GIS [illegible] the Park Service.

### e. Financial Situation

With the exception of some larger, research-oriented park units which receive extra funding for their scientific programs, almost all other park units described the financial situation of the GIS programs as clearly insufficient. Some of the GIS beginners among the park units tend to underestimate the financial implications of a well functioning GIS.

**Recommendation:**

The NPS should stress the significance of the GIS for resource management and should seek to open further internal sources of funding to implement and maintain a statewide GIS. The GIS must be a substantial component of the future management directives of the NPS in order to achieve full public and political support.

III. Recommendations for the Specific Park Goals Phenomena (4)

**a. Long-Term Projects:**

The findings demonstrated that most of the lower scoring park units (GIS beginners and/or low performance parks) lack a certain perspective for the long-term goals of their GIS program. These parks are mainly oriented towards traditional (infrastructure-related) management objectives and do not see the entire wide scope of potential GIS applications.

**Recommendation:**

The NPS should design a long-term monitoring and management concept which serves as a model for all park units when designing or selecting their own specific projects. This "model program for long-term projects" could include basic strategies and examples of how to integrate and arrange the necessary GIS applications and operations.

**b. Short-Term Projects:**

The evaluation of these projects demonstrated the need for a more precise definition of short-term projects versus long-term projects. Low and medium performing park units have not developed a full perspective for the schedule and concept of their future GIS applications.

**Recommendation:**

The NPS should, as in the recommendation for long-term projects, develop some guidelines in order to define the character of typical short-term projects. When short-term projects have been identified, the park units should set up schedules for park-specific short-term programs .

**c. Completed Projects:**

The dearth of completed projects among low performing GIS users does not necessarily mean that the park units did not gain any benefits from the new technology. The improvement of the park's inventory can be a very satifying result of its own. However, each park unit can make efforts to achieve some earlier results (by selecting simple projects) in order to demonstrate the system's potentials to the park management and in order to get more hands-on experience with the GIS.

In one case, a low performing park (actually a biosphere reserve) examplifies very well the phenomena of a one-dimensional focus on science-oriented projects. Although ranking relatively low in the overall comparison, this park unit did not name (...and not complete) any small-scale projects but thinks of GIS applications mainly in the context of large and complex science-scenarios (acid rain, nuclear winter predictions).

**Recommendation:**

The NPS should suggest to all park units, no matter how well developed their GIS capabilities are, to start and to continue with the design of simple, straight-forward-oriented GIS applications for concrete and obvious management tasks ( e.g. park infrastructure, location maps).

**d. Resource Management Plan**

The resource management plan (which represents the major management guidelines for each park) includes GIS related directions for future management tasks in only 12 of all samples.

**Recommendation:**

All GIS-operating park units should include general and specific GIS applications as an integral component in their resource management plan.

IV. Recommendations for the Management Philosophy (2)

**a. Role of Research** The analysis of the park units' future applications for a GIS implies a rather diffuse attitude towards the role of science and research among the park units.

**Recommendation:**

The NPS should define (maybe redefine) the role of research for the management of natural resources and should formulate guidelines for the specific functions of the GIS within this context.

**b. Super-Regional Context**

Some park units still hesitate to view resource management as a discipline that exceeds park boundaries and that develops concepts for a super-regional approach.

**Recommendation:**

The NPS should encourage the resource management staffs of all park units to think and plan in broad ecological perspectives that encompass the entire natural region or ecosytem, of which the park unit is a part.

## 5.4. SUMMARY

Skill in information management has become a significant foundation for efficient resource management. In response to the progressive and revolutionary developments in the field of computer cartography, the National Park Service took the initiative ten years ago to implement the Geographic Information System nationwide.

This study evaluated various aspects of the current state of the GIS implementation by focusing on its technical, institutional, (park) goal-oriented, and general management phenomena. The findings document a number of positive impacts on the quality of resource management in the NPS. The significance of these advantages for the future of park management (enhanced inventory, greater analytical capabilities, etc.) exceed the technical and organizational difficulties for which a series of recommendations has been proposed. However, sufficient financial support (mainly for maintaining technical facilities and for developing adequate GIS staffs) is an essential requirement for a successful continuation of the GIS implementation.

Besides the direct technical facilitation of the daily and traditional tasks of resource management within the park system, the findings of this study indicate that GIS can:

- induce more sophisticated and interdisciplinary management strategies,
- lead to a redefinition of the role of research and science in the parks, and,
- result in new approaches towards the enhancement of inter-agency cooperation.

