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An Assessment of Bison Habitat in the Mills/Mink Lakes Area, Northwest Territories, Using Landsat Thematic Mapper Data

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ABSTRACT. Landsat 5 Thematic Mapper data were used to classify and map wood bison (*Bison bison athabascae*) habitat in an area of 3383.5 km^2 in the vicinity of Mills and Mink lakes, Northwest Territories. Digital image analysis techniques were used to enhance and classify satellite data acquired 31 August 1986 to determine the distribution and extent of forage habitats. Visual interpretation of cover types was carried out using a radiometric enhancement, consisting of a power contrast stretch, applied to spectral bands 5 (shortwave), 4 (near infrared), and 3 (red) and displayed as a colour composite image (red/green/blue). A DIPIX Technologies ARIES III image analysis system was used to perform an unsupervised classification of 16 spectral classes using a maximum likelihood classifier. The resultant thematic map was used during the summer of 1988, when aerial and ground surveys of the study area were carried out. Colour infrared photographs (1:20 000 scale) obtained in 1988 were also used as part of the reference data set to assist in selecting training areas for use in a supervised classification. Ground data were also collected during the summer of 1989 to increase the number of training areas and provide test sites for an accuracy assessment. In the final habitat classification, the ten physiognomic cover types were water, aspen forest, coniferous/mixed forest, sedge meadow, willow savanna, hordeum meadow, wetland complex, peat plateau/burned meadow, burned peat plateau, and burn-aspen regeneration. The Thematic Mapper data was geometrically corrected and smoothed using a post-classification filter. Results of the digital image analysis were produced as hard copy thematic maps and tabular summaries. Overall accuracy of the classification was 91% with the two important winter forage habitats — sedge meadow and willow savanna — having accuracies of 95% and 75% respectively. These forage habitats collectively represent 4.6% of the study area, or 153.3 km^2.

Digital image analysis of Landsat Thematic Mapper data proved to be an effective and cost efficient method of mapping bison habitat in a large area of the boreal forest.

Key words: bison habitat, boreal forest, digital image analysis, supervised classification, Landsat Thematic Mapper data, habitat mapping, *Bison bison athabascae*, remote sensing

RÉSUMÉ. On a utilisé l'appareil de cartographie thématique Landsat 5 pour classifier et cartographier l'habitat du bison des bois (*Bison bison athabascae*) sur une superficie de 3383,5 km^2 aux environs des lacs Mills et Mink, dans les Territoires du Nord-Ouest. On s'est servi des techniques d'analyse d'images numériques pour accentuer et classifier les données obtenues par satellite le 31 août 1986 dans le but de déterminer la distribution et l'étendue des habitats de pâturage. L'interprétation visuelle du type de couvert a été réalisée à l'aide d'une accentuation radiométrique consistant en une augmentation du contraste d'intensité appliquée aux bandes 5 (ondes courtes), 4 (infrarouge proche) et 3 (rouge) du spectre et affichée comme une image composée en couleur (rouge/vert/bleu). On s'est servi d'un système d'analyse d'images DIPIX Technologies ARIES III pour réaliser une nomenclature non dirigée de 16 classes spectrales à l'aide d'un classeur de probabilité maximale. On a utilisé la carte thématique ainsi obtenue lors de relevés aériens et au sol effectués dans la zone d'étude au cours de l'été de 1988. On s'est aussi servi des photos couleur infrarouge (échelle de 1:20 000) obtenues en 1988, comme élément de l'ensemble des données de référence pour aider à choisir les zones d'entraînement devant servir à une classification dirigée. On a aussi recueilli au cours de l'été de 1989 des données au sol pour augmenter le nombre de zones d'entraînement et fournir des sites d'essai pour une évaluation de la précision. La classification finale de l'habitat a donné dix types de couverts physionomiques: l'eau, le peuplier faux-tremble, la forêt de conifères/forêt mixte, la prairie à laîches, la prairie à saules, la prairie à orge, le complexe de terres humides, le plateau tourbeux/prairie brûlée, le plateau tourbeux détruit par le feu, et la régénération par le peuplier faux-tremble à la suite d'un feu. Les données provenant de l'appareil de cartographie thématique ont été corrigées géométriquement et régularisées à l'aide d'un filtre utilisé après la classification. Les résultats de l'analyse des images numériques ont été reportés sous forme de cartes thématiques et condensés sous forme de tableaux imprimés. La précision globale de la classification était de 91 p. cent, et les deux grands habitats de pâturage (la prairie à laîches et la prairie à saules) avaient une précision de 95 et 75 p. cent respectivement. Ces habitats de pâturage représentent ensemble 4,6 p. cent de la superficie sur laquelle portait l'étude, soit 153,3 km^2.

