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ALASKA INTERIM LAND COVER MAPPING PROGRAM--
FINAL REPORT

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ABSTRACT

In 1985, the U.S. Geological Survey initiated a research project to develop an interim land cover data base for Alaska as an alternative to the nationwide Land Use and Land Cover Mapping Program. The Alaska Interim Land Cover Mapping Program was subsequently created to develop methods for producing a series of land cover maps that utilized the existing Landsat digital land cover classifications produced by and for the major land management agencies for mapping the vegetation of Alaska. The program was successful in producing digital land cover classifications and statistical summaries using a common statewide classification and in reformatting these data to produce 1:250,000-scale quadrangle-based maps directly from the Scitex laser plotter. A Federal and State agency review of these products found considerable user support for the maps. Presently the Geological Survey is committed to digital processing of six to eight quadrangles each year.

Any use of trade, product, industry, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

INTRODUCTION

The U.S. Geological Survey (USGS) has the mission to produce and maintain base maps and related thematic maps for the Nation. As part of this responsibility the USGS conducts a variety of national topographic mapping programs and a national land use and land cover program. The latter, which has concentrated on the lower 48 States and Hawaii, produces land use and land cover data (primarily at 1:250,000 scale) in graphic and digital form in response to Federal and State needs for systematic information for land resource planning and management.

Since the establishment of the Earth Resources Observation System (EROS) Field Office in Anchorage, Alaska, in 1980, the USGS has participated in numerous land cover mapping projects cooperatively with other Federal and State agencies. These projects have resulted in the development of digital data bases and map products providing land cover and terrain information for more than two-thirds of Alaska. These data bases, derived through the digital analysis of Landsat multispectral scanner (MSS) satellite data and Digital Elevation Model (DEM) data sets (reformatted from the Defense Mapping Agency's Digital Terrain Elevation Data), were developed to meet the specific resource planning and management information needs of each of the participating agencies.

Each land cover classification system was unique to the agencies' specific management goals. Although all agencies used the same ground-based system (Viereck and Dyrness, 1980) to describe plant communities, little consistency was found among the final map legends. The data produced through these cooperative projects are in the public domain; however, no standard USGS map products were produced as part of the projects.

Conventional land use and land cover mapping in Alaska by the USGS is limited to the Valdez 1:250,000-scale quadrangle. No plans exist at present to continue the conventional land cover mapping of Alaska, owing primarily to the limitations of the classification developed by Anderson and others (1976) for mapping Alaska's wildland environment and individual agency commitments to their own distinct resource mapping programs. Moreover, a conventional approach of mapping land use and land cover by manual interpretation of aerial photography would require decades to complete.

In 1985, the USGS initiated the research phase of a land cover mapping program in Alaska, which incorporated the existing land cover data and classifications necessary for mapping unique vegetation types, as an alternative to the nationwide Land Use and Land Cover Mapping Program. This project was initiated as an interim solution to the mapping of land use and land cover in Alaska, thus the name: The Alaska Interim Land Cover (AILC) Mapping Program. The program objectives were to produce standard 1:250,000-scale quadrangle-based maps, digital land cover classifications, and statistical summaries using a common statewide land cover classification system. For areas previously classified, the digital land cover data were to be converted to the AILC statewide system, thereby minimizing the cost. The land cover for the remainder of the State was to be classified directly to the statewide system (Shasby and others, 1985; Fitzpatrick-Lins and others, 1987).

The development of a consistent common land classification scheme for Alaska was a primary factor in implementing the AILC Mapping Program. Federal and Alaska State personnel experienced in the use of Landsat data for mapping vegetation and land cover participated in a series of interagency workshops to develop the classification scheme for the interim program. The resultant classification scheme adequately addressed the information needs of the USGS's Land Use and Land Cover Mapping Program and provided land cover categories useful to the participating agencies.

The classification system, comprised of 17 land cover types, is presented in table 1. At present, the system represents a combination of the Anderson and others (1976) Level II scheme and the Viereck and Dyrness (1980) vegetation classification system, the most widely used system for describing vegetation communities in Alaska. The establishment of a link between the interim scheme and the Viereck-Dyrness classification system was a critical element to ensure the utility of the interim map products.

BACKGROUND

The research phase of the AILC Mapping Program developed the methods for producing six interim L-series (land use) maps: Arctic, Dillingham, Fairbanks, Meade River, Mount Michelson, and Valdez. The six quadrangles were selected to address specific research needs. Quadrangles from distinctly different ecozones were chosen that were representative of different agencies' data bases. Valdez was chosen for comparison with the existing land use and land cover map. Adjacent quadrangles, Arctic and Mount Michelson, were selected as a test of the edge-matching process.

