MIDLAND VEGETATION MONITORING PROGRAM
PREOPERATIONAL CHARACTERIZATION OF VEGETATION
AND VEGETATION DAMAGE SYNDROMES IN THE
VICINITY OF THE MIDLAND ENERGY CENTER

Consumers Power Company
Environmental Department
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ABSTRACT

Approximately 22 square miles in the vicinity of the Midland Energy Center were classified under the Michigan Land Cover/Use Classification System. Large scale, false-color infrared photographs and ground-truthing methods were used in making these determinations. These photos and methods were also used in assessing existing vegetation damage in this 22 square mile area. Type A damage, damage affecting individual trees, was characterized for 312 ten-acre cells containing dwellings and/or horticultural crops. Type B damage, damage affecting stands of trees ≥ 0.1 acre in extent, was mapped wherever it occurred in the study area. Over 40 percent of forested areas contained areas meeting Type B mapping criteria. The relative incidences of both damage types are discussed. Damage types and their expression in local species and under local site conditions are discussed briefly.

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1.0 INTRODUCTION

The Midland Vegetation Monitoring Program (VMP) is an integral part of Consumers Power Company's Midland Environmental Protection Plan (EPP). The purpose of the VMP is to determine what effect, if any, icing attributable to the vapor plume from the cooling pond has on local trees and shrubs. This report summarizes the baseline data which were collected to allow an operational appraisal of this effect. The objectives of this report are twofold:

1. To spatially describe and characterize vegetative cover and land use within approximately 3 km (2 miles) of the Midland Energy Center and

2. To spatially describe and characterize existing vegetation damage syndromes affecting trees within the same perimeter.

Completion of the first objective provides baseline (or preoperational) data on both vegetative cover and land use in the vicinity. A comprehensive study of this type had not been done previously. Completion of the second objective provides a body of baseline data for future comparison in the assessment of the impact, if any, of the Midland Energy Center operation on surrounding vegetation.

Both land cover/use mapping and vegetation damage analysis rely on an aerial photographic base verified by observations on the ground. The

photographs are straight vertical, precision photographs of large scale to allow accuracy in data identification and transfer. The photographs were taken using false-color, near-infrared film. This film is well-suited for vegetation and land use mapping work and is widely used. These photographs will be preserved as the ultimate data base for comparison with future conditions.

This report responds to a May 22, 1978 request by the Nuclear Regulatory Commission (NRC) to provide maps of offsite vegetation within at least 3 km (2 miles) of the site boundary.[1] The only description of vegetation available at that time was Michigan State University's report[2] on the preconstruction vegetation within the site boundaries. At the time of the request, the photographic base did not exist to allow detailed land cover/use mapping. The photographic base was developed in June of 1981. In making their request, the NRC also specified that, where possible, the same vegetation mapping units be used as those by Michigan State University.[2] The NRC did, however, allow latitude for the use of comparable systems. We have chosen to use the Michigan Land Cover/Use Classification System.[3] There are several reasons for this choice:

1. The Michigan Land Cover/Use Classification System is the official State land cover/use classification system. It is widely used by State agencies and natural resource professionals through the State.

2. The Michigan system is derived from a national classification system; it is intelligible to land use professionals nation-wide.

3. While less detailed than the system used by Michigan State in the ASER, the system both stresses dominant tree species and allows mapping through aerial photographic interpretation, which cannot be done with the former system. It thus combines essentially equivalent information for a project of this nature with ease of data acquisition.

4. The system used by Michigan State requires on the ground access to study areas. Consumers Power Company experience in trying to lease study plot sites in the ≈22 square mile project area indicated that such access could not be obtained in many areas.

Thus, while the Michigan Land Use/Cover Classification System differs somewhat from that used by Michigan State University in the ASER, we feel it is superior for this application.

As noted above, the preoperational data base characterizing existing vegetation damage was also created to enable an assessment of the operation of the Midland Energy Center on local vegetation. In addressing this issue, the VMP is consistent with the criteria set forth in the US Nuclear Regulatory Guide 4.11, "Terrestrial Environmental Studies for Nuclear Power Stations."[4] Together with the fog and ice monitoring program being conducted by the Consumers Power Company Environmental Department's Meteorology and Air Quality Section, the VMP focuses on an issue where, in the words of this regulatory guide, "an adverse relationship between station operation and the terrestrial community is reasonably thought to exist." Since experience at the Dresden Nuclear Plant indicates

that physical damage to vegetation attributable to pond-induced icing will probably be slight,[5] the VMP further satisfies the monitoring criteria of the US NRC Regulatory Guide 4.11 in that it provides a basis for evaluating "long-term impacts or unanticipated changes" due to station operation.

2.0 METHODS

The Study Area

The map of the VMP study area is reproduced as Figure 1. The study area comprises about 22 square miles and includes the following lands: Sec 25, 26, 27, 28, 29, E 1/2 30, E 1/2 31, 32, 33, 34, 35, 36 T14NR2E (Midland) and Sec 1, 2, 3, 4, 5, E 1/2 6, E 1/2 7, 8, 9, 10, 11, 12 T13NR2E (Ingersoll), Michigan. The study area contains the Midland Energy Center and includes a perimeter extending outward approximately 3 km (2 miles). Portions of the Dow Chemical Company/Dow Corning Corporation industrial complex and small portions of the City of Midland lying north and east of that complex are excluded. Even within the nominal boundaries of the study area, certain lands have been excluded. These are Dow Chemical Company or Dow Corning Corporation lands where proprietary industrial equipment and processes are based.

The areas of primary interest to the VMP are forested areas or areas which are shrub-covered. In Figure 1, forested areas are shown as shaded areas. While largely accurate, the forest cover data is somewhat dated since Figure 1 is derived from 1973 United States Geological Survey (USGS) maps.

Aerial Photography

Aerial photography of the study area was conducted by the Abrams Aerial Survey Corporation of Lansing, Michigan. The photographs were taken in late June of 1981 to coincide with the period when all trees would be fully leafed and the new foliage would reflect infrared light at a high level of spectral reflectance.

False-color, near-infrared, color positive film (CIR) was chosen for this application because: (1) Tree species have characteristic, differential spectral reflectances in the wide, near-infrared band, which aids in species identification and cover typing. (2) the near-infrared band is very sensitive to deviations in spectral reflectance due to injury. While CIR film will not detect physiological stress that is not visible in the visible spectrum, the contrast of visible stress symptoms in CIR is more dramatic than that produced by films sensitive to the visible spectrum, making it the preferred medium. (3) CIR film is less affected by haze than other films.[6] Color positive film produces 9 x 9 inch, color transparencies for mapping use on a light-table.

The photographs conform to high standards of precision and accuracy. The photographs are straight vertical, 60 percent overlap stereo pairs with a tolerance of ±5 percent accuracy in the center 6 inches of the 9 x 9 inch transparencies.

Two sets of large scale photographs were taken. The smaller scale, 1:6000 (1 inch = 500 feet) was used as the base scale for mapping both land cover/use types and vegetation damage. This mid-range scale was useful in identifying spatial patterns in the vegetation that were not

as apparent at the larger scale. The larger scale, 1:2000 (1 inch = 167 feet) was used for the analysis of single tree damage and to verify the identity of patterns visible at the smaller scale. Choice of these scales was influenced by Shipley et al.,[7] who found them useful in analyzing the effects of salt stress on vegetation attributable to drift from nuclear plant cooling towers.

Information Transfer

The aerial photographs are the ultimate data source for the VMP. Information from the individual aerial photographs, verified through on the ground surveys, was transferred to maps for summary and spatial analysis. Mylar overlays were made using 1:24,000 USGS quadrangle maps enlarged to 1:6000, the same scale as the smaller-scaled aerial photographs. A grid composed of row-column-numbered 10-acre grid cells was photographically imposed on the mylar as an aid in orientation and data capture. A light-table was used for transferring mapping data from the 1:6000 transparencies to the mylar. Stereoscopes of 2x, 4x, and a hand lens at 2x were used to aid in classification of cover and damage types. Minor adjustments were made optically to reconcile differences between the map and the photo resulting from distortion in either or both. The larger scale photographs with a proportional 10-acre mylar grid were used as a reference for the detail necessary in assigning cover type or vegetation damage designations.

Separate maps were created for: (1) land cover/use typing, (2) Type "A" vegetation damage, and (3) "Type B" vegetation damage. These mapping categories will be discussed in more detail below. Original maps in all

three categories will be retained for documentation. Copies of land cover/use maps and maps of "Type B" damage accompany this report.

Land Cover/Use Mapping

The Michigan Land Cover/Use System[3] is based on a system developed by Anderson et al[8] for use by the United States Geological Survey. The Michigan system, which is highly consistent with this national system, is a hierarchical system with four levels of complexity corresponding to the levels of resolution determined by the needs of individual studies and the resolution possible with various remote sensing technologies. The hierarchy is an inverse geometric progression, with minimum mapping areas ranging from 235-3700 acres for level 1 (such units would be suitable for mapping on a national scale) to 2-10 acres for local mapping units. The VMP uses level III, the level appropriate for State and regional planning - 10-60 acre minimum mapping area. A listing of level III categories is found in the key preceding the VMP land cover/use maps, Figures 2-5.

Vegetation Damage Characterization

The goal of this phase of the VMP study was simply to identify existing vegetation damage and more widespread damage syndromes in the study area. Identification of causal factors responsible [illegible] damage was not a goal of this study. The VMP will not investigate causal factors of vegetation damage unless there appears to be a reasonable link between that damage and the operation of the Midland Energy Center.

A system for the identification of vegetation damage was modified from P A Murtha's "A guide to air photo interpretation of forest damage in Canada."[6] The modified system is far less detailed than Murtha's, but includes three of his four major damage types: (1) Damage Type I: trees are completely, or almost completely defoliated; (2) Damage Type II: trees show some defoliation through the presence of bare branches, or malformation; and (3) Damage Type III: physiological damage - trees that show foliage as a color which is not consistent with normal foliage color of the species involved. Since the VMP focuses on structural damage due to icing, Damage Type II was subdivided into two parts: one damage type for tree tops, where icing effects are often most evident, another for damage elsewhere in the tree. Murtha's Damage Type IV, trees which show no visible sign of damage while still deviating from normal CIR color, was rejected because recent research has shown the category to be invalid.

Following Murtha,[6] the four damage types were further divided into Type A damage, for individual trees, and Type B damage, where groups of trees ≥0.1 acre in extent are affected. To Murtha's Type B damage, we added an index of severity: (1) Class 1 = 10-20% affected; Class 2 = 20-40% affected; Class 3 = >40% affected.

In applying this classification system in a study area of about 22 square miles, two levels of effort were used. For Type A, single tree damage, the mapping of every ailing tree in the study area would be of dubious value. Therefore, we limited Type A damage assessment to those grid cells containing dwellings or horticultural crops. A tally of trees in each of the four Type A damage types was made for each cell. Trees

included within the bounds of Type B areas were excluded from the tally. In this manner, the valuable trees important in an urban forestry program were thoroughly assessed, as were orchards and ornamental nursery plantings. Type B damage assessment was mapped on a separate mylar overlay wherever it occurred. Again, photographs at 1:6000 served as the mapping base; photos at 1:2000 were used for detailed analysis in both Type A and B mapping.

A field survey of grid cells meeting Type A criteria was made in 1982. The survey had the dual purpose of ground-truthing aerial photos and recording vegetation damage which had occurred since the photos. The figures from this field survey have not been added to this study; the results presented reflect photographic tallys only. Results of the field survey will be maintained and updated as the need occurs.

3.0 RESULTS AND DISCUSSION

Land Cover/Use Classification

Land cover/use maps for the study area are included as Figures 2-5. A map key precedes the figures for ease in interpretation.

Preoperational Vegetation Damage Assessment: Type A Damage

A total of 312 grid cells, (about 22 percent of the 1408 10-acre grid cells in the study area) either contained one or more dwellings or horticultural crops, dictating that they be examined for Type A vegetation damage. Type A damage summaries for these 312 cells are displayed in histogram form in Figures 6-9. No descriptive statistics have been run comparing the means and distributions of the data; such

statistics would not be very meaningful. However, a few qualitative comments can be made about these histograms.

Trees categorized in Damage Type 1A (Figure 6) are dead or almost dead. Since such trees are usually removed promptly from suburban yards and from horticultural plantings, it is not surprising that almost half of the grid cells investigated show no Type 1A damage. Nevertheless, it is not uncommon to see trees in this damage type that have not been removed. Usually, these trees are small and/or located some distance from the dwelling. Birches (Betula spp.), Lombardy poplar (Populus nigra), cottonwood (P. deltoides) and small American elm (Ulmus americana) are species commonly seen in these situations.

Commonly, Type 1A damage in a suburban setting involves from one to several trees. Where single species plantings around houses have been extensive and a disease outbreak occurs (eg, Lombardy poplar fencerows), numerous trees may be involved. However, most of the Type 1A damage seen in Figure 6 which exceeds five trees per cell results from counts made where houses have been built in wooded areas. In these cases, counts in the 10-acre cell around the house often include numerous dead trees which are not in the managed yard. The number of these high count cells would be even greater were it not for the fact that, in areas with extensive Type 1 damage, the damage is mapped as Type 1B.

