MICHIGAN DEPARTMENT OF NATURAL RESOURCES
Wildlife Division Report No. 3174
December 1992

DEERYARD MAPPING WITH LANDSAT THEMATIC MAPPER*

by
Michael L. Donovan and Dale L. Rabe

INTRODUCTION

Deeryards provide thermal protection for deer during severe winter weather. Suitable winter cover is important in determining the carrying capacity of an area for white-tailed deer (*Odocoileus virginianus*) in northern Michigan. In the eastern Upper Peninsula (UP), deeryards are usually associated with northern white cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and black spruce (*Picea mariana*). In the western UP, deeryards are generally associated with mixes of hemlock (*Tsuga canadensis*), white spruce (*Picea glauca*), and balsam fir (Verme 1973). Quality of deeryards is also related to canopy closure of conifers, at least for white cedar and hemlock (Michigan Department of Natural Resources, unpublished report).

Long-term population management of deer in northern regions requires knowledge about the availability of suitable deer yarding areas. Unfortunately, there is no complete and up-to-date inventory of deeryard areas for all land ownership's in northern Michigan. Satellite image processing has a great deal of potential as an efficient and cost-effective way to inventory and map potential deeryards over large areas, such as Michigan's Upper Peninsula.

The Landsat Thematic Mapper (TM) records spectral signatures in seven wavelength bands. Most of these bands were designed to provide information on vegetation (Swain and Davis 1978, Lillesand and Kiefer 1979). Many studies have reported upon the utility of satellite data for vegetation mapping (Klock et al. 1985, Koeln et al. 1986). Researchers have been able to discriminate between different tree species using satellite imagery (Klock et al. 1985, Maclean and Giese 1990). However, the ability to distinguish canopy closure of conifer species has not been adequately demonstrated in previous studies.

OBJECTIVES

The purpose of this study was to determine if TM data could be used to identify and map conifer habitats that provide winter yarding for deer. This includes both species composition and canopy closure.

* A contribution of Federal Aid in Wildlife Restoration, Michigan Project W-127-R

METHODS

Study Areas

Landsat TM imagery was acquired for three UP areas, each approximately 225 square kilometers in size (approximately 81 sq. mi.). These areas were selected based upon the variation in forest types and geomorphology. The "Mead Yard", located on the Menominee and Dickinson County border, is characterized by glacial drumlins oriented in a northeast-southwest direction. This area is dominated by northern hardwoods and hemlock in the uplands and northern white cedar in the lowlands. The "Bark River Yard", located on the Menominee and Delta County border, is bisected by sand lake plain to the east and glacial drumlins to the west. This area contains northern hardwoods, aspen, and hemlock in the uplands and predominately black spruce, white cedar, balsam fir, hemlock, and tamarack (*Larix laricina*) in the lowlands. The "Petrel Grade Yard", located in Alger County, is characterized by poorly drained sand lake plain. Northern Hardwoods dominate the uplands and northern white cedar and black spruce dominate the lowlands of this area. Jack pine is also found on the poorly drained sand lake plain.

Image Analysis and Training Site Selection

The three scenes used in this study were part of the full scene Landsat TM image for Path 23 Row 28, recorded on 29 July 1988 when atmospheric conditions were generally cloud and haze free. A PC ERDAS software system was used for all image processing and raster GIS work.

The imagery for all three study sites was enhanced using a principle component algorithm. The rotation matrix was computed from six bands (1-5 and 7) of raw imagery for conifer cover types as determined from a visual masking procedure. This enhanced imagery was then used to locate training sites in the field. Training sites were selected to represent the range of conifer species and canopy closure present in each study area. Training sites were also selected for broad categories of non-conifer land covers. The final habitat classification categories are listed in Table 1.

Using the ERDAS software package, training site image statistics for each classification category were analyzed to determine classification routine, band combinations, and image enhancement techniques that gave the greatest separation of training site signatures in spectral space. It was determined that all six bands of raw imagery (unenhanced) used in a maximum likelihood classification gave the greatest separation of the training sites.

Table 1. Habitat classification categories examined in each study area.

	Study Area		
Habitat Classification	Mead Yard	Bark River	Petrel Grade
Black Spruce 70+ [a]	x	x	x
Cedar 70+	x	x	x
Cedar 40-70 [b]	x	x	x
Hemlock 50+ [c]	x	x	
Jack Pine	x	x	x
Red Pine	x	x	x
White Pine	x		
Northern Hardwood	x	x	x
Aspen/Birch	x	x	x
Non-Forested	x	x	x
Water	x	x	x

[a] 70+ means greater than 70% total canopy closure for specified tree species. Training sample for all pines were over 70% canopy closure.

[b] 40-70 means more than 40% but less than 70% of canopy closure for specified tree species.

[c] 50+ means greater than 50% total canopy closure for specified tree species.

An ERDAS geographic information system (GIS) file was produced from the six-band maximum-likelihood classification for each study area. The final GIS map produced from each study area was rectified to the Michigan State Plane Coordinate system and used to ground truth the classification procedure.

All study sites were aggregated for validation of the original classifications. This was done because the imagery from the three study sites came from same TM full scene. Locating exact pixels for ground truthing was very difficult because of insufficient identifiable landmarks in the study areas. Therefore, most ground truthing of sites was done near roads where relatively precise locations could be determined. The dominate classification of the stand was evaluated and the actual composition of the stand recorded in order to determine whether the classification performed satisfactorily.

