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LAND USE CHANGE DETECTION WITH LANDSAT-2 DATA FOR MONITORING AND
PREDICTING REGIONAL WATER QUALITY DEGRADATION

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ABSTRACT

The overall objective of this research investigation is to compare LANDSAT 1 & 2 imagery for land use change detection which may be correlative with variations in water quality. During the late summer and early fall of 1975, LANDSAT imagery was used to construct a map showing forest cover changes in the Cossatot River watershed of southwestern Arkansas (period of imagery coverage October 1972 to April 1975). Most of the changes were the result of commercial timber harvesting in the heavily forested upper half of the watershed. During the 30 month interval of LANDSAT monitoring, clearcut areas increased by 180 percent. Unfortunately only limited and incomplete historical water quality records are available for this area. Field investigations have revealed that at least during low or base flow conditions, the extent of land use change is not reflected in the stream water quality; however, an attempt will be made to obtain more meaningful water quality data.

During this past quarterly period, it has become obvious that while point-source pollution can be generally detected using the water quality sampling data collected by both State and Federal Agencies, non-point source contamination attributable to changing land use is completely masked. Preliminary data analysis would suggest that storm event water quality sampling is far more indicative of the actual influence of land use than information collected during scheduled periods. In addition to collecting storm event data, we are attempting to develop a computer program to analyze, model, and predict water quality under varying conditions, including land use and storm event data.

Introduction

The quality of surface waters can be influenced by many factors; however, land usage now appears to be the dominating factor causing the change in water quality of most streams and rivers in the United States. The extent to which land use change detection with LANDSAT 1 & 2 data can be used for monitoring and predicting regional water quality degradation is the fundamental question to be answered by this investigation. There are two obvious approaches that can be used in evaluating LANDSAT applicability; first, LANDSAT 1 & 2 imagery could be compared for change detection, then areas of change examined for water quality trends; and second, one might observe changes in historical water quality records and then determine if any land use changes have occurred. During the initial phases of this research investigation we are using both approaches.

Problems

One of the original major objectives of this investigation was to utilize historical stream water quality data (collected by various State and Federal agencies) with changes in land use. Although a great majority of samples were obtained biweekly, a number of stations were only sampled monthly. Inconsistency in sampling data has caused data analyses problems, however; regression analyses have been completed for most of Arkansas' water quality sampling stations.

Areas of obvious land use change (mostly forest clearcutting) detected on LANDSAT imagery often do not coincide with any of the sampling stations within the state's network, and consequently historical data are lacking. Even where adequate water quality data are available, it is becoming obvious that samples have been collected during the time period which does not

reflect the true relationship between water quality and land use. For example, when flow information is analyzed with water quality records, much of the collecting is accomplished during low flow or base flow conditions. While point-source pollution (sewage effluent etc.) may be obvious during low flow, most non-point-source contamination (mostly from surface runoff) attributable to changing land use will not influence the water quality. More specifically, during base flow conditions, we are seeing mostly groundwater in the streams which is controlled primarily by the kind of rocks and soil through which the water moves. Surface runoff (which will be influenced by land use) then, will have maximum input to stream water quality during storm events, and not during times of base flow.

We have selected several test sites to obtain storm event data during the approaching winter months of 1975, and spring and early summer months of 1976. Water quality sites from where land use changes are obvious will be contrasted with those where changes are minimal.

Accomplishments

Imagery Analysis. LANDSAT imagery was used to construct a map showing changes in forest cover in the Cossatot River watershed (530 sq mi) of Southwestern Arkansas for the period from October 1973 to April 1975.

Two color composite images of the Arkansas Ouachita region were used in completing the change detection map. Land use was first drafted from a NASA composite image acquired on 4 October 1972. EROS Data Center Photo/Scene ID Number for this image is 81073162335G200. The second (change) portion of the map was drafted from data contained on a LANDSAT -2 image with an acquisition date of 19 April 1975. By using the Diazo process, an IR color composite was constructed in the University of Arkansas Remote Sensing

Lab using positive transparencies of MSS Bands 4, 5 and 7, Photo/Scene ID number 82087161225N000. Data transfer from both images was accomplished with a Bausch & Lomb Zoom Transfer Scope.