Development of the digital classifications and map products was shared by the USGS's EROS Field Office in Anchorage, Alaska; the Geographic Investigations Office at the Western Mapping Center in Menlo Park, California; and the Eastern Mapping Center and the Office of Research in Reston, Virginia. The Western Mapping Center prepared digital data sets for the Mount Michelson and Meade River quadrangles, while the EROS Field Office produced digital data for the Arctic, Valdez, Fairbanks, and Dillingham quadrangles. The final map products were developed at the Eastern Mapping Center. Overall coordination of the program was the responsibility of the Office of Research.

The major research efforts of the project were reformatting the land cover classifications to the statewide classification, producing color separates for the land cover maps directly from the digital data through the use of a laser plotter, registering the separates to the 1:250,000-scale topographic base, preparing area statistics for each township to be presented on the back of each paper map product, and producing specifications for release of the digital map products.

Table 1.--Interim digital Landsat classification for use in Alaska

Proposed USGS Alaska land cover classification Level I	Level II	Corresponding Viereck et al.* Level III
I. Forest (forest canopy cover of one-third or more)	A. Needleleaf forest (over two-thirds of tree cover contributed by needleleaf species)	Closed needleleaf forest Open needleleaf forest
	B. Broadleaf forest (over two-thirds of tree cover contributed by broadleaf species)	Closed broadleaf forest Open broadleaf forest
	C. Mixed forest (broadleaf or needleleaf species contribute one-third to two-thirds of the tree cover)	Closed mixed forest Open mixed forest
II. Shrub (forest canopy cover of less than one-third and shrub canopy cover of one-third or more)	A. Tall and low shrubland	Closed tall shrub scrub Closed low shrub scrub Open low shrub scrub Needleleaf woodland Broadleaf woodland
	B. Dwarf shrubland and related communities (rarely exceeding 50 cm in height) Needleleaf woodland	Closed low shrub scrub Open low shrub scrub Closed dwarf shrub scrub Open dwarf shrub scrub
III. Herbaceous (vegetation with 5% or more of vascular and nonvascular (mosses and lichens) cover and less than one-third cover of woody plants)	A. Dry or moist herbaceous	Dry graminoid herbaceous Mesic graminoid herbaceous Dry forb herbaceous Mesic herbaceous Needleleaf woodland Broadleaf woodland
	B. Wet herbaceous	Wet graminoid herbaceous Wet forb herbaceous
	C. Aquatic herbaceous	Aquatic herbaceous
	D. Mosses	Mosses Needleleaf woodland Broadleaf woodland
	E. Lichens	Lichens Needleleaf woodland Broadleaf woodland
IV. Agriculture		
V. Urban		
VI. Barren	A. Sparse vegetation B. Nonvegetated (rock, soil)	
VII. Water	A. Clear and (or) deep B. Turbid and (or) shallow	
VIII. Ice and snow		

*The Viereck et al. classification system is strictly for vegetation and does not apply to land use or nonvegetated lands.

METHODS

The integrated approach to collecting field data and analyzing aircraft, Landsat, and terrain data used by the USGS and all cooperators to produce land cover classifications is that described by Fleming (1985). Landsat false-color composite images and high-altitude color-infrared aerial photographs are used to locate representative ground sample sites, and helicopter surveys are used to collect ground data. Digital Landsat MSS image and digital terrain data are combined in a digital data base approach. The data base used in the classification process is in grid-cell format, generally 50 meters in size, and registered to maps with a Universal Transverse Mercator (UTM) projection.

The procedures for preprocessing the Landsat data and classifying land cover are similar to those reported by Fleming and Hoffer (1979) and are summarized in table 2. After the preliminary spectral classification results are obtained, they are incorporated into the digital data base where other data sources are used in postclassification processes to improve accuracy. Three common postclassification procedures include the use of: (a) physiographic masks, (b) digital terrain elevation data, and (c) winter Landsat scenes (Shasby and

Table 2.--Land cover classification procedures

Analysis Procedures	Task Examples
Screen and preprocess Landsat data	Fix bad scan lines, perform radiometric destriping, mosaic adjacent scenes.
Register Landsat and ancillary data to map base	Select and digitize control points, generate transformation, resample, and register digital data sets.
Identify area(s) to be classified	Digitize study area boundaries and create appropriate digital masks.
Stratify raw Landsat data	Identify environmentally similar areas, locate training blocks within each type, and develop training statistics.
Field data collection	Delineate homogeneous areas on aerial photos. Visit training blocks in the field and describe vegetation associated with each area.
Perform preliminary classification	Classify training blocks and produce preliminary classification map.
Classification refinement	Use postclassification procedures to make more precise land cover product. Adjacent scenes are mosaicked and formatted to cover standard map quadrangle.
Conversion to standard classification	Merge categories and modify the classification to the standard AILC classification. Allow for overedge data.

