

Red Tart Cherry Site Inventory



FOR
GRAND TRAVERSE COUNTY
MICHIGAN

CONTENTS

A FRUIT SITE INVENTORY	i
Objective	i
RED TART CHERRY SITE INVENTORY	1
Site Requirements for Red Tart Cherries	1
Soil Factors	1
Physiographic Factors	2
Climatic Factors	2
FRUIT SITE RATING SHEETS	3&4
Map Preparation	5
Explanation of Colors	5
Interpretation of the Map	7
Modification of Hazards	7
HOW TO USE THE RED TART CHERRY SITE INVENTORY	8
Locating Areas	8
Finding Information	8
APPENDIX	9
REFERENCE MATERIAL	12
INDEX TO MAP SHEETS	13
LEGEND	14

CHERRY SITE MAPS



A FRUIT SITE INVENTORY

A method of identifying and mapping red tart cherry sites was developed in Northwestern Michigan. The basic procedure described here for cherry sites can be adapted to other geographic areas and for other fruit crops with exacting requirements of soil, topography, and climate.

Objective

The objective of the red tart cherry site inventory is to evaluate a parcel of land in a given location according to its capability to consistently produce cherry crops. Such an inventory is valuable for determining the location, extent, and quality of available red tart cherry sites.

Areas with the favorable combination of soil and climate for producing red tart cherries are located and evaluated. This type of information is useful in many ways, one of which is protecting these rather limited areas from being despoiled by the pressures of other land uses.

Dependable red tart cherry sites are in demand for other uses. Generally high-lying, they are choice locations for home building. Community planners need to recognize the value of these relatively scarce sites, to set priorities on their use, and to give protection, if necessary, to the environmental condition that makes these sites productive. Construction of a building complex or even the raised roadbed of a new highway built across a major air drainage way may change a good, frost-protected site to one that is unsatisfactory for production of sensitive crops.

The site inventory also may help prevent the planting of orchards on unfavorable sites. The grower, the processing industry, and the community suffer as a result of fruit planted on marginal sites. The red tart cherry industry illustrates this problem. It has had a history of feast and famine for many years. The years of high production have usually resulted in low prices. Low production years resulted in higher prices. Generally, the high price years encouraged growers to plant new orchards, many on marginal sites. When these trees come into production, those on marginal sites bear only in years of favorable weather conditions. This increases the already fluctuating production--high years of favorable weather, very low in others.

Processors and market outlets are dependent on a stable supply of cherries. The cherry processor cannot maintain plant capacity to handle peak production that occurs only 2 or 3 years out of 10. When the market is glutted, prices drop to a level where neither grower nor processor can operate at a profit. In years of low production, only the most favorable sites produce a good crop of cherries. Some growers have nothing to sell, and the processor has equipment standing idle. The industry is always faced with the problem of furnishing a uniform annual supply in order to attract the consumer to purchase cherries and not a substitute fruit. It is difficult for an industry to maintain its position in the market place with such wide variations in production caused in part by orchards planted on marginal sites.

A rating system has been developed as a way to inventory tart cherry sites in order to meet the needs of the growers, processors, community planners, and others. Inventoried information can:

1. Assist the potential fruit grower in selecting a site for a profitable enterprise.
2. Assist the present fruit grower in reassessing present orchards and in planning future plantings.
3. Assist growers in relocating in a more favorable location or in obtaining a larger economic unit.

Other Uses:

1. Agriculture assessment - to delineate lands that should receive tax consideration if they are to be maintained in agricultural use.
2. Zoning commissions - to delineate potential fruit sites and plan for nonconflicting uses adjacent to fruit areas.
3. Planners of community services - to cause the least amount of fragmentation of ownership.
4. Comprehensive areawide planners - to establish basis for a stable industry.
5. Investors - to evaluate risks in capital investments pointed toward developing fruit-producing areas with a favorable and stable base.
6. Tourists - fruit production increases and enhances the tourism and recreational potential of an area. Tourists are a byproduct of the total fruit industry.

Agencies or groups that might use a fruit site inventory include:

1. Processing groups
2. Banks or credit organizations
3. Nurseries
4. Irrigation and other equipment suppliers
5. Fruit specialists
6. Agricultural research groups
7. Climatologists
8. Resort and recreation groups
9. Zoning and planning boards
10. Real estate sales organizations

RED TART CHERRY SITE INVENTORY
Grand Traverse County, Michigan

Field work by: Guy E. Springer, Hermann L. Weber, Marvin H. Hansen, Richard H. Drullinger, Virgil Thayer, all of the Soil Conservation Service; George A. McManus, Extension Director, Grand Traverse County; Dr. Charles Kesner, District Horticulture Agent, Cooperative Extension Service, Michigan State University; Geel Van Den Brink, National Weather Service.

GRAND TRAVERSE COUNTY is in the northwestern part of the Lower Peninsula of Michigan (fig.1). It has a total area of about 464 square miles, or 296,960 acres. In 1970 the county had a population of 39,175. Traverse City, at the south end of Grand Traverse Bay, is the county seat and is the cultural, medical, commercial, and communications center of northwestern Lower Michigan. Traverse City is 210 miles northwest of Detroit, 125 miles north of Grand Rapids, 150 miles north-northwest of Lansing, and 85 miles south-southwest of the Straits of Mackinac.



Figure 1.—Location of Grand Traverse County in Michigan.

Site Requirements for Red Tart Cherries

In Grand Traverse County, Michigan, the inventory was developed based on the site requirements of the Montmorency red tart cherry. This fruit occupies the largest acreage and has the greatest economic impact of the fruits grown in the county.

Following are factors which make a desirable red tart cherry site in Grand Traverse County, which is typical of several counties in Northwest Michigan.

Soil Factors

The most desirable soil is a well-drained sandy loam, well aerated, with medium to high natural fertility with medium to moderately high available water capacity, moderate to moderately rapid permeability, and 48" or more of depth to permit unrestricted root expansion for good tree growth and anchorage. Soils with these characteristics usually respond favorably to management practices and have, among other physical characteristics, desirable thermodynamic properties.

Physiographic Factors

Physiographic features of the site determine to a large extent the microclimate, which in turn influences yield of cherries. Differences of soil, cover, elevation, and exposure are responsible for microclimatic variations that are extremely important. The desirable site would be one on which all effects of local climate are favorable for best production. Slope gradient should be 2 to 12% to permit ease of equipment use and other soil management practices yet still provide adequate air drainage. Slope should be fairly uniform with well-defined water and air flowage ways. There should be no constriction or obstruction to the cold air flowage ways. The site should be located so that cold air from adjacent land does not drain over or onto it. Also, it is more desirable to have air drained into a cold air storage basin over water than into a cold air storage basin over land. Orchards should be planted above the principal spring freeze line 1/ of the cold air storage basin. Finally, the general exposure should permit the crop to take full advantage of sunshine yet not be exposed to damaging winds during pollination and fruit bearing.

Climatic Factors

The spring temperature should remain cool to retard fruit bud development in order to minimize danger of damage due to spring freezes. During the pollination-fertilization period of bloom, temperatures should exceed 50° F. in daytime for bee activity and should not drop below 28 to 30° F. for any period of time. The site should be as free of fog as possible. Warm sunny days without desiccating winds are important for good pollination and fruit set.

The lowest winter temperatures seldom, if ever, should get as low as -15 to -20° F. for tart cherries. An insulating cover of snow can provide for uniform soil temperature, but whether or not this is a significant factor in fruit production is not known. (Sunshine reflected from the snow cover may cause wide and rapid variations of temperature in tree trunks, resulting in tree damage which leads to reduced production. Management techniques can control this problem.)

The factors and weights given them for tart cherry sites are shown on the Fruit Site Rating Sheet.

1/ See Appendix for definition.

FRUIT SITE RATING SHEET

I. Soil Factors

	<u>Rating Value</u>	<u>Actual Score</u>
A. <u>Texture: 1/ Possible Score = (40)</u>		
(Sands (predominate))	10	
Sandy (Loamy sands (predominate))	20	
Coarse loamy	40	
Fine loamy	30	
Clayey	10	
Clayey (very fine)	5	
Organic	0	
B. <u>Drainage: Possible Score = (40)</u>		
Well drained	40	
Moderately well drained	30	
Somewhat poorly drained	20	
Poorly and very poorly drained	10	
C. <u>Restrictions to Rooting: Possible Score = (20)</u>		
No restrictions to 48"	20	
Coarse fragments	10	
Pans	5	
Bedrock less than 48"	5	
Salinity -		
Alkalinity -		

(Total possible score = 100)

I. Total Actual Score _____

II. Physiographic Factors

A. <u>Slope: Possible Score = (35)</u>		
2-12%	35	
0-2%	30	
12-18%	15	
Over 18%	10	
B. <u>Elevation above Principal Spring Freeze Line: Possible Score = (30)</u>		
100 ft.+	30	
50-100 ft.	25	
20-50 ft.	20	
Less than 20 ft.	0	
C. <u>Air Drainage: Possible Score = (35)</u>		
Uninterrupted airflow to major air storage basin	35	
Minor obstruction to air flow to major air storage basin	25	
Major obstruction to air flow to air storage basin	5	

(Total possible score = 100)

II. Total Actual Score _____

1/ Refers to soil family texture.

FRUIT SITE RATING SHEET (cont'd)

III. Climatic Factors

	<u>Rating Value</u>	<u>Actual Score</u>
A. <u>Spring Temperatures: Possible Score = (70)</u> Probability of damaging freeze or cold weather during fruit set during 10-year period.		
(2 in 10)	70	
(3-4 in 10)	40	
(5-6 in 10)	10	
B. <u>Winter Temperatures: Possible Score = (30)</u> Probability of extreme cold winter temperature during 10-year period.		
(2 in 10)	30	
(3-4 in 10)	5	
(5-6 in 10)	0	
(Total possible score - 100)	III. Total Actual Score	

(Fog and hail were not given individual ratings.)

Summary of Scores Section I _____
 " II _____
 " III _____

Site Rating or Total Score _____

Interpretation of Fruit Site Ratings

<u>Total Score</u>	<u>Map Color</u>	<u>Difficulty of Overcoming Limitations to Production</u>
300-290	Green	Slight
285-225	Yellow	Moderate
220-170	Red	Severe
165 or less	No Color	Very Severe

Following onsite examination and scoring of each item in the rating sheet, the total score for a site is obtained by adding the sums of the rating scores for the soil, physiographic, and climatic factors. This total is referred to as Fruit Site Rating.

Map Preparation

Colors and ad hoc symbols are used to identify and to delineate fruit sites. The ranges (interval) of fruit site ratings used in the red tart cherry site inventory in Grand Traverse County are shown with map colors and degree of limitation on the bottom of the Fruit Site Rating Sheet.

Explanation of Colors

GREEN

The areas colored green on the map are within the narrow range of 290 to 300. These represent the most desirable red tart cherry sites. The major soils are well drained, moderately coarse textured, and have no restricted root zone within 48 inches of the surface. The slopes range from 2 to 12 percent. The elevation above the principal spring freeze line is over 50 feet. Air flow is unimpeded or is blocked only by minor obstructions that can be easily removed. The probability of damaging freeze or cold weather during the time of fruit set is 2 years or less in 10 years. The probability of extreme cold winter temperatures is 2 years or less in 10 years. The soils, physiographic features, and microclimate individually and collectively create few limitations to production.

YELLOW

Areas colored yellow on the map have a range of 225 to 285. They are good tart cherry producers but need intensive management practices to overcome the moderate limitations to production. One to three of the following factors may cause the lowered site rating:

1. Moderately low available moisture capacity.
2. Moderately low natural fertility.
3. In some locations, a water table within 4 or 5 feet of the surface.
4. Slopes somewhat steeper than 12 percent.
5. Elevations less than 50 feet but over 20 feet above the principal spring freeze line.

The probability of damaging freeze or cold weather or fog during blossom time or the probability of extremely low winter temperatures is not more than 3 to 4 years in 10 years.

Other features that may depress the rating are: areas needing random drainage; areas of nearly level land within dish-shaped terrain in which cold air is likely to stagnate; blockages that stop air movement; or small areas that are adversely affected because of very coarse or fine soil inclusions. Symbols are used to indicate these features on the map.

RED

Areas colored red have a range from 170 to 220. The severe limitations are difficult to overcome by management. All limitations should be considered carefully before planning to plant these areas to red tart cherries.

Where small areas of this range occur within areas with fewer limitations, it may be feasible to consider corrective measures. One limiting factor of sufficient severity which cannot be corrected will suffice to rate a site between 170 - 220. Adverse characteristics are:

1. Low available moisture capacity.
2. Low natural fertility.
3. Moderately slow permeability.
4. Slopes that cause some difficulty in efficient machinery operation.
5. Elevations near or at the principal spring freeze line with a probability of a freeze of 4 to 5 years in 10 years or extreme low temperature of 4 to 5 years in 10 years.
6. Major obstruction to air flow.

UNCOLORED

Areas having a rating of 165 or below are uncolored on the map. The limitations are so severe that these areas are not considered as red tart cherry sites.

The principal limiting factors are:

1. Poorly drained soils.
2. Slopes that are too steep for orchard equipment operation.
3. Location below the principal spring freeze line with a frequency of 6 or more of 10 years of spring freeze and the same probability of extreme low winter temperatures.

INTERPRETATION OF THE MAP

In arriving at a fruit site rating, it is assumed that modern soil and orchard management practices are to be applied. Special efforts are made not to be influenced in a site evaluation of a particular parcel by effects of either a substantially higher or lower level of management than is the norm on a producing orchard now occupying such a site. It is realized that improvements in management practices will continue to affect production in the future, but they are not likely to change a site rating.

Modification of Hazards

Available weather data is useful in broad determinations of whether or not certain crops can be considered for an area. The microclimate influences that affect fruit set cannot be obtained from existing weather data.

The site rating was made on the basis of the "natural characteristics" of the site and not a rating for the possibility of using artificial heating for freeze protection. The need for additional microweather information is recognized. Such information would permit refinement in estimating the size of cold air storage basins in relation to drainage areas. The fruit site inventory was developed by today's standards of plant selection for red tart cherry planting stock. It does not rule out the possibility of improved varieties through a plant selection program that may reduce the site requirements of today's planting stock. The use and interpretations of the site map will not eliminate the need for onsite study and investigation for individual tracts.

Colors used on the map indicate the relative degree of hazard that exists for producing red tart cherries. (The colors are consistent with those used on traffic signs.) Some of these hazards can be controlled. Also, some sites colored yellow or red may be as productive as the green colored sites if the limiting factors are corrected.

A minor air flow block may be removed by opening up wooded areas or even by removing undergrowth. Small ridges of earth may be flattened with little effort. A major block to air flow such as a large earth obstruction can require major engineering to remove. This may be economically advisable if the cost-return ratio is favorable.

Areas with favorable air drainage but too steep for orchard operations may be reclaimed by reshaping the slopes. Where steep slopes are remade to more gentle slopes to accommodate mechanized operations, problems of severe erosion, rapid runoff, reduced aeration, and unbalanced plant nutrition in the exposed substratum soil material can result. Very intensive soil management is needed for a number of years to overcome these difficulties.

Sites rated low because of low available moisture capacity may be made productive with irrigation and intensive fertilization. Small wet spots may be drained, but tile drainage of orchards sometimes requires increased maintenance because of clogging of fruit-tree roots.

Minimizing the rate of heat loss by taking advantage of landforms that provide for freedom from frost should be the first consideration before introducing artificial heat.

HOW TO USE THE RED TART CHERRY SITE INVENTORY

Locating Areas

At the back of this report is an index map and the red tart cherry site inventory map consisting of many sheets. On the index map are rectangles numbered to correspond to the sheets of the site map so that the map for any area can be located easily. On each map the site boundaries are outlined. Ad hoc symbols appearing within site boundaries are explained in the legend sheet. Small islands of desirable red tart cherry sites occur in the unmapped area. Generally, they are too small in size to be considered for commercial orchards.

Findng Information

Explanation of colors used, page 5.

Definition of terms used are given in the appendix.

Explanation of ad hoc symbols given in legend, on back of Index to Maps.

Soil information is found in the published USDA Soil Survey Report for Grand Traverse County, Michigan.

For selected readings on climate, refer to references given in the appendix.

APPENDIX

For uniform interpretation and understanding definitions or explanations are given here for some of the terms used in this report.

