International Journal of Computer Science and Informatics

Volume 3 | Issue 4 Article 2

April 2014

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MEGHA GUPTA
IITM Gwalior, Gwalior, meghagupta492@yahoo.com

ANKITA KHARE
IITM Gwalior, Gwalior, ankita.khare27@gmail.com

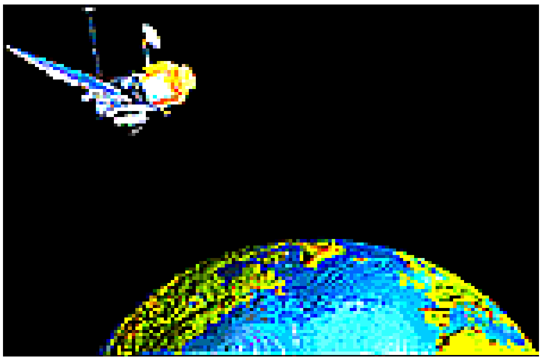
SRASHTI PATHAK
IITM Gwalior, Gwalior, srashti.cseengg@gmail.com

ROLE OF REMOTE SENSING AND GIS IN FORESTRY

MEGHA GUPTA[1], ANKITA KHARE[2] & SRASHTI PATHAK[3]

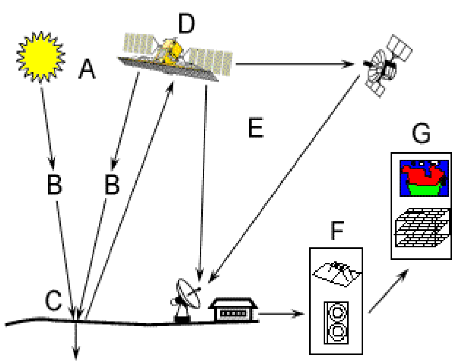
[1,2,3]Student(cs),IITM Gwalior, Gwalior
Email:meghagupta492@yahoo.com, ankita.khare27@gmail.com, srashti.cseengg@gmail.com
Mr. Pradeep Yadav, Asst. Prof. (CS/IT Dept.) IITM College

Abstract:- The Earth is constantly under observation from dozens of satellites orbiting the planet and collecting data. They are engaged in something called "remote sensing": the act of obtaining information about something without being in direct contact with it. Now-a-days the field of Remote Sensing and GIS has become exciting and glamorous with rapidly expanding opportunities. Many organizations spend large amounts of money on these fields. Here the question arises why these fields are so important in recent years. Two main reasons are there behind this. Now-a-days scientists, researchers, students, and even common people are showing great interest for better understanding of our environment. Development in complicated space technology which can provide large volume of spatial data, along with declining costs of computer hardware and software has made Remote Sensing and G.I.S. affordable to not only complex environmental/spatial situation but also affordable to an increasingly wider audience.



INTRODUCTION

Remote sensing is the examination or the gathering of information about a place from a distance. Such examination can occur with devices (e.g. - cameras) based on the ground, and/or sensors or cameras based on ships, aircraft, satellites, or other spacecraft.
Today, the data obtained is usually stored and manipulated using computers. The most common software used in remote sensing is ERDAS Imagine, ESRI, MapInfo, and ERMapper.



1.Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Target (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception, and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)

GEOGRAPHICAL INFORMATION SYSTEM

The expansion of GIS is Geographic Information System which consists of three words, viz. Geographic, Information and System. Here the word 'Geographic' deals with spatial objects or features which can be referenced or related to a specific location on the earth surface. The object may be physical/natural or may be cultural / man made. Likewise the word 'Information' deals with the large quantity of data about a particular object on the earth surface. The data includes a set of qualitative and quantitative aspects which the real world objects acquire. The term 'System' is used to represent systems approach where the environment consists of a large number of objects / features on the earth surface and their complex characteristics are broken down into their component parts for easy understanding and handling.

Over the past eight years, GIS technology has been widely accepted by public as well as private forestry agencies. In large part this has been a result of the benefit of using GIS technology over current forest maps. The primary management tool for timber production in America is the forest inventory. It is used to access the existing forest resource and develop harvest schedules and treatment programs to project future timber supplies and for other operational planning activities. Forest inventory data is collected using remote sensing techniques.

With GIS technology, the average age of the information in the forest data base could be reduced from 20 years to only a few weeks. The time factor alone has led to a wide acceptance and large demand for GIS applications in forestry.

VARIOUS APPLICATIONS OF GIS AND REMOTE SENSING:

FOREST MANAGEMENT

Forestry involves the management of a broad range of natural resources within a forested area. In addition to timber, forests provide such resources as grazing land for animals, wildlife habitat, water resources and recreation areas. The U.S. Forest Service is responsible for the management of forest harvesting, grazing leases, recreational areas, wildlife habitat, mining activities as well as protecting endangered species. To balance the competing resource conservation and resource use, activities must be accommodated. Accessing the feasibility of these multiple uses is greatly enhanced by the use of GIS techniques.

