

COMPUTER ANALYSIS OF LANDSAT DATA FOR EVALUATING
WILDFIRE ON THE SENEY NATIONAL WILDLIFE REFUGE

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ABSTRACT

POST-FIRE LANDSAT MULTISPECTRAL SCANNER IMAGERY OF THE FALL, 1976, SENEY NATIONAL WILDLIFE REFUGE WILDFIRE WAS ANALYZED WITH THE COMPUTER-ASSISTED TECHNIQUES OF THE EARTH RESOURCES DATA CENTER, ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN. EVALUATION OF IMAGE CATEGORIZATION REVEALED THE FOLLOWING: 1) FIRE BOUNDARIES COULD BE MAPPED IN ALL BUT THOSE AREAS WHERE FIRE EXISTED SOLELY AS A LIGHT SURFACE FIRE UNDER THE FOREST CANOPY, 2) SIMILAR SPECTRAL SIGNATURES FROM BURNED AREAS AND MARSHES PREVENTED THEIR SEPARATION IN THE CATEGORIZATION, AND 3) DEGREE OF BURN COULD NOT BE DETERMINED. CLASSIFICATION AREA TABULATIONS ARE PRESENTED FOR THE SENEY REFUGE.

PROBLEM STATEMENT

LANDSAT MULTISPECTRAL SCANNER IMAGERY POTENTIALLY SERVES AS A VALUABLE DATA SOURCE FOR THE EVALUATION OF WILDFIRE. EXTENSIVE REMOTE SENSOR COVERAGE OF THE SENEY NATIONAL WILDLIFE REFUGE WILDFIRE OF 1976, INCLUDING MULTIDATE COLOR INFRARED PHOTOGRAPHY AND LANDSAT MSS IMAGERY, IN CONJUNCTION WITH THOROUGH GROUND SURVEYS, MADE POSSIBLE AN ASSESSMENT OF THE UTILITY OF THE LANDSAT DATA FOR WILDFIRE EVALUATION.

OBJECTIVES

THE OBJECTIVES OF THE STUDY WERE:

1. TO DETERMINE THE ACCURACY OF LANDSAT IMAGERY TO EVALUATE THE AREA BURNED IN THE WALSH DITCH FIRE, SENEY NATIONAL WILDLIFE REFUGE, USING COMPUTER-ASSISTED ANALYSIS.
2. TO DETERMINE THE TOTAL AREA OF BURN, THE AREA WITHIN THE FIRE PERIMETER LEFT UNBURNED, AND THE AREA

- WITHIN THE WILDLIFE REFUGE THAT WAS BURNED.
3. TO CLASSIFY THE BURN AREA INTO SUB-CATEGORIES OF THE DEGREE OF BURN.

BACKGROUND

A LIGHTNING STRIKE RESULTED IN FIRE IN THE SENEY NATIONAL WILDLIFE REFUGE, LOCATED IN MICHIGAN'S UPPER PENINSULA, ON 30 JULY, 1976. REFUGE POLICY DICTATED THAT THE FIRE BE ALLOWED TO BURN AS LONG AS IT REMAINED WITHIN THE REFUGE BOUNDARY. BY 11 AUGUST, THE FIRE NO LONGER WAS CONFINED TO THE REFUGE, AND FIRE SUPPRESSION WAS INITIATED. NOT UNTIL 21 SEPTEMBER WAS THE FIRE FINALLY BROUGHT UNDER CONTROL, BY WHICH TIME AN ESTIMATED 74,000 ACRES HAD BEEN BURNED (SUGARBAKER, 1979). A MAP OF THE REFUGE AND FIRE BOUNDARY IS PRESENTED IN FIGURE 1.

IN A PREVIOUS STUDY, SUGARBAKER (1978, 1979) CONSTRUCTED FIRE BOUNDARY, POST-FIRE VEGETATION, AND PRE-FIRE TO POST-FIRE VEGETATION CHANGE MAPS FROM COLOR IR AERIAL PHOTOGRAPHY AND GROUND SURVEYS. MANUAL INTERPRETATION OF LANDSAT IMAGERY BY SUGARBAKER REVEALED THE POTENTIAL OF THIS DATA SOURCE FOR ACCURATELY MAPPING FIRE BOUNDARIES FOR ALL BUT LIGHT SURFACE FIRES WHICH OCCUR UNDER FOREST CANOPIES. AN ASSESSMENT OF BURN SEVERITY FROM THE LANDSAT IMAGERY WAS INCONCLUSIVE.

THE WORK OF SUGARBAKER SERVED AS THE BASIS FOR THIS PROJECT. THE RESULTS AND EXTENSIVE DATA SET DERIVED FROM THAT STUDY PROVIDED A UNIQUE OPPORTUNITY TO DEMONSTRATE THE UTILITY OF COMPUTER-ASSISTED ANALYSIS OF LANDSAT MSS DATA FOR EVALUATING THE EFFECTS OF WILDFIRE.

DESCRIPTION OF STUDY AREA

A THOROUGH DESCRIPTION OF THE VEGETATION COMMUNITIES PRESENT IN THE SENEY NATIONAL WILDLIFE REFUGE HAS BEEN DOCUMENTED BY SUGARBAKER (1978, 1979) AFTER THAT OF HEINSELMAN (1965). THE STUDY AREA IS A VAST SANDPLAIN PRODUCED BY THE DEPOSITION OF GLACIER OUTWASH COVERED FOR THE MOST PART BY A BLANKET OF PEAT. NUMEROUS SAND KNOLLS INTERRUPT THE PEAT THROUGHOUT THE AREA TO SUPPORT UPLAND VEGETATION TYPES.

