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# Ecological Effects of Pipeline Construction through Deciduous Forested Wetlands, Midland County, Michigan

## Interim Report
## (August 1988-August 1990)

GRI-91/0045

Gas Research Institute
Environment & Safety Research Department

July 1991

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# ECOLOGICAL EFFECTS OF PIPELINE CONSTRUCTION THROUGH DECIDUOUS FORESTED WETLANDS, MIDLAND COUNTY, MICHIGAN

INTERIM REPORT

(August 1988-August 1990)

Prepared by

S.D. Zellmer, J.R. Rastorfer,* and G.D. Van Dyke*

Reclamation Engineering and Geosciences Section
Energy Systems Division
Argonne National Laboratory (ANL)
9700 South Cass Avenue
Argonne, Illinois 60439

For

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Contract No. 5088-252-1770

GRI Project Manager
H. Ronald Isaacson
Environment & Safety Research Department

July 1991

*Rastorfer is associated with the Department of Biological Sciences, Chicago State University (CSU), Chicago, and the ANL/CSU Cooperative Herbarium, and Van Dyke is associated with the Department of Biology, Trinity Christian College, Palos Heights, Illinois.

## Research Summary

| | |
|---|---|
| Title | Ecological Effects of Pipeline Construction through Deciduous Forested Wetlands, Midland County, Michigan |
| Contractor | Argonne National Laboratory<br>GRI Contract Number 5082-254-0690 |
| Principal Investigators | J.R. Rastorfer and G.D. Van Dyke |
| Report Period | August 1988-August 1990 |
| Objective | To document temporal and spacial aspects of both positive and negative impacts on vegetation resulting from the establishment of a pipeline right-of-way (ROW) through deciduous forested wetlands in east central Michigan. |
| Technical Perspective | New federal regulations, which are being considered but not yet implemented and are designed to protect wetlands, make information on both positive and negative impacts of gas pipeline ROWs on wetlands essential for the gas pipeline industry. This study is designed to document the temporal and spacial extent of positive and negative effects on vegetation resulting from the establishment and maintenance of a pipeline ROW through deciduous forested wetlands in east central Michigan. Such information will facilitate the permitting process and may suggest modifications in installation and maintenance practices to mitigate negative impacts. |
| Results | All results at this time are preliminary, because a study such as this must be long term to properly measure effects that may take years or decades to develop. Observations made during data collections indicate that damage was done to the forest edge beyond the ROW at one of the two study sites during construction, when logs from the clearing operation were pushed into the forest edge rather than being removed from the site. Plant species established from the seed mixture that was applied to the ROW after construction reduced the wetland characteristic of the vegetation developing on the ROW during the first year following pipeline construction. Tree stumps that had not interfered with construction operations and had remained in place on the ROW allowed small adjacent reservoirs of native understory species to survive. The minimal amount of time between ditching and backfilling allowed vegetative propagules of native species to survive on the ROW and in the pipe-ditch |

soil. Hand seeding of the ROW in wetland areas without complete tillage also contributed to survival of native species.

**Technical Approach**

Two sites were selected for this study on the basis of the presence of wetland soils, vegetation, and other characteristics. One site is in a relatively mature, second-growth forest; the other is in a second-growth forest with the same soil type, but it shows evidence of selective logging in the recent past. Belt transects, parallel to the ROW, were established on the ROW and in the forested wetland at preselected distances from the edge of the ROW. Understory and ROW vegetation were and continue to be measured using coverage estimates for each species within forty 1 x 1-m quadrats within each of seven 1 x 100-m belt transects at each site (for a total of 280 quadrats). Counts of individuals by species are being made for all woody plants with stems <2 cm in diameter at breast height (dbh). Stem diameters and species counts are being recorded for all woody plants with stems ≥2 cm dbh in 10 x 10-m plots constituting three 10 x 100-m belt transects in the forested portion of each site. Two years of data have been collected at each site, and a third and a fourth year of data will be collected during the 1991 and 1992 growing seasons. Then analyses of the data will be performed, and a final first-phase report will be prepared during the two subsequent years.

**Project Implications**

Information of the type provided by this study will be increasingly required during the permitting process for future pipeline construction through forested wetlands. Information that suggests ways (1) to minimize both the extent and duration of negative impacts on adjacent wetland communities, (2) to facilitate reestablishment of wetland vegetation on the ROW, and (3) to enhance beneficial aspects with respect to the habitats of wildlife and endangered species, can facilitate the permitting process. These data will also be of value in selecting maintenance practices that enhance the wetland value of the ROW.

GRI Project Manager
H. Ronald Isaacson
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Reclamation Engineering and Geosciences Section
Energy Systems Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439-4815

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Implementation of recent federal and state regulations promulgated to protect wetlands makes information on effects of gas pipeline rights-of-way (ROWs) in wetlands essential to the gas pipeline industry. This study is designed to record vegetational changes induced by the construction of a large-diameter gas pipeline through deciduous forested wetlands. Two second-growth forested wetland sites mapped as Lenawee soils, one mature and one subjected to recent selective logging, were selected in Midland County, Michigan. Changes in the adjacent forest and successional development on the ROW are being documented. Cover-class estimates are being made for understory and ROW plant species using 1 x 1-m quadrats. Counts are also being made for all woody species with stems < 2 cm in diameter at breast height (dbh) in the same plots used for cover-class estimates. Individual stem diameters and species counts are being recorded for all woody understory and overstory plants with stems ≥ 2 cm dbh in 10 x 10-m plots. Although analyses of the data have not been completed, preliminary analyses indicate that some destruction of vegetation at the ROW forest edge may have been avoidable during pipeline construction. Rapid regrowth of many native wetland plant species on the ROW occurred because remnants of native vegetation and soil-bearing propagules of existing species survived on the ROW after pipeline construction and seeding operations.

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| Rights-of-Way | Succession |
| Vascular Plants | Bryophytes |
| Species Inventory | Cover Class |

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# Preface

The research described in this report was performed by the Reclamation Engineering and Geosciences Section of Argonne National Laboratory's Energy Systems Division as part of the Right-of-Way Research Program sponsored by the Gas Research Institute. This multiyear, multidisciplinary research effort began in 1983 in response to an assessment study of the environmental concerns of 20 natural gas transmission companies. Study results indicated a lack of quantitative research data demonstrating the effectiveness of right-of-way rehabilitation following pipeline construction. The study also established that little research had been conducted to evaluate the recovery of both natural and managed ecosystems or to determine cost-effective right-of-way management practices to ensure effective habitat rehabilitation on rights-of-way.

The major goal of the Right-of-Way Research Program is to reduce the environmental and economic costs associated with the installation and maintenance of natural gas pipelines. The program has an established committee of industry representatives who assist in formulating program objectives to achieve three goals:

- Quantitative documentation of industry pipeline-construction methods and right-of-way reclamation practices,
- Development of a data base to evaluate the environmental effects of pipeline construction and right-of-way reclamation methods, and
- Development and testing of technologies that minimize costs and mitigate negative environmental effects of pipeline construction.

Several Right-of-Way Research Program studies are being conducted to determine the impacts of current or past pipeline construction methods on wetlands. This study is designed to determine the ecological effects of pipeline construction through deciduous forested wetlands in the east-central part of the lower peninsula of Michigan. This interim report describes the two study sites, the data collection methods, and the initial observations of and suggestions for pipeline construction through forested wetlands. Preliminary data analyses indicate both sites met the established criteria for deciduous forested wetlands. Information from this study will provide the natural gas pipeline industry with quantitative data on the ecological effects of a typical pipeline construction project through forested wetlands in the upper Midwest. These data can be used to predict the effects of pipeline construction through forested wetlands in areas with similar vegetative communities, soils, and climatic conditions. Observations from this study can also be used to mitigate negative ecological impacts of pipeline construction through comparable forested wetlands.

Donald O. Johnson, Manager
Right-of-Way Research Program

## Acknowledgments

This study, *Ecological Effects of Pipeline Construction through Deciduous Forested Wetlands, Midland County, Michigan*, was made possible only because of the cooperation and contributions of a number of individuals and organizations. Mr. B.J. Haskins and the State of Michigan, Department of Natural Resources, granted permission for the study to be conducted on their properties and have allowed vegetation and soil samples to be collected at the sites. Mr. C.L. Conley, Area Forest Manager of the Gladwin Field Office, provided background information on the Michigan State site (Site 2). We extend special thanks and recognition to these individuals and the State of Michigan, Department of Natural Resources.

Dr. J.J. Rochow, Staff Environmental Scientist with Consumers Power Company, was instrumental in initiating the study and locating the study sites and has acted as liaison between Midland Cogeneration Venture Limited Partnership (the pipeline owner) and Argonne National Laboratory (ANL). We are indebted to Dr. Rochow, his staff and associates, and both companies for their assistance.

The Gas Research Institute is gratefully acknowledged for providing funding for this research effort. Dr. H.R. Isaacson, project manager, has furnished guidance and support, and we especially appreciate his interest and assistance.

Several students have provided assistance during the study. James E. Frelichowski (1989 and 1990) and Matthew Solcum (1989) were summer research participants at ANL. Dwight E. Huslin (January-June 1989) and Jay A. Clemente (September 1990-present) have assisted in the ANL-Chicago State University (CSU) Cooperative Herbarium. Kee Beom Lee (graduate -- October 1989-May 1990) and Erika Green (undergraduate -- September 1990-present) have been CSU Department of Biological Sciences student assistants. We appreciate the efforts of all these students.

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# Ecological Effects of Pipeline Construction through Deciduous Forested Wetlands, Midland County, Michigan

## Interim Report (August 1988-August 1990)

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## Abstract

Implementation of recent federal and state regulations promulgated to protect wetlands makes information on effects of gas pipeline rights-of-way (ROWs) in wetlands essential to the gas pipeline industry. This study is designed to record vegetational changes induced by the construction of a large-diameter gas pipeline through deciduous forested wetlands. Two second-growth forested wetland sites mapped as Lenawee soils, one mature and one subjected to recent selective logging, were selected in Midland County, Michigan. Changes in the adjacent forest and successional development on the ROW are being documented. Cover-class estimates are being made for understory and ROW plant species using 1 x 1-m quadrats. Counts are also being made for all woody species with stems <2 cm in diameter at breast height (dbh) in the same plots used for cover-class estimates. Individual stem diameters and species counts are being recorded for all woody understory and overstory plants with stems $\geq$2 cm dbh in 10 x 10-m plots. Although analyses of the data have not been completed, preliminary analyses indicate that some destruction of forest vegetation at the forest edge may have been avoidable during pipeline construction. Rapid regrowth of many native wetland plant species on the ROW occurred because remnants of native vegetation and soil-bearing propagules of existing species survived on the ROW after pipeline construction and seeding operations.

## 1 Introduction

The installation of a large-diameter pipeline through a forest -- a process that involves the clear cutting of the right-of-way (ROW), trenching, backfilling, grading, and seeding operations -- removes or destroys essentially all of the aboveground plant biomass. Trenching and backfilling alter the chemical and physical properties of the soil in the pipe ditch (Zellmer and Taylor 1988). Subsequently, secondary vegetational development (succession) occurs on the ROW, until stabilized yet dynamic treeless plant communities (an anthropogenic disclimax or arrested succession) develop as a consequence of ROW maintenance practices (Niering and

Goodwin 1974). Furthermore, the clearing of the forest from the ROW alters the light, wind, temperature, and microclimatic factors within the new forest edge from those in the forest interior (Ranney et al. 1981). The development of vegetation on the ROW results in the formation of zones of integration called ecotones (Daubenmire 1968; Spurr and Barnes 1973), where the plant communities of the ROW confront the plant communities of the adjacent forest. Little information is available on the temporal and spatial aspects of these ecotones.

Quantitative data on the temporal and spatial aspects of the edge effects within the forest, the temporal development of the anthropogenic disclimax on the ROW, and the temporal and spatial aspects of the development of ecotones within the forest edge are important to the gas-pipeline industry. Such information is essential to provide answers to questions raised by federal, state, and local regulatory agencies responsible for the construction permitting process. Data related to forested wetlands (for a definition, see Cowardin et al. 1979) are increasingly important, as impending federal and existing state regulations concerning wetland protection (Federal Interagency Committee for Wetland Delineation 1989; Michigan Department of Natural Resources 1988a, 1988b) are enforced. The absence of such data slows down the permitting process and adversely affects construction schedules for new gas transmission pipelines.

This study is intended to provide the gas pipeline industry with information on both the negative and beneficial aspects of vegetational changes on and adjacent to pipeline ROWs through northern broad-leaved deciduous forested wetlands. It is designed to provide answers to questions such as these:

- What type of plant communities develop on the ROW?
- If wetland communities should develop on the ROW after construction, how soon will they meet wetland vegetational criteria?
- What vegetational changes, if any, occur within the forest edge adjacent to the ROW?
- What plant species, if any, are likely to be lost from the forest edge?
- What new plant species, if any, invade the forest edge?
- How far do vegetational changes within the forest edge extend into the forest?
- Will the wetland status of the forest edge be affected with respect to vegetation?

Answers to these questions will not only facilitate the permitting process but may suggest possible modifications in pipeline installation and maintenance practices to minimize the negative impacts and maximize the beneficial aspects of ROWs through northern broad-leaved deciduous forested wetlands.

# 2 Background

This review of vegetational and related ROW studies is primarily concerned with ROWs for underground natural gas transmission pipelines (GPLs). However, essentially no vegetational studies on GPL ROWs have been done from a long-term ecological point of view. In contrast, ROWs for aboveground electrical transmission lines (ETLs) have received considerable attention (Byrnes and Holt 1987; Crabtree 1984; Tillman 1976, 1981). Therefore, any of these studies that are relevant to this investigation are covered in this brief review. Although noteworthy vegetational studies have been done for highway and railroad ROWs (Byrnes and Holt 1987; Crabtree 1984; Tillman 1976, 1981), they are not considered here because roadways are sufficiently different, with respect to design and postconstruction usage, to warrant separate consideration.

Four aspects of GPL ROW installations as they affect vegetation are discussed:

1. The initial clearing of the vegetation,

2. The effects on soil properties,

3. The postconstruction establishment and development of vegetation, and

4. The composition of stable plant communities maintained by cyclic maintenance practices.

Generally, a strip of vegetation approximately 25 m (75 ft) wide must be cleared to install a large-diameter (≥38 cm or 15 in.) GPL. Clearing essentially devastates the existing aboveground plant biomass by removing or mechanically damaging it. Moreover, most of the aboveground plant vestiges that might have remained after the clearing operations disappear during trenching, pipeline installation, backfilling, and any associated grading activities. In effect, the end result of the GPL installation operations is a strip of highly disturbed land that is often laid bare (Arner 1966; Egler 1954; Zellmer and Taylor 1988). Furthermore, the soil is affected by the GPL construction operations. In some situations, vehicular equipment compacts soils on the working side of the ROW (Steinhardt et al. 1987). Trenching (especially the single-ditching method), backfilling, and grading operations mix the soil horizons and result in pipe-ditch soils (the column of soil over the buried pipeline) without soil profiles. The upper layers of soil on either side of the pipe ditch may be also be disturbed by trenching, backfilling, and associated grading operations. Hence the chemical and physical properties of the soils are altered, and soil erosion rates in hilly areas can be accelerated as a result of pipeline construction activities (Arner 1966; de Jong and Button 1973; Taylor et al. 1987; Zellmer and Taylor 1988; Zellmer et al. 1987). The consequence of GPL installation activities, which decimate aboveground vegetation and alter soil characteristics, is the production of highly disturbed and/or barren ROWs. Under most climatic conditions, vascular and nonvascular plants become established on new GPL ROWs, except in cases where edaphic factors have changed beyond plant tolerances or soil erosion rates are too high for plants to survive.

The taxonomic composition and structural features of plant communities that develop on highly disturbed or bare GPL ROWs are usually determined by the native vegetation that is reestablished and by the seed mixtures that are applied during the closing GPL construction activities. Native plants result from the preexisting and surrounding vegetation and the soil propagule bank; the presence of regenerative roots, rhizomes, stems, and stumps; and the immigration of seeds, spores, and gemmae (Brown 1987; Harper 1977; Hutnik et al. 1987). Although operational seeding of introduced species has been a common practice on GPL ROWs, recent reports indicate that under most environmental situations, either natural revegetation or the use of native plant species is considered the most ecologically sound approach to establishing vegetation on highly disturbed and bare GPL ROWs (Downey 1976; Farnworth 1981; Johnson 1984; Long and Ellis 1984; Odegard et al. 1984).

The development of vegetation to stabilized yet dynamic anthropogenic disclimax communities on GPL ROWs depends on preexisting and surrounding floristic elements, GPL installation activities, and maintenance practices. For GPL ROWs, stable nonwoody plant communities are usually desired, because they allow the ROW to be inspected more easily and allow the heavy, mechanized equipment needed to repair buried pipelines to move more freely. Nonwoody vegetation is also desirable because these herbaceous plants become readily discolored from pipeline leaks and can be detected by aerial inspections (Arner 1960; Egler 1954).

In treeless ecosystems such as marshes, natural revegetation occurs rapidly after carefully planned GPL installation operations. Hence, GPL ROWs in such ecosystems generally require no maintenance to eliminate woody taxa (Farnworth 1981; Krone et al. 1987; Odegard et al. 1984). Forest ecosystems, on the other hand, do require maintenance to exclude woody plants. Unfortunately, the number of ecological studies on the methods used to achieve stable, herbaceous-dominant communities on GPL ROWs within forested (and shrub) habitats (compared with those on ETL ROWs) is few (Byrnes and Holt 1987; Crabtree 1984; Nickerson and Thibodeau 1986; Niering et al. 1986; Niering and Goodwin 1974; Thibodeau and Nickerson 1986; Tillman 1976, 1981). Mowing and herbicide applications are commonly used to maintain herbaceous communities on GPL ROWs. However, studies on ETL ROWs and, to a lesser extent, GPL ROWs indicate that burning, when applicable, is an economically and ecologically effective method of eliminating woody plants from ROWs (Arner 1960, 1981; Arner et al. 1976, 1987; Huntley and Arner 1984; Olson et al. 1984).

With respect to this study, adequate information is not available to enable the prediction of the successional stages of vegetational development on the ROW segments to stable, nonwoody communities (anthropogenic disclimax herbaceous communities). Therefore, vegetational development must be monitored on the ROW and the forest edge until a stable anthropogenic disclimax, as determined by the maintenance method and cycle, is reached. After the 1992 field season, monitoring at four- or five-year intervals over the next 10, 20, or more years will probably be required for the plant communities on the ROW segments to become stable enough so that results can be obtained on the interactions of ROW plant communities and adjacent forest communities (Magnuson 1990).