L'analyse d'images numériques des données obtenues avec l'appareil de cartographie thématique Landsat s'est révélée une méthode efficace et rentable pour cartographier l'habitat du bison dans une vaste région de la forêt boréale.

Mots clés: habitat du bison, forêt boréale, analyse d'images numériques, classification dirigée, données obtenues avec l'appareil de cartographie thématique, cartographie de l'habitat, *Bison bison athabascae*, télédétection

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INTRODUCTION

The Department of Renewable Resources, Government of the Northwest Territories, is responsible for managing an expanding population of free-ranging wood bison (*Bison bison athabascae*) in an area encompassing the Mackenzie Bison Sanctuary. In 1963, 18 disease-free wood bison were transplanted from Wood Buffalo National Park into the Bison Sanctuary, an area of 6248 km^2. Since their reintroduction to the sanctuary, the herd has increased in size to an estimated population of 1863 animals in 1989 (Gates *et al.*, in press). The area now occupied by wood bison extends west of the Mackenzie Bison Sanctuary into the Mills and Mink lakes area, an area exceeding 9000 km^2 (Larter, 1988).

The primary objective of the remote sensing project was to classify and map important forage habitats for wood bison. In doing so, it was also important to determine the accuracy of the final classification and determine the cost effectiveness of using remote sensing techniques.

This study was designed to complement other biological studies being conducted as part of the Mackenzie Wood Bison Management Plan (N.W.T., Department of Renewable Resources, 1987).

STUDY AREA

The study area covers approximately 3384 km^2 bordered on the north by Mink Lake (61°58′N) and on the south by

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the Mackenzie River (61°20′N). This area lies directly west of the Mackenzie Bison Sanctuary and extends from the community of Fort Providence to Mills Lake (Fig. 1).

The Mills/Mink lakes area lies within the Great Slave Plain, which forms part of the Interior Plains physiographic province (Bostock, 1964). Glacial Lake McConnell was present over the entire area during the Pleistocene era as the Wisconsin Laurentide ice sheet retreated eastward. The terrain is low lying and nearly flat, with elevations ranging from 190 m in the north to 160 m in the south. Much of the area is covered by imperfectly drained till and glaciolacustrine deposits (Craig, 1965).

The study area is located in the Upper Mackenzie Section of the Boreal Forest Region (Rowe, 1972). Coniferous forest is predominately black spruce (*Picea mariana*) and tamarack (*Larix laricina*) where moist to wet soil conditions prevail. Mixed forest contains stands of white spruce (*P. glauca*), trembling aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Pure stands of aspen and poplar are common along river drainages, such as the Horn River. Stands of white birch (*Betula papyrifera*) and white spruce can be found on the islands of the Mackenzie River and adjacent riverine forest. Dwarf birch (*B. glandulosa*) is common in open birch bogs of poorly drained peat and muskeg.

Open habitats consist of wet and mesic meadows, willow savanna, complex wetlands, and several different types of regenerating burns. *Carex aquatilis* and *C. atherodes* are the dominant species in wet sedge meadows, where wet soil conditions are found year-round. Willow savannas (*Salix* spp.) are common in the southern part of the study area near Mills Lake and also occur as small openings in the forest where soil moisture conditions tend to be mesic. Large meadows of squirrel-tail grass (*Hordeum jubatum*) are found in the northern section of the study area near Mink Lake. The vegetation in the Mink Lake area has changed greatly over the past ten years, following a wildfire in the area in 1980.

