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FOREST REGENERATION ASSESSMENT FROM HIGH-RESOLUTION SATELLITE DATA

Summary of Final Report

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INTRODUCTION

The objective of this study was to determine the potential of high-resolution LANDSAT Thematic Mapper (TM) and SPOT satellite data, analyzed by digital classification methods, for the preliminary stratification of coniferous forest regeneration. In the early 1980s, the Ontario Centre for Remote Sensing (OCRS) experimented with the use of low-resolution data from the early LANDSAT satellites for this purpose. Although this imagery was utilized with great success for generalized vegetation cover mapping, it was found to provide insufficient detail for stratifying regeneration on cutovers.

During this same period, OCRS was developing an operational regeneration assessment procedure based on colour infrared aerial photography. This technique not only permitted stratification of cutover areas, but also provided a method of visual plot sampling from which the stocking and density of the new trees could be estimated (Goba et al. 1982). This procedure has been successfully implemented by field offices of the Ministry and by commercial forestry operations in Ontario. Significant cost savings and increased productivity over the traditional intensive field survey have been demonstrated.

On the basis of experience with both the low-resolution satellite data and the airphoto-based assessment procedure, it was postulated that high-resolution satellite data might offer sufficient detail for a preliminary stratification, even if it did not permit a closer examination of the quality of regrowth.

METHODOLOGY

Three study sites were selected within the Precambrian Shield of northwestern Ontario and the Clay Belt of north-central Ontario (Figure 1). These sites, located at Ignace, Smooth Rock Falls and Eaglehead Lake, contained a wide range of forest cutover age classes and thus provided the opportunity to attempt identification of regenerated forest at various stages of growth.

LANDSAT TM and SPOT imagery recorded in late spring and summer were obtained for each of the study areas. Previous work in airphoto-based regeneration assessment had indicated that the optimum period for conifer regeneration assessment was late spring, after the snow had melted and before deciduous trees were in full leaf. Later in summer, the spreading crowns of the deciduous trees tended to obscure the tapered tops of the conifers. The same time-period was expected to be best for recognizing conifer regeneration on the high-resolution satellite data; nevertheless, good-quality, cloud-free summer images were examined as well. (Results ultimately showed the necessity of using both dates together.)

The digital satellite data was read on the OCRS digital image analysis system and geometrically corrected to and combined with latitude and longitude coordinates and a UTM grid. Large 1:30,000-scale image-maps were then produced of the images using the OCRS Versatec electrostatic colour plotter. From these maps, cutovers were selected within each study site for detailed field examination. The maps were also used in the course of the fieldwork, both for orientation and for recording the location of the field sampling sites.