# 3 Goals and Objectives

The overall intent of several studies in the Right-of-Way Research Program is to determine the impacts of current or past pipeline construction methods on wetlands. This study has three major goals, and several objectives have been designed to meet each of these goals. The goals and objectives are as follows:

1. Document any vegetational changes that occur in the forested wetlands adjacent to the ROW at the study sites.

    a. Characterize and monitor the vegetation in the forested wetlands away from the ROW as a reference control and to document changes not induced by the ROW.

    b. Document new species invading the edge of the forested wetlands that might have resulted from the presence of the ROW and maintenance practices.

    c. Document the loss of species from the edge of the forested wetlands that might have resulted from the presence of the ROW and maintenance practices.

    d. Document changes in species abundance at the edge of the forested wetlands that might have resulted from the presence of the ROW and maintenance practices.

2. Document vegetational succession on the ROW, from the time the pipeline is installed until stable, managed (anthropogenic disclimax) plant communities develop.

    a. Document the initial, or pioneer, stages of vegetational succession on the ROW to aid in determining wetland characteristics and effects of and necessity for seeding operations.

    b. Document later successional stages and the more or less stable anthropogenic disclimax community that has formed under the maintenance regime, to determine its effects on wetland characteristics.

3. Provide insights and suggestions on lessening the ecological impacts of future pipeline installation operations on forested wetlands.

    a. Suggest modifications in construction practices that will ensure that the ROWs through forested wetlands remain wetlands.

b. Suggest installation and maintenance practices that will maximize the beneficial aspects of the diversified habitat.

c. Suggest installation and maintenance practices that will minimize negative impacts in terms of both temporal and spatial changes.

d. Consider site installation and maintenance practices in terms of their effects on successional trends and wetland benefits.

# 4 Approach

Locations of construction projects for new, underground, large-diameter, gas transmission lines in the north-central region of the United States were reviewed, and inquiries were made with respect to the possible participation of one or more pipeline companies. After a suitable construction project was located, the proposed route of the ROW was inspected, and potential ecologic study sites within the forested wetlands were identified. The criteria used to select study sites were (1) vegetational homogenity, (2) level topography, (3) a single soil series, and (4) a water table near the soil surface. Two sites were selected, and necessary legal agreements among Argonne National Laboratory, the pipeline owner (Midland Cogeneration Venture Limited Partnership), and each site owner (Billy J. Haskins and Michigan's Department of Natural Resources, State Forest Land) were secured.

This investigation is designed to analyze the compositional and structural changes that occur in forested communities adjacent to the ROW as a result of the installation of the gas pipeline and the maintenance of the ROW. Also of interest are the compositional and structural changes that occur during the serial development of plant communities on the ROW itself. To analyze these features of plant communities, data are being taken of the understory taxa in 1 x 1-m (3.28 x 3.28-ft) plots along permanent transects and the overstory taxa in permanent 10 x 10-m (32.8 x 32.8-ft) plots. The understory transects are located both on the ROW and in the forest at selected intervals from the ROW, from adjacent to the ROW to a distance considered beyond its influence. In contrast, the overstory plots are located only in the forest at selected intervals from the ROW, from adjacent to the ROW to a distance considered beyond its influence. Data collection began immediately after installation of the pipeline and will continue seasonally (summers) through the fourth growing season. After the fourth growing season, sampling will be repeated every four to five years, until two or more samplings substantiate stable anthropogenic disclimax plant communities on the ROW.

In addition to vegetational sampling, a taxonomic inventory is being taken, with voucher specimens of the plant species that occur on the sites and immediate surrounding areas. This taxonomic inventory is necessary not only to facilitate identification of species during data collection but also to evaluate the sites with respect to the invasion of new species, the loss of pre-ROW species, and the assessment of wetland vegetational components. The analysis of field data will provide ecological information on dominance, diversity, and frequency to aid in determining compositional changes at the species level and compositional and structural changes at the community level.

# 5 Site Selection

As the result of a collaborative effort, personnel at the Gas Research Institute (GRI), Consumers Power Company (CP), and Argonne National Laboratory (ANL) determined that a route proposed for the construction of a large-diameter pipeline (26 in. or 66 cm) by the Midland Cogeneration Venture Limited Partnership in the east-central portion of Michigan's lower peninsula could be a potential location for plant ecologic studies. The construction of the GPL, under the direction of CP, in 1989 began east of Shepherd in Isabella County and ended near Midland in Midland County. Because the route of the GPL crossed both farm and poorly drained forested lands, the resulting ROW and adjacent areas would provide suitable sites in deciduous forested wetlands for the proposed wetland study.

With respect to the ROW and adjacent forest plant community studies, two investigators from ANL met with two representatives from CP (the supervisor of its Environmental Department and its ROW agent) on August 3 and 4, 1988, to tour portions of the proposed ROW and identify potential study sites. Three sites at different locations in Midland County were evaluated.

The group decided that the forest stand that was inspected first would be most suitable for studying how lowland forest ecology is affected by the construction of a gas pipeline. The study site is in the southern half of the southeast quarter of Section 25, T. 14N, R. 2W, in Greendale Township, Midland County, Michigan (Fig. 1). It is next to and north of an unimproved section of Gordonville Road (1.61 km or 1 mile from Castor Road on the east to an unimproved section of Magrudder Road on the west). This site had the best qualifications because (1) it was an advanced second-growth stand of hardwood deciduous forest trees with an apparent high degree of homogeneity in the understory layers, (2) it contained some hydric plant taxa, (3) it had nearly level topography, (4) it had seemingly little edaphic variation, and (5) there was no evidence of recent logging or any other major disturbance. In addition, the land was considered to be in a trust, and a review of the relationship between the trustee and CP indicated that there would be no problem in securing permission to conduct ecologic studies on this property.

After the August trip, ANL arranged for legal agreements with the landowner, Mr. Billy J. Haskins. At that time, ANL learned that because of an exchange of property between Mr. Haskins and the Michigan Department of Natural Resources, the parcel of forested land contracted for the study was not located at the site selected during the August 1988 field trip. During a field trip on October 13-17, 1988, the actual contracted parcel owned by Mr. Haskins was located. A stand of deciduous forest in an area mapped as Lenawee silty clay loam soil (Hutchison 1979) was identified on Mr. Haskin's property and designated as Site 1. It is about 1450 meters (4690 ft) west of the junction of Gordonville and Castor Roads and north of the unimproved Gordonville Road. Also during this field trip, preliminary vegetational studies were made, and similarities and differences between this site and the other site selected during the August field trip were noted (Figs. 2 and 3). Although the soil, topography, and relative position of the two sites with respect to unimproved Gordonville Road are essentially the same, the vegetation of Site 1 differs structurally from that at Site 2. Site 1 has a younger population of trees and a thicker shrubby

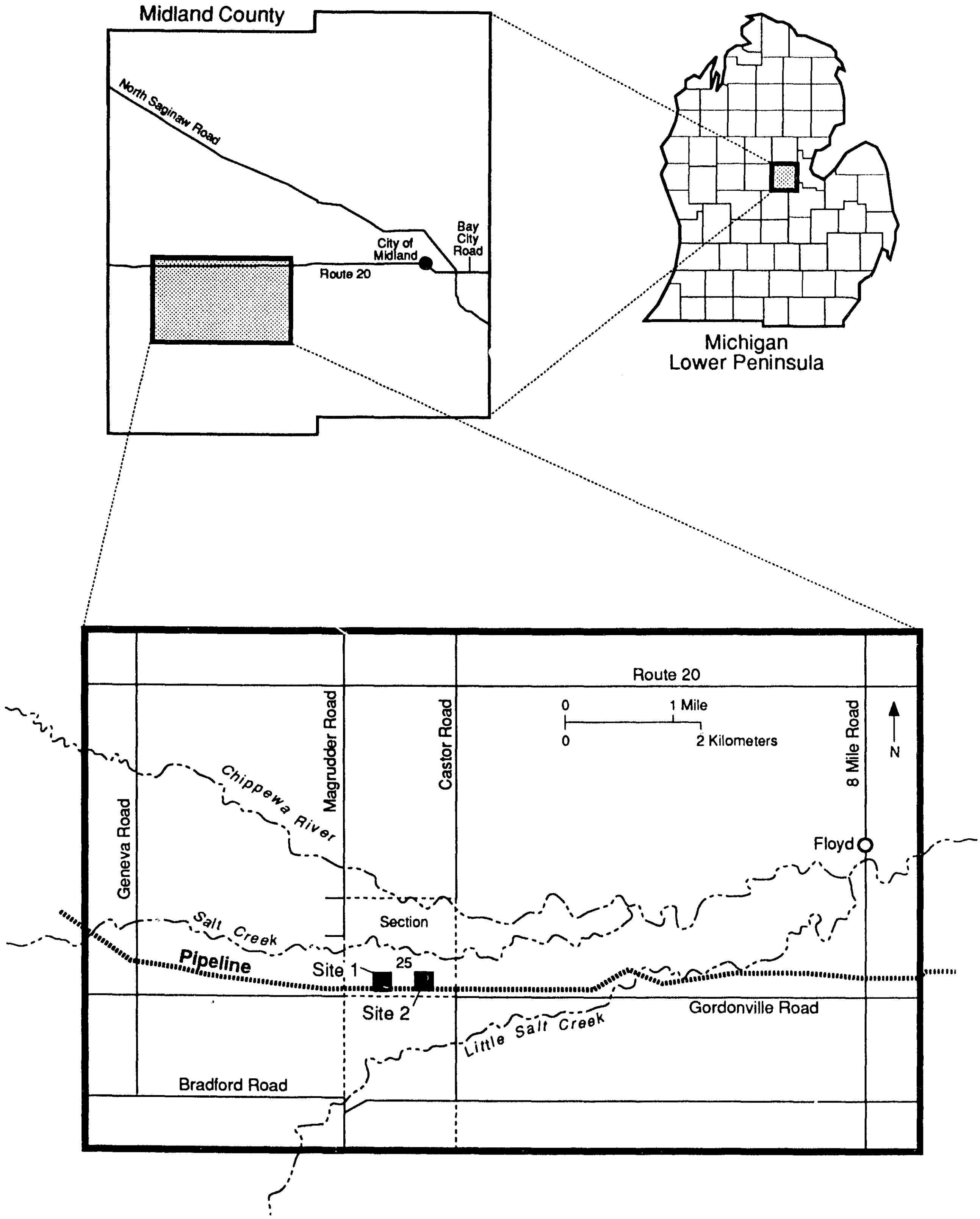


FIGURE 1 Locations of Sites 1 and 2 in Section 25 of Greendale Township, Midland County

FIGURE 2  March 1989 Photograph Showing Typical Forest Characteristics of Site 1

FIGURE 3  March 1989 Photograph Showing Typical Forest Characteristics of Site 2

understory, and the herbaceous layers seem to be more heterogeneous at Site 1. These observations and the presence of relatively new stumps indicate that Site 1 had been recently disturbed by selective logging.

Following the October field trip, the vegetation at Site 1 (Mr. Haskin's property) was reevaluated with respect to the more mature vegetation at the other original site, now known to be on Michigan state forest land. This evaluation generated the idea of using both sites to conduct concurrent studies comparing the effects of GPL construction on a recently selectively logged forested wetland and a more mature forested wetland. Such a comparison may provide information on the responses of two different successional stages of forested wetlands. Following discussions with colleagues and approvals by appropriate institutions, ANL secured legal permission to conduct studies in the stand of Michigan state forest land, which was designated as Site 2.

# 6 Area Description

Midland County is in the Saginaw Lowland, one of the six physical regional subdivisions in the southern peninsula of Michigan recognized by Veatch (1953) (also see Albert, Deaton, and Barnes 1986). Saginaw Lowland is composed mostly of lake beds and has an elevation of less than 200 ft above Lake Huron (Fig. 4). Topographically, Midland County is flat to undulating, with a low relief (Fig. 5). The total area of flat surfaces greatly exceeds the total area of slopes. The slopes generally have a low gradient; if they are steep, the slope is short and ranges from 0-6% (Hutchison 1979). Midland County's flatness is a manifestation of its geological history, which is briefly reviewed in the soils section that follows the section on climate.

## 6.1 Climate

Midland County has a temperate continental climate, which is essentially uniform throughout the county (Brunnschweiler 1964; Eichmeier 1964; Hutchison 1979; Strommen 1974). The average daily temperature in summer is 20.8°C (69.5°F), and the average daily temperature in winter is -3.8°C (25.1°F). In summer, the average daily maximum temperature is 27.1°C (80.8°F), with the highest average monthly temperature in July, at 22.4°C (72.4°F). In winter, the average daily minimum temperature is only -7.8°C (17.9°F), with the lowest average monthly temperature in January and February, at -4.0°C (24.8°F). The hottest temperature recorded was 41.1°C (106°F) on July 24, 1934. The coldest temperature recorded was -34.4°C (-30°F) on February 10, 1912. Temperatures recorded at Midland for the period 1930-1974 indicate that in five of ten years, there will probably be 150 days on which the daily minimum temperature will be higher than 0°C (32°F). Also, in five of ten years, the first freeze date (0°C, 32°F, or lower) is likely to be October 6 or earlier and the last freeze date, May 8 or later (Hutchison 1979).

Precipitation in Midland County is relatively uniform throughout the year, ranging from monthly averages of 40 mm (1.57 in.) during the winter to 80 mm (3.13 in.) during the summer. The county has a total average annual precipitation of 744 mm (29.3 in.), 58% of which falls during the major portion of the growing season, April through September. Annual average precipitation in the form of snow is 970 mm (38.2 in.); however, the maximum depth at any single time during the period of record (1946-1975) was 711 mm (28.0 in.). Standard relative humidity measurements have not been recorded at Midland, Michigan; however, data have been recorded at Lansing, Michigan, located about 80.5 km (50 miles) south of the city of Midland. The highest yearly average relative humidity is 84% at 7:00 a.m., and the lowest yearly average relative humidity is 62% at 1:00 p.m. The highest monthly average is 92% in September at 7:00 a.m.; the lowest monthly average is 48% in June at 1:00 p.m. Data recorded at Lansing show that the prevailing wind is from the southwest, with the highest average daily wind speeds ranging from 19.3-20.1 km (12.0-12.5 miles) per hour for January through April. The lowest average daily wind speeds range from 14.0-15.4 km (8.7-9.6 miles) per hour for June through August.

Although Midland County and the remainder of the state have a continental climate, Michigan differs somewhat climatically from its neighboring midcontinental states because its two

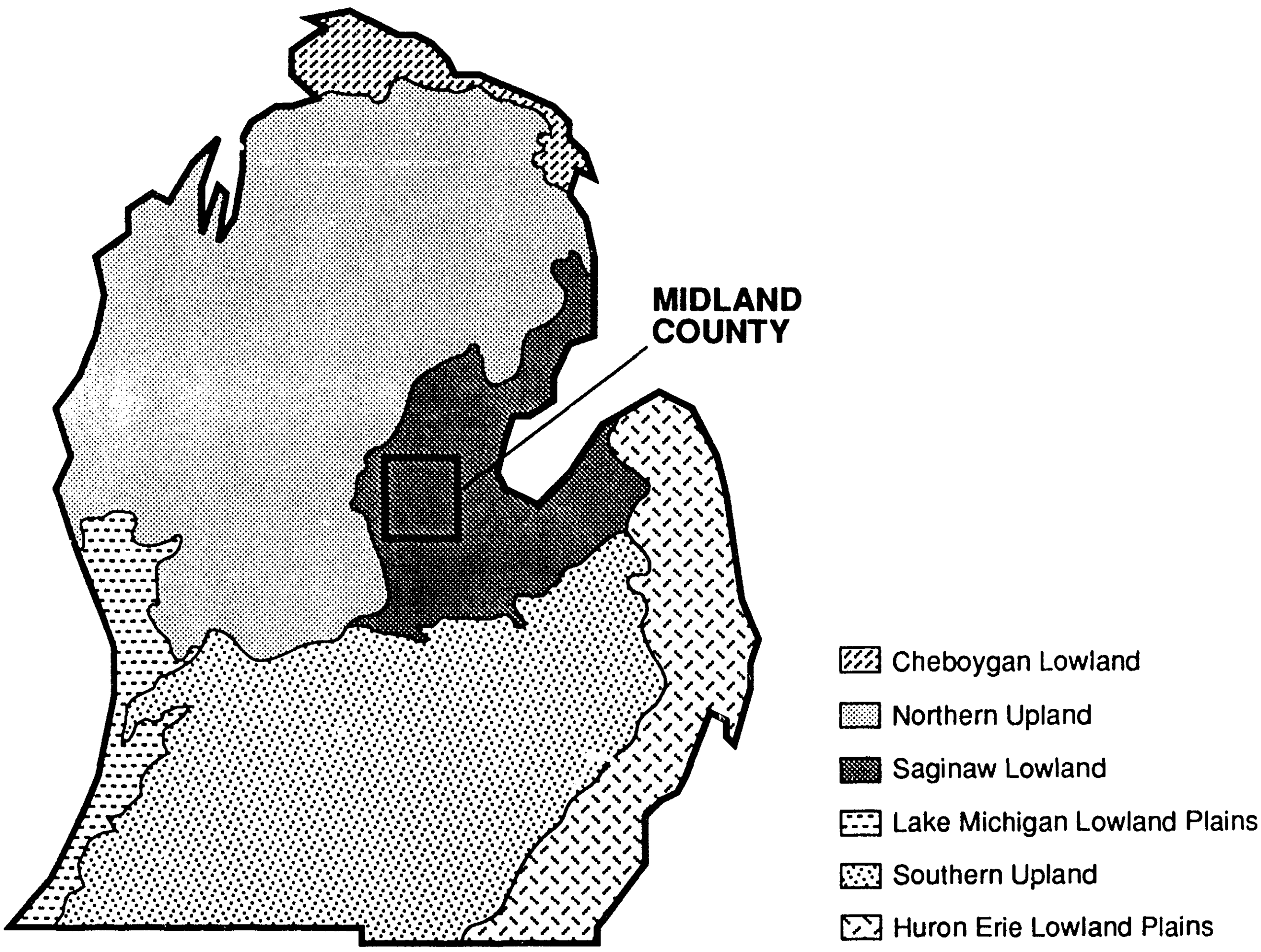


FIGURE 4 Physiogeographic Regional Subdivisions of Michigan's Lower Peninsula (Adapted from Veatch 1953)

peninsular portions are each surrounded on three sides by members of the Great Lakes. Because the lakes have a stabilizing effect on temperature, the winters are milder and the summers are generally cooler in Michigan than they are at the same latitudes in Wisconsin and Minnesota (Eichmeier 1964; Seeley 1964; Strommen 1974). In Michigan's lower peninsula, the latitude, topography, temperature, and precipitation patterns since the last continental glaciation have produced two climatic regions -- a cooler and drier northern region and a relatively warmer and wetter southern region -- with a climatic swing zone across the central portion of the peninsula from the Saginaw Bay area westward. The interaction of climatic factors with parent materials of soil and developing vegetation has likewise manifested itself in two edapho-vegetational regions and a transition zone (Fig. 6). These edaphic and floristic features of Midland County are considered in the next sections.