Conditions affecting the microclimate of a particular site can increase or decrease the hazard of frost, fog, or other localized climate important to the production of fruit or other very sensitive crops. Following is an attempt to define items that must be recognized in evaluating fruit sites. These are things which the experienced grower unconsciously considers when looking at a potential orchard site. By experience these items have been found to influence success or failure of orchards on various sites over many years.

Air Flowage Way

This is assumed to be the same flowage way as used by water except that it may be modified by physical conditions that affect air movement but that may not hinder water flow.

Air Movement

The movement of air under calm (no wind) conditions is due to changes in temperature of the air. Warm air moves upward because it is less dense (lighter), and when moving upward it expands and cools. Cooling causes the air to become more dense, making it descend. This movement by convection is a principle which orchardists attempt to use and manipulate to their advantage. Unlike water, air moving down a slope tends to pile up behind a barrier and may build up to several times the height of the barrier before flowing over it and on downslope. It is suggested that this buildup may be caused by the leading edge being forced upward as it mixes with upward-moving air warmed by radiation from the top of the barrier. Surface drag caused by resistance to air flow over ground vegetation also influences the downward flow of colder air. Observations indicate that convection movement of air down an air flowage way is not at a steady rate but tends to surge, then slow, then surge ahead again.

Airshed

For this application it can be assumed that the airshed will be the same area as a watershed contributing to a common outlet or storage basin.

Air Storage Over Water

Air flowage ways ending over water are more desirable than those ending over land. Water, having better heat conductivity and greater heat storage than soil, warms the incoming cold air in contact with it causing that air to rise, thus making room for more cold air entering from the flowage way.

Fog Damage

This refers to periods of daytime fog that inhibit the pollination of blossoms or that can cause delay in application of sprays for control of diseases. These conditions may occur in small pockets or they may be common to larger areas that are subject to marine influence.

Major Obstruction

A closed barrier or constriction in an air flowage way which will require large expenditures of time and money to correct is considered a major obstruction. Examples are: raised roadbed or buildings constructed across an air flowage way; or large earth ridges or even conifer swamps which slow cold air movement to lower elevations. (When a solid stand of conifer trees, or deciduous trees when leaved out, are in the path of air movement, the tops of the trees become the base of the air flowage way or basin. Such a condition has a very high radiation factor due to needle or leaf surface and a very small absorption factor.)

Minor Obstruction

A minor obstruction is a constriction of air flowage way which can be readily removed at relatively small cost. Examples are: trees or small earth ridges which impede air movement to lower elevations.

Microclimate

This refers to the climate of an area, usually small, over which weather conditions are substantially the same. Differences of soil, soil cover, elevation, and other factors can be responsible for significant variation in microclimate in areas only a few yards to a few hundred feet apart.

Principal Spring Freeze Line

The principal spring freeze line is a locally determined elevation line which separates favorable from unfavorable spring temperatures for red tart cherry production. Above this line the frequency of loss of crop due to spring freeze is less than 5 years in 10, below this line loss is likely to occur more often than 5 years in 10. The frequency or severity of loss decreases with increase of elevation above the principal spring freeze line.

Spring Damage

This refers to partial or complete kill of fruit due to below-freezing temperatures occurring from the time of spring bud swell to 14 to 18 days after bloom. It may include poor pollination and fruit set because of cold cloudy days, rain, or fog during blossom time.

Storage Basin

The lowest area to which air drains of its own free flow (under radiation-convection conditions).

Minor Storage Basin

Area in which air may be held until sufficient fill takes place for overspillage to a major basin.

Size of Storage Basin

No definite criteria are available to say how large a storage basin should be for a definite drainage area. The larger the drainage area, the greater the size of the storage basin needed. It should be of sufficient size to permit the storage of cold air until daylight hours and accompanying warming.

Winter Temperature Injury

Injury to fruiting buds and wood caused by temperature extremes or rapid fluctuation.

1. Wood injury associated with immaturity - early winter
2. Injury associated with drought (long periods of extremely cold air) - midwinter
3. Injury to wood and bark due to extremely fast drop in temperature (moderate winter temperature to very frigid temperature) - midwinter
4. Injuries characteristic of late winter conditions (after rest period is broken--still in dormancy)

Injury such as trunk splitting that causes major damage to structure of tree received a zero rating for red tart cherries.

REFERENCE MATERIAL

Research Report 26 - Farm Science, Michigan Freeze Bulletin, Mich. State Un., Agric. Exp. Sta. 1965.

Frost and Prevention of Frost Damage, Floyd D. Young. Farmer's Bulletin No. 1484, 1967 Rev.

World Meteorological Organization - Tech. Note 51 - Protection Against Frost Damage, World Meteorological Organization #133, T.P. 60.

Types of Spring Freezes in Michigan - Their Relationship to Protection Equipment, Ceel Van Den Brink, ESSA Weather Bureau, Mich. State Un., East Lansing, Mich. 1968.

Research Report 78 - Natural Resources Meteorological Drouth in Michigan, N. D. Strommen, C. Van Den Brink, and E. H. Kidder, Mich. State Un., Agric. Exp. Sta., East Lansing, Mich. 1969.

The Helicopter Rotor as a Means of Controlling Frost Damage in Fruit Orchards, C. M. Hansen, Reprint from Quarterly Bulletin of Mich. Agric. Exp. Sta., Vol. 34, No. 2, pp. 182-185, Nov. 1951, Mich. State Un.

Soil Survey, Grand Traverse County, Michigan, Series 1958 No. 34, issued Jan. 1966, USDA, SCS, in cooperation with Mich. Agric. Exp. Sta.

Proceedings of Air Drainage and Land Forming Workshop for Frost Control on Fruit Sites - Traverse City, Michigan. Compiled by USDA, SCS, 1969.

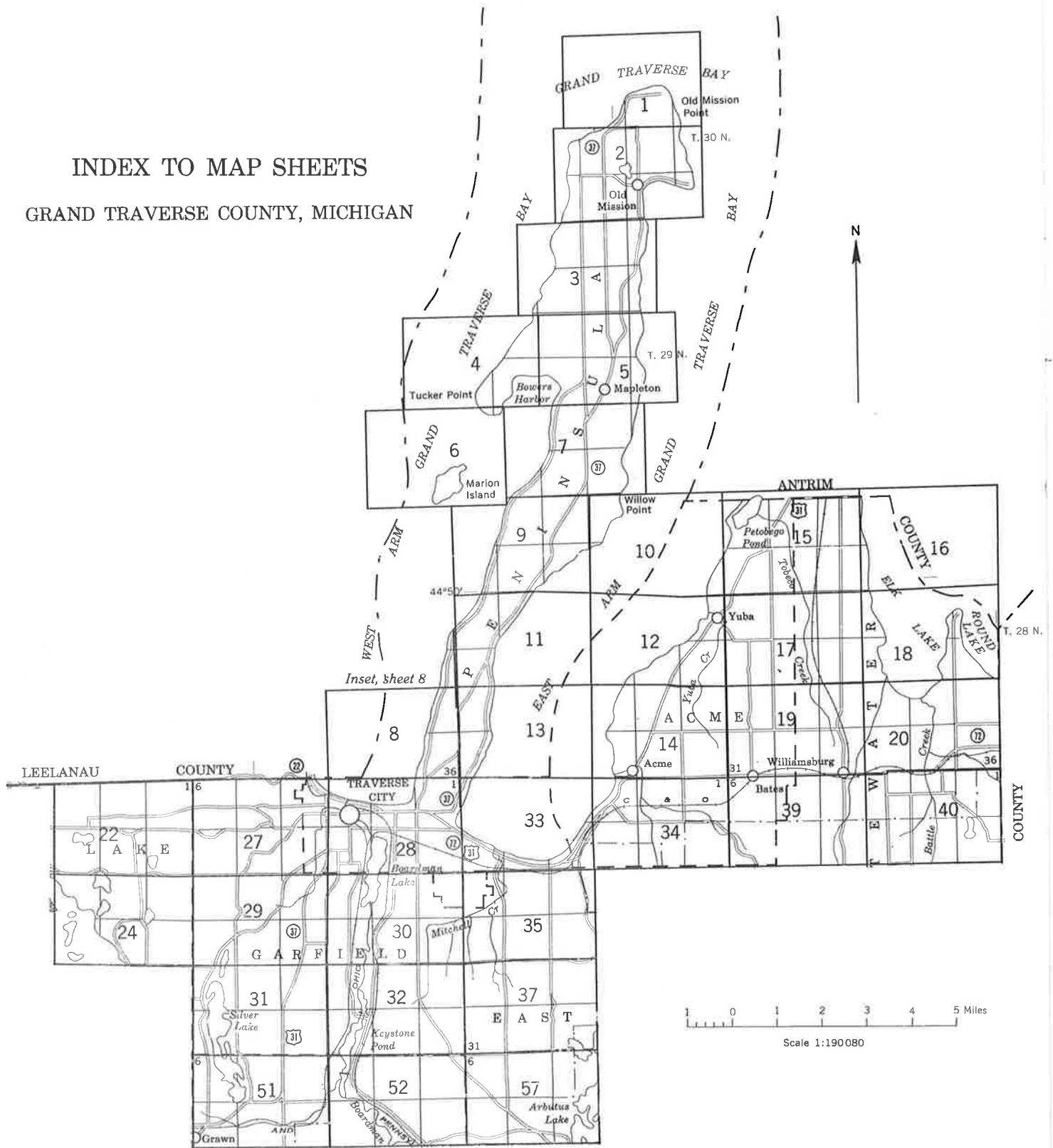
The Local Climate of NES, Hedmark, Dr. K. Utaaker, Dept. of Meteorology, Un. of Bergen, Norway, 1963.

Land Reshaping for Cherry Orchards, Guy E. Springer. Paper presented to ASAE Dec. 17, 1958, Chicago, Ill.

Climate of Michigan by Stations - Michigan Weather Service in cooperation with U. S. Weather Bureau.

INDEX TO MAP SHEETS

GRAND TRAVERSE COUNTY, MICHIGAN



GRAND TRAVERSE COUNTY, MICHIGAN CONVENTIONAL SIGNS

WORKS AND STRUCTURES

HIGHWAYS AND ROADS	
DUAL _____	
GOOD MOTOR _____	
POOR MOTOR _____	
TRAIL _____	
HIGHWAY MARKERS	
U.S. _____	
STATE _____	
RAILROADS	
SINGLE TRACK _____	
BRIDGES AND CROSSINGS	
GRADE _____	
BUILDINGS	
SCHOOL _____	
CHURCH _____	
STATION _____	
MINES AND QUARRIES	

PITS, GRAVEL, OR OTHER	

CEMETERIES	

DAMS _____	

BOUNDARIES

COUNTY _____	
TOWNSHIP, U.S. _____	
SECTION LINE, CORNER _____	
MINOR CIVIL DIVISION _____	
STATE FOREST BOUNDARY _____	

INTERPRETATIONS FOR FRUIT SITE RATING

TOTAL SCORE	MAP COLOR
300 - 290	
285 - 255	
220 - 170	
165 OR LESS	

DRAINAGE

STREAMS	
PERENNIAL _____	
INTERMITTENT, UNCLASS. _____	
DITCHES _____	

LAKES AND PONDS	
PERENNIAL _____	
INTERMITTENT _____	
WELLS _____	
SPRINGS _____	
MARSH _____	
WET SPOT _____	
ALLUVIAL FAN _____	
DRAINAGE END _____	

RELIEF

ESCARPMENTS	
OUTCROPS OTHER THAN BEDROCK _____	
PROMINENT PEAKS _____	
DEPRESSIONS	
CROSSABLE WITH TILLAGE IMPLEMENTS _____	
NOT CROSSABLE WITH TILLAGE IMPLEMENTS _____	
CONTAINS WATER MOST OF THE TIME _____	

AD HOC SYMBOLS

PHYSIOGRAPHIC FEATURES CAUSE LOWER TEMPERATURES DURING CRITICAL BLOSSOM PERIOD _____	L
CONCAVE SURFACE CAUSING SLOW AIR MOVEMENT _____	U
MAJOR BLOCK TO DOWNWARD AIR MOVEMENT _____	Δ
SOILS WITH SPECIAL LIMITATIONS _____	S
TOPOGRAPHIC FEATURES WITH MANY DEPRESSIONS THAT COLLECT AND HOLD COLD AIR. ALSO KNOWN AS PITTED TOPOGRAPHY OR KETTLES. _____	K



G R A N D

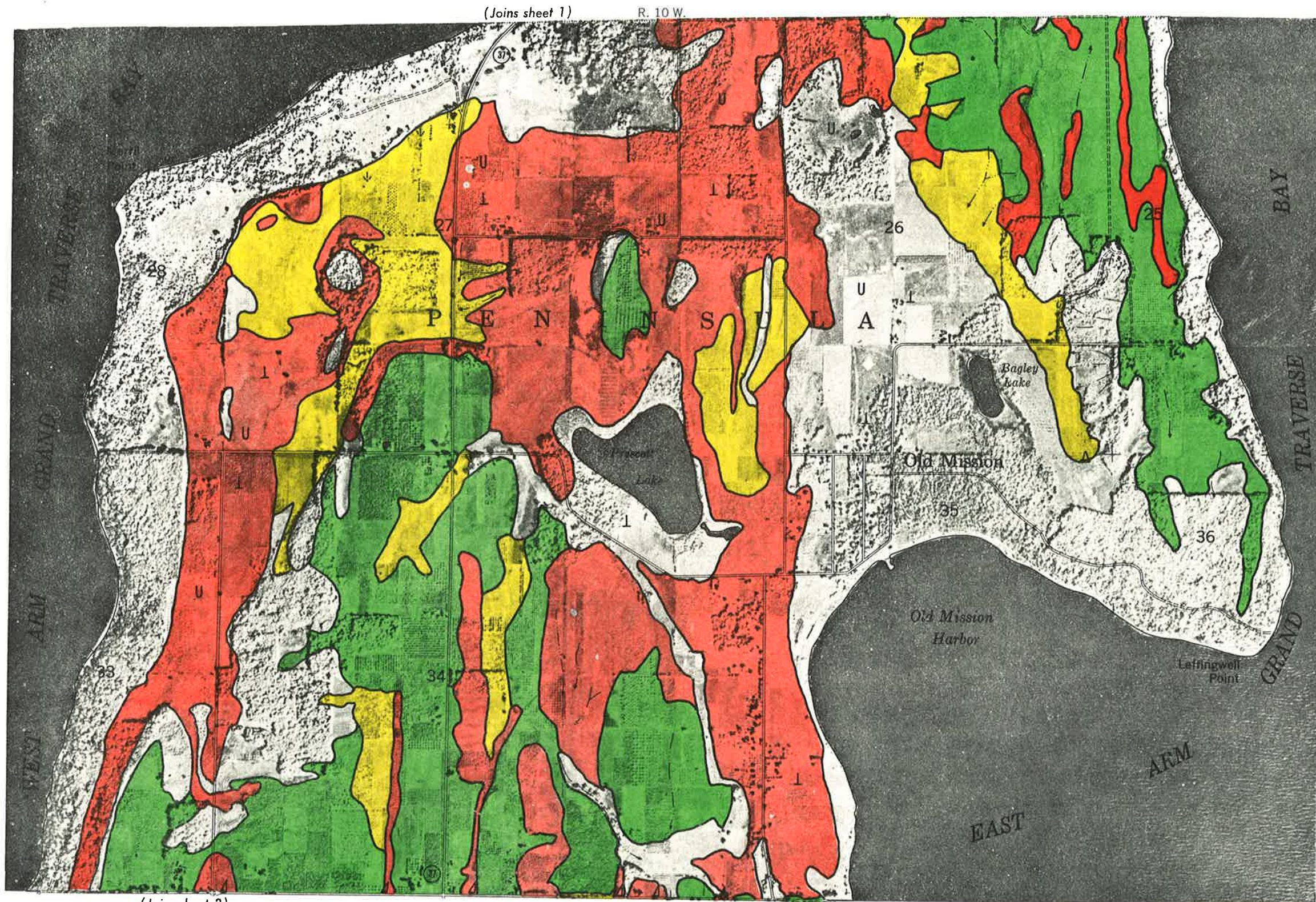
T R A V E R S E

B A Y



0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 2



(Joins sheet 1)