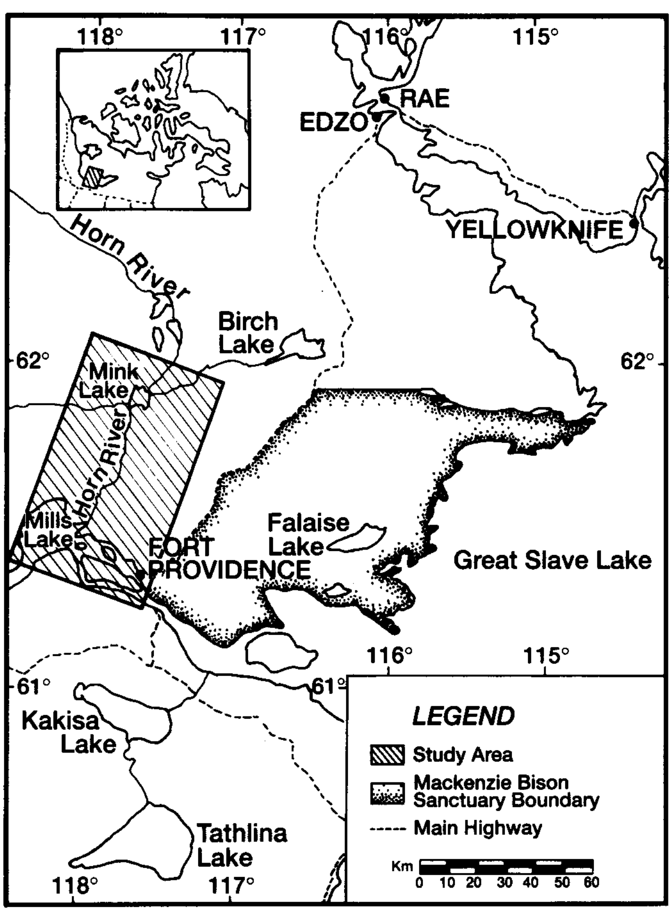

FIG. 1. Location of the Mills/Mink lakes study area, N.W.T.

METHODS

In 1988, Landsat 5 Thematic Mapper (TM) data acquired 31 August 1986 were obtained from the Prince Albert Satellite Station in Prince Albert, Saskatchewan. Both a three-band (5-red, 4-green, 3-blue) 185 mm colour transparency and a set of seven-band computer-compatible tapes were purchased for visual and digital image analysis purposes respectively. The TM imagery was cloud free and provided the best spatial (30 m pixels) and spectral resolution of satellite data available for a habitat assessment.

The colour transparency included a standard histogram equalization enhancement applied to the digital data by the Mosaics system of the Canada Centre for Remote Sensing. A histogram equalization enhancement redistributes pixel values more evenly over the full range of grey values, which improves the visual quality of the image. Examination of the transparency allowed for a preliminary analysis of vegetation cover types and the selection of a sub-area of the full Landsat scene for detailed investigation using digital image analysis techniques.

Digital image analysis was carried out at the Northwest Territories Centre for Remote Sensing, in Yellowknife, Northwest Territories, using a DIPIX Technologies ARIES III image analysis system. Descriptions of standard ARIES III software tasks are given by Piwowar (1990) and Dipix Systems Limited (1987).

Prior to the collection of ground data in the summer of 1988, the digital data were enhanced using standard ARIES enhancements such as histogram equalization, linear stretch, power stretch, logarithmic transformation, exponent transformation, and principal components transformation.

An unsupervised classification of the study area was performed using a maximum likelihood classifier applied to spectral bands 1-5 and 7, to produce 16 spectral classes. In an unsupervised classification, ground data is not required to perform this procedure. The computer analyzes the image data and determines the naturally occurring classes in the image (Piwowar, 1990). The classification was plotted at 1:50 000 and 1:125 000 using a Megatronix Corporation ACT II ink jet plotter for use during the 1988 field study.

Ground data were collected over a two-day period, 27 and 28 August 1988. A Bell 206-B Jet Ranger was used to take oblique 35 mm photographs of a number of sites from each of the 16 classes of the unsupervised classification. Where possible, large, homogeneous sites were selected for later use as training areas in a supervised classification. On the ground, vegetation was described and additional 35 mm photographs were taken. Plant species were identified according to Porsild and Cody (1980).

In addition to the field data collected, colour infrared 1:20 000 aerial photographs were obtained in mid-August 1988 for the southern portion of the study area from Fort Providence to Mills Lake.