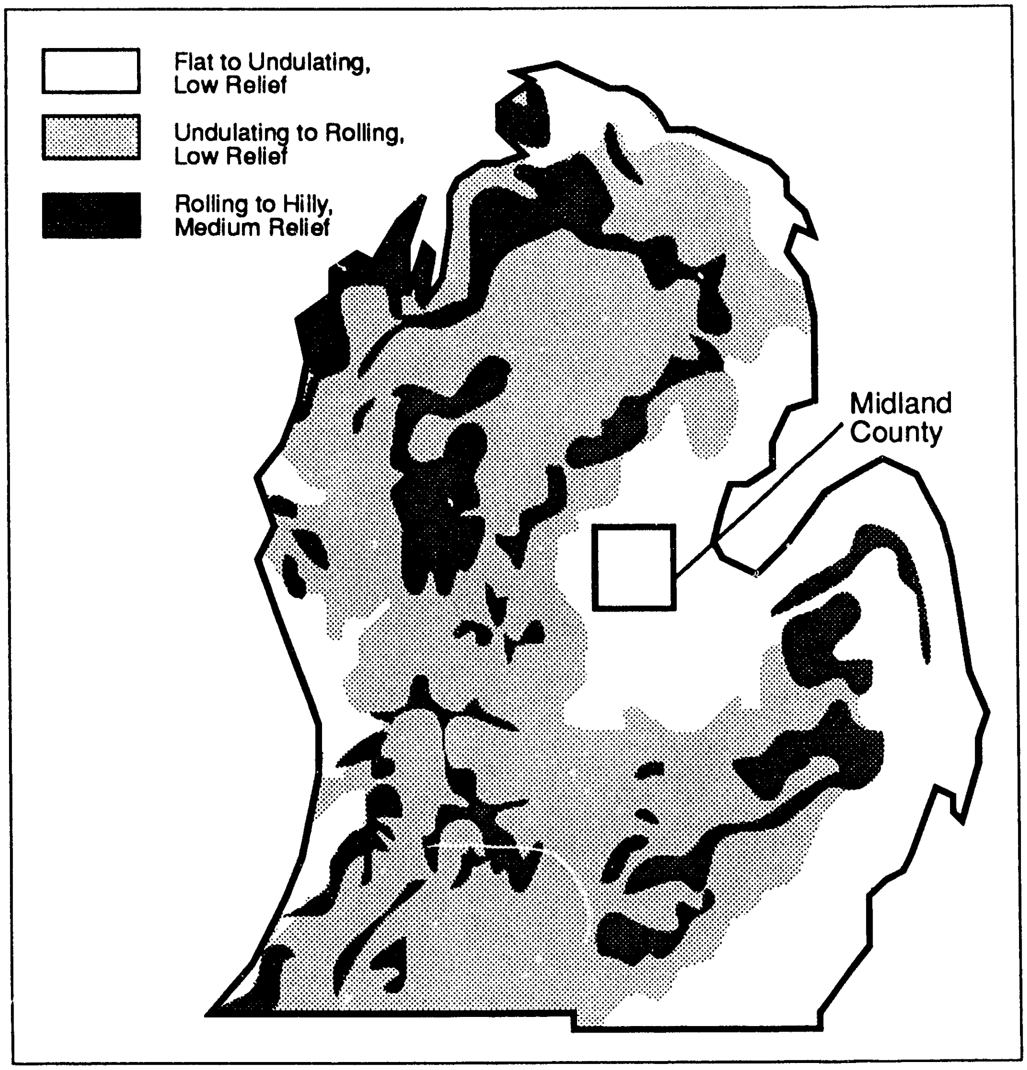


FIGURE 5 Generalized Relief (Topographical) Features of Michigan's Lower Peninsula (Adapted from Veatch 1953)

## 6.2 Soils

Soil genesis in Midland County was initiated on different deposits resulting from glacial activities (Dorr and Eschman 1970; Farrand 1988; Kelly 1964; Martin 1958, 1964). Glacial till overlays Pennsylvanian bedrock. Other parent materials consisting of lacustrine, outwash, alluvium, and dead aquatic plant materials deposited over the glacial till during the maximum and subsequent diminishing stages of glacial Lake Saginaw, 10,000-12,000 years ago (Fig. 7). Following their deposition, some of these materials were reworked and redeposited by the actions of wind and water. Except for some recent alluvial deposits, soils in Midland County are mature and have distinct horizons (Hutchison 1979; Miller 1964; Veatch 1953).

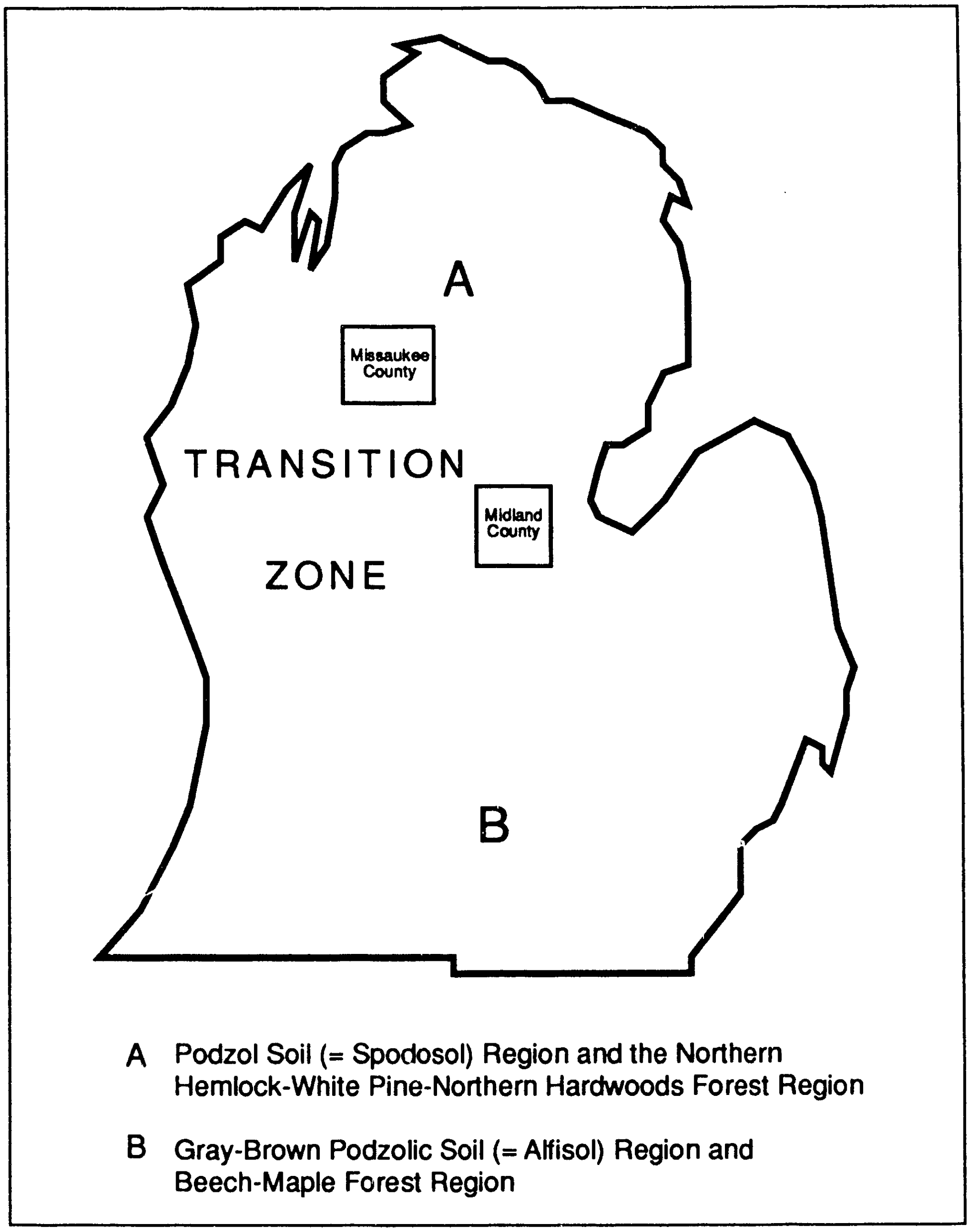


FIGURE 6 Major Forest and Soil Regions of Michigan's Lower Peninsula (Adapted from Braun 1974 and Veatch 1953)

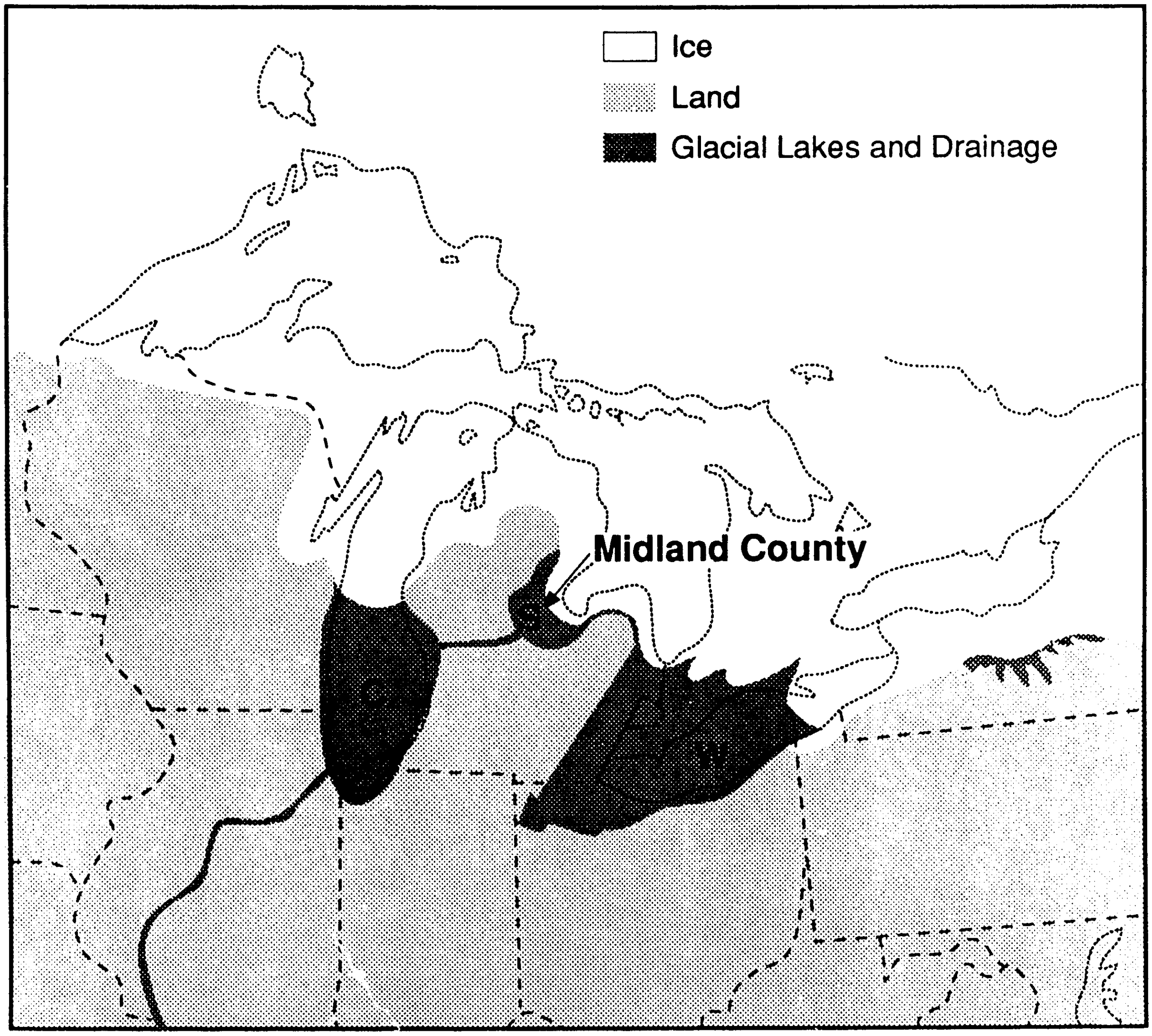


FIGURE 7 Three Midcontinental Glacial Lakes. C = Lake Chicago, S = Lake Saginaw, and W = Lake Whittlsey (Adapted from Dorr and Eschman 1970)

Midland County has seven major soil associations based on parent materials, textural compositions, topographic features, and drainage patterns (Hutchison 1979). In Greendale Township (location of the study sites), the major soil association is designated Kingsville-Pipestone-Covert. The soils of this association are characterized as being nearly level to gently sloping and poorly to moderately well drained. These soils also have a sandy subsoil or upper substratum in outwash or glacial lake deposits. Interwoven among the soil units of this association are soil units of other associations. Both study sites have been mapped as the Lenawee silty clay loam (fine, mixed, nonacid, mesic Mollic Haplaquods) by Hutchison (1979), one of the interweaving soils that is a component of the Lenawee-Bower-Wixom association (Fig. 8). The soils of this association are characterized as being nearly level to gently sloping and very poorly to somewhat poorly drained. They have either a loamy and clayey subsoil or a sandy and loamy subsoil and were formed in glaciolacustrine and till deposits (Hutchison 1979; Martin 1958).

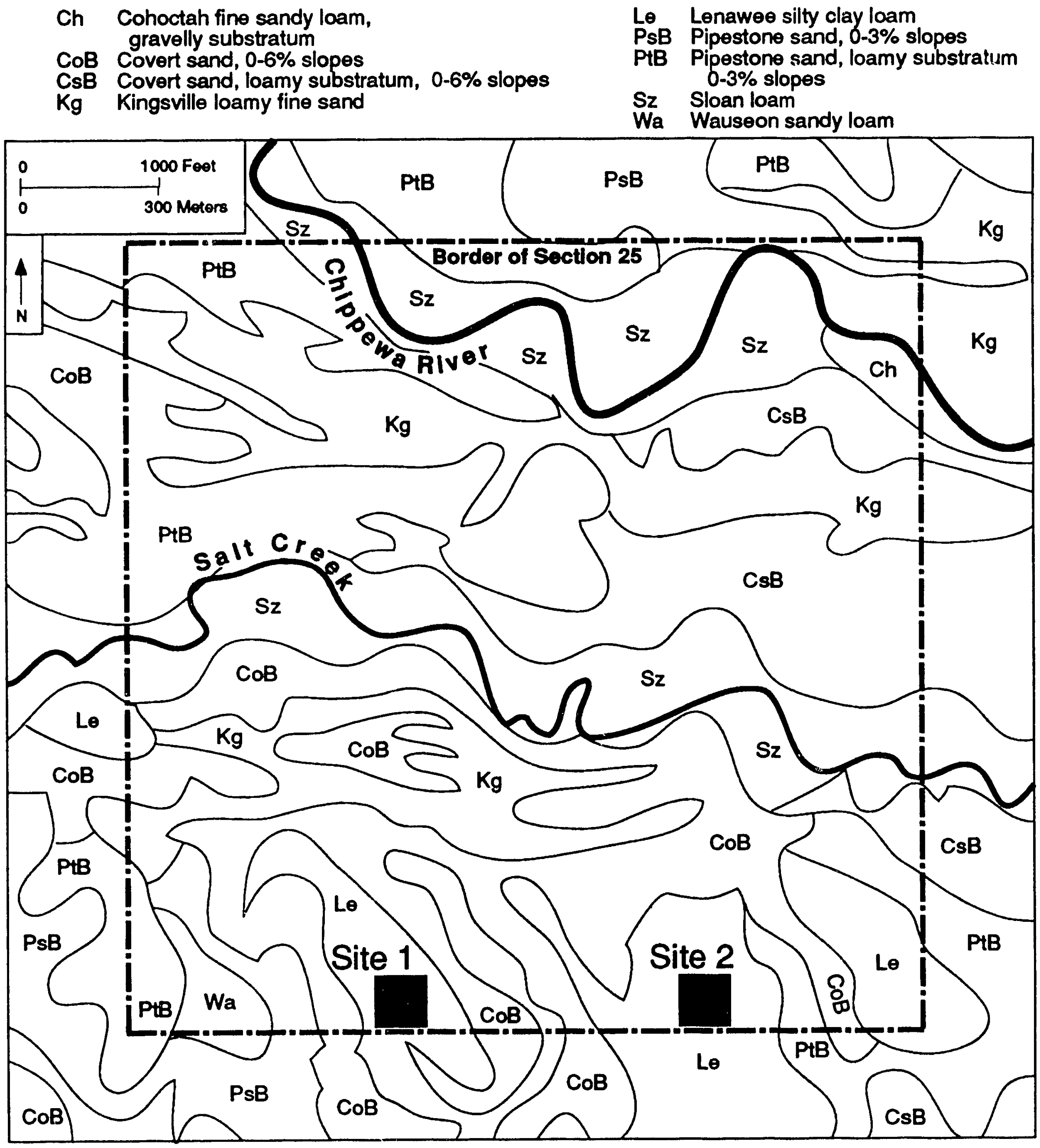


FIGURE 8 Soil Map of Section 25 of Greendale Township, Midland County. Sites 1 and 2 are located on Lenawee soils (Adapted from Hutchison 1979)

Lenawee soils were formed in clay or loam lacustrine deposits with 0-2% slopes that comprise broad flat areas and drainage ways. These soils are characterized as being moderately slowly permeable, poorly or very poorly drained, and subject to frequent flooding. The surface layer is typically a black silty clay loam about 22.9 cm (9 in.) thick. The mottled subsoil is about 78.7 cm (31 in.) thick, and its upper part consists of a dark grayish brown, firm silty clay loam; its middle is a light brownish gray, firm silty clay; and its lower part is a grayish brown, very firm silty clay (Hutchison 1979). Additional pedologic features of the Lenawee soil (under cultivation) are described in App. A. A particularly important characteristic of Lenawee soils with respect to this study is that they are considered hydric soils (USDA, Soil Conservation Service 1987).

