United States Department of the Interior

NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

IN REPLY REFER TO:

FEB 21 1985

~~A(40)~~485
N-16

To: Regional Directors and Park Superintendents

From: Associate Director, Natural Resources

Subject: Manager's Guide to Resource Information Systems

I am pleased to provide you with a copy of the "Manager's Guide to Resource Information Systems," a guidebook for NPS park managers on the use of geographic information systems techniques.

I believe you will find this an excellent initial reference to this topic. In the Remote Sensing-Digital Cartography User Needs Assessment meetings which were held throughout the Service this past summer, both experienced users and new or potential users of these techniques found the information in this guidebook to be useful and pertinent to their needs and questions.

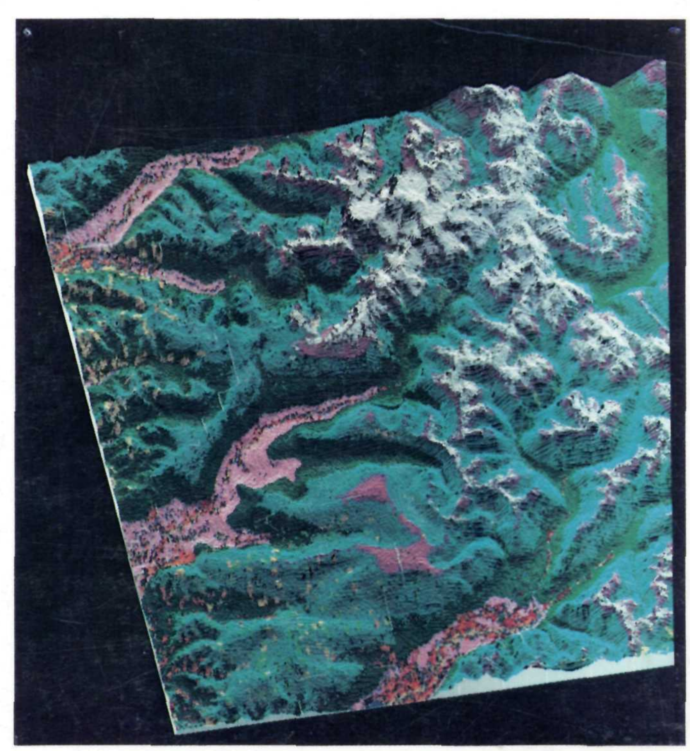
Distribution of this guidebook is part of a major commitment on the part of the Geographic Information Systems Field Unit to increase Servicewide awareness and understanding of the potential applications of remote sensing and digital cartography to actual park planning and management situations. The Field Unit is also anticipating completion of a videotape on geographic information systems this year, for eventual distribution throughout the Service.

Please circulate the enclosed guidebook to all interested members of your staff. Further questions on the material presented may be directed to the Geographic Information Systems Field Unit in Denver.

Dick Briceland

MAPS AND THE MANAGER

A MANAGER'S GUIDE TO RESOURCE INFORMATION SYSTEMS



Volume 1:

Mapped Information

Besieged as we are by ever-mounting pressures on our parks and their fragile resources, we search for more and better knowledge to protect and manage our resources. It is not enough simply to collect and analyze information. We must develop and promote ways to make this information directly useful to park management. This guide is designed to accomplish that objective. Use of the techniques that it describes and advocates can go a long way toward fostering the effective use of information in managing our parks.

Russell E. Dickenson

Director, National Park Service

About the logo:
The logo attempts to portray computers and computer technology (represented by the computer display terminal) in the service of management (represented by the ranger hat). We do indeed hope that management can "hang its collective hat" — at least partly — on these capabilities in dealing with resource problems and issues.

Cover illustration:
The 3-dimensional display of part of Olympic NP shows Mt. Olympus and the eastern portions of the Hoh, Queets, and Quinault river drainages. It was produced by merging computer classified Landsat multispectral data with digital terrain data using ELAS (Earth Resources Laboratory Applications Software). This perspective display has a rotation of -10 degrees and a tilt of 45 degrees. The colors represent various landcover classes: green is western hemlock/Douglas fir, cyan is western hemlock/Douglas fir/silver fir, light pink is western hemlock/Sitka spruce, dark pink is silver fir/mountain hemlock/subalpine fir, and yellow is clearcuts outside the park boundary.

Harvey Fleet

William P. Gregg, Jr.

Jean Mathews, editor

Geographic Information Systems Field Unit (WASO - Denver)
in cooperation with Special Science Projects Division (WASO)

June 1984

This publication is dedicated to park managers. It is intended to help them make better use of maps. It describes useful and powerful ways of harnessing mapped information in the service of management.

WOULD MAPS MAKE YOUR MANAGEMENT JOB EASIER?

DO YOU HAVE TROUBLE GETTING THE MAPS YOU NEED WHEN YOU NEED THEM?

DO YOU EVER WISH THERE WERE A WAY YOU COULD GET ALL THE INFORMATION AND ONLY THE INFORMATION YOU WANT WHEN YOU NEED IT?

There _is_ a way to do these things. It's called a GEOGRAPHIC INFORMATION SYSTEM -- a GIS.

WHY DOES A MANAGER NEED A GIS?

Park Resources are continually changing. Do you know how they are changing in your park? Do you know the causes of these changes? Can you predict future conditions? Are you prepared to make a convincing case for appropriate management responses?

Can you identify your sensitive resources? Do you know how management practices are affecting them?

Do you have enough mapped information to meet your needs? Is it quickly and easily accessible? Is it available in the forms best suited to persuade any audience of the wisdom of your management practices?

Can you describe and quantify the effects of specific influences on your park's resources? Are you prepared to propose alternative ways for dealing with those influences and to assess their effectiveness?

If the answer to any of these questions is "no," you stand to benefit from a GIS.

WHAT IS A GIS AND WHAT DOES IT CONTAIN?

A GIS is an automated system for creating, managing, analyzing, and displaying mapped information. It contains mapped information about your park's resources. Each type of information, such as vegetation, soils, roads, cultural sites, and boundaries, is a "theme." Together, these themes make up the park's data base. As more themes are added, or existing themes are updated, the data base grows and becomes ever more useful and powerful.

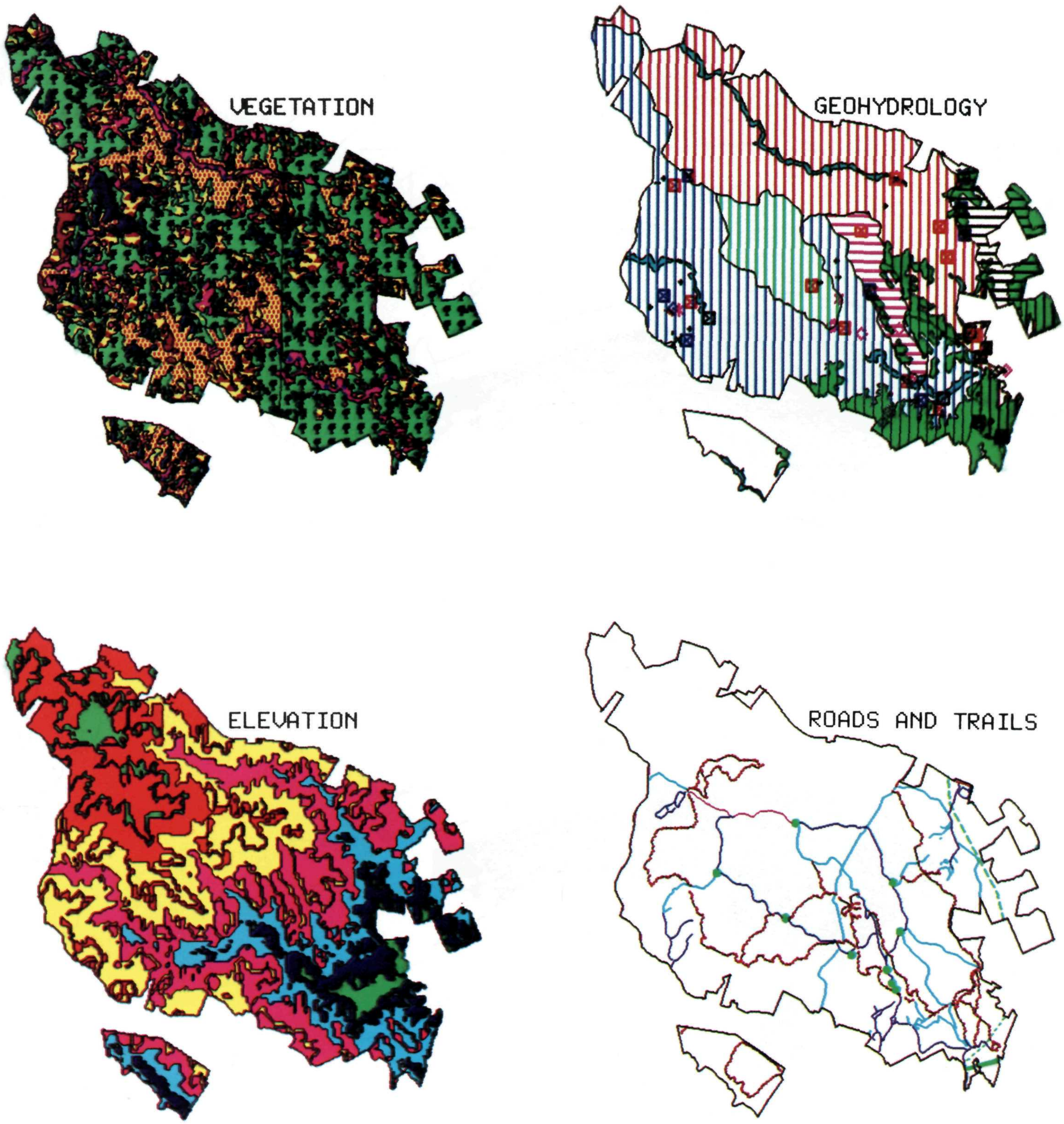


Fig. 1. The data base for Prince William Forest Park consists of several themes.