Damage Type 2A (Figure 7) includes trees that have tops that are dead, partly dead, or malformed. This type of damage is common in urban areas, particularly where homes have been recently built in wooded areas or where old maples occur on farmsteads and in plantings along

rural roads. Conversely, this type of damage is rare in recently built subdivisions which were developed on open ground where trees are not generally large enough to exhibit this damage type. The average developed suburban lot or farmstead might have 0-5 Type 2A trees per developed lot. Numbers greater than that usually reflect a total count of the forest surrounding recently built homes. Red maple (Acer rubrum), silver maple (A. saccharinum) and sugar maple (A. saccharum) are commonly involved species. The upper branches of the older, open-grown trees appear to be particularly susceptible to ice storm damage; older maples also suffer from what is commonly called "maple decline" syndrome. In subdivisions recently developed in wooded areas, dead-topped trees are common where construction activity has seriously impacted tree physiology through root damage, overfill, soil compaction, alteration of drainage patterns, sun scald, or direct trauma.

In Damage Type 3A (Figure 8), the top remains intact, but damage is evident elsewhere in the tree. It is difficult to detect this damage type from the air since foliage above the affected area screens it from the aerial camera. On the basis of our field surveys, this damage type appears to be more common than the photographs indicate. This damage type is common in cottonwoods, American elm, weeping willow (Salix babylonica), box elder (Acer negundo) and other species in the local area.

In Damage Type 4A (Figure 9), tree foliage color is abnormal. This damage type is indicative of physiological stress which can result from a multitude of factors, both physical and biologic. Several

species which exhibited Type 4A damage at the time of the study were: quaking aspen (P. tremuloides), American elm. Lombardy poplar and the several native and imported birch species.

Preoperational Vegetation Damage Assessment: Type B Damage

The Type B damage category includes those damage syndromes that affect trees to the extent that spatial groupings of damaged trees can be identified. Often such damage occurs to only one species in the forest stand. For example, only quaking aspen or American elm may be affected, with other trees showing normal foliage. Such damage syndromes often reflect diseases which affect individual species. While the causes of these syndromes may appear to be species specific and rather clearcut, the etiology of these diseases is often complicated by both genetic and environmental factors. In other cases, many, most or all species in the stand may be affected to the same or varying degrees. These spatial groupings may reflect the impact of pervasive environmental factors such as drainage problems, fire, ice storms, excessive fill, airborne pollution, and so on. Insect outbreaks may also be pervasive and affect many tree species. All three types of spatial damage syndromes are apparent in the area.

Table I summarizes the extent of spatial damage syndromes in the study area. Some degree of damage with a spatial parameter is found in over 40 percent of the extant forest cover. Maps of Type B damage are included as Figures 10-13.

The most obvious syndromes, to scientist and layman alike, are the syndromes where trees are dead or almost completely defoliated. These account for more than 93 percent of the total damaged area and include nearly 1300 acres. The most widespread damage involves large numbers of dead or dying quaking aspen wherever they occur throughout the study area. Severe (1B3) damage to this species is not uncommon. Paper birch (B. papyrifera) is similarly affected, but is far less widespread. Both species appear to be affected by severe insect and disease problems. Both these species and several other species are also commonly affected by syndromes which appear to be drainage-related. Roads, pipelines, agricultural systems, etc, often interrupt local drainage patterns, resulting in permanent or seasonal flooding in portions of the study area. Many of the more severe instances of Type 1B damage appear to be caused by drainage problems.

In aggregate, Damage Types 2B and 3B comprise slightly less than 3 percent of Type B damage. These figures seem low when compared with their observed incidences in Type A damage, where they constituted proportionally more of the damage. Type 2B especially seems underrepresented. This apparent underrepresentation may be due to two factors: (1) the growth form of trees in forest stands tends to cover much of this damage with new foliage, making the damage difficult to detect from aerial photographs, and (2) the vertical growth form of forest-grown trees may be less susceptible to physical damage than the more horizontal growth form of open-grown trees of the same species. These hypotheses are not testable with the present data, but they both appear to be valid contributing factors, as indicated by field observations.

Damage Type 4B was not recorded in stands where the above syndromes were more prevalent. It is thus somewhat underrepresented. In a few areas, Types 4B and 1B seemed roughly equal, and both were recorded for the same area. However, in sum, the majority of Type 4B damage, which constitutes about 4 percent of all damage types, represents new foci of damage in the forest stands.

4.0 SUMMARY AND CONCLUSIONS

Land use in the vicinity of the Midland Energy Center is complex. Included in the study area are heavily industrialized areas, older residential communities, new subdivisions and strip residential development, sparsely settled farmland, and extensive areas of forested land. Land use in the study area is also dynamic. A comparison of present land use patterns with those shown on 1973 US Geologic Survey maps shows an increase in strip residential development and subdivisions and a proliferation of single family dwellings within forested areas. The increased number of dwellings within forested areas have both further segmented the extant forest and increased the probability of impact to vegetation, an impact that may not become obvious to a homeowner until several years after the houses and access roads are completed. Land use changes have resulted in an overall increase in the probability of landowner contact with vegetation damage syndromes.

Vegetation damage near houses and horticultural operations (Type A damage) in the study area appears not to differ from what would be expected in this area of Michigan. Planted birch trees suffer from birch borer and leaf-miner damage; small elm trees in fencelines and yards succumb to Dutch Elm Disease. Lombardy poplar fencelines often show disease

symptoms. Evergreen shrubs show evidence of winter exposure or insect infestation. Trees around new houses often show evidence of top or limb damage due to physical injury or to problems resulting from overfill. Near older houses, maples planted decades ago show signs of maple decline syndrome. Such damage is typical of what one would expect to find given the history of the land use-vegetation interface in this region.

At first glance, the incidence of Type B damage in the area's extant forest seems high. Overall, 10 percent or more of the trees are affected in 41 percent, or 1392 acres, of the forest. However, the majority of this damage is attributable to mortality and morbidity in aspen and birch, two relatively short-lived species inhabiting, for the most part, sites which are relatively poorly suited for their growth. These damage rates do not seem unreasonable under these circumstances. Additionally, much of the extant forest is found on poorly drained, somewhat sterile soils that offer poor sites for most tree species. Again, the damage in the study area associated with these elaphic conditions is not unexpected. In general, the healthiest forests are found where good quality sites are well-stocked with tree species suited to those sites. In the study area, the best sites for tree growth are also the best sites for agriculture and have been converted to that use.

This study has fulfilled its objectives: (1) spatially describing and characterizing vegetative cover and land use in the study area, and (2) spatially describing and characterizing existing vegetation damage syndromes in that area. These data will be sufficient for measuring what effect, if any, operation of the Midland Energy Center has on local vegetation.

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TABLE I

INCIDENCE OF TYPE B VEGETATION DAMAGE IN THE STUDY AREA

Damage Type*	Acres Affected	% of Forested Area**
1B1	775	23.0
1B2	354	10.5
1B3	171	5.1
2B1	18	0.5
2B2	8	0.2
2B3	2	0.1
3B1	3	0.1
3B2	7	0.2
3B3	0	0.0
4B1	32	0.9
4B2	18	0.5
4B3	4	0.1
Total	1392	41.2

*See key to tree damage designations preceding Figure 6.

**Total calculated forest acreage = 3375 acres.

Substation
BOUNDARY
29
28
M I D L A N D
Bullock Creek
Creek
Brine Well
M I D L A
Drain
32
33
34
Midland Ch
Substation
Waite and Debolt
BOUNDARY
ROAD
Bullock Creek Ch
Brine Well
Branch
5
4
3
Sandpit
8
9
Drain 10
Poseyville
(BM 639)
ROAD
EAST
BROOKS
ROAD

Figure 1. Study Area, Midland Vegetation Monitoring Program.

Midland Vegetation Monitoring Program
Key to Figures 2-5
Michigan Land Cover/Use Classification System
Level III

1 URBAN & BUILT UP

11 Residential

111 Multi-family, medium- to high-rise
112 Multi-family, low-rise
113 Single-family/duplex
114 Strip residential
115 Mobile home parks
116 Group and transient quarters
119 Other residential

12 Commercial, Services, & Institutional

121 Primary/central business district
122 Shopping Center
123 Strip development
124 Secondary/neighborhood business district
125 Other commercial and services
126 Other institutional
127 Indoor cultural, public assembly, and recreation

13 Industrial

131 Primary metal production (milling, smelting, forging)
132 Petrochemicals (storage, refining, etc)
133 Primary wood processing (lumber, pulp, paper)
134 Stone, clay, glass (cement, brick, etc)
135 Metal fabrication (secondary manufacturing)
136 Non-metal fabrication
139 Other (miscellaneous)

14 Transportation, Communication & Utilities

141 Air transportation
142 Rail transportation
143 Water transportation
144 Road transportation
145 Communications (areas of towers, etc)
146 Utilities

(15) Map Industrial Parks under appropriate category in Commercial Services & Institutional (12) or Industrial (13)

16 Mixed

17 Extractive

171 Open pit
172 Shaft
173 Wells
179 Other extractive

19 Open & Other

191 Outdoor cultural
192 Outdoor public assembly
193 Outdoor recreation
194 Cemeteries
199 Other

2 AGRICULTURAL LAND

21 Cropland, Rotation & Permanent Pasture

211 Cultivated cropland
212 Hay, rotation and permanent pasture

22 Orchards, Bush-Fruits, Vineyards & Ornamental Horticulture Areas

221 Tree fruits
222 Bush-fruits and vineyards
223 Ornamental horticulture

23 Confined Feeding Operations

231 Livestock
232 Poultry
239 Other

(28) Inactive Land (These plant communities will be mapped under herbaceous rangelands (31).)

29 Other Agricultural Land

291 Farmsteads
292 Greenhouses and mushroom houses
293 Race tracks
299 Other

3 RANGELAND

31 Herbaceous Rangeland

311 Upland herbaceous rangeland
312 Lowland herbaceous rangeland

32 Shrub Rangeland

321 Upland shrub rangeland
(322) Lowland shrub rangelands (for level III use wetlands 612)

4 FOREST LAND

41 Broadleaved Forest (generally deciduous)

411 Upland hardwoods
412 Aspen, white birch, and associated species
413 Lowland hardwoods

42 Coniferous Forest

421 Upland conifers
422 Lowland conifers

43 Mixed Conifer-Broadleaved Forest

431 Upland hardwoods and pine associations
432 Aspen, birch with conifer associations
433 Lowland hardwoods with cedar, spruce, tamaract, etc, associations
434 Upland conifers with maple, elm, ash, aspen and birch, etc, associations
435 Lowland conifers with maple, elm, ash, aspen, birch, etc, associations

5 WATER

51 Streams & Waterways

511 Small streams and rivers
512 Medium streams and rivers
513 Large streams and rivers

52 Lakes

521 Ponds
522 Small Lake
523 Small Lake
524 Medium Lake
525 Medium Lake
526 Large Lake
527 Large Lake
528 Very large Lake
529 Very large Lake

53 Reservoirs

532 Ponds
532 Small Reservoirs
533 Small Reservoirs
534 Medium Reservoirs
535 Medium Reservoirs
536 Large Reservoirs
537 Large Reservoirs
538 Very large Reservoirs
539 Very large Reservoirs

54 Great Lakes

6 WETLANDS

61 Forested (wooded) Wetlands

(611) Wooded swamps (mapped under forestry categories 412, 422, 433, 435)
612 Shrub swamps

62 Non-Forested (non-wooded) Wetlands

(621) Marshland meadow (grazed meadows will be mapped under permanent pasture 2123. Ungrazed meadows will be mapped lowland herbaceous rangeland 312.)
622 Mudflats
623 Shallow marshes
624 Deep marshes
(625) Open water (refer to Water 5)

