APPLICATION OF SATELLITE REMOTE-SENSING DATA TO LAND SELECTION AND MANAGEMENT

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ABSTRACT

The Alaskan regional Native corporations currently are engaged in the selection of land entitlements authorized in the Alaska Native Claims Settlement Act by the U.S. Congress in 1971. The areas of the public domain reserved for selection by native groups are vast and remote, and the time available for land selection tends to rule out land-use planning done by conventional means. Doyon, Ltd. of central Alaska is one of the regional corporations which faces such a massive resource management challenge. With Bureau of Indian Affairs and NASA funds, the University of Alaska undertook a pilot project to demonstrate the utility and economy of satellite data in preparing thematic maps of a wilderness area emphasizing those resources of greatest interest to the potential owner.

Vegetation maps delineating potential commercial timber and maps of suggested mineral prospecting areas of seven scattered regions were prepared by interpretation of LANDSAT images, coupled with a limited amount of ground truth. Images acquired both in winter and summer seasons were registered to township maps and used in making interpretations of the areal extent of commercial timber potentials. The amount of snow cover visible through the forest canopies was found to be a useful indicator of timber potentials. No attempt was made to estimate timber volume. The satellite images were also interpreted to identify the nature of bedrock where this was possible. Identification was also made of characteristic topographic features which are typical of flood plain deposits or of the well-developed trellis drainage patterns which can indicate the strike of structural grain of underlying Cretaceous sedimentary rocks. The presence of igneous and mixed igneous and metamorphic rocks were indicated by combinations of spectral differences and anomalous interruptions of local radial drainage patterns.

Based in part on these newly-generated resource inventories of some 8,500 square miles, Doyon, Ltd, is now making land selection decisions. For example, Doyon has petitioned the Secretary of the Interior for a change in one boundary of a native regional deficiency withdrawal area to better accommodate the mix of resources of prime interest to this native group.

Verification of the vegetation interpretation of satellite data was performed on a spot basis by inspection from low altitude aircraft. Good conformity was found between the timber maps prepared from the satellite images and the selected test areas. The scope of work did not permit quantitative measurement on a statistical basis of the classification accuracy.

INTRODUCTION

Currently the Alaskan regional Native corporations and village councils are engaged in selection of lands authorized by the Alaska Native Land Claims Settlement Act. The work reported here was performed as a result of a request by Doyon, Ltd., a regional corporation of interior Alaskan Natives, for assist-

ance in obtaining resource materials and in training their personnel for this process of land selection and the management of lands selected.

The Geophysical Institute, with support from the Bureau of Indian Affairs, U.S. Department of the Interior, agreed to generate thematic maps from remote-sensing data analysis to aid Doyon, Ltd. in their selection process. This project was conceived as a pilot program of resource surveys designed to assist Alaskan Native corporations and villages in the process of land selection and management after selection.

One goal of this project was to demonstrate the utility of LANDSAT data for land use analysis in Alaska in view of the general lack of resource data - particularly vegetation and land use maps - throughout Alaska. The University of Alaska has been a major participant in the LANDSAT program, and as a result of this activity, has brought scientists together from geology, ecology, forestry, mineral engineering, wildlife management, hydrology, meteorology, agriculture, and the marine sciences to develop methods for applying remotely sensed data to regional land use surveys in Alaska.

It is believed that many of the techniques and approaches which have been developed can be utilized directly by regional and village corporations in the process of making land use decisions. This report illustrates those techniques and provides guidelines which can be applied to other regional corporations, village corporations, state and regional governmental agencies facing similar land use decisions.

PRODUCT PREPARATION

All existing Alaskan resource data, including the recently acquired LANDSAT data, was used to provide a resource base for land use maps and/or prospecting area maps of 250 townships considered to be of high priority for selection decision by Doyon, Ltd. In addition, township and range data were projected onto 1:250,000 scale LANDSAT images to aid direct use of the imagery for land use decisions.

Prospecting Area Maps

The objective of the mineralization analysis was to delineate areas for which interpretation of LANDSAT images, combined with existing ground and aerial data, indicated a favorable probability of metallic or non-metallic mineral products. It should be emphasized that the object of this analysis was not to pinpoint mineral deposits on the basis of LANDSAT data. However, interpretation of LANDSAT data in conjunction with other available geophysical data, including the distribution and characterists of known ore deposits, was used to define areas where <u>further prospecting</u> is warranted.