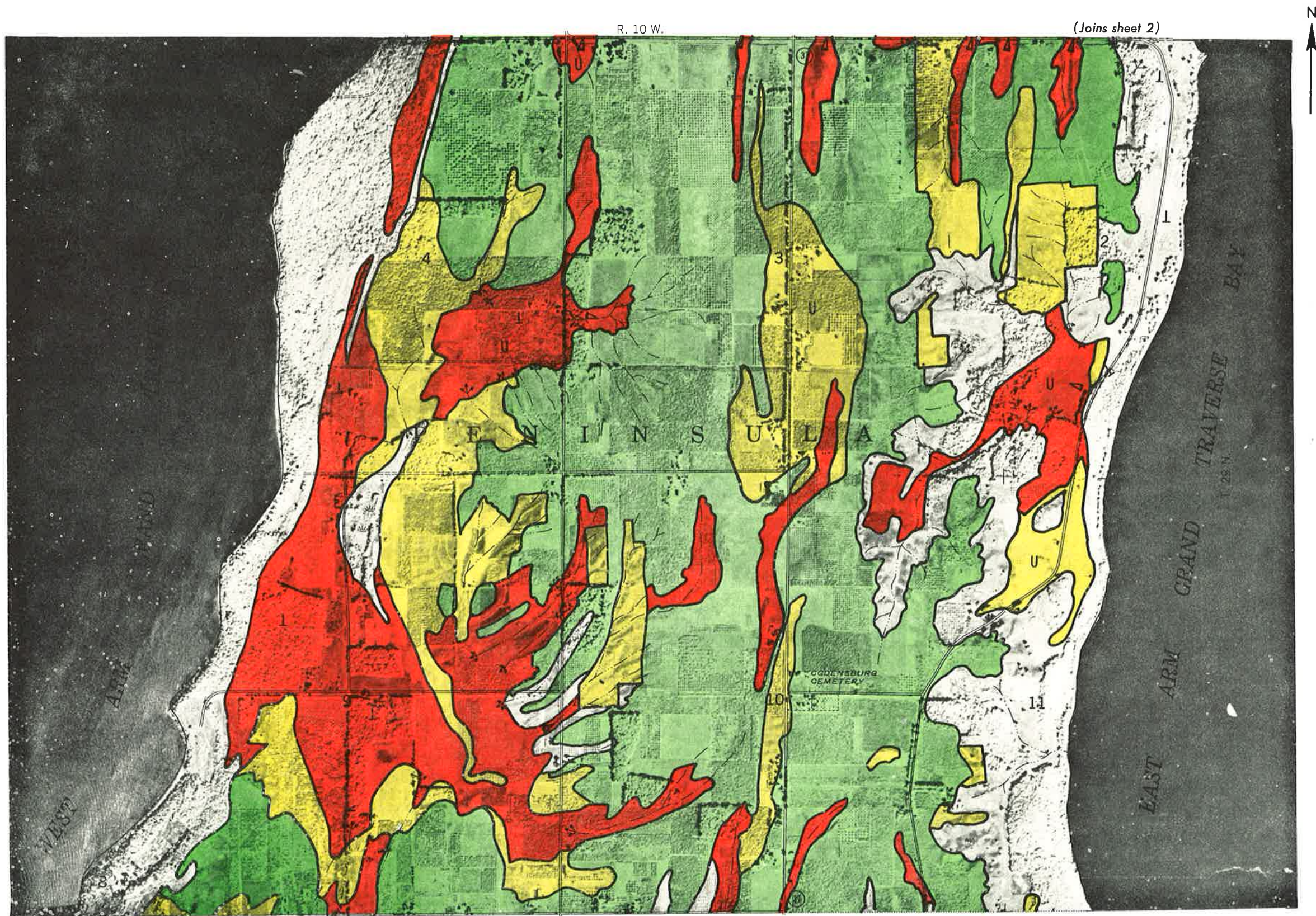
R. 10 W.

(Joins sheet 3)

T. 30 N.

0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 3



0 1/2 Mile Scale 1:15 840 0 3 000 Feet



GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 5



0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 6



R. 11 W. | R. 10 W.

(Joins sheet 4)



Neah-Ta-Wanta Point

BAY

TRAVERSE

P E N I N S U L A

GRAND

ARM

WEST



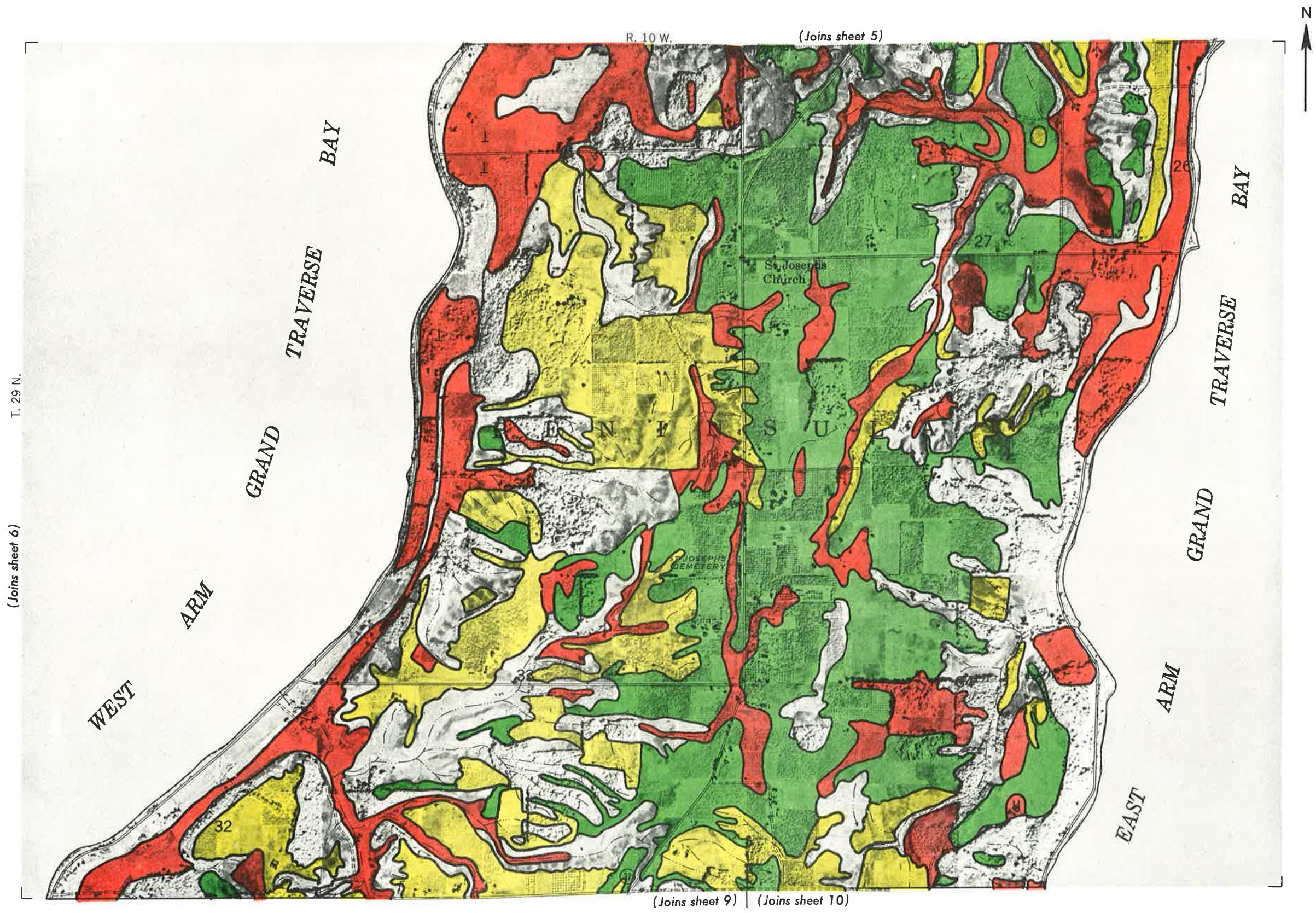
(Joins sheet 9)

(Joins sheet 7)

T. 28 N. | T. 29 N.

0 1/2 Mile Scale 1:15 840 0 3 000 Feet

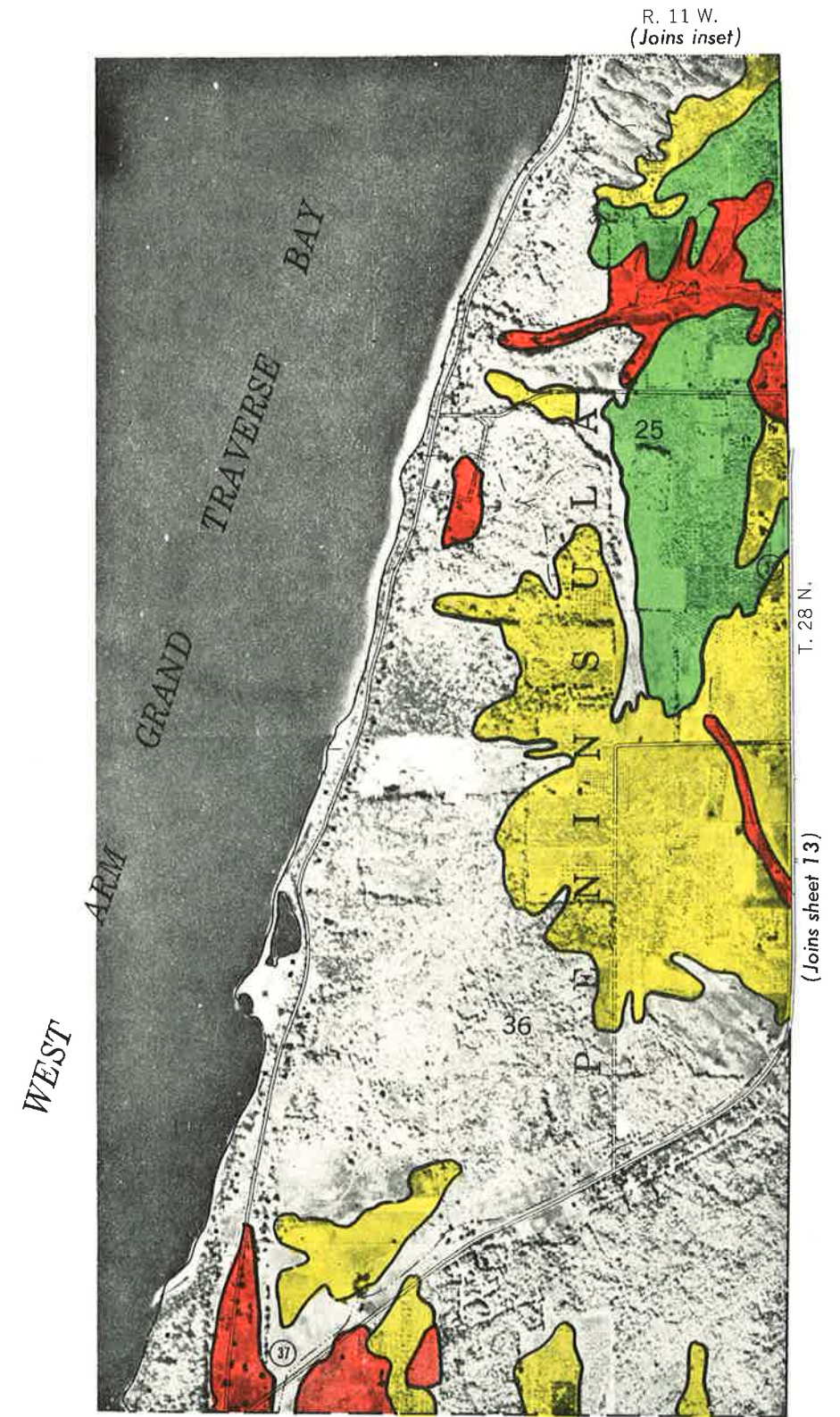
GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 7



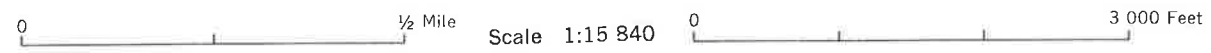
0 1/2 Mile Scale 1:15 840 0 3 000 Feet

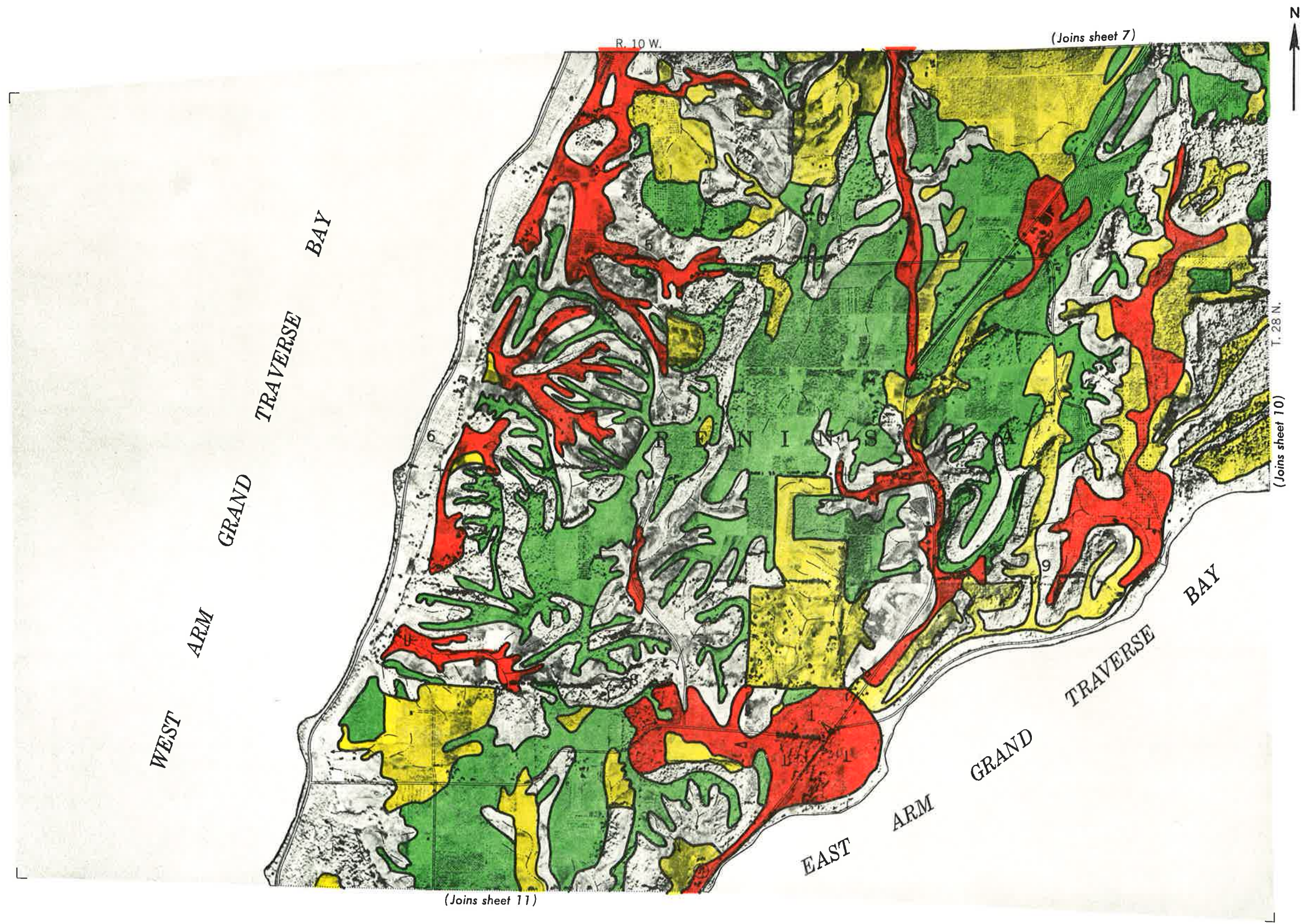


(Joins upper right)