7 BARREN

71 Salt Flats (not applicable to Michigan)

72 Beaches & Riverbanks

721 Sand beach
722 Gravel beach
723 Riverbanks
729 Other

73 Sand Other than Beaches

731 Sand dunes
739 Other

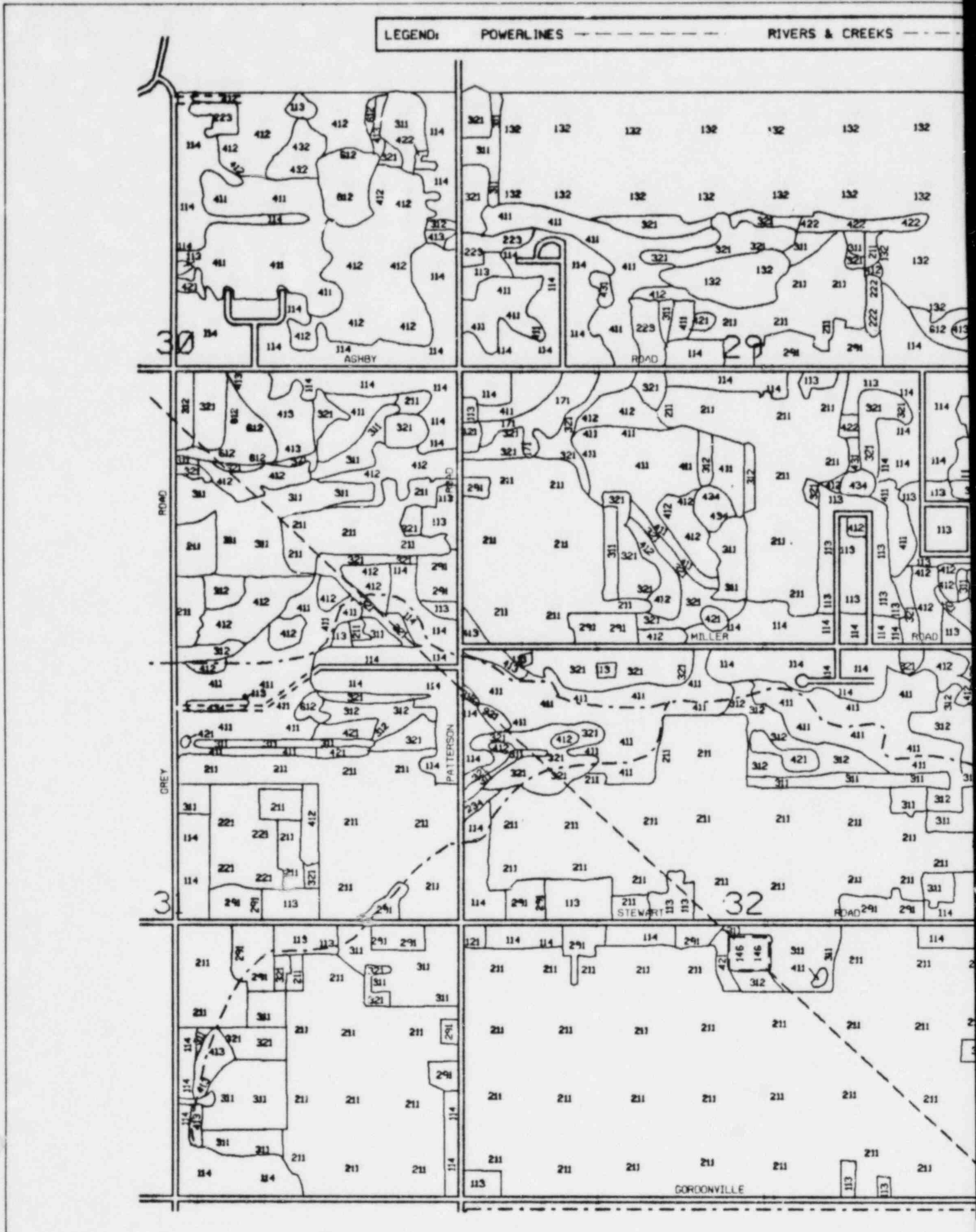
74 Bare Exposed Rock

741 Rock knobs
742 Escarpments
743 Shoreline rock outcrop
744 Riverbank
749 Other

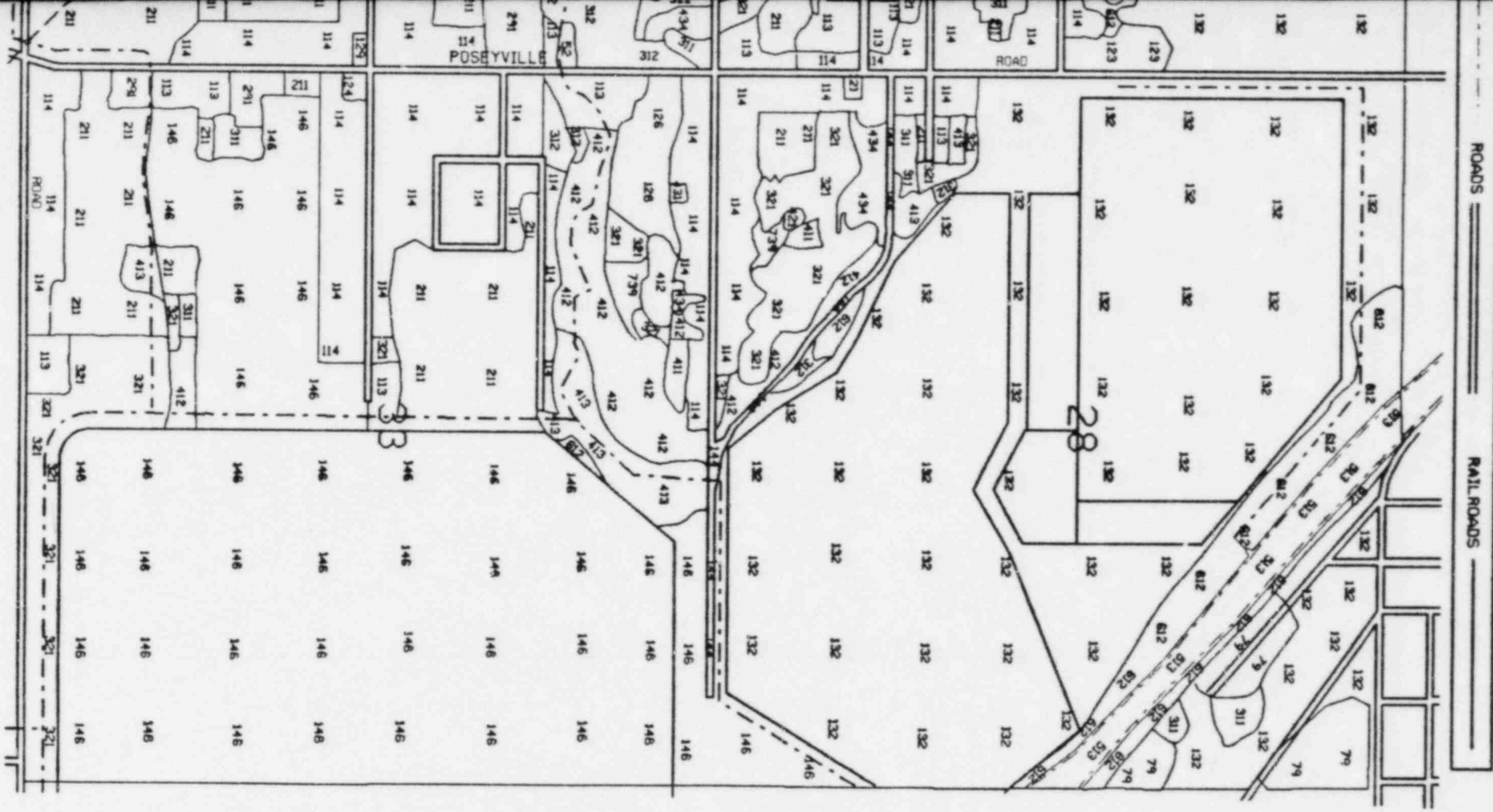
75 Transitional Areas

79 Other

GAD/12-13-82



LEGEND: POWERLINES
RIVERS & CREEKS
30
29
31
32
ASHBY
ROAD
MILLER
ROAD
GREY ROAD
PATTERSON ROAD
STEWART
ROAD
GORDONVILLE



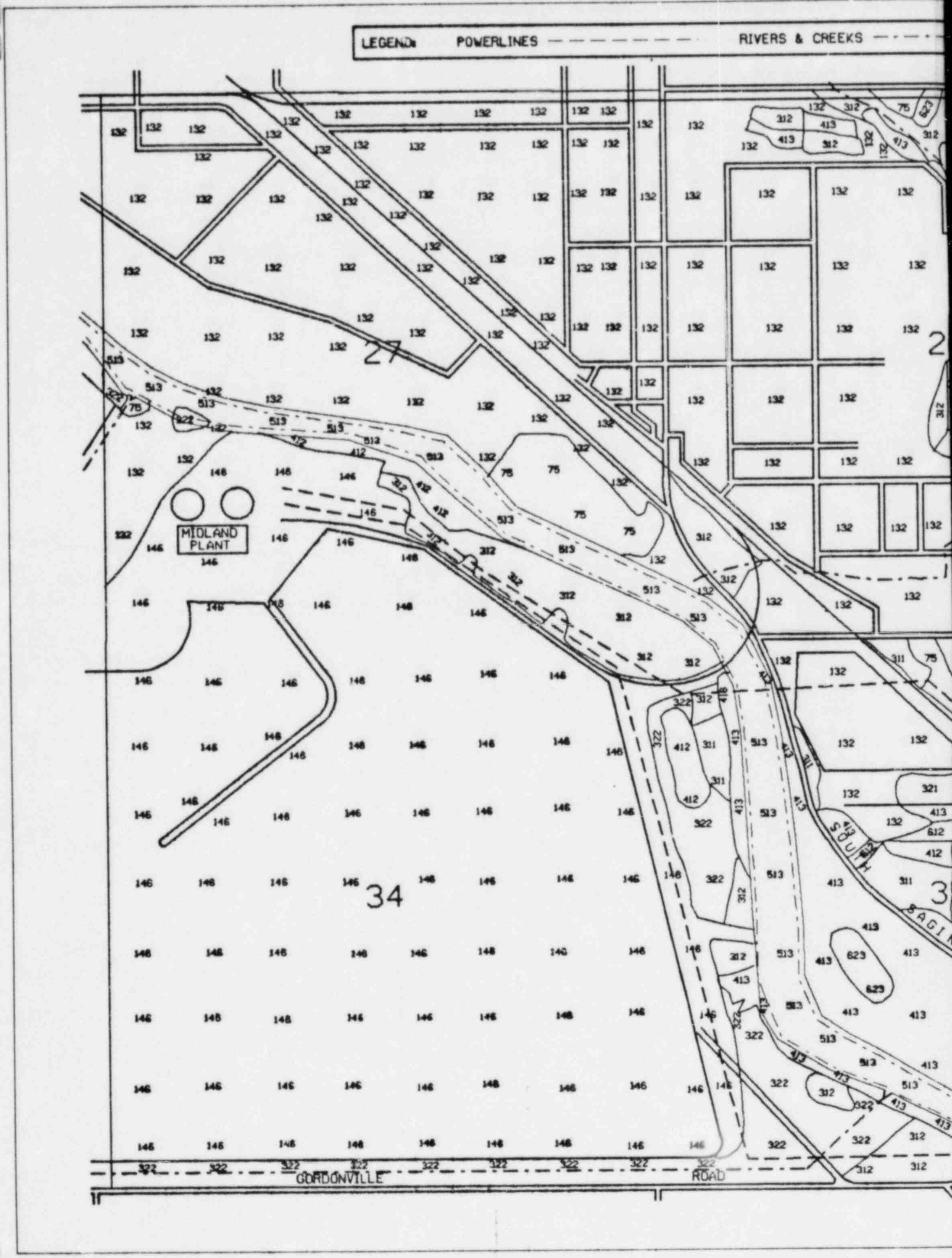
MIDLAND VEGETATION MONITORING PROGRAM

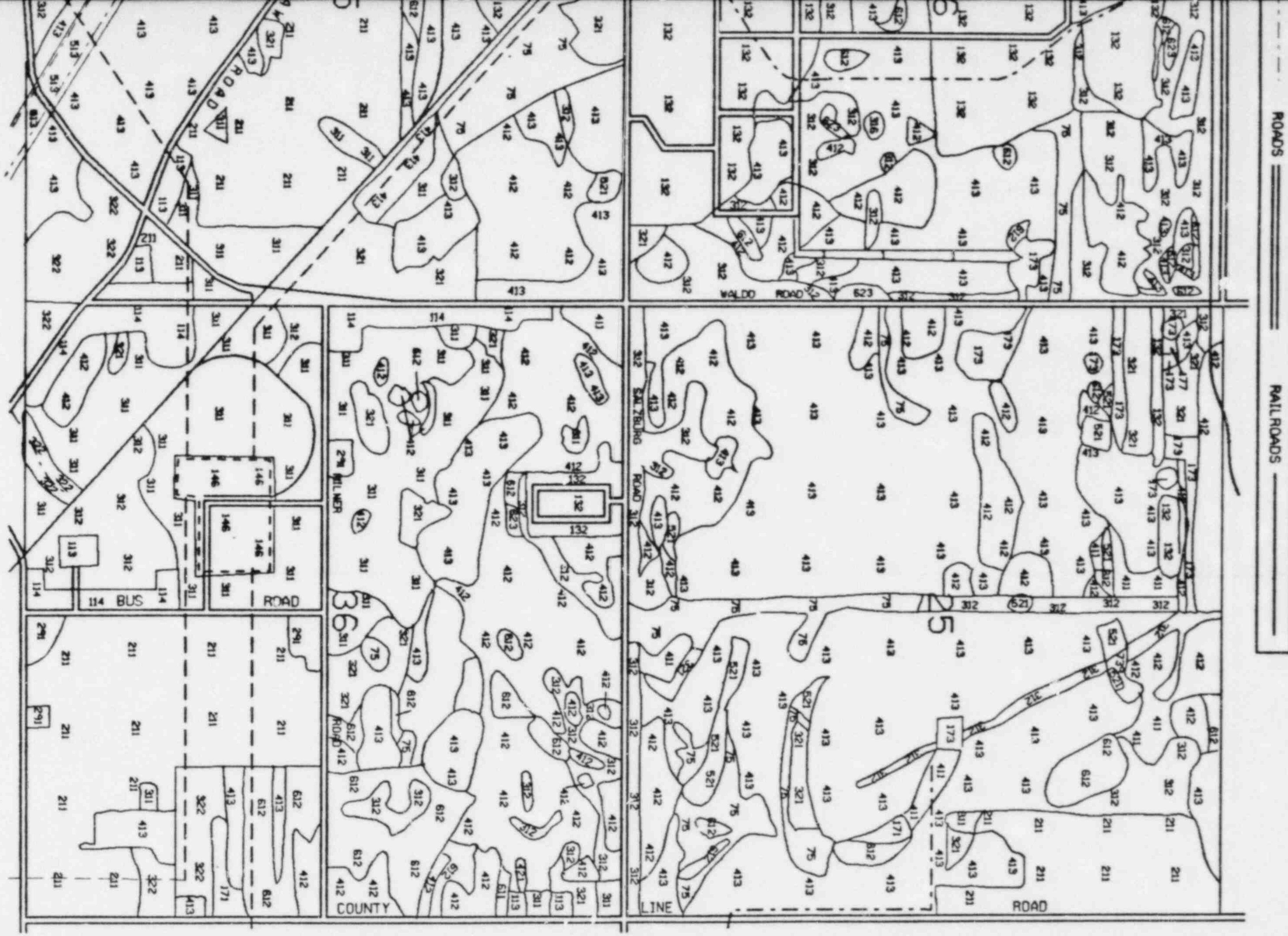
MICHIGAN LAND COVER/USE CLASSIFICATION

NORTHWEST QUADRANT

QSØ:[4Ø,1ØØ]MIDMAPNWQ.ØØ1

Figure 2

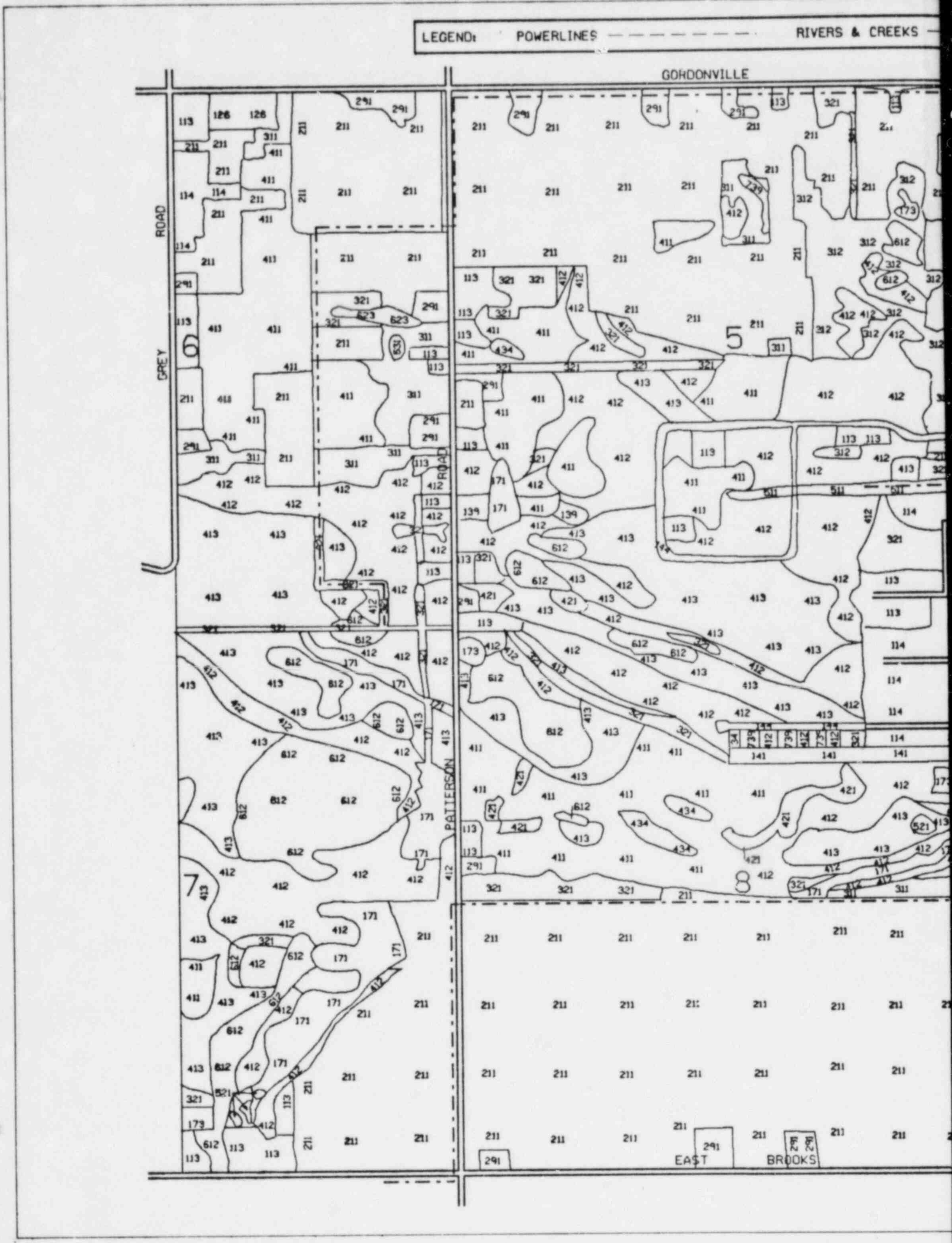

LEGEND:
POWERLINES
RIVERS & CREEKS
27
34
MIDLAND PLANT
GORDONVILLE ROAD

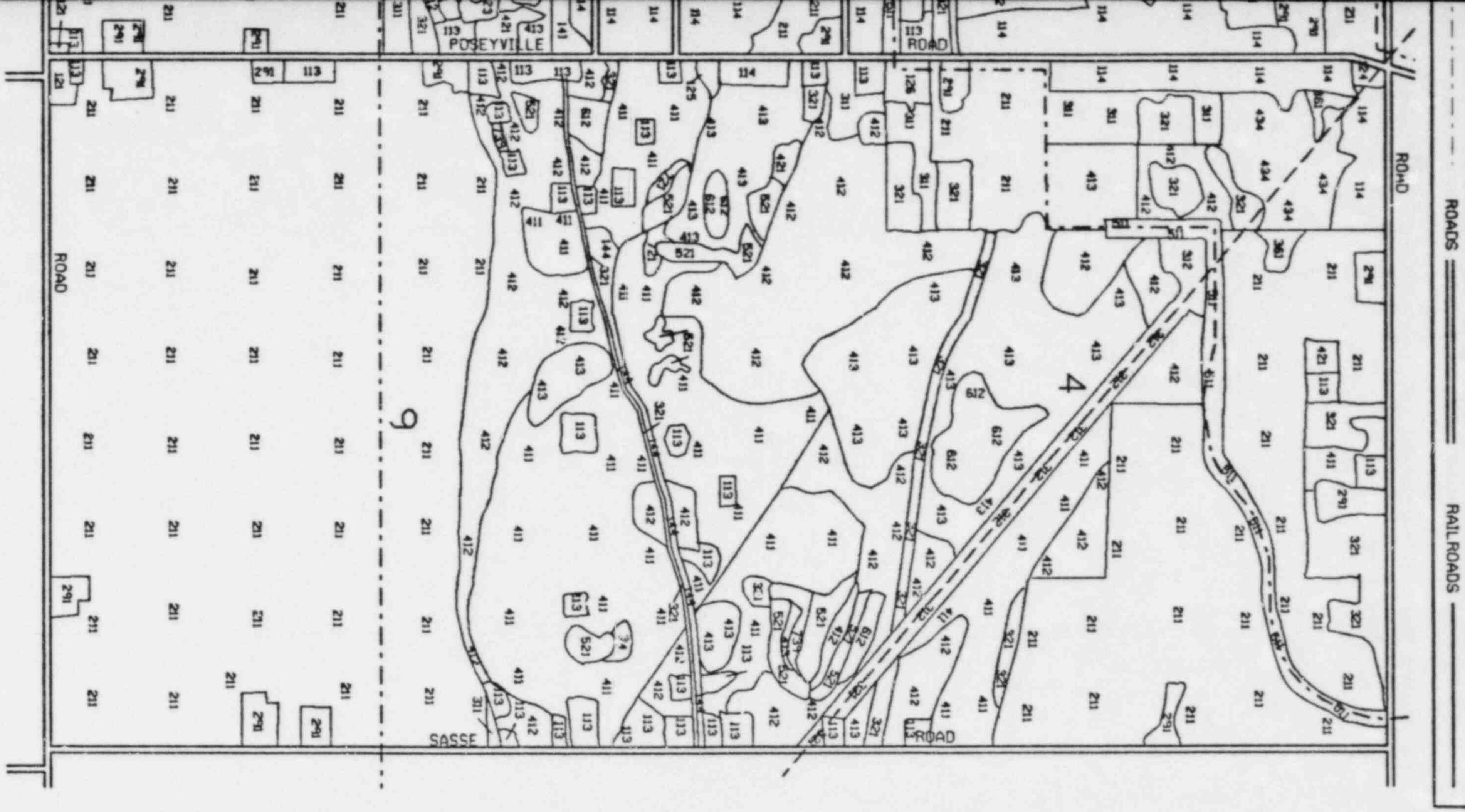


MIDLAND VEGETATION MONITORING PROGRAM

MICHIGAN LAND COVER/USE CLASSIFICATION

NORTHEAST QUADRANT   Figure 3   QSØ:[4Ø.1ØØ]MIDMAPNEQ.ØØ1


LEGEND: POWERLINES
RIVERS & CREEKS
GORDONVILLE
GREY ROAD
PATTERSON ROAD
EAST BROOKS
5
6
7
8



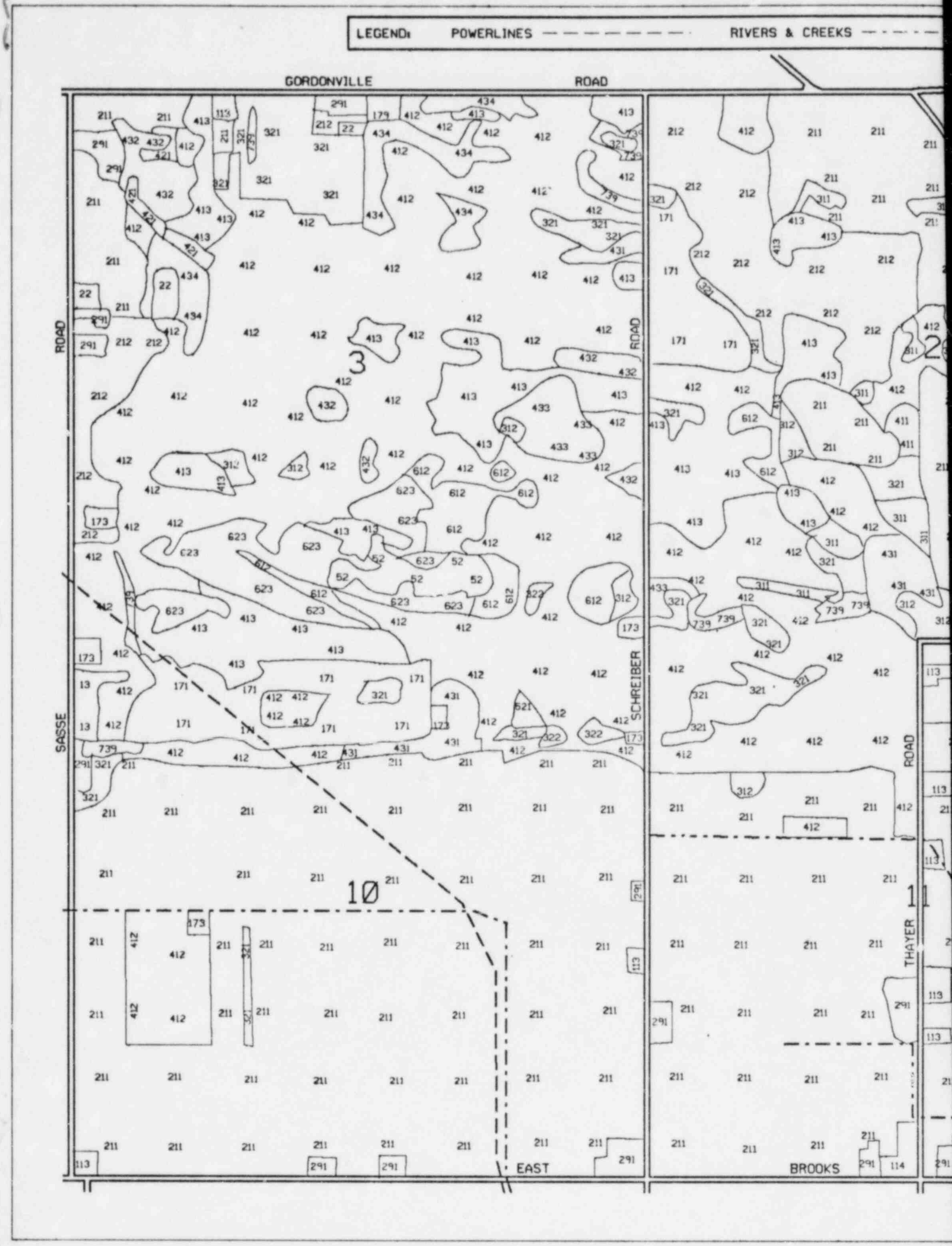
MIDLAND VEGETATION MONITORING PROGRAM

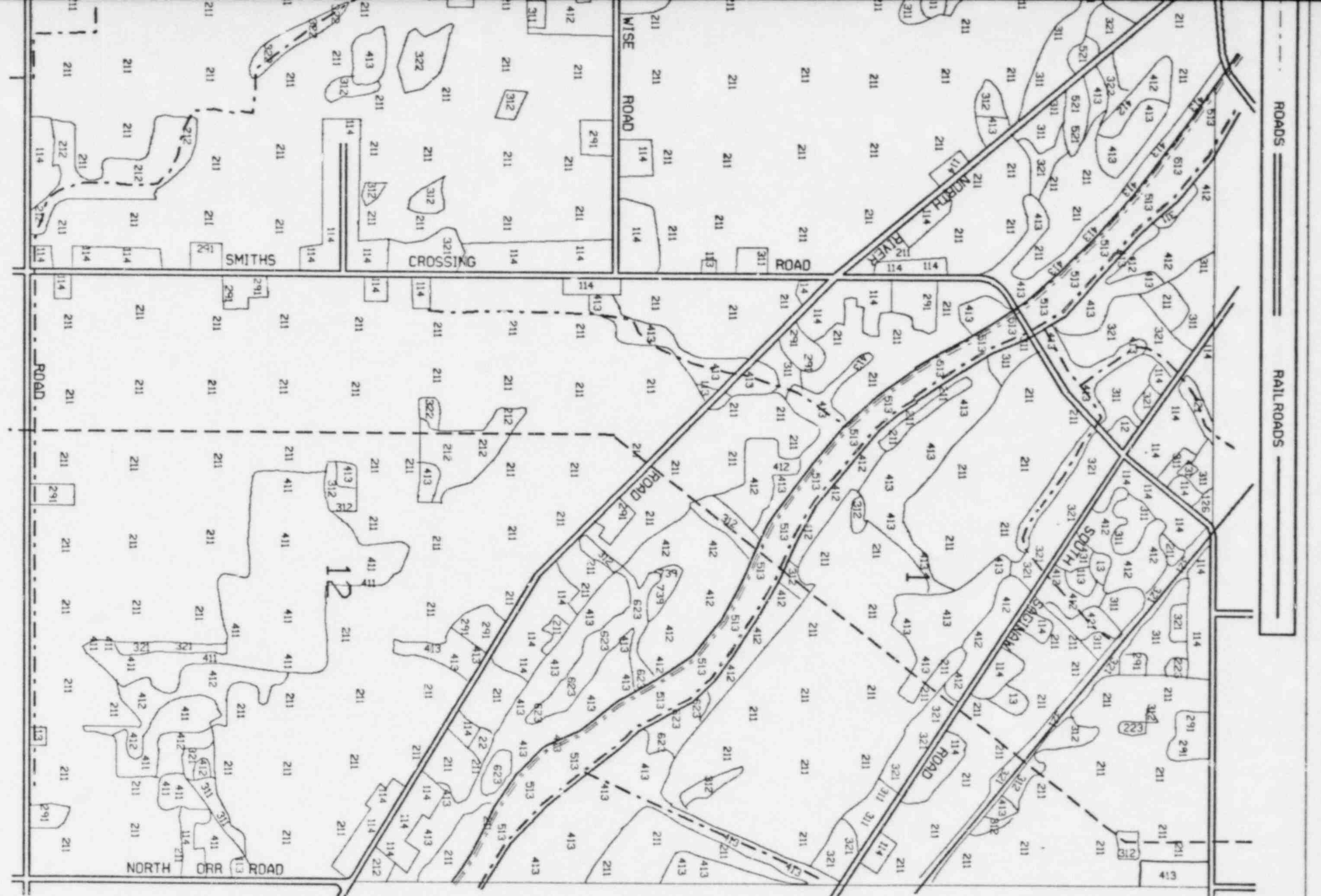
MICHIGAN LAND COVER/USE CLASSIFICATION

SOUTHWEST QUADRANT

QS0:[40,100]MIDMAPSWQ.001

Figure 4


LEGEND: POWERLINES
RIVERS & CREEKS
GORDONVILLE ROAD
SASSE ROAD
SCHREIBER ROAD
THAYER ROAD
EAST
BROOKS