WHAT CAN A GIS DO?

The GIS derives its unique power from two sources: the **computer form** of the data base and the **computer programs** that analyze and display it.

A GIS can produce high quality maps in a wide variety of scales, content, and formats:

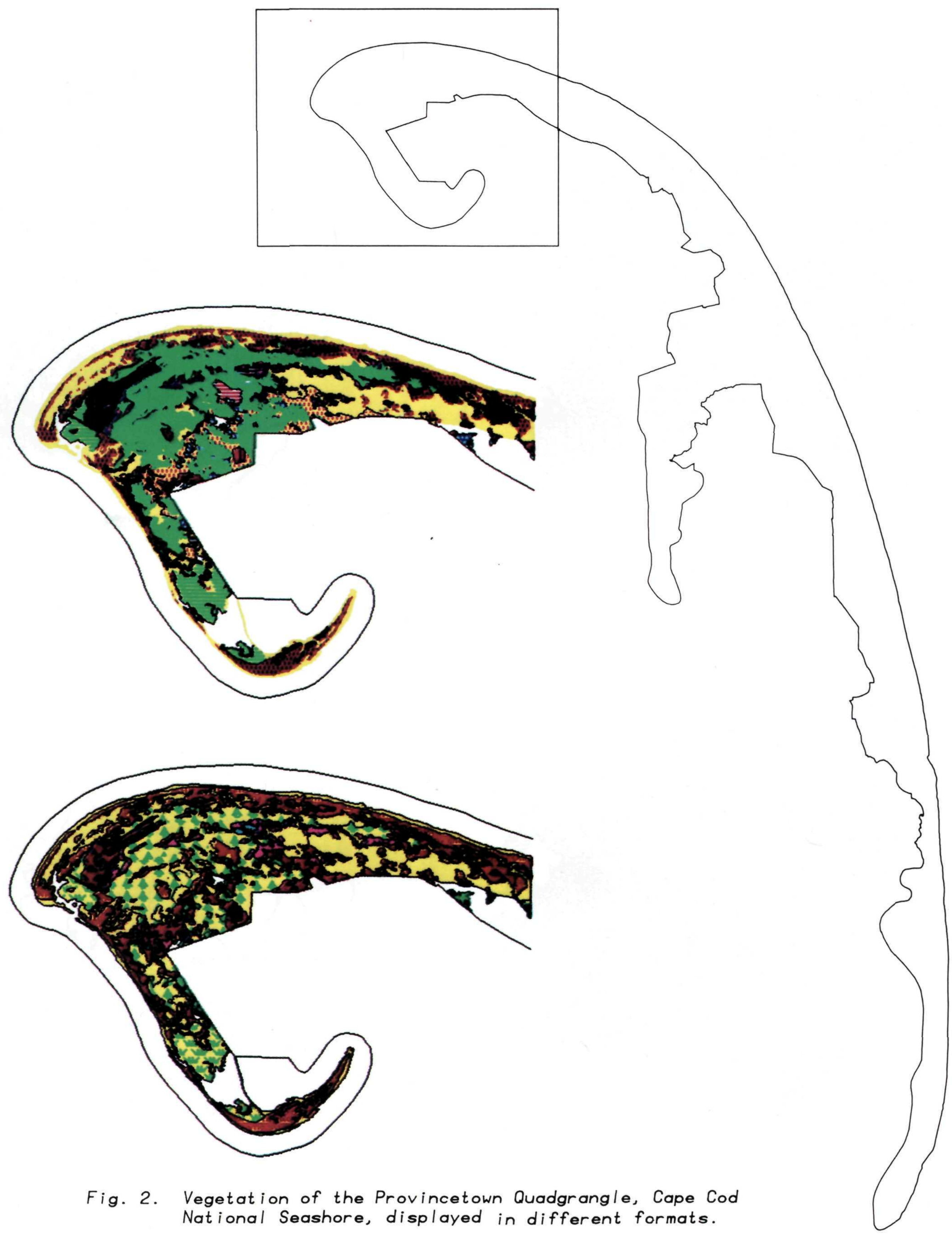


Fig. 2. Vegetation of the Provincetown Quadgrangle, Cape Cod National Seashore, displayed in different formats.

A GIS can show areas visible from selected vantage points:

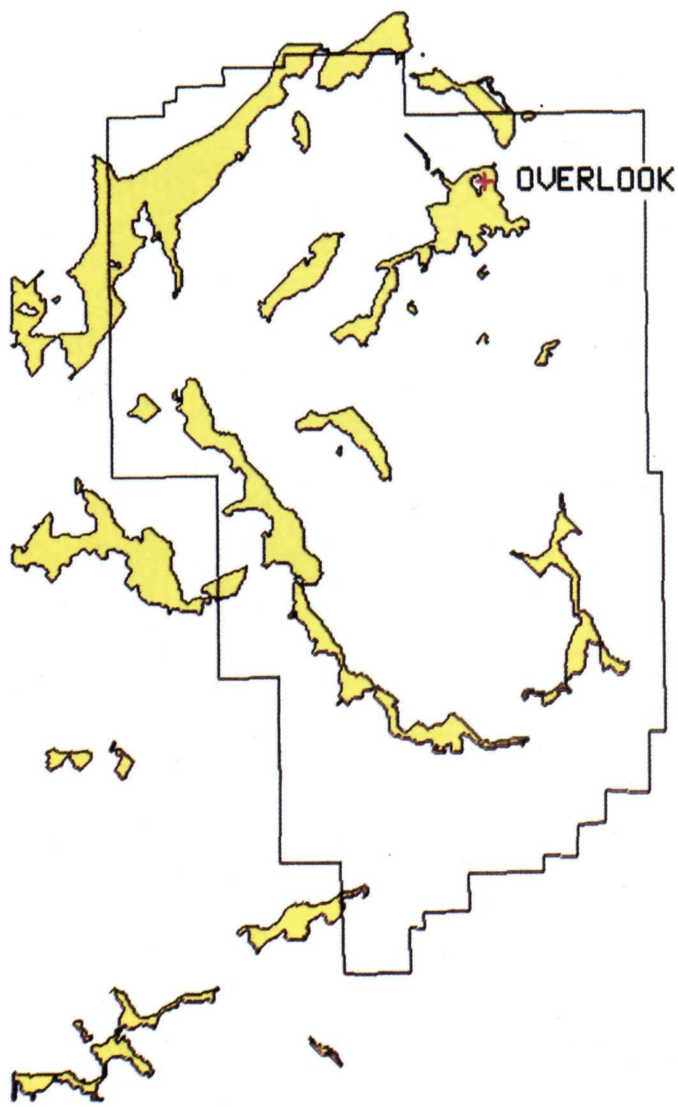
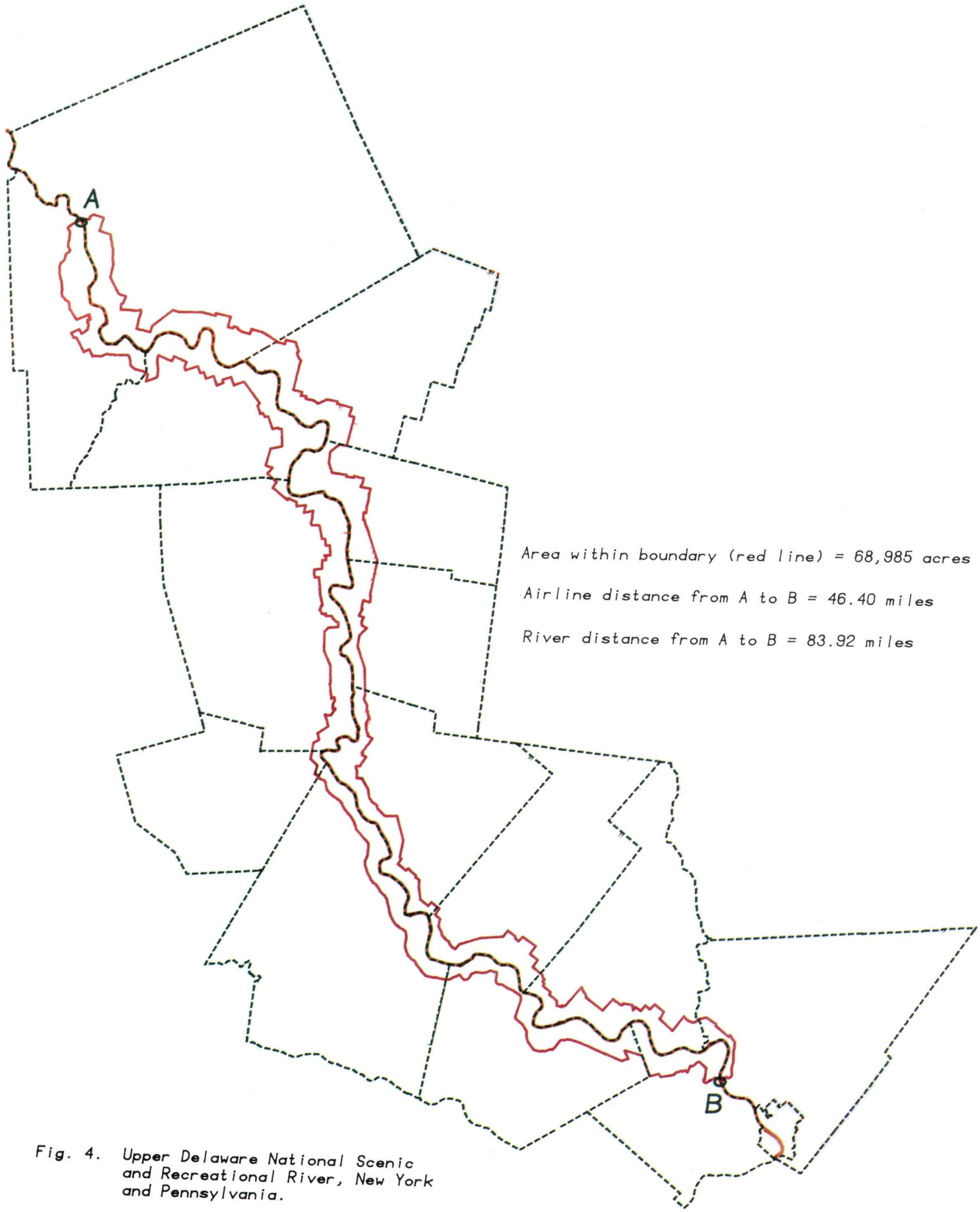