Considering these encouraging prospects, the National Park Service might serve as an intriguing model for other land management agencies. Participation in the scientific program "Man and the Biosphere" could also supply the NPS with a valuable opportunity to demonstrate this technolgy's benefits on an international scale. The far-sighted use of the Geographic Information System will hopefully provide an important contribution towards overcoming the limitations of territorial jurisdictions for the management of natural resources. The National Park Service stands poised and ready to play a leading role in the intelligent use of the Geographic Information System.

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# APPENDIX A:

## Letters

Dirk Wascher
5042 - 21st Ave. N.E.
Seattle, WA. 98105

Mr. Harvey Fleet
U.S. Department of the Interior
National Park Service/RMR & DSC
12795 West Alameda Parkway
P.O. Box 25287
Denver, CO. 80225-0287

Dear Mr. Fleet:

This is the announced letter (phone call on 1/30/89) which takes the first steps towards the implementation of the telephone survey I plan to conduct. The topic of my thesis (as you can see in the attached copy of the thesis proposal) will concentrate on the analysis of the management of natural resources. I therefore plan to primarily contact National Park units (in contrast to culturally-oriented units) where the management of natural resources is a main objective.

Hence, I would like to ask you for a comprehensive list of National Park units which represent at least one of the following attributes:

--units which were established to serve the maintenance and preservation of natural resources,

--units with such complex functions that the use of a GIS is strongly recommended in order to manage large, spatial data,

--units which have to improve their management of natural resources,

--units where a "true" GIS has been established,

--units which currently use alternative computer systems (e.g. CAD), but in which the integration into the GRASS/SAGIS system is highly recommended,

--units with GIS results and applications which can be regarded as having a "prototype" character.

Although I am planning to interview about 15 to 20 respondents, the list I am asking for should contain all units which fulfill one or more of the above mentioned attributes. It would be helpful, however, if you could indicate the level of priority in the GIS strategy of the Denver Service Center (e.g. perhaps by underlining the most important units). Each unit of the list should feature the name, address and phone number of the person in charge of the resource management/GIS.

In addition, I will also need your assistance with the following matter. As I mentioned on the phone, I am sending you a draft of a "letter of endorsement" which I would like to be a part of my first letter to the National Park units which will be contacted for the interview. Please read carefully through this sample draft and change or add to it as is necessary. Then please format the letter as you would any NPS correspondence which is directed to all NPS units. Such an "endorsement" will certainly help to improve the understanding, readiness, and response rate of the telephone survey.

Here is a short summary of all the steps towards the implementation of the interviews:

1. I will receive the list of contact addresses and your letter of endorsement

2. I will send my letter (with your endorsement letter attached) to each selected respondent, stating the main topics of the interview, describing the process and time frame for the study, and announcing my first phone call.

3. I will make the initial phone call to set up an appointment time and date for the interview session.

4. I will conduct the telephone interview (approximately 30-45 minutes).

Finally, the decision to concentrate on the management of natural resources is partly influenced by the results of the 1988 North Atlantic Region Study of the University of Boston. The intention of my study, however, goes beyond regional aspects of resource management and therefore will focus on a special aspect of resource management in the park system. The emphasis on natural resources coincides with:

1. the character of GIS (operations with large scale data materials),
2. the availability of existing data,
3. the format and time frame of my thesis,
4. my personal bias in this subject matter towards an ecological orientation.

Besides the telephone list and you letter of endorsement, I would like to ask you for the following additional information:

1. Is there any written official NPS policy or directive regarding the implementation of GIS systems?

2. Does a catalog of NPS goals exist for the management of single units as well as the whole (internal/official program) that I could refer to--or is there a knowledgeable person whom I could contact?

3. Is there any material which evaluates the status and quality of the resource management in the NPS...
   a. before GIS became a matter of interest (internal papers, conference materials, etc.?)
   b. in addition to the use and implementation of GIS (general aspects of cartographic material in NPS).

After having raised so many questions and requests, I want to give you at least a brief summary of what I have done so far. Besides the reading of various GIS and NPS materials and my own participation in a GIS course at the University of Washington, I have talked with Jim Agee at the UW, to James Larson and Ed Menning at the NPS regional office and visited Gina Rochefort at the NP Mount Rainier office (for a demonstration of their GIS facilities). I am also in contact with your colleague Maury Nyquist, who also has sent me some materials. Professor Dr. Darryl Johnson from the College of Forest Resources of the UW offered his assistance in the design of a valid and reliable survey instrument.

I have had to delay my scheduled appointment with Professor W. Smith from Western Washington University in Ellensburg (for a demonstration of GRASS) because of the snow that has fallen during the past 24 hours. This freak weather has rendered local roads treacherous and has turned the 100-mile pass road across the Cascades into an invincible obstacle!