THE CENTER OF THE AREA BURNED IS COMPOSED OF TREELESS STRING BOGS AND TOPOGRAPHICALLY ORIENTED STRIPS OF BOG FOREST. MAJOR SPECIES INCLUDE TAMARACK (LARIX LARICINA (DUROI) K. KOCH) AND BLACK SPRUCE (PICEA MARIANA (MILL.) B.S.P.). THESE FOREST TYPES ARE FOUND TO TRAIL DOWNSLOPE FROM SMALL SAND KNOLLS OF RED AND WHITE PINE (PINUS RESINOSA AIT. AND P. STORBUS L.).

IN THE SOUTHERN PART OF THE BURN AREA THE BOGS AND BOG FORESTS ARE REPLACED BY SAND KNOLLS SURROUNDED BY MEADOWS OF SEDGES (CAREX SPP.) AND COTTONGRASSES (ERIOPHORUM SPP.).

TO THE NORTH, THE AREA OF BURN IS COMPOSED OF STRING GRASS MEADOWS, WHICH ARE WATERWAYS, AND VARIOUS FOREST TYPES SURROUNDING THE MEADOWS. MAJOR FOREST TYPES INCLUDE TAG ALDER LOWLANDS, SPRUCE-FIR, ASPEN, AND UPLAND PINE FORESTS.

METHODOLOGY

GROUND REFERENCE USED IN THE STUDY WAS PROVIDED BY MR. LARRY SUGARBAKER (NOW WITH THE WASHINGTON DEPARTMENT OF NATURAL RESOURCES). THESE MATERIALS INCLUDED U.S. FISH AND WILDLIFE SERVICE COLOR INFRARED (CIR) AERIAL PHOTOGRAPHY (NOMINAL SCALE, 1:15,840) OBTAINED ON 11 MAY 1977 AND CIR PHOTOGRAPHY (NOMINAL SCALE, 1:68000) OBTAINED ON 18 SEPTEMBER 1976.

MAPPED INFORMATION INCLUDED POST-FIRE VEGETATION AND PRE-FIRE TO POST-FIRE VEGETATION CHANGE MAPS AND A FIRE BOUNDARY MAP DRAWN ON U.S. GEOLOGICAL SURVEY 7.5 MINUTE QUADRANGLE SHEETS AT A SCALE OF 1:24,000. ALL MAPS WERE CONSTRUCTED BY SUGARBAKER IN A PREVIOUS STUDY OF THE SENEY WILDFIRE (1978, 1979). A LANDSAT COMPUTER COMPATIBLE TAPE (CCT) FROM 11 MAY 1977 (IDENTIFICATION NUMBER 2840-15325; POST-FIRE AND THE SAME DATE AS THE CIR PHOTOGRAPHY) WAS SUPPLIED BY THE U.S. FISH AND WILDLIFE RESEARCH LABORATORY IN LAUREL, MARYLAND.

THE FACILITIES OF THE EARTH RESOURCES DATA CENTER (ERDC) OF THE ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN (ERIM) WERE USED IN THE STUDY. THE MAJOR ELEMENTS OF THE ERDC EMPLOYED INCLUDED: THE ERIM MULTISPECTRAL DATA ANALYSIS SYSTEM (MDAS) FOR THE ANALYSIS OF THE LANDSAT CCT, THE ERDC DATAGRID DIGITIZER FOR DIGITIZING THE MAPPED DATA, AND THE OPTRONICS FILM RECORDER FOR THE PRODUCTION OF FILM PRODUCTS.

THE ANALYSIS PROCEEDED WITH A SUPERVISED CATEGORIZATION OF THE LANDSAT SCENE IN THE AREA OF THE SENEY FIRE. TRAINING SETS OF VARIOUS LAND COVER TYPES WERE SELECTED ON THE MOVING WINDOW DISPLAY (MWD) AND ANALYZED BY MULTIVARIATE CATEGORICAL PROCESSING. FOLLOWING SATISFACTORY CLASSIFICATION, A CATEGORIZED LANDSAT SCENE WAS GENERATED AND PLACED ON DISK FILE FOR SUBSEQUENT FILMING. SOME MANUAL INTERPRETATION AND EDITING OF THE CATEGORIZED SCENE WAS PERFORMED ON THE MWD PRIOR TO FILMING.

IN ORDER TO ASSESS THE ACCURACY OF THE LANDSAT CATEGORIZATION, A COMPARISON OF THE COMPUTER CLASSIFIED BURN AREA AND THE GROUND TRUTH BURN AREA WAS UNDERTAKEN. FOLLOWING GEOMETRIC PROCESSING, ERDC DIGITAL POLYGON FILES FROM DIGITIZED GRAPHICAL DATA CAN BE CONVERTED TO LANDSAT SCAN LINE AND PIXEL ELEMENT COORDINATES AND THEN OVERLAYED WITH A CLASSIFIED

LANDSAT SCENE FOR COMPARISON. FOR THIS ANALYSIS, UNBURNED AREAS WITHIN THE FIRE BOUNDARY (INCLUDING PONDS) AND AN UNBURNED "WINDOW" EXTERIOR TO THE FIRE PERIMETER WERE DIGITIZED ON THE U.S.G.S. 1:24,000 SHEETS AND PLACED IN A POLYGON FILE TO BE MERGED WITH THE LANDSAT CLASSIFIED SCENE.

THE BOUNDARY OF THE SENEY REFUGE WAS ALSO DIGITIZED AND PLACED ON FILE IN ORDER TO CREATE BURN AREA TABULATIONS FOR THE REFUGE. AFTER GEOMETRIC PROCESSING, THE REFUGE BOUNDARY WAS OVERLAYED WITH THE CLASSIFIED LANDSAT SCENE AND THE PIXELS WITHIN THE BOUNDARY TABULATED ACCORDING TO THE CLASSIFICATION.

