An Integrated Approach for Automated Cover-Type Mapping of Large Inaccessible Areas in Alaska

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ABSTRACT: The Alaska National Interest Lands Conservation Act, passed by Congress in December 1980, required that State and Federal agencies responsible for land and resource management develop comprehensive management plans to assess wildlife habitat, oil and gas exploration and development, wild and scenic rivers, land disposal, timber production, and archaeological and cultural resources. Primary information required for comprehensive planning are descriptions of vegetation, land, and water cover. However, the lack of any detailed cover type maps in the state necessitated that a rapid and accurate approach be employed to develop maps for 329 million acres of Alaska within a sever-year period. This goal has been addressed by using an integrated approach to computer-aided analysis which combines efficient use of field data with the only consistent statewide spatial data sets available: Landsat multispectral scanner data, digital elevation data derived from 1:250,000-scale maps, and 1:60,000-scale color-infrared aerial photographs.

INTRODUCTION

IN ALL DISCIPLINES involving land management, there exists a need for timely, reliable information on which to base resource management decisions. This was emphasized with the Alaska National Interest Lands Conservation Act (ANILCA), which requires the development of management plans for extensive areas of Alaska, characterized as relatively inaccessible. One of the biggest problems raised by ANILCA legislation was the need to develop managment plans for extensive areas of Alaska, for which little resource information was available describing the vegetation, wildlife, water, soil, and geology.

One of the most important types of resource information required for comprehensive planning is a current data base of the vegetation/land/water surface cover, subsequently referred to as "cover type." The U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management, and Alaska Department of Natural Resources have land management responsibilities that needed basic cover type information. These agencies, through the USGS EROS Field Office have developed and have used the integrated analysis approach discussed in this paper to classify 245 million acres of Alaska in the last seven years (Shasby and Carneggie, 1986).

The integrated analysis technique combines field data with three consistent state wide data sets: Landsat multispectral scanner (MSS) data, digital elevation model (DEM) data derived from 1:250,000-scale topographic maps, and 1:60,000-scale high altitude color-infrared aerial photographs (HAP). There are, however, several areas in the state of Alaska where (a) a cloud-free, summer Landsat MSS scene has never been collected; (b) the DEM data have numerous anomalies and gaps in their coverage; and (c) the Alaska HAP photography has several areas for which there is no coverage, despite attempts for complete coverage since 1977. In spite of the minor gaps, the coverage for all three of the primary data types has been adequate for all land-cover mapping projects. The 1:63,360-scale USGS topographic maps represent another statewide data set and were used to accurately register the Landsat MSS data sets. Only regional geologic or soils data were available for a limited number of areas and were used in only one project (Markon and Talbot, 1986).

The integrated analysis approach for developing land-cover information from Landsat MSS data has been under development since the mid-1970s (Fleming *et al.*, 1975). Many studies since have shown that digital processing of MSS data requires some interpretation and or integration using aerial photography and/or some type of ground observations (Hoffer and staff, 1975). But using MSS data in rugged terrain or complex areas requires a fully integrated approach to efficiently combine the MSS data with the aerial photography, field observations, and digital topographic information to yield accurate cover-type information at the approximate resolution of Landsat MSS data, 50 meters (Fleming and Hoffer, 1979).

The integrated approach builds a set of data bases that allow many types of information to be derived. The overall goal of this paper is to describe an integrated approach of combining the various data sets, and the information that can be developed. The specific objectives are (1) to describe the analysis approach for cover-type mapping, (2) to document the improvement in accuracy of the Landsat MSS data classification when including other types of data, and (3) to describe some of the types of information that can be derived from the integrated data base.

The description of the analysis technique will be illustrated using data from just one of the 13 U.S. Fish and Wildlife National Wildlife Refuges (NWR) in Alaska for which this approach was used. Although Kanuti NWR was one of the smaller refuges—approximately 1.43 million acres—the larger projects used the same procedure to analyze as many as 12 Landsat MSS scenes for a single refuge and to map areas over 50 million acres, including the surrounding "area of influence."