The importance of this type of information to the user must be clearly recognized. The size of the areas under investigation was so great that the cost of doing a rapid reconnaissance for identification of favorable prospecting areas by any other means would be prohibitive. This was particularly true in view of the time frame within which the land selections must be completed.

The basic procedures in a prospecting area analysis are:

(1) Assemble and organize all geophysical data relating to the likelihood of ore deposits in the area under study. These data are organized to indicate the distribution of potential mineralization regions of similar types and the nature of the geological control prevailing in each region.

(2) Prepare maps of mining districts, known mining claims and other relevant data and locate these on LANDSAT images.

(3) Interpret the LANDSAT data to identify distinctive features of the geologic environment, land forms, vegetation, and tectonic faults which can be associated with each potential mineralized province, and determine which combination of these features might justify extending the boundaries of known mining districts or projecting the trends of known deposits into new areas.

(4) Prepare maps of the study area indicating locations of favorable prospecting areas.

As previously noted, this process does not immediately pinpoint ore deposits. However, it is believed to have served the land selection requirements of the regional corporation effectively, because those requirements called for a selection by Doyon of approximately one-third of the lands held available for settlement purposes. Hence, all that was required was the determination of mineralized areas suitable for further prospecting. All these areas, comprising less than one-third of the land available for selection could be selected leaving the possibility of selection of other lands for yet other purposes.

Land Use Maps

Land use maps of Alaskan areas are of increasing importance with the current rush into land disposition and resource exploitation. Such maps provide a spatial basis for a resource inventory as well as a possible basis for a quantitative inventory of selected resources. Thus they serve as an effective tool in the land selection process. Land use maps may help in organizing activities compatible with a natural environmental integrity and hence with regeneration potentials, esthetic qualities and the rational, long-range needs of the exploiter.

The land use maps prepared as part of this project are essentially vegetation maps depicting broadly-defined vegetation types at the scale of 1:250,000. Although botanically coarse and of small scale, these maps provide more information, especially spatial, than any previous maps of the areas and are a step toward the production of more meaningful land use maps in Alaska.

The basic procedures in preparation of the land use maps were as follows: The maps were drawn from LANDSAT images. The reasons for this were (1) LANDSAT image availability, (2) the usefulness of LANDSAT imagery for mapping broadly-defined vegetation types over large areas in a relatively short time and (3) lack of complete aerial photograph coverage. LANDSAT images used for mapping were 16"x20" photographically enlarged prints produced at a scale of 1:250,000. The land use nomenclature adopted for this map series is a system developed by James R. Anderson of the U. S. Geological Survey.

Some of the scenes, were obtained by the satellite in the late winter, when the landscape was generally snow-covered, but when plants taller than the snow pack were free of snow. In the forest zone of interior Alaska snow accumulation by late winter usually is about one meter, after taking into account for recrystallization and compaction. Further snowfall in late winter is normally infrequent and light. These scenes permitted estimations of vegetation structure based on gray scale continuum related to plant height and cover.

Other scenes, obtained in the summer, were printed in color infrared. These permitted several coarse floristic distinctions based on some knowledge of the infrared reflectance of high-cover species or groups of species.

Information from the winter and summer images overlaid together was used in making vegetation distinctions to the extent that they may be expressed by the classification system that was adopted. Interpretations were also based on physiographic information obtained from topographic maps, as there are general relationships between vegetation and physiography.

The identification of vegetation containing trees of possible commercial grade of timber first required the identification of forest vegetation, then an estimation of composition and stature using the kinds of spectral and physiographic information described above. A quantitative definition of commercial timber was not intended. The commercial stands depicted on the maps are those in which the occurrence of a number of larger trees suitable for lumber production appears likely. This extension of vegetation-type classification to include possible commercial timber was performed because other than mineralization, timber resources represent a major possible consideration for the land selection decisions of Doyon, Ltd.

The materials prepared for the Kaltag selection area in western Alaska along the Yukon River will illustrate the kinds of thematic maps produced from LANDSAT images.

LANDSAT image 1038-21301 shown in Figure 1 illustrates the northern half of this selection area. This area is relatively remote, even by Alaskan standards. There are no settlements along the Yukon for nearly 140 km south of Kaltag. There are no roads to or within the area nor are there any airfields. The only transportation available is by barge along the Yukon River during the summer. The only known mineral extraction within the area occurred early in this century when two small coal deposits located on the river bank were mined. Logging, was limited to production of cord wood for steamboats. Today it appears that the mineral potential is still largely unexplored and many fine stands of commercial-sized spruce and hardwoods are found within the area.

