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APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM AND REMOTELY SENSED DIGITAL DATA IN THE NATIONAL WILDLIFE REFUGE PLANNING PROCESS IN ALASKA.

ABSTRACT The Alaska National Interest Lands Conservation Act (ANILCA), established by Congress in 1980, mandated the preparation of "Comprehensive Conservation Plans" for each of the 16 refuges established in Alaska by 1987. The primary objectives of the plans are to (a) inventory and describe the resources and values, (b) specify management programs for conserving the fish and wildlife resources/values, (c) specify other compatible uses, and (d) specify opportunities for fish and wildlife oriented recreation, research, and education.

Large-scale landcover data sets are generated from the analysis and classification of LANDSAT digital images and form the basis for most environmental modelling activities in the planning process. Digital terrain information in the form of elevation, slope, and aspect are obtained from the analysis of Digital Elevation Models. Both the landcover data and the terrain data are geometrically registered to the 1:250,000/1:63,360 scale USGS quadrangle maps.

The Geographic Information System (GIS) organizes and manages the environmental data, analyzes the data in the generation of habitat productivity and resource suitability models, summarizes the analysis results for the evaluation of environmental impacts expected from the implementation of several refuge management alternatives, and displays the results in graphic form for the preparation of draft and final documents.

Currently, some 32 million acres of National Wildlife Refuge lands in Alaska are in various stages of the planning process involving the use of GIS technology. Beyond this are an additional 45 million acres remaining to be planned within the next 3 years.

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INTRODUCTION

In 1980, the Congress established 16 new refuges in Alaska with the passage of the Alaska National Interest Lands Conservation Act (HR-97). ANILCA added approximately 70 million acres to the existing 7 million acres of National Wildlife Refuges in Alaska. One of the conditions mandated by the act was the requirement to prepare a "Comprehensive Conservation Plan" (CCP) for each refuge by 1987. The CCP must (a) inventory and describe the natural resources and values, (b) specify management programs to conserve fish and wildlife resources and values, (c) specify other uses of the natural resources which are compatible with the purposes of the refuge, and (d) specify opportunities for fish and wildlife oriented recreation, research, and education.

The National Wildlife Refuges in Alaska are typically characterized by very large expanses of unsurveyed land, remoteness, inacessibility, very sparse populations of indigenous people dependant upon the natural resources for a subsistence lifestyle, and a general lack of detailed, comprehensive information. The smallest refuge is over 800,000 acres, with the largest being nearly 22 million acres (larger than the state of Maine). Of the 16 refuges only 3 are "touched" by roads. The vast majority are accessible only by air or water, and then only at certain times of the year. Very little detailed, quantitative data exists for most of the refuges. Of the data that is available, most originated as the result of broad reconnaisance surveys many years ago.

In view of the scope of the ANILCA mandate and faced with the 1987 deadline, it became obvious to the Fish & Wildlife Service (FWS) staff that traditional data collection and analysis techniques were not suitable for addressing the planning requirements on the vast expanses of refuge lands in Alaska. Therefore, the decision was made to employ the use of automated techniques and systems for collecting, storing, retrieving, analyzing, and displaying the various environmental and socio-economic data needed in the planning process. The regio al computer facility was established in Anchorage to provide the necessary hardware, software systems, and expertise required to implement the automated capabilities. The hardware configuration is based around a Data General MV8000 minicomputer with 6 megabytes of memory, 1 gigabyte of disk storage, high-speed Calcomp drum plotter, and associated peripheral devices, including 2 digitizing tables and several Tektronix graphic display terminals. The Geographic Information System is based upon geoprocessing software systems in the form of "GRID"/"PIOS" (Environmental Systems Research Institute) and "AMS"/"MOSS" (Autometric, Inc.). Installation of the hardware and software systems was completed in early 1982.

The FWS refuge planning organization consists of 3 planning teams, each with a planner, assistant planner/writer, biologist, and public involvement specialist, as well as a support group of resource specialists, such as botanists, geologists, socio-economists, cartographers, etc. In addition, the Office of Information Resources Management provides operational support in the form of computer systems analysts, programmer/analysts, and computer operators. In total, there are approximately 25 - 30 people working directly in support of the refuge planning process within the region. At any one time, there are at least 6 refuges involved in some phase of the planning process, with the "average" time to develop and review a typical refuge plan requiring 2 - 3 years.

REFUGE PLANNING PROCESS

The basic Refuge Planning Process employed by FWS in Alaska is very similiar to the standard land use planning process utilized by most government agencies, with a few exceptions. It is a logical, step by step process which moves from data collection through analysis to formulation of alternatives and selection of a recommended course of action to achieve a set of planning goals and objectives. The refuge planning process stresses the mandate of Congress to conserve fish and wildlife resources, and at the same time, to accommodate other resource uses as they are compatible with the purposes of the refuge.