Now I realize that it took far more words to describe the procedure and details of my study than I had originally expected. I hope that my explanations help to make the major purposes of my requests understandable. If you have any questions, suggestions, or proposals, please do not hesitate to contact me.

I thank you in advance for your kind assistance and support of this study.

Sincerely,

March 15, 1989

Mr. Harvey Fleet
U.S. Department of the Interior
National Park Service / RMR & DSC
12795 West Alameda Parkway
P.O. Box 25287
Denver, CO. 80225-0287

Dear Mr. Fleet:

Once again I am sending you my thanks for you strong and encouraging support of my project. I was very glad to receive all the helpful and comprehensive information for the forthcoming telephone interview.

Last week I had my official "Thesis Presentation" in front of the professor and graduate students of the Department of Landscape Architecture. The faculty was very impressed by the advanced state of my study and expressed their appreciation for the cooperation that is coming from your side. My thesis committee fully endorsed the topic of my thesis.

This week I am going to send out my first contact letter (including your "letter of endorsement") to the park units of the category (d) and (f) of you address list. I am expecting to conduct the major part of the interviews in the first week of April.

If I am in need of additional information, I will contact you again. For the next few weeks, however, I will be busy conducting and analyzing the interviews. Again, many thanks!

Sincerely,

Dirk Wascher
5042 - 21st Ave., N.E.
Seattle, WA 98105
Home phone: (206) 526-8358

March 15, 1989

Address (To all selected Park Units)

Dear:

I am writing this letter to introduce you to my research project for the University of Washington, and to kindly ask you for your participation in a forthcoming telephone interview.

As a graduate student in the Master of Landscape Architecture degree program, I am working on a thesis about the Geographic Information System in the National Park Service. The exact and complete title of my thesis is the following:

The Role and Function of the Geographic Information System for the Management of Natural Resources in the National Park Service (A Critical Assessment)

The purpose of this study is to evaluate the appropriateness and efficacy of the GIS for the planning and management of natural resources in the National Park Service. Drawing upon literature, material from the existing NPS experiences (workshops, other studies), and data gathered from the upcoming telephone survey, this study will give recommendations for the performance of technical and functional aspects of the management of natural resources, and is designed to focus on the following four main categories of interest:

1. technical phenomena of the GIS implementation (hardware/software),
2. institutional phenomena of the GIS implementation (staff training, (decision-making),
3. function of the GIS within the management philosophy of the NPS (serving or reigning),
4. expectations of the NPS and its units towards the benefits for the specific management goals and future tasks.

The key research method to be employed will be a telephone survey with selected units of the NPS. The cooperation and support of the Service Center in Denver (please see attached "letter of endorsement") and the regional office here in Seattle, has turned out to be excellent. Following my request, Mr. Harvey Fleet from the Denver Service Center sent me a complete list of the NP units in question. The Regional Office of the NPS in Seattle offered me the use of their administrational telephone network to conduct the interviews.

The list of NP units features your address as one of the offices which could provide me with helpful information. Hence, I would like to ask you for your cooperation and participation in my telephone interview.

I am planning to give you an initial call between the 27th and the 31st of March to set up a convenient time in which to conduct the interview.

**The main interview will be scheduled for a time between the 3rd and 7th of April.**

The interview will ask questions about each of the four categories mentioned on the previous page. It will take about 30 to 40 minutes and will feature a mixture of multiple choice, short answer-type questions as well as some "open-ended-type" questions.

I hope that the outcome of this study will also meet you interests in this subject matter and that the proposed timing of the interview will find a place in your schedule for the first week in April.

I am looking forward to my first phone contact with you. Thank you in advance for you assistance.

Sincerely,

Dirk Wascher
5042 - 21st Ave., N.E.
Seattle, WA 98105
Home phone: (206) 526-8358

United States Department of the Interior

NATIONAL PARK SERVICE
GEOGRAPHIC INFORMATION SYSTEMS
P.O. BOX 25287
DENVER, COLORADO 80225-0287

IN REPLY REFER TO:

February 28, 1989

To: GIS Coordinators and Specialists, National Park Service

From: Harvey Fleet, GIS Division, Denver

Subject: Mr. Dirk Wascher

Mr. Dirk Wascher is a candidate for the degree of Master of Landscape Architecture at the University of Washington. His thesis will examine the effectiveness of Geographic Information System technology for resource management in the NPS. He proposes to base part of his research on a telephone survey with you and, possibly, members of your resource management staff. The quality of the results of his study will depend strongly on your participation and the thoughtfulness and candidness of your responses.