For example, the GIS for Flathead National Forest in Montana includes digital terrain data, vegetation associations from Landsat satellite data, timber compartments, land types, precipitation, land ownership, administrative districts and the drainage network. The GIS has been utilized for such analyses as timber harvesting, habitat protection and planning the location of scenic roads.

U.S. Forest Service and GIS Implementation

Virtually as government forest management agencies in North America have acquired or are acquiring a GIS. GISes have been widely used by the U.S. Forest Service. In the mid-1980's three national forests were selected as GIS evaluation sites. They were George Washington National Forest in Virginia, the Tongass National Forest in Alaska and the Siuslaw National Forest in Oregon. At each of these sites, a GIS was installed and comprehensive data bases for these national forests were implemented. A cost/benefit analysis was kept on the GIS systems for a three year period. The U.S. Forest Service has decided, after the three year period, to implement a standardized GIS data base for the entire forest service. A $150 million procurement has been initiated for GIS hardware and software to be installed in 600 locations beginning in 1991.

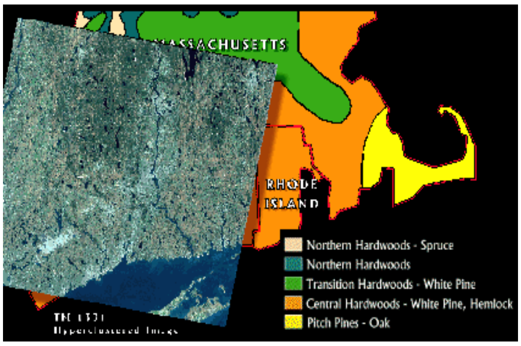
How Canada is Using GIS in Forestry

In Canada, almost every forestry agency has either implemented GIS or is in the process of implementing GIS technology. Forestry is a huge industry in the provinces. British Columbia's forest cover is 50 million hectares which is about 40% of the Canadian timber supply. (Aronoff, p.9) Before GIS, the forest databases were updated by aerial photography, field sampling methods and manual drafting. Under the GIS program, the forest maps were digitized and a forestry inventory can be updated constantly. GIS provides a way for forestry agencies to manage and manipulate their databases. Landsat satellite is used to update the individual maps that need current information due to forest harvesting and forest fires.

TIMBER MANAGEMENT

Timber management focuses on efforts to provide a continuous supply of trees for economically optimal wood production. In the recent past, foresters have relied on wood supply models to guide planning for optimal harvests that usually ignore specific geographic locations. These simulations describe the problem as follows:

While today's models are sufficient for defining and developing a spatial management design strategies for wood supply, they lack consideration of the geographic structure of forests and are insufficient for design of wildlife sensitive and operationally, i.e., economically, acceptable management.



GIS has now made it possible to incorporate spatial components into harvest planning and simulation models. In some cases, the modeling capabilities of a particular GIS may be used directly to aid decisions about timber harvesting; in other cases, an external model is linked to a GIS database. These models are typically called Decision Support Systems (DSS) or Spatial Decision Support Systems (SDSS).

Moore and Lockwood (1990) developed a planning system known as the HSG Wood Supply Model that directly incorporates a GIS to assist in the design and evaluation of long-range timber harvest schedules. In the HSG system, the fundamental GIS data layer is a forest stand inventory in which each stand is assigned attributes of the year of stand origin, productivity of the site, area, relative stocking factor.

GIS, FOREST FIRE AND FIRE MANAGEMENT

Forest fires have an important influence on the vegetation cover, animals, plants, soil, stream flow, air quality, microclimate, and even general climate. The loss of timber is obvious and so is the damage to life and property. The loss of recreation value of the forest and the destruction of wildlife habitat are also consequences of forest fires.

Researchers and scientists have long been trying to predict the behavior of a forest fire. Computer modeling has been the effort of many scientists using high resolution remote-sensing satellite imagery, powerful software, and GIS. In order to model a forest fire, the techniques for obtaining , analyzing and displaying spatial information in a timely and cost-effective manner are needed. As forest fires are spatial, GIS is used as a tool for modeling. A fire simulation program called FIRE! has been developed using ARC/Info. "The model puts the power of comprehensive fire behavior prediction into the hands of qualified ground resource managers where it can be most effectively applied."

Forests are often at risk of being destroyed by forest fires. So remote sensing can be used in efforts to reduce the risk and minimize damage if a fire occurs. Weather information allows foresters to calculate risk assessments and isolate the areas most susceptible to fire. Those areas can be closely monitored by satellites, such as high resolution Advanced Very High Resolution Radiometer (AVHRR) and Satellite Pour l'Observation de la Terra (SPOT). Images from these satellites are readily available and small fires show up on them almost immediately.