It is organized into six broad phases, each of which has a number of steps. In order to accomplish each step, several tasks must be completed. The following is a list of the major phases and steps involved in the process, in the order in which they normally occur.

PHASE	STEP
(I) Pre-planning	(1) Establish planning framework
	(2) Identify issues and concerns (public meeting)
	(3) Establish planning criteria (objectives)
(II) Inventory	(4) Database definition and design
	(5) Data collection and conversion
	(6) Database development and implementation
(III) Analysis	(7) Characterize resource potential suitability/ capabiltity
	(8) Determine resource utilization demands/trends
	(9) Identify resource/use conflicts and compatibilities
	(10) Delineate planning analysis units
(IV) Synthesis	(11) Develop resource management scenarios
	(12) Formulate alternative courses

		of action
	(13)	Assess environmental impacts & consequences
	(14)	Evaluate alternatives (trade-offs)
	(15)	Select recommended course of action
(V) Review and Preparation	(16)	Review & finalize selected course of action
	(17)	Prepare draft/final planning documents
(VI) Plan Implementation and Monitoring	(18)	Implement selected course of action (Plan)
	(19)	Monitor performance of Plan
	(20)	Update Plan, as needed

A major data item in the databases for the refuge planning process is landcover type. It forms the basis of most environmental models. Due to constraints with respect to the vast expanses of land, remoteness, lack of current, detailed, comprehensive data, inacessibility, and the short time frame for planning, it was decided that landcover type data be acquired from LANDSAT digital image data. Large-scale landcover data sets are generated from the analysis and classification of the images, in conjunction with digital terrain data from Digital Elevation Models. Both the LANDSAT and digital terrain data are geometrically registered to the appropriate 1:250,000 or 1:63,360 scale USGS quadrangle base maps.

The involvement of GIS technology has become an integral part of Phases II-V in the planning process. The GIS (a) organizes and manages the refuge data, (b) analyzes the data in the generation of habitat productivity and resource suitability models, (c) summarizes the analytical results for the evaluation of environmental impacts expected from the implementation of several management alternatives, and (d) displays the results in graphic form for the preparation of planning documents. Many individual steps and tasks in the planning process rely upon the capabilties of the GIS. The following sections summarize the major points of the GIS involvement.

DATABASE DEVELOPMENT

The development of the databases for each of the refuges in the refuge planning process involves three major steps, each of which requires the GIS. Once the major issues, concerns, and problems have been identified by the planning staff through public "scoping" meetings, they are analyzed to formulate the major questions which need to be addressed in the refuge plan. From these questions, a comprehensive list of data elements required to answer the questions is assembled. While the planning staff identifies the sources of the data elements and acquires them, the computer systems analysts complete the definition and design of the database in which the data elements are to be stored. This step involves decisions about the (a) organization of the data elements for efficient storage, retrieval, and analysis, (b) coding schema to represent the values of the data elements, and (c) structure of the database.

Following the acquisition of the data elements, they are assembled and prepared for conversion to digital form. The process of conversion involves "digitizing" the spatial (map) data and "key entry" of the text/tabular data associated as attributes with the spatial data. Conversion of large amounts of data is a very time consuming, expensive, but essential process in the development of databases for large refuges. At times, there may be certain data elements which already exist in a digital form, such as the LANDSAT derived landcover type data and the digital terrain data. In this case, these need only to be "reformatted" to change them into a structure compatible with the remainder of the database. The majority of the data elements are in the format of digitized lines, points, and areas, or what is referred to as "vector" data. In order to be compatible with the landcover type and the digital terrain data, which are in "raster" (grid cell) format, the vector data must be transformed through a procedure called "rasterization". Once in the raster format, it is combined with the existing raster data and loaded into the previously defined database, along with its associated text/tabular data (attributes). At this point the refuge planning database is complete and ready to be utilized in support of the next phase of the planning process.

DATA ANALYSIS

The data analysis phase utilizes the GIS to accomplish two major objectives. The first is to characterize the nature of the specific resources, values, and land uses within the refuge. This involves selecting various data elements and/or items from the database and displaying them in order to better understand the nature of the individual data elements and the relationships amongst them. The analysis of public issues, concerns, and problems identified a number of important species of fish and wildlife, as well as several important uses of the refuge's resources and values. The second objective is to determine (a) the potential productivity of the environment as fish and wildlife habitat, and (b) the potential capability/suitability of the environment to support various land uses. A crucial technique to accomplish this is "modelling". A model combines various essential data elements in a logical manner according to the relationships that characterize the phenomenon in the real world. It seeks to "simulate" the nature of an individual, population, event, process, etc., so that the planning staff can study the phenomenon without the need for large amounts of empirical data.