STUDY AREA

Kanuti NWR is located in north central Alaska and encompasses two land resource areas, Interior Lowlands and Highlands (Rieger *et al.*, 1979). The study area is in the northern boreal subzone (Hamet-Ahti *et al.*, 1974). The climate is cold and continental with a mean annual temperature and precipitation for Allakaket, located along the west central edge of the refuge, of -7.1°C and 338 mm, respectively. Vegetation data suitable for management planning for Kanuti NWR are nonexistent. There are no published descriptions of the vegetation. Knowledge of the vegetation of the refuge comes primarily from scattered accounts such as Drury (1956) for the Upper Kuskokwim, Johnson and Vogel (1966) for Yukon Flats, and Buckley

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and Libby (1957) for a portion of Interior Alaska. Published vegetation maps that include the refuge are the state-wide map by the Joint Federal-State Land Use Planning Commission of Alaska (Selkregg, 1976) at a scale of 1:2,500,000 and a map by Kuchler (1966) at a scale of 1:7,500,000. Both maps summarized six similar vegetation classes in the area, although they were too broad to provide information appropriate for planning.

METHODS

A multistage sampling system was used to integrate the field data, aerial photographs, digital Landsat data, and topographic data. This involved selecting six to ten training areas, or blocks, for each Landsat scene, the approximate size of a frame of aerial photography (12.8 km square). Aerial photographs for each training area were examined, and a stratified sample of 20 to 30 plots, each 10 to 50 acres in size and representing the spectral range and spatial variation of the different cover type, was delineated and later visited on the ground. Due to the remoteness of the management units, the field data were collected using a helicopter. This approach of block sampling increases the efficiency of field data collection as well as increasing the efficiency of the data analysis. The field plot descriptions were summarized, entered into a tabular data base, and delineated in the MSS data. This approach facilitates the automated cover type classification process. The field data were used to label the spectral classes; evaluate the accuracy of the classification; develop strata from the topographic data, winter season Landsat MSS data, physiological, and other ancillary data; and describe the final vegetation classes. The major steps are outlined in Figure 1. The following section will describe in detail the integrated approach used to develop the cover type map for the Kanuti NWR.

DATA SELECTION/DEFINITION

The analysis area was defined as the refuge, and its surrounding "area of influence." In practice, this involved extending the analysis to the edge of the Landsat scene or a 1:250,000 quadrangle boundary. A relatively cloud-free Landsat MSS scene (ID 21634-21001, 14 July 1979) that covered the entire refuge was acquired, both in computer compatible format (CCT) and a 1:250,000-scale false color composite (FCC) print. The scene selection was based on the most recent, relatively cloud-free data collected during the relatively short "summer" period of July and August. A second Landsat MSS scene (ID 21490-20553, 2 February 1979) was selected during the later part of winter when the ground was snow covered and the sun elevation was high enough to provide sufficient light.

The second source of data for the analysis was DEM topographic information, digitized from 1:250,000-scale topographic maps and available in 1° by 1° sections from the USGS National Cartographic Information Center. The data were in a latitude/longitude projection with 3 by 6 arc-second grid cells, or pixels, each approximately 92 metres in size. Because the study area extended just south of the 66° latitude line, topographic data were required for two quadrangles, Bettles and Tanana.

The third data set used was the aerial photography. The only coverage for the Kanuti NWR area was the 1:60,000-scale CIR photography. Copies of the flight line maps for the two quadrangles were obtained to use as aids in selecting training blocks.

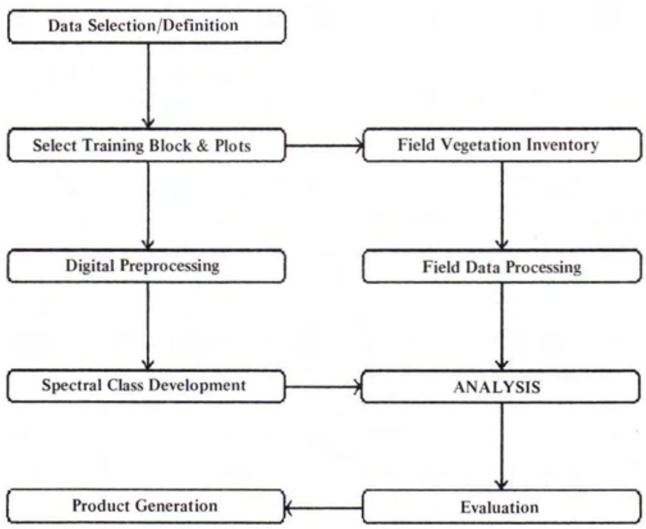

FIG. 1. Flowchart of the basic steps in analysis procedure to integrate field data, aerial photography, topographic information, and Landsat MSS data.