DATA PRODUCTS

Figure 2 shows the map of possible prospecting areas prepared from the results of this study. After a review of the scant geologic literature available, the areas were identified in which the surface rocks are dominantly igneous or metamorphic, because these are most likely to contain deposits of metallic minerals. The character of these areas, in terms of topography and extent of outcrop, was determined from the study of available maps, LANDSAT imagery and observations during a light aircraft flight over the entire withdrawl area. The recommendations based on this analysis were as follows:

1. Areas covered by flood plain (the dotted area) on the other alluvial deposits were delineated on the LANDSAT imagery and were removed from further consideration because of the great expense of determining the nature of the underlying bedrock.

2. Areas where the surface rocks are cretaceous sedimentary rocks (identifiable on LANDSAT images by their characteristic of trellis drainage pattern of weathered sedimentary rocks) are shown with horizontal stippling. These rock types have low potential for mineralization and mineral exploration. These areas were not recommended for mineral exploration despite the existence of coal deposits which are of apparent limited extent.

3. The region of mixed sedimentary and igneous rocks, shown with left-stippling would have been a candidate for prospecting. However, a geological reconnaissance had been performed in that area with negative results.

4. The Blackburn Hills are largely granitic rocks, and are shown with vertical stippling. It appears to contain a granitic pluton and possibly radial dikes. We recommend that this area be prospected by stream sampling techniques.

5. A topographic dome structure located in the Kaiyuh Mountains contains one of the few known prospects in the withdrawl area and has been denoted by cross-hatched stippling. The prospect is located on a hilltop with shallow overburden and yielded molybdenum sulfide minerals in a quartz vein associated with a rhyolite porphyry. We suggested that this area be prospected for the possibility of low grade copper and molybdenum ores often associated with these types of rocks.

6. An area consisting of the Kaiyuh Mountains, and their topographic extension to the southwest is shown as right-stippling and was designated as an area for low-density prospecting. The mixture of igneous and metamorphic rocks of the Kaiyuh Mountains extends to the southwest as identified by the irregular drainage pattern indicative of this rock type.

Figure 3 is the land-use map of the Kaltag withdrawal area delineating eight major ecological communities. Of these, three were differentiated in terms of the apparent potential for marketability of hardwoods and softwoods based upon tree size alone. This distinction was denoted with a "C" classification signifying "potentially commercial" forests. However, a true commercial classification would depend on many factors far beyond the scope of this analysis.

The areas containing chiefly large-sized trees are denoted by cross-hatched stippling. Distinction has been made between broad-leaved forests containing chiefly birch (Betula papyrifera), aspen (Populus tremuloides), and balsam poplar (Populus balsamfera) as categories 41 and 41C; needle-leaved forests consisting of white spruce (Picea glauca) and black spruce (Picea mariana) as categories 42 and 42C; and mixed forests as categories 43 and 43C.

One of the goals of the regional corporation was to map the forests that have commercial timber potential to aid in their decision-making process of land selections. Generally we extended our analyses well beyond the boundaries of the withdrawal area, particularly where it was apparent that a forest or mineralized zone exceeded the extent of the area available for selection. Figure 4 is a third map showing the areas of potentially commercial timber (horizontal stippling) and areas for further prospecting (vertical stippling).

This map is useful from several points of view. The regional corporation was still in the process of negotiating with the federal government for changes in the withdrawal boundaries. The corporation could, for instance, negotiate for an entire forested area instead of an uneconomical portion of a potentially commercial forest.

Owing to an early deadline for land selections the map also supports selection decisions without the requirement of extensive field surveys. The Native Corporation may select only one out of three acres contained in the withdrawal area, and in the Kaltag area two-thirds of the land available for selection has no potential for forest products for easily identifiable mineral deposits. In this instance, the land selection process can be based completely upon the interpretation of LANDSAT image analyses.

Finally, by using these maps the directors of the corporation could make strategic decisions concerning the allocation of exploratory resources during the limited time available for preliminary surveys.