3
2
10
11



MIDLAND VEGETATION MONITORING PROGRAM

MICHIGAN LAND COVER/USE CLASSIFICATION

SOUTHEAST QUADRANT

QS0:[40,100]MIDMAPSEQ.001

Figure 5

MIDLAND VEGETATION MONITORING PROGRAM

KEY TO TREE DAMAGE DESIGNATIONS

Condition	Designation
1. Tree(s) defoliated or almost completely so; single trees, scattered trees, or groups of trees <0.1 acres in extent	1A
2. Trees defoliated, or almost completely defoliated; groups of trees ≥ 0.1 acres in extent	1B
3. Tree top(s) show(s) some defoliation or malformation; single trees, scattered trees or groups of trees <0.1 acres in extent	2A
4. Tree top(s) show(s) some defoliation or malformation; groups of trees ≥ 0.1 in extent	2B
5. Tree defoliation evident in parts of the tree(s) other than the top; single trees, scattered trees, or groups of trees <0.1 acres in extent	3A
6. Tree defoliation evident in parts of the trees other than the top; groups ≥ 0.1 acres in extent	3B
7. Tree foliage color is abnormal on near-infrared photographs or as determined by ground investigation; single trees, scattered trees, or groups of trees <0.1 acre in extent	4A
8. Tree foliage color is abnormal on near-infrared photographs or as determined by ground investigation; groups of trees ≥ 0.1 acres in extent	4B

Type B Damage Severity Index

Class 1 ≈ 10-20% affected
Class 2 ≈ 20-40% affected
Class 3 > 40% affected

Example: A group of trees ≥ 0.1 acres in extent, 25% of which showed top damage or malformation, would be rated 2B2.