TWO FILM PRODUCTS WERE GENERATED TO ASSIST IN THE ANALYSIS. A COMPUTER ENHANCED FALSE-COLOR IMAGE (BANDS 4,5, AND 7), RECORDED AT A SCALE OF 1:312,000, SERVED AS A REFERENCE TO THE SENEY AREA AND HELPED TO IDENTIFY CERTAIN GROUND FEATURES ON THE MWD. A COLOR-CODED IMAGE OF THE CATEGORIZED SCENE WAS RECORDED AT A SCALE OF 1:374,500 AND ASSISTED IN THE FINAL EVALUATION.

A FLOW CHART OF THE METHODOLOGY IS PRESENTED IN FIGURE 2.

RESULTS

A TOTAL OF FOURTEEN TRAINING SETS AND ASSOCIATED GROUPS WERE USED IN THE FINAL CATEGORICAL ANALYSIS OF THE SENEY LANDSAT IMAGE (FIGURES 3A AND 3B). FOR SEVERAL LAND COVER TYPES, BURN, WATER, AND AGRICULTURAL LAND, IT WAS NECESSARY TO SELECT TWO OR THREE TRAINING SETS TO FULLY REPRESENT THOSE COVER TYPES. IN PARTICULAR, AT POINTS WHERE THE FIRE CROSSED THE WALSH DITCH, SEVERAL SPECTRAL SIGNATURES WERE VISIBLE ON THE IMAGERY. TWO TRAINING SETS WERE CHOSEN AS BURN IN THIS AREA. TRAINING SETS OF THE SAME COVER TYPE WERE KEPT SEPARATE IN THE CATEGORICAL ANALYSIS, BUT EACH COVER TYPE WAS

REPRESENTED BY ONLY ONE COLOR IN THE COLOR-CODED CATEGORIZED IMAGE (FIGURE 4; THE COLOR KEY IS LOCATED IN THE TABLE). THE CATEGORIZED LAND COVER TYPES ARE PRESENTED IN THE TABLE. THE MICHIGAN LAND COVER/USE CLASSIFICATION SYSTEM (MLUCRC, 1976) WAS USED TO DESCRIBE THE CATEGORIES AS THEY WERE IDENTIFIED FROM SUGARBAKER'S POST-FIRE VEGETATION MAP.

EVALUATION OF INITIAL TRAINING SET HISTOGRAMS REVEALED THAT VARIOUS DEGREES OF BURN COULD NOT BE SEPARATED BASED ON SPECTRAL CHARACTERISTICS. TRAINING SETS WERE SELECTED IN AREAS OF HOMOGENEOUS BURN, BUT SELECTED SO AS TO BE REPRESENTATIVE OF DIFFERENT ZONES OF RELATIVE BURN AS MANUALLY INTERPRETED BY SUGARBAKER (1979) FROM THE LANDSAT IMAGERY (FIGURE 5). ALL TRAINING SETS EXHIBITED SIMILAR SPECTRAL SIGNATURES, AND THE ATTEMPT TO CLASSIFY BURN SEVERITY WAS ABANDONED. IT IS PROBABLE THAT SUGARBAKER'S CLASSIFICATION REFLECTED CHANGES IN PERCENT OF COVER BURNED RATHER THAN THE POTENTIAL DIFFERENCES IN SPECTRAL REFLECTANCES FROM AREAS OF BURN.

TRAINING SET SELECTION WAS SUCCESSFUL IN DIFFERENTIATING BURN FROM WATER. FIGURE 3A REVEALS THAT COUNTS IN BAND 7 FOR WATER WERE SIGNIFICANTLY LOWER THAN THOSE FOR BURN AND THUS PERMITTED SEPARATION OF THESE TWO COVER TYPES. CLASSIFICATION IN AREAS OF VERY SHALLOW WATER AND/OR NON-FORESTED WETLANDS (MLUCRC CLASSIFICATIONS 6230/6240) PROVED TO BE NOT SO SUCCESSFUL. THE SPECTRAL SIGNATURE OF THESE AREAS WAS SIMILAR TO THAT OF THE BURN TRAINING SETS, RESULTING IN THE MISCLASSIFICATION OF THESE MARSHES AS BURN. ATTEMPTS TO DESIGNATE A MARSH TRAINING SET PROVED FRUITLESS DUE TO THE LACK OF A HOMOGENEOUS AREA OF MARSH LARGE ENOUGH TO BE ENCLOSED BY THE CURSOR. THE RESULTS OF THE FINAL CATEGORICAL ANALYSIS DISPLAYED THE PERIMETERS OF MOST PONDS AS A RING OF "BURN" ONE OR TWO PIXELS DEEP AND "BURN" WAS FOUND TO RUN PARALLEL TO ALL THE WATERWAYS IN THE STUDY AREA. THE PROB-

LEM WAS RECONCILED BY MANUAL EDITING OF THE CATEGORIZED SCENE. BASED ON THE MAPPED GROUND TRUTH, PIXELS SHOWING "BURN" OUTSIDE THE FIRE PERIMETER WERE SURROUNDED WITH THE CURSOR ON THE MWD AND THEIR GROUP NUMBER ALTERED TO THAT OF A CATEGORY DESIGNATED AS NON-FORESTED (NON-WOODED) WETLANDS. IT IS UNKNOWN HOW MANY PIXELS WERE ALTERED BY THE MANUAL INTERPRETATION.

SUGARBAKER (1979) FOUND THE MAY LANDSAT IMAGE PERMITTED MAPPING OF THE FIRE BOUNDARY FROM MANUAL INTERPRETATION IN ALL BUT THOSE AREAS WHERE THE FIRE EXISTED SOLELY AS A LIGHT SURFACE FIRE UNDER FOREST OVERSTORIES. THE RESULTS OF THIS STUDY SUPPORT THIS CONCLUSION. IN THOSE AREAS OF HEALTHY FOREST CANOPY, THE LANDSAT MSS IS UNABLE TO DETECT THE PRESENCE OF SURFACE PHENOMENON, WITH THE RESULT THAT SOME AREAS OF RECORDED BURN (BASED ON MAPPED GROUND TRUTH) WERE CATEGORIZED AS NON-BURN BY THE COMPUTER ANALYSIS.