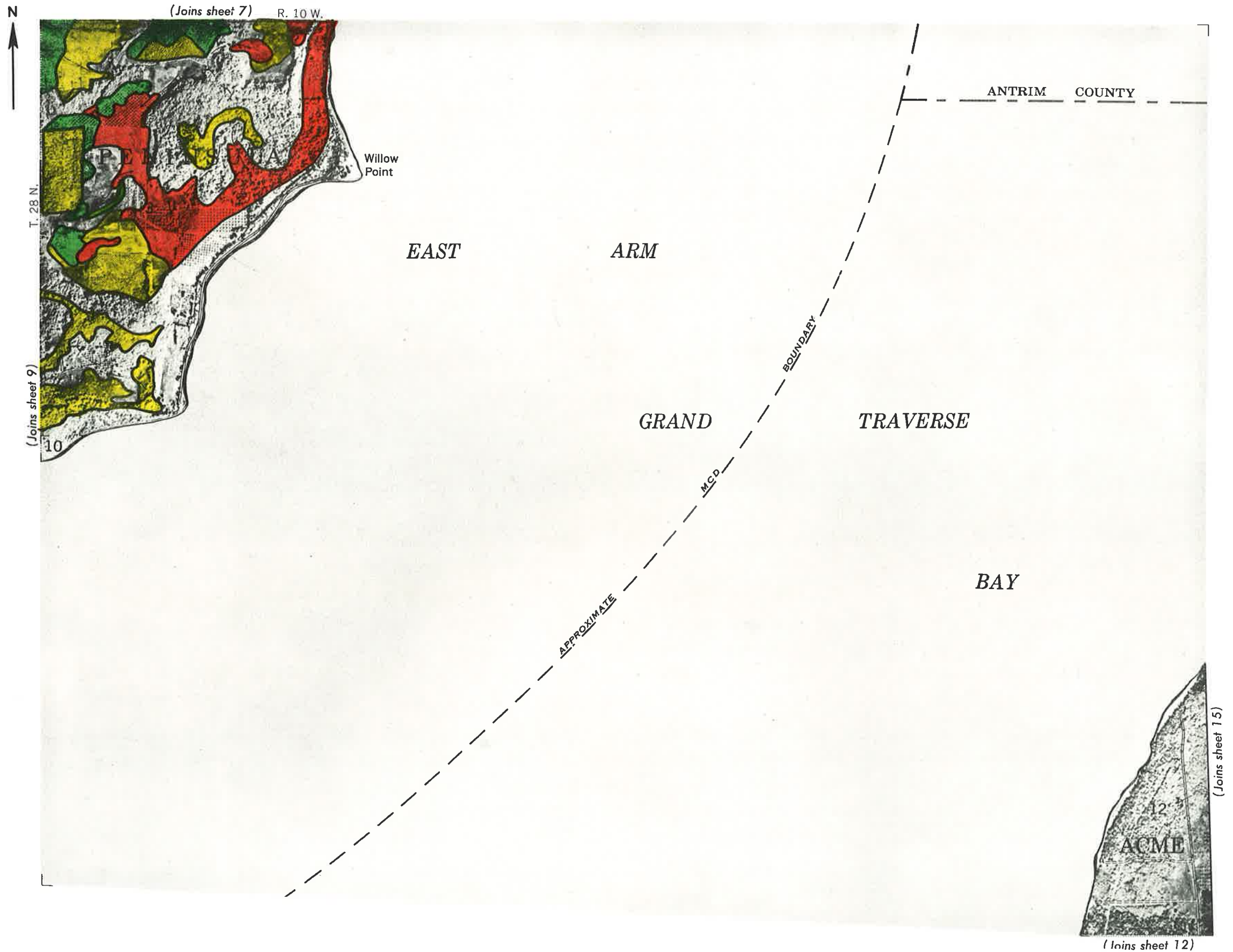
(Joins sheet 28)



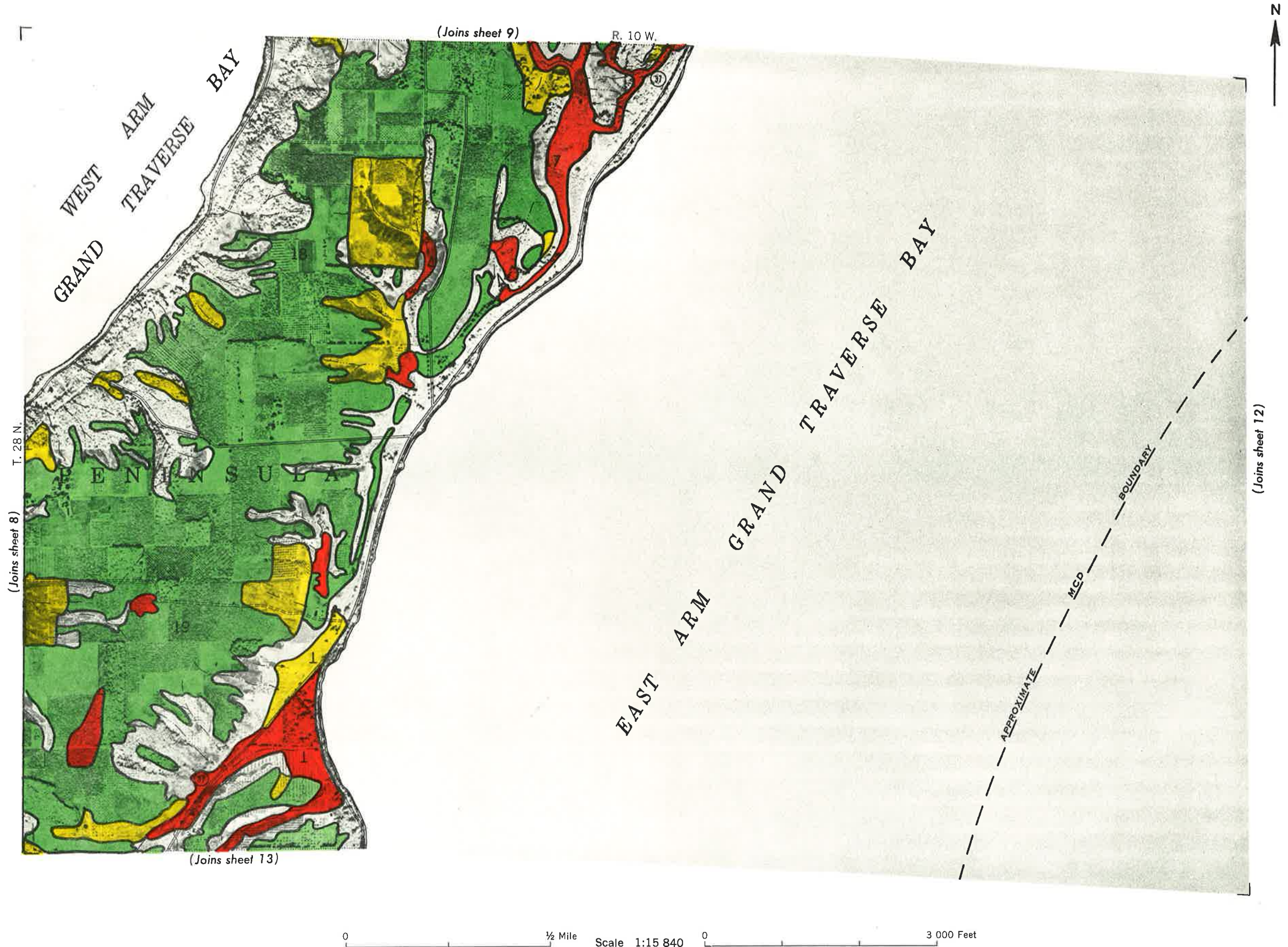


0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 10



0 1/2 Mile Scale 1:15 840 0 3 000 Feet



(Joins sheet 8)

T. 28 N.

(Joins sheet 9)

R. 10 W.

WEST ARM
GRAND TRAVERSE BAY

ENNIS PENINSULA

EAST ARM
GRAND TRAVERSE BAY

APPROXIMATE
MCD
BOUNDARY

(Joins sheet 12)

(Joins sheet 13)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet



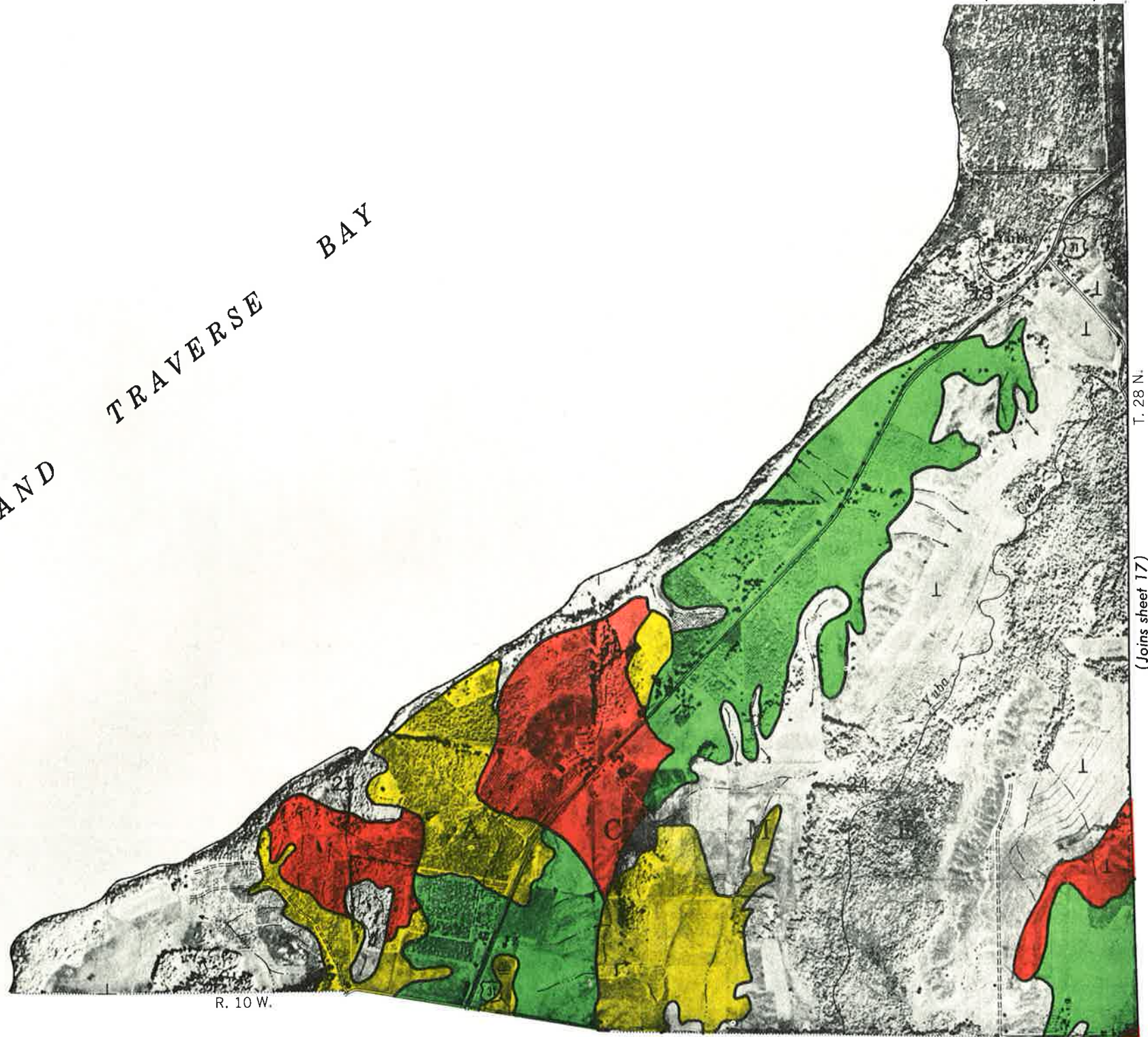


APPROXIMATE M.C.P. BOUNDARY

(Joins sheet 11)

EAST ARM GRAND TRAVERSE BAY

(Joins sheet 10)

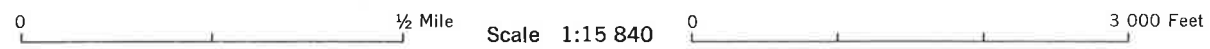


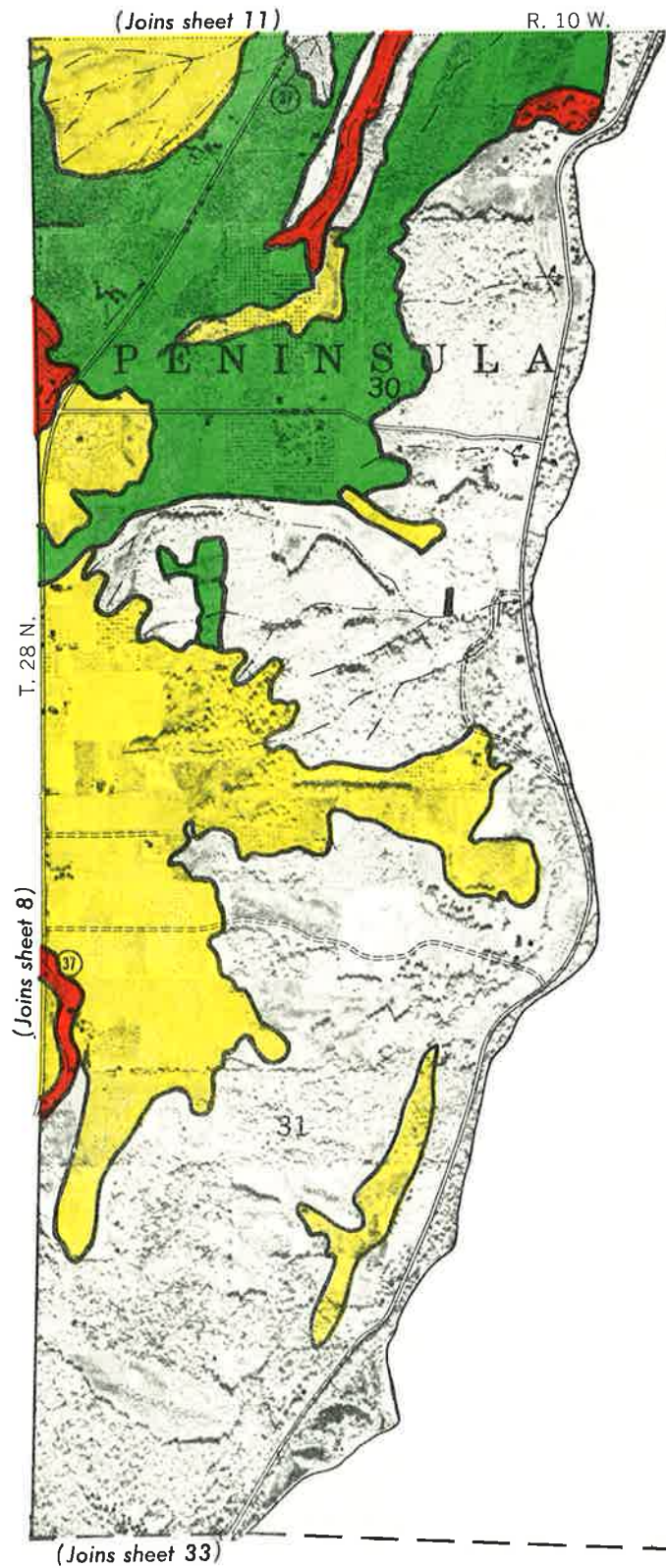
R. 10 W.