MIDLAND VEGETATION MONITORING PROGRAM
DAMAGE TYPE 1A
FREQUENCY OF OCCURRENCE
n = 312

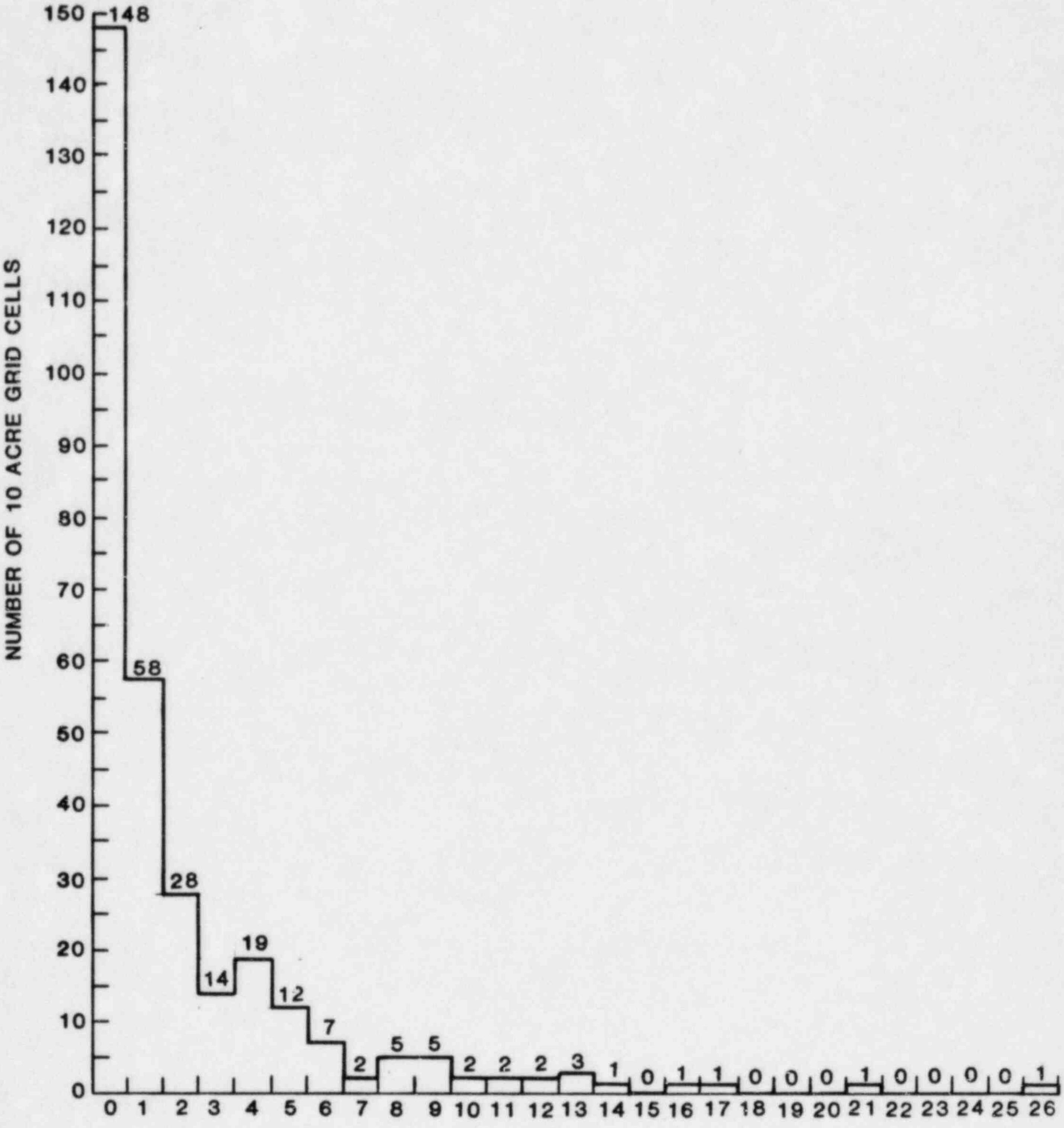


Figure 6

MIDLAND VEGETATION MONITORING PROGRAM
DAMAGE TYPE 2A
FREQUENCY OF OCCURRENCE
n=312

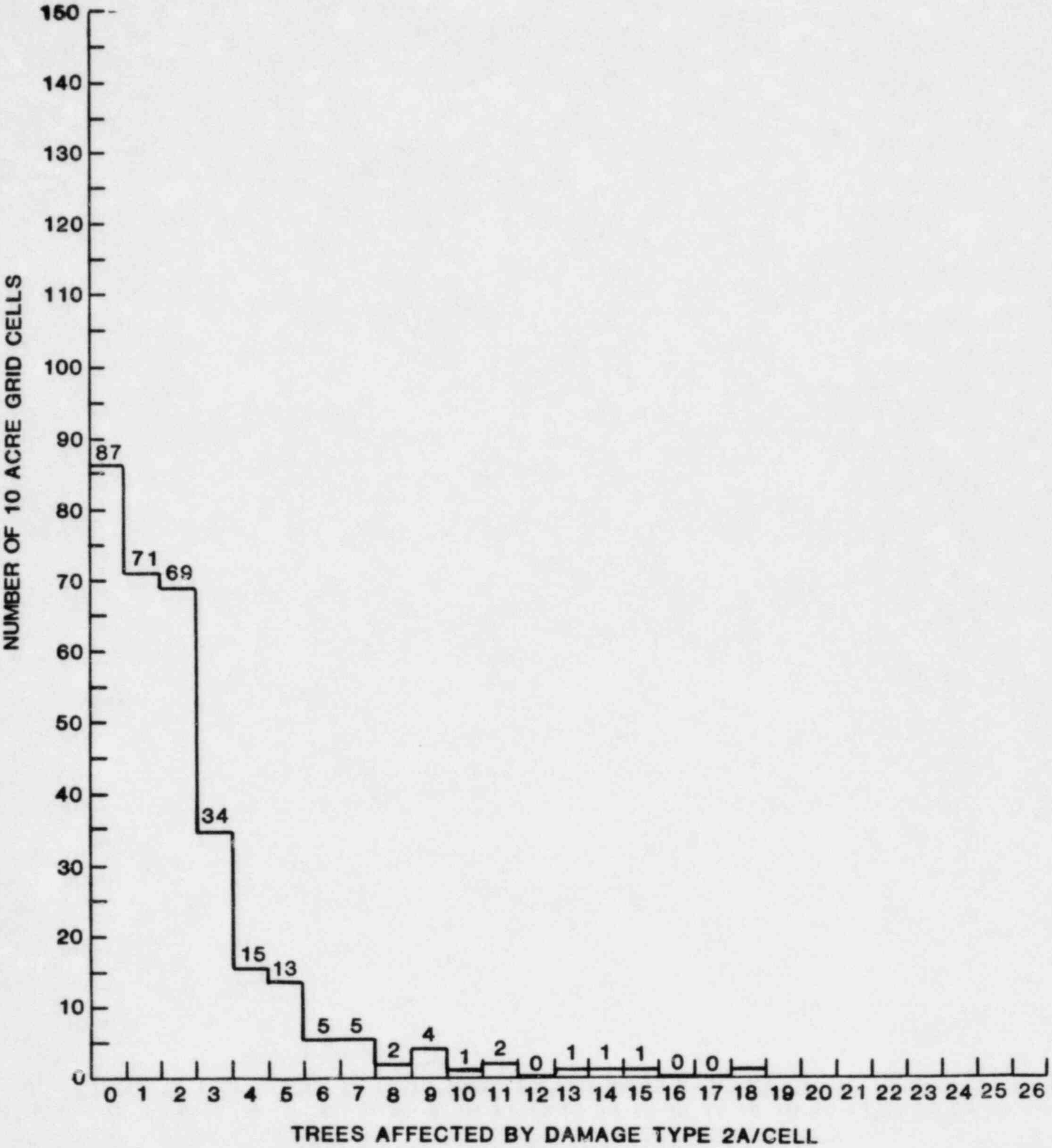


Figure 7

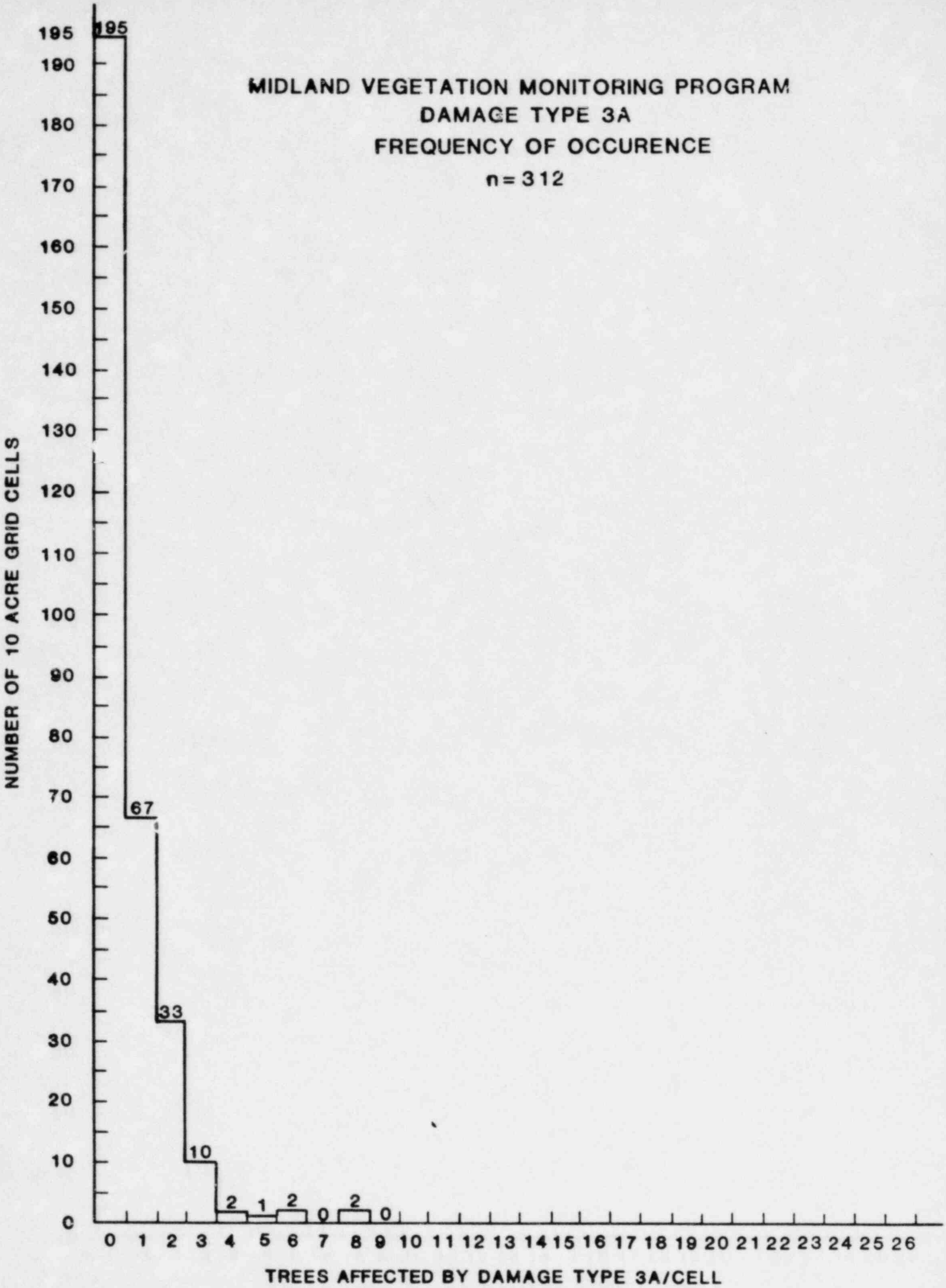

MIDLAND VEGETATION MONITORING PROGRAM
DAMAGE TYPE 3A