IT WAS ORIGINALLY INTENDED TO DERIVE AN ESTIMATE OF THIS ERROR BY MERGING THE DIGITIZED NON-BURN AREA FILE WITH THE LANDSAT CATEGORIZED SCENE. TIME LIMITATIONS PRECLUDED THIS ANALYSIS AS IT WOULD HAVE BEEN NECESSARY TO CONVERT THE ENTIRE DIGITIZED NON-BURN POLYGON FILE TO LANDSAT SCAN LINE AND PIXEL ELEMENT COORDINATES. COMPLETION OF THIS ERROR ANALYSIS IN A FUTURE STUDY WOULD BE MOST BENEFICIAL FOR ASSESSING THE UTILITY OF LANDSAT MSS IMAGERY FOR EVALUATING WILDFIRE.

THE EXTENT OF THIS ERROR, EVALUATED BY VISUAL REVIEW, WAS ESTIMATED TO BE GREATEST IN THE AREA DIRECTLY SOUTH OF ROUTE 28 AND IN THE AREA DIRECTLY WEST OF DRIGGS RIVER ALONG THE EASTERN BOUNDARY OF THE FIRE. THESE AREAS GENERALLY WERE MAPPED AS CONIFEROUS OR MIXED CONIFER-BROADLEAVED FOREST (MLUCRC CLASSIFICATION 4200/4300) BY SUGARBAKER (1979).

WHERE THE CANOPY WAS CLOSED AND UNBURNED, SURFACE FIRE DETECTION WAS POSSIBLE ONLY FROM THE AERIAL CIR PHOTOGRAPHY.

IT WAS DESIRABLE TO OBTAIN AREA TABULATIONS FOR THE FIRE WITHIN THE SENEY NATIONAL WILDLIFE REFUGE BOUNDARY. TIME LIMITATIONS DID NOT PRECLUDE THIS ANALYSIS. THE COMPUTER WAS EMPLOYED TO OVERLAY THE DIGITIZED REFUGE BOUNDARY WITH THE LANDSAT SCENE AND TO TABULATE THE PIXELS WITHIN THE REFUGE BASED ON THE PRECEDING CATEGORIZATION. THE TABLE LISTS THE AMOUNT OF LAND COVER WITHIN THE REFUGE BOUNDARY FALLING WITHIN A PARTICULAR CATEGORY IN ACRES, SQUARE KILOMETERS, AND AS A PERCENTAGE OF THE TOTAL. PROCESSED AT A REJECTION LEVEL OF FOUR STANDARD DEVIATIONS, APPROXIMATELY ONE-FIFTH OF THE LANDSAT SCENE WITHIN THE REFUGE REMAINED UNCATEGORIZED. THE DESIGNATION OF FURTHER TRAINING SETS WAS DEEMED UNNECESSARY BY THESE INVESTIGATORS AS THIS WOULD NOT HAVE SERVED TO ALTER THE RESULTS OR CONCLUSIONS OF THIS STUDY. ACCORDING TO THIS CATEGORIZATION, TWENTY-SEVEN PER CENT OF THE SENEY NATIONAL WILDLIFE REFUGE WAS BURNED IN THE 1976 WILDFIRE.

CONCLUSIONS

THE TOTAL AREA OF BURN AND THE AREAS OF OTHER LAND COVER TYPES WITHIN THE SENEY NATIONAL WILDLIFE REFUGE WERE DETERMINED BY COMPUTER TABULATION OF PIXELS WITHIN THE REFUGE BOUNDARY. WITHOUT THE INCORPORATION OF THE DIGITIZED NON-BURN POLYGON FILE, A COMPARATIVE ANALYSIS OF LANDSAT BURN CATEGORIZATION AND GROUND SURVEY WAS NOT DETERMINED. MANUAL REVIEW OF BOTH DATA SETS INDICATED THAT THIS ASSESSMENT WOULD BE POSSIBLE WITH ADDITIONAL STUDY.

THE DIGITAL SCENE PROVIDED THE RAPID ACCOUNT OF THE EXTENT OF THE FIRE BOUNDARY AND THE AREAS OF OBVIOUS UNBURN, AND

SHOULD PROVIDE THE BASIS FOR MAPPING THESE AREAS. LAUER AND KRUMPE (1973), IN A NASA STUDY OF WILDLAND RESOURCES OF NORTHERN CALIFORNIA, CONCLUDED THAT LANDSAT EVALUATION OF POST-FIRE AREAS WAS SUPERIOR TO GROUND SURVEY, WITH A TEN TO ONE COST ADVANTAGE. EQUALLY IMPORTANT IN THEIR STUDY, A MUCH HIGHER ACCURACY OF ACTUAL DAMAGED AREA WAS OBTAINED FROM LANDSAT IMAGERY ANALYSIS. THE SENEY DIGITAL SCENE INDICATED SMALL BURN EXTRUSIONS BEYOND THE MANUALLY INTERPRETED PERIMETER, AND THUS MAY HAVE REVEALED FIRE-JUMP AREAS OVERLOOKED IN THE ORIGINAL EVALUATION BY THE GROUND CREW SURVEY. VERIFICATION WOULD REQUIRE FURTHER ANALYSIS WITH GROUND TRUTH.

