ABSTRACT / The US National Park Service must map forest cover types over extensive areas in order to fulfill its goal of maintaining or reconstructing presettlement vegetation within national parks and monuments. Furthermore, such cover type maps must be updated on a regular basis to document vegetation changes. Computer-aided classification of small scale aerial photography is a promising technique for generating forest cover type maps efficiently and inexpensively. In this study, seven cover types were classified with an overall accuracy of 62 percent from a reproduction of a 1:120,000 color infrared transparency of a conifer-hardwood forest. The results were encouraging, given the degraded quality of the photograph and the fact that features were not centered, as well as the lack of information on lens vignetting characteristics to make corrections. Suggestions are made for resolving these problems in future research and applications. In addition, it is hypothesized that the overall accuracy is artificially low because the computer-aided classification more accurately portrayed the intermixing of cover types than the hand-drawn maps to which it was compared.

A primary goal of national park management in the United States is to maintain, or where necessary recreate, "biotic associations within each park ... as nearly as possible in the condition that prevailed when the area was first visited by the white man" (Leopold and others 1963). This goal was the recommendation of the Secretary of the Interior's Advisory Board on Wildlife Management. It was incorporated into the administrative policies of the National Park Service on 10 July 1964 (US National Park Service 1968). This study addresses one of the many scientific problems that are encountered in maintaining or reconstructing presettlement forests, namely, developing an efficient procedure for accurately mapping forest cover types over extensive areas.

Vegetation Mapping

Hand-drawn maps

The first step in vegetation reconstruction is to describe and map existing vegetation. To obtain the necessary descriptive information, the vegetation is first stratified into relatively homogeneous cover types. These cover types serve as the basis for sampling vegetation characteristics.

Computer Classified Maps

Computer-aided classification of vegetation from remotely sensed data has a relatively short history. Most of the work done in this field has dealt with multispectral scanner data such as are produced by the Landsat satellite. In a 1974 Laboratory for Applications of Remote Sensing (LARS) study (Hoffer 1976), for instance, five cover types were differentiated from Landsat imagery of southwestern Colorado. The types were coniferous forest, deciduous forest, grassland, water, and barren. The classification achieved 91 percent agreement with aerial photo-interpretation and field checks. In a subsequent, more intensive test over a smaller forested area, 77 percent accuracy was achieved in differentiating pine, spruce-fir, oak, aspen, grassland, water, and barren areas (Hoffer and Fleming 1978).
Bryant and others (1978) achieved 59 percent agreement between a Landsat data classification of northern Maine and ocular photo-interpretation of the same area. The types classified were softwood, mixed-wood, and hardwood. Hoffer and others (1979) found that the overall performance of Landsat classifications of forest cover types can be increased by as much as 15 percent by using topographic data in addition to spectral data.

Kessell and Cattelino (1978) tested the adequacy of Landsat imagery as a data base for high resolution (1 to 100 ha) site inventories. Several problems with Landsat data were encountered. Although a single picture element of Landsat imagery is approximately 57 by 79 m, more than one picture element was required for the accurate interpretation of features. The investigators also discovered a 10 degree rotation in Landsat imagery printouts; this could cause the naive user to make great errors in transferring information from the images to maps. Furthermore, they noted poor agreement between Landsat imagery over forested lands and reliable ocular interpretation of 1:100,000 false color infrared aerial photographic coverage of the same area. Finally, features in the Landsat imagery were displaced as a result of image distortion. They concluded that the results of their tests were “not encouraging for site-specific use of the Landsat imagery data base” (Kessell and Cattelino 1978).

Mead and Meyer (1977) reached a similar conclusion regarding the use of Landsat digital data for classification of forest types and land use classes in Minnesota. Using state-of-the-art classification techniques they were unable to produce a classification of Landsat data of high enough accuracy to be of use to forest managers.

Less work has been done in the field of computer-aided classification of vegetation from small scale aerial photography. Akca (1971) discussed the potential for mapping forest types through microdensitometric analysis of black and white imagery. Hoffer (1971) described the use of automatic data processing (ADP) in quantitative classification of aerial photography. Multiband and multieidulmion imagery at a scale of 1:120,000 covering agricultural crops and trees was analyzed. Using these two types of imagery, corn, soybeans, pasture, and trees were classified with an overall correctness of over 90 percent (Hoffer 1971).

In a more recent study of vegetation in south central Indiana, LARS investigators compared digitized data from small scale photography with three channels of multispectral data as data sources for an ADP classification technique (Coggleshall and others 1974). Six cover types were classified from the scene: deciduous forest, coniferous forest, water, forage, corn, and soybeans. Classification results indicated that the overall performance of the multispectral scanner data was about 81 percent. The accuracy of the classification based on photographic data was about 48 percent. The classification of the scanned photography included much misclassification of deciduous forest. The disparity in the accuracies between the two classifications was attributed mainly to the fact that the photography utilized was second generation, and to the greater dynamic range and higher spectral resolution of the scanner system as compared with the photographic system (Coggleshall and others 1974).

Kan and others (1975) studied the effect of image resolution on the accuracy of computer-aided classifications. They classified forest types in Texas from aerial photography taken at various altitudes. They concluded that high altitude imagery resulted in better classification accuracy than low altitude imagery because the level of homogeneity perceived by the sensor increased with an increase in altitude.

Given recent technical developments in densitometry of aerial photographic products (Scarpace 1978) and the increasing sophistication of image analysis techniques, computer-aided classification of vegetation from small scale aerial photography has become a potentially valuable vegetation mapping procedure. This study shows that complex forest vegetation can be classified and mapped with a reasonable degree of accuracy from computer analysis of small scale aerial photography.

Study Area

This study is based primarily on data from Bear Island, one of the twenty-two Apostle Islands in Lake Superior. Bear Island is in the Apostle Islands National Lakeshore (Fig. 1). Because of its considerable topographic variability, Bear Island supports a large subset of the diverse plant communities of the archipelago. Thus classification and mapping results from Bear Island can also be extended to much of the lakeshore's vegetation.

Physical Features

At its extreme points, Bear Island is approximately 3.9 km from north to south and 2.6 km from east to west. Its dominating topographic feature is a glacial drumlin, which rises in the southern half of the island to an elevation of 254 m. This hill slopes down to an elevation of 190 m on the northern end of the island.

Much of the sandstone bedrock of Bear Island is