SELECT TRAINING BLOCKS AND PLOTS

The sampling areas or training blocks were selected by visually interpreting the Landsat MSS FCC prints and locating the blocks in areas which represented the total range of spectral variation. Other criteria for training block selection included differences in landform, soils, vegetation, surficial geology, spatial distribution, and availability of color infrared aerial photographs (HAP). Seven training blocks were selected (Figure 2), each approximately the same size as one frame of the 1:60,000-scale photography, 11 by 11 km (256 by 256 pixels). Final block placement was based on the location of the center photo in a group of frames that provide stereo coverage. Each block was labeled using an alphanumeric character and outlined on the 1:250,000-scale maps for use during the field work.

The photographs were interpreted to delineate spectrally homogeneous areas, referred to as field plots or polygons. Plots were selected to (a) cover the full range of spectral variability within the block, (b) be representative samples of all of the cover types present within a block, and (c) sample the full range of each cover type. The center photograph of the stereo triplet was used to delineate the field plots. Sampling intensity ranged from 15 to 30 polygons per block, depending on the complexity in the block. A north arrow and block label were annotated on the photographs but the plots were not numbered. The plots were numbered later in the field, in the order they were sampled.

FIELD INVENTORY

The field data collection consisted of a combined helicopter and ground survey, using a four man crew: the pilot, two people to collect the field data, and a navigator/photographer. Most plots were visited on the ground for a short time, typically 5 minutes, and a general description of the physiognomy and dominant woody species and their proportions were recorded. If a polygon encompassed more than one community type, as in a string bog, each was described individually. The boundaries of the polygons were checked in the field and adjusted on the photographs to make sure the plot contained only the described community(s). Some plots were dropped from the field sampling when a sufficient number had already been sampled. Also, plots were occasionally added when a new community was located while in transit between plots.

A series of 35-mm photographs, usually three, was taken to document each plot. One oblique was taken from the helicopter approximately 100-feet above ground during the approach to the plot. The second photograph was an oblique from the ground

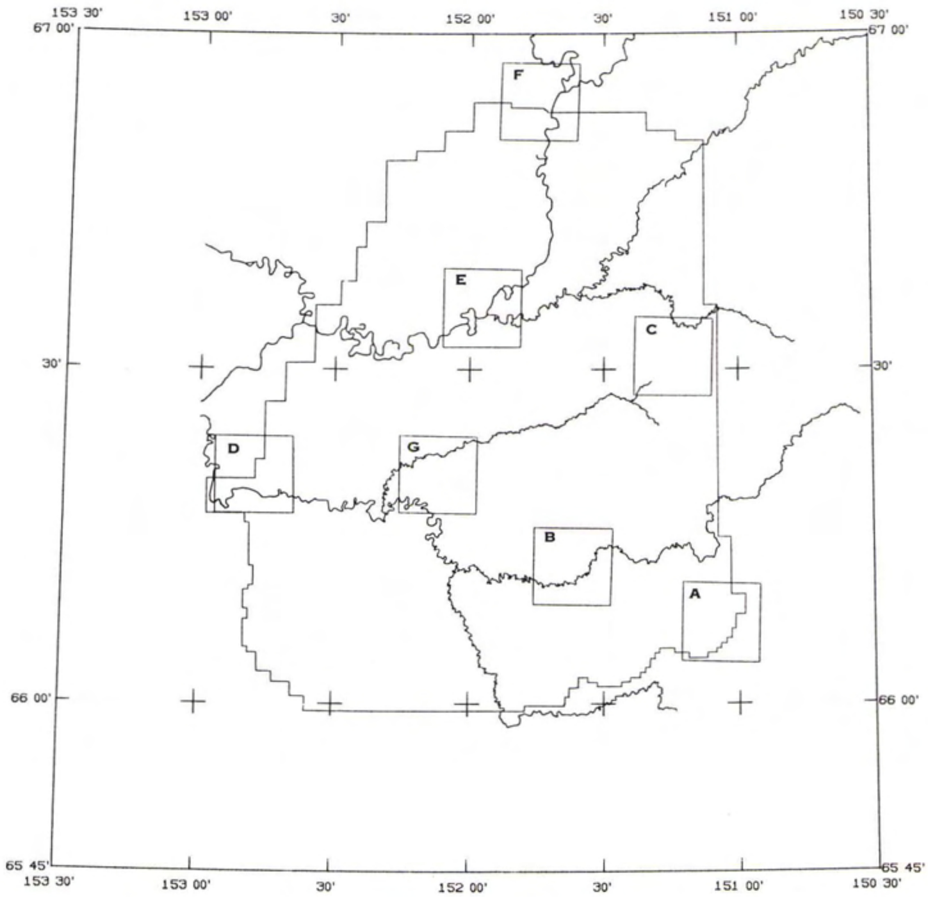

FIG. 2. Kanuti NWR with training blocks outlined.