Fig. 3. Areas seen from the Gordon Flats Overlook, Tar Sands Lease Unit, Utah.

A GIS can determine areas, distances, and lengths:



Area within boundary (red line) = 68,985 acres

Airline distance from A to B = 46.40 miles

River distance from A to B = 83.92 miles

Fig. 4. Upper Delaware National Scenic and Recreational River, New York and Pennsylvania.

A GIS can integrate themes to produce composite maps showing where features intersect or overlap:

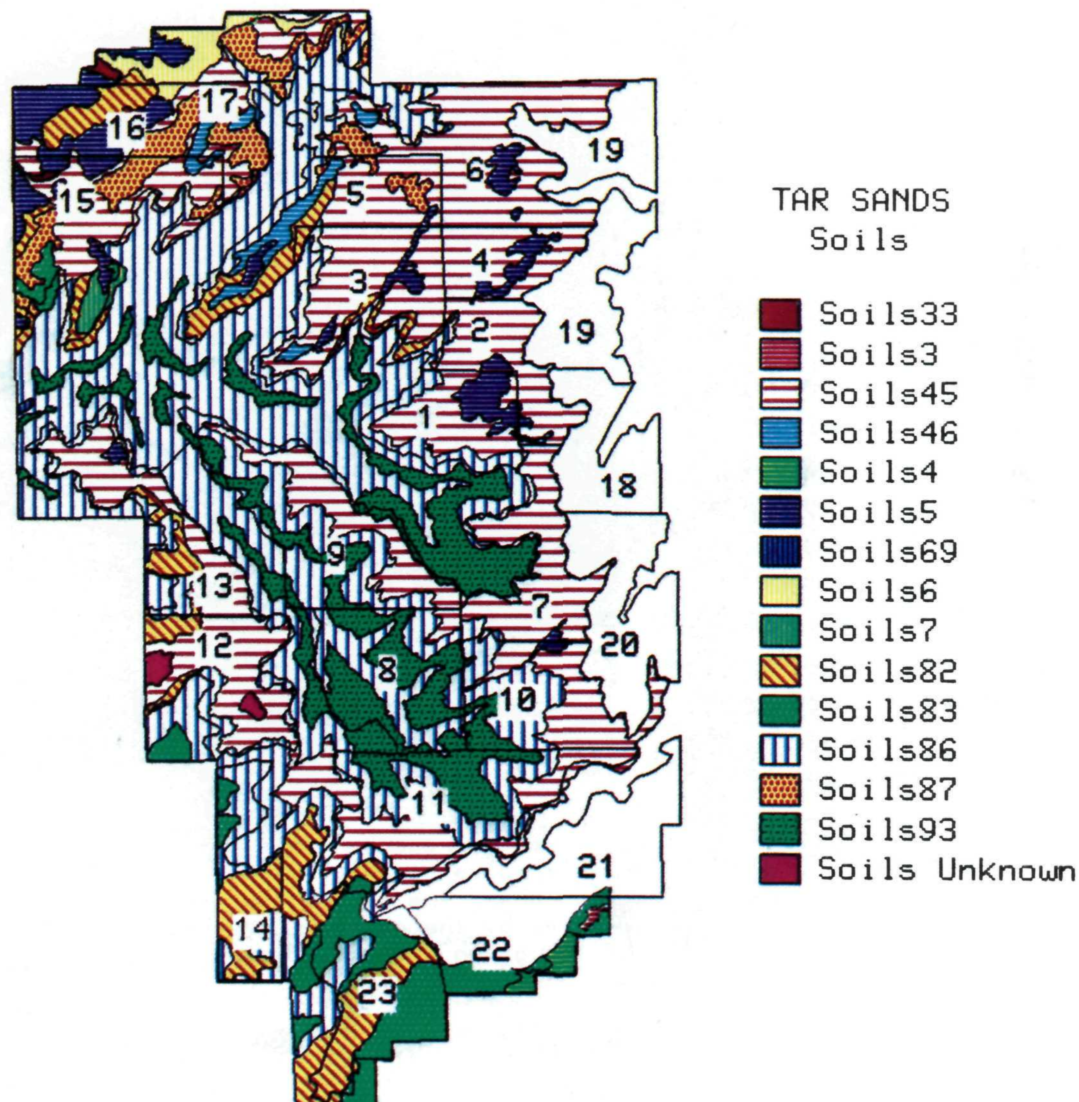


Fig. 5. Composite map of soils classes and hydrocarbon extraction zones (numbered and outlined in black) for the Tar Sands Lease Unit, Utah.