FREQUENCY OF OCCURENCE
n = 312
NUMBER OF 10 ACRE GRID CELLS
TREES AFFECTED BY DAMAGE TYPE 3A/CELL
195
67
33
10
2
1
2
0
2
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 195
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Figure 8

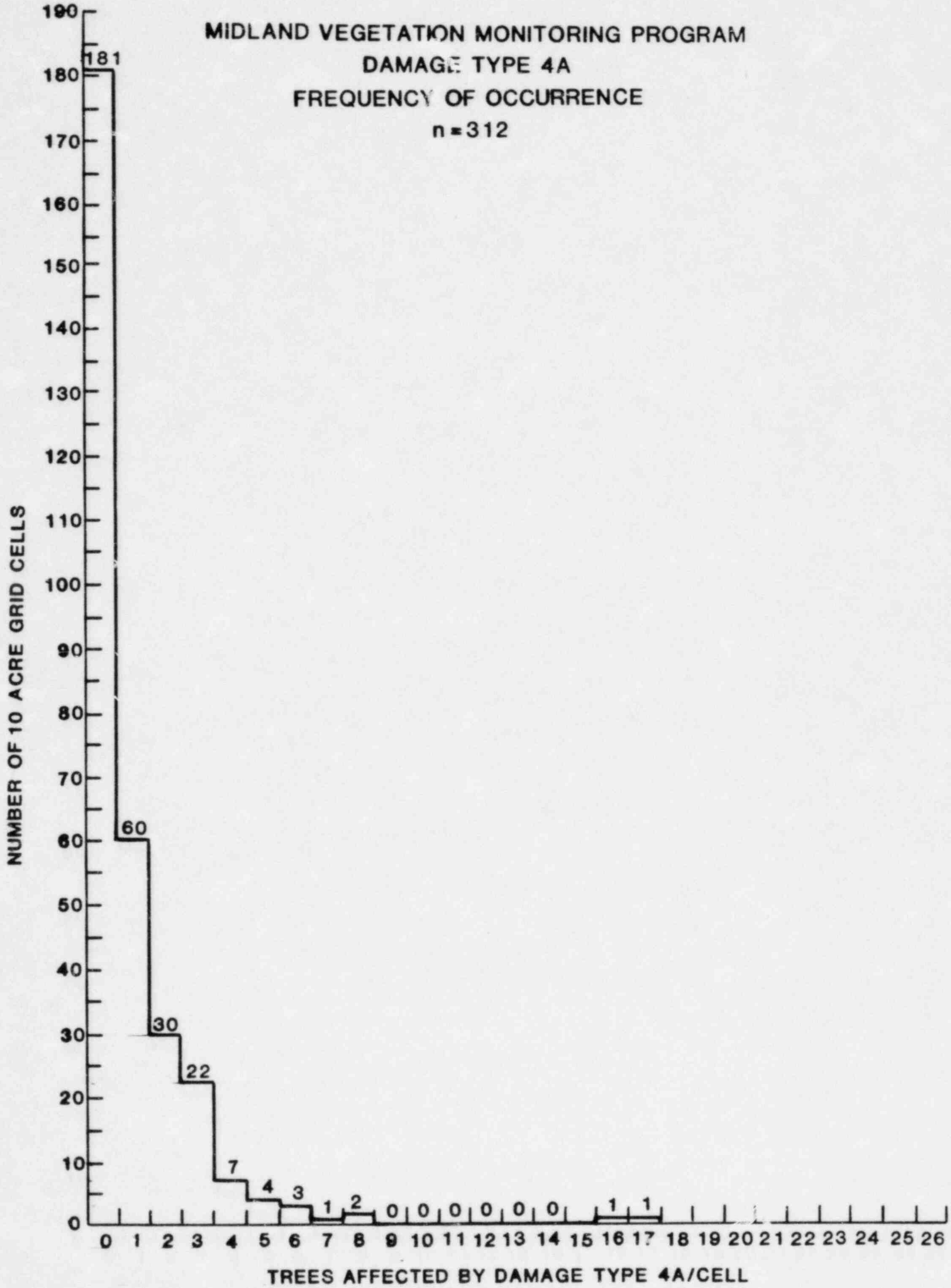
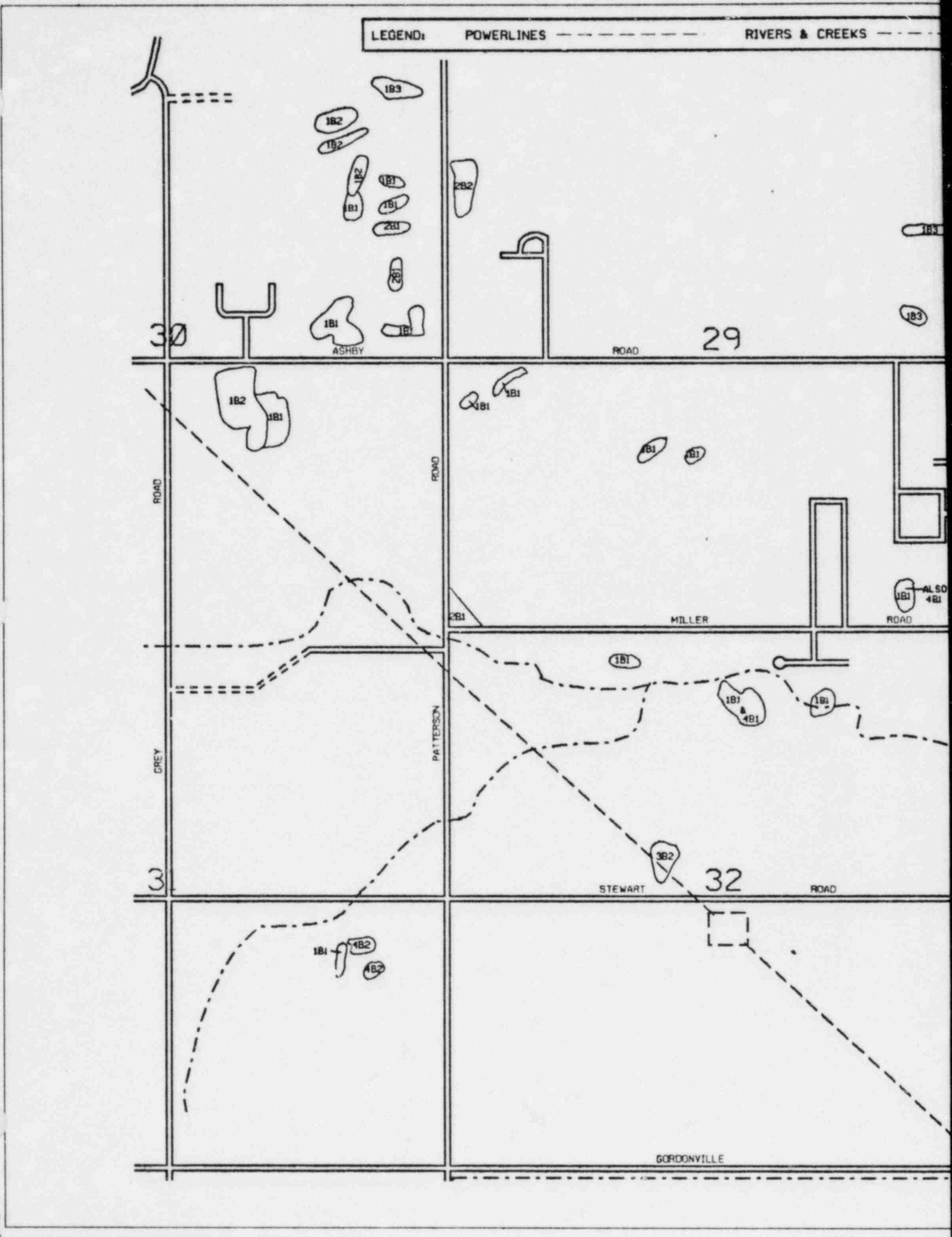
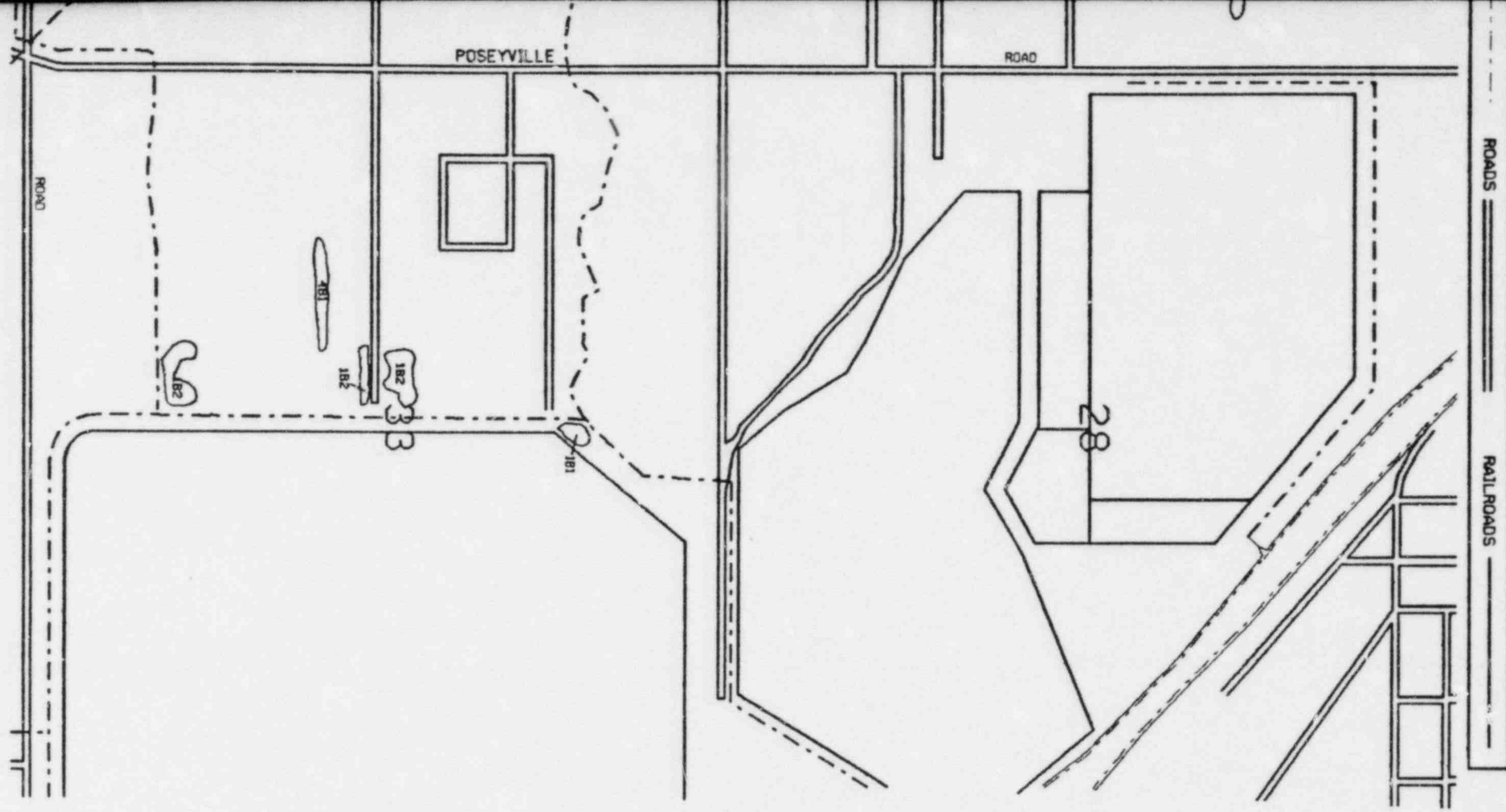