The process of modelling in a GIS involves 9 major steps, which illustrate a logical flow of information from the initial idea and development of the model to the final results.

(1) Develop "conceptual" model
   * Define relationships among elements of the environment, the data specifications, and the criteria for the model.
(2) Develop "logical" model
   * Determine GIS program logic required to implement conceptual model.
(3) Write GIS program code to implement logical model
(4) Key enter GIS program code
(5) Execute GIS program code
(6) Display results of the model
   * Graphic output (plots)
   * Tabular reports (printouts)
(7) Verify model results
   * Modify previous steps as necessary and repeat
(8) Generate final results of the model
(9) Document the model

The conceptual model is developed most often by resource experts familiar with the phenomenon in question, in conjunction with the planning staff. Once it has been finalized, a computer systems analyst translates the conceptual model into a logical model, programs the GIS code, and executes it to produce the specified results. The results are verified by the resource experts and planning staff, and modifications are requested, if necessary. The GIS provides the capability to run through several iterations of a model, thereby allowing the planning staff to examine several different sets of data specifications and model criteria in a relatively short period of time. Traditional methods have involved intensive manual "overlays" of many data sets on a light table, which is very time consuming, and in some cases, limiting with respect to complex models.

The results of the modelling process are output as graphic displays (plots) and tabular reports (printouts) which show the location of the derived data elements (ie. classes of Brown Bear habitat potential), as well as the description of their characteristics (ie. area, frequency of occurrence, etc.). These output products are utilized by the planning staff to assist in answering the questions defined in the pre-planning phase. Sometimes the results of several models form the input to a larger, more complex model. For example, several individual bird species habitat potential model results could be combined into one model of habitat value for <u>waterfowl</u>.

<u>ASSESSMENT OF ALTERNATIVES</u>

The analysis phase leads to the synthesis phase where the analytical results provide the basis of the formulation of alternative courses of action, each of which is designed to address the issues, concerns, and problems of the refuge to a different degree and with a different management strategy. In order to provide a rational, logical, and defensible position for selecting one of the alternatives at a later point in the process, an assessment of the environmental impacts to be expected from implementing each alternative must be completed.

Each alternative develops a set of management units, which allocate specific resource management and utilization activities to different areas of the refuge. The particular geographic boundaries of these management units may vary from one alternative to another. In order to assess the environmental impacts from each alternative, the GIS is used to "composite" (overlay) the boundaries of each management unit in each alternative with the modelling results and characteristics of the resources, values, and land uses for the same area. The result of the compositing procedure is a summary of the number of acres of each resource, value, land use characterisic, and/or modelling result within each management unit in each alternative. (ie. in alternative A, management unit 101, there are 130 acres of critical Brown Bear habitat, 485 acres of gramminoid marsh, 89 acres of State Patented land, etc.)

Using these acreage summary reports and the descriptions of the management strategies, the planning staff assess the nature, scope, extent, and magnitude of the impacts to the individual resources and values that could be expected from the implementation of each alternative. Each of the alternatives are assessed in the same way, and a narrative is produced to accompany the acreage summary reports. Following the assessment of the alternatives, the results are combined and tabulated for all the alternatives. By comparing the assessment results for each alternative with the other alternatives, the differences (changes) between the alternatives are summarized. These differences are indicated as "trade-offs" between the alternatives and are utilized by the planning staff to evaluate the alternatives for the purpose of ranking them. The evaluation and ranking are later used to assist decision-makers in selecting a recommended course of action (alternative).