SUMMARY

LANDSAT imagery has been applied in central Alaska to earth resources management activities of a Native regional corporation in central Alaska which is entitled to select one-third of the land in a withdrawal area designated for this purpose from the public domain. Although the application of LANDSAT data was extended to 250 townships, only those 47 townships involved in the Kaltag withdrawal area are reported in this paper. They are illustrative of the methods used throughout seven regions in the interior Alaska which are subjects of Native land selection processes.

Thematic maps delineating highly probable areas for commercial timber and for mineral exploration were developed from satellite images using photo interpretation techniques coupled with a very limited amount of ground truth and correlation with geologic reports. These maps, which constitute a new, type-specified resource inventory, have been used by Doyon, Ltd. in making land-selection decisions. These resource inventories have proven to be exceptionally cost-beneficial and timely to generate, largely owing to the synoptic scope and ready availability of LANDSAT data.

Some 2 million acres have been selected as part of the land entitlement of Doyon, Ltd., and these selections were based heavily upon the thematic maps produced from analysis and interpretation of LANDSAT data. The value of these lands can be estimated in the range from $20 million to $200 million. A most conservative assumption is that the application of LANDSAT data at least doubled the value of the land selected in comparison with the land not selected. The benefits of this application can range between $10 million and $100 million, although this can not be defined precisely. This means that the benefits exceed the cost of the application of LANDSAT data by a factor ranging from 250:1 to 2,500:1, not taking into account the cost of development and deployment of the spacecraft or the cost of acquisition and dissemination of the data from the spacecraft.

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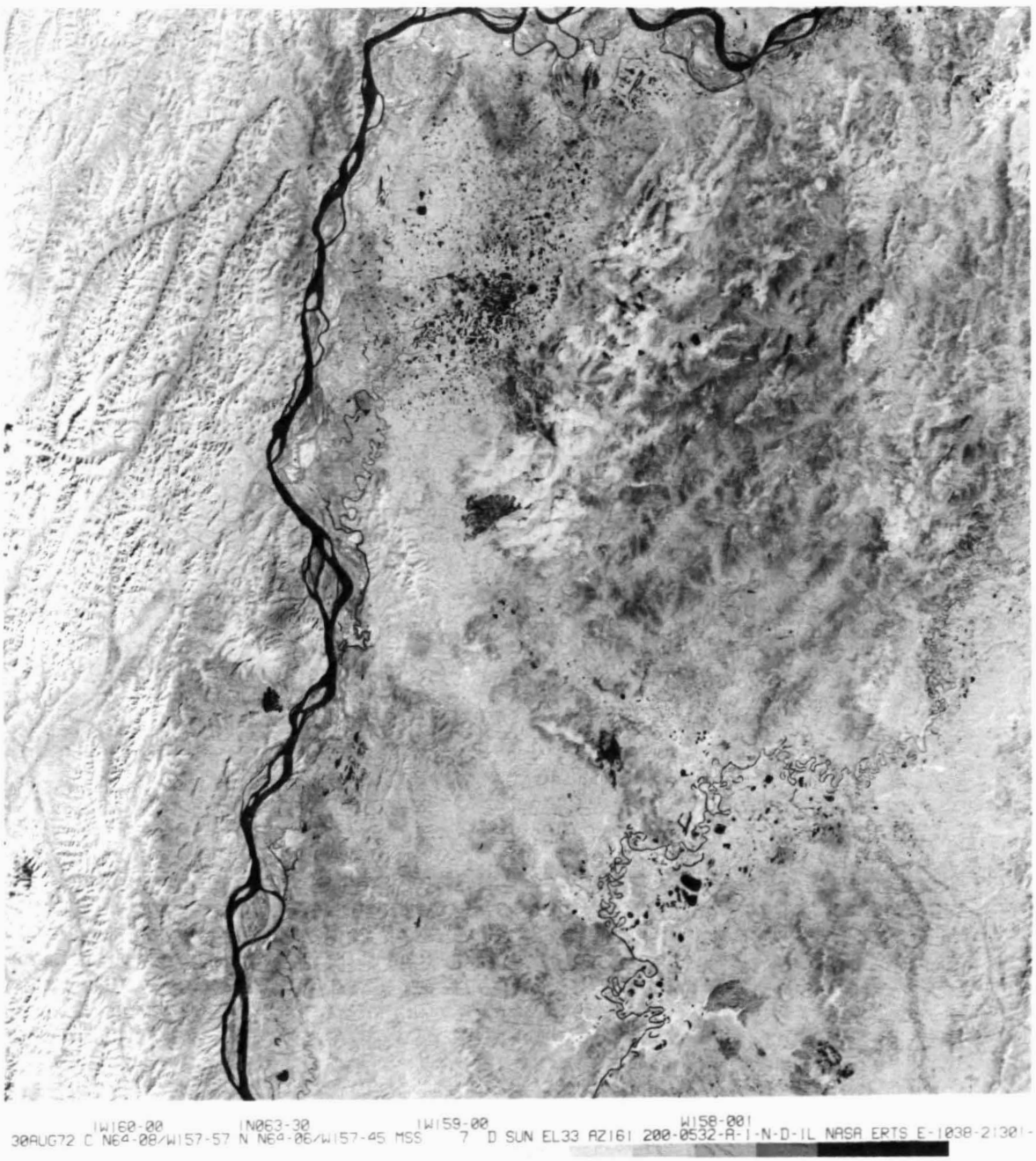