A supervised classification was the next approach taken to classify the image and produce a thematic map of the study area. This technique relies on ground data where the analyst identifies training areas or examples of particular classes and instructs the computer to find all other like areas in the scene.

The ground reference data were used to produce an initial supervised classification of 16 classes using the ARIES maximum likelihood classifier. Bands 2 (green), 3 (red), 4 (near infrared), 5 and 7 (shortwave infrared) were selected for this procedure. Band 1 (blue) was omitted from the classification because of its susceptibility to haze and smoke, which may have been present over the study area when the image data were captured. A minimum of 1000 pixels for each training area was used wherever possible. Because some cover type classes were quite small, however, some training areas consisted of only 300-400 pixels.

The thematic map produced from the supervised classification was used during the next field season, when additional reference data were collected to improve the training area data set and provide ground control sites for an accuracy assessment. The study area was also reduced in size to the present 3383.5 km^2 to focus on the main area of interest and to reduce computer-processing time during subsequent image analysis procedures.

National Topographic System (NTS) topographic maps at a scale of 1:50 000 were used in a map-to-image geometric correction of the digital imagery prior to final image classification. The 1989 ground data were incorporated into the training areas, which were purified at 95%. The purification procedure performs a maximum likelihood thresholding function and selects those pixels within a specified percentage of the mean (Dipix Systems Limited, 1987).

Each of the 16 classes was examined using ARIES tasks to produce scattergrams and auto-correlation tables to determine how spectrally different each of the class signatures was. If the scattergrams showed class signatures overlapping by more than 50% or there was greater than 10% correlation between any two classes, then the classes were combined. The final classification of ten cover types was smoothed using a 3 × 3 post-classification filter.

An accuracy assessment of the final product was carried out as described by Story and Congalton (1986). The accuracy assessment determined the overall accuracy of the classified image as well as the individual class accuracies. Accuracy is measured as a percentage of the image that has been correctly classified when compared to ground reference data.

Project costs using remote sensing techniques were compared to conventional techniques of intensive field studies and air photo interpretation to determine a measure of cost effectiveness.

RESULTS AND DISCUSSION

Visual Image Analysis

The 185 mm Thematic Mapper colour transparency (band 5-red, band 4-green, band 3-blue) provided information on very broad cover types, such as coniferous, deciduous and mixed forest areas, meadows, wetlands, burned areas, and water bodies. ARIES III enhancements applied to raw digital data in bands 1-5 and 7 were successful in improving the image for further interpretation of vegetation cover types. The best combination of bands and enhancements was produced by applying a power stretch to bands 3, 4, and 5 and displaying them as a red (band 5), green (band 4), and blue (band 3) colour composite. A power stretch enhancement is a non-linear stretch that allows the distribution of pixels to be modified by changing a mathematical function. Contrast enhancement of the image was greatly improved by this "fine-tuning" approach.

Digital Image Analysis

Unsupervised Classification: The unsupervised classification was only moderately successful in differentiating vegetation cover types that are important forage habitats for bison. Sixteen spectral classes were selected for this procedure. This number of classes was derived from an examination of merge factors where the optimum number of classes for image interpretation is between ten and twenty (Piwowar, 1990). The resultant classification was produced as a thematic map for field checking. With this initial classification, it was found that many of the classes were unimportant to the study. For example, deciduous, coniferous, and mixed forest types were all separate classes. Two water classes showing clear and turbid water were also produced. Ground data suggested that soil moisture was a significant factor influencing the classification of vegetation types. The Mills Lake area proved to be of particular concern since water levels in the marsh vary considerably from the forest edge to the Mackenzie River annually. Although Mills Lake supports sedge meadows and areas of submergent and emergent vegetation, much of this area was "unclassified".

The unsupervised classification produced an unacceptable level of unclassified data. Greater than 5% of the study area was unclassified and included important bison habitat. The use of an unsupervised classification as a thematic map during field studies without ground data or prior knowledge of the area was not the best approach. For the first field season, a colour plot of an enhanced image would have been a more useful tool, since the data are not classified or grouped into themes.