IN FINAL CONCLUSION, OBJECTIVE EVALUATION OF THE FIRE PERIMETER IS AVAILABLE THROUGH THE UTILIZATION OF DIGITAL LANDSAT ANALYSIS, ESPECIALLY IN DOMINATE FOREST STANDS WITH HOMOGENEOUS GROUND COVER. A CRITICAL REVIEW OF LANDSAT SCENE AND APPROPRIATE SCENE DATE MUST BE UNDERTAKEN FOR OPTIMUM EVALUATION OF FIRE IN MIXED VEGETATIVE CANOPIES AND IN AREAS OF WETLAND.

FUTURE STUDIES SHOULD INVESTIGATE BAND RATIOING METHODS TO SEPARATE WETLAND AND BURN SIGNATURES.

RECOMMENDATIONS

THE COMPUTER ASSISTED ANALYSIS OF THE SENEY WILDFIRE SUPPORTS SEVERAL RECOMMENDATIONS FOR FUTURE STUDIES OF POST-FIRE EVALUATION IN AREAS OF MIXED CANOPY AND WETLAND. FIRST, ACQUISITION OF APPROPRIATE LANDSAT SCENE(S) IS A DEFINITE REQUIREMENT. INCORPORATION OF MULTIPLE SCENE DATES MIGHT BE ADVANTAGEOUS SINCE CROWN FOLIAGE MAY REMAIN FOR MANY WEEKS BEFORE DROPPING, AND GREEN-UP, PARTICULARLY IN WETLANDS, IS HIGHLY VARIABLE. SECOND, THE ACQUISITION OF THE MAXIMUM AMOUNT OF SUPPORTIVE DATA SUCH AS GROUND TRUTH OF VEGETATIVE

COVER TYPES AND SOIL TYPES AND CLIMATOLOGICAL RECORDS IS IMPERATIVE. LAST, UTILIZATION OF BAND RATIOING METHODS COULD PROVIDE DEFINITIVE ANALYSIS IN BURN AND WETLAND AREAS.

WITH THESE RECOMMENDATIONS, THE RESULTS OF FUTURE FIRE STUDIES WITH LANDSAT DATA WOULD FURNISH A PRODUCT OF ENORMOUS COST SAVINGS AND GREATER ACCURACY THAN THAT OF CONVENTIONAL GROUND SURVEY TECHNIQUES.

ACKNOWLEDGEMENT

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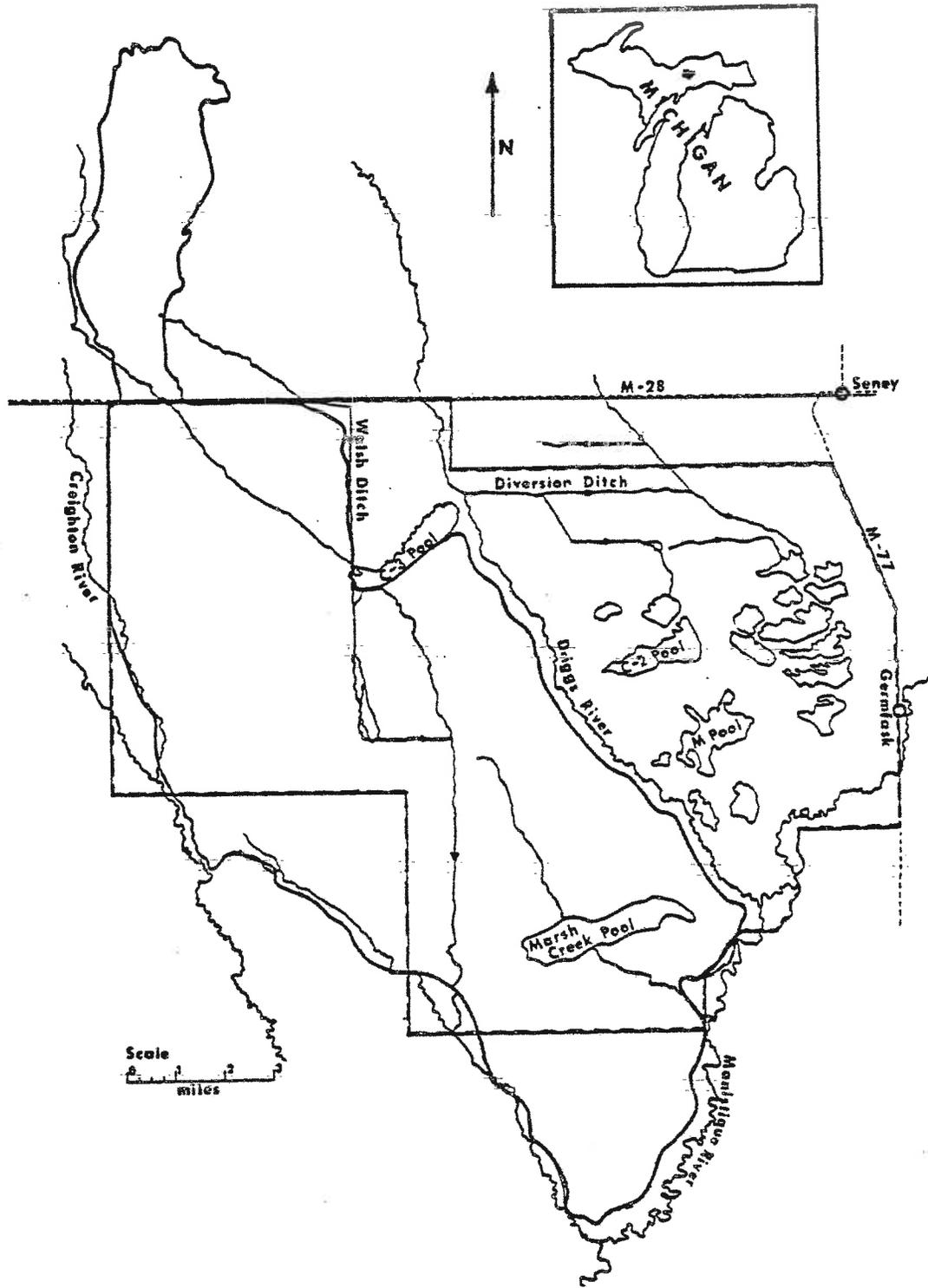


FIGURE 1. SENEY NATIONAL WILDLIFE REFUGE, UPPER MICHIGAN (FROM SUGARBAKER, 1979).