Figure 1. LANDSAT image of a portion of the Kaltag withdrawal area. A resource inventory of this remote region was prepared for land selections by a Native group.

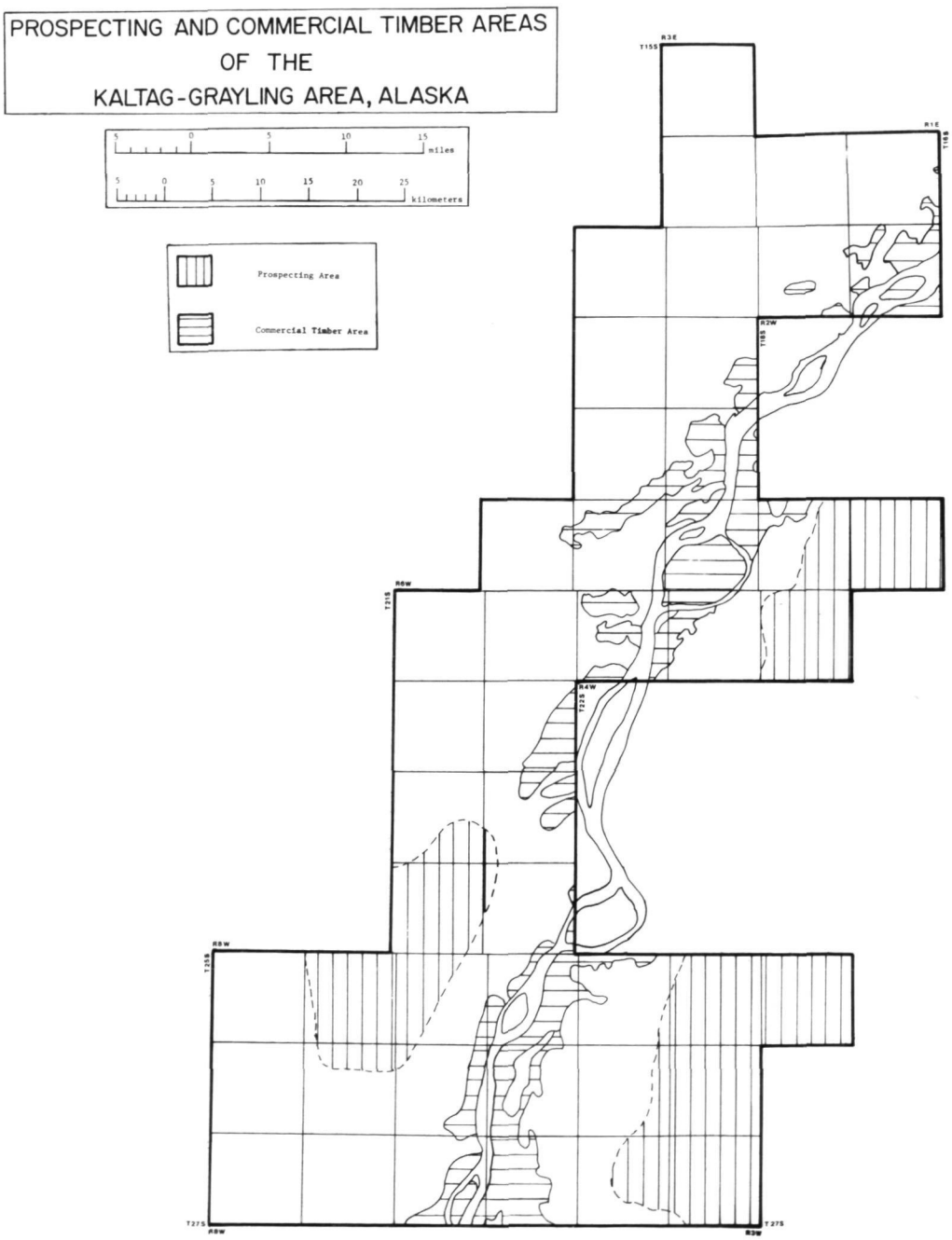

Figure 2. Mineral prospecting areas of the Kaltag withdrawal area. The