Because I feel his thesis may be of interest and utility to the National Park Service, I endorse his work and ask you to cooperate fully with him when he contacts you.

Many thanks!

Harvey Fleet

# APPENDIX B:

## Questionnaire

# TELEPHONE - QUESTIONNAIRE
**With 22 Units of the National Park Service**

( Part of the Thesis in the MLA Program )

by
Dirk Wascher

Unit:
Interview-Subject:
Date:

Introduction

| | |
|---|---|
| name: | Dirk Wascher |
| topic of the study : | The Role and Function of the GIS for the Management of Natural Resources in the NPS |
| length : | 30 - 40 minutes, 4 categories |

The University of Washington requires that information provided in these interviews be kept strictly confidential. Hence, the final report will group data, and eill therefore not make any references to individual park units or persons and their responses.

## 1.Technical phenomena of the GIS implementation

1.01 What system is presently in use ?

Hardware ..................................................................................................

..................................................................................................

Software : ..................................................................................................

1.02 When was the GIS established ? ........................

**For the following questionssimply to indicate yes or no !**

1.03 Regarding who implemented the system in your unit :

___ did a staff member initiate contact to purchase system

___ did staff acquire Public Domain system from other federal unit (MOSS)

___ did the Denver Service Center (which person: ..........................................................)

___ others : ..................................................................................

**Please indicate again yes or no**

1.04 Do you use your GIS for data analysis operations like ( what about .....)

___ reclassification functions

___ overlay functions (arithmetic, logical, and statistical

___ distance functions

___ neighborhood functions

___ cartographic modeling ( = produce flow-charts for a series of spatial analysis operations for land evaluation and planning)

___ optimization/linear model ( = for optimal interpolation)

___ network flow ( avoid data redundancy / hierarchical systems for polygons)

___ viewshed functions

1.05 Now I am going to read you 5 ways of data input devices and I'd like you to tell me which method you most commonly use :

___ manual input into a grid/vector system

___ digitizing

___ automated scanning

___ video digitizer

___ analytical stereo plotters

1.06 Which of the following 4 major data output devices is most commonly in use :

___ <u>hard copy maps</u>

 ___ line printer

 ___ graphic plotter

 ___ electrostatic plotter

 ___ ink-jet plotter

 ___ color film recorder

___ <u>statistical tabulations</u>

___ <u>computed data files</u>

___ <u>digital elevation models</u>

1.07 Do you have a clear preference for either

___ vector, or

___ raster methods, or

___ no preference

**Again, please indicate with a yes or a no**

1.08 When deciding between vector and raster, which of the following issues is of concern for you ?

___ volume of graphic data

reason : ..............................................................................................

..............................................................................................

..............................................................................................

___ loss of information

reason : ..............................................................................................

..............................................................................................

___ crude vs. fine display

reason : ..............................................................................................

..............................................................................................

___ difficulty with spatial analysis

reason : ..............................................................................................

..............................................................................................

___ use of remote sensed data

reason : ..............................................................................................

..............................................................................................

____ display and plotting

reason : ..................................................................................................

..................................................................................................

____ retrieval, updating and generalization of attributes

reason : ..................................................................................................

..................................................................................................

____ accuracy of results

reason : ..................................................................................................

..................................................................................................

____ others : ..................................................................................................

..................................................................................................

1.09 Do you think that the decision for the UNIX-based, 32-bit graphics work-station with GRASS and SAGIS meets the management needs of your unit ?

____ yes

____ no

what is the main advantage.: ..................................................................................................

..................................................................................................

what is the main disavantage : ..................................................................................................

..................................................................................................

1.10 Is there any other system that you would prefer?

____ yes

____ no

If yes, which other system : ..................................................................................................

..................................................................................................

What advantage does this system have over your present system ?

..................................................................................................

..................................................................................................

**Again please respond with a yes or a no**

1.11 Which of the following types of errors occur most frequently when working with the GIS :

___ errors based on the data format

___ errors based on the age of data

___ errors associated with digitizing

___ errors associated with combining attributes in overlays

___ errors associated with polygon operations

___ others : ........................................................................................................

1.12 Do you use any of the following remote sensing data ?

___ Landsat (80 m)

___ TM (30 m)

___ Spot (20 m)

1.13 Have you found the resolution of the satellite data that you are using is appropriate for your management goals ?

What is the main advantage. ..............................................................................................

..............................................................................................................................

What is the main disadvantage: ..............................................................................

..............................................................................................................................