MIDLAND VEGETATION MONITORING PROGRAM
DAMAGE TYPE 4A
FREQUENCY OF OCCURRENCE
n = 312
NUMBER OF 10 ACRE GRID CELLS
TREES AFFECTED BY DAMAGE TYPE 4A/CELL
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
181
60
30
22
7
4
3
1
2
0
0
0
0
0
0
1
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Figure 9



LEGEND: POWERLINES
RIVERS & CREEKS
1B3
1B2
1B2
2B2
1B1
1B1
1B1
2B1
1B1
1B1
1B1
1B3
1B3
30
ASHBY
ROAD
29
1B2
1B1
1B1
1B1
1B1
1B1
ROAD
ROAD
1B1
ALSO
4B1
2B1
MILLER
ROAD
1B1
1B1
4B1
1B1
PATTERSON
GREY
3B2
3
STEWART
32
ROAD
1B1
4B2
4B2
GORDONVILLE



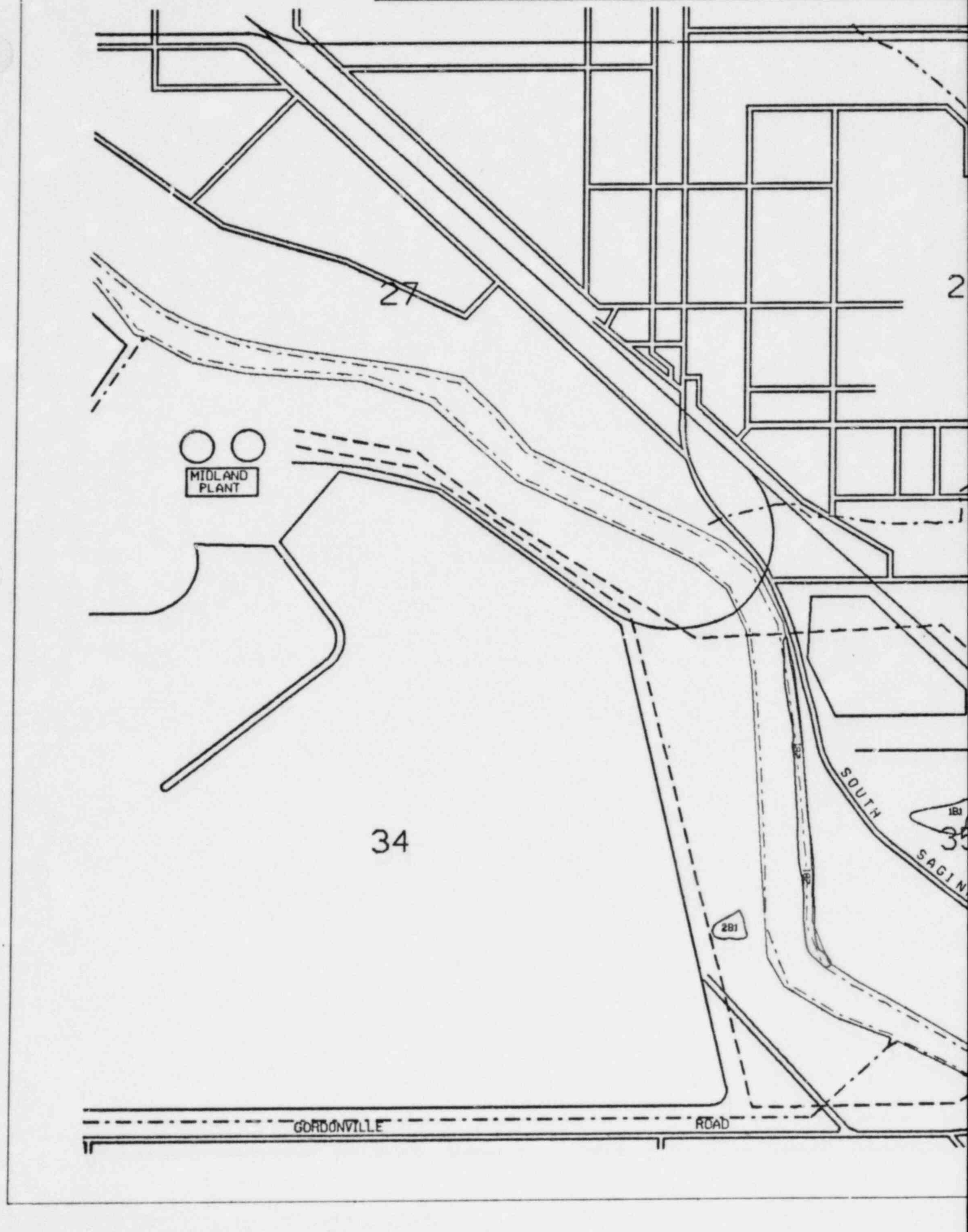
MIDLAND VEGETATION MONITORING PROGRAM

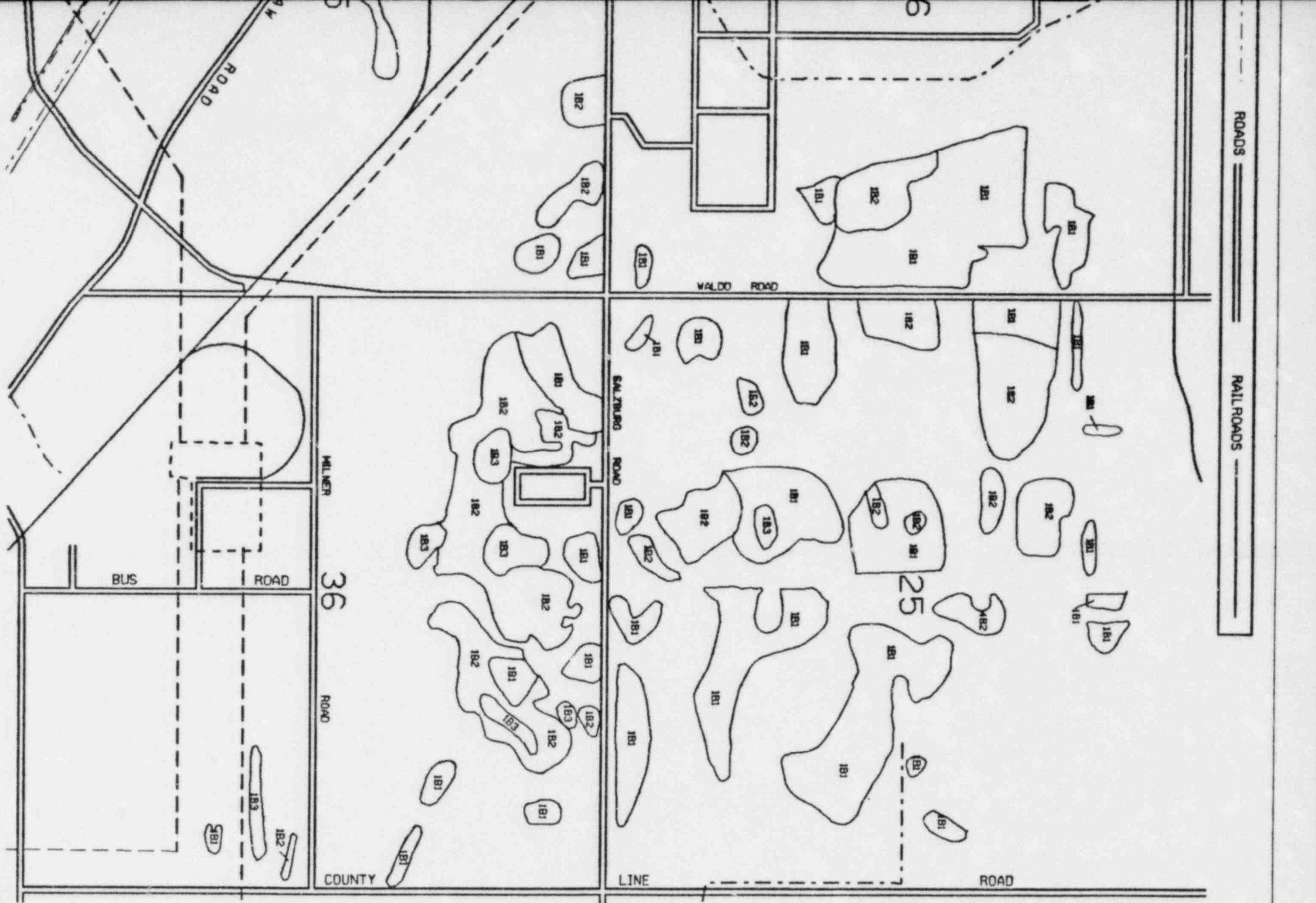
LOCATION OF EXISTING 'TYPE B' DAMAGE SYNDROMES