Supervised Classification: Ground data collected in 1988 and 1989, as well as colour infrared aerial photographs, were used as a basis for the selection of training areas in the supervised classification procedure. Sixteen classes were initially chosen based on field surveys of vegetation cover types and earlier examination of the Thematic Mapper data. This classification would have provided a great deal of detail in distinguishing among cover types, especially forage habitats. However, both scattergrams and auto-correlation tables revealed that significant overlap (i.e., greater than 50% overlap for scattergrams or greater than 10% correlation by auto-correlation tables) existed among many classes. By grouping classes that represent important forage habitats and grouping other less important cover types, it was possible to increase individual class accuracy and produce an acceptable classification and thematic map. Table 1 shows how the initial classification of sixteen classes was refined by grouping classes to produce the final classification of ten cover types. The class "peat plateau — black spruce and lichen" was not included in the final classification because of spectral confusion with several other classes. A matrix of maximum likelihood signatures is presented in Table 2, which shows no significant correlation (i.e., greater than 10%) between any of the signature files. For the supervised classification, unclassified pixels were less than 1% of the total area.

In the final product, the two classes — sedge meadow and willow savanna — are the primary winter forage habitats for bison. Collectively, they represent 4.6%, or 153.3 km^2, of the 3383.5 km^2 study area. Sedge meadow and willow savanna were found to have class accuracies of 95 and 75% respectively. *Carex atherodes*, a dominant plant species found in both of these classes, is known to constitute greater than 96% of the wood bison's winter diet (Larter, 1988).

Table 3 provides a summary of the class composition for the Mills/Mink lakes study area, as well as the assessed accuracy for each class. Class accuracy ranged from 75 to 100%, with an overall accuracy of 91% achieved using a total of 172 test sites.

A forest fire in 1980 has played an important role in changing the vegetation within the study area. Burned vegetation cover type classes represent 21.4%, or 724.3 km^2, of the total area. A description of the three different burn classes is given in the following section on cover type classes. Other large cover type classes include forested areas, 24.7%, and wetlands, 39.2%. Hordeum meadows, which represent less than 1% of the study, are also important as bison habitat.

As stated earlier, class confusion was resolved primarily by merging classes with similar spectral signatures. One area where confusion was not resolved through the supervised classification procedure was in the area of Mills Lake. Some parts of the marsh were classified as "coniferous/mixed forest" where, in fact, sedge meadows were present. Unfortunately, ground data were not available for the same year the satellite data were captured and the reasons for this misclassification are not known. The Mills Lake area commonly encounters fluctuating water levels, which may have contributed to incorrect results.

Supervised classification techniques proved to be far more successful than the unsupervised approach. In the supervised classification procedure, classes are based on spectral signatures of selected training areas rather than a "machine" analysis of reflectance histograms used in the unsupervised classification procedure. With adequate ground data and the selection of training areas, the analyst can better define the range of reflectance values for each class.

A cost/benefit ratio of 15:1 was calculated for this study, where remote sensing techniques were compared to conventional methods of intensive field studies and air photo interpretation.

TABLE 1. Class groupings produced for the final supervised classification

Initial Classes	Final Classes
1) Water →	1) Water
2) Aspen forest →	2) Aspen forest
3) Coniferous forest →	3) Coniferous/mixed forest
4) Mixed forest →	3) Coniferous/mixed forest
5) Wet meadow (*Carex atherodes*) →	4) Sedge meadow
6) Wet meadow (*C. aquatilis*) →	4) Sedge meadow
7) Mesic meadow →	4) Sedge meadow
8) Willow savanna →	5) Willow savanna
9) Hordeum meadow →	6) Hordeum meadow
10) Bog/muskeg →	7) Wetland complex
11) Patterned fen →	7) Wetland complex
12) Peat plateau →	8) Peat plateau/burned meadow
13) Burned meadow →	8) Peat plateau/burned meadow
14) Burned peat plateau →	9) Burned peat plateau
15) Burn-aspen regeneration →	10) Burn-aspen regeneration
16) Peat plateau-black spruce and lichen	

Cover Type Classes of the Final Supervised Classification

The following is a brief description of the ten classes produced by the maximum likelihood classifier in the supervised classification procedure.

