MAPPING JACK PINE DISTRIBUTION BY SATELLITE

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ABSTRACT.--Satellite imagery was used to determine the distribution of *Pinus banksiana* Lamb. in a portion of central Ontario. Uniform, even-aged stands of fire origin had characteristic color and texture patterns which were easily distinguished from other natural vegetation. Accuracy of satellite image interpretation was checked by comparing with forest type maps, and was found to be very high - areas as small as 32 hectares could be positively identified and located. Use of small-scale satellite imagery gave a perspective not before available, since natural groupings of P. *banksiana* were readily apparent over large areas.

The P. *banksiana* distribution maps generated by a province-wide satellite survey will enable the forest geneticist to examine the population structure of the species in Ontario and plan a systematic sampling program which will identify genetically sound material for future tree improvement work.

INTRODUCTION

IN ONTARIO, JACK PINE (*Pinus banksiana* Lamb.) is a very important component of the boreal forest, comprising about one-third of all softwood timber harvested (Ontario Ministry of Natural Resources, 1978). Because of the serotinous nature of its cones, the species is especially adapted to reseed itself in extensive, pure, even-aged stands following fires (Rowe and Scotter, 1973). This characteristic results in a mosaic of jack pine stands distributed across the landscape, occupying the dry, sandy soils to which it is well adapted (Morgenstern, et al 1975).

Because of its relative importance in boreal Ontario, jack pine provenance testing was begun in the early 1950's with a small number of widely distributed seed sources. Currently, three provenance trials which include Ontario seed sources are yielding information on geographic variation (Yeatman, 1974a). Results show that in addition to clinal variation associated with climatic factors, there is considerable variability between provenances within certain geo-climatic regions. Provenance data indicates a region of slow growth north of Lake Superior and east of Lake Nipigon (Yeatman, 1976). The regions of western Quebec and southeastern Ontario have significant amounts of variation between provenances (Yeatman, 1978). For example, progeny tests indicated relative uniformity among stands within the Upper Ottawa Valley (Yeatman, 1975); however, progeny from a source located 40 miles west grew significantly taller than Ottawa Valley trees (Yeatman, 1974b).

With confirmation of inter-population variation from existing provenance tests, the next stage in jack pine genetic improvement is clear. Regional population structure and variation must be determined so that superior breeding populations or stands can be identified and silviculturally managed as seed collection areas to supply the immediate and near-future needs of Ontario's reforestation effort. In addition, the identification of genetically superior populations will enable the forest geneticist to move to the next phase of development, selecting superior stands for seed production and superior individuals for inclusion in seed orchards and breeding populations (Buchert, 1978; Yeatman, 1978).

The need for accurate jack pine distribution information upon which to base a tree improvement plan led to the idea of using satellite imagery to map the extent of jack pine occurrence in Ontario. The characteristic pure, evenaged stands seemed ideal for differentiation from other boreal species by radiance values from LANDSAT multispectral scanners. Briefly, LANDSAT satellites circle the earth in a near-polar orbit; passing over North America in a north-to-south direction at an altitude of about 912 km (570 miles), any given point on the earth's surface (except a small circular area at each pole) is covered every nine days. The multispectral scanner (MSS) continuously records radiance measurements of a 185 km (111 miles) wide swath of the earth's surface in four spectral bands, with a resolution of 79 x 79 m or 0.6 ha (259 x 259 ft., or 1.5 acres) (Zsilinzsky, 1973; Kalensky and Sayn-Wittgenstein, 1974; de Steiguer, 1978). Two Canadian stations receive MSS data, which is then stored on magnetic tape. When needed, data-created images of one or more bands are produced electronically and copied on photographic film.

To determine the feasibility of recognizing jack pine on small-scale satellite images, a pilot project was initiated. Images of an area of known jack pine occurrence were examined and compared to forest type maps compiled from aerial photographs.

MATERIALS AND METHODS

An area in central Ontario was chosen for examination (Figure 1) and two LANDSAT images were used in the comparison, image E-20388-15370, a winter scene of 14 February 1976 (Figure 2) and image E-20496-15335, a late spring scene of 1 June 1976. Contact paper prints of scale 1:1,000,000 were obtained from Integrated Satellite Information Services, Prince Albert, Saskatchewan in each of two MSS false-color composites, Color-1 (combination of bands 4, 5 and 7) and Color-2 (combination of bands 5, 6 and 7). The images of the two dates cover an identical area of 34,000 km^2 (13,000 square miles) north of Lake Huron and east of Sault Ste. Marie, Ontario (track 22, position 27). Included in the images are the towns of Espanola and Elliot Lake in the south and Chapleau and Gogama in the north.