1.14 Are you taking field trips for point-sampling to confirm LANDSAT data?

___ yes

___ no

1.15 Does your inventory lack any major thematic map or data source?

If yes, what is it and why is it so hard to purchase the data?

..............................................................................................................................

..............................................................................................................................

..............................................................................................................................

1.16 Do you think that there is enough financial support to produce efficient GIS results?
If not, what might be the reason for low funding?

..........................................................................................................................................

..........................................................................................................................................

## 2.Institutional phenomena of the GIS implementation

2.01 How many persons are presently working with the GIS?

2.02 What is the academic training of the GIS staff members and from which professional field do they come from?

| | Major | Degree | Professional Field | Age | Years | Division | Job |
|---|---|---|---|---|---|---|---|
| a) | ........ | ........ | | | ........ | | ........ |
| b)....... | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| c)....... | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| d)....... | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| e)...... | ........ | ........ | ........ | ........ | ........ | ........ | ........ |

2.03 Do you think that the number of staff members who work with the GIS is sufficient in order to meet the requirements of a successful resource management ?

2.04 In your opinion, what kind of academic/professional background is needed for the positions in question?

........................................................................................................

2.05 Did you or other staff members participate in GIS-related training programs?

| | how many times | how many days/year |
|---|---|---|
| a)...................... | ........................ | ........................ |
| b)...................... | ........................ | ........................ |
| c)...................... | ........................ | ........................ |
| d)...................... | ........................ | ........................ |

2.06 Do you attend national and regional GIS conferences and workshops?

___ yes

___ no

If yes, how often: ........................................................

Can you name some examples ........................................................................................

2.07 Did you present a paper or poster about your GIS experience?

___ yes

___ no

2.08 Do you think there is enough communication between the GIS users in the NPS?

___ yes

___ no

**Explain**:

2.09 Has there been any "user requirement analysis" for the implementation of a GIS in your unit?

___ yes

___ no

2.10 Are the results of the GIS-projects excepted among park members from other divisions ?

___ yes

___ no

If not, what might be the reason(s) ..........................................................................................

..........................................................................................................................................................

..........................................................................................................................................................

**Please indicate with yes and no**

2.11 Do you see the need for cooperation with the GIS or other agencies, such as:

___ Bureau of Land Management

___ Army Corps of Engineers

___ National Forest Service

___ Department of Transportation

___ Fish and Wildlife

___ Soil Conservation Service

___ Bureau of Indian Affairs

___ others: ..........................................

( Questions about decision making processes.)

2.12 Which kind of organization of the GIS within the NPS do you prefer:

___ decentralized or

___ centralized ?

Please state some reasons

..................................................................................................................................

..................................................................................................................................................................................

2.13 In relation to your work with GIS, do you consider the primary role of the Denver Service Center as one of

___ strong leadership and guidance

___ basic support

___ periferal advice, as needed

## 3. Expectations of the NPS and their units towards the Application of GIS for specific Park Goals and Problems

3.01 Do you expect that the GIS will significantly change the role of research and science in your unit?

___ yes

___ no

3.02 What are the long-term commitments for the application of GIS in your park?

a) ..........................................................................

b) ..........................................................................

c) ..........................................................................

3.03 Please name the specific management items you will need to focus on in the future (short-term goals):

a) ..........................................................................

b) ..........................................................................

c) ..........................................................................

3.04 Please, name the most important projects you have completed with the help of GIS.

a) Name : ..........................................................................

Function : ..........................................................................

b) Name : ..........................................................................

Function : ..........................................................................

c) Name : ..........................................................................

Function : ..........................................................................

d) Name : ..........................................................................

Function : ..........................................................................

3.05 Is there a means of assessing the effectiveness of GIS results?

___ yes

___ no

3.06 Do you expect that the GIS will improve the quality and quantity of the park's inventory?

If yes, can you give some examples in what ways?

...........................................................................................

...........................................................................................

3.07 Does your resource management plan mention explicitly the application of GIS for certain management goals?

___ yes

___ no

## 4. The role of the GIS within the management philosophy of the NPS.

4.01 Which of the following 3 applications do you consider to be of main interest for a GIS:

___ research projects

  ___ conceptual models (ecology, interaction)

  ___ long-term studie

  ___ baseline inventory and monitoring

___ management, planning and communication

  ___ quantification of indicators

  ___ analysis of trends, risks, potentials

  ___ assess effectiveness of management after implementation

___ conflict resolution and cooperation

  ___ inter-agency communication

  ___ as a part of a super-regional computer network structure

  ___ expanding responsibility (geographically) **please explain !**

4.02 Did you discover new management tasks through your experience with GIS?

If yes , please give an example : ....................................................................................

