062790

Paper No. 90-3030
AN ASAE MEETING PRESENTATION

GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS IN AGRICULTURE AND NATURAL RESOURCES

by

C.J. Johannsen, Director
Laboratory of Applications for Remote Sensing

B.A. Engel, Assistant Professor
Department of Agricultural Engineering

R. Norberto Fernandez, Resource Information Manager
Laboratory for Applications of Remote Sensing

Purdue University
West Lafayette, Indiana 47907

Written for presentation at the
1990 International Summer Meeting
sponsored by
The AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
Hyatt Regency Columbus
at Ohio Center
Columbus, Ohio
June 24-27, 1990

SUMMARY:
Geographic Information Systems (GIS) provide many opportunities for managing information from many different sources. Applications discussed include: inventories for watershed analysis, determining crop production, soil erosion, wildlife habitat change, drought assessment, and research assisted by the GIS developed for the Indian Pine Natural Resources Field Station.

KEYWORDS:
Geographic Information Systems, Remote Sensing, Natural Resources, Satellites, Vegetation

ASAE
American Society of Agricultural Engineers

St. Joseph, MI 49085-9659 USA

GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS IN AGRICULTURE AND NATURAL RESOURCES

INTRODUCTION.

Since World War II, the United States have been in the throes of change that many refer to as the "information revolution". Author Alvin Toffler (1980), in his book The Third Wave, described three waves or revolutions that have radically changed the course of history, human condition and destinies of nations. The First Wave was that time from when a woman (the first farmer) planted a seed in the soil and the Agricultural Revolution was born, perhaps 15,000 year ago. The Second Wave which started about 300 years ago was called the Industrial Revolution.

The Third Wave of dynamic change in human history is now underway. This wave, that Toffler characterized as evolutionary changes in communication and information flow, is commonly called the "Information Revolution". It is also a time when we must reexamine our use of resources and our relationships to our environment, our life styles, and our ineffective political processes of crisis management as we confront one dilemma after another.

An important aspect that obscures our understanding of the use of our resources especially land, is that societies around the world that occupy and use lands still operate across the broad spectrum described by Toffler. Some still operate in the first wave, others in the second; only a few societies are beginning to use technologies and concepts of the Third Wave for developing, managing and conserving natural resources. In the United States, for example, many Federal and State Agencies are now making extensive uses of the technologies we call remote sensing and geographic information systems since both are useful for inventorying and monitoring natural resources as well as providing decision makers with useful data.

WHAT ARE GEOGRAPHIC INFORMATION SYSTEMS?

A geographic information system is a formal process for gathering, storing, analyzing, and dissiminating information about natural resources and social-economic data. Many times the information is in the form of a map that identifies such features as soil types, property units, townships, watersheds, and transportation networks. Databases associated with maps can be interacted through the GIS with the map information, used as part of a classification, or incorporated with a model or expert system to provide new data and information about a specific geographic area (Engel *et al.*, 1990a, 1990b). Remotely sensed data, such as those obtained from aircraft and satellite systems, are a valuable input to providing current information into a geographic information system (Johannsen, 1987).

Many resource managers have found that GIS provides a cost, effective approach for planning, development, management, and conservation of natural resources. The systems have been rather expensive in the past, but new developments in hardware and software have brought about great cost reductions. The user must be aware that the quality of the data in the system and the database maintenance is essential for accurate up-to-date information. Additionally, users need to be aware that there is a significant cost to inputing data in a geographic information system.

INFORMATION PROJECTS AND PROGRAMS.

GIS may appear to be a relatively new tool. The emphasis here is on tool as we are not talking about a new discipline. It is not really new as we have been using information systems for over 20 years. Dr. Roger Hoffer while at Purdue University in 1975 used elevation information and LANDSAT data to separate different vegetation categories (Hoffer, 1975). At that time, no one told him that he was using a geographic information system.

The best way to illustrate GIS applications is to discuss projects that employ this approach. Remote sensing was used in a number of these projects and one should remember that this is another tool at the disposal of resource managers.

WATERSHED INVENTORY.

One of the early projects using GIS was conducted by the Soil Conservation Service (SCS) working with the Laboratory for Applications of Remote Sensing (LARS) at Purdue University (Weismiller *et al.*, 1977) to look at watersheds in Chariton County, Missouri. This project used Landsat data to map land cover and overlaid this information with digital township, watershed, and physiographic position maps.

Physiographic maps, drafted from topographic and soil association maps, enabled the display of Landsat land cover categories by landscape positions, including bottom lands, gently sloping uplands and moderately steep uplands. Use of this information illustrated that one could make maps showing land cover by specific subwatershed areas and supply acreage of each cover type within a watershed. Further work with SCS showed that the data were useful for estimating runoff and sediment yields from a watershed during a certain time period of a specific rain storm (Weismiller *et al.*, 1977).

COUNTY LANDCOVER ANALYSIS.

Gentry County, Missouri had been experiencing significant changes through the 1970s with rolling pastures being plowed and planted to corn and soybeans. Cattle prices on the decline with grain crops increasing in price were significant factors in influencing this change. Through the use of Landsat data and its combination with a detailed soil map, it was possible to document this change as well as to calculate the total production potential of corn or soybeans for the trade area in Gentry County (Johannsen and Barney, 1981).

When an advisory committee viewed the information compiled about this County, an agribusiness representative noted that there had been a significant shortage or elevator space and railroad cars to move grain crops from the area during the previous years. Moreover, the potential for fertilizer and chemical sales had increased dramatically. Such specific data for all counties would have been advantageous to any industry dealing with the sale of agriculture supplies and products.

When SCS personnel reviewed the data, they noted a significant increase in soil erosion in the same county. The lose of pasture acres and dramatic increase in row crops on rolling land provided significant information needed by SCS technicians. Not only were they able to locate severe erosion, they were also able to adjust their manpower needs to assist in the soil conservation effort.