In addition to parent materials and relief (topography), climate is an important factor in the development of soils. Although climatic differences probably did not have significant effects on the maturation of different soils within Midland County, the county is in a part of the lower peninsula that was, and apparently still is, subject to climatic tension. Here the cooler climatic elements of northern Michigan intermix with the warmer climatic elements of southern Michigan. This area across the central portion of the lower peninsula is considered a climatic transition zone or tension zone (Fig. 6) that supports transition soils (Veatch 1953). These transition soils undoubtedly represent a mosaic of soils, similar to some of the soils formed by podzolization in the podzol soils (= spodosol) region in the northern part of the lower peninsula and in the gray-brown podzolic soil (= alfisol) region of the southern part of the lower peninsula. The northern boundary of the alfisol region generally coincides with the southern limits of white pine (*Pinus strobus*) communities (Braun 1974; Hutchison 1979; Miller 1964; Veatch 1953; Whiteside et. al. 1963, 1964).

Vegetation also has an essential role in the development of soils, and, conversely, soils have an effect on the development of vegetation. These concepts are considered when selected aspects of Michigan's vegetation are discussed in the next section. The focus is on the transition zone, especially for the study areas in Midland County.

## 6.3 Vegetation

No specific studies on the original vegetation of Midland County, Michigan, were located. Darlington's (1945) thorough review of floristic work done as early as 1827 in Michigan (accompanied by a comprehensive bibliography) does not mention Midland County, although it does list several other counties in reference to various botanical studies. The history of Michigan's forests as affected by anthropogenic developments is discussed by Davis (1964), McIntire and McKee (1964), and Smith (1964). Several recent botanical workers synthesized qualitative and quantitative information and made interpretations that led to a generalized compositional and structural classification of Michigan's forest and nonforest communities, both regionally and locally (Braun 1974; Darlington 1945; Elliott 1953; Maycock and Curtis 1960; Voss 1972).

The native forest vegetation of the lower peninsula of Michigan has two major climatic climax regions. The hemlock-white pine-northern hardwood forest region (formation) in the northern portion coincides with the podzol soil (spodosol) region; the beech-maple forest region (formation) in the southern portion coincides with the gray-brown podzolic soil (alfisol) region

(Fig. 6). In addition, there is a vegetational transition zone extending across the middle of the lower peninsula, where the floristic elements from both forest regions integrate (Fig. 6).

The hemlock-white pine-northern hardwood forest region is characterized by a mosaic of deciduous hardwood forests, coniferous forests, and mixed hardwood-coniferous forests. The climax forest dominants include *Acer saccharum* (sugar maple), *Fagus grandifolia* (American beech), *Tilia americana* (basswood), *Betula lutea* (yellow birch), *Tsuga canadensis,* (eastern hemlock), *Ulmus americana* (American elm), *Acer rubum* (red maple), *Fraxinus americana* (white ash), *Quercus rubra* var. *borealis* (northern red oak), *Fraxinus nigra* (black ash), and *Pinus strobus* (eastern white pine). However, these taxa do not occur in all parts of the region (Fig. 9). Furthermore, *Picea glauca* (white spruce) and *Abies balsamea* (balsam fir) are considered important components in the northern limits of this region (Braun 1974; Maycock and Curtis 1960).

In the beech-maple forest region, *Fagus grandifolia* and *Acer saccharum* are the dominant trees. Associated arborescent taxa include *Ulmus americana, Tilia americana, Liriodendron tulipifera* (tulip tree), *Quercus borealis* var. *maxima* (red oak), *Carya ovata* (shagbark hickory), *Platanus occidentalis* (sycamore), *Celtis occidentalis* (northern hackberry), *Fraxinus americana, Prunus serotina* (black cherry), and *Juglans nigra* (black walnut). As do other vegetational formations, the beech-maple forest region consists of a mosaic of plant communities, where deviations from normal topography and soils support different climax communities (Braun 1974).

Floristic features of the transition zone across the middle portion of the lower peninsula apparently have received little attention from a plant ecological perspective. Braun (1974) mentions that going northward from the beech-maple forest region, the occurrence of hemlock and white pine is accompanied by an increasing number of northern herbaceous and shrub species indicative of the transition to the hemlock-white pine-hardwood forest region. When beech-maple communities occur north of the transition zone, their understory components are species of northern affinity such as *Acer pensylvanicum* (striped maple), *Acer spicatum* (mountain maple), *Viburnum lentago* (nannyberry), *Rubus idaeus* var. *strigosus* (wild red raspberry), *Lonicera canadensis* (American fly honeysuckle), *Sambucus pubens* (red-berried elder), *Aralia nudicaulis* (wild sarsaparilla), *Dryopteris spinulosa* (shield fern), *Maianthemum canadense* (wild lily-of-the-valley), and *Clintonia borealis* (corn lily) (Braun 1974). Voss (1972, 1985) has found that some plant species rarely occur south of the transition zone, whereas other species of southern origin rarely occur north of this zone. In the genus *Carex* (sedge), for example, *Carex aenea* is well represented in the northern portion of the lower peninsula (and across the upper peninsula) but has not been found south of Midland County. In contrast, *Carex muskingumensis* is rather widespread in the southern portion of the lower peninsula but has not been discovered north of Midland County. A list of additional plants with one of these two distribution patterns compiled from the taxon distribution maps published in Voss (1972, 1985) is provided in App. B. Taxa of this study will be compared with the taxa listed in App. B to ascertain whether changes in the diversity of forest communities (excluding taxa from seeding the ROW) caused by the ROW are related to plants of northern or southern affinities.

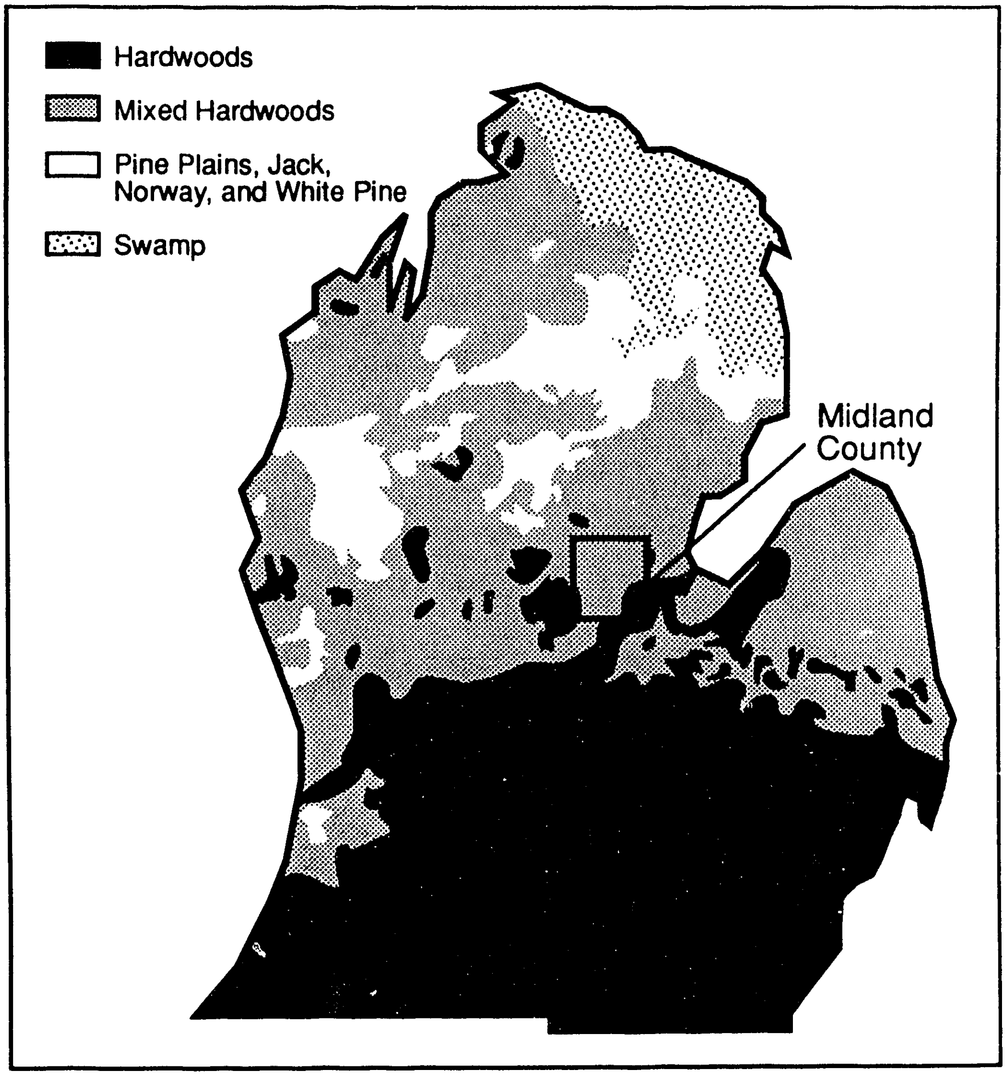


FIGURE 9 Vegetation Map Depicting the Original Forests of Michigan's Lower Peninsula (Adapted from McIntire and McKee 1964)

The way in which the floristic elements from the northern and southern portions of the lower peninsula are expressed in the heart of the transition zone (Midland County) has not been the focus of any known botanical studies. The closest detailed study within recent years seems to be Elliott's (1953) impressive study of Missaukee County (Fig. 6), located along the northern margin of the transition zone. He used density and basal areas to analyze the trees and shrubs on stands of upland second-growth hardwood forest in six different soil series of the podzol group. Elliott concluded that the county's second-growth hardwood stands, as a group, represented an anthropogenic disclimax. Also, the dominant trees of this disclimax represented members of the northern hardwood forest, namely *Acer saccharum*, *Fagus grandifolia*, *Tilia americana*, *Fraxinus americana*, *Betula lutea*, *Tsuga canadensis*, *Ulmus americana*, and *Ulmus thomasi* (cork elm). Mixed among these taxa, but of less importance, were *Betula papyrifera* (white birch), *Quercus rubra* var. *borealis*, *Acer rubrum*, *Populus grandidentata*, (bigtooth aspen), *Populus tremuloides* (quaking aspen), and *Prunus pensylvanica* (pin cherry). The boreal trees and shrubs reported by

Elliott (App. C) will be compared with those at the sites. It is important to determine whether climatic modifications within the edge of the forest favor elements of northern or southern origin and thus influence the direction of vegetational shifts.

# 7 Pipeline Construction

Activities involved with pipeline construction included surveying the ROW; clearing the woody vegetation from the ROW; excavating a ditch approximately 2 m (6.6 ft) deep and 1 m (3.3 ft) wide; distributing, welding, and installing the pipe; backfilling the ditch; and final grading and seeding the ROW with a mixture of grasses and legumes. Pipeline construction at the two study sites took place during the spring and early summer of 1989 (Fig. 10). The final survey for the pipeline was done during early April 1989. By this time, some of the larger trees had already been removed from the ROW at Site 1 (between October 17, 1988, and March 6, 1989), but no trees had been removed from the ROW at Site 2. The remainder of the trees were cleared from the ROW at both sites during late April and early May 1989. Slash was used to construct a crude roadbed in wet areas on the working side of the pipeline (the southern portion of the ROW). All logs had been removed from the ROW at Site 1, but the logs from the clearing operation at Site 2 were piled in a row along the northern edge of the ROW. In several places, logs had rolled into the adjacent forest on the north side of the ROW.

Pipeline installation at the sites occurred between May 18 and 25, 1989. At that time, standing water covered approximately 50% of the soil surface of the ROW at each site. Because of the wet soil conditions, trenching was carried out with a backhoe, working from the crude slash road. Excavated soil was piled on the northern portion of the ROW, and some soil spilled into the adjacent forest at both sites. In some places at Site 2, the excavated soil nearly covered the logs piled along the northern edge of the ROW. The welded and coated pipe was placed in the pipe ditch soon after ditching was complete, and the trench was backfilled with sufficient soil to anchor the pipe. Final grading of the ROW was carried out in mid-June 1989 and involved burying stumps and other debris, which were excavated during the trenching operation, in the ROW and final leveling of the pipe ditch. Stumps that did not interfere with the trenching operation were allowed to remain rooted. The slash road was abandoned at both sites, and the logs were also left along the northern edge of the ROW at Site 2. It appears that during the trenching and backfilling operations through both sites, there was no effective procedure for separately removing and replacing topsoils and subsoils. During backfilling and final grading, some of the logs along the northern edge of the ROW at Site 2 were pushed up to 5 m (16.4 ft) into the adjacent forest to recover the soil that had spilled over the row of logs during trenching. Also at Site 2, an intermittent furrow paralleling the pipeline on the storage side of the ROW was excavated during the backfilling and final grading. Apparently the soil from the furrow area was used to help fill the pipeline ditch.

The ROW at both sites was hand seeded on June 14, 1989. Specifications called for the use of two seed mixtures. One mixture designated for use on organic soils consisted of:

*Lotus corniculata*, birds-foot trefoil, at 4.5 kg/ha (4 lb/acre);
*Phleum pratense*, Timothy, at 5.6 kg/ha (5 lb/acre);
*Agrostis gigantea*, redtop grass, at 3.4 kg/ha (3 lb/acre);
*Trifolium hybridum*, alsike clover, at 2.2 kg/ha (2 lb/acre); and
*Trifolium repens*, white Dutch clover, at 3.4 kg/ha (3 lb/acre).

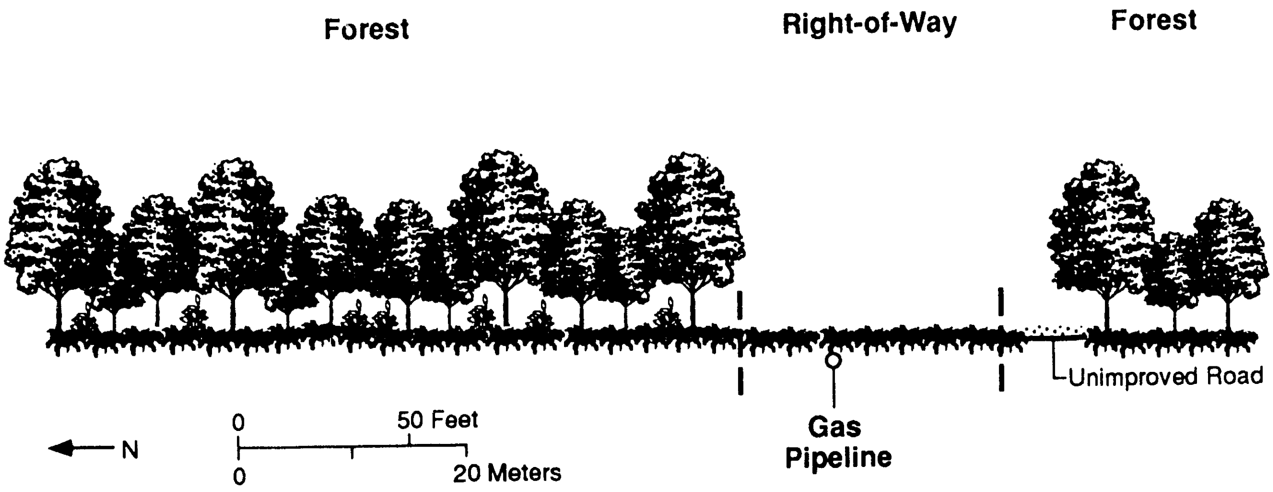


FIGURE 10 Sectional Drawing Typifying the Physiognomy of Sites 1 and 2: Adjacent Forest, Right-of-Way, and Unimproved Gordonville Road

The second mixture designated for use on mineral soils consisted of:

> *Festuca rubra*, red fescue, at 33.6 kg/ha (30 lb/acre);
> *Festuca arundinacea*, tall fescue, at 11.2 kg/ha (10 lb/acre);
> *Lolium perenne*, perennial ryegrass, at 5.6 kg/ha (5 lb/acre);
> *Bromus inermis*, smooth bromegrass, at 5.6 kg/ha (5 lb/acre);
> *Agrostis gigantea*, redtop grass, at 1.1 kg/ha (1 lb/acre); and
> *Trifolium repens*, white Dutch clover, at 1.1 kg/ha (1 lb/acre).

In addition, 224 kg/ha (200 lb/acre) of 12-12-12 fertilizer, equivalent to 26.9 kg/ha (24 lb/acre) of N, $P_2O_5$, and $K_2O$ each, was to be applied to seeded sections of the ROW. It would seem that the seed mixture for organic soils should have been used on both sites; however, a verification of which one of the seed mixtures was actually applied could not be made.

During the site visit in mid-August 1989, the surface of the ROW at Site 1 had considerably more exposed soil and less standing water than did the surface of the ROW at Site 2. The ROW at Site 2 had several large depressions on the north side of the pipe ditch, indicating that the cleanup crew must have had difficulty gathering enough soil to fill the pipe ditch and had resorted to borrowing soil from the north side of the ROW to fill it. This lack of soil had occurred partially because the excavated soil had spilled over and into the logs piled on the northern edge on the ROW at Site 2. The abandoned logs at Site 2 remained relatively undisturbed until October 1989, when portions were removed by individuals with permits to cut firewood in state forest lands.

There has been no evidence of additional work related to the GPL installation activities on the ROW at either site since early July 1989. Incidental traffic by off-road vehicles and the pick-up trucks used by firewood cutters in October 1989 has created deep ruts in some of the wetter areas. Most of the logs still remain on the ROW and in the adjacent forest at Site 2.

# 8 Methods

This study is comparative with respect to both structural and floristic aspects of plant communities; thus, it is directed toward the descriptions and analyses of major vegetational synusiae (layers) and designated trees, shrubs, brambles, vines, forbs, graminoids, pteridophytes, and bryophytes. (Graminoids include grasses, sedges, and rushes; pteridophytes include ferns and fern allies such club mosses and horsetails; and bryophytes include mosses, liverworts, and hornworts.) Also, to determine methods of making ecological measurements, the vegetation has been divided into three gross structural components: the overstories of adjacent forest communities, the understories of adjacent forest communities, and the ROW plant communities. The overstory component consists of trees and shrubs with stems ≥2 cm (≥0.78 in.) in diameter at breast height (dbh, the stem diameter at 1.5 m [58.6 in.] above the ground surface). The understory component consists of seedlings of trees and shrubs with a stem dbh <2 cm, brambles, vines, forbs, graminoids, pteridophytes, and bryophytes. Sampling is being carried out on the ROW and in the adjacent forest north of the ROW, because there is no forest remaining between the southern boundary of the ROW and the unimproved Gordonville Road (Fig. 10). The use of the forest south of the unimproved Gordonville Road for the study is unacceptable because of the road and its edge effects. In addition, edge effects of the ROW on the adjacent forest are likely to be more pronounced along the northern boundary of the ROW, because of greater insolation at the understory level, than along the southern boundary of the ROW.

