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REMOTE SENSING TECHNIQUES IN ENVIRONMENTAL MONITORING

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ABSTRACT

Increasing public awareness about environmental concerns is creating pressures on land managers. There is a need to develop provincial land use policy that benefits the majority of British Columbians, rather than representing the wishes of special interest groups. Before such a policy can be developed, information is required about the land base, its uses and socio-economic benefits, and about the wishes of its owners, as well as those affected by possible changes in the current landscape and ecological equilibrium.

Air and spaceborne remote sensing techniques provide cost effective tools for acquiring fundamental information that is required in land use planning and resource management. Geographic information systems, on the other hand, are needed for the management, manipulation and application of this land related information.

In this paper, the author gives a brief overview of the state-of-the-art technology that is currently used, or may be applied in the future, for geo-referenced land information systems.

INTRODUCTION

Airborne remote sensing techniques became popular after the second World War and have presented increasing applications in resource management. The conventional vertical aerial photographs, between 1:10,000 and 1:60,000 scales, have been utilized extensively by land managers during the past 25 years, especially in resource mapping and forest management. Geometric correction of these images have undergone a variety of phases, resulting in the production of maps, orthophotos and mosaics.

Spaceborne remote sensing, on the other hand, seems to have had a more controversial development. Although it can be more cost effective than its airborne counterpart, frequent misapplication and an overemphasis on research and development have shortchanged the potentials of this technology. With their gradually increasing resolution capabilities, images from such sources as Thematic Mapper (from the U.S. Landsat) and SPOT (from the French satellite), will likely find greater applications in the future.

A relative newcomer to this technological development is the airborne scanner, such as MEIS (a multispectral imaging system with a "push broom" scanner which can obtain data at varying resolutions, depending on the flying height of the aircraft.) Although it is considered to be somewhat costly, its high resolution will place it in a challenging position relative to medium and large scale aerial photography.

LAND INFORMATION SYSTEMS AND ENVIRONMENTAL MONITORING

Conventional hardcopy maps have reached a level of obsolescence as the principal source of information about the land and its resources. Because of the high demand for the land base by competing users, information requirements have changed from a single resource description to a multiple use one. In addition, the data must be stored so that it can be manipulated in a flexible manner. For this reason, geographic information systems have reached a general acceptance in resource management.

This new technology also allows the derivation of a wide range of products from the core data base, such as thematic maps, showing land use options and capabilities. Colour enhancement of such maps, combined with graphic illustrations of land productivity are also becoming highly popular.

However, as soon as a map is compiled, there is a high probability of it becoming out of date. Of course, this is mainly the case with renewable resources where changes may be caused by human activity, as well as by environmental factors. Hence, monitoring of the environment has become a major discipline in science.

Technology used for environmental monitoring depends largely on the level of detail used to describe a particular area, the frequency in occurrence of change, and the urgency of determining a particular change due to its potential impact. In addition, the type of technology used may depend on the extent of the area to be monitored, such as a region, country or even on a global basis.

TECHNOLOGICAL CHALLENGES

Traditionally, large field parties have been used to survey the land. Timber cruising, geological surveys and resource inventories had many common elements prior to the introduction of remote sensing techniques. Medium and small scale aerial photographs have provided opportunities to examine large areas in terms of such interest parameters as timber types, land forms, geological formations and agricultural uses. Extensive ground surveys have changed gradually to multiphase and multistage sampling designs, and for quality control. As the resolution of airborne remote sensing products has improved, even more field work has been substituted with large scale aerial photographs and photo sampling has become a new challenge to statisticians. Information that could only be obtained in the past from ground surveys, can now be closely approximated with the combination of extensive photo and limited ground sampling, used within the context of double sampling, or even higher order multiphase sampling designs. This was possible by correcting or "ground truthing" estimates from photographs from the sample measurements made on the ground.

Satellite imagery, such as the early versions of Landsat multispectral scanner data, has become fairly popular in a relatively short period of time, mainly because large areas can be covered frequently at lower cost than with conventional photographs. However, its low resolution has reduced its use mainly to monitoring changes, except in research and development environments, where claims have been made beyond its operational capabilities. With the advent of Thematic Mapper products, both spatial and spectral resolution have improved considerably, and the operational usefulness of spaceborne scanner products have increased, In addition, the release of SPOT data has shown resolution capabilities that can match conventional aerial photographs in many areas.