1) Water: The study area contains a variety of water bodies, including the Mackenzie River and other smaller rivers, lakes, creeks, and streams. All water bodies were grouped into one class whether the water was clear or turbid, deep or shallow.

2) Aspen Forest: Pure stands of trembling aspen and balsam poplar are common in the southern parts of the study area and are often associated with river drainages. The Horn River is a typical drainage system where large homogeneous aspen stands are found.

3) Coniferous/Mixed Forest: Much of interior region of the study area is dominated by black spruce and tamarack where moist soil conditions exist. These species are commonly found in mixed forest with stands of trembling aspen and balsam poplar. Although this grouped class covers nearly 25% of the study area, it does not represent important forage habitat for bison.

4) Sedge Meadow: The sedge meadow class consists of both wet and mesic meadows. Wet meadows are commonly dominated by *Carex aquatilis, C. atherodes,* or *C. rostrata*. Grasses such as *Calamagrostis* spp. and *Scolochloa festucacea* are also present in wet meadows of shallow standing water. Cat-tail (*Typha latifolia*) and some dwarf birch may be present

TABLE 2. Auto-correlation signature table for the maximum likelihood signatures

	Auto-correlation distance (ACD)[1]									
Signature file	Water	Aspen forest	Coni/ mixed	Sedge meadow	Willow savanna	Hordeum meadow	Wetland complex	Peat/burned meadow	Burned peat plateau	Burn-aspen regen
Water	0.0	115.6	13.5	160.6	57.6	169.6	22.1	88.2	113.2	28.1
Aspen forest	115.6	0.0	15.4	29.0	7.6	36.0	15.5	30.5	60.5	23.9
Coni/mixed forest	13.5	15.4	0.0	42.8	18.3	45.7	10.0	30.0	52.2	6.3
Sedge meadow	160.6	29.0	42.8	0.0	3.3	6.1	6.1	4.2	22.8	11.6
Willow savanna	57.6	7.6	18.3	3.3	0.0	15.9	6.8	11.6	25.3	12.1
Hordeum meadow	169.6	36.0	45.7	6.1	15.9	0.0	8.6	3.9	34.5	11.8
Wetland complex	22.1	15.5	10.0	6.1	6.8	8.6	0.0	3.0	14.5	2.8
Peat plateau/burned meadow	88.2	30.5	30.0	4.2	11.6	3.9	3.0	0.0	11.4	4.4
Burned peat plateau	113.2	60.5	52.2	22.8	25.3	34.5	14.5	11.4	0.0	4.6
Burn-aspen regen	28.1	23.9	6.3	11.6	12.1	11.8	2.8	4.4	4.6	0.0

[1]An ACD value of 0.0 indicates a 100% correlation between signature files; 0.5 indicates approximately 50% correlation; 1.0 indicates approximately 30% correlation; and 2.0 indicates approximately 10% correlation.

TABLE 3. Supervised classification summary of Mills/Mink lakes study area

Class	Percentage of total area	Area in km^2	Accuracy (percent correct, (n))
1) Water	8.8	296.7	100 (21)
2) Aspen forest	7.2	245.4	100 (25)
3) Coniferous/mixed forest	17.5	592.6	89 (28)
4) Sedge meadow	0.8	25.8	95 (20)
5) Willow savanna	3.8	127.5	75 (20)
6) Hordeum meadow	0.3	8.7	100 (4)
7) Wetland complex	39.2	1329.0	89 (28)
8) Peat plateau/burned meadow	5.5	185.9	86 (7)
9) Burned peat plateau	0.1	1.6	100 (6)
10) Burn-aspen regeneration	15.8	536.8	77 (13)
Multi-classified pixels	0.0	0.0	
Unclassified pixels	1.0	33.4	
TOTAL	100	3383.5	91 overall

in association with willow shrubs. Some of the wet meadows found north of the Mackenzie River near Mills Lake are small openings in black spruce forest.

Mesic meadows are generally found in drier areas as a fringe between willows (*Salix* spp.) and stands of immature aspen. Both *Carex atherodes* and *C. aquatilis* are common, along with a variety of other plant species, such as *Calamagrostis* spp. and *Geum aleppicum*. These drier sites also support several species of grass, such as *Agrostis scabra*, *Horteum jubatum*, and *Agropyron* spp.