## 8.1 Sampling Procedures

Because the northern edge of the ROW was not clearly marked after pipeline construction, it was located at each site by measuring 22.86 m (75 ft) north from the lath stakes put down by the pipeline surveyors to mark the southern ROW boundary. At at each site, a random point along the northern edge of the ROW was selected as a western boundary for the understory vegetational study area. From this point, a distance of 104 m (341.2 ft) was measured eastward, along the northern edge of the ROW, to establish the eastern boundary of the study area. Subsequently, these western and eastern boundary points were used as starting points to establish the south-north boundary lines for the sampling transects. Along these south-north lines, transect markers (1/2 x 24-in. steel reinforcing rods) were placed 1, 5, 13, 25, 41, and 61 m into the forest from the northern edge of the ROW (Fig. 11). Also, rod transect markers were placed at the same intervals midway between the western and eastern boundaries for orientation purposes. East and west transect markers were placed 104 m apart, to allow 2 m on each end of each 100-m (328-ft) transect, so the area within or next to the quadrats to be sampled along the transects would not be trampled on. All transect marker rods are identified with metal tags. In addition, more permanent steel markers (automobile axles) were driven into the ground to near the soil surface, 1 m in from the west transect marker rods, 1 m in from the east transect marker rods, and 13 and 61 m north from the northern edge of the ROW.

The actual establishment of a transect line for each data-collection area is being accomplished by attaching the zero end of a 100-m survey tape to a 2-m chain that is attached to the

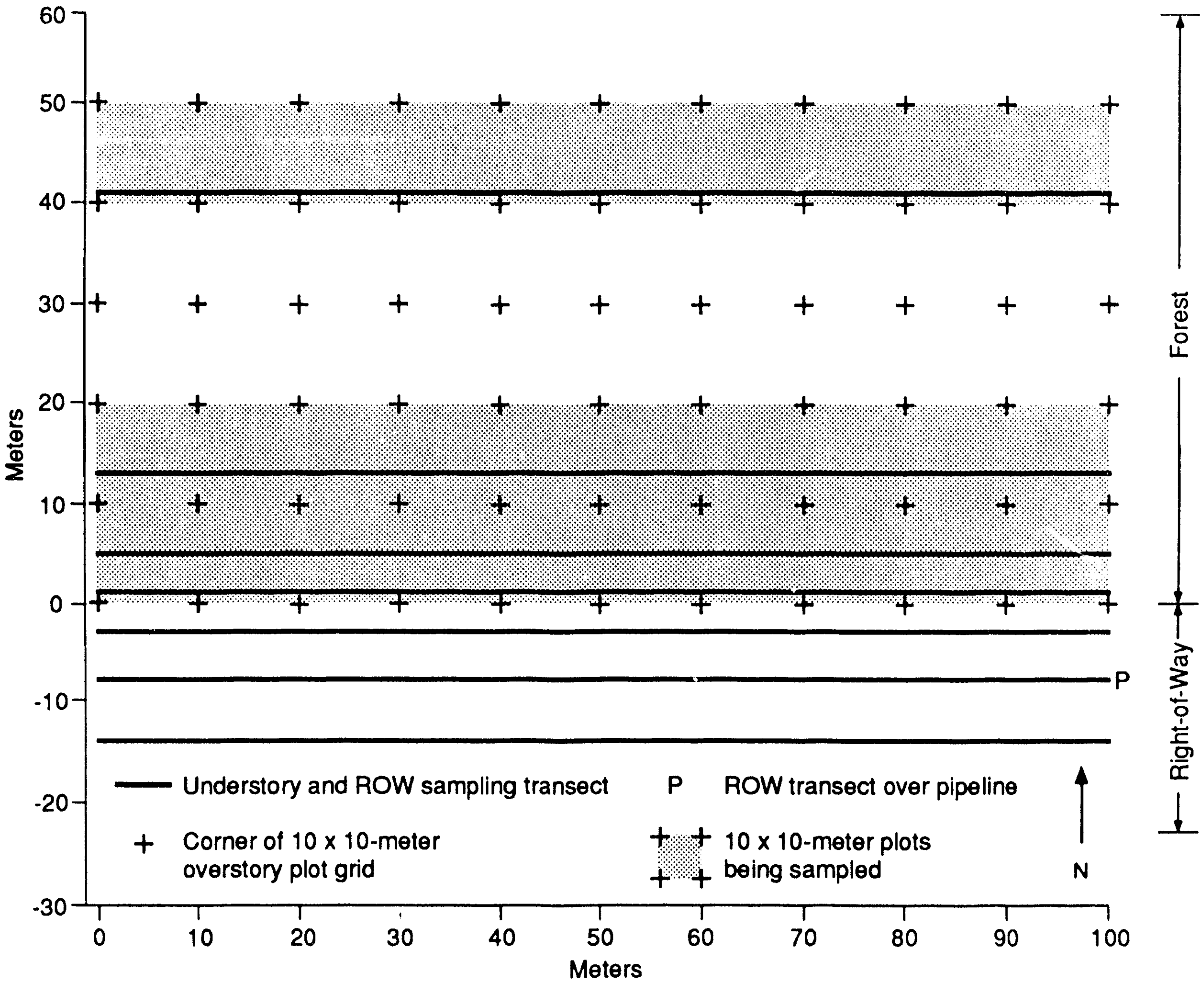


FIGURE 11 Positions of Understory Transects, Right-of-Way Transects, and Overstory Plots for Both Sites

western marker rod. The tape is stretched to the eastern end of the transect and attached to a second 2-m chain that is attached to the eastern marker rod. The chain length is then adjusted to make the survey tape taught. To visually facilitate the placing of the tape through the forest and to avoid trampling on the sampling side (south) of the transect lines, yellow lath stakes were installed at 10-m intervals along the transect lines in the forested portions of each site. Because lath stakes are thin and weak, short oak stakes were implaced at 20-m intervals as backup markers along the same transect lines.

Transect markers in the forest were used as references to establish the east and west ends of the ROW sampling transects. Three parallel transect lines, placed 3, 7.6 (over the GPL), and 14 m south of the northern edge of the ROW, were established at each site. Neither steel nor lath markers were installed on the ROW because maintenance vehicles were expected to travel there. However, coded oak stakes were placed at the ends and at 20-m intervals along each ROW transect line to facilitate the reestablishment of the 100-m transect during data collection. For sampling, a survey tape is placed on the transect line in a matter similar to that described for the forest transects, except that the steel rods used to attach the chain extensions are being removed after each data-collection effort.

To sample the understory, cover-class values and individual counts of selected taxa are being recorded on prepared data sheets for four transects in the forested portions and three transects in the ROW at each site (App. D). A 1 x 1-m quadrat frame is placed along the southern edge of the 100-m survey tape randomly, either immediately east or west of the odd-numbered meter marks on the tape. One quadrat is sampled at all odd-numbered meter marks from 5 to 43 and 55 to 93, resulting in a total of 40 quadrats per transect. The ends and the centers of the transects are not used so that no sampling is done in areas that would get trampled.

In the forested portion at each site, the transect lines used for sampling are located 1, 5, 13, and 41 m north of the north edge of the ROW. To help keep the data organized, numbers were assigned to these transects: 101, 105, 113, and 141 for Site 1 and 201, 205, 213, and 241 for Site 2. In the ROW at each site, the transect lines used for sampling are located 3, 7.6 (over the GPL), and 14 m south of the northern edge of the ROW. (A transect located 5 m south was sampled in 1989, but it is no longer being used for vascular plant sampling.) Numbers assigned to these transects are 503, 507.6, and 514 for Site 1 and 603, 607.6, and 614 for Site 2.

To establish plots for overstory sampling, a grid of 10 x 10-m plots that is 100 m wide (west-east and parallel with the ROW) and 50 m deep (south-north) was superimposed on the understory-forest transects at each site. Red lath stakes mark the location coordinates of the grid. The starting location for the grid at each site was 2 m east of the western boundary of the forest-understory transects along the northern edge of the ROW. From this starting point, at each site, laths were placed in a row from west to east at 10-m intervals along a 100-m line. The grid at each site was completed by establishing five more rows of laths located 10, 20, 30, 40, and 50 m north of the northern edge of the ROW (Fig. 11).

To sample the overstory, stem diameters are measured for all individuals of each overstory species (trees and shrubs with stems $\geq$2 cm dbh) in three 10 x 100-m belt transects with the long axis of the transect parallel to the ROW. Each belt transect is made up of ten 10 x 10-m plots. The three transects cover the areas extending from 0 to 10, 10 to 20, and 40 to 50 m north of the northern edge of the ROW (Fig. 11). Prepared data sheets (App. E) are used to record the dbh (in centimeters) as measured with a diameter tape. In addition, the location of each individual overstory species is mapped in each 10 x 10-m plot. The mapping is done on prepared sheets, on which each 10 x 10-m plot is subdivided into 1 x 1-m units (App. F) and each overstory plot is assigned a number that reflects the site and location (App. G).

Systematic sampling of the bryophyte synusiae to ascertain cover estimates for individual species is being carried out by collecting core specimens along transect lines. A 100-m tape is used to establish two transect lines, one 10 m north and the other 40 m north of the northern edge of the ROW, for sampling in the forested portion at each site. On the ROW, at each site, the transect lines are 5 m south of the northern edge of the ROW. Sampling is done at 0.5-m intervals along the transect lines with a 5.8-cm-diameter coring device. Sample cores are taken near the southern edge of the transect line in the forested portions at each site and near the northern edge of the transect line on the ROW at each site. Only sample cores that contain shoots of mosses or liverworts are kept in labelled brown paper bags for laboratory analyses.

## 8.2 Plant Inventories

According to Daubenmire (1968, pg. 39):

> At the beginning of any serious study of a plant community it is important not only to learn precisely which species are present, but to be able to recognize them at different stages of development. The time is not long past when the field biologist felt well satisfied with his work after presenting a mere list of the dominants, identifying these as they came into flower. It is now widely acknowledged as poor policy to learn only a few dominants and neglect the remaining flora. Subordinate and even rare plants often have much value for indicating special conditions, present and past, and they sometimes foretell the future. All species have some indicator significance, whether it is known at present or not.

The documentation of species with voucher specimens is also critical, because any changes in the floristic elements, especially the loss of a species, can be confirmed with credibility only if a voucher specimen has been preserved.

In this study, voucher specimens of vascular plants are collected for each species except for those considered rare or known to be endangered. Specimens freshly collected in the field are referenced by collection number and field notes and placed in plant presses for drying. When dry, specimens are mounted on standard-size herbarium sheets (Porter 1967). When provided with an information label, each mounted specimen provides permanent documentation of a given species. Rare and endangered plant species are photographed *in situ* (in their habitats), and prints (19.5 x 16 cm or 8 x 16 in.) of the photographs are mounted on standard-size herbarium sheets with appropriate labels to be used as herbarium specimens to provide permanent documentation.

Voucher specimens of bryophytes are also being prepared. Field-collected specimens are placed in small, numbered, brown paper bags, and field notes are recorded. The specimens are dried in the bags and stored for laboratory work. Specimens too large or too wet to be dried in collection bags are removed from the bags and dried separately. Collected bryophytes are usually air dried at room temperature, but sometimes oven drying (at about 70°C or 180°F) is needed for large collections. Finally, the bryophyte voucher specimens are placed in bond paper packets (ca. 10 x 15 cm or 4 x 6 in.) with appropriate labels. Because bryophytes are small, the use of packets is usually the herbarium technique chosen for handling specimens (Conard 1979). These herbarium specimens provide permanent documentation of the mosses and liverworts collected from the sites.

Many taxonomic reference sources are being used to key the vascular plant voucher specimens, to confirm field identifications or identify unknown species. Particularly important for this study are these manuals on Michigan's flora: Barnes and Wagner (1981) for trees, Billington (1949) for shrubs, Smith (1966) for wildflowers, Voss (1972) for gymnosperms and monocots, and Voss (1985) for dicots in part (Saururaceae-Cornaceae). Additional helpful manuals include but are not limited to these: Cores and Ammous (1958), Fernald (1950), Gleason (1952a,b,c), Graves (1956), Hithchcock (1950a,b), and Swink and Wilhelm (1979).

For the vascular plant species in the study collection, the scientific names follow those used by Voss (1972, 1985) when they are included in the families covered in the two volumes presently in print on Michigan's flora. For the species in the remaining dicot families and the pteridophytes, the scientific names follow those used by Gleason, volume one (1952a) and volume three (1952c). During the identification process, critical information for each specimen of vascular plant is recorded on taxon data sheets (App. H); similar taxon data sheets are also used for the bryophyte species. Major taxonomic references for Michigan's bryoflora are Crum (1983) and Darlington (1964) for mosses and Steere (1940) for liverworts. In addition, other useful manuals include but are not limited to Conard (1979), Schuster (1966, 1969, 1974, 1980), and Welch (1957). Scientific names for the species of bryophytes in the study collection follow those used by Crum and Anderson (1981a,b) for the mosses and Conard (1979) for liverworts.

## 8.3 Qualitative Procedures

As identifications of the vascular plant voucher specimens are confirmed, a master list of species, by scientific name, is being compiled. This list includes family and common names as well as collection numbers. Separate plant lists for the forest and ROW plant communities at the sites are being periodically compiled. Such lists are needed for determining possible additions to or losses from the site plant communities. The final list will be compared with the list of known vascular flora reported for Midland County (App. I), and information on new species will be added to county records.

Taxon lists for the bryophytes will be prepared in the same format as that used for the vascular plants, except common names will not appear in the master list, since they are essentially unknown for mosses and liverworts.

Taxon lists of the vascular plants with reference to different growth forms are also being prepared from time to time for trees, shrubs, brambles, vines, forbs, graminoids, and pteridophytes. Such lists can provide information about possible structural changes in forest and ROW plant communities at the sites.

## 8.4 Quantitative Procedures

The quantitative procedures used to measure vegetational components are determined by the particular units of measure that were chosen for analysis in this study. The histories, applications, merits, and limitations of these different units of measure (such as density, cover, biomass, etc.) have been thoroughly reviewed in the ecologic literature. Noteworthy references include Bonham (1989), Daubenmire (1968), Greig-Smith (1964), and Mueller-Dombois and Ellenberg (1974).

This study employs density, cover, basal area, and frequency, all of which can be measured by nondestructive sampling techniques.

Density refers to the number of individuals per unit area (or volume). It is being determined for the woody taxa of the overstories of the forest communities and the understories of the forest and ROW plant communities. For the overstories, counts of trees and shrubs with stems of ≥2 cm (>0.79 in.) dbh are being made in 10 x 10-m plots. Dead stems are not included for density determinations, but the death of any trees and shrubs during the study will be noted. Counts are being made in 1 x 1-m plots for vines, shoots of brambles, and understory trees and shrubs with stems of <2 cm dbh.

Cover for a plant species is a measure of dominance and is expressed as the percentage of the ground surface covered by the vertical projection of the total foliar spread of all individuals of a species in a specified area. The concept of cover can also include inanimate environmental components, such as rocks, logs, and water. In this study, cover estimates are being made by recording cover-class values (Apps. J and K) for the understory taxa of the forest and ROW plant communities in 1 x 1-m plots. Cover estimates are also being made for bryophytes, pteridophytes, graminoids, and forbs. Cover estimates are being made for individual species of ferns, fern allies, grasses, sedges, rushes, vines, brambles, and seedlings of trees and shrubs (with stems <2 cm dbh). When applicable, cover estimates are also being made for exposed mineral soil, bare logs, stumps, and standing water. Cover estimates for individual species of mosses and liverworts are being made from field-collected sample cores (5.8 cm or ca. 3 in.). Because bryophytes are small and because microscopy is needed to identify species of mosses and liverworts, the sample cores are being analyzed in the laboratory.

Basal area is an assessment of dominance and refers to the aggregate cross-sectional area at or near ground level of individual plants in a specified area. The basal areas of the trees and shrubs are determined for the overstories of the sites. Stems ≥2 cm dbh are being measured within 10 x 10-m plots. The diameters are then converted to circular areas, and the circular areas are summed for each species.

Frequency provides information about the distribution of a taxon, without regard to its density or dominance, and is expressed as a percentage of occurrence of a taxon in a series of plots of the same size. In this study, for the understory species (except bryophytes), frequency is being calculated from the same data recorded to determine percent cover. For the overstory species, frequency is being calculated from the same data recorded to determine basal areas. Frequencies of understory and overstory taxa cannot be combined or meaningfully compared in this study, even for the same species, because different quadrat and plot sizes are being used (1 x 1 m and 10 x 10 m). For the mosses and liverworts, frequency is being ascertained from core specimens.

# 9 Field Trip Summaries

This summary of field trips from August 1988 through August 1990 is taken from a series of more comprehensive reports prepared shortly after each field trip for internal records. During all the field trips except the first one in August 1988, at least some plant specimens were collected for taxonomic work and to build a collection of voucher specimens. Still photographs were also taken during each trip. Because these two activities are routine for this project, they are not mentioned in these brief summaries.

## 9.1 August 3-4, 1988

Investigators: S.D. Zellmer and J.R. Rastorfer, in collaboration with Dr. John Rochow, Supervisor, Environmental Department, Consumers Power Company, and Mr. Thomas Morvant, ROW agent representing Consumers Power Company.

Activities: Three potential study sites were reconnoitered. One was considered to be most suitable for the study; it can be classified as a deciduous forested wetland. This site is located a short distance west of the junction of Castor and Gordonville Roads and is now designated Site 2 on Michigan state forest land.

## 9.2 October 13-17, 1988

Investigators: S.D. Zellmer, J.R. Rastorfer, J.D. Taylor, and G.D. Van Dyke.

Activities: The location of Site 1 within the boundary of Mr. Billy Haskins' property was established. To make an ecologic evaluation of this site, the densities and basal areas of species of trees and shrubs in six different plots (4 x 25 m) were determined and recorded. Several increment bores were taken from selected trees to determine age. Soil cores were inspected to confirm soil map information, and soil samples were collected for laboratory analyses.