A GIS can prepare, on demand, high-quality charts, tables, and graphs in a fraction of the time traditionally required to produce such graphics:

	Soil Type															
Extraction Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1	0.0 0.000% 0.000%	0.0 0.000% 0.000%	307.0 13.148% 20.291%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	398.0 2 131% 26.305%	812.0 4.697% 53.668%	1517.0
2	7.0 .179% .574%	0.0 0.000% 0.000%	76.0 3.255% 6.235%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	29.0 .155% 2.379%	1108.0 6.409% 90.894%	1220.0
3	234.0 5.975% 9.618%	0.0 0.000% 0.000%	153.0 6.552% 6.289%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	44.0 7.213% 1.808%	425.0 2.276% 17.468%	1592.0 9.208% 65.434%	2448.0
4	0.0 0.000% 0.000%	0.0 0.000% 0.000%	194.0 8.308% 18.459%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	857.0 4.957% 81.541%	1051.0
5	435.0 11.108% 20.365%	0.0 0.000% 0.000%	80.0 3.426% 3.745%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	153.0 8.027% 7.163%	335.0 54.918% 15.684%	335.0 1.794% 15.684%	814.0 4.708% 38.109%	2152.0
6	0.0 0.000% 0.000%	0.0 0.000% 0.000%	154.0 6.595% 5.064%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	143.0 7.503% 4.702%	43.0 7.049% 1.414%	310.0 1.660% 10.194%	2396.0 13.859% 78.790%	3046.0
7	0.0 0.000% 0.000%	0.0 0.000% 0.000%	21.0 .899% 1.306%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	30.0 .546% 1.866%	0.0 0.000% 0 000%	0.0 0.000% 0.000%	99.0 .530% 6.157%	1460.0 8.445% 90.796%	1610.0
8	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	600.0 10.911% 20.360%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	1402.0 7.507% 47.574%	939.0 5.431% 31.863%	2941.0
9	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	1207.0 21.949% 53.692%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	963.0 5.156% 42.838%	84.0 .486% 3.737%	2254.0
10	0.0 0.000% 0.000%	0.0 0.000% 0.000%	40.0 1.713% 2.001%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	243.0 4.419% 12.156%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	717.0 3.839% 35.868%	1002.0 5.796% 50.125%	2002.0
11	81.0 2.068% 2.658%	35.0 1.476% 1.149%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	694.0 12.620% 22.777%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	1160.0 6.211% 38.070%	1075.0 6.218% 35.281%	3045.0
12	200.0 5.107% 10.499%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	142.0 100.000% 7.454%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	349.0 1.869% 18.320%	1221.0 7.062% 64.094%	1912.0
13	271.0 6.920% 15.354%	0.0 0.000% 0.000%	36.0 1.542% 2.040%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	397.0 2.126% 22.493%	1067.0 6.172% 60.453%	1771.0
14	576.0 14.709% 43.472%	95.0 4.007% 7.170%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	659.0 3.529% 49.736%	0.0 0.000% 0.000%	1330.0
15	189.0 4.826% 7.055%	135.0 5.694% 5.039%	380.0 16.274% 14.184%	152.0 80.000% 5.674%	26.0 35.135% .971%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	499.0 26.180% [illegible]	40.0 6.557% 1.493%	132.0 .707% 4.927%	1143.0 6.611% 42.665%	2696.0
16	375.0 9.576% 15.632%	0.0 0.000% 0.000%	695.0 29.764% 28.970%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	41.0 7.009% 1.709%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	654.0 34.313% 27.261%	143.0 23.443% 5.961%	83.0 .444% 3.460%	411.0 2.377% 17.132%	2402.0
17	41.0 1.047% 2.318%	0.0 0.000% 0.000%	190.0 8.137% 10.741%	0.0 0.000% 0.000%	48.0 64.865% 2.713%	544.0 92.991% 30.752%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	382.0 20.042% 21.594%	2.0 .328% .113%	199.0 1.066% 11.249%	373.0 2.157% 21.085%	1779.0
18	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	5.0 .029% .361%	5.0
19	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	4.0 .023% .153%	4.0
20	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	9.0 .052% .455%	9.0
21	0.0 0.000% 0.000%	12.0 .506% .667%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	12.0
22	2.0 .051% .113%	404.0 17.039% 22.799%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	31.0 100.000% 1.749%	180.0 100.000% 10.158%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	617.0
23	699.0 17.850% 32.664%	1141.0 48.123% 53.318%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	0.0 0.000% 0.000%	201.0 1.076% 9.393%	0.0 0.000% 0.000%	2041.0
Total	3110.0	1821.0	2326.0	152.0	74.0	585.0	0.0	31.0	180.0	142.0	2774.0	1831.0	607.0	7858.0	16352.0	37843.0

Fig. 6. Cross-tabulation of soils and hydrocarbon extraction zones shown in Fig. 5. Time to produce: twenty seconds. The first figure of each triplet is acres, the second the percentage of the given soil type occupied by the extraction zone, and the third the percentage of the given extraction zone occupied by the soil type.

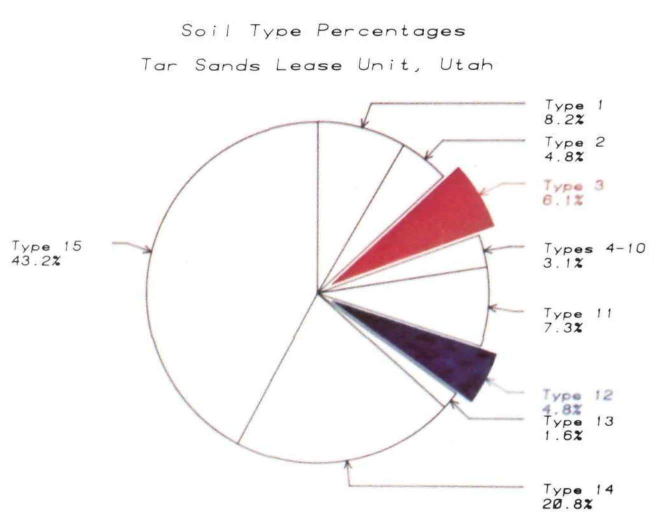


Fig. 7. Pie chart of acreages of soil types shown in Fig. 5, expressed as percentages of all soils. Time to produce: two minutes.

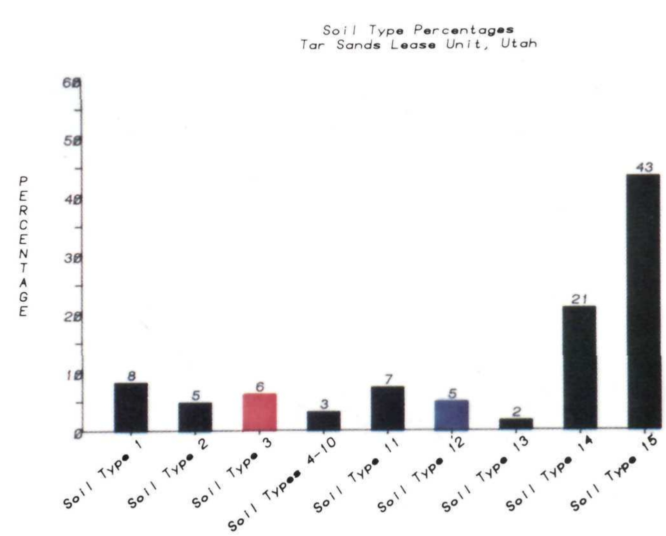


Fig. 8. Bar chart of same data as in Fig. 7. Time to produce: two minutes.

A GIS can produce new derived maps or analyses:

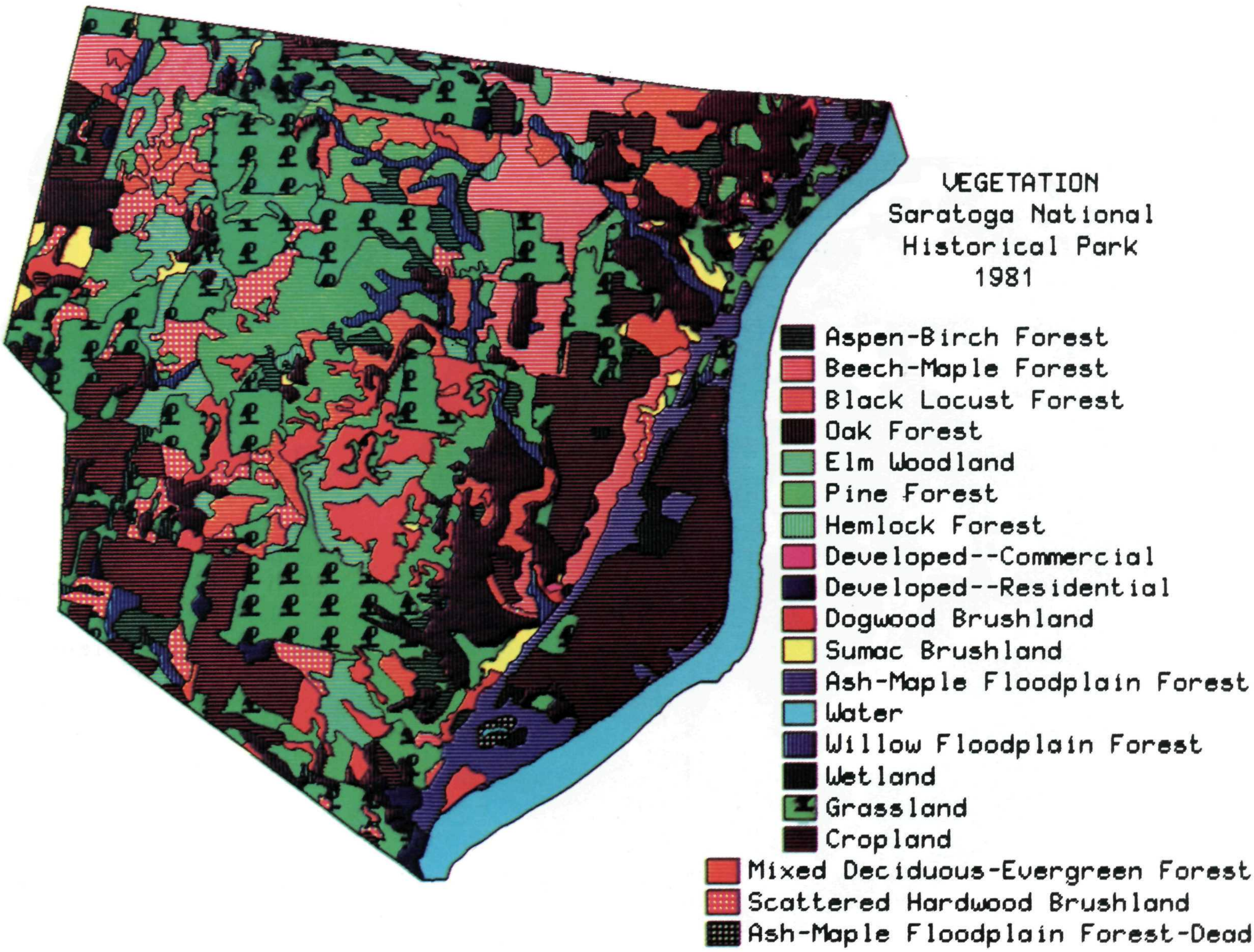


Fig. 9a. Vegetation of Saratoga National Park.

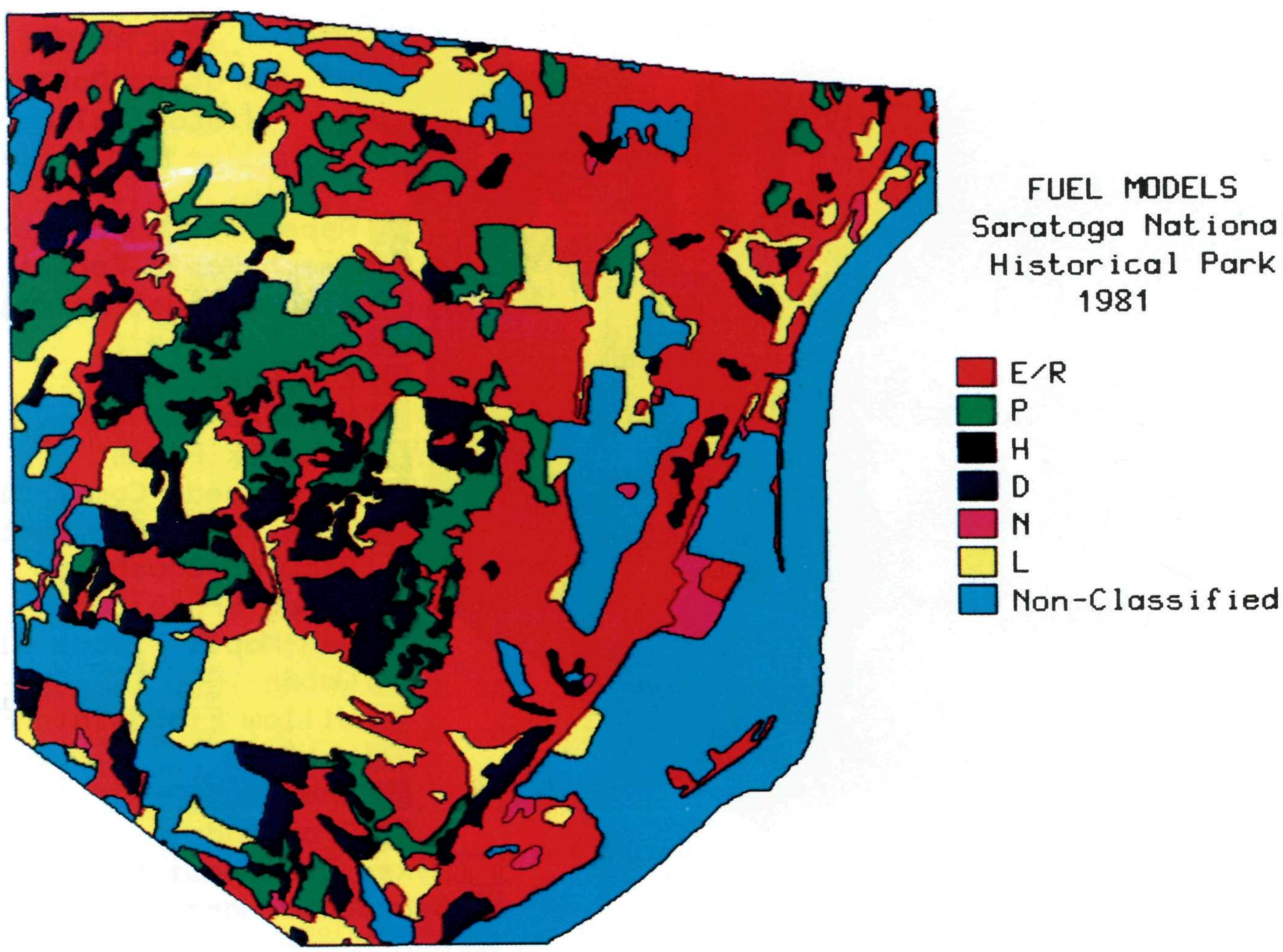


Fig. 9b. Fuel models map for Saratoga National Historical Park derived by combining vegetation classes with similar flammabilites (according to the National Fire Danger Rating System).

A GIS can detect changes, analyze trends, or project possible future conditions:

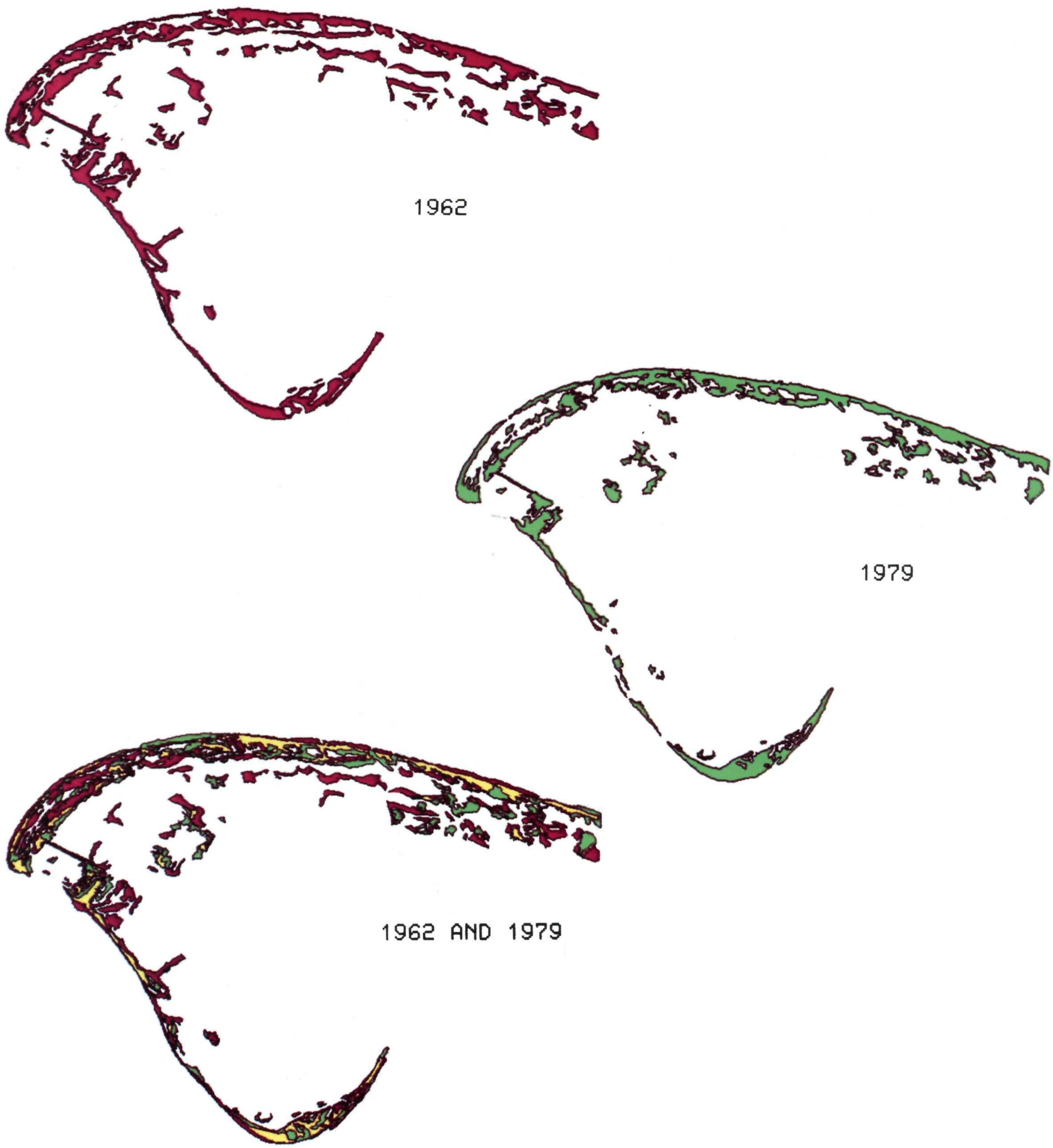


Fig. 10. *Comparison of the distribution of beach grass in 1962 and 1977 for Cape Cod National Seashore, Provincetown Quadrangle.*

What all this means to managers is that their paper maps, with their fixed scales and contents, become a powerful digital data base capable of producing high-quality maps uniquely tailored to specific needs.