cross-hatched and vertically stippled regions are the prime regions for exploration.

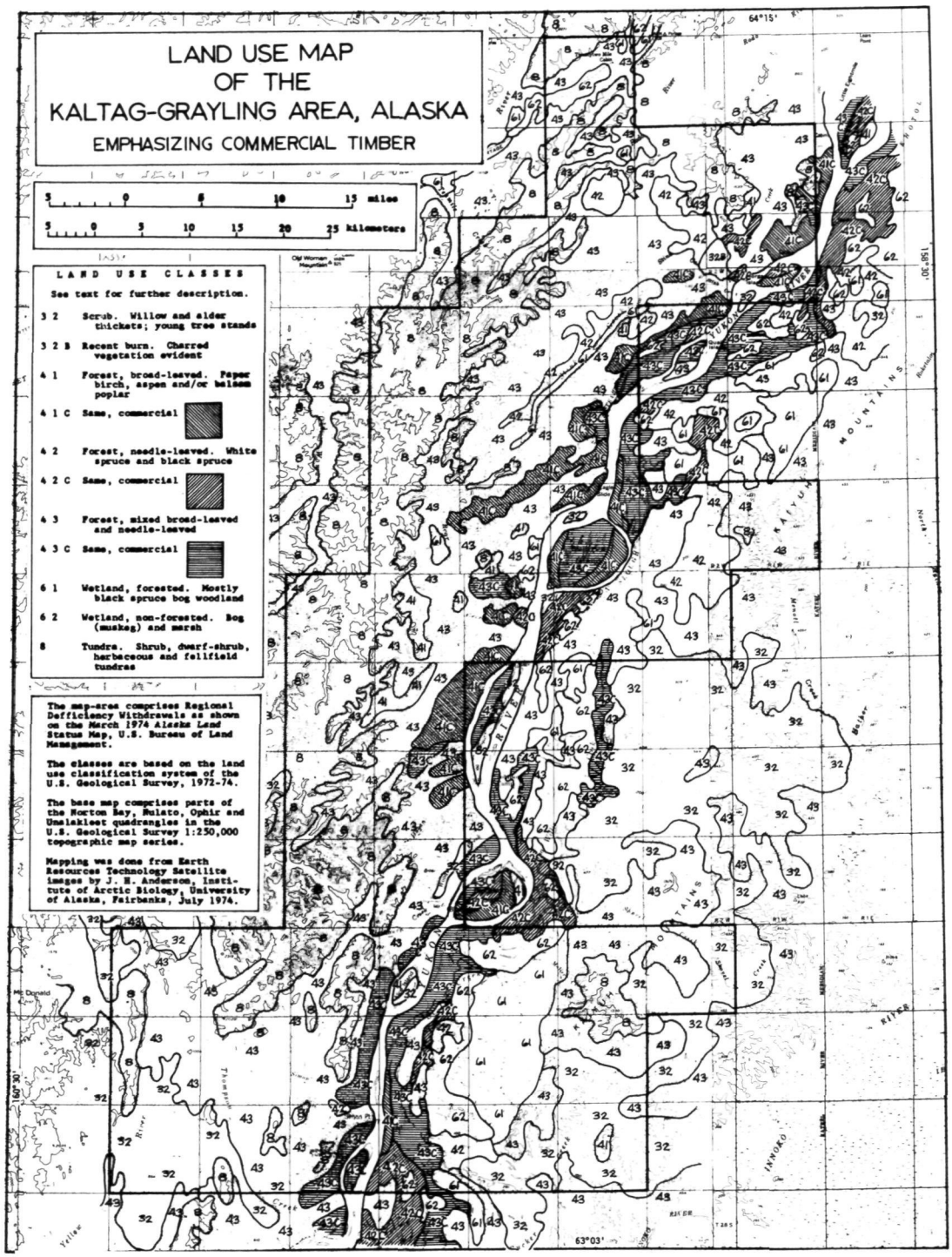

Figure 3. Land-use map delineating 8 major ecological communities. The stippling denotes potentially commercial stands of 3 types of forests.