## 9.3 March 6-10, 1989

Investigators: J.R. Rastorfer and G.D. Van Dyke.

Activities: Reference materials on endangered plant species, wetlands, and other natural features were obtained from the Michigan Department of Natural Resources (MI DNR) in Lansing, on the way to Midland County. A review of the research plans, especially for the second site on Michigan state forest land (Site 2), was discussed with a state forester, Mr. Michael Conley, at his office in Gladwin, Michigan. The Department of Biological Sciences and the main library at Central Michigan University in Mt. Pleasant was visited to assess the university's herbarium and botanical/ecological literature resources. Data were recorded to determine densities and basal areas of trees and shrubs in six plots (4 x 25 m) to make an ecologic evaluation of Site 2.

## 9.4 April 11-16, 1989

Investigators: J.R. Rastorfer and G.D. Van Dyke.

Activities: Site 1 and Site 2 were inspected, and video-tape recordings were made of the forest characteristics at each site to provide visual documentation of the sites before vegetation is cleared from the ROW. The locations of surveyor stakes that delineate the ROW through each site were noted and recorded. Data were collected to determine densities and basal areas of species of trees and shrubs in two 10 x 150-m belt transects at Site 2 for evaluation and to test sampling adequacy. Cover-class values were recorded collectively for the bryophyte synusia along two 150-m transects using a 20 x 50-cm frame.

## 9.5 May 10-12, 1989

Investigators: G.D. Van Dyke and S.D. Zellmer.

Activities: Different phases of the gas pipeline construction operations were observed, discussed, and recorded on video tape. Information was obtained from Mr. Richard Lybarger, the field construction superintendent for Consumers Power Company, on pipeline construction procedures and the two seed mixtures to be sown on the nonagricultural ROW. The major objective of this trip was to observe and document the construction of a study site to compare the effects of single- and double-ditching on agricultural crop production. This second objective is the subject of another ongoing research effort sponsored by GRI and located nearby on the same pipeline ROW.

## 9.6 May 22-26, 1989

Investigators: J.R. Rastorfer, G.D. Van Dyke, and J.E. Frelichowski.

Activities: Additional video-tape recordings were made of different phases of the gas pipeline installation operations. The northern boundary of the ROW was located at each site using the surveyor stakes along the southern boundary of the ROW. Markers were placed in the forested portion of each site for four transects at points 1, 5, 13, and 41 m north of the northern edge of the ROW.

## 9.7 June 5-13, 1989

Investigators: J.R. Rastorfer, G.D. Van Dyke, J.E. Frelichowski, and M.G. Slocum.

Activities: Cover-class values were recorded for understory taxa along three transects in the forested portion of each site. The transect located 1 m north of the northern edge of the ROW could not be analyzed because the grading work on the ROW was not completed. Seedling counts of trees and shrubs and shoots of brambles and vines were also recorded. Data from forty 1 x 1-m quadrats were collected along each transect; hence, a total of 240 quadrats were sampled. The 10 x 10-m grid network of lath, used to analyze the overstory components (trees and shrubs), was installed in the forested portion of each site. Cover-class values for standing surface water were recorded in the forested portion of each site to provide comparative information for the two sites. These cover estimates were done using the 1 x 1-m quadrat along a transect located 30 m north of the northern edge of the ROW.

## 9.8 June 5-8, 1989

Investigator: G.D. Van Dyke.

Activities: Plant specimens were collected from Sites 1 and 2 and from the surrounding area for taxonomic work in preparation for ecologic sampling in August 1989.

## 9.9 July 17-21, 1989

Investigators: J.R. Rastorfer and J.E. Frelichowski.

Activities: The bryophyte synusia was systematically sampled along two transects in the forested portions of each site. A total of 192 bryophyte samples were collected from 804 sample points. Selected vascular plants were collected from both sites and from the surrounding area for additional taxonomic work in preparation for the ecologic sampling in August 1989.

## 9.10 August 7-16, 1989

Investigators: J.R. Rastorfer, G.D. Van Dyke, and M. Slocum.

Activities: Cover-class values were recorded for the understory species along four transects in the forested portion and one transect in the ROW segment of each site. In addition to cover-class values, counts were also recorded for seedlings of trees and shrubs and shoots of brambles and vines. Forty 1 x 1-m quadrats were sampled along each transect, resulting in understory taxa data for a total of 480 quadrats. Trees and shrubs with stems $\geq$2 cm dbh were recorded by species on the ten 10 x 10-m plots from the three belt transects at each site, resulting in overstory taxa data for a total of 60 plots.

### 9.11 October 12-15, 1989

Investigators: J.R. Rastorfer and G.D. Van Dyke.

Activities: Several vascular plant specimens, critical because of their late maturity, were collected. Lath markers were placed at selected locations in the forested portion and on the ROW at each site for additional soil sample collections. Voucher specimens were collected for mosses seen for the first time on the ROW after pipeline construction activities.

### 9.12 June 4-8, 1990

Investigators: G.D. Van Dyke and J.E. Frelichowski.

Activities: Plant specimens were collected in preparation for ecological sampling in August 1990. Cover-class values were recorded for standing surface water in the forested portion of each site.

### 9.13 July 2-6, 1990

Investigators: J.R. Rastorfer and J.E. Frelichowski.

Activities: Three new transects were established on each ROW at each site. A special collection of plant specimens was made on the ROW in preparation for ecological sampling in August 1990.

### 9.14 July 23-August 4, 1990

Investigators: J.R. Rastorfer, G.D. Van Dyke, and J.E. Frelichowski.

Activities: Cover-class values were recorded at the two sites for the understory species and other environmental components (e.g., logs, stumps, and mineral soil) in 40 quadrats on each of 14 transects. At each site, three transects were on the ROW and the remaining four transects were within the forested portions. The numbers of tree and shrub seedlings and bramble and vine shoots were also recorded. Data from a total of 560 quadrats were collected. Individual shrubs and trees were relocated in the 10 x 10-m plots using the plot maps made during the August 1989 sampling. A few questionable identifications and diameter measurements were either confirmed or corrected. The major significance of this re-examination was in providing insights into the morphological range of green ash and into the red maple/silver maple and pin oak/red oak population complexes. Several trees, especially those along the northern boundary of the ROW, had died since the August 1989 data collection. The bryophyte synusia were sampled along a transect of the ROW segment at each site. A total of 201 sample points were checked at each site, and 115 samples were collected at Site 1 and 69 samples were collected at Site 2.

# 10 Results and Discussion

Voucher specimens of most plant species found on the sites and nearby areas were collected starting in October 1988 and during the 1989 and 1990 growing seasons. Herbarium specimens were prepared for more than 200 vascular plant species. Vegetational data to determine dominance, density, and frequency were collected from the ROW and adjacent forest communities at each site during the 1989 and 1990 growing seasons. Cover-class values on the percentage of ground covered by standing water within the forest communities were recorded during June of 1989 and 1990 at each site. Soil samples were collected at each site for laboratory analyses. Although data reduction and data analyses are still in progress, the following preliminary data interpretations, results, and observations are provided.

The Federal Interagency Committee for Wetland Delineation (1989) established the soil, hydrologic, and vegetation requirements that have to be met for an area to be classified as a jurisdictional wetlands; these are defined in its wetlands manual. A preliminary analysis of the data collected indicated that the forested portions of both sites qualify as jurisdictional wetlands. One requirement is that the soil be hydric. Both sites have been mapped as the Lenawee silty clay loam by Hutchinson (1979), and Lenawee soils are classified as hydric (number 2B2 or 3) by the USDA Soil Conservation Service (1987). A field inspection of the soils using a 5-cm-diameter orchard auger revealed that the profiles appeared to match that of the Lenawee soil. Another requirement for a jurisdictional wetland is that standing water must stay on the soil surface for at least seven days in a row. Field observations verified that both sites had standing surface water during April, May, and June in 1989. On June 12, 1989, standing water covered 18.1% of the ground surface at Site 1 and 75.8% of the ground surface at Site 2. These observations indicate that both sites meet the soil and hydrologic criteria for jurisdictional wetlands as defined in the wetlands manual.

Although species dominance (on the basis of coverage, density, or basal areas) must be determined before one can ascertain whether the hydrophytic vegetation criterion for jurisdictional wetlands is met, it seems likely that both sites meet this criterion. Collection data from 1989 for Site 1 indicate that 62% of the species found in the forested wetland (81 species in number) are classified in the wetlands manual as obligate wetland (OBL), facultative wetland (FACW), or facultative wetland or nonwetland (FAC) species. Collection data from 1989 for the forested wetland of Site 2 indicate that 61% of the species (73 species in number) were OBL, FACW, or FAC species (Table 1). It seems likely that the vegetation in the forested portion of each site will meet the hydrophytic vegetation criterion established for jurisdictional wetlands, because only 50% of the dominants must fall in these three categories to meet this criterion. It also seems likely that the forested wetland portion of each site will generally fit the classification of palustrine, forested, deciduous, seasonally flooded (PFO1C) as given by Cowardin et al. (1979). Table 2 (which appears after the text of this section) lists the plant species found at the sites and in the adjacent areas, their wetland classification, and habit.

A preliminary analysis of data collected during the 1989 and 1990 growing seasons from the ROW at Site 1 indicates that 18 of 30 species or 60% are classified as OBL, FACW, or FAC. Of these 18, 10 are introduced agronomic species, of which 1 is FACW, 3 are FAC, and 6 are

TABLE 1 Number of Species in the Forested and Right-of-Way Portions of Sites 1 and 2, by Indicator Category

| | | | Indicator Category[a] | | | | |
|---|---|---|---|---|---|---|---|
| Site | Location | Total[b] | OBL | FACW | FAC | FACU | UPL |
| 1 | Forested wetland | 131 | 19 | 39 | 23 | 32 | 18 |
| 2 | Forested wetland | 114 | 15 | 34 | 20 | 27 | 18 |
| 1 | Right-of-way | 30 | 8 | 4 | 6 | 9 | 3 |
| 2 | Right-of-way | 25 | 8 | 4 | 6 | 5 | 2 |

[a]Wetland indicator categories are from Reed (1988): OBL = obligate wetland, FACW = facultative wetland, FAC = facultative wetlands or nonwetlands, FACU = facultative upland, and UPL = obligate upland.

[b]The numbers of species are based on specimen collection data from 1989 for the forested portions and from 1989 and 1990 for the right-of-way portions.

FACU. At Site 2, 18 of 25 species or 72% are classified as OBL, FACW, FAC (Table 1). Of these 18, 8 are introduced agronomic species, of which 1 is FACW, 3 are FAC, and 4 are FACU. Some of the introduced species are from a seed mixture applied to the ROW and some are weedy species that invaded from surrounding areas. None of the seeded species at either site are OBL, and only one species at each site is FACW. The seeded and weedy species detract from the wetland characteristics of the ROW. Table 3 (which appears at the end of this section) lists the plant species found on the ROW at the sites and on the adjacent ROW segments, their wetland classification, and habit. A final determination of the ROWs' wetland status will be made after additional data collection and analyses.

Cover-class data were collected at each site during June and August of 1989 and August of 1990. Woody stem counts were made in each 1 x 1-m quadrat sampled, and measurements of stems $\geq$2 cm dbh were recorded for each tree in 10 x 10-m plots during August of each year. Analysis of these data will provide a baseline to measure future changes and distinguish the long-term influences of the ROW from influences due to year-to-year climatic influences. Several additional years of data collection will be required to determine the initial impacts of the ROW on the forest.

As described previously under pipeline construction, logs and soil from clearing and trenching activities had spilled a short distance into edge of the adjacent forest at Site 2. Attempts to recover the soil that had spilled into the row of logs resulted in them being pushed farther into the forest. Some of the soil remained among the logs, resulting in reduced amounts for backfilling. The row of logs also has both direct and indirect effects on the establishment of vegetation on the ROW. The logs exclude vegetation from the space they occupy and shade some of the ROW soil. ROW vegetation has also been disturbed by traffic, mostly four-wheel-drive trucks involved in scavenging firewood from the row of logs. Presently, it is uncertain whether the logs and soil remaining in the row of logs will affect the local hydrology enough to cause vegetational changes. Nevertheless, any adverse effects from the row of logs could have been avoided if all the logs would have been removed from the site during clearing operations.

Another practice that should be monitored carefully during pipeline construction is the discharge of water pumped from the pipe ditch. At both Sites 1 and 2, some of this water was discharged sufficiently close to the edge of the forest to cause soil erosion and deposition in the edge of the forest.

In the ROW clearing procedure, stumps that did not interfere with construction activities were left rooted. As a result, some of the stumps resprouted. In addition, areas immediately around these stumps were protected, allowing some formally forest understory species to survive on the ROW. Moreover, the minimal time between ditching and backfilling allowed plant propagules to survive in the excavated soil and regenerate following ROW cleanup operations. Hand seeding the ROW without complete tillage allowed the survival and resprouting of some native species while providing ground cover for erosion control on the ROW. General observations indicate that during the second year of growth, seeded species (especially *Agrostis gigantea*) and species of Eurasian origin were much more evident on the ROW than native species. Additional data collections are necessary to determine the long-term effect of seeded and weedy species on the vegetative community of the ROW. Although numerous native species were present on the ROW, changes in their relative dominance can be determined only after the collection and analysis of cover-class data for several years.

TABLE 2 Provisional List of Plants Found at Sites 1 and 2 and Surrounding Areas, Midland County, October 1988-October 1989

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Acer rubrum* | Red maple | FAC | NT | 1,2 |
| *Achillea millefolium* | Common yarrow | FACU | PNF | |
| *Actaea pachypoda* | White baneberry | | | 2 |
| *Actaea rubra* | Red baneberry | | | 1 |
| *Agrimonia gryposepala* | Tall hairy grovebur | FACU+ | PNF | |
| *Alisma plantago-aquatica* | Broad-leaf water plantain | OBL | PNEF | |
| *Alnus rugosa* | Speckled alder | OBL | NT | 1,2 |
| *Amelanchier arborea* | Downy serviceberry | FACU | NT | 1,2 |
| *Amelanchier bartramiana* | Bartram's serviceberry | FAC | NS | |
| *Amphicarpaea bracteata* | American hog-peanut | FAC | APNFV | 1,2 |
| *Anemone quinquefolia* | American woodland thimble-weed | FAC* | PNF | 2 |
| *Anemone virginiana* | Tall thimble-weed | NI | PNF | |
| *Apocynum androsaemifolium* | Spreading dogbane | | | |
| *Apocynum sibiricum* | Prairie dogbane | FAC+ | PNF | |
| *Aralia nudicaulis* | Wild sarsparilla | FACU | PNF | 1,2 |
| *Aralia racemosa* | Spikenard | | | 1,2 |
| *Arisaema triphyllum* | Swamp jack-in-the-pulpit | FACW- | PNF | 2 |
| *Asclepias incarnata* | Swamp milkweed | OBL | PNF | |
| *Aster lateriflorus* | Calico aster | FACW- | PNF | 1,2 |
| *Aster ontarionis* | Ontario aster | FAC | PNF | 1,2 |
| *Aster puniceus* var. *firmus* (=*A. lucidulus*) | Shiny aster | FACW+ | PNF | 1 |
| *Aster sagittifolius* | Arrow-leaved aster | | | |
| *Aster simplex* var. *interior* (=*A. simplex*) | Panicled aster | FACW | PNF | 1 |
| *Aster umbellatus* | Flat-top white aster | FACW | PNF | 1,2 |
| *Athyrium filix-femina* | Subartic lady fern | FAC | PNF3 | 1,2 |
| *Betula papyrifera* | Paper birch | FACU+ | NT | 1,2 |
| *Botrychium virginianum* | Rattlesnake fern | FACU | PNF3 | |
| *Brachyelytrum erectum* | Brachyelytrum | | | 1,2 |
| *Calamagrostis canadensis* | Blue-joint reedgrass | OBL | PNG | 1,2 |
| *Carex bromoides* | Brome-like sedge | FACW+ | PNGL | 1,2 |
| *Carex crinita* | Fringed sedge | FACW+ | PNEGL | 1,2 |
| *Carex cristatella* | Crested sedge | FACW+ | PNEGL | 1,2 |
| *Carex gracillima* | Graceful sedge | FACU* | PNGL | 1,2 |
| *Carex intumescens* | Bladder sedge | FACW+ | PNGL | 1,2 |

TABLE 2 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Carex lacustris* | Lakebank sedge | OBL | PNEGL | 1 |
| *Carex lupulina* | Hop sedge | OBL | PNEGL | 1,2 |
| *Carex normalis* | Larger straw sedge | FACW | PNGL | 1,2 |
| *Carex pedunculata* | Peduncled sedge | | | 2 |
| *Carex rosea* | Rose-like sedge | | | 1,2 |
| *Carex scoparia* | Pointed broom sedge | FACW | PNGL | 1 |
| *Carex stipata* | Crowded sedge | | | 1,2 |
| *Carex stricta* | Uptight sedge | OBL | PNEGL | 1 |
| *Carex tenera* | Slender sedge | FAC+ | PNGL | 1,2 |
| *Carex tuckermanii* | Tuckerman's sedge | OBL | PNGL | 1,2 |
| *Carpinus caroliniana* | American hornbean | FAC | NT | 1,2 |
| *Centaurea maculosa* | Spotted knapweed | | | |
| *Cephalanthus occidentalis* | Common buttonbush | OBL | NT | |
| *Cicuta maculata* | Spotted water-hemlock | OBL | PNF | 1,2 |
| *Cinna arundinacea* | Stout wood-reedgrass | FACW | PNG | 1,2 |
| *Circaea lutetiana* | Southern broad-leaf Enchanter's nightshade | FACU | PNF | 1 |
| *Cirsium arvense* | Creeping thistle | FACU | BIF | 1 |
| *Cirsium vulgare* | Bull thistle | FACU- | BIF | 1,2 |
| *Clintonia borealis* | Blue breadlily | FAC+ | PNF | 1,2 |
| *Conyza canadensis* | Canada horseweed | FAC- | ANF | 1 |
| *Cornus canadensis* | Canada bunchberry | FAC | NS | 1,2 |
| *Cornus foemina* | Stiff dogwood | FACW- | NS | 1,2 |
| *Cornus stolonifera* | Red-osier dogwood | FACW | NS | 1 |
| *Crataegus punctata* | Dotted hawthorn | | | 1,2 |
| *Crataegus* sp. | Hawthorn | | | |
| *Cryptotaenia canadensis* | Canada honewort | FAC | PNF | |
| *Cypripedium acaule* | Pink lady's slipper | FACW | PNF | |
| *Cypripedium calceolus* | Small yellow lady's slipper | FAC+ | PNF | 1 |
| *Desmodium candense* | Showy tick trefoil | FAC- | PNF | 1 |
| *Desmodium glutinosum* | Pointed-leaved tick trefoil | | | 1,2 |
| *Diervilla lonicera* | Northern bush honeysuckle | | | 1 |
| *Dryopteris austriaca* var. *spinulosa* (=*D. dilatata*) | Mountain woodfern | FAC | PNF3 | 1,2 |
| *Echinochloa crusgalli* | Barnyard grass | FACW | AIG | |
| *Elymus virginicus* | Virginia wild-rye | FACW- | PNG | 1,2 |
| *Epilobium ciliatum* | Hairy willow-herb | FACU | PNF | 1 |