HOW DOES A PERSON GET STARTED?

By making two crucial decisions: (1) what themes are needed in the park's data base, and (2) at what scale (level of resolution) should the data be displayed? For example, a vegetation theme entered into the data base at 1:1000 (1 in. = 83.3 feet) would have a minimum display resolution of twenty-one feet and would allow the display of individual trees, such as might be necessary in monitoring Dutch Elm disease. At a scale of 1:24000 (1 in. = 2000 feet), the minimum mapping area would be about one acre and would allow one to see plant communities. At a still smaller scale of 1:250000 (1 in. ≅ 4 miles), the display resolution would decrease to approximately one mile and would show only major plant associations. A highly detailed base map, although at first thought desirable and necessary, is not always the best choice. The more detailed the base map, the higher the costs. On the other hand, however, the elements of a highly detailed data base can usually be aggregated together to form comprehensive, general, synoptic overviews: the converse is **not** true. That is to say, less detailed data **cannot** be disaggregated to show more detail in any local area, because the required resolution is not present in the first place. Put simply, you can never get more detail than that originally entered into the data base, but you can almost always get less.

Each manager must decide the scale of the data base according to his or her own management needs. The following table can help here. You may also wish to discuss this question with NPS remote sensing and digital cartography specialists in Denver.

Table 1: Relationship Betweeen Map Scales and Resolution.

Display Scale	Minimum "On-the-Ground" Size of Discernible Features (in feet)
1:1200 (1" = 100')	25
1:3600 (1" = 300')	75
1:6000 (1" = 500')	125
1:12000 (1" = 1,000')	250
1:24000 (1" = 2,000')	500
1:62500 (1" = 1 mi)	1302
1:125000 (1" ≅ 2 mi)	2604
1:250000 (1" ≅ 4 mi)	5208

Once you have decided on the themes and the scales, you may start recording the data on USGS topographic base maps or other suitable, accurate maps. USGS topographic maps are available in scales of 1:24000 and 1:62500 and should be obtained in a mylar version, which is dimensionally stable under a wide variety of temperature and humidity conditions. This latter point is critical when it comes to entering thematic data into a digital data base. Smaller scale "Park Specials," at 1:125000 and the standard series 1:250000 quadrangles, can be used for certain applications where higher resolution is not required. For higher resolution applications requiring scales up to 1:12000 (1 in. = 1000 feet), the 1:24000-scale quadrangles can be enlarged. Further enlargement (beyond 1:12000) of the 1:24000-scale maps is not recommended, because the source map's resolution and accuracy are too coarse. In such cases special base maps must be prepared.

HOW DO I KNOW WHICH THEMES TO ENTER INTO THE GIS DATA BASE?

Your park's resources management plan (RMP) should contain most of what you need to know for answering this question. List the resource problems that it identifies. Then list the resource themes for which maps would help solve these problems. The detail you need to solve the problems will determine the detail needed in mapping the resource themes.

Now think for a minute about **potential** problems that the RMP may not have covered, particularly those that may be developing subtly, quietly, and inconspicuously over long periods. These changes may be powerful indicators of the health of your park's resources. Detecting them early may help you prevent major problems from developing later. The GIS may also help identify subtle problems that were not previously apparent because of the many types of data needed to reveal them.

Also, remember that your RMP must be updated regularly. The GIS is tailor-made to help you with this task (assuming that the data base is also kept current).

This is also the time to assemble and organize your available maps and related material. This process will give you the opportunity to identify missing data and to integrate complementary themes. At this point, you may wish to consult with NPS remote sensing and digital cartography specialists in Denver.

ARE THERE ANY STANDARD THEMES THAT EVERY PARK SHOULD HAVE IN ITS DATA BASE?

Boundaries, land use, vegetation, roads, topography, and physical plant are good candidates for inclusion in every park's GIS.

NOW CAN I START BUILDING MY GIS DATA BASE?

Once you have decided on the scale of your base map or maps, and have selected the themes you wish to enter into your data base, you can start transferring your existing map information to the base map. It is usually best to transfer each theme, such as geology or cultural features or landownership, to its own mylar overlay carefully registered to a mylar base map. You may need to photographically reduce or enlarge a mylar base map to the same scale as your map themes. Exercise caution not to enlarge small scale maps beyond their limits of resolution, lest you give a false impression of the actual location of the lines. A fine-line (double-zero or triple-zero) India ink pen is best for the transfer work. Avoid broad, vaguely-defined lines. Depending on the scale of the thematic map, features can be entered as precise outlines or merely as points or symbols. This is an excellent time to resolve any ambiguities and discrepancies in the data base about the names and locations of features. You may be amazed at how many uncertainties there are! The importance of making corrections at this time cannot be overstated, because failure to do so can result in increased costs, delays, and troubles in using the data base later on.

Following these procedures will allow the actual entry of the themes into the data base to progress quickly and easily. It will also minimize the number of inaccuracies and inconsistencies that have to be corrected later. Care must be taken to label all features clearly and accurately.

Once this transfer process has been completed, your data are ready to be entered into the computer.

WHAT DO I DO ABOUT ACQUIRING AND ENTERING DATA THAT I DO NOT HAVE?

Remote sensing can potentially help you obtain some of these missing data. It is now an established and widely used tool for this purpose. Aerial photographs, as well as digital data from sensors on satellites and aircraft, can provide a synoptic view of your total resource as well as a detailed view of specific areas for closer inspection and analysis. For example, the new Landsat Thematic Mapper gathers information covering 10,000 square miles, yet it has the resolution to show every quarter-acre within those 10,000 square miles. Maps of vegetation, land use, and other resource features can be produced by interpreting aerial photographs. They can also be produced by using a computer to analyze and classify digital data.

HOW DO I DECIDE ON THE BEST GEOGRAPHIC SCOPE FOR MY GIS DATA BASE?

As a long-term goal, the GIS data base should include both the park and the surrounding region that directly affects it. A physiographic or political boundary or a road might be an appropriate data base boundary, which might also be adjusted to include selected natural or cultural features influencing the park. There are no hard and fast rules for selecting the data base boundary. However, the manager and his staff will generally know what a reasonable geographic scope should be.