A wildlife biologist observing the dataset noted a significant decrease in timber habitat along with the pasture acreage. The loss of these habitats affected the deer population as well as other wildlife in the area.

An agriculture meteorologist viewing the data questioned if the changing cropping patterns in the area could have a significant impact on climatic patterns in the region. Changes in evapotransporation and loss of moisture at different times of the year could affect rainfall intensities and timing in areas several hundred miles away.

The most interesting point of having different advisory committee members looking at the same data was that they each interpreted the data based upon their own background and experiences. The map showing the locational aspects of data contributed significantly to their understanding and interpretations. It also reinforces that we see what we know.

1988 DROUGHT ANAYSIS.

The 1987 growing season in the Midwest was excellent due to adequate rainfall, warm temperatures and high humidity at the appropriate growth stages of corn and soybeans. The 1988 growing season was a contrast and will be known as the drought of the 80s.

LARS scientists working in cooperation with the National Oceanic and Atmospheric Administration (NOAA), the EROS Data Center and the Agriculture Research Service at Beltsville, Maryland used weather satellite images along with a geographic information system to study the effects of this drought. LARS digitized the Indiana Soil Association Map and locations of 121 weather stations so that this information could be studied in conjunction with the satellite images.

Soil patterns could be clearly distinguished by the variation in photosynthetically active biomass during 1988 (Lozano-Garcia *et al.*, 1990). It was very evident that the claypan soils in the northeast part of Indiana did not provide enough moisture nor was there enough rainfall received to sustain the vegetation in the areas. Farmers in this area recorded some of the lowest corn and soybean yields in the State.

THE INDIAN PINE NATURAL RESOURCES FIELD STATION.

The Indiana Pine Field Station, located eight (8) miles west of Purdue University, encompasses 100 square miles (259 square kilometers) of land area in the prairie-forest transition zone of the Midwestern United States. The field station serves as a site for interdisciplinary activity in basic and applied research, coordinated and disseminated in part through the development of multilayered databases and the application of advanced geographic information system technology.

The Indian Pine geographic information system includes soils, topography, watershed boundaries, drainage patterns, land cover (from numerous photography and satellite images) as well as road networks and utility information. Groundwater contamination research was had already been facilitated through the use of this data set (Ascough *et al.*, 1989). Purdue University's Agronomy Research Center, Animal Science Research Center, Martell Forest, Wildlife Station, Ross Biological Station and other lands are located within the field station. We are currently in the process of developing more detailed GIS structures for these land units for organizing and monitoring research activities. The field station serves as an interdisciplinary tool for undergraduate, graduate and continuing education. The use of the Indian Pine Field Station will assist in providing rapid and comprehensive understanding of both regional and global environmental processes.

A LOOK TO THE FUTURE.

There is significant usefulness that can be made of geographic information systems and seems to be limited only by funding and the imagination of those working with the system. Existing systems have been used for a variety of projects, such as inventory or assessment of forest cover, agricultural crops and wildlife habitats; the monitoring of forest conversion and timber harvesting, water resources or urban development; and the analysis of land impacts and mineland reclamation.

The future promises the development of better methods of collecting data, the possibility of more timely information and cost effective techniques, and procedures for bringing data and information to the users. There will be more flexibility in data selection, more versatility in data analysis procedures, and better distribution systems with a variety of graphic and map products. One can tailor maps, tables, and graphs to the users needs. Training opportunities for bringing more users in contact with this technology have already started. Many Universities are providing courses at the graduate and undergraduate level on geographic information systems.

The challenge of professional workers and decision makers is to learn how this technology can help to manage data and information about cultural and natural resources. One needs to plan now for the use of the limited resources available for integrating geographic information systems into the workplace as an aid in the decision making process.

REFERENCES:

Ascough, J., L. Deer, B. Engel, and E. Monke. 1989. Integrating geographical information and decision support systems to evaluate potential groundwater contamination. ASAE Paper No. 89-7608, ASAE, St. Joseph, MI.

Engel, B.A., C. Baffaut, J.R. Barrett, J.B. Rogers, D.D. Jones. 1990. Knowledge transformation. Applied Artificial Intelligence 4:67-80.

Engel, B.A., D.B. Beasley, and J.R. Barrett. 1990. Integrating expert systems with conventional problem solving techniques using blackboards. Computers and Electronics in Agriculture. 4(4):287-302.

Hoffer, R.M. and Staff. 1975. Natural Resources Mapping in Mountainous Terrain by Computer Analysis of ERTS - 1 Satellite Data Research. Bulletin 919, Agricultural Experiment Station, Purdue University, 124 pp.

Johannsen, C. J. and T. W. Barney, 1981. "Remote Sensing Applications for Resource Management," Journal of Soil & Water Conservation, Vol. 36 No. 3, pp. 128-132.

Johannsen, C.J., 1987. "Information Management," Chapter 3 in Making Soil and Water Conservation Work: Scientific, State and Federal Policy Perspectives D. W. Halbach, C. F. Runge and W. E. Larson (Eds.) Soil Conservation Society of America, Ankeny, IA, pp 37-45.

Lozano-Garcia, D.F., R.N. Fernandez and C.J. Johannsen, 1990. "Assessment of Regional Biomass-Soil Relationships using Vegetation Indexes. Submitted to Jour. of IEEE Geoscience and Remote Sensing Society.

Toffler, Alvin. 1980. The Third Wave. William Morrow & Co., New York, New York. 537 pp.

Weismiller, R.A., I.D. Persinger, and O.L. Montogomery. 1977. Soil Survey from digital analysis of satellite sensor and topographic data. Soil Science Society of America Journal 42: 1166-1170.