Carneggie, 1986). The accuracy of the Landsat classifications is improved significantly with digital strata masks in the postclassification process.

For each individual classification to be converted to the AILC system, an analysis of the vegetative component of each unit is conducted. This analysis attempts to identify species composition, physiognomy, amount of cover, nonvegetative elements within the unit, topographic delimiters, and degree of overlap between units. Results are compared to the Viereck and Dyrness (1980) system and then to the AILC system to identify the best map category assignment for each unit of the original classification. Reference to the original classification interpretation materials is critical for the conversion process; these include original spectral cluster definitions, color-infrared and black-and-white photographs of quadrangle areas, notes from field assessment of vegetation, and Landsat scene false-color composite images.

By merging some original spectral clusters and separating others, a final conversion to the common statewide system is achieved. On some quadrangles, additional stratification with DEM data, digital physiographic data, and digital MSS data sets acquired during the winter is useful for fully discriminating among mapped units. In some cases, the final conversion is verified by other Alaskan vegetation experts. Emphasis is on conversion of the classifications in the quadrangle areas to be mapped in the AILC system. At the map edges, the land cover is justified with the adjoining maps, if available.

The digital data in the statewide classification are verified for geometric accuracy at the USGS's EROS Data Center. If more than a four-pixel root-mean-square error exists, the geometric registration is redone at the field office. Once the geometric accuracy of the classified data set is verified, it is reformatted to be read by the Scitex system. The printed map product, complete with area summary statistics on the reverse, is produced directly from the digital files at the USGS's Eastern Mapping Center (table 3).

The Scitex laser plotter is used to produce film negative separates at 1:250,000 scale for printing the color map product. Two copies of the digital data are sent first to the Scitex edit station; the first copy, with embedded tick marks, is used in scaling the plot, and the second copy is used for plotting the color separates at the proper scale without the obliterating tick marks. These files store the data by the classification scheme. At the edit station, the data are recombined into four channels representing three process colors (yellow, magenta, and cyan) for plotting the color negatives.

To scale the image, the Scitex operator first produces a grey-scale plot with tick marks. This plot is checked against the computer-drawn UTM projection and neatline. Slight adjustments to scale are made if required and rechecked before plotting the color separate negatives at final scale from the data, without the tick marks. At this time the first proof is made on stable-base material.

During the research stage of developing the AILC maps, defining the map extent from the digital terrain data caused some image shortfall at the neatline. For this reason, where possible, the classification is now processed overedge and the map extent is defined by the computer-generated map projection. Much of this problem was that the DEM data in the

Table 3.--Preparation of digital data for printing

Procedures	Task examples
Verify registration of digital data to UTM projection	Verify geometric accuracy ±4 pixels, add map corner points and geographic coordinate tick marks in the Landsat digital classification
Reformat digital data for Scitex processing	Reformat IDIMS digital data to Scitex format, select color codes for each land cover element
Scitex plot for scaling	Produce Scitex gray-scale positive at scale with geographic tick marks for registration to 1:250,000-scale base
Plot color separates on Scitex	Correct to true scale and plot screened color negative separates without internal tick marks
Verify positional accuracy of printed land cover data	Prepare color proof of color separates registered to the computer-generated map projection and UTM grid, select identifiable points and verify positional accuracy
Prepare final map for printing	Prepare map collar information and statistical tables for reverse side of the maps
Print final map	Register all materials, print final map

WGS72 datum used by the Defense Mapping Agency had been registered to a UTM map projection without first being converted to the NAD27 datum used by the USGS for topographic base maps. According to a February 1987 memo from Joel Morrison, USGS, "the shift in datum in Central Alaska for the horizontal plane is as much as 170 meters." Scaling and registration problems can be avoided in the future if the DEM data are converted to the proper datum before the UTM projection is calculated.