Although it was preferable to have separate wet meadow and mesic meadow classes based on the dominant plant species, there was not a significant difference in spectral signatures for individual sedge species.

5) Willow Savanna: Willow savannas appear as a complex of open meadows interspersed between patches of willow (*Salix* spp.). *Carex rostrata* and *C. atherodes* are the dominant sedge species. Grasses are also present and include such species as *Calamagrostis* spp., *Hordeum jubatum*, *Beckmannia syzigachne*, and *Scolochloa festucacea*. Willow-herb (*Epilobium angustifolium*) and sweet coltsfoot (*Petasites* sp.) are also found in wet areas and depressions.

6) Hordeum Meadow: Hordeum jubatum, or squirrel-tail grass, is commonly found in mesic meadows in the Mink Lake area. Large homogeneous fields of this grass are distinctive and are characterized by high spectral reflectance. These areas are easily classified as a separate class.

7) Wetland Complex: The wetland complex class comprises birch bogs, patterned fens, ponded fens, and muskeg. Birch bogs typically have higher vegetation cover and less ponded water than patterned fens or ponded fens. *Salix* spp., *Betula glandulosa*, and *Carex aquatilis* are the dominant plant species. Willow (*Salix* spp.) and sedge (*C. aquatilis*) are the dominant vegetation in patterned fens where an understorey of cat-tail and bulrush (*Scirpus* spp.) is present. Ponded black spruce fens and some of the more wet patterned fens are typically shallow mud bottom ponds with bands of dead black spruce, some live tamarack, willow shrub, dwarf birch, and sedge (*Carex aquatilis*). Water smartweed (*Polygonum amphibium*) is common in some of the larger ponds.

8) Peat Plateau/Burned Meadow: This composite class of peat plateaus and burned meadows was grouped because of similar spectral reflectance. Peat plateaus are commonly covered with a dense mat of Labrador-tea (*Ledum* spp.), *Cladina mitis*, and mosses. Many of the areas contain sparse stands of living and dead black spruce. White spruce and jack pine (*Pinus banksiana*) are sometimes present. Mountain avens (*Dryas* spp.), cloudberry (*Rubus chamaemorus*), cotton-grass (*Eriophorum* spp.), and sphagnum moss are present in moist peaty areas. Burned meadows within the study area have regenerated with a vegetative cover of dwarf birch, willow, reed-bentgrass, wild barley, and some aspen saplings.

9) Burned Peat Plateau: Fires in the peat plateaus have occasionally burned the peat to a depth greater than 20 cm. Consequently, very little regrowth has occurred in these areas and approximately 50% of the ground cover remains as charred peat. Vegetative cover consists of Labrador-tea, cloudberry, some dwarf willow and regenerating aspen, and pine of less than 0.5 m high. Lichen cover is virtually nonexistent and the charred remains of black spruce are still present.

10) Burn-Aspen Regeneration: Trembling aspen and some veteran black spruce are the dominant tree species in this class. Aspen saplings have regenerated to a height of 1.5 m and willow shrubs are also establishing themselves in the area. Small pockets of black spruce forest are still present and burned, and dead trees are still standing. The understory is predominately mosses, with some willow-herb.

CONCLUSIONS

Digital image analysis of Landsat Thematic Mapper data proved to be an effective and cost efficient method of classifying and mapping important forage habitats for wood bison. Although it was not possible to analyze the data to produce separate classes based on individual plant species (e.g., *Carex atherodes*), it was possible to group classes to produce a meaningful classification and thematic map. Thematic Mapper data, with 30 m pixels, gave an acceptable level of detail both spectrally and spatially, and with a high degree of accuracy. Digital image analysis using supervised classification techniques proved to be the most effective method for assessing bison habitat in the boreal forest of the Northwest Territories.

Similar successes using remote sensing techniques have recently been achieved in the Northwest Territories. Resource inventory and mapping studies have included wetlands (Wakelyn, 1990), muskox habitat (Ferguson, 1991-this issue) and moose habitat (Case, unpubl. data).

The results of this study will be analyzed with data from intensive field studies to examine grazing pressure, composition, and forage availability to determine the carrying capacity of the area.

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