T. 28 N.

(Joins sheet 17)

(Joins sheet 14)



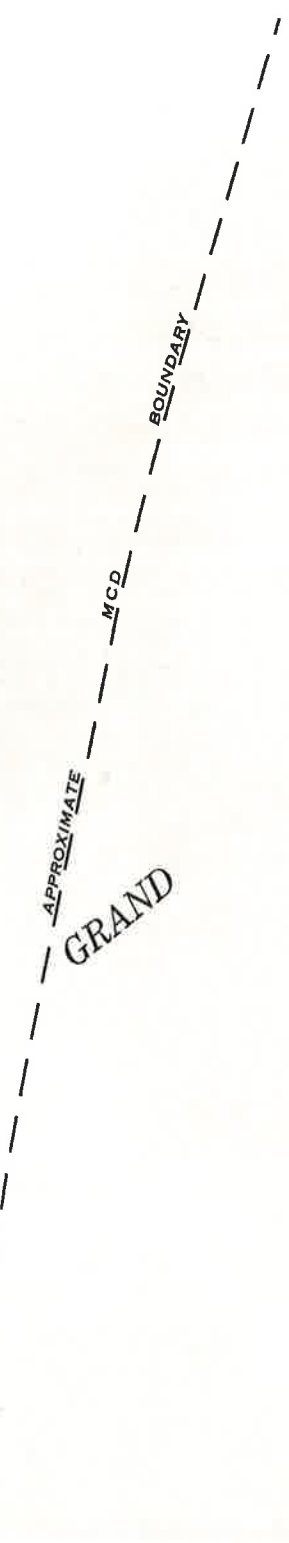


EAST
ARM

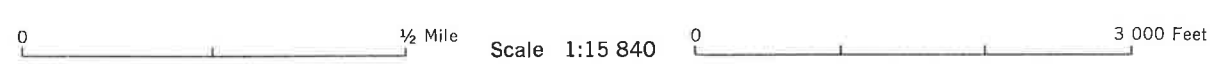
GRAND

TRAVERSE

BAY

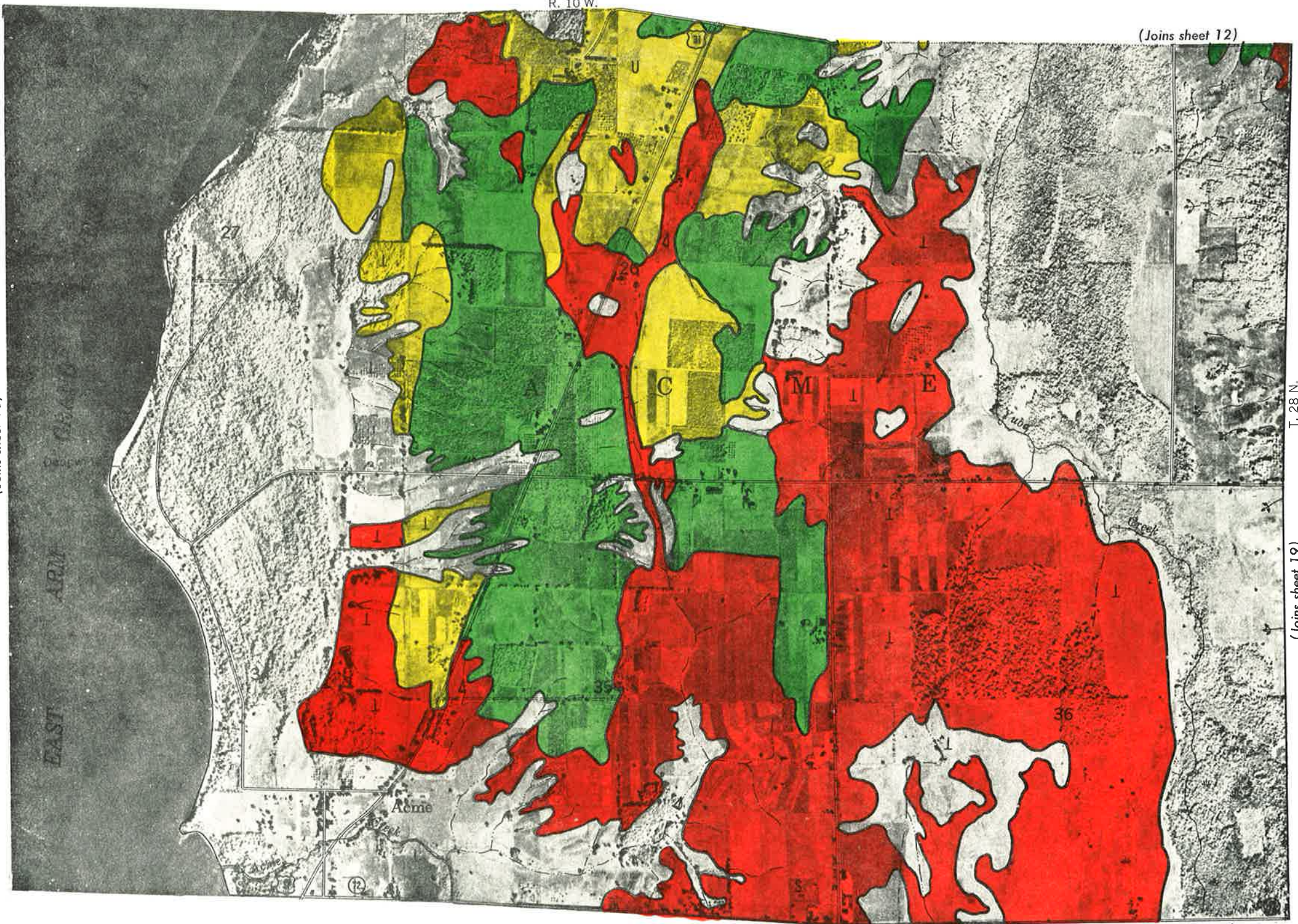


(Joins sheet 14)





(Joins sheet 13)

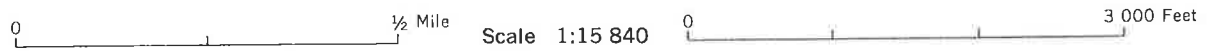


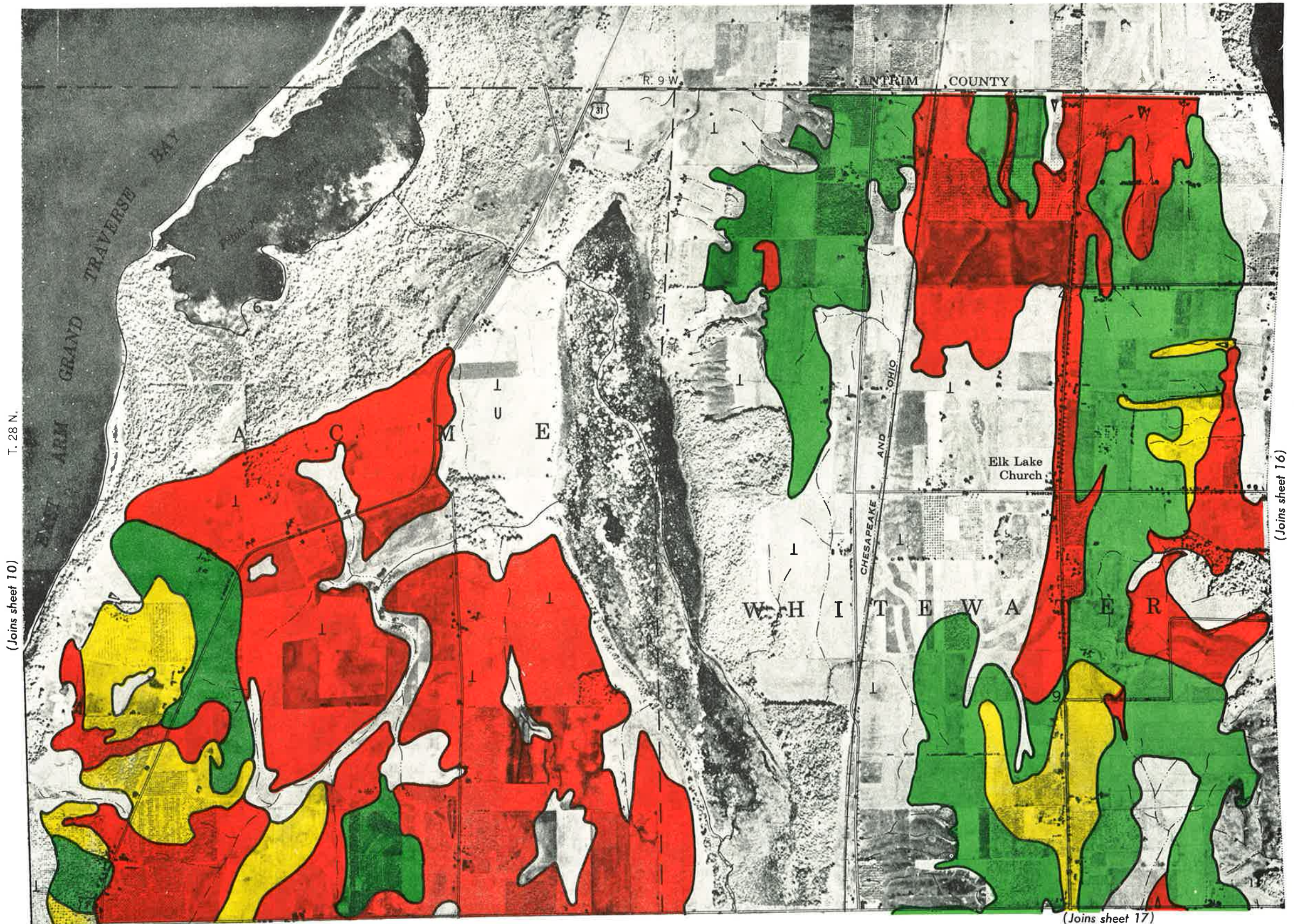
(Joins sheet 12)

T. 28 N.

(Joins sheet 19)

(Joins sheet 34)





T. 28 N.

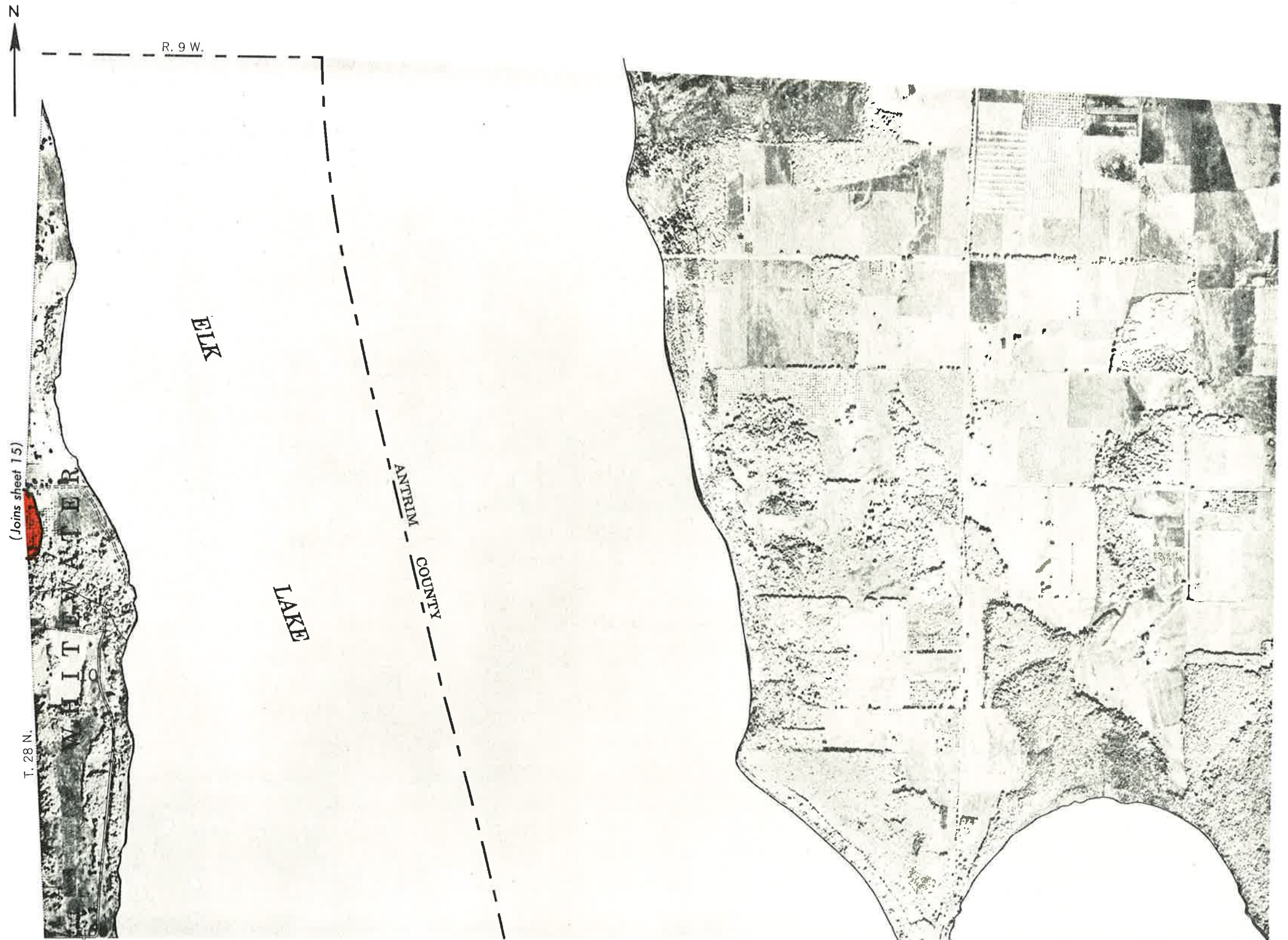
(Joins sheet 10)

(Joins sheet 16)

(Joins sheet 17)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet





(Joins sheet 15)

T. 28 N.

WILLET WATER

R. 9 W.

ELK

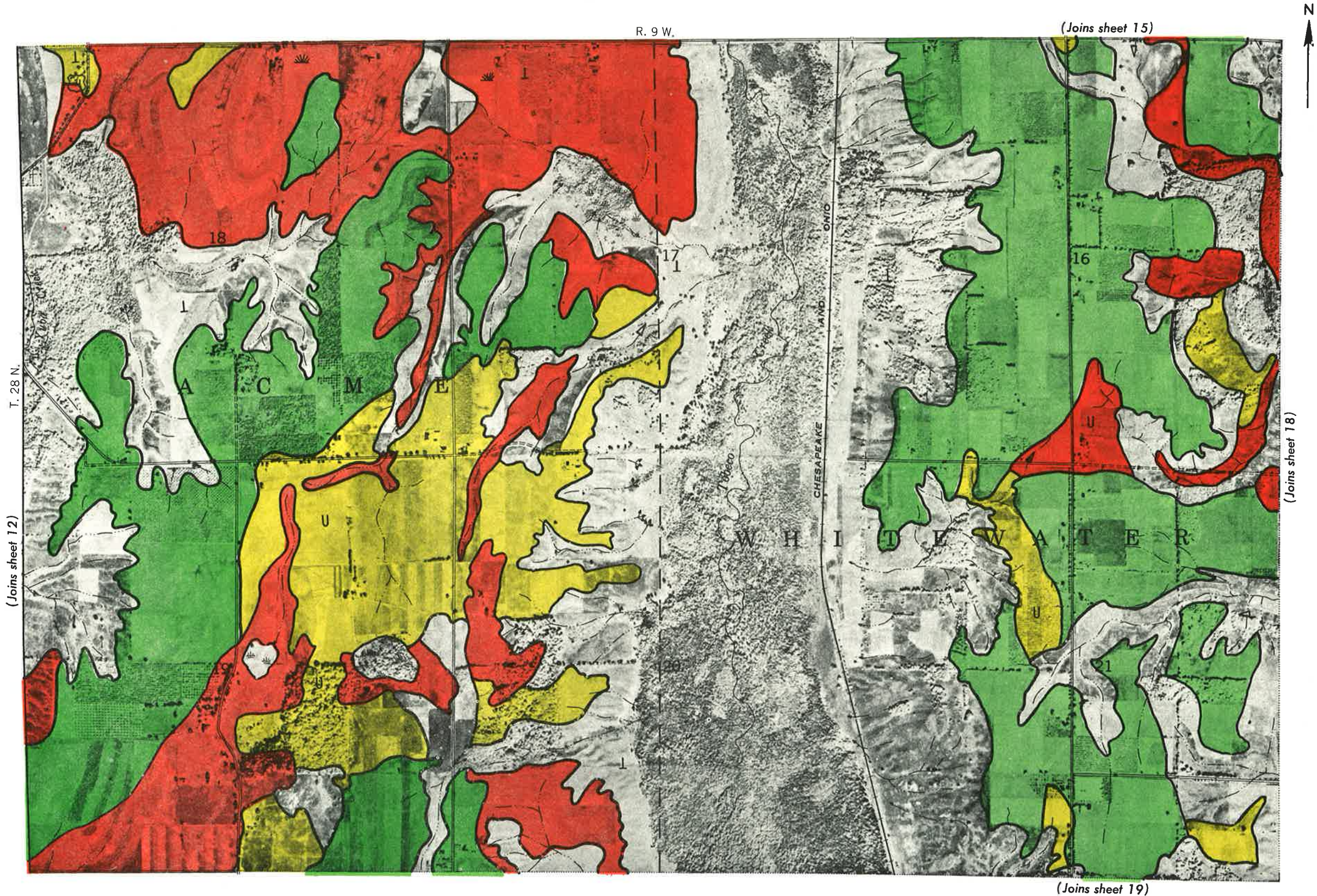
LAKE

ANTRIM COUNTY

(Joins sheet 18)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 17



(Joins sheet 12)