The color separates produced on the Scitex laser plotter and the blue, red, and black separates of the topographic map are all registered to the UTM projection for each quadrangle. The registration and positional accuracy of the stable-base color proof are verified before the map is printed. Minor adjustments to the grid placement may be made at this time. Meanwhile a map collar is prepared to a standard format, complete with color legend and Landsat scene index. This map collar separate is registered to the other separates in final preparation for printing.

Area summaries are generated for each AILC map in Alaska by merging the Bureau of Land Management file of township and range data with the land cover classification data. The area statistics allow the user to compute the acreage of each land cover type by township. These tables are formatted to fit the back of the map in the traditional way--by typesetting. Then the actual computer-generated tabular statistics, reformatted by use of a word processor, are printed and photoreduced to fit the table, eliminating the tedious and costly step of typesetting the entire table.

Each final AILC digital data set is also formatted according to data distribution specifications described in the Data Users Guide (U.S. Geological Survey, 1987a) for distribution to the public. Specifications were developed during the project to ensure that potential users of the land cover in digital form would be supplied with sufficient ancillary information to allow them to best interpret and understand the data. The format of the data as recorded on magnetic tape was also designed to meet the recommendations of the Landsat Ground Station Operators Working Group for release of image data on tape (Landsat-D CCT Standards Committee, 1979).

PRODUCTS

The initial AILC L-series maps and the digital land cover classifications available are Arctic, Dillingham, Fairbanks, Meade River, Mount Michelson, and Valdez (see table 4). Digital land cover and DEM data from the AILC Mapping Program are maintained at the USGS's EROS Field Office in Anchorage. Information about the AILC products may be obtained from the USGS's Earth Science Information Centers.

Table 4.--AILC Mapping Program L-series maps available

		Map extent		
Series #	Map name	SE corner	NW corner	Cost
L-205	Meade River	70° lat -156° long	71° lat -159° long	$2.40
L-206	Mt. Michelson	69° lat -144° long	69° lat -147° long	$2.40
L-207	Arctic	68° lat -144° long	69° lat -147° long	$2.40
L-208	Fairbanks	64° lat -147° long	65° lat -150° long	$2.40
L-209	Valdez	68° lat -144° long	69° lat -147° long	$2.40
L-210	Dillingham	59° lat -156° long	60° lat -159° long	$2.40

A wide variety of products, other than those described as standard products, will be available directly from the Alaskan data base or can be derived by the user through additional processing of specific files within the data base. For example, geometrically corrected Landsat data will be available where processed. Landsat MSS scenes are screened and preprocessed to fix bad data lines and remove radiometric striping. The preprocessed scenes are registered to a map base by means of selecting and digitizing control points, generating a transformation, and resampling and registering the data. During the process of making land cover classifications, a spectral cluster classification image is created for each Landsat scene that captures the diversity in spectral reflectance for the area within the scene. As many as 40-60 spectral classes may be included in any single scene. Because many users wish to pool spectral classes in a manner that is specific to their own resource inventory or management problem, these spectral classification images will be archived and made available to the user community.

FOLLOW-ON

Once the first of the AILC L-series maps was available, the USGS held a workshop in Alaska for Federal and State representatives to evaluate the potential of the maps and related products for their needs. The response of the representatives was supportive of the program and was reported in the Land Use and Land Cover Program Review Addendum (U.S. Geological Survey, 1987b). Interest in the land cover products ranged from users whose need was for the initial spectrally clustered data to users who would like to see printed maps.

In keeping with its mission to produce National land use and land cover maps for the entire United States, the USGS has developed a program for Alaska to produce a standard 1:250,000-scale land cover map product based on digital Landsat classification as an alternative to the conventional Land Use and Land Cover Mapping Program used in the lower States. In response to priorities and agency requests, the USGS plans to produce six to eight AILC digital classifications each year through 1992. The digital data base approach will also yield quadrangle formatted and registered Landsat MSS summer and winter data, detailed classified MSS data sets, DEM data sets, and other various ancillary data types that are utilized in the mapping effort. The data base will provide a very flexible source of information for use by interested agencies for their own specific applications.

The production of printed AILC L-series maps in the future will depend on having a strong user agency requirement or cooperative funding. The USGS does not intend to produce additional printed maps at this time without a specific user request. AILC Mapping Program products for the near future will be digital data sets in a standard classification and format. The final recommendation of this report is that the term *interim* be discontinued in describing these Alaska land cover products.

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