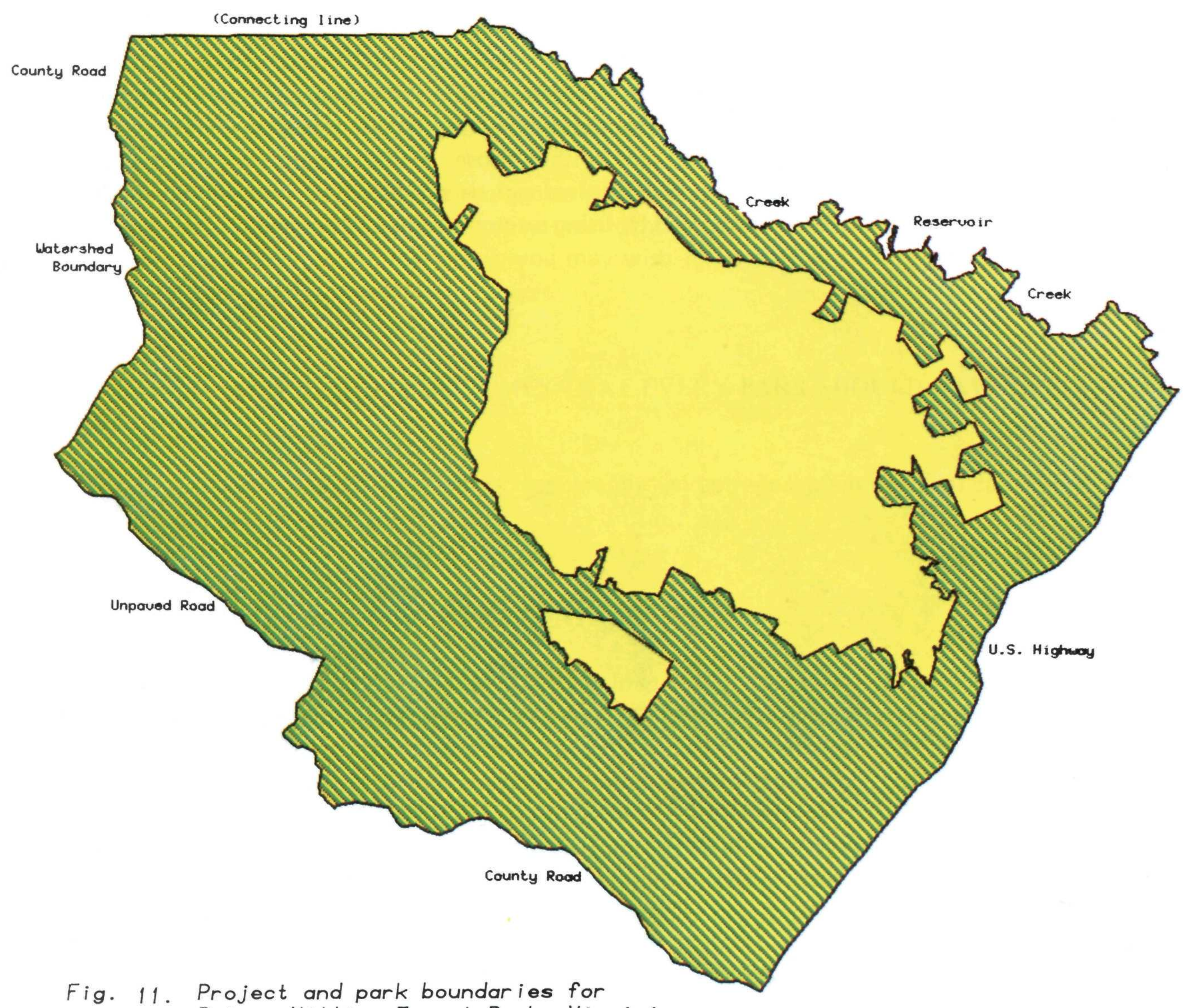


Fig. 11. Project and park boundaries for Prince William Forest Park, Virginia.

In parks larger than 25,000 acres you may find it desirable to establish your data bases on two, or even three, levels of geographic scope for local-site, parkwide, and regional applications, respectively.

Local-site applications, such as for development planning, would utilize larger scale, very high resolution data bases, such as 1:12000 or 1:6000. Parkwide applications, such as assessing particular park wildlife habitats or determining the length of the park's trail system, would use intermediate scale, medium resolution data bases, such as 1:24000 or 1:62500. Regional applications, such as assessing the effects of regional land use changes on migrations of park wildlife, would involve small scale, relatively low resolution data bases of 1:125000 or less.

HOW DO REMOTE SENSING DATA DIFFER FROM DATA ENTERED INTO THE COMPUTER FROM EXISTING MAPS?

Remote Sensing data are usually "grid-cell" data, that is, they show land features (like vegetation types, roads, or archeological sites) to be either present or absent in discrete chunks, or squares, of the earth's surface. The size of these squares, or cells, depends on the elevation and resolution of the sensing device. Cell sizes used by the Service commonly range between eight and eighty meters on a side. Naturally, the smaller the cell size, the more the detail and the greater the specificity in your data. The tradeoff is the increase in data volume and computational requirements ("number crunching"), which go up as the square of the number of cells. Maps based on these data use colored or black-and-white cells as basic building blocks.

Data entered from maps – "digital cartographic data" -- are typically "line-type" data, that is, they show land features as lines or points on a map. Thus, a vegetation type, or a road, or an archeological site is represented as a series of connected points. The number and accuracy of the points depends upon the scale of the source map and the selected data-entry, or digitizing, tolerances. Output products are displayed as colored or black-and-white line drawings.

DOES ALL THIS MEAN I HAVE TO LEARN A WHOLE NEW TECHNOLOGY?

Absolutely not. You don't have to understand how a telephone or television works in order to make it work for you. It's the same with remote sensing and digital cartography.

All you need to know is that information on your park can be collected in the form of photographs and/or digital data. This information can be turned into a variety of maps suited to your immediate needs.

Specialists in the NPS remote sensing program are available to interpret photographs or classify digital data to generate maps for you.

Displays of selected themes in the Tuolumne Meadows area produced by the ELAS software from the Yosemite digital data base:

Fig. A. Color infrared rendition of aircraft scanner data used to produce thematic landcover classes. (Resolution = fifteen meters).

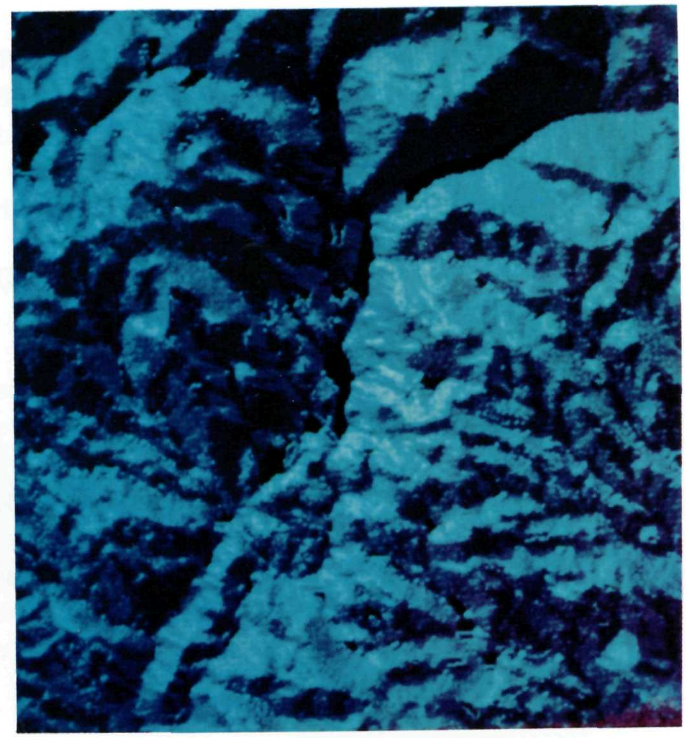


Fig. B. Nine aspect classes derived from digital elevation data. The classes are shown using a color table that simulates shaded relief.

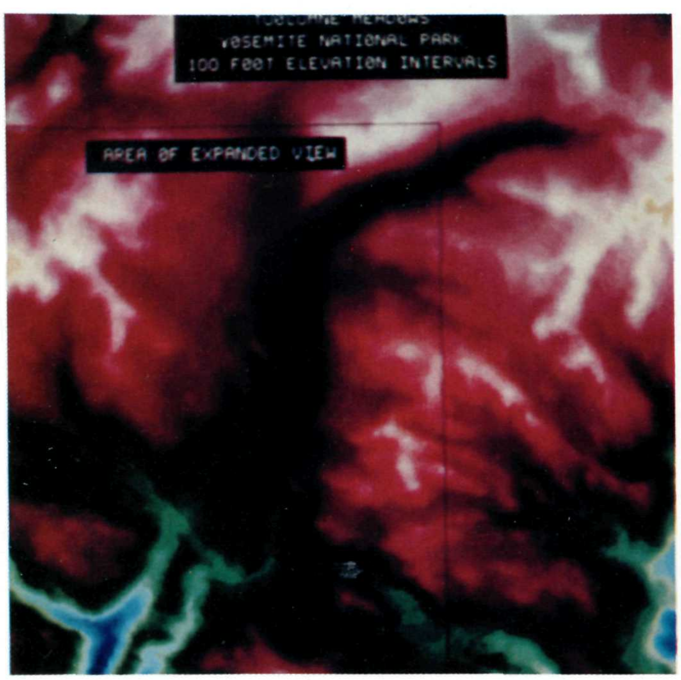


Fig. C. Direct, overhead view of digital elevation data. Different colors represent different contour intervals (blues (lowest) — greens — reds — pinks — browns (highest)).