RESULTS

The classification matrix (Figure 1) summarizes the results of field validation of the habitat types. Due to small sample sizes for some habitat types, it was hard to make any strong quantitative statement about the accuracy of those types, although the trends in the results of the classification were encouraging.

There was good separation of lowland conifer stands dominated by a single species. The producers accuracy (the percentage of ground reference points for a category that were classified correctly) was 75% or above for black spruce, Cedar 70+, and hemlock. Only Cedar 40-70 (67%) was lower than 75% correctly classified. Non-conifer categories such as northern hardwoods and aspen/birch were correctly classified 79% and 90% of the time, respectively. These categories were not a high priority for the study and were only evaluated secondarily.

Although the maximum likelihood classification algorithm forced every pixel in the image to be classified into a category, the classification system did not adequately encompass all possible habitat types that occur on the study areas. Therefore eleven (11) ground reference pixels did not fit into the classification system but were classified into one of the existing classes. Most of these ground reference pixels were in lowland conifer stands consisting of near equal mixes of cedar, black spruce, balsam fir, and tamarack in varying canopy closures. Most of these pixels were classified as either low density cedar (Cedar 40) or hemlock. Much more work needs to be done in refining training samples for these mixed conifer categories.

DISCUSSION

Although more work needs to be done to determine the resolution limits for separation of conifer stands by species composition and canopy density, the results of the pilot study were favorable. The stands of cedar or hemlock with canopy closures greater than 70% were identified as providing the highest quality winter cover for deer in northern Michigan (Michigan Department of Natural Resources, unpublished report). The results of this study indicated that it is technically feasible to identify relatively homogeneous stands of cedar and hemlock at these relatively high canopy closures.

Landsat TM can provide the wildlife manager with imagery over large geographic regions at a relatively low cost (presently $4,400.00 for approximately 12,000 sq. mi. of coverage). Using digital image processing a wildlife habitat inventory can be performed at a very low cost per unit area. Recent

Figure 1. Classification matrix comparing satellite image classification of habitat types with ground-truthed observations.

Satellite Classification of Habitat	Ground Truthed Classification													
	Blk Spruce	Cedar	Cedar	Hemlock	Jack	Red	White	North Hard/	Northern	Aspen/	Non-	Water	Other	Users
	70+CC	70+CC	40-70CC	50+CC	Pine	Pine	Pine	Hemlock	Hardwood	Birch	Forested			Accuracy
Blk Spruce 70+CC	6													1.00
Cedar 70+CC	1	9	1										1	0.75
Cedar 40-70CC			14	2									5	0.67
Hemlock 50+CC	1		6	7		1							4	0.37
Jack Pine														no data
Red Pine						1							1	0.50
White Pine														no data
North Hard/Hemlock								2	3	1				0.33
Northern Hardwood									11					1.00
Aspen/Birch										9				1.00
Non-Forested											2			1.00
Water														no data
Producers Accuracy	0.75	1.00	0.67	0.78	no data	0.50	no data	1.00	0.79	0.90	1.00	no data	n/a	

cost estimates acquired by the Wildlife Division, Michigan Department of Natural Resources, were less than $10.00 per sq. mi.

It is important to remember that this type of imagery alone may not be suitable for the analysis of habitat for all wildlife species. The spectral, spatial and temporal resolution of the TM imagery may limit the use of TM imagery for wildlife habitat analysis. For example, habitat analysis that requires the identification of understory vegetation or tree stocking density are usually more difficult than analysis that only requires the identification of dense canopied forest stands. Where ancillary information can be included with TM imagery in a habitat classification routine, the results are often improved significantly over using TM imagery alone. Two types of ancillary information that can improve the results of a TM classification are digital soils and digital elevation data.

Computer image processing of TM data can provide the wildlife manager with a tool for inventorying habitats over large geographic areas without regard for land ownership. Because TM imagery is in a digital format, inventory data can easily be entered into a GIS along with other sources of ancillary information, and used for spatial analysis. Using this type of data processing scenario, a wildlife manager can easily track changes in the landscape over time, model wildlife's response to those changes, and therefore make the most efficient use of their time.

REFERENCES

Klock, G.O., P. Gum, and L. E. Jordan III. 1985. Developing a Resource Management Data Base for The Okanogan National Forest from Multispectral Imagery and the Use of GIS. In Proceedings of the Tenth Annual William T. Pecora Memorial Symposium on Remote Sensing, Ft. Collins Colorado. pp. 144-152.

Koeln, G.T., P. Caldwell, D.E. Wesley, and J.E. Jacobson. 1986. Inventory of Wetlands with Landsat's Thematic Mapper. In Tenth Canadian Symposium on Remote Sensing, Edmonton, Alberta, Canada.

Lillesand, T.M. and R.W. Kiefer. 1979. Remote Sensing and Image Interpretation. John Wiley and Sons, New York, N.Y. 581pp.

Maclean A.L. and R.L. Giese 1990. An In-Depth Assessment of Thematic Mapper Imagery for Forest Type Mapping of Northern Hardwood and Conifer Forests in the Lakes States Area.

Swain P.H. and S.M. Davis. 1978. Remote Sensing The Quantitative Approach. McGraw-Hill, Inc., New York, N.Y. 133pp.

Verme, L.J. 1973. Movements of White-tailed Deer in Upper Michigan. J. Wildl. Manage. 37(4):545-552.