(Joins sheet 15)

(Joins sheet 18)

(Joins sheet 19)



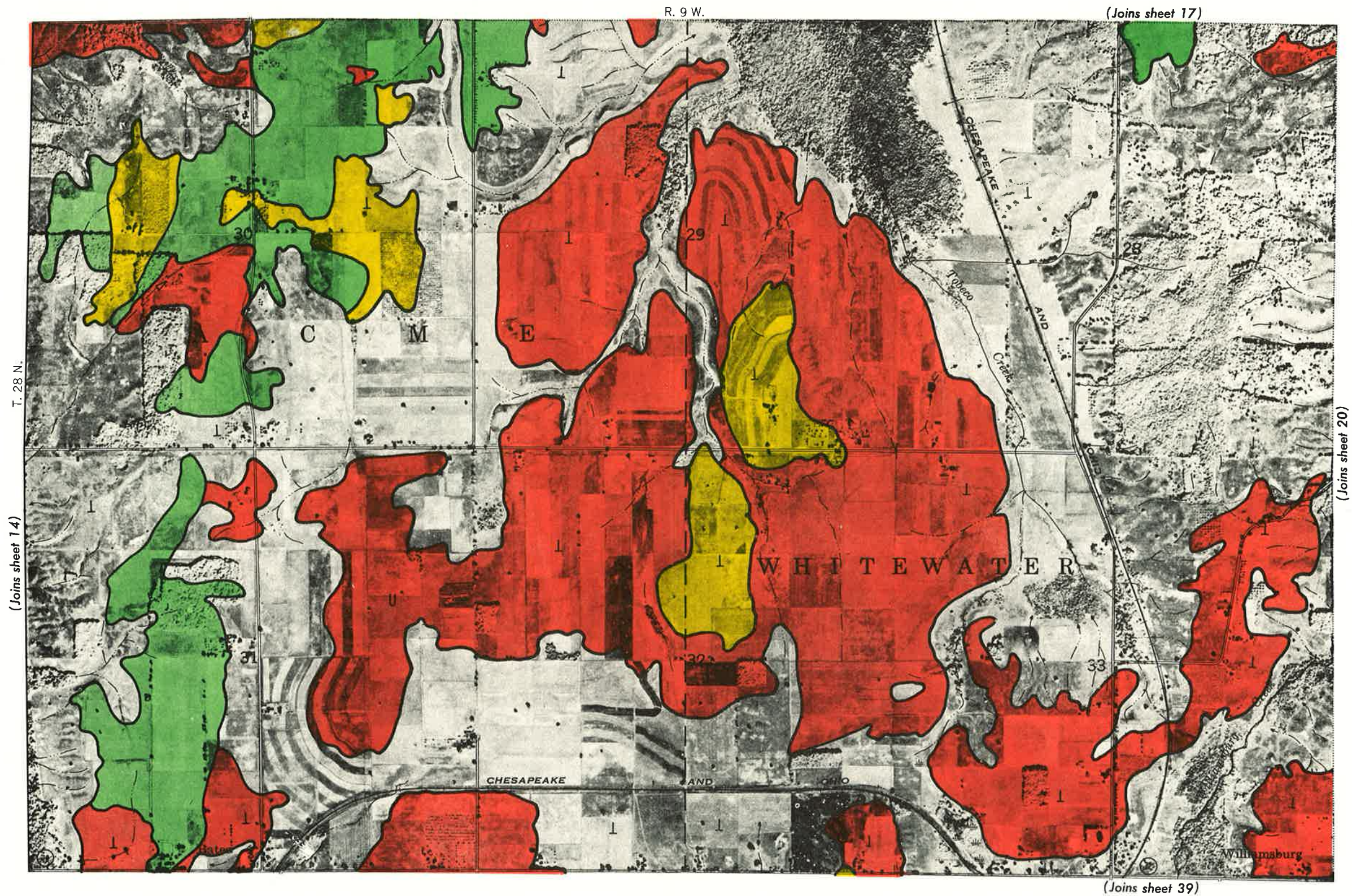
0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 18



0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 19



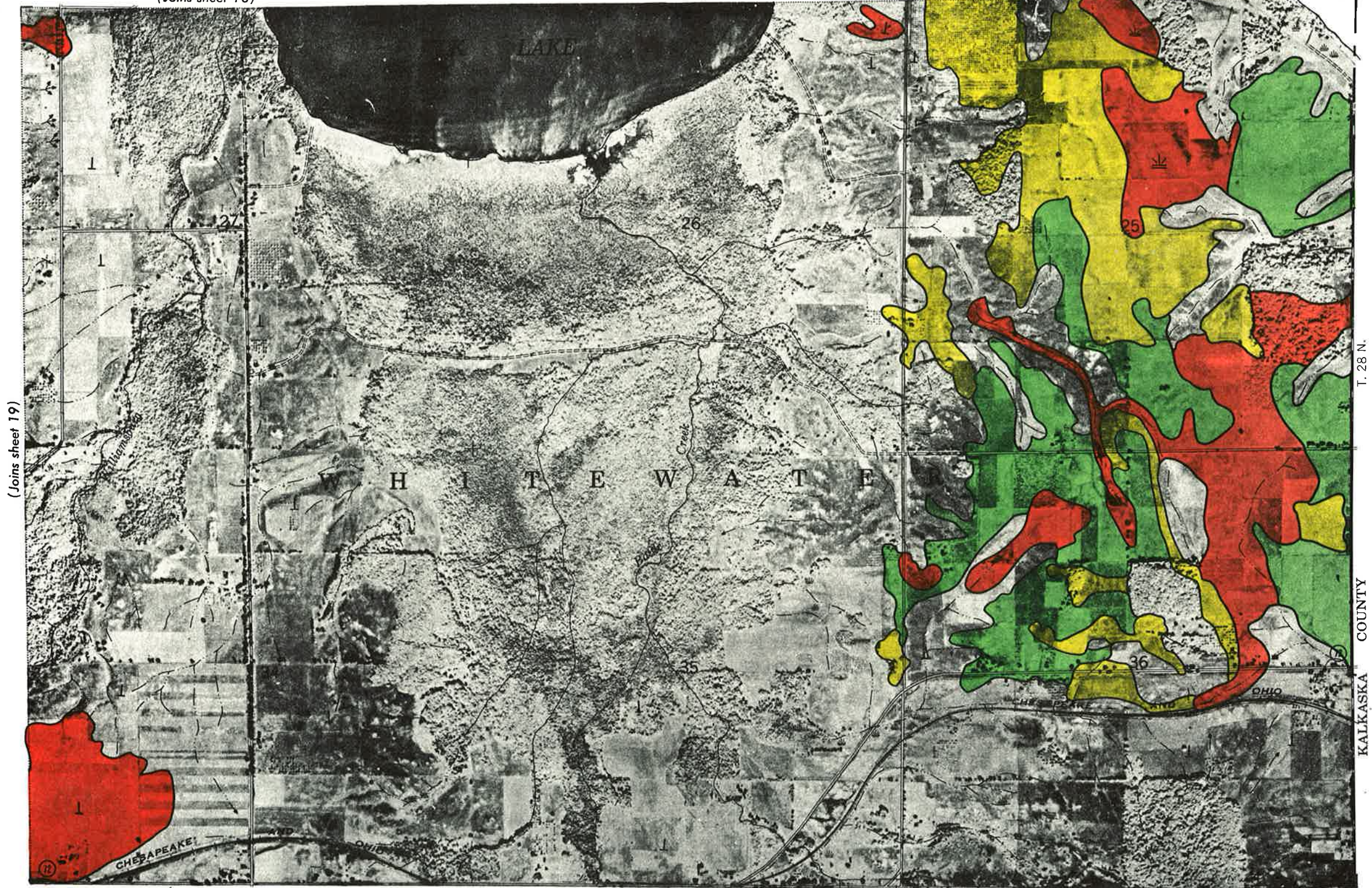
0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 20



(Joins sheet 18)

R. 9 W.



(Joins sheet 19)

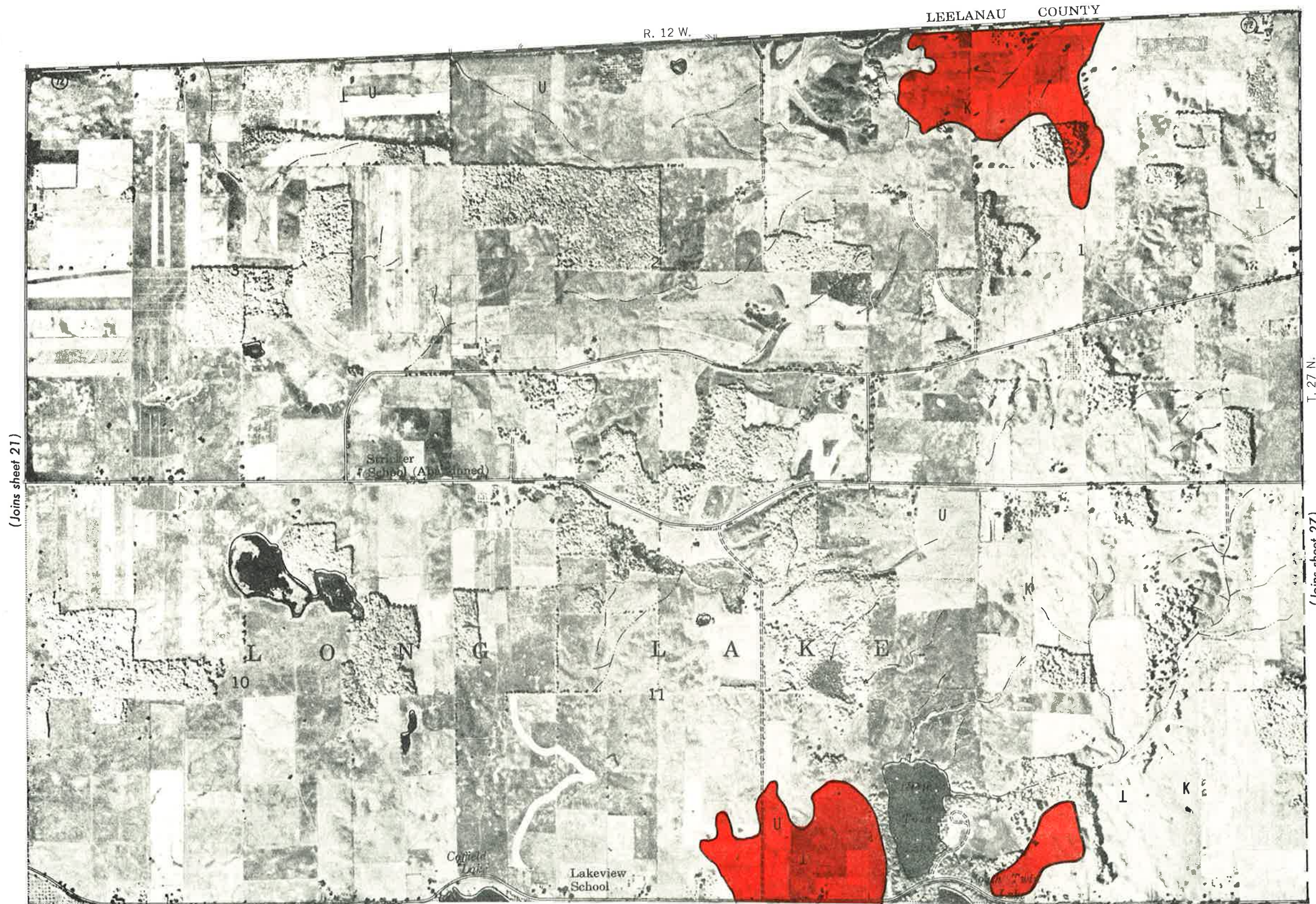
T. 28 N.

KALKASKA COUNTY

(Joins sheet 40)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 22



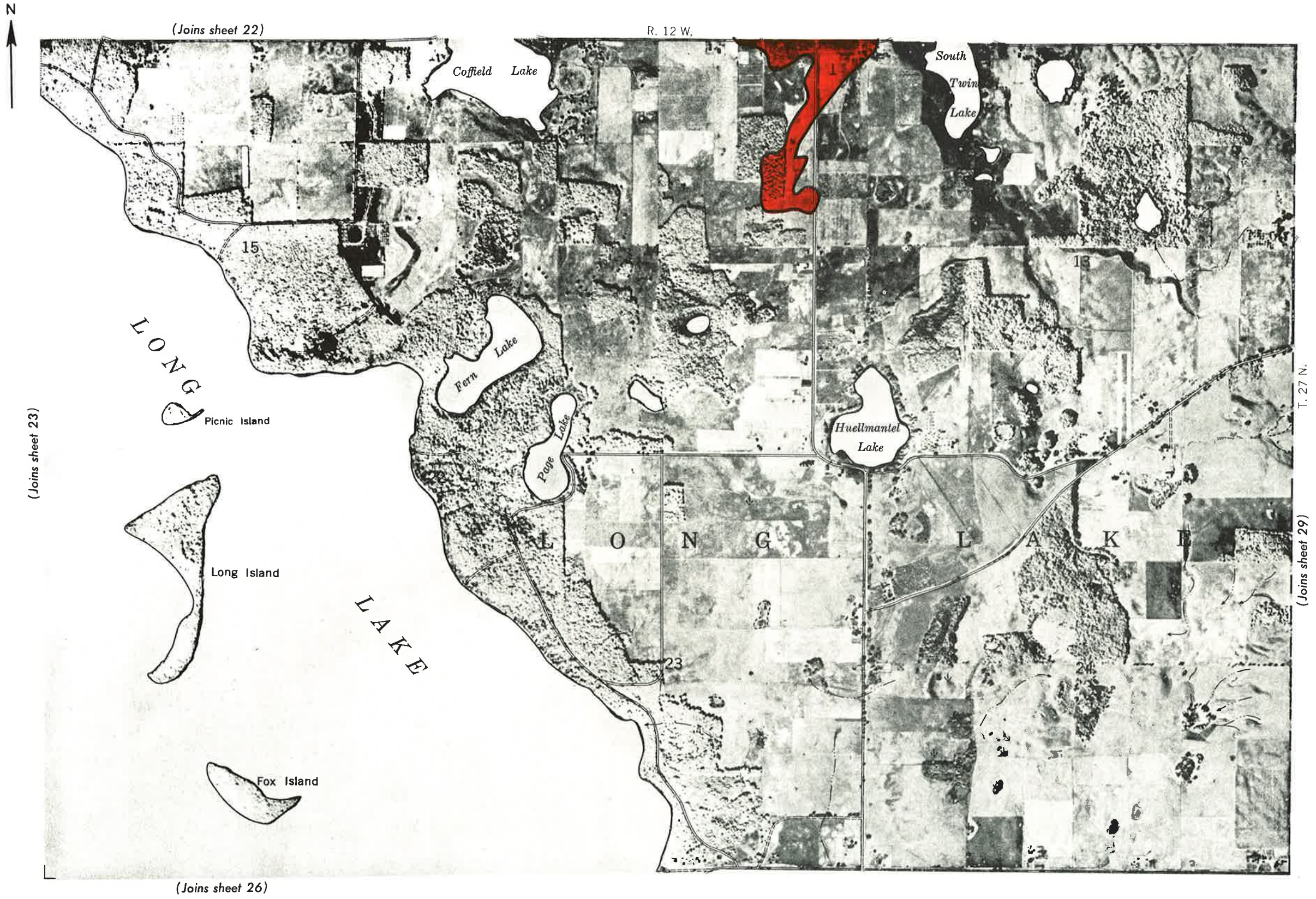
(Joins sheet 21)