TABLE 2 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Epilobium coloratum* | Purple-leaf willow-herb | OBL | PNF | 1,2 |
| *Equisetum arvense* | Field horsetail | FAC | PNH2 | 2 |
| *Erigeron philadelphicus* | Philadelphia fleabane | FACW | BNF | 2 |
| *Erigeron strigosus* | Prairie fleabane | FAC- | ANF | |
| *Euonymus obovata* | Running strawberry bush | | | 1,2 |
| *Eupatorium perfoliatum* | Common boneset | FACW+ | PNF | 1,2 |
| *Fagus grandifolia* | American beech | FACU | NT | 1 |
| *Festuca obtusa* | Nodding fescue | FACU+ | PNG | 1,2 |
| *Fragaria virginiana* | Virginia strawberry | FAC- | PNF | 1,2 |
| *Fraxinus pennsylvanica* var. *subintegerrima* | Green ash | FACW | NT | 1,2 |
| *Galium asprellum* | Rough bedstraw | OBL | PNF | 1,2 |
| *Galium obtusum* | Blunt-leaf bedstraw | FACW+ | PNF | 1,2 |
| *Galium triflorum* | Sweet-scent bedstraw | FACU+ | PNF | 1,2 |
| *Gaultheria procumbens* | Teaberry | FACU | NS | 1,2 |
| *Geranium maculatum* | Purple crane's bill | FACU | PNF | 1,2 |
| *Glyceria striata* | Fowl manna grass | OBL | PNEG | 1,2 |
| *Hamamelis virginiana* | American witch-hazel | FACU | NST | |
| *Helianthus giganteus* | Tall sunflower | FACW | PNF | 2 |
| *Hieracium aurantiacum* | Orange hawkweed | | | |
| *Hypericum perforatum* | Common St. John's-wort | | | |
| *Ilex verticillata* | Common winterberry | FACU+ | NTS | 1,2 |
| *Iris virginica* | Virginia blueflag | OBL | PNF | 1 |
| *Juglans nigra* | Black walnut | FACU | NT | |
| *Juncus articulatus* | Jointed rush | OBL | PNGL | |
| *Juncus brevicaudatus* | Narrow-panicle rush | OBL | PNGL | |
| *Juncus bufonius* | Toad rush | FACW+ | ANGL | |
| *Lilium michiganense* (=*L. canadense*) | Canada lily | FAC+ | PNF | 2 |
| *Lolium perenne* | Perennial ryegrass | FACU | PIG | 1,2 |
| *Lonicera dioica* | Mountain honeysuckle | FACU | NWV | 1,2 |
| *Lotus corniculata* | Birds-foot trefoil | FAC- | PIF | 1,2 |
| *Lycopodium clavatum* | Running pine | FAC | PNC | |
| *Lycopodium obscurum* | Tree clubmoss | FACU | PNC | 2 |
| *Lycopodium tristachyum* | Ground pine | | | |
| *Lycopus americanus* | American bugleweed | OBL | PNF | 1,2 |
| *Lycopus virginicus* | Virginia bugleweed | OBL | PNF | 1,2 |
| *Maianthemum canadense* | Wild lily-of-the-valley | FAC | PNF | 1,2 |

TABLE 2 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Medeola virginiana* | Indian cucumber root | | | 1,2 |
| *Melampyrum lineare* | American cow-wheat | FAC- | AIF | |
| *Mentha arvensis* | Field mint | FACW | PNF | |
| *Mimulus ringens* | Allegheny monkey-flower | OBL | PNF | |
| *Mitella diphylla* | Two-leaf bishop's-cap | FACU+ | PNF | 1,2 |
| *Mollugo verticillata* | Green carpet-weed | FAC | ANF | |
| *Monarda fistulosa* | Wild bergamot | FACU | PNF | |
| *Muhlenbergia mexicana* | Mexican muhly | FACW | PNG | 1,2 |
| *Naumbergia thyrsiflora* (=*Lysimachia thyrisiflora*) | Tufted loosestrife | OBL | PIF | 1,2 |
| *Onoclea sensibilis* | Sensitive fern | FACW | PNEF3 | 1,2 |
| *Osmorhiza claytonii* | Hairy sweetcicely | FACU- | PNF | 1 |
| *Osmorhiza longistylis* | Smoother sweetcicely | FACU- | PNF | 1,2 |
| *Osmunda cinnamomea* | Cinnamon fern | FACW | PNEF3 | 2 |
| *Osmunda regalis* | Royal fern | OBL | PNF3 | 1,2 |
| *Ostrya virginiana* | Eastern hop-hornbean | FACU | NT | 1 |
| *Oxalis fontana* (=*O. europaea*) | Upright yellow wood sorrel | FACU | PIF | 1 |
| *Oxalis stricta* | Yellow wood sorrel | | | |
| *Panicum boreale* (=*Diachanthelium boreale*) | Northern witch grass | FACU+ | PNG | 1 |
| *Parthenocissus quinquefolia* | Virginia creeper | FAC- | NWV | 1,2 |
| *Penthorum sedoides* | Ditch-stonecrop | OBL | PNF | |
| *Phalaris arundinacea* | Reed canary grass | FACW+ | PNG | |
| *Phleum pratense* | Timothy | FACU | PIG | 1,2 |
| *Plantago rugelii* | Black-seeded plantain | FAC | PNF | 1,2 |
| *Poa palustris* | Fowl bluegrass | FACW+ | PNG | 1 |
| *Poa pratensis* | Kentucky bluegrass | FAC- | PNG | 1,2 |
| *Podophyllum peltatum* | Mayapple | FACU | PNF | 2 |
| *Polygala paucifolia* | Gay wings | FACU | PNF | 1,2 |
| *Polygonatum pubescens* | Hairy Solomon's-seal | | | 1,2 |
| *Polygonum pensylvanicum* | Pennsylvania smartweed | FACW+ | ANEF | |
| *Polygonum virginianum* | Virginia knotweed | FAC | APNF | |
| *Populus deltoides* | Eastern cottonwood | FAC+ | NT | 1,2 |
| *Populus grandidentata* | Big-tooth aspen | FACU | NT | 1 |
| *Populus tremuloides* | Quaking aspen | FAC | | 1,2 |
| *Potentilla simplex* | Old field cinquefoil | FACU- | PNF | |
| *Prenanthes altissima* | Tall rattlesnake-root | FACU | PNF | 1,2 |

TABLE 2 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Prunella vulgaris* | Heal-all | FAC | PIF | 1 |
| *Prunus pensylvanica* | Fire cherry | FACU-* | NST | 2 |
| *Prunus serotina* | Black cherry | FACU | NT | 1 |
| *Prunus virginiana* | Choke cherry | FAC- | NST | 1,2 |
| *Pteridium aquilinum* | Bracken fern | FACU | PNF3 | 1,2 |
| *Pyrola elliptica* | Shinleaf | | | 1 |
| *Quercus bicolor* | Swamp white oak | FACW+ | NT | 1,2 |
| *Quercus rubra* var. *borealis* | Northern red oak | FACU | NT | 1,2 |
| *Ranunculus abortivis* | Subalpine butter-cup | FACW- | BPNF | 2 |
| *Ranunculus pensylvanicus* | Pennsylvania butter-cup | OBL | APNEF | |
| *Ranunculus recurvatus* | Hooked butter-cup | FACW | PNF | 1,2 |
| *Rhamnus alnifolia* | Alder-leaf buckthorn | OBL | NS | 2 |
| *Ribes americanum* | Wild black currant | FACW | NS | 1,2 |
| *Ribes cynosbati* | Prickly gooseberry | | | 1,2 |
| *Rorippa palustris* | Bog yellowcress | OBL | ANEF | |
| *Rosa palustris* | Swamp rose | OBL | NS | 1 |
| *Rubus allegheniensis complex* | Allegheny blackberry | FACU+ | NS | 1,2 |
| *Rubus hispidus* | Bristly blackberry | FACW | NS | 1 |
| *Rubus idaeus* var. *strigosus* (=*R. strigosus*) | Red raspberry | FACW- | PNS | 1,2 |
| *Rubus pubescens* | Dwarf blackberry | FACW+ | PNF | 1,2 |
| *Rudbeckia hirta* | Black-eyed Susan | FACU | BPNF | |
| *Salix amygdaloides* | Peach-leaf willow | FACW | NT | 1,2 |
| *Salix bebbiana* | Bebb willow | FACW+ | NS | 1 |
| *Salix discolor* | Pussywillow | FACW | NS | |
| *Salix exigua* | Sandbar willow | OBL | NS | |
| *Salix fragilis* | Crack willow | FAC+ | IT | 1,2 |
| *Salix rigida* | Heart-leaf willow | FACW+ | NS | |
| *Sanicula gregaria* | Clustered black-snakeroot | FAC+ | PNF | |
| *Sanicula marilandica* | Black-snakeroot | NI | PNF | |
| *Scirpus atrovirens* | Green bulrush | OBL | PNEGL | 1 |
| *Scutellaria lateriflora* | Blue skullcap | OBL | PNF | 1,2 |
| *Sium suave* | Hemlock water-parsnip | OBL | PNEF | |
| *Smilacina racemosa* | Feathered false-Solomon's-seal | FACU | PNF | 1,2 |
| *Smilax tamnoides* | Bristly greenbrier | | | 1,2 |
| *Solidago altissima* | Tall golden-rod | FACU | PNF | |
| *Solidago gigantea* | Giant golden-rod | FACW | PNF | 1 |

TABLE 2 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Solidago graminifolia* (=*Euthamia graminifolia*) | Flat-top fragrant golden-rod | FACW- | PNF | 1 |
| *Solidago juncea* | Early golden-rod | | | |
| *Solidago rugosa* | Wrinkled golden-rod | FAC+ | PNF | 1,2 |
| *Solidago ulmifolia* | Elm-leaved golden-rod | | | 1,2 |
| *Sonchus uliginosus* (=*S. arvensis)* | Field sowthistle | FAC- | PIF | |
| *Spiraea alba* | Narrow-leaf meadow-sweet | FACW+ | NS | 1,2 |
| *Steironema ciliatum* (=*Lysimachia ciliatum*) | Fringed loosestrife | FACW | PNF | 1,2 |
| *Stellaria longifolia* | Long-leaf starwort | FACW+ | PNF | 1 |
| *Taraxacum officinale* | Common dandelion | FACU | PIF | 1,2 |
| *Thelypteris palustris* (=*T. thelypteroides*) | Marsh fern | FACW+ | F3 | 1,2 |
| *Tilia americana* | American basswood | FACU | NT | 1,2 |
| *Toxicodendron radicans* | Poison ivy | FAC+ | NWVS | 1,2 |
| *Trientalis borealis* | American starflower | FAC+ | PNF | 1 |
| *Trifolium repens* | White clover | FACU+ | PIF | 1,2 |
| *Trillium grandiflorum* | Large-flowered trillium | | | 1,2 |
| *Ulmus americana* | American elm | FACW- | NT | 1,2 |
| *Uvularia grandiflora* | Large-flowered bellwort | | | 2 |
| *Vaccinium corymbosum* | Highbush blueberry | FACW | NS | 1,2 |
| *Verbena hastata* | Blue vervain | FACW+ | PNF | 1,2 |
| *Viburnum acerifolium* | Maple-leaved arrowwood | | | 1 |
| *Viburnum cassinoides* | Withe-rod | FACW | NS | 1,2 |
| *Viburnum lentago* | Nannyberry | FAC+ | NTS | 1,2 |
| *Viola blanda* var. *palustris* | Sweet white violet | FACW- | PNF | 1,2 |
| *Viola conspersa* | American dog violet | FACW- | PNF | 1,2 |
| *Viola macloskeyi* | Smooth white violet | | | 2 |
| *Viola pubescens* | Downy yellow violet | FACU- | PNF | 1,2 |
| *Vitis riparia* | River-bank grape | FACW- | NWV | 1,2 |

TABLE 2 (Cont'd)

Footnotes:

[a]Names in parentheses indicate synonyms used in Reed (1988).

[b]Region 3 indicator categories are from Reed (1988) as follows:

| | | |
|---|---|---|
| FAC | = | Facultative, equally likely to occur in wetlands or nonwetlands. |
| FACU | = | Facultative upland, usually occur in nonwetlands but occasionally found in wetlands. |
| FACW | = | Facultative wetland, usually occur in wetlands but occasionally found in nonwetlands. |
| NI | = | No indicator, insufficient information available to determine an indicator status. |
| OBL | = | Obligate wetland, almost always occur in wetlands under natural conditions. |

+ following an indicator indicates a frequency toward the high end of the category (more frequently found in wetlands).
- following an indicator indicates a frequency toward the low end of the category (less frequently found in wetlands).
* identifies tentative assignments.

[c]Plant habit codes are as follows:

| | | | | | |
|---|---|---|---|---|---|
| A | = | Annual | HS | = | Half shrub |
| B | = | Biennial | H2 | = | Horsetail |
| C | = | Clubmoss | I | = | Introduced |
| E | = | Emergent | N | = | Native |
| F | = | Forb | P | = | Perennial |
| F3 | = | Fern | S | = | Shrub |
| G | = | Grass | T | = | Tree |
| GL | = | Grasslike Cyperaceae | V | = | Herbaceous vine and Juncaceae |
| H | = | Partly woody | WV | = | Woody vine |

[d]Numbers indicate whether species were recorded for Site 1 or Site 2. If no numbers are listed, plants were recorded for surrounding areas but not within study sites.

TABLE 3 Provisional List of Plants Found on the Right-of-Way, Midland County, July 1989-August 1990

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Achillia millefolium* | Common yarrow | FACU | PNF | 1 |
| *Agrimonia gryposepala* | Hairy tall groovebur | FACU+ | PNF | |
| *Agrostis gigantea* | Black bent grass | NI | PNG | 1,2[e] |
| *Alisma plantago-aquatica* | Broad-leaf water plantain | OBL | PNEF | |
| *Ambrosia artemisiifolia* | Annual ragweed | FACU | ANF | 1,2 |
| *Asclepias incarnata* | Swamp milkweed | OBL | PNF | |
| *Aster graminifolia* | Aster | | | 2 |
| *Bromus inermis* | Smooth brome | | | 2 |
| *Bromus japonicus* | Japanese brome | FACU | AIG | |
| *Carex vulpinoidea* | Fox sedge | OBL | PNEGL | 1,2 |
| *Centaurea maculosa* | Spotted knapweed | | | |
| *Cerastium fontanum* (=*C. vulgatum*) | Common mouse-ear chickweed | FACU | PIF | |
| *Circea lutetiana* | Southern broad-leaf Enchanter's nightshade | FACU | PNF | 1 |
| *Cirsium arvense* | Creeping thistle | FACU | PIF | 1,2[e] |
| *Cirsium vulgare* | Bull thistle | FACU- | BIF | 1[e] |
| *Conyza canadensis* | Canada horseweed | FAC- | ANF | 1,2[e] |
| *Dactylis glomerata* | Orchard grass | FACU | PIG | |
| *Echinochloa crusgalli* | Barnyard grass | FACW | AIG | 1,2 |
| *Eleocharis obtusa* | Blunt spikerush | OBL | APNEGL | |
| *Erigeron philadelphicus* | Philadelphia fleabane | FACW | BIF | |
| *Erigeron strigosus* | Prairie fleabane | FAC- | ANF | |
| *Eupatorium perfoliatum* | Common boneset | FACW+ | PNF | 1,2[e] |
| *Festuca arundinacea* | Kentucky fescue | FACU+ | PIG | 1,2 |
| *Glyceria striata* | Fowl manna grass | OBL | PNEG | 1,2 |
| *Hieracium auranthiacum* | Orange hawkweed | | | |
| *Hieracium florentinum* | | | | |
| *Hieracium pratense* | | | | |
| *Hypericum majus* | Large Canadian St. John's-wort | FACW | ANF | |
| *Hypericum perforatum* | Common St. John's-wort | | | |
| *Juncus articulatus* | Jointed rush | OBL | PNGL | 1,2[e] |
| *Juncus brevicaudata* | Narrow-panicle rush | OBL | PNGL | |
| *Juncus bufonius* | Toad rush | FACW+ | ANGL | 1,2 |
| *Juncus effusus* | Soft rush | OBL | PNEGL | |
| *Lobelia cardinalis* | Cardinal flower | OBL | PNF | 2[e] |

TABLE 3 (Cont'd)

| Species Name[a] | Common Name | Region 3 Wetland Index[b] | Plant Habit[c] | Sites Where Recorded[d] |
|---|---|---|---|---|
| *Lolium perenne* | Perennial ryegrass | FACU | PIG | 1,2[e] |
| *Lotus corniculata* | Birds-foot trefoil | FAC- | PIF | 1,2[e] |
| *Medicago lupulina* | Black medic | FAC- | AIF | |
| *Melampyrum lineare* | American cow-wheat | FAC- | AIF | |
| *Mimulus ringens* | Allegheny monkey-flower | OBL | PNF | 1[e] |
| *Panicum implicatum (=Dichanthelium acuminatum)* | Panic grass | FAC | PNG | 1,2[e] |
| *Penthorum sedoides* | Ditch-stonecrop | OBL | PNF | 1,2[e] |
| *Phleum pratense* | Timothy | FACU | PIG | 1 |
| *Plantago major* | Common plantain | FAC+ | PIF | 1,2[e] |
| *Poa pratensis* | Kentucky bluegrass | FAC- | PNG | |
| *Polygonum* sp. | | | | 2[e] |
| *Potentilla norvegica* | Norwegian cinquefoil | FAC | ABPNF | 1,2[e] |
| *Potentilla simplex* | Old field cinquefoil | FACU- | PNF | |
| *Ranunculus pensylvanicus* | Pennsylvania butter-cup | OBL | APNEF | |
| *Ranunculus recurvatus* | Hooked butter-cup | FACW | PNF | |
| *Ranunculus scleratus* | Celery-leaf butter-cup | OBL | APNEF | |
| *Rorippa palustris* | Bog yellow cress | OBL | ANEF | |
| *Rudbeckia hirta* | Black-eyed susan | FACU | BPNF | 1[e] |
| *Salix amygdaloides* | Peach-leaf willow | FACW | NT | 1,2[e] |
| *Salix exigua* | Sandbar willow | OBL | NS | 1,2[e] |
| *Sanicula gregaria* | Clustered black-snakeroot | FAC+ | PNF | |
| *Sanicula marilandica* | Black-snakeroot | NI | PNF | |
| *Scirpus acutus* | Hard-stem bulrush | OBL | PNEGL | 1,2 |
| *Solidago graminifolia (=Euthamia graminifolia)* | Flat-top fragrant goldenrod | FACW- | PNF | 1,2[e] |
| *Trifolium repens* | White clover | FACU+ | PIF | 1,2[e] |
| *Typha* sp. | Cattail | OBL | PNEF | 1,2 |
| *Verbascum thapsus* | Common mullein | | | 1 |
| *Verbena hastata* | Blue vervain | | | 1 |

TABLE 3 (Cont'd)

Footnotes:

[a]Names in parentheses indicate synonyms used in Reed (1988).