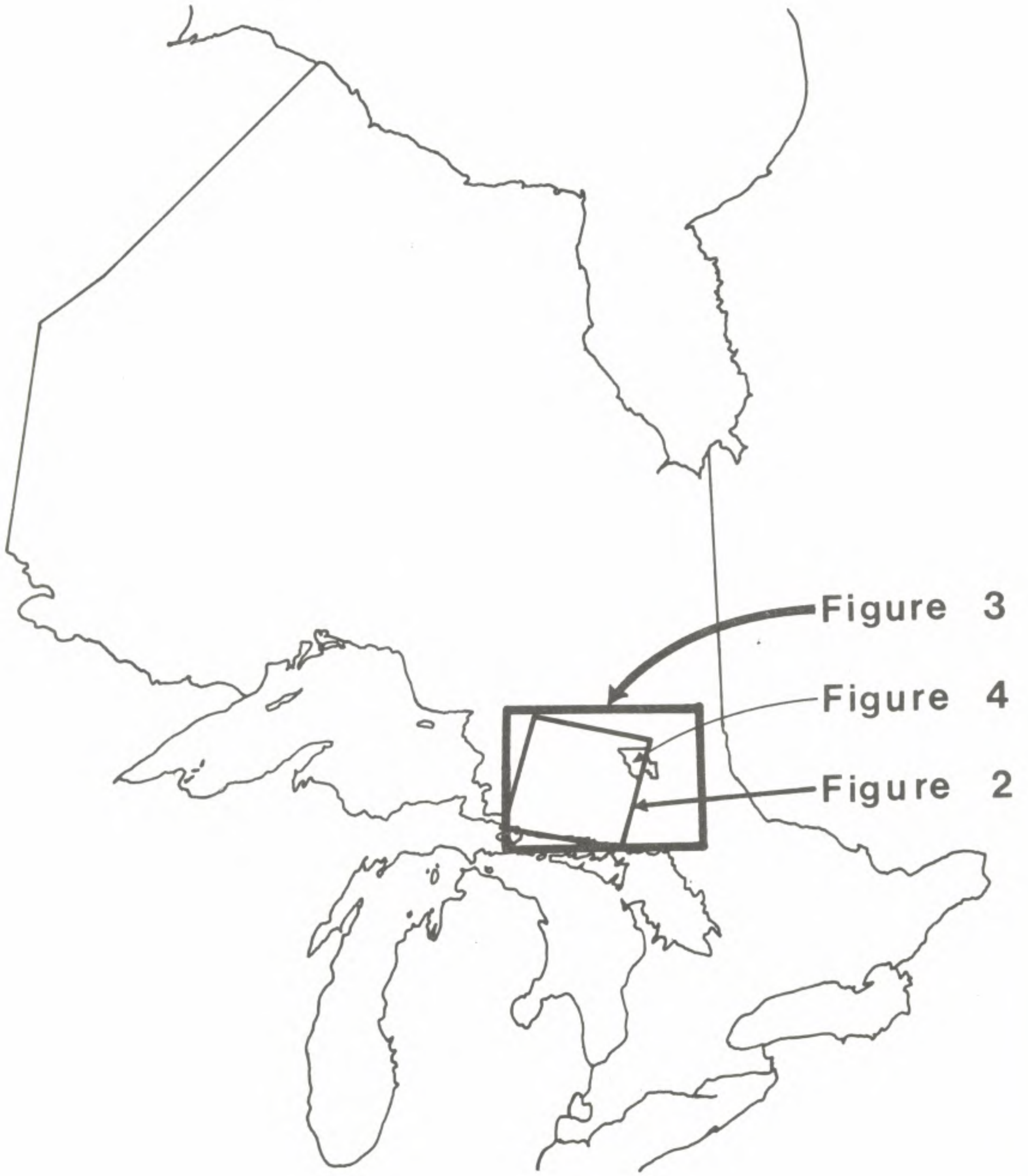

Figure 1. Map of central Ontario showing area of study. Relationships between base map (Fig. 3), satellite image (Fig. 2) and type map "ground truth" (Fig. 4) are indicated.

Figure 2. Black and white reproduction of Color-1 composite winter LANDSAT image of study area in central Ontario.

Information from the satellite images was transferred to a 1:500,000 series National Topographic System basemap, number 41 N.E. (Chapleau-Sudbury) (Figure 3), by a Bausch & Lomb Zoom Transfer Scope.