showing the typical cover type of the plot and the third was a more detailed vertical photograph of the ground cover. Other information was also collected while at each plot, including indications of fire, flood, and general soil and soil moisture conditions.

Several field plots in each block were selected for a more detailed inventory of the major vegetation types, requiring approximately 1 hour of field time each. Quantitative descriptions were undertaken to record the floristic composition, structure, and major site features of the stands. To be acceptable for sampling, a stand had to be homogeneous and representative of the community from which it was sampled. Stand descriptions were made from single plots and employed a 10- by 10-metre quadrat for non-forest vegetation and a 20- by 20-metre quadrat for forest vegetation. Quantitative cover values were estimated for each species for nine cover abundance classes (Westhoff and Van der Maarel, 1973).

DIGITAL DATA PREPROCESSING

The July 1979 Landsat scene was obtained in computer compatible tape format and analysis was initiated by selecting a subsection of the scene covering the refuge and adjacent lands. The Landsat subscene was geometrically corrected to a Universal Transverse Mercator (UTM) projection. Two geographic reference points were selected on each 1:63,360-scale topographic map and the corresponding points were located in the subscene. These points were used to estimate a second-order, least-squares polynomial transformation equation that registered the Landsat subscene to a 50-meter UTM grid. Examination of mean residual errors associated with the transformation equation estimated the registration error at less than one pixel. The final registered, 50-meter resolution, raster data base consisted of 3,050 lines by 3,000 columns in size, 5.6 million acres. To complement the summer Landsat scene and to reduce classification error, a winter Landsat MSS (WMSS) scene was registered to the 50-meter UTM grid using the same geometric correction procedure.

The 1° by 1° sections of digital elevation data were mosaicked together and registered to the 50-meter UTM grid. The elevation data were smoothed using a 5 by 5 averaging filter to reduce the effects of anomalies and then the other topographic variables were calculated. They included slope, in percent; aspect, in 2° increments (north = 0 and 180, east = 45, south = 90, and west = 135); and relative amount of solar illumination (SI), using the sun elevation and azimuth of the summer MSS scene.

SPECTRAL CLASS DEVELOPMENT

Spectral training classes were developed using a clustering algorithm on the Landsat MSS data from the seven training blocks. A clustering algorithm was used to define discrete groups of pixels (clusters) on the basis of their reflectance in the four Landsat spectral bands. The seven sample blocks were divided into two sets and mosaicked together, one set with three blocks and the other with four. Each set of blocks was then clustered into a maximum of 40 spectral classes. The clustering algorithm grouped pixels of similar reflectance values, maximized the statistical distance between classes of dissimilar pixels, and provided statistical descriptors (mean vector and covariance matrix) for each spectral class. Generating more than one set of statistics provided independent estimates of the spectral classes in the Landsat data. The statistics files were then merged into one file of 44 spectral classes by pooling and deleting spectral classes.

Field Data Processing

A descriptive summary of each polygon visited in the field was entered into a tabular data base for storing, retrieving, and analyzing. The descriptive summary entered for each site into the "plot" level tabular data set included alphanumeric block label, polygon number, moisture regime (that is, xeric, mesic, tidal), lifeform (that is, forest, scrub, marsh), and the four dominant plant species or groups of species.

The "plot" tabular data were used first to develop the map legend classes. This was accomplished by collapsing the data into unique combinations of the plot descriptors—specifically, the moisture regime, the two most dominant plant species, and the lifeform—and combining input from the planners and field personnel. The result was a preliminary list of cover-type classes, which were numbered, and the "legend class" number coded into the plot summary tables.