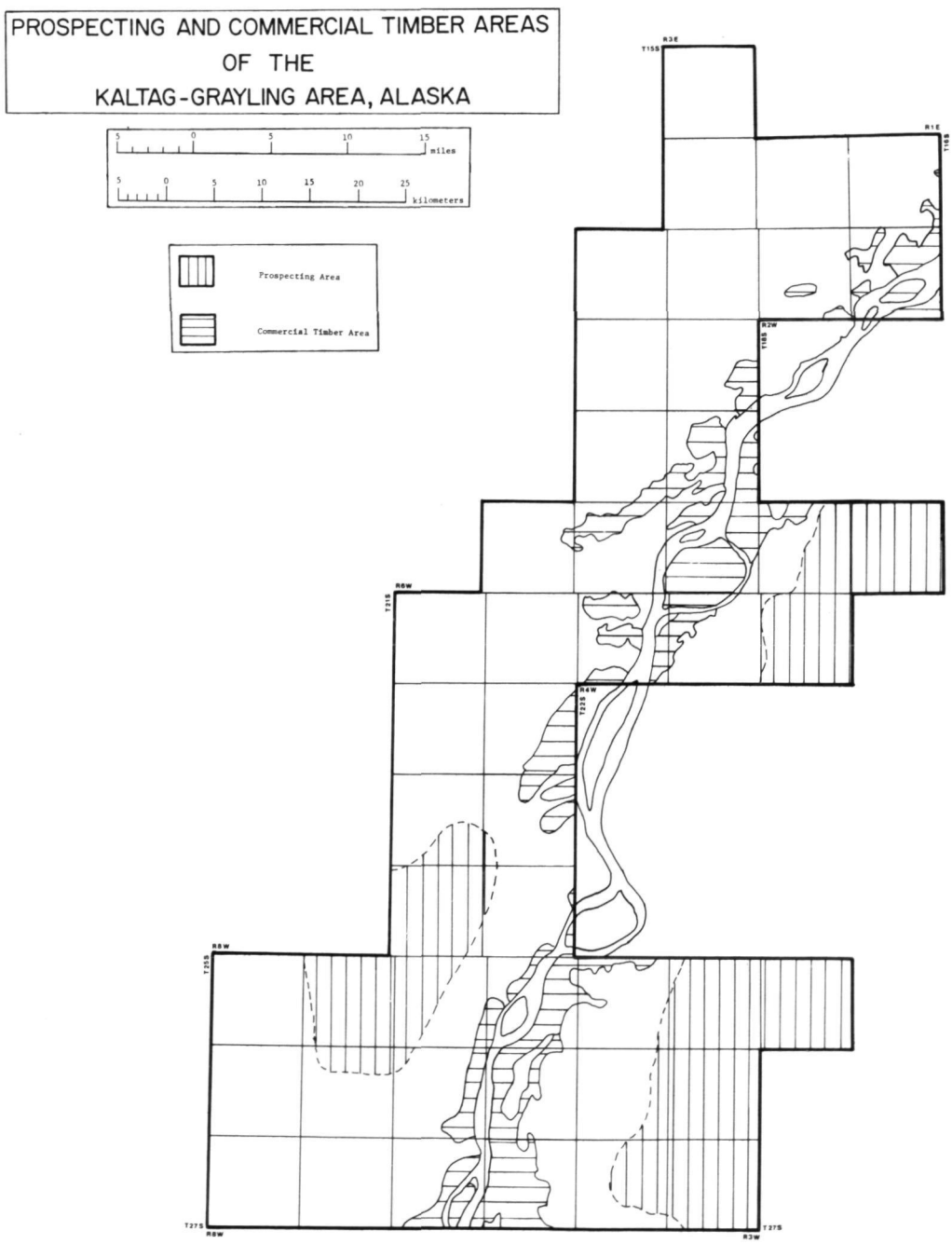

Figure 4. Inventory map for the Kaltag region showing commercial timber and mineral resources.