T. 27 N.

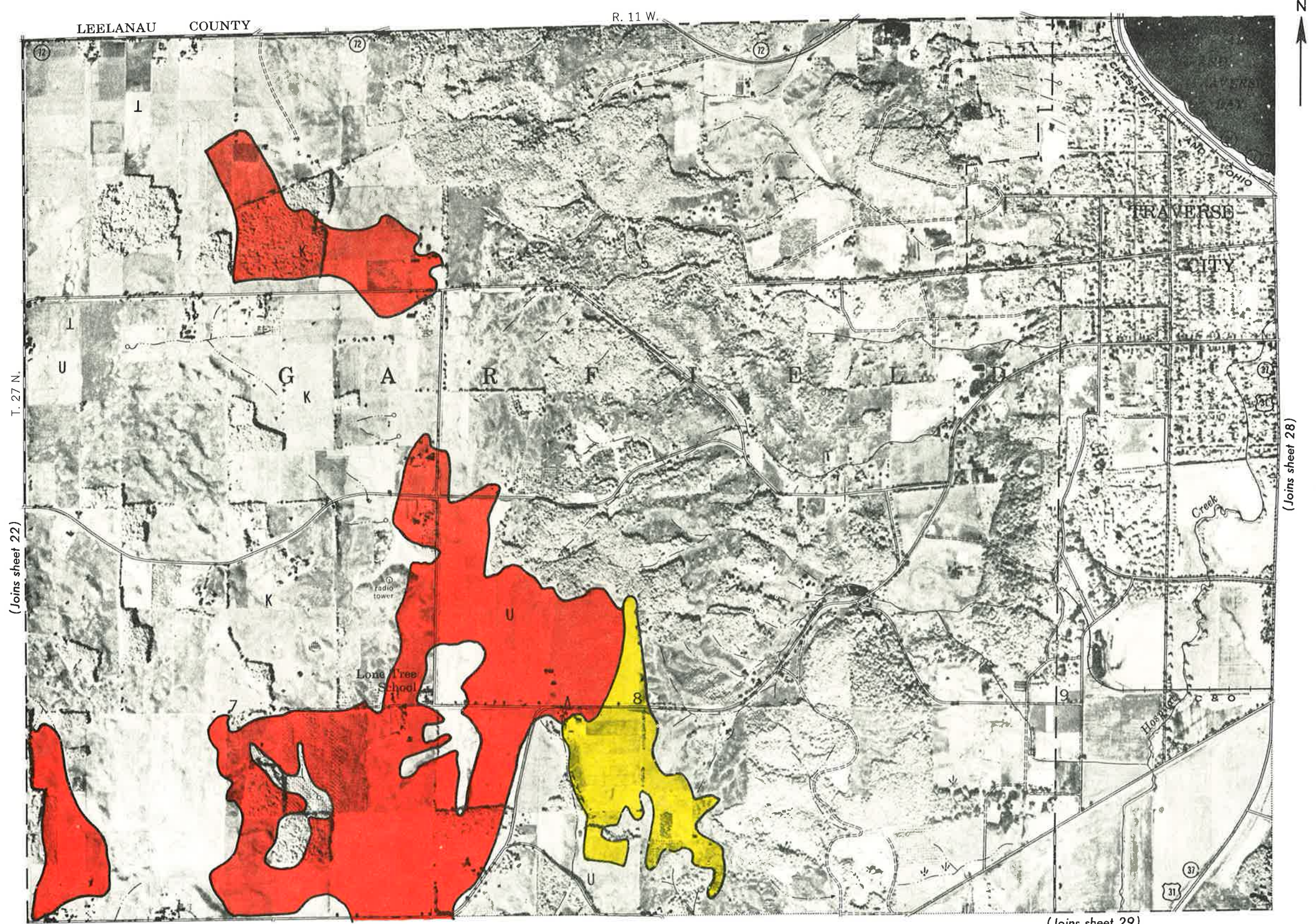
(Joins sheet 27)

(Joins sheet 24)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet



GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 27



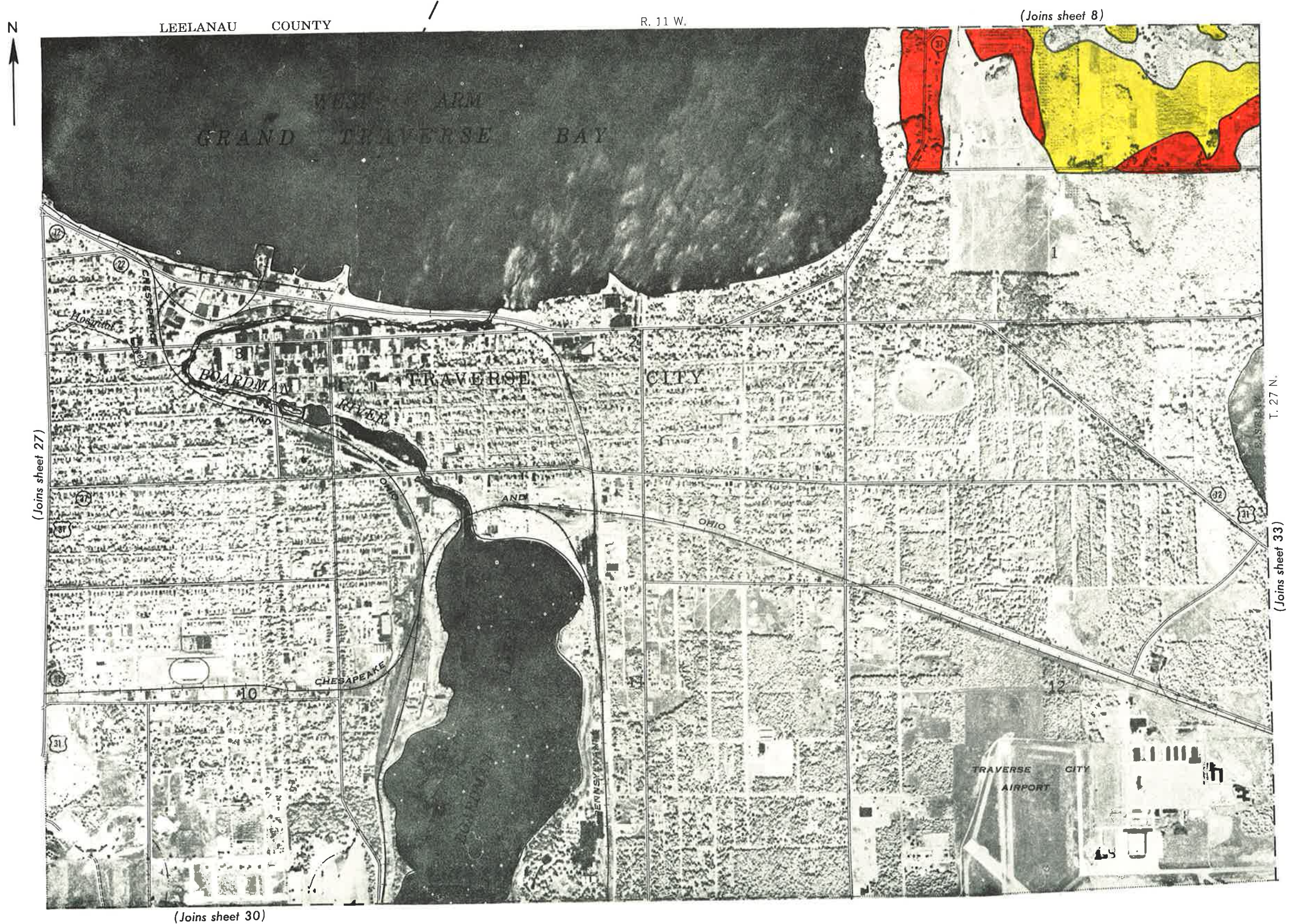
(Joins sheet 22)

(Joins sheet 28)

(Joins sheet 29)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 28



LEELANAU COUNTY

R. 11 W.

(Joins sheet 8)



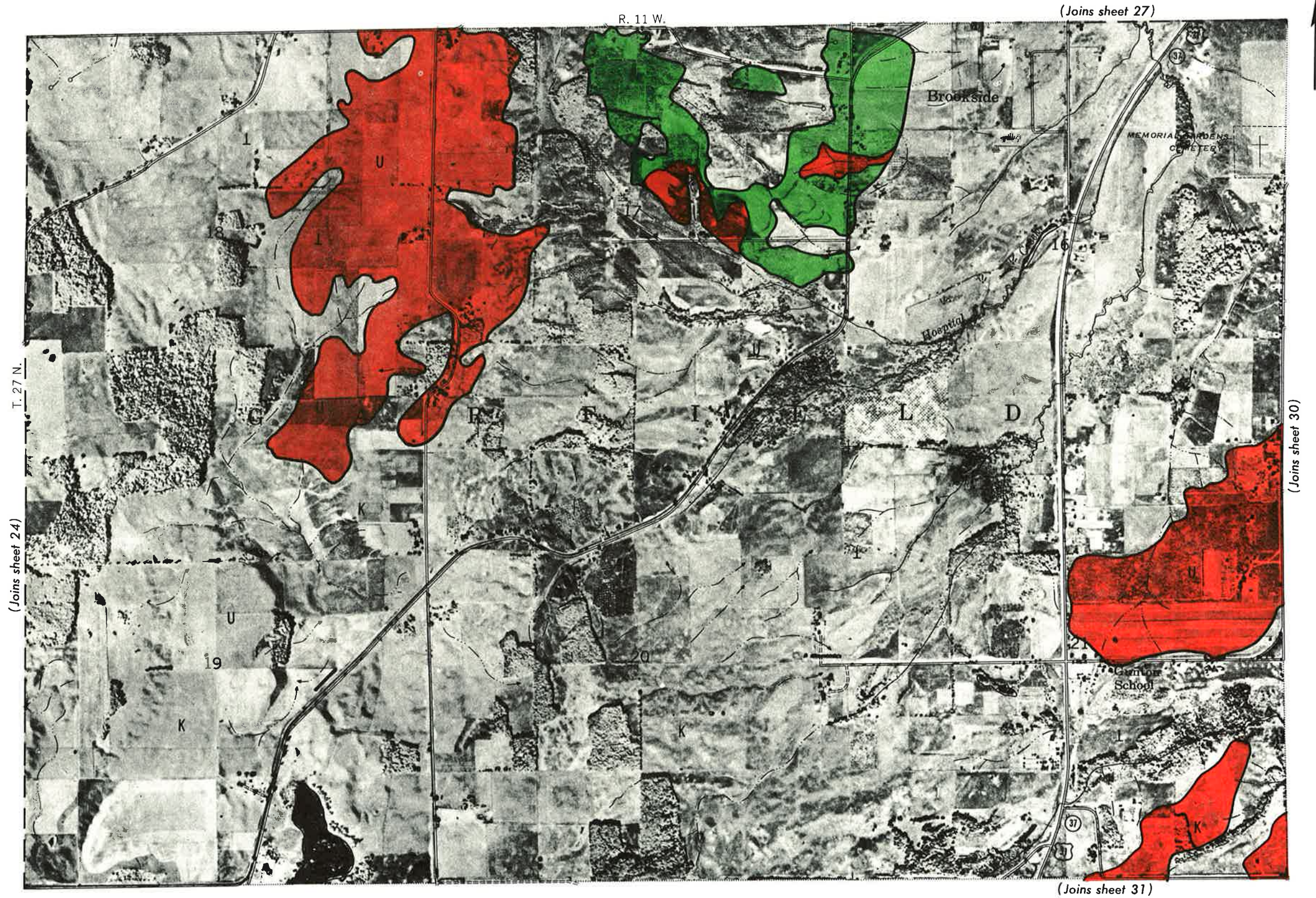
(Joins sheet 27)

T. 27 N.

(Joins sheet 33)

(Joins sheet 30)

0 1/2 Mile Scale 1:15 840 0 3 000 Feet



0 1/2 Mile Scale 1:15 840 0 3 000 Feet



(Joins sheet 28)

R. 11 W.

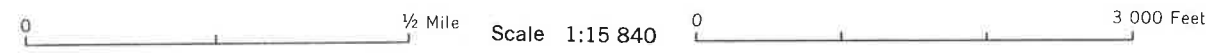


(Joins sheet 29)

T. 27 N.

(Joins sheet 35)

(Joins sheet 32)



GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 31



0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 32



(Joins sheet 31)

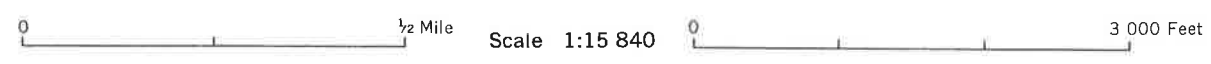
(Joins sheet 30)

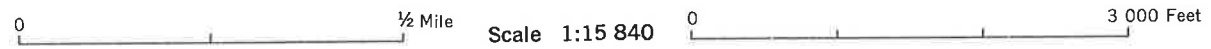
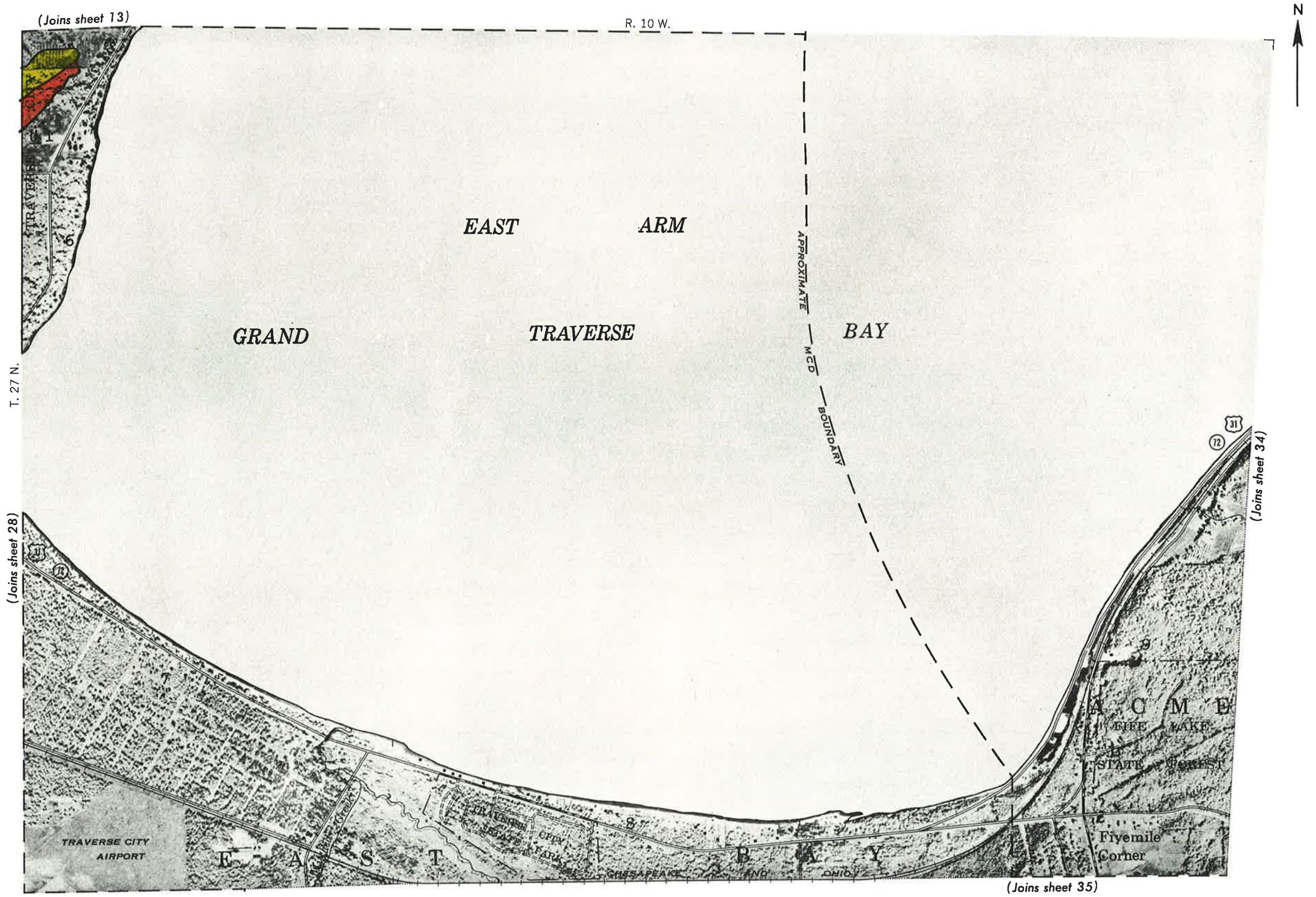
R. 11 W.