..........................................................................................................................................

4.03 Did the GIS implementation influence the definition of goals in the resource management of your park?

If yes, how ? ..........................................................................................................

..........................................................................................................................................

4.04 Based on the implementation of GIS, have there been any new approaches to the cooperation with other agencies?

If yes, can you give an example? ..........................................................................

..........................................................................................................................................

4.05 Do you think that the GIS technology is transparent enough

____ to allow democratic processes and

____ to gain public acceptance?

If you see some problems, please state your reasons : ..............................................................

..............................................................................................................................................

..............................................................................................................................................

4.06 How do you see the significance of the GIS for the quality of the management of natural resources in your park unit?

____ high significance

____ above average sign.

____ average sign.

____ below average significance

____ low sign.

**<u>Thank you very much for your participation in this interview!!!</u>**

# List of Addresses (Interview Partners)

Mr. Ted Simon
Gulf Islands National Seashore
Ocean Springs, MS 39564Mr.

Rick Harris
Indiana Dunes National Lakeshore
1100 N. Mineral Springs
Porter, IN 46304

Mrs. Allison Robb
Grand Teton National Park
P.O. Box 170
Moose, WY 83012

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# APPENDIX C:

## Response Table

| PARK UNIT | 1.01 SOFTWARE | 1.02 START | 1.04 OPER. | 1.05 INP. | 1.06 OUTP. | 1.07 VEC/RAS | 1.08 PREF. | 1.09 SATIS | 1.10 OTH. |
|---|---|---|---|---|---|---|---|---|---|
| A | Sag/Map | 86 | 4 | 3 | 2 | non | 5v/2r | Y | Y |
| B | Sag/Gr | 88/89 | 1 | 3 | 2 | r/v | 2v/2r | y | n |
| C | Sagis | 82/83 | 3 | 3 | 2 | non | 4v/4r | y | y |
| D | Sagis | 83 | 3 | 3 | 2 | vector | 6v/1r | y | y |
| E | Sag(Gr) | 88 | 0 | 3 | 2 | vector | 7v/1r | n | y |
| F | Gr(S,E) | 88 | 4 | 2 | 2 | raster | 5r/2v | y | y |
| G | Sag(Gr) | 85/87 | 2 | 3 | 3 | vector | 3v/1r | y | n |
| H | Gr(Sag) | 86/87 | 1 | 2 | (2)? | non | 3v/4r | n | y |
| I | Gr/S/CD | 88 | 1 | 3 | 2 | vector | 3v/2r | n | n |
| J | Sag/Gr | 88 | 1 | 2 | 1 | non | - | y | n |
| K | Bl/Eb | 83/88 | 3 | 2 | 4 | raster | 2v/3r | n | y |
| L | Gr/S/El | 78/88 | 3 | 2 | 3 | non | 3v/5r | y | n |
| M | Sag/Gr | 84 | 2 | 2 | 3 | non | 3v/2r | n | y |
| N | Gr(sag) | 88 | 1 | 1 | 3 | non | - | - | n |
| O | Sag/dos | 88 | 1 | 2 | 2 | non | 2r | y | y |
| P | G/S/CD | 87/89 | 3 | 4 | 3 | non | 1v/4r | n | y |
| Q | Sag/Gr | 82/84 | 3 | 3 | 4 | raster | 3v/5r | y | n |
| R | Sag/Gr | 85 | 4 | 3 | 3 | raster | 3v/5r | y | n |
| S | Sag/gr? | 83/84 | 1 | 3 | 2 | non | 1v/2r | y | y |
| T | Sag(gr) | 86 | 1 | 2 | 2 | vector? | 1v/5r | n | y |
| U | Sag/Gr | 86 | 2 | 3 | 2 | vector | 2v | y | y |