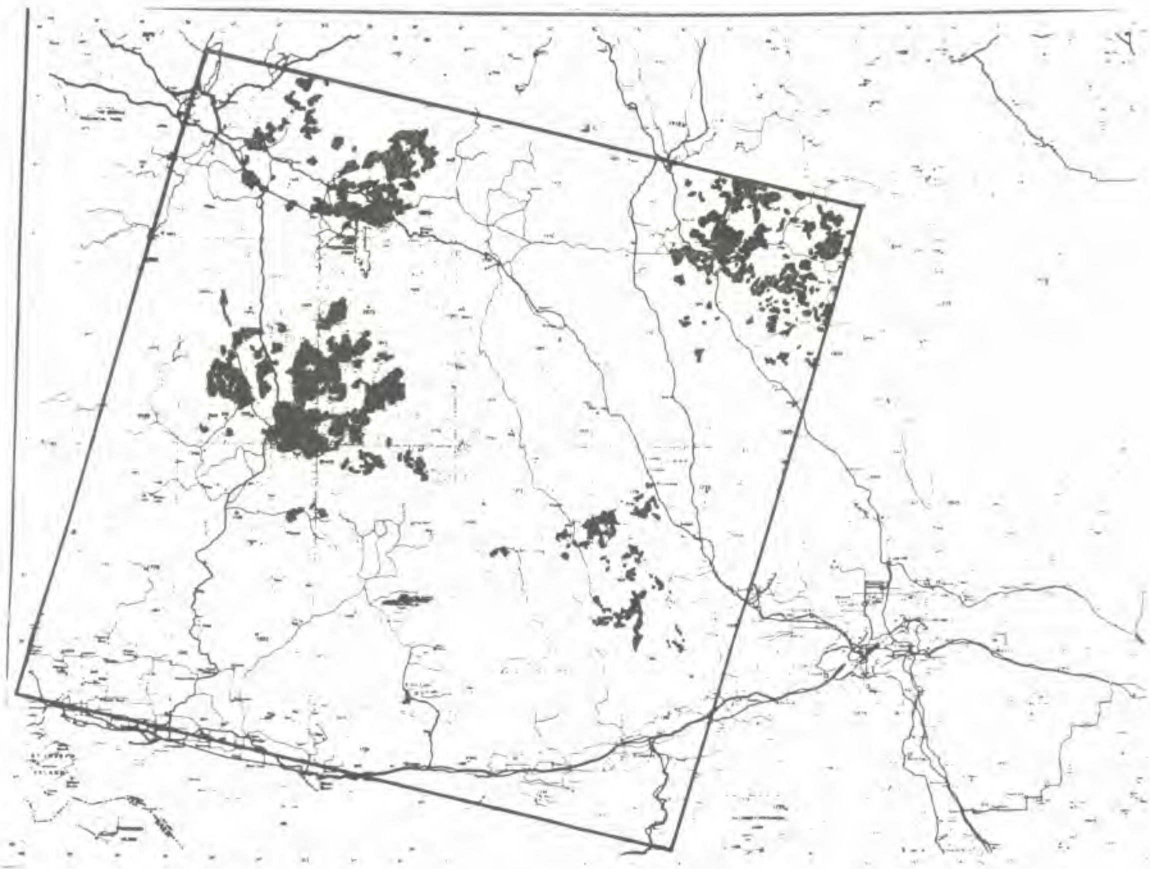

Figure 3. Black-and-white reproduction of 1:500,000 National Topographic series base map. Jack pine interpreted from satellite imagery shows up as black areas.

This instrument allows for optical matching of maps and images of different scales, and also can optically reduce geometric distortions common in remotely sensed data. Suspected jack pine occurrence was first matched to local geographic features on the basemap, such as lakes or rivers, and then penciled on.

In order to assess accuracy of image interpretation, areas on the basemap which were shaded as jack pine stands were compared with large-scale (1:63,000) forest type maps of those areas with suspected jack pine concentrations (Figure 4). On the type maps lakes and rivers were first colored blue, then stands with 60 percent or more jack pine were outlined and finally shaded red. This "ground truth" was then visually compared with both imagery and basemap.

Figure 4. Black-and-white reproduction of the south part of the Shining Tree Management Unit Forest type map used as "ground truth". Stands with 60 percent or more jack pine are shaded red, while lakes and rivers are colored blue.