A second "pixel" tabular data base was built from the digital raster data sets (spectral classification, WMSS, elevation, slope, aspect, and SI) for the field data collection sites. A digital color monitor was used to display the false color MSS composite of each block, and the boundaries of the polygons were delineated with the aid of the aerial photography. The boundaries were stored as vector files using image coordinates. Because all of the data sets were registered to the same UTM grid, data could be extracted for each plot from the raster data sets. A program was developed to take the boundary vector files and extract data from the raster data sets and output a "pixel" level tabular data set. The "pixel" data set contained, for each 50-meter grid cell that fell into one of the plots, the following variables: alphanumeric block label, plot number, spectral class, elevation in metres, slope, aspect, WMSS reflectance value from band 7, and solar illumination.

The block and plot labels are the common link between the two tabular data sets. The relation between them allows data to be transferred from one set to the other. The first application of this relation was to add the legend class numbers from the "plot" data set to the "pixel" data set. This has many applications, most importantly to provide the information necessary to develop and evaluate strata for classification refinement.

Analysis

In this step two major functions, labeling and stratification of the spectral classes, were performed to achieve the most accurate classification possible with the existing data. Both functions were repeated several times with an evaluation after each iteration of labeling.

The process of labeling spectral classes was accomplished primarily through analysis of the tabular data sets. First, a contingency table was prepared to quantify the correlations between the legend classes and the spectral classes. Each spectral class was given a preliminary label, as determined by the legend class with the highest frequency for that spectral class. Then, each spectral class was checked and evaluated visually on a digital display screen, both within the training blocks and throughout the entire scene. Spectral classes that included more than one legend class or did not agree with the label from the field data were noted and determination of the cause was explored (that is, moisture conditions, topography).

A contingency table summarizing the accuracy of the classification was built by recording the spectral classes to their preliminary classification and using the field data labels. The table estimates the accuracy of each legend class and indicates which classes were being confused and estimates the amount of error. This information was very useful for quickly determining which legend classes were not being classified accurately.

Evaluation of the preliminary classification indicated which classes needed to be stratified to improve the accuracy. Strata were developed using the previous evaluation of each spectral class, notes from the visual check, the mixtures of vegetation types associated with each spectral class, the spectral class distribution of each vegetation type, and statistical analysis of the tabular data set. Histograms, scatterplots, discriminate analysis, and other summaries were run on the variables in the "pixel" tabular data base. The discriminate analysis function was used to determine the most important variables, but could not be relied upon to automatically develop the strata, because not all of the variables are "normally" distributed.

The WMSS and SI data were the most important, followed by elevation data. A stratum derived from the WMSS was useful to separate types of vegetation on relatively flat terrain. Three classes of WMSS data—low, medium, and high reflectance—were identified that separated vegetation according to lifeforms, corresponding to trees, shrubs, and dwarf shrubs, respectively. Three classes were developed from the SI data: low, slopes facing away from the sun (NW); flat, terrain with less than 5 percent slope; and high, slopes facing the sun (SE). From these two data sets, SI and WMSS, five strata were developed; low SI, high SI, flat with low WMSS, flat with medium WMSS, and flat with high WMSS.

The strata were assigned numbers and the variable added to the "pixel" tabular data base. A new variable was created using a unique value for each combination of spectral class and strata. The process of labeling classes was repeated using the new spectral/strata classes. In classes where confusion existed, each combination of spectral and strata classes was evaluated to identify correlations between the stratified classes and the legend classes. This process of labeling the classes, visual checks, evaluation, development of strata, and application of strata for more labeling was repeated several times. The second iteration of strata included several classes of elevation data. The third iteration included slope classes that separated tall shrub from other vegetation types. Several other minor strata were developed, including a "supervised" delineation of cloud shadows to distinguish them from water bodies. At the end of the process, when the classification was judged acceptable, the final accuracy was estimated for all legend classes. At this point a preliminary cover map was produced.

Evaluation

The cover-type classification was evaluated by refuge and planning staff. Several minor changes were requested to make the product more usable. One was to change the legend and add two legend classes that had been grouped into more general classes during the analysis procedure. The planning staff requested adding several of the vector data sets to the map product, including refuge boundary, streams, roads, and a pipeline.

The requested changes were made and the final cover-type map completed. This included adding a legend, geo-referenced base category information, and the rest of the information normally found on the map collar. Also, the solar illumination variable was used to add a shaded relief appearance to the classification.