Examination of the Cossatot watershed on both the 1972 and 1975 color images reveals an area generally dominated by the red hues of healthy forest vegetation. Slight variations in darkness appear to indicate distributions between deciduous and conifer forest. In a few areas it is possible to delineate stands of either strictly deciduous trees (light red) or strictly conifer trees (dark red). However, most of the forest has an intermediate hue which appears to be characteristic of a mixed forest. Agricultural lands may be readily distinguished against the forest background by their bright orange hues, as well as by their regular geometric patterns. Clearcut forest areas on the 1972 image are mostly characterized by a pronounced gray color. During the field check, it was discovered that controlled burning is used to eliminate remaining deciduous cover after the harvesting of pines in the mixed forest. This appears to account for the gray colors noted on the 1972 image. The 1975 image has no such gray areas, but does include a number of additional sites, with colors ranging from pale gray-red to a bright, off-white hue which is principally composed of pale blue-green from the Band 7 (Cyan) component of the image.

A field check of a portion of the commercial timber forest of the Cossatot area was conducted on 4 and 5 August, 1975. A total of 28 suspected clearcut sites were located on the ground. Twenty-seven of these were confirmed as clearcuts. (On about one quarter of the sites, deadened hardwoods remained in place following pine removal). General accuracy of the map produced from interpretation of the LANDSAT imagery was thus confirmed. The

single error detected in the field was due to a confusion of the light tones produced by a large stand of strictly deciduous vegetation with the similar tones which characterize many clearcuts. The misidentification was made on the April, 1975 image, and it is believed that such errors would be less likely if the imagery was acquired later in the growing season.

Estimates of total areas (in square miles) in each of four principal land-cover categories were made at the completion of the mapping project. These data are summarized for the entire watershed as follows:

	October 1972 <u>sq mi</u>	April 1975 <u>sq mi</u>	Percent Change
URBAN	3.5 (1%)	3.5 (1%)	No change
AGRICULTURAL	75.1 (14.0%)	76.6 (14.5%)	+ 2%
FOREST	434.7 (82.0%)	404.8 (76.5%)	- 7%
CLEARCUT	<u>15.7 (3.0%)</u> 529.0 (100%)	<u>44.1 (8.0%)</u> 529.0 (100%)	+ 180%

Attempts to relate the observed changes in land cover with changes in water quality by a comparison of past and present stream conditions have thus far proven unsuccessful. A search of available water quality records for Arkansas has failed to produce continuous, thorough data for this stream for the period prior to 1972. Regularly scheduled monitoring of water quality in the Cossatot by the State Department of Pollution Control and Ecology did not begin until the spring of 1974. Prior to that time, a limited number of sample analyses were made by the Water Resources Division of the U.S. Geological Survey. Unfortunately, USGS records do not include any data for the middle portion of the watershed (below the commercial timber forest) after 1959. In 1971, the U.S. Army Corps of Engineers in-

cluded a water quality study of the Cossatot in an Environmental Impact Statement prepared for the Gillhan Dam project in the middle watershed. Only a single sample collection was made at each of four different sites. Samples were collected on a one-time basis only at four different sites within the watershed. Because of the lack of historic water quality data, an attempt will be made to monitor more recently acquired data. In addition, we plan to monitor this area during a storm event.

Water Quality Data Analysis

Arkansas water quality data have been collected by various State and Federal agencies for over 40 years. These data have been compiled, published, and stored in a data retrieval system by the Arkansas Department of Pollution Control and Ecology, and by the USGS (in cooperation with the Arkansas Geological Commission). Arkansas water quality data are stored on magnetic disk in the IBM 370 computer system of Optimum Systems Incorporated of Bethesda, Maryland. Minimal effort has been expended to analyze these data in detail in an attempt to define long term trends, seasonal variation, or water quality characteristics of data collection points. Water grab samples are taken on a regular basis at over 200 sites in the state. The great majority of samples are taken every two or three months, but in some cases the samples are or were taken bi-weekly. Although Arkansas water quality studies have been published, consideration was given only to mean values over periods of months and sometimes years. While it has been possible to detect obvious stream pollution using this method, variation and fluctuation in water quality is masked. In addition, data analysis suggests that the stream water quality reflected in historic

records does not reflect the influence of changing land use, but simply reflects point-source contamination. In an attempt to make use of the historical water quality data, we are attempting to develop a computer program to analyze, model, and predict water quality under varying conditions, including land use. Storm event data will be an integral part of this program development.

Significant Results None

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Recommendations None

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