| 1.11 ERR. | 1.12-1.14 SAT. | 1.15 THEME | 1.16 $$$ | **INDEX 1** | P | 2.01 EPL. | 2.02 G-I-S | 2.03 SUFF. | 2.05 TRAINING. | 2.06-2.07 CONF. | 2.08 CO | 2.09 URA | 2.10 ACC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| b,c | 3 | -3 | n | **9 + 3 = 12** | A | 1 | 70%-3 | n | 160h-4 | 3 | y? | y | y |
| d | 0 | -1 | y | **6 + 0 = 6** | B | (2) | (90%) | n | (80h)-1 | 1 | y? | y | y |
| d,g | 3 | -1 | y | **8 + 3 = 11** | C | 1 | ? - 3 | n | 120h-4 | 3 | n | n | y |
| b | 0 | -1 | n | **8 + 0 = 8** | D | 2 | 70%-3 | n | 40h-1 | 0 | n | y | y |
| - | 0 | -1 | n | **5 + 0 = 5** | E | 2 | 60%-3 | n | 90h-2 | 2 | n | y | y |
| d | 3 | -1 | y | **8 + 3 = 11** | F | 5 | 80%-4 | n | 200h-2 | 3 | y | y | y |
| c | 0 | -1 | y | **8 + 0 = 8** | G | 3 | ? - 3 | n | 80h-1 | 2 | n | n | y |
| b,c | 2 | -1 | n | **5 + 2 = 7** | H | 1 | 30%-2 | n | 30h-1 | 2 | n | y | n/y |
| - | 1 | -1 | n | **6 + 1 = 7** | I | 1 | 10%-1 | n | 75h-3 | - | n | n | y |
| - | 0 | ? | y | **4 + 0 = 4** | J | 0 | 0%-0 | n | 30h-2 | - | n | n | y |
| b,c | 3 | -3 | y | **9 + 3 = 12** | K | 1 | 40%-2 | n | 140h-4 | 3 | n | y | y |
| f | 3 | -1 | ? | **8 + 3 = 11** | L | 3 | 80%-4 | n | 200h-3 | 2 | n | n | y |
| c,d | 0 | -1? | y | **7 + 0 = 7** | M | 1 | ? -1 | n | 40h-2 | 2 | y | n | n/y |
| - | - | -1 | - | **5 + 0 = 5** | N | 1 | 20%-1 | n | 40h-2 | - | n | n | y |
| - | 2 | -1 | n | **5 + 2 = 7** | O | 0 | 2%-0 | n | 130h-3 | - | n | y | y |
| a,b,c | 1 | -1 | n | **10 + 1 = 11** | P | 1 | 20%-1 | n | 40h-2 | - | n | y | y |
| f | 2 | - | n | **10 + 2 = 12** | Q | 3 | 55%-3 | n | 80h-1 | 3 | n | y | y |
| a | 3 | | n | **10 + 3 = 13** | R | 4 | 285%-4 | n | 170h-2 | 4 | n | y | y |
| b,c | 2 | -1 | n | **6 + 2 = 8** | S | 3 | ? -1 | n | 40h-1 | 3 | n | y | y |
| c | 2 | -1 | n | **5 + 2 = 7** | T | 1 | 30%-2 | n | 120h-3 | 3 | n | y | y |
| c,f | 1 | - | n | **7 + 1 = 8** | U | 1 | ? -1 | n | 40h-1 | 3 | n | y | y |

| 2.11 COOP. | 2.12 ORG. | INDEX 2 | 3.01 ROLE | 3.02 LONG | 3.03 SHRT | 3.04 COMP | 3.05 ASS. | 3.06 INVT. | 3.07 RMP | INDEX 3 | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6+4 - 4 | cen. | 10 + 4 - 14 | 1 | 3 | 2 | 1 | 0 | 1 | 1 | 6 + 3 - 9 | A |
| 7 - 2 | dec. | 2 + 2 - 4 | 0 | 3 | 2 | 0 | 0 | 1 | 1 | 5 + 2 - 7 | B |
| 6 - 2 | dec. | 10 + 2 - 12 | 0 | 3 | 2 | 3 | 1 | 1 | 1 | 8 + 3 - 11 | C |
| 6+3 - 4 | dec | 4 + 4 - 8 | 1 | 3 | 1 | 3 | 0 | 1 | 1 | 7 + 3 - 10 | D |
| 2+1 - 1 | cen. | 7 + 1 - 8 | 0 | 2 | 2 | 0 | - | 1 | 0 | 4 + 1 - 5 | E |
| 5+4 - 4 | dec. | 9 + 4 - 13 | 0 | 4 | 1 | 0 | 1 | 1 | 1 | 5 + 3 - 8 | F |
| 2+1 - 1 | dec. | 6 + 1 - 7 | 0 | 2 | 2 | 3 | 1 | 1 | 1 | 7 + 3 - 10 | G |
| 3+2 - 2 | dec. | 5 + 2 - 7 | 0 | 2 | 3 | 1 | 1 | 1 | 0 | 6 + 2 - 8 | H |
| 2 - 1 | cen | 4 + 1 - 5 | 1 | 2 | 2 | 0 | 0 | 1 | 0 | 4 + 2 - 6 | I |
| (5)- 1 | cen. | 2 + 1 - 3 | 1 | 3 | 3 | 0 | 0 | 1 | 0 | 6 + 2 - 8 | J |
| 4+3 - 4 | dec. | 9 + 4 - 13 | 1 | 3 | 3 | 4 | 1 | 1 | 0 | 10+ 3 - 13 | K |
| 4 - 1 | dec. | 9 + 1 - 10 | 0 | 3 | 3 | 1 | 0 | 1 | 1 | 7 + 2 - 9 | L |
| 4+1- 2 | cen | 5 + 2 - 7 | 1 | 1 | 2 | 0 | 1 | 1 | 0 | 3 + 3 - 6 | M |
| 4 - 1 | cen. | 3 + 1 - 4 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 3 + 3 - 6 | N |
| 4+3 - 4 | dec. | 3 + 4 - 7 | 1 | 4 | 1 | 0 | 1 | 1 | 1 | 5 + 4 - 9 | O |
| 5+2 - 3 | dec. | 3 + 3 - 6 | 0 | 3 | 2 | 1 | 1 | 1 | 0 | 6 + 2 - 8 | P |
| 3+3 - 3 | cen. | 7 + 3 - 10 | 1 | 4 | 3 | 2 | 1 | 1 | 1 | 9 + 4 - 13 | Q |
| 3 - 1 | dec. | 10 + 1 - 11 | 0 | 3 | 2 | 3 | 0 | 1 | 0 | 8 + 0 - 8 | R |
| 5+3 - 4 | dec. | 5 + 4 - 9 | 0 | 4 | 3 | 0 | 0 | 1 | 0 | 7 + 1 - 8 | S |
| 6+4 - 4 | cen. | 8 + 4 - 12 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 7 + 4 - 11 | T |
| 3+1 - 1 | cen. | 5 + 1 - 6 | 0 | 2 | - | 1 | 1 | 1 | 1 | 3 + 3 - 6 | U |