Product Generation

The Landsat derived classification was used to produce the first intermediate-scale cover-type map published for Kanuti NWR. Seven major classes and 17 subclasses were distinguished on the final map. A map product was produced at 1:250,000-scale for the entire refuge. Acreages were calculated for each cover type and a tabular summary was generated. A detailed vegetation description of each cover-type class was made. A "User's Guide" was written (Talbot *et al.*, 1985) describing the analysis methods and containing the detailed description of the vegetation found in the refuge, including field photographs of the "typical" vegetation types. Map products were also generated for the topographic variables. The elevation, slope, and aspect data were grouped into classes, color coded, and used to generate final annotated map products. The elevation class map used the solar illumination data to add a shaded relief appearance to the product.

RESULTS AND DISCUSSION

The major products were the maps and a data base of digital vegetation/water/land-cover information, elevation, slope, and aspect data that land and resource management agencies can use for many applications in developing land management plans. An integrated approach to computer-aided analysis was used to efficiently combine the field data with the Landsat MSS data, HAP, and topographic data which rapidly produced an accurate cover-type map.

One of the important benefits of an integrated analysis was the efficiency of collecting the field data. Concentrating the field data collection in a small number of blocks minimized the travel. Yet the blocks were large enough that each block provided a wide range of spectral signatures to be sampled. The field work for the seven blocks in Kanuti NWR required two and one half days to complete, at a cost of $8,000 for the helicopter, pilot, and fuel. The cost of the field work was only 0.16 of a cent per acre, significantly reducing the cost of the field data collection.

A second important benefit is to simplify the interaction of the analyst with the data by automating parts of the procedure. The major applications include using the field data to label spectral and stratified classes, estimate the accuracy of the classification, develop strata from the ancillary data, and describe the final vegetation classes. The cost of the data analysis is difficult to estimate in terms of dollars. The amount and type of charges vary greatly between various computer systems, depending on who owns it. One way to describe the cost of data analysis is to use the length of time in man-days required to complete the analysis. During the Kanuti NWR analysis approximately 8 man-days of analysis time were required.

The third important benefit of an integrated analysis approach was the improvement in accuracy at a refined level of detail. This is possible by incorporating ancillary data into the analysis procedure. The accuracy of the classification for Kanuti NWR was estimated using the training samples at each iteration of the stratification process, and is shown for each class in Table 1. As each of the strata were added into the classification, the overall accuracy improved, particularly in the vegetation classes. The non-vegetated classes of water, cloud, snow, and rock were accurately classified using only the spectral data and thus did not improve in accuracy. Relying on a discriminate analysis function to automatically classify the data using all of the stratification variables did not significantly increase the accuracy over using only the MSS data. Any type of data that has project-wide coverage can be included in the analysis procedure as a strata. Some of those that have been used on various projects include elevation, slope, aspect, winter season Landsat MSS data, physiological units, soils, fire history, watersheds, and "supervised" knowledge or interpretation.

Although the training sample is not an independent test sample, a number of studies that have spent considerable effort to evaluate the Landsat classification (Krebs, 1980; Rohde and Miller, 1981) have shown no significant difference between training field accuracies and independent test samples. A valid sampling structure for the training data is important, and was evident in the Kanuti project by a high correlation between the size of classes in the training sample and the acreage of each class in the final classification.

A fourth benefit is the great number of applications that can use the data bases built during the analysis. One application is making detailed qualitative and quantitative descriptions of the vegetation types found in the project area. Descriptions were developed summarizing the composition of each community type in terms of the types and abundance of the species present. Table 2 is an example of a quantitative description which summarizes for each vegetation type the average percent of ground cover in each of ten groups of species. This description gives a profile of structure and composition of the vegetation classes. A second application is building models from the data bases. The digital data bases were the basic input for extensive modeling by the planning and management personnel, particularly for the distribution of wildlife and wildlife habitats. The data also can be used to model the distribution of a plant species within the project area. In order to model the entire range of a plant species, however, the sample would have had to be representative of the total distribution of the community, and this is usually not the case within one project area. A third application is using the cover-type information as a basic stratification for mapping more intensive study areas, usually based on photo-interpretation of the HAP photography (Tande and Jennings, 1986).

A fifth benefit is the consistency of the classifications between scenes in multiple scene projects; this has many advantages, particularly for merging the classifications. For projects which require multiple MSS scenes, each scene was classified using the spectral MSS data first, then stratification was completed using groups of scenes having similar cover types. The final products, both digital and map, were formatted to correspond to 1:250,000-scale USGS topographic maps. For each quadrangle, the scene coverage was cut from the classifications and then spliced together.