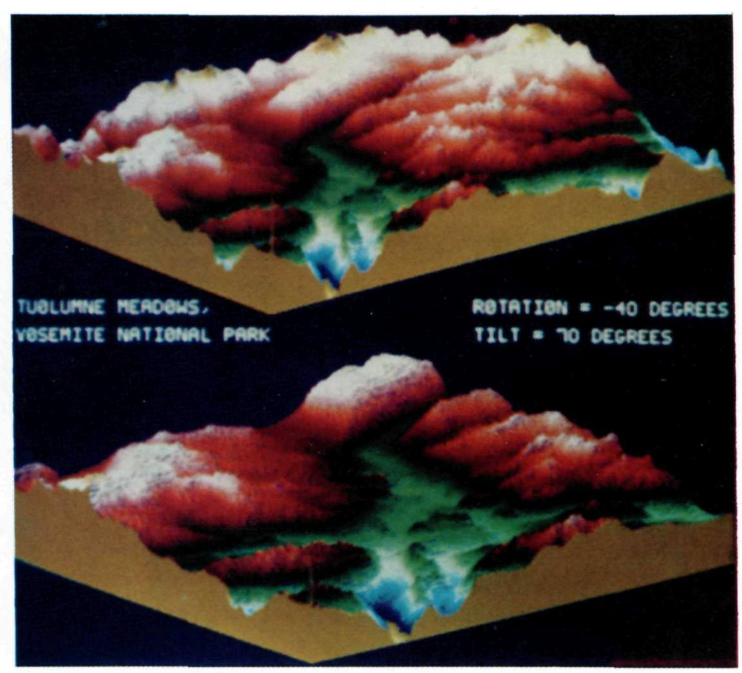


Fig. D. Three-dimensional perspectives produced from digital elevation data.

HOW DO I HARNESS ALL THIS INFORMATION TO MEET MY NEEDS?

In two ways. At first, you can rely on specialists to develop your data bases and prepare the products you need. Then, after you have developed a data base, you may want to manipulate your data, do analyses, and generate products yourself. Once established in your own park, these capabilities will make it possible for you to make full, timely use of the information in the data base. In some cases, existing equipment may be suitable for this task. In others, it may be necessary to purchase additional hardware. Such equipment could include a special computer device or terminal for displaying maps and working with the data base, a telephone hook-up to the computer where the data base and software are located, and machines for generating hard-copy products. Note that the same equipment for working with a GIS can also be used for administrative applications. Procuring computer equipment to perform **both** cartographic and administrative applications can result in significant cost savings over acquiring these capabilities separately.

WHAT IS THE PRICE TAG ON ALL OF THIS?

Three things determine the cost of a GIS: data acquisition, data entry, and use of the data base. These in turn are influenced by many factors, such as the size of your park, the number and complexity of the resource themes, the required map resolution, the need for new remotely sensed data to fill gaps, the amount of on-the-ground verification you desire, and whether you choose to have your own equipment to access and use the data base. Data acquisition and entry usually constitute the lion's share of the cost — perhaps as much as 90 percent. However, the GIS should be looked upon as a long-term undertaking, which need only involve modest cost in any one year. Over the years it increases in cost effectiveness as additional applications are made. The first step might entail the entry into the data base of only a single theme, such as the park boundary (in a 100,000-acre park this cost would be less than $1,000). In each subsequent year, you may add themes to the data base as your needs require and your budget permits.

The largest single cost item in building a data base is acquiring remotely sensed data (whether these are digital data from satellites or aircraft or black-and-white, color, or color-infrared aerial photos) and producing new thematic maps from these data. These costs typically range around three to five cents per acre. Cooperative agreements between the National Park Service and other agencies make it possible to acquire consistently high-quality data at bargain rates. For applications such as vegetation mapping in parks larger than 50,000 acres, data from the new Landsat Thematic Mapper will probably be the most cost-effective type, because they provide the best tradeoffs between resolution, acquisition costs, and analysis costs. Repetitive coverage also provides a mechanism for routine periodic monitoring.

In summary, the costs associated with building a digital cartographic data base for your park will be around $0.03 to $0.05 per acre for acquiring aerial photographs or multispectral data and producing a themetic map, such as for land use or vegetation. The cost will be about $1.00 per polygon to digitize thematic data from existing maps, or between five hundred and five thousand dollars per theme, depending on the number of polygons. Costs of analyses can run anywhere from several hundred to several thousand dollars per year; requisite hardware; if what you have isn't satisfactory, starts at about $5,000.

WHAT CAPABILITIES DO WE NOW HAVE?

The NPS remote sensing and digital cartography programs have capabilities in six areas: (1) data gathering, (2) map preparation, (3) data entry, (4) data management and analysis, (5) data display, and (6) software development. Data gathering involves taking aerial photographs, collecting remotely sensed digital data, or procuring existing photography, maps, and digital data from a wide range of sources. Map preparation involves interpreting aerial photographs and classifying digital data to produce thematic maps, such as vegetation and land use. Data entry involves digitizing existing maps (note that this is not necessary for digital remotely sensed data, because they are already in a computer-compatible form). Data management and analysis involves using the data base to produce answers to questions. Data display involves producing maps, tables, charts, and graphs to illustrate these answers or simply to describe park resources. Software development involves revising existing software and developing new software as requirements arise.

The appendix contains an overview of existing NPS equipment and computer software for remote sensing and digital cartography.

HOW DO I AVAIL MYSELF OF THESE CAPABILITIES?

Specialists in the Geographic Information Systems Field Unit in Denver (303-776-7939 or FTS 236-7939) can provide cost estimates and suggestions for building your data base. They are also available to provide advice on the selection of hardware and software for GIS applications and to give training on the use of ELAS and SAGIS (see Appendix).

HARNESSING THE GIS

SUMMARY

The GIS provides the capability to get an up-to-date, accurate, and precise picture of your park's resources. The capability for producing maps at any scale, combination of themes, or format is what makes this possible.

Ask yourself how many times you would have benefited from having quick access to accurate, relevant resource data, with maps prepared in a timely fashion . . . in justifying personnel and other budgetary requests . . . in answering Congressional inquiries . . . in presenting arguments and positions . . . in explaining and defending your management practices before a variety of audiences.

To set up and use a GIS data base, then, you need to:

-- decide on a scale and map base.

-- select the themes to be entered.

-- arrange to have missing data gathered, classified, and mapped.

-- transfer existing data to mylar base maps.

-- arrange to have the data entered into the computer.

A geographic information system can make your job easier and improve your effectiveness. In particular, it can help you take better care of the resources under your stewardship. It will do none of these things unless you make use of it. It's worth your consideration.

Acknowledgements:

Many people contributed generously to this publication. Maury Nyquist of the Remote Sensing Section spent many hours reviewing the text. Keith Hoofnagle of Olympic National Park provided the pithy — and entertaining — cartoons (many thanks also to Roger Contor, Alaska Regional Director, for making his services available to us). And special credit to Peter Strong, whose programming skills make many of the techniques described in this guide possible.

Geographic Information Systems Field Unit

The Geographic Information Systems Field Unit performs thematic map production, digital cartography, and GIS analyses.

The **Remote Sensing Program** produces thematic maps through aerial photointerpretation or computer-assisted classification of digital multispectral data. Traditional techniques are used to produce thematic maps from black-and-white, natural color, or color intrared aerial photographs. The photographs are interpreted to delineate features of interest, such as vegetation, land use, and other landcover features. Boundaries of these features are drawn directly on the photographs and these outlines are then registered and transferred to base maps using a zoom transferscope.

Thematic map production from multispectral data is a computer-intensive task. The digital data, which come from either satellite or aircraft scanners, are read into the computer, classified, and registered to a base map. In addition, topographic and other digital data are frequently merged into the data base to enhance the classification as well as to provide additional information for deriving new themes. The resultant classified "surfaces" can then be extensively analyzed and used to produce new thematic maps (e.g., wildlife habitat) or for building models such as are required for predicting fire behavior.

The Earth Resources Laboratory Applications Software (ELAS) is used to classify and analyze multispectral, topographic, and other geographically registered digital data. This software comes from the Earth Resources Laboratory of NASA and has very powerful data management and GIS capabilities. The U.S. Forest Service's BEHAVE software is also used for fuels modeling and fire behavior prediction. These software packages are running on a VARIAN minicomputer system with a COMTAL color image display device. An electrostatic printer/plotter is used to produce high-resolution gray-scale output. A computer tape can also be produced for use on a cooperating agency's Optronix laser beam film recorder to make high-resolution hard-copy color output.

The **Digital Cartography Program** accepts maps from a variety of sources, including photointerpretation, and enters them into the computer through digitizing and scanning. Digitizing uses a digitizing tablet to convert line or point data to digital format. Scanning accomplishes the same task through an automated procedure and is used for large, complex jobs. The digital data are entered into the computer and edited as necessary. The mapfiles enable the analysis and display of the information on the original maps.

The Systems Applications Group Information System (SAGIS) is used to enter, edit, analyze, and display digital cartographic data. SAGIS is a collection of computer programs running on a Control Data Corporation CYBER mainframe computer. High resolution Tektronix display devices, in conjunction with three digitizing tablets and two plotters, support the digital cartographic activities. An interface between SAGIS and ELAS makes it possible to move data between the two systems.

Previous applications of the ELAS and SAGIS systems have included change detection, identification of potential wildlife habitat, determination of covertype use by wildlife, identification of threats to parks, determination of development suitability and feasibility, fire behavior modeling, and fire fuel-model mapping.