FIGURE 2. SENEY NATIONAL WILDLIFE REFUGE WILDFIRE PROJECT

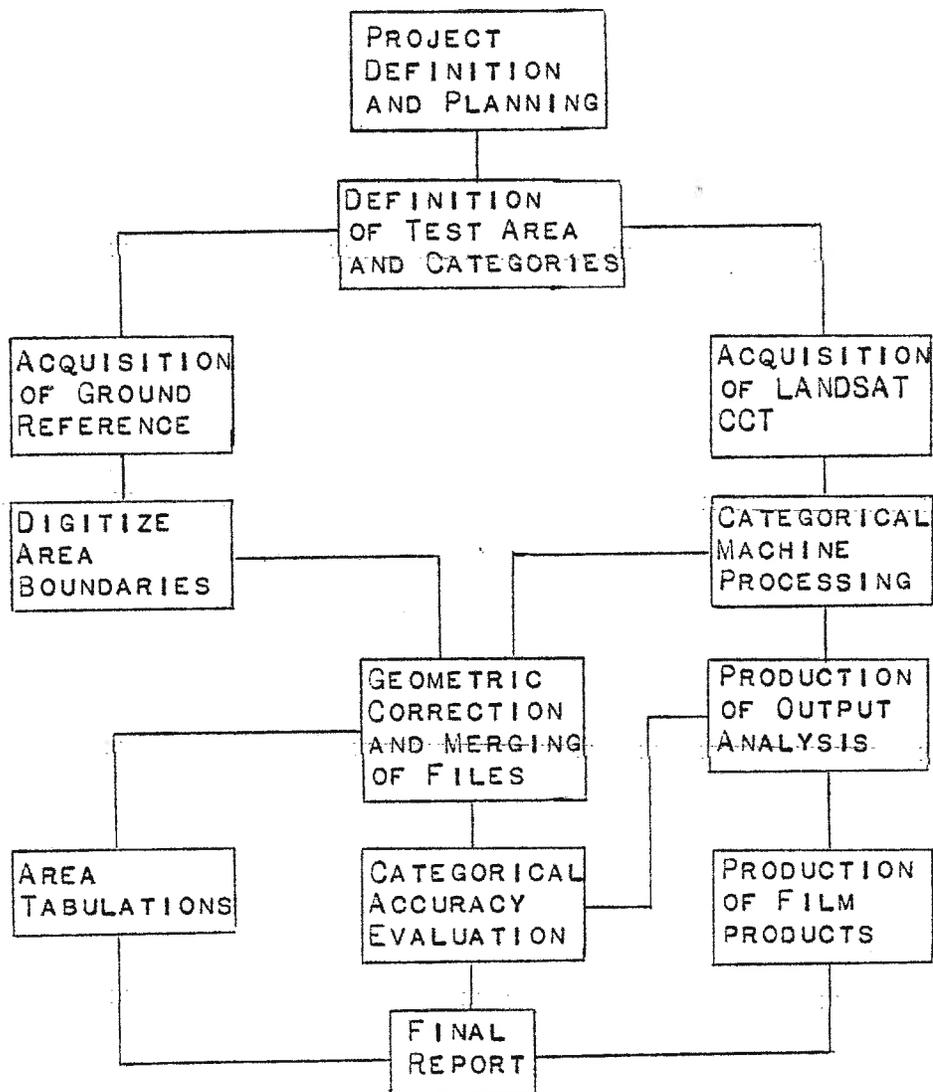


FIGURE 3A

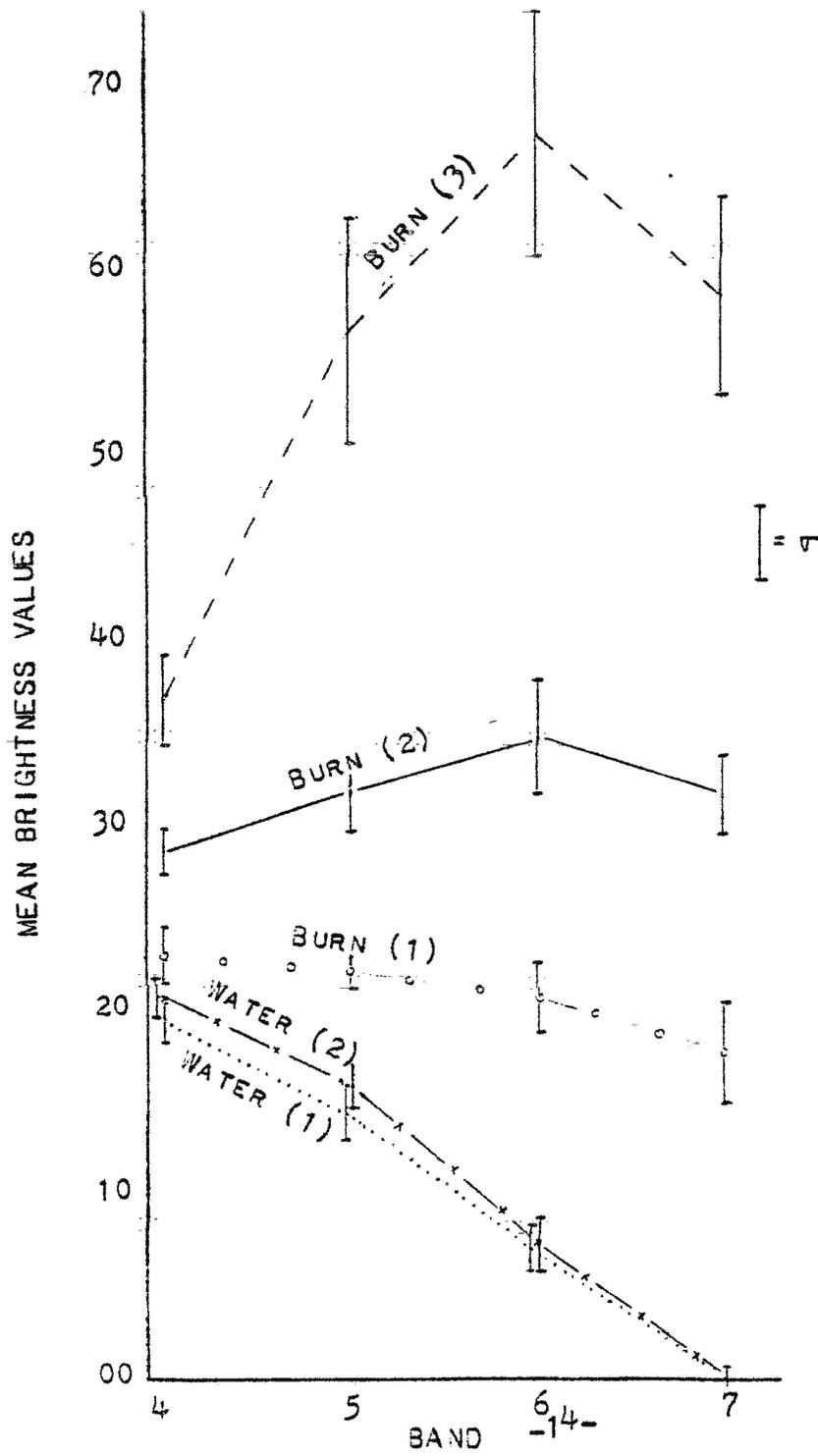


FIGURE 38

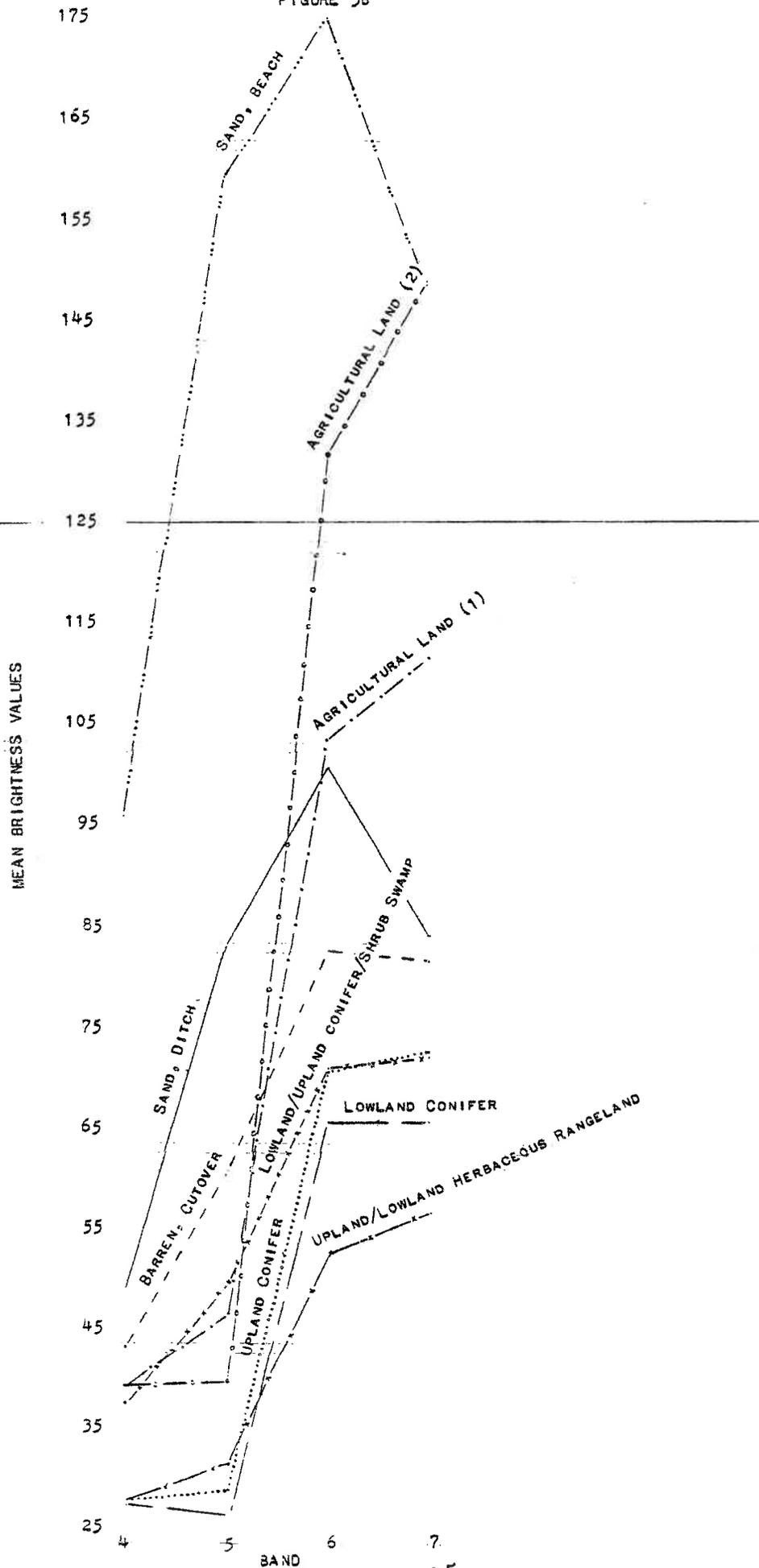


TABLE: AREA TABULATIONS
AND COLOR ASSIGNMENTS

<u>CATEGORY</u>	<u>MLUCRC CLASSIFICATION</u>	<u>COLOR ASSIGNMENT</u>	<u>PERCENT OF TOTAL</u>	<u>ACRES</u>	<u>Sq.Km.</u>
BURN	7500	BRIGHT RED	27.32	25829	104.52