The effect of fire on forest resources is another important management concern. Management activities include fire prevention, wildlife control, prescribed burning, and post-fire recovery actions. The modeling capabilities of GIS have been quite effective in this context. Forest fire managers have used GIS for fuel mapping, weather condition mapping, and fire danger rating There are various Fire behavior models that have been developed from fuel models to predict the fire intensity based on factors such as slope, elevation, site exposure, wind speed, relative humidity, cloud cover, temperature, and live and dead fuel moisture. Remote sensing contributes to fire-fighting efforts, as well. Data on wind direction and speed, and the dryness of surrounding areas can help predict the directions and speed at which a fire spreads. With this information, firefighters can be dispatched with maximum effectiveness and safety, and fires can be put out before they cause much damage.

Radar and thermal sensing allow for constant observation of fires, unaffected by clouds, smoke, or other conditions that hinder aerial observation.

After a fire, damage can be quickly and inexpensively assessed by using AVHRR or Landsat Thematic Mapper data. With accurate information on the area of the burn scar, amount of biomass destroyed and the amount of smoke and air pollution, forest managers can efficiently proceed with recovery and planning.

During every stage of forest management, foresters can use remote sensing data to estimate future urban spread and population growth. Then, forest management can be planned taking into account the future needs of settlements. Urban planning data can also be applied to the management of urban forestry, to create inventories of trees in parks and on streets.

SAVING WILDLIFE AND OTHER PLANT SPECIES

The logical extension of commercial forestry is logging, and the nature of the industry requires long-term planning for cutting and regrowth. The accurate data from aerial photography and satellite images are used for planning and monitoring of these activities.
Before logging can take place, GIS assessments of forest ecosystems are performed to assess the impact on local wildlife species. This is another application of GIS, which usually uses SPOT or AVHRR satellite data to map regions where animal habitats are located. A remotely sensed tree species inventory can be used to identify rare or endangered plant species, as well as the habitats of animal species, based on the type of surrounding land cover.

Once the distribution of species is known, it can be incorporated into detailed and extensive maps, which are used to plan logging and regrowth. By using remote sensing data, foresters can make optimally informed decisions. They can be aware of the species distribution in a forest, the projected yields from logging, which areas contain habitats that cannot be disturbed, and how much land is needed for growth of settlements. After sections of forest are cut down, GIS and aerial photography techniques can be used to assess the speed and success of re-growth.

SOME OTHER APPLICATIONS OF REMOTE SENSING WHICH ARE HELPING FORESTRY

For ship route planning, Synthetic Aperture Radar (SAR) data is transmitted to ships in real-time. SAR systems provide long-range, high resolution images using extensive electronic processing of data, and can monitor the ocean surface and detect wave height and movement. Scatterometers, high frequency microwave radar sensors designed to sense ocean surface condition, are used to measure wind speed and direction at the surface. Combined data from these sensors provide reliable information on ocean activity and facilitate efficient route planning.

Ships themselves are tracked with radar to pinpoint their location and proximity to other ships. Using up-to-date remote sensing information, ships can travel via the most efficient routes, and can avoid hazardous conditions and collisions to transport timber without losses.
Finally, if an accident does take place during shipping, remote sensing can be used to minimize damage.

Rescue personnel use radar and aerial sensing to quickly locate a damaged ship. In the case of an oil spill, remote sensing information can be used to map the extent of the spill and track its spread by monitoring wave movement and wind speed.

By making shipping more effective, remote sensing aids the forestry industry at the end as well as the beginning of the timber cycle. From rising and monitor healthy forests to transporting the resulting timber to its destination, remote sensing is a valuable tool for forestry. However, forestry is only one example of the vast number of uses of remote sensing. With the use of multiple sensors and varied data locate and understanding techniques, remote sensing is a versatile tool that can provide data about the surface of the earth to suit to any need.

CONCLUSIONS

The range of applications reviewed in this paper is clear demonstration to the significant value of forests and the potential of GIS to aid in their management. Despite the diversity of applications, however, a number of broad conclusions can be reached about the role of GIS in forestry:

1. GIS applications can strongly benefit from remote sensing and image processing technologies. Forests are complex assemblages of species that lend themselves well to broad-level inventory through remote sensing. However, the need for strong ground-truth remains paramount and it is likely that satellite positioning systems(such as GPS) will play an important role in augmenting traditional forest survey activities.

2. Forests are a dynamic resource, affected by many concurrent ecological processes and direct management interventions. Simulation modeling has been applied in forestry. Simulation or *process* modeling is one of the more challenging areas of GIS applications and it is likely that this activity will increase as the research and tools to support this kind of application become more prevalent.

3. It is clear that throughout the world, forests are subject to many demands. As a result,many forest management problems have the nature of multi-objective planning procedures.

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