NORTHWEST QUADRANT QSØ:[4Ø,1ØØ]MIDMAPNWQ.ØØ1

Figure 10

LEGEND: POWERLINES — — — — — — — RIVERS & CREEKS — · — · —

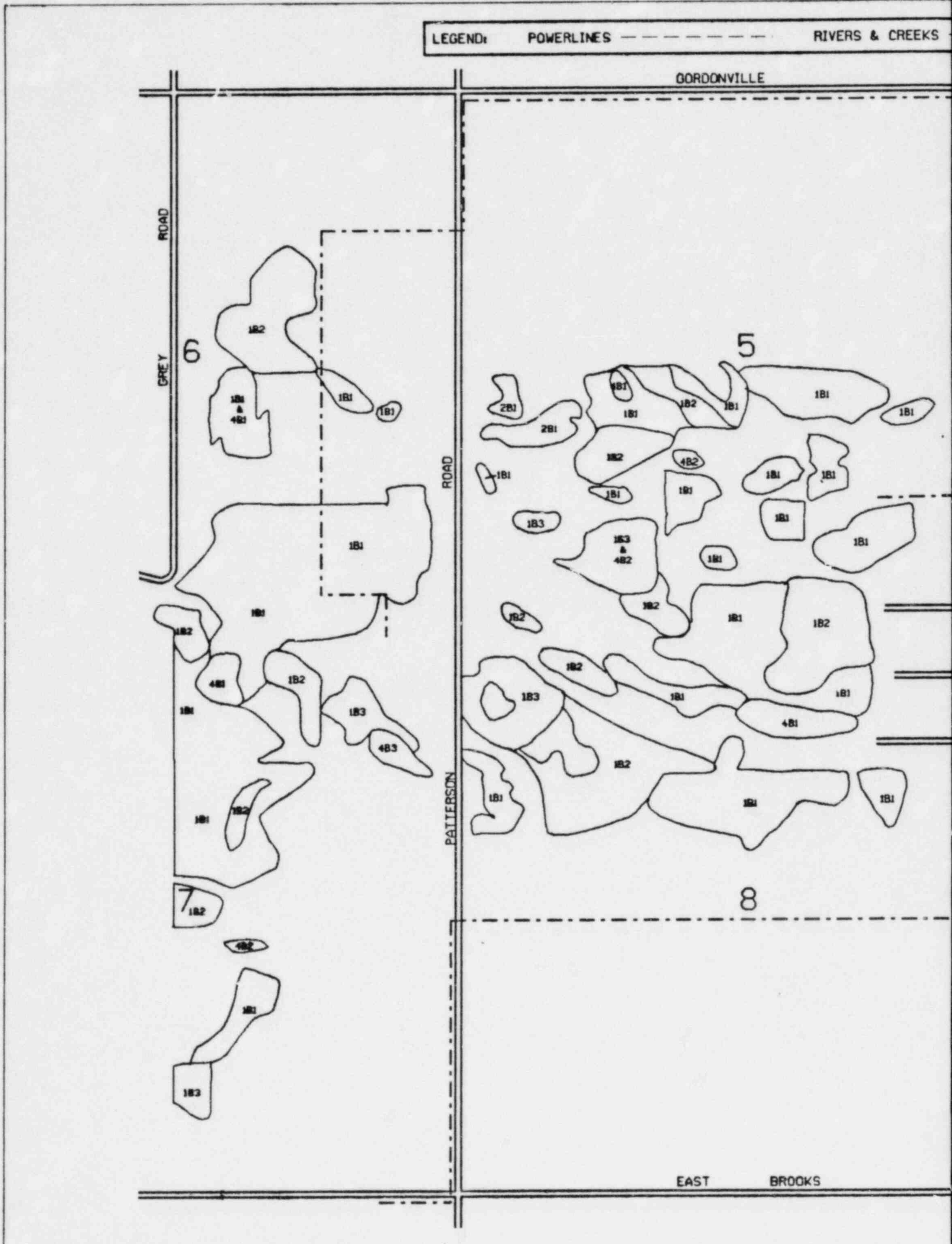




MIDLAND VEGETATION MONITORING PROGRAM

LOCATION OF EXISTING "TYPE B" DAMAGE SYNDROMES

NORTHEAST QUADRANT Figure 11 QS0:[40,100]MIDMAPNEQ.001


LEGEND: POWERLINES
RIVERS & CREEKS
GORDONVILLE
GREY ROAD
PATTERSON ROAD
EAST BROOKS
5
6
7
8
1B2
1B1 & 4B1
1B1
1B1
1B1
1B1
1B2
4B1
1B2
1B1
1B3
4B3
1B1
1B2
1B2
4B2
1B1
1B3
2B1
2B1
4B1
1B1
1B2
1B1
1B1
1B1
1B2
4B2
1B1
1B1
1B1
1B1
1B3
1B3 & 4B2
1B1
1B1
1B2
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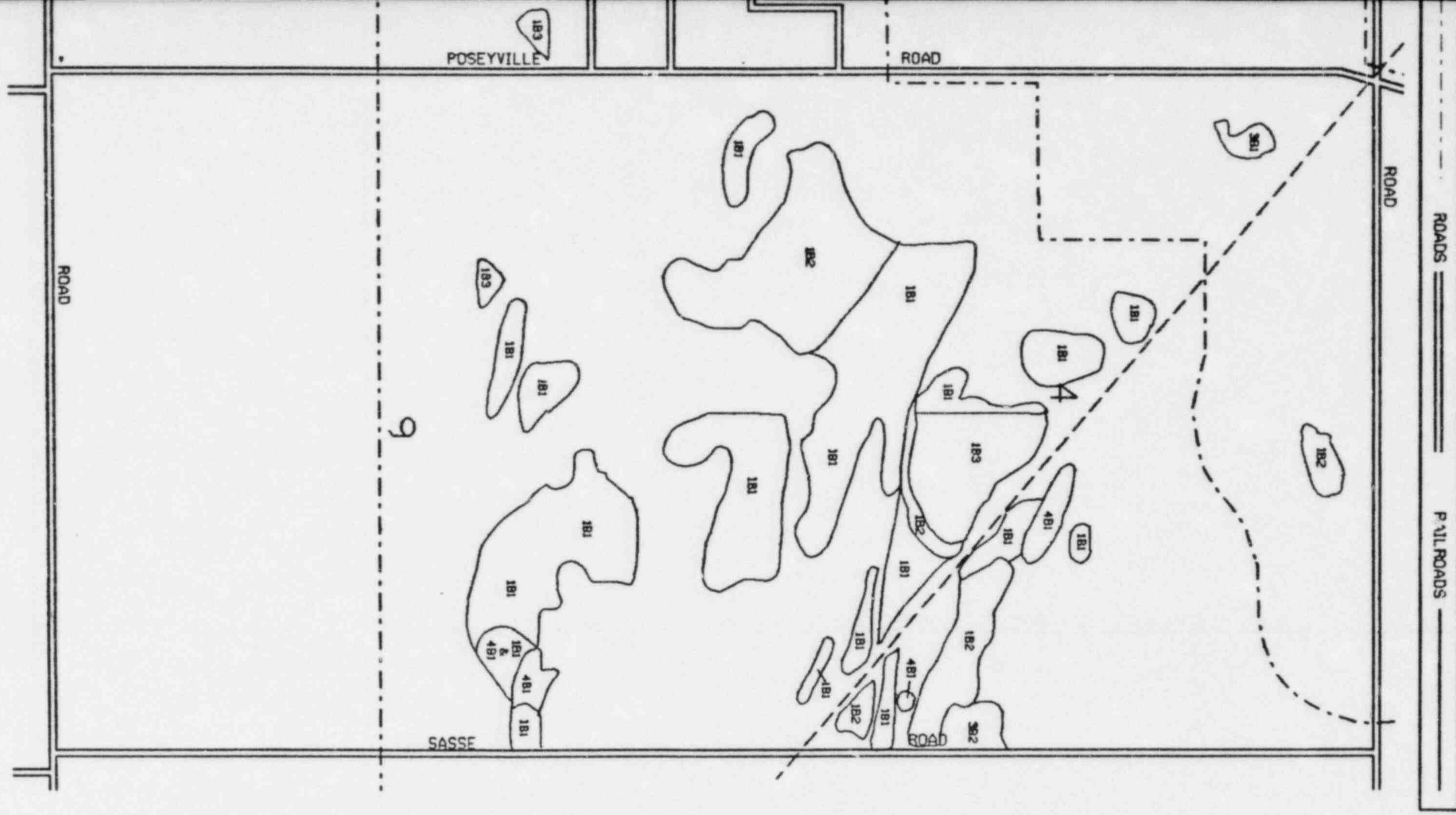
4B1
1B2
1B1
1B1
1B1

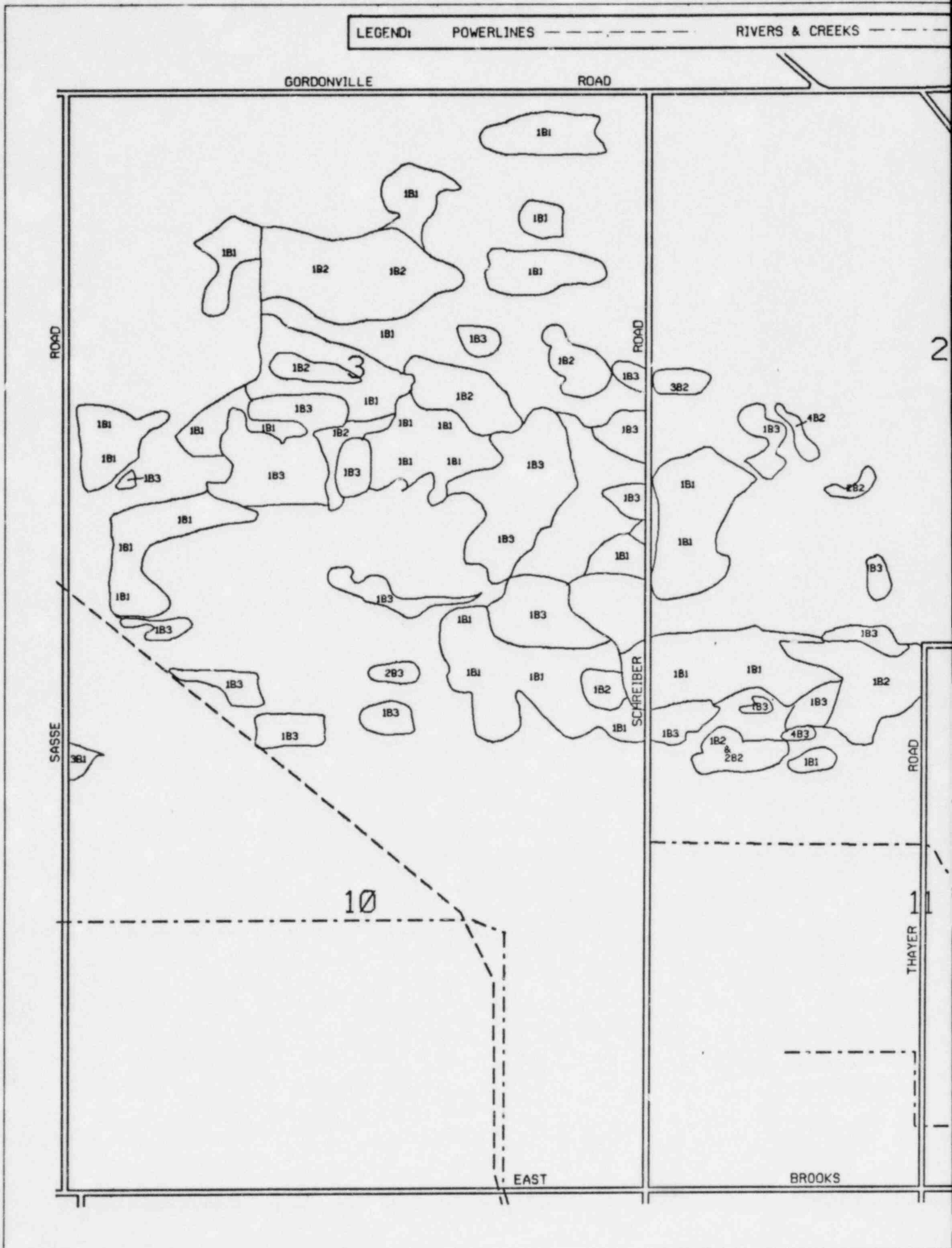


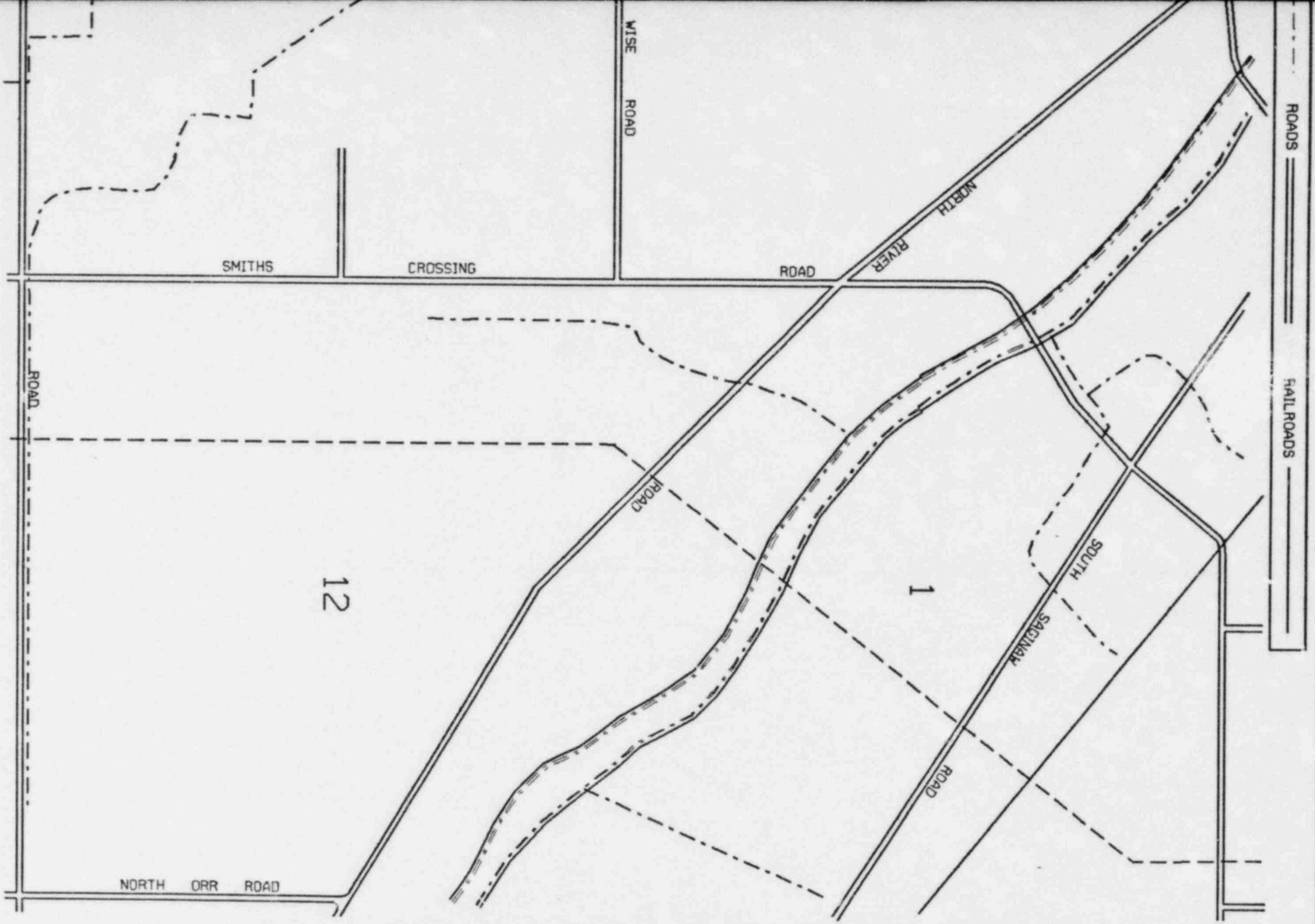
MIDLAND VEGETATION MONITORING PROGRAM

LOCATION OF EXISTING "TYPE B" DAMAGE SYNDROMES

SOUTHWEST QUADRANT QSØ:[4Ø,1ØØ]MIDMAPSWQ.ØØ1

Figure 12


LEGEND: POWERLINES
RIVERS & CREEKS
GORDONVILLE ROAD
SASSE ROAD
SCHREIBER ROAD
THAYER ROAD
EAST BROOKS
2
3
10
11
1B1
1B2
1B3
2B2
2B3
3B1
3B2
4B2
4B3
1B2 & 2B2



MIDLAND VEGETATION MONITORING PROGRAM

LOCATI... OF EXISTING 'TYPE B' DAMAGE SYNDROMES
SOUTHEAST QUADRANT QSØ:[40,100]MIDMAPSEQ.ØØ1

Figure 13