LOWLAND/UPLAND CONIFER/SHRUB SWAMP	4220/4210/6120	BRIGHT GREEN	19.66	18582	75.20
UPLAND/LOWLAND HERBACEOUS RANGELAND	3110/3120	CYAN	13.09	12371	50.06
NON-FORESTED (NON-WOODED) WETLANDS	6200	BLUE GREEN	4.19	3958	16.02
BARREN, CUTOVER	7900	MEDIUM GRAY	3.38	3190	12.91
UPLAND CONIFER	4210	MEDIUM GREEN	3.17	2997	12.13
AGRICULTURAL LAND	2100	PINK	2.59	2451	9.92
WATER	5000	BRIGHT BLUE	2.35	2219	8.98
LOWLAND CONIFER	4200	BROWN	1.72	1629	6.59
SAND, DITCH	7390	YELLOW	0.38	361	1.46
SAND, BEACH	7210	WHITE	0.01	12	0.05
UNCATEGORIZED	-	BLACK	22.13	20921	84.67
		TOTALS	100.00	94520	382.51

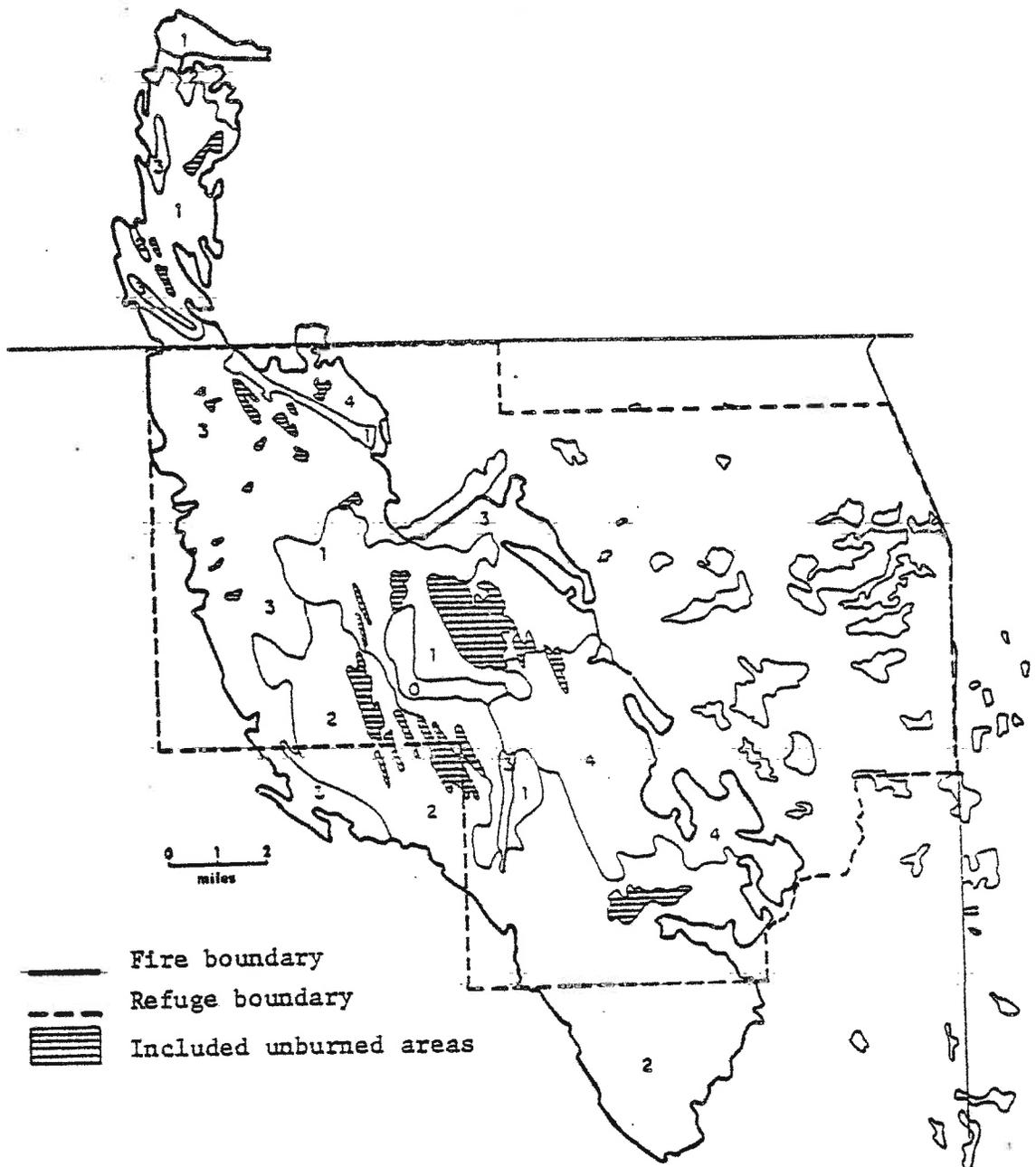


FIGURE 5. INTERPRETATION OF LANDSAT SCENE (11 MAY 1977) FOR DEGREE OF BURN. ON A RELATIVE SCALE, A ZERO INDICATES A COMPLETE BURN AND FOUR INDICATES A LIGHT BURN (FROM SUGARBAKER, 1979).