DOCUMENTATION

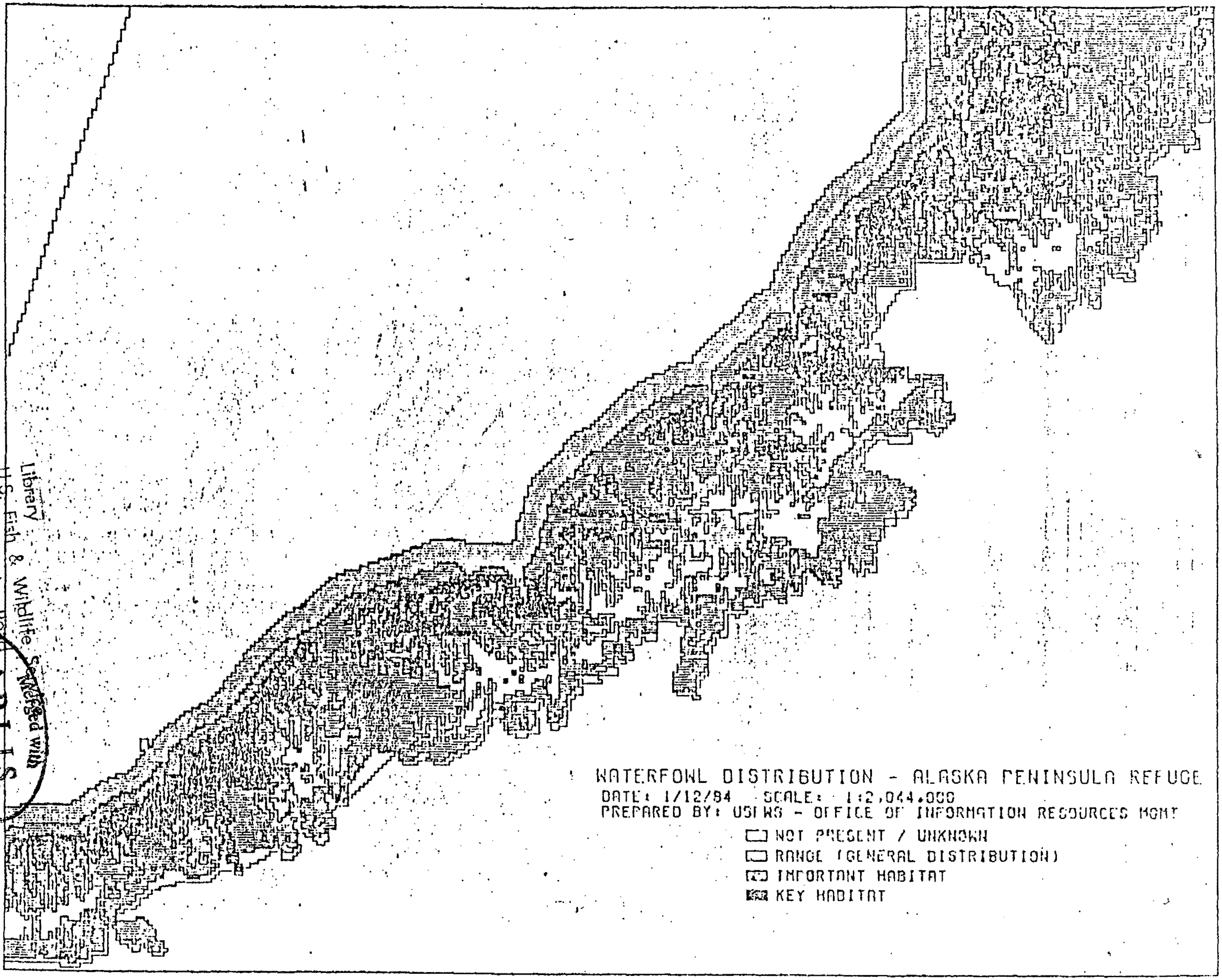
The last phase of the refuge planning process in which the GIS is involved to a significant extent is the review and preparation phase. Once a decision has been reached on the recommended course of action, and it has been through the public review procedure, the plan must be prepared in draft and final forms. The preparation of the plan involves documenting the steps in the planning process and the results of the various phases. Much of the documentation consists of the graphic displays (plots) and tabular reports (printouts) generated during the analysis and synthesis phases.

As a final task, the GIS is utilized to produce copies of the significant graphic displays in a form suitable for publication in the draft and final documents. The plots are generated at a size and scale consistent with the size and format of the rest of the document. The specifications of shading, color, symbology, annotation, etc. on the graphic displays are chosen to produce output products that are legible, easy to interpret, informative, and aesthetically pleasing. Examples of this phase are to be found in the appendix.

CONCLUSIONS

The National Wildlife Refuge Comprehensive Conservation Planning Process in Alaska is a complex activity being implemented under significant contraints on time, personnel, information, and budget. The process must respond effectively to a Congressional mandate for the development of plans on 77 million acres of refuge lands by 1987. Automated Geographic Information System technology and remotely sensed digital data have been successfully integrated into various phases of the refuge planning process, and has enabled a relatively small planning organization with limited resources to complete several plans close to schedule.

In addition, the utilization of GIS technology has provided a logical, systematic, and quantitative element to the overall planning process, which has helped to more effectively document the process, thereby establishing an added measure of credibility to the final plan. The use of remotely sensed digital data and GIS technology in the planning process is very well supported by the planning staff, as well as the executive management staff within the Alaska region and the Washington, D.C. office. The strategy in the future will involve increasing the capabilities of the automated systems, improving the efficiency of the entire support operation, and transferring more of the responsibility and capability for utilization of the automated systems directly to the planning staff. In the final analysis, the only real measure of the value and effectiveness of the GIS technology in refuge planning is whether or not it improves refuge management, and ultimately, the conservation of fish and wildlife resources.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