| 4.02 TASK | 4.03 GOAL | 4.04 COOP. | 4.06 SIGN. | INDEX 4 | PARK | NET TOTAL | GROSS TOTAL | DIFF. | FINAL CLASSES |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 4 | 4 | 4 | 12 + 4 = 16 | A | 37 | 51 | 14 | A2 |
| 4 | 0 | 2 | 1 | 6 + 1 = 7 | B | 19 | 24 | 6 | C1 |
| 4 | 4 | 2 | 2 | 10 + 2 = 12 | C | 36 | 46 | 12 | A3 |
| 0 | 0 | 4 | 4 | 4 + 4 = 8 | D | 23 | 34 | 10 | B5 |
| 0 | 0 | 2 | 4 | 2 + 4 = 6 | E | 18 | 24 | 6 | C4 |
| 0 | 4 | 2 | 4 | 6 + 4 = 10 | F | 28 | 42 | 14 | B2 |
| 4 | 4 | 4 | 4 | 12 + 4 = 16 | G | 33 | 41 | 8 | A4 |
| 0 | 0 | 2 | 4 | 2 + 4 = 6 | H | 18 | 28 | 10 | C2 |
| 0 | 0 | 0 | 2 | 0 + 2 = 2 | I | 14 | 20 | 6 | C8 |
| 4 | 0 | 0 | 4 | 4 + 4 = 8 | J | 16 | 23 | 7 | C6 |
| 0 | 0 | 4 | 2 | 4 + 2 = 6 | K | 32 | 44 | 12 | A5 |
| 4 | 0 | 4 | 2 | 8 + 2 = 10 | L | 32 | 40 | 8 | A6 |
| 0 | 0 | 2 | 1 | 2 + 1 = 3 | M | 17 | 23 | 6 | C5 |
| 0 | 0 | 2 | 4 | 2 + 4 = 6 | N | 13 | 21 | 8 | C9 |
| 4 | 4 | 4 | 4 | 12 + 4 = 16 | O | 25 | 39 | 14 | B4 |
| 4 | 0 | 0 | 2 | 4 + 2 = 6 | P | 23 | 31 | 8 | B6 |
| 4 | 4 | 4 | 4 | 12 + 4 = 16 | Q | 38 | 51 | 13 | A1 |
| 0 | 0 | 0 | 2 | 0 + 2 = 2 | R | 28 | 34 | 6 | B3 |
| 0 | 0 | 0 | 2 | 0 + 2 = 2 | S | 18 | 27 | 9 | C3 |
| 4 | 0 | 4 | 4 | 8 + 4 = 12 | T | 28 | 42 | 14 | B1 |
| 0 | 0 | 0 | 2 | 0 + 2 = 2 | U | 15 | 22 | 7 | C7 |