T. 27 N.

(Joins sheet 37)

(Joins sheet 52)





GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 34



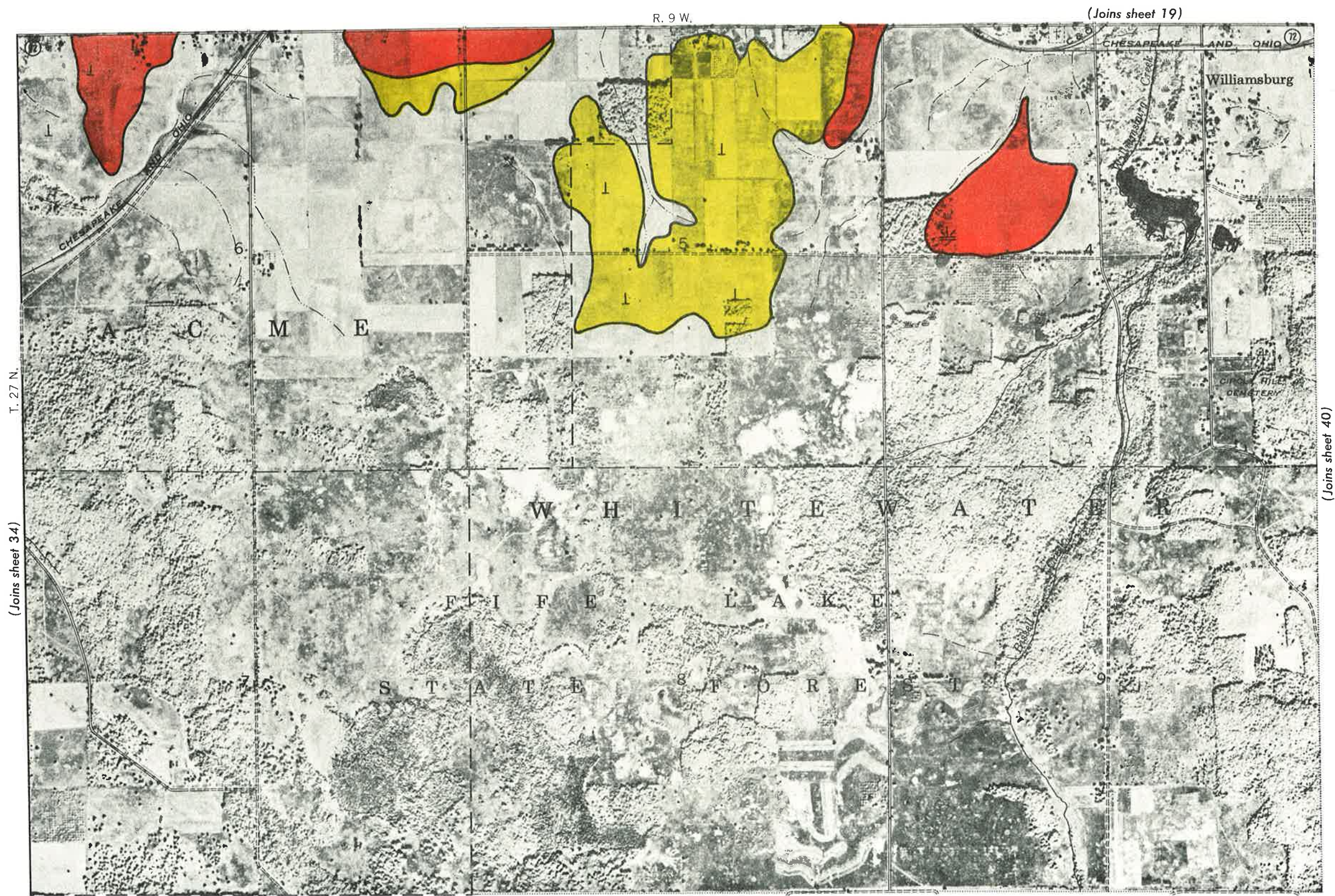
0 1/2 Mile Scale 1:15 840 0 3 000 Feet



GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 37



0 1/2 Mile Scale 1:15 840 0 3 000 Feet



T. 27 N.

R. 9 W.

(Joins sheet 19)



(Joins sheet 34)

(Joins sheet 40)

(Joins sheet 41)

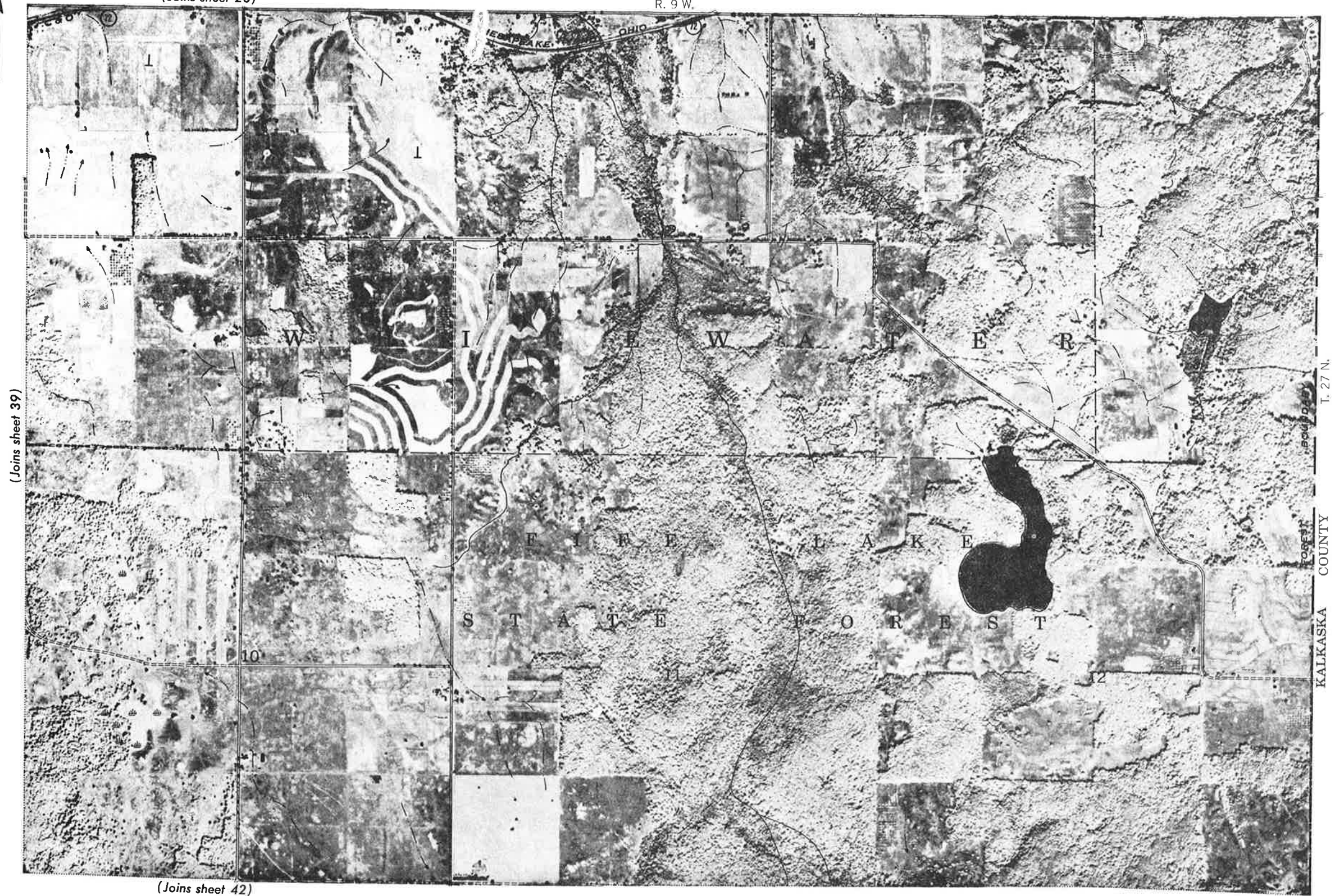
0 1/2 Mile Scale 1:15 840 0 3 000 Feet

GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 40



(Joins sheet 20)

R. 9 W.

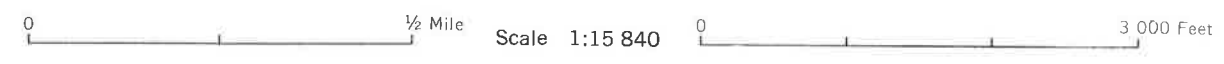


(Joins sheet 39)

T. 27 N.

KALKASKA COUNTY

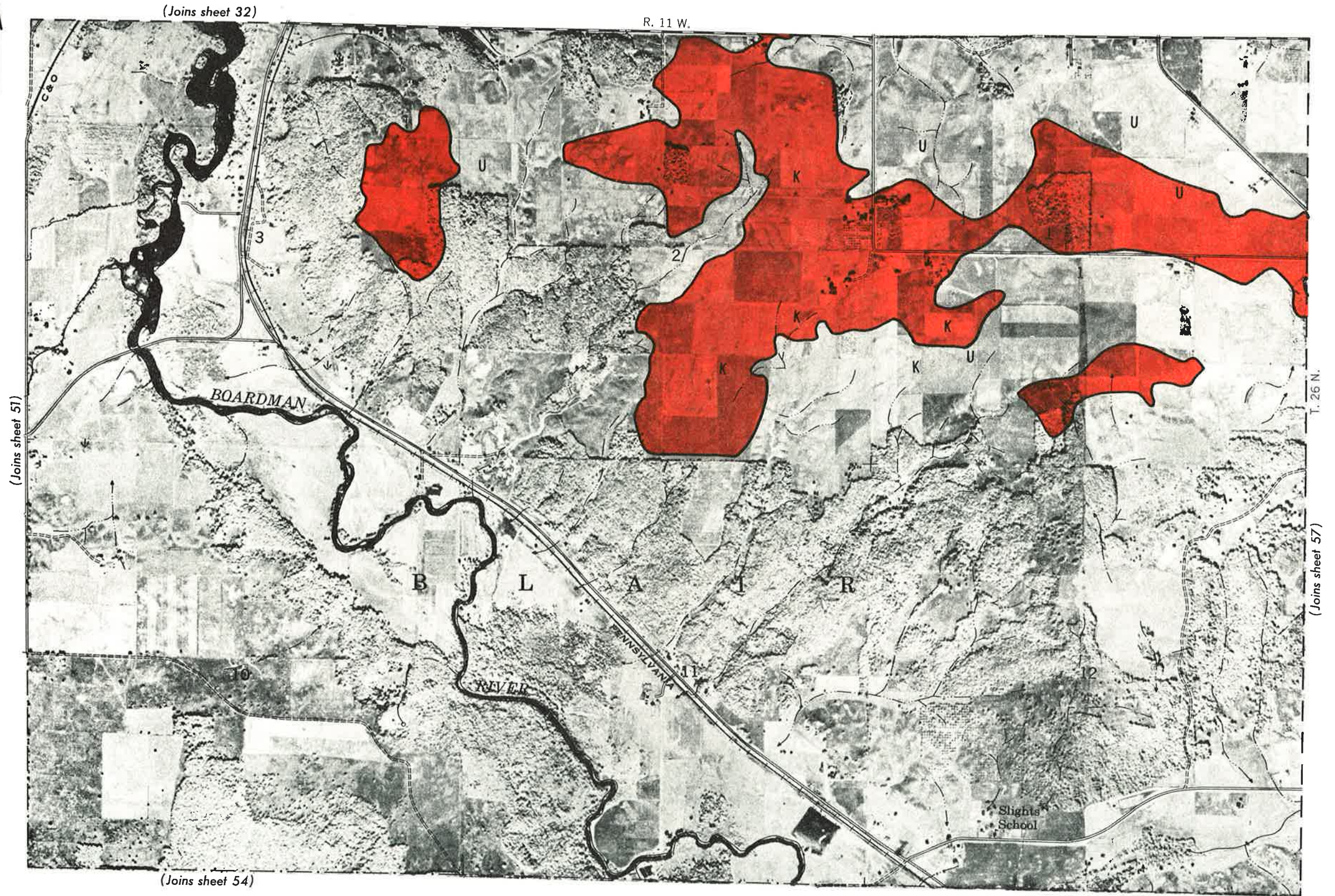
(Joins sheet 42)



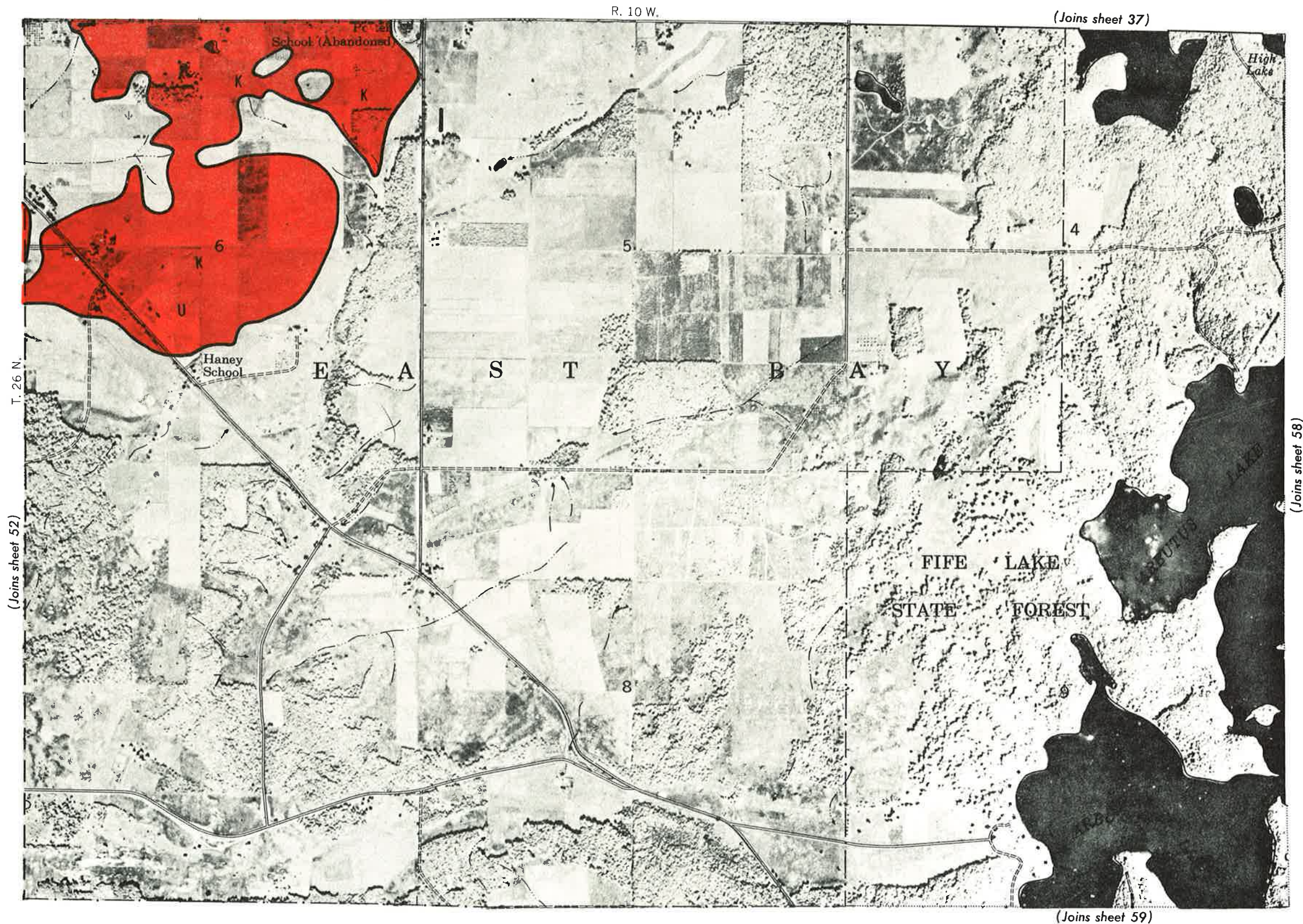
GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 51



0 1/2 Mile Scale 1:15 840 0 3 000 Feet



GRAND TRAVERSE COUNTY, MICHIGAN — SHEET NUMBER 57



0 1/2 Mile Scale 1:15 840 0 3 000 Feet