SUMMARY

An integrated approach for computer-aided analysis is a powerful and flexible tool for vegetation/water/land-cover type mapping. The techniques are extendable to any size area. The major benefits include

- Efficient technique for collecting field data. Large areas can be sampled with minimum effort.
- Simplify and improve the interaction of the analyst with the different data sets.
- Improve the accuracy of the classification when mapping at a detailed level of vegetation types.
- Build an accurate set of data bases that can be used for many types of application, particularly modeling the distribution of wildlife and wildlife habits.

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TABLE 1. THE ACCURACY OF A COMPUTER-AIDED CLASSIFICATION OF LANDSAT MSS DATA IS INCREASED, A RESULT OF USING ANCILLARY DATA TO IMPROVE THE CLASSIFICATION.

		CLASSIFICATION ACCURACY (Percent)				
Preliminary Vegetation Class	Sample Size	MSS Only	MSS + SI&WMSS	Prior + Elevation	Prior + Slope	Discrimant Analysis
Open Spruce Forest	1648	46.8	74.8	75.1	75.1	56.1
Closed Mixed Forest	283	0.0	0.4	50.3	50.3	52.7
Open Birch Forest	447	25.7	50.3	53.8	53.8	51.2
Closed Birch Forest	795	64.2	65.7	72.1	72.1	16.1
Open Tall Shrub	578	61.6	68.3	71.9	71.9	44.6
Closed Tall Shrub	290	0.0	25.2	63.8	63.8	18.3
Dwarf Shrub/Graminoid Tussock	2809	64.6	80.0	77.9	78.6	64.8
Prostrate Dwarf Shrub Tundra	176	92.6	92.6	92.6	92.6	85.8
Closed Dwarf Shrub Tundra	357	0.0	0.0	78.4	96.9	56.3
Aquatic Forb Marsh	757	99.6	99.6	99.6	99.6	96.8
Water	216	84.7	84.7	84.7	84.7	84.7
Cloud Shadow	232	0.0	0.0	84.5	84.5	91.4
Cloud/Snow	241	100.0	100.0	100.0	100.0	93.4
Total/Average	8829	54.9	66.7	76.2	78.2	57.2

TABLE 2. SUMMARY OF THE PERCENT OF THE VEGETATION CLASSES PRESENT IN EACH OF TEN GROUPS OF PLANT SPECIES.

	Percent of Ground Cover that was:									
Final Vegetation Class	Spruce	Birch	Tall Shrub	Dwarf Shrub	Prostrate Shrub	Gram-inoid	Forb	Lichen	Moss	Barren
Open Spruce Woodland	27.0	0.0	1.0	29.0	0.0	8.0	2.0	36.0	35.0	0.0
Open Spruce Forest	57.0	0.0	20.0	27.0	0.0	13.0	13.0	17.0	27.0	0.0
Closed Mixed Forest	35.0	38.0	22.0	10.0	0.0	3.0	3.0	2.0	22.0	0.0
Open Birch Forest	6.0	44.0	18.0	34.0	8.0	8.0	6.0	24.0	46.0	0.0
Closed Birch Forest	0.0	81.0	30.0	9.0	1.0	6.0	10.0	5.0	17.0	0.0
Open Tall Shrub	0.0	0.0	38.0	32.0	0.0	38.0	5.0	0.0	35.0	0.0
Closed Tall Shrub	0.0	1.0	84.0	3.0	0.0	3.0	1.0	0.0	0.0	0.0
Dwarf Shrub/Graminoid Tussock	1.0	0.0	3.0	50.0	0.0	41.0	2.0	15.0	20.0	1.0
Prostrate Dwarf Shrub Trundra	0.0	0.0	0.0	25.0	35.0	35.0	5.0	65.0	0.0	70.0
Closed Dwarf Shrub Tundra	0.0	0.0	0.0	75.0	15.0	35.0	10.0	5.0	5.0	5.0
Aquatic Forb Marsh	0.0	0.0	0.0	0.0	0.0	7.0	63.0	0.0	0.0	0.0
Hydric Graminoid Marsh	0.0	0.0	0.0	7.0	0.0	73.0	13.0	0.0	27.0	0.0

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