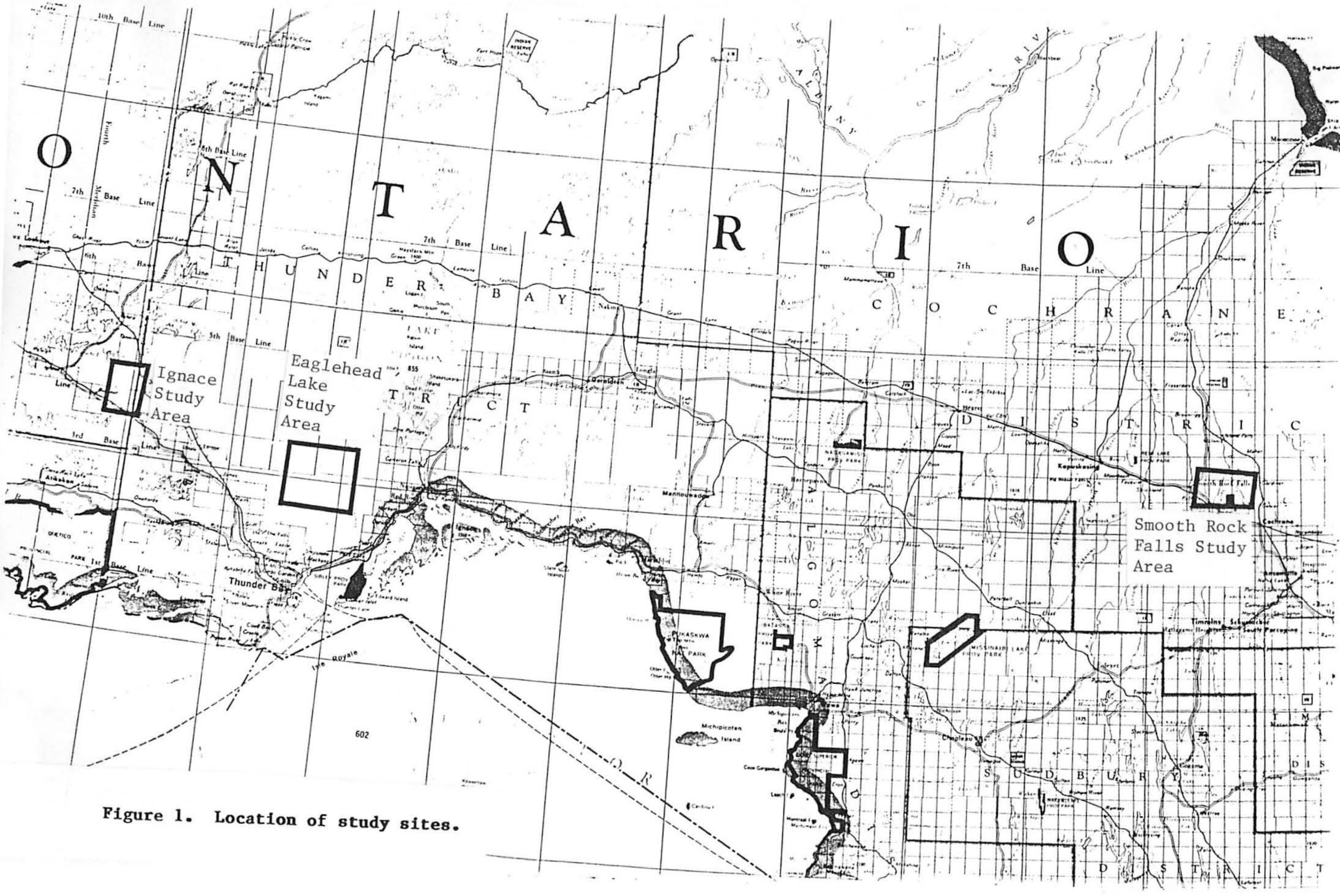

Figure 1. Location of study sites.

The field checking was carried out for all four study sites over a one-week period, using helicopter transport. The field crew consisted of two foresters, a forest technician specialized in regeneration surveys and a geomorphologist specialized in applied digital image analysis. The following observations were recorded: type of regeneration (natural or planted), estimated age of the regeneration, stocking, type of ground cover (grass, shrubs, slash, etc.) and site topography. The sequential stocked-quadrat tally method (Dick, 1963) was used to determine stocking. A stocking chart annotated with a 95%-confidence curve was employed in recording the stocking samples to ensure that a sufficient number of samples were taken.

Following completion of the fieldwork, the locations of the field-checked sites were pinpointed on the digital satellite data for each study area. Values obtained from the pixels covering these locations indicated the intensity of reflectance from the scene, in the green and red visible-light bands and in invisible bands of near-infrared (non-thermal) energy. The set of values from all bands for a single field-checked location formed the "spectral signature" representing the vegetation conditions of that location. Each signature was defined as a distinct map class. Through the use of image analysis software, all occurrences of this same signature over the surrounding cutover site were identified and colour-coded.

The classification map produced from extrapolating the spectral signatures proved too detailed for convenient ground-checking; it would have been difficult to locate very small, isolated occurrences of the classes in the field, with any precision. This level of detail resulted both from the narrowness of the classes defined from the spectral signatures and from the high resolution of the satellite data itself (30 metres for LANDSAT TM and 20 metres for SPOT). The analysis results were, therefore, "filtered" to remove all occurrences smaller than 2 ha -- an element still much finer than could have been isolated on the low (80-metre) resolution of earlier satellite data.

The first field excursion had been conducted to obtain ground information about the classes, to form the basis of initial image analysis. The purpose of the second field excursion was to check whether the digital analysis method had been successful in extending the classification over areas not previously studied in the field -- that is, whether the vegetation in an area was actually and exclusively what the map said it was.

Maps were produced of all study sites at a scale of 1:50,000 to display the final classification results. From a close comparison of the field data, including on-site photography with these maps, an assessment was made of the value of high-resolution satellite data analysis for the purpose of initial regeneration stratification.

FINDINGS

A separate discussion of each of the three study areas is provided in the complete report, including a description of the process of preparing and analyzing the data and a statement of findings and conclusions. The conclusions reached are as follows.

The relatively homogenous areas of well-stocked jack pine regeneration present over the *Ignace* study area offered ideal conditions, for the use of digital satellite data classification for the initial stratification of conifer regeneration. Results from the Ignace study area suggest, however, that the method is unreliable for distinguishing and identifying regeneration classes. The primary reason is that spectral information gathered from a vertical perspective above regenerated areas is an amalgam of values from the conifer crowns, values from the cover or whatever vegetation is open to the sky between the trees, and values from any deciduous crowns towering over the conifers. The seasonal variation in breadth of contrast across the scene can also introduce false distinctions. Still, satellite imagery does provide an overview of cutovers and, in the case of multi-year logging operations, serves to trace the general progress of cutting and regeneration. It can be invaluable as a reference base for compiling and recording regeneration data from field records and airphoto assessment.

Analysis of both the *Smooth Rock Falls* and *Eaglehead Lake* sites indicated that regeneration assessment based on classification of high-resolution satellite imagery is not feasible. Although the field data collected over the two sites is too little to allow a rigorous statistical treatment of the samples, comparison of regeneration survey plots located in any particular satellite data-based class suggested that regeneration has little influence on the results of digital classification of satellite imagery. Visual inspection and photographs of readily identifiable areas representing satellite data-based regeneration classes supported this observation; the general land cover, of which the conifer regeneration is but a small part, seems to be the deciding factor in the outcome of digital image analysis. Common sense and theoretical considerations would lead to the same conclusion.

The vague correspondence between satellite data-based classes and the age of the cutover (the latter being loosely linked to the age of the planted or natural regeneration) is, therefore, due to the changes of vegetation in general within the cutover. Consequently, the greatest value of satellite data for the assessment of cutovers appears to be in its ability to provide up-to-date, site-specific information on the absence, presence, type and extent of competing vegetation.

LITERATURE CITED

Goba, N., Pala, S. and Narraway, J. 1982. An instruction manual on the assessment of regeneration success by aerial survey. Forest Resources Group, Ont. Min. Nat. Res., Toronto, Ont. 50 pp + appendices.