The major technological challenge of the 90's will be, however, the replacement of conventional aerial photographs with high resolution airborne scanner data, such as MEIS. When analyzed and colour enhanced, MEIS products can appear as if they were large scale aerial photographs, but have the main advantage of being in digital form. Once a library of spectral signatures can be compiled for such applications as forestry, agriculture, geology, land use, land production capability and environmental sensitivity, high resolution airborne scanner imagery will challenge aerial photo interpretation in a manner similar to the replacement of manual drafting by GIS.

The development of remote sensing technology has, in the past, occurred as a joint effort between researchers and resource managers. This development has not progressed as fast as it could have, mainly because both the users and those who have had major control on funding the new technology, have learned their resource management skills in a more conventional and manual environment for data acquisition. Hence, remote sensing techniques, especially those involving satellites, have undergone some scepticism and even resistance.

However, with the increasing concerns by the public about the environment and the changes that are being inflicted upon the land base, resource managers will be subject to scrutiny at a scale previously unimagined. Rightly or wrongly, practices previously considered acceptable and even cost effective, will be challenged. And the chances are that the challengers will have up-to-date information about the land base, using remote sensing technology, combined with powerful geographical information systems. In addition, in many cases the resource managers' own data will be used as the base, over which space and airborne scanner data will be displayed, showing the adverse effects on the environment.

Entrepreneurs working with land information systems are just a few steps away from setting up data marts, where, on floppy disks, information may be purchased about most parts of the world. Conflicts of land use and resource management practices, whether involving forestry, mining, agriculture or range, will be dealt with in the 90's from a new power base: current information, which can be manipulated at ease to highlight areas of concern.

Availability of information about the natural resources of a region, province or country created further problems or challenges. Surveillance of natural resources by competitors could become an active industry, creating both marketing and legal problems.

GIS AS THE INFORMATION SERVER

Information that is being accumulated about our resources and environment is constantly increasing. A large portion of the data is already in digital form and is georeferenced. As new descriptive statistics are becoming available at frequent intervals with remote sensing techniques, the size of the data base will create major information management problems. Geographic information systems have the functional capabilities of acting as information servers as well as data managers.

Currently, in British Columbia, a relatively large number of GIS installations have been initiated, many of which are PC-based, using 386 machines with at least 80 megabytes of storage. Most of these systems have been acquired to carry out contract work for the expanded forest inventory program. However, some of the consultants and contractors involved in this program are seeking expansion to other disciplines, such as land use allocation, environmental monitoring and mining. As the momentum of the digital conversion of land information increases, PC-based systems could become limiting factors to production and throughput. Provided that the healthy economic climate of this high tech industry continues in British Columbia, expansion of GIS installations from PCs to workstations and to more powerful processors, such as microVAX and VAX computers, will occur. Alternatively, the PC industry will advance in response to this demand, and microcomputer systems will be available to address increasing processing needs.

The projected expansion of the GIS industry will result in further decreases in cost for digital conversion, as well as for the management and distribution of land-related information. In fact, this expansion will likely move to a situation where a few wholesale distributors of land information feed the data to retailers, who will turn it into products that can be examined in a user friendly manner, perhaps even with home computers.

CONCLUSIONS

Public pressure on resource managers, to justify their decisions with respect to land use and environmental issues, will result in increased applications of remote sensing and GIS technologies. Demands for land-related information will increase and the data distribution industry will expand. A more informed public, and, in particular, special interest groups, will help to resolve some of the existing land use conflicts. At the same time, readily available data can become powerful weapons against decisions which are contrary to public interest.

Conventional aerial photographic products will be replaced by airborne multispectral scanner data in resource management, while the use of satellite imagery will expand in global environmental monitoring. Remote sensing technology will become the principal tool for data acquisition. GIS, on the other hand, will be used for the management and distribution of georeferenced land information.