RESULTS

Jack pine has a distinctive color tone and texture which, with a little practice and experience, is easily recognizable on LAINDSAT color-composite winter images. When comparisons between imagery and forest type maps were made, those areas on Color-1 composites appearing as reddish-brown (5 YR 4/6; Munsell Soil Color Charts) were verified as jack pine. Winter imagery proved to be much more valuable than imagery acquired during the growing season, because in winter mixed vegetation appeared blue in the false-color rendition, while jack pine remained reddish-brown. In summer however, all vegetation appeared reddish-brown; all but the largest jack pine stands became indistinguishable from surrounding vegetation. Unique to pure stands of jack pine was a smooth uniform texture, probably conditioned by age and height uniformity as well as dense stocking. Subtle color tones appeared to be conditioned by stand age, with younger stands (20-35 years) generally appearing somewhat lighter than older stands (40+ years). However, stand age was not an important factor in distinguishing jack pine from other species. In areas where the type map showed several or many adjacent stands, satellite imagery depicted a general concentration of jack pine - individual adjacent stands were not generally recognizable. Resolution of jack pine/mixed vegetation was surprisingly good; critical comparisions between imagery and forest type map showed that stands composed of 60 percent jack pine or more could be positively identified and located.

Jack pine was also distinguishable on MSS Color-2 composites, appearing as a greenish-blue tone (2.5B 4/8; Munsell Color Charts for Plant Tissues). Here, however, contrast between jack pine and non-jack pine vegetation was not as great as on Color-1 composites, since all other vegetation appeared as different shades of blue. Furthermore, unlike Color-2 imagery, stand age differences were not discernable as tonal difference.

Initially, there was some confusion between jack pine occurrence and mature, mixed red and white pine stands in one area, on the north shore of Rawhide Lake. However, after verification by type map and further experience in identifying jack pine, it became quite apparent that the red-white pine stands were very much darker in color than the jack pine, and no further misclassifications were made. To further test image reliability, small areas identified as jack pine on the image were then located on type maps. Although there was some difficulty in locating small, individual stands on the type map, in all cases interpretation from imagery data proved to be correct - stands as small as 32 hectares (80 acres) were spotted on the image and verified on the type map.

In the pilot study area, three main concentrations of jack pine were identified, as well as several smaller, outlier areas. Although geographically separated, it is not known whether they are components of a single population or are genetically distinct, questions which can only be answered by systematically sampling and testing representative material from each area.

DISCUSSION

Previous attempts at classifying forest vegetation using satellite data have met with varying degrees of success (Kalensky and Sayn-Wittgenstein, 1974; Kirby, 1974; Heller, 1975; Jano, 1975; Dodge and Bryant, 1976; de Steiguer, 1978). Oswald (1974) was able to differentiate pure lodgepole pine from mixed stands by visually interpreting color-composite satellite imagery. Zsilinzsky and Pala (1978) reported successful classification of various forest types through digital analysis of LANDSAT imagery; using computer techniques, stands of

50 percent or more jack pine were recognizable. Although digital analysis promises a significant increase in the scope of LANDSAT imagery, conventional interpretation methods are very useful, particularly when only one species is involved.

Jack pine, with its unique biological and silvical characteristics, can easily be recognized on winter LANDSAT imagery in the boreal forests of Ontario. This, combined with small-scale forest type maps provides the forest geneticist with a unique, valuable tool for systematically assessing all significant components of the jack pine population. With a precise distribution map showing the spatial and geographic arrangement of natural groupings, all major areas of jack pine occurrence can be sampled, with frequency or intensity of sampling dependent upon the relative importance of the individual component to the overall distribution pattern. Such a distribution map does not take into account those areas in which jack pine is a small component of the stand, nor does it attempt to forecast the influence that future fires may have on changing the present distribution.

A distribution map based upon satellite imagery will not in itself define the genetic structure on Ontario's jack pine, nor will it be possible to select genetically superior stands from such images or maps. However, it will provide vital information from which to formulate hypotheses for testing. It will provide the basis for a systematic inventory of the existing jack pine gene pool resource, from which genetically superior stands can be selected, and from which population structure can be studied. It will also provide basic information upon which to plan and organize a coordinated approach to establishment of seed collection areas and subsequent seed distribution. As a follow-up to the early provenance tests, jack pine distribution mapping can be envisioned as the second step in a multi-stage approach to intensive jack pine tree improvement. The very broad perspective available from remotely sensed data will give valuable insight and a new approach in determining and utilizing genetic variation in jack pine.

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