[b]Region 3 indicator categories are from Reed (1988) as follows:

| | | |
|---|---|---|
| FAC | = | Facultative, equally likely to occur in wetlands or nonwetlands. |
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+ following an indicator indicates a frequency toward the high end of the category (more frequently found in wetlands).
- following an indicator indicates a frequency toward the low end of the category (less frequently found in wetlands).
* identifies tentative assignments.

[c]Plant habit codes are as follows:

| | | | | | |
|---|---|---|---|---|---|
| A | = | Annual | HS | = | Half shrub |
| B | = | Biennial | H2 | = | Horsetail |
| C | = | Clubmoss | I | = | Introduced |
| E | = | Emergent | N | = | Native |
| F | = | Forb | P | = | Perennial |
| F3 | = | Fern | S | = | Shrub |
| G | = | Grass | T | = | Tree |
| GL | = | Grasslike Cyperaceae | V | = | Herbaceous vine and Juncaceae |
| H | = | Partly woody | WV | = | Woody vine |

[d]Numbers indicate whether species were recorded for Site 1 or Site 2. If no numbers are listed, plants were recorded for surrounding areas but not within study sites.

[e]Indicates that the plants occurred up to 5 m north of the ROW in areas of disturbance.

# 11 Recommendations

Recommendations based on observations made during the first two years of the study are listed here:

1. Construction contracts should ensure that the logs from the ROW are properly removed to avoid potential adverse ecological impacts on native plant communities.

2. Care should be taken to ensure that excavated soil does not spill beyond the boundaries of the ROW, causing adverse ecological impacts in adjacent native plant communities.

3. Water pumped from the pipe ditch should be directed so that it will not cause soil erosion or deposition that could adversely affect adjacent native plant communities.

4. Stumps that were allowed to remain on the ROW, even when cut to ground level, did provide protection to some floristic elements throughout the construction activities. Hence, the policy of removing only those stumps necessary for installation of the pipe should be continued.

5. Seeding the ROW of the study sites was probably unnecessary due to its level topography, poor drainage, and apparently abundant soil reserve of native plant propagules. Seeding areas consisting of native vegetation should only be done when deemed necessary to control erosion. Furthermore, it should be done with native species, if at all possible, and should use methods involving minimal soil disturbance to conserve the soil bank of plant propogules.

An incidental note: During the summer of 1990, it was noted that ditches along county roads just southeast of the study sites were deepened by the county. These deeper ditches could provide increased drainage of the general area and might even lower water levels in the study sites. Pipeline companies should take careful note of any such activities to ensure that any negative impacts on affected wetlands are not attributed to the construction and maintenance of the ROW.

Recommendations for completion of the present phase of this study are as follows:

1. Field data collection should be continued through the 1992 growing season using present procedures, followed by a complete data analysis and the preparation of a report on the initial phase of this study.

2. Recommendations for additional data collection after 1992 should be made on the basis of an analysis of the stage of development of the vegetation on the ROW. The recommendations should include time intervals for such studies (for

example, every five years) until two successive sets of data indicate that stable communities have formed on the ROW.

3. An analysis of any changes that may have occurred in the edge of the forest adjacent to the ROW should be used to make recommendations for follow-up studies in the forest edge. Again, studies should continue at intervals to be determined until stabilization occurs.

Suggestions for related studies are provided below:

1. Studies comparing the ecological impacts of different ROW maintenance practices on wetland vegetation are needed.

2. Studies on the ecological impacts of off-road vehicles on ROW wetland vegetation should be considered.

3. The ecological impacts of the corduroy (slash) road on the development of wetland vegetation should be studied.

4. Whether or not seeding with introduced agronomic species enhances or retards the development of native vegetation on the ROW needs to be investigated.

5. If negative vegetational impacts are noted in the edge of the forest adjacent to the edge of the ROW because of increased wind and light penetration, studies should be designed to test different ways to minimize such impacts, such as the planting of native shrubs on the ROW adjacent to the forests.

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## Appendix A:

## Description of the Typical Pedon for Lenawee Silty Clay Loam in Midland County*

Ap 0 to 9 in.; black (10YR 2/1) silty clay loam, gray (10YR 5/1) dry; moderate fine granular structure; firm; few fine roots; slightly acid; abrupt smooth boundary.

B21g 9 to 18 in.; dark grayish brown (10YR 4/2) silty clay loam; few fine prominent yellowish brown (7.5YR 5/6, 5/8) mottles; moderate medium angular blocky structure; firm; few fine roots; slightly acid; clear wavy boundary.

B22g 18 to 25 in.; light brownish gray (10YR 6/2) silty clay; common medium prominent strong brown (7.5YR 5/6, 5/8) mottles; moderate medium angular blocky structure; firm; neutral; gradual wavy boundary.

B23g 25 to 40 in.; grayish brown (10YR 5/2) silty clay; common fine faint light brownish gray (10YR 6/2) and common medium prominent strong brown (7.5YR 5/6, 5/8) mottles; massive; very firm; medium acid; clear wavy boundary.

C1g 40 to 46 in.; reddish gray (5YR 5/2) silty clay; common fine prominent light brownish gray (2.5Y 6/2), strong brown (7.5YR 5/6), and reddish yellow (7.5YR 6/8) mottles; massive; very firm; slight effervescence; mildly alkaline; clear wavy boundary.

C2g 46 to 52 in.; reddish brown (5YR 5/3) silty clay; common fine prominent grayish brown (2.5Y 5/2) and common medium prominent strong brown (7.5YR 5/6) mottles; massive; very firm; strong effervescence; moderately alkaline; clear wavy boundary.

C3g 52 to 60 in.; grayish brown (2.5Y 5/2) silty clay; common medium prominent reddish brown (5YR 5/4) and reddish yellow (5YR 6/6, 6/8) mottles; massive; very firm; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 25 to 50 in. The solum ranges from medium acid to neutral in the A and B21g horizons and from slightly acid to mildly alkaline in the lower part of the B horizon. The clay content in the control section averages between 35% and 45%.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is dominantly silty clay loam but in places is silt loam and loam. Some pedons have an A2 horizon.

The B horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 1 or 2. It is silty clay loam or silty clay and contains thin layers of silt loam, clay, or very fine sand. Some pedons have a B1 horizon.

The C horizon has hue of 5YR to 10YR, value of 5 or 6, and chroma of 2 to 6. It is stratified silt loam to silty clay. Reaction is mildly alkaline or moderately alkaline.

*Source: Hutchison (1979), pg. 36.

## Appendix B:

## Selected Vascular Plants in Lower Michigan

This is a selected list of vascular plants with distributions in the lower peninsula of Michigan from the transition zone northward or from the transition zone southward (Voss 1972, 1985).

| Plant Name | Location | Vol. | Page |
|---|---|---|---|
| *Sparganium angustifolium* | N | 1 | 82 |
| *Beckmannia syzigachne* | N | 1 | 206 |
| *Carex adusta* | N | 1 | 278 |
| *Carex aenea* | N | 1 | 278 |
| *Carex houghtoniana* | N | 1 | 310 |
| *Scirpus microcarpus* | N | 1 | 358 |
| *Calypso bulbosa* | N | 1 | 438 |
| *Arceuthobium pusillum* | N | 2 | 100 |
| *Arabis caucasica* | N | 2 | 294 |
| *Ribes glandulosum* | N | 2 | 333 |
| *Ribes hudsonianum* | N | 2 | 333 |
| *Potentilla tridentata* | N | 2 | 429 |
| *Tamarix parviflora* | N | 2 | 583 |
| *Epilobium palustre* | N | 2 | 621 |
| *Juniperus virginiana* | S | 1 | 68 |
| *Eragrostis pilosa* | S | 1 | 122 |
| *Briza media* | S | 1 | 130 |
| *Bromus pubescens* | S | 1 | 135 |
| *Puccinellia distans* | S | 1 | 148 |
| *Cinna arundinacea* | S | 1 | 198 |
| *Leersia virginica* | S | 1 | 212 |
| *Carex seorsa* | S | 1 | 270 |
| *Carex muskingumensis* | S | 1 | 278 |
| *Carex gracilescens* | S | 1 | 300 |
| *Carex amphibola* | S | 1 | 304 |
| *Carex swanii* | S | 1 | 309 |
| *Carex hirsutella* | S | 1 | 309 |
| *Carex haydenii* | S | 1 | 313 |
| *Carex emoryi* | S | 1 | 315 |
| *Carex lupuliformis* | S | 1 | 330 |
| *Arisaema dracontium* | S | 1 | 367 |
| *Polygonatum biflorum* | S | 1 | 400 |
| *Allium canadense* | S | 1 | 414 |

| Plant Name | Location | Vol. | Page |
|---|---|---|---|
| *Hypoxis hirsuta* | S | 1 | 424 |
| *Sisyrinchium atlanticum* | S | 1 | 429 |
| *Habenaria ciliaris* | S | 1 | 442 |
| *Corallorhiza odontorhiza* | S | 1 | 452 |
| *Liparis liliifolia* | S | 1 | 454 |
| *Saururus cernuus* | S | 2 | 40 |
| *Salix sericea* | S | 2 | 49 |
| *Carya glabra* | S | 2 | 59 |
| *Quercus bicolor* | S | 2 | 82 |
| *Quercus muehlenbergii* | S | 2 | 84 |
| *Polygonum virginianum* | S | 2 | 119 |
| *Polygonum orientale* | S | 2 | 123 |
| *Chenopodium rubrum* | S | 2 | 140 |
| *Chenopodium urbicum* | S | 2 | 141 |
| *Amaranthus tuberculatus* | S | 2 | 146 |
| *Amaranthus hypochondriacus* | S | 2 | 149 |
| *Portulaca grandiflora* | S | 2 | 153 |
| *Silene virginica* | S | 2 | 183 |
| *Nuphar advena* | S | 2 | 199 |
| *Isopyrum biternatum* | S | 2 | 225 |
| *Jeffersonia diphylla* | S | 2 | 232 |
| *Liriodendron tulipifera* | S | 2 | 236 |
| *Cardamine hirsuta* | S | 2 | 285 |
| *Arabis laevigata* | S | 2 | 295 |
| *Sedum ternatum* | S | 2 | 316 |
| *Crataegus crus-galli* | S | 2 | 399 |
| *Crataegus pruinosa* | S | 2 | 408 |
| *Crataegus mollis* | S | 2 | 408 |
| *Crataegus lucorum* | S | 2 | 413 |
| *Agrimonia parviflora* | S | 2 | 442 |
| *Agrimonia pubescens* | S | 2 | 443 |
| *Trifolium dubium* | S | 2 | 455 |
| *Desmodium paniculatum* | S | 2 | 467 |
| *Lespedeza hirta* | S | 2 | 470 |
| *Oxalis corniculata* | S | 2 | 503 |
| *Euonymus atropurpurea* | S | 2 | 544 |
| *Althaea officinalis* | S | 2 | 573 |
| *Elaeagnus angustifolia* | S | 2 | 605 |
| *Hydrocotyle umbellata* | S | 2 | 652 |

# Appendix C:

# Woody Plants In Missaukee County

This is a list of presence classes for tree and shrub species in 98 stands of upland second-growth hardwoods in Missaukee County, Michigan (Elliott, 1953, pg. 275).

| Plant Name | Percent | Class |
|---|---|---|
| Trees | | |
| *Acer saccharum* | 95 | 5 |
| *Fagus grandifolia* | 86 | 5 |
| *Ulmus americana* | 57 | 3 |
| *Tilia americana* | 57 | 3 |
| *Fraxinus americana* | 43 | 3 |
| *Ulmus thomasi* | 35 | 2 |
| *Ulmus rubra* | 33 | 2 |
| *Prunus serotina* | 40 | 2 |
| *Acer rubrum* | 30 | 2 |
| *Tsuga canadensis* | 37 | 2 |
| *Betula lutea* | 19 | 1 |
| *Betula papyrifera* | 9 | 1 |
| *Quercus rubra* var. *borealis* | 15 | 1 |
| *Quercus alba* | 5 | 1 |
| *Pinus strobus* | 5 | 1 |
| *Pinus resinosa* | 3 | 1 |
| *Thuja occidentalis* | 4 | 1 |
| *Fraxinus nigra* | 1 | 1 |
| *Ostrya virginiana* | 58 | 3 |
| *Prunus pensylvanica* | 41 | 3 |
| *Populus grandidentata* | 22 | 2 |
| *Populus tremuloides* | 3 | 1 |
| *Amelanchier* sp. | 8 | 1 |
| *Crataegus* sp. | 1 | 1 |
| Shrubs | | |
| *Acer spicatum* | 4 | 1 |
| *Corylus cornuta* | 8 | 1 |
| *Cornus alternifolia* | 12 | 1 |
| *Ribes cynosbati* | 2 | 1 |
| *Rosa* sp. | 1 | 1 |
| *Sambucus pubens* | 3 | 1 |
| *Viburnum acerifolium* | 6 | 1 |
| *Spiraea* sp. | 1 | 1 |

# Appendix D:

## Field Data Sheet Used to Record Cover-Class Numbers and Selected Shoot Counts for Understory Taxa

COVER CLASS DATA SHEET FOR ANL/GRI ROW PROJECT, MIDLAND CO., MI

REMARKS

Page:_____ of _____Page(s). Serial Number: ____________________

Site: _______________ Date(d/m/y): ____________________

Transect Number: ______ Quadrat Size: __________ Number: ______

Data Collector(s): ______________________________

(1)= 0-5% (2)= 5-25% (3)= 25-50% (4)= 50-75% (5)= 75-95% (6)= 95-100%

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | M Pt | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 |
| | O/E | | | | | | | | | | | | | | | | | | | | |
| | Q No | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| | M Pt | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 71 | 73 | 75 | 77 | 79 | 81 | 83 | 85 | 87 | 89 | 91 | 93 |
| TAXON | O/E | | | | | | | | | | | | | | | | | | | | |

| TAXON | | | | | | | | | | | | | | | | | | | | | | FILE NAME |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
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| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
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| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
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| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |
| | 01 | | | | | | | | | | | | | | | | | | | | | 20 |
| | 21 | | | | | | | | | | | | | | | | | | | | | 40 |

# Appendix E:

## Field Data Sheet Used to Record Stem Diameters for Overstory Taxa

TREE DATA GRI/ANL DECIDUOUS FOREST PIPELINE ROW STUDIES
MIDLAND CO. MICHIGAN

SITE NO.: ___ LOCATION: ___ 1/4 SECTION 25, T-14-N, R-2-W
PLOT LOCATION: ___ m. EAST, ___ m . NORTH OF SW EDGE OF FOREST
DATE:______________ WORKERS: ___________________________________

| TREE SPECIES | DIAMETERS GREATER THAN 2 CM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Acer rubrum | | | | | | | | | | |
| Acer | | | | | | | | | | |
| Betula papyrifera | | | | | | | | | | |
| Crataegus | | | | | | | | | | |
| Fagus grandifolia | | | | | | | | | | |
| Fraxinus americana | | | | | | | | | | |
| F. pensylvanica | | | | | | | | | | |
| Populus grandidentata | | | | | | | | | | |
| P. tremuloides | | | | | | | | | | |
| Prunus serotina | | | | | | | | | | |
| Quercus alba | | | | | | | | | | |
| Quercus bicolor | | | | | | | | | | |
| Q. coccinia | | | | | | | | | | |
| Q. rubra | | | | | | | | | | |
| Q. velutina | | | | | | | | | | |
| Salix bebbiana | | | | | | | | | | |
| Tilia americana | | | | | | | | | | |
| Ulmus americana | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

# Appendix F:

# Field Data Sheet Used to Map Overstory Taxa

TREE DATA GRI/ANL DECIDUOUS FOREST PIPELINE ROW STUDIES
MIDLAND CO. MICHIGAN

SITE NO.: ___ LOCATION: ___ 1/4 SECTION 25, T-14-N, R-2-W
PLOT LOCATION: ___ m. EAST, ___ m . NORTH OF SW EDGE OF FOREST
DATE:_____________ WORKERS: ________________________________

___N, ___E ___N, ___E

___N, ___E ___N, ___E

# Appendix G:

## Coordinates and Numbers for 10 x 10-Meter Plots Used to Analyze Overstory Taxa

| Site 1 | | | Site 2 | | |
|---|---|---|---|---|---|
| 00E, | 00N | 1000 | 00E, | 00N | 2000 |
| 10E, | 00N | 1001 | 10E, | 00N | 2001 |
| 20E, | 00N | 1002 | 20E, | 00N | 2002 |
| 30E, | 00N | 1003 | 30E, | 00N | 2003 |
| 40E, | 00N | 1004 | 40E, | 00N | 2004 |
| 50E, | 00N | 1005 | 50E, | 00N | 2005 |
| 60E, | 00N | 1006 | 60E, | 00N | 2006 |
| 70E, | 00N | 1007 | 70E, | 00N | 2007 |
| 80E, | 00N | 1008 | 80E, | 00N | 2008 |
| 90E, | 00N | 1009 | 90E, | 00N | 2009 |
| 00E, | 10N | 1100 | 00E, | 10N | 2100 |
| 10E, | 10N | 1101 | 10E, | 10N | 2101 |
| 20E, | 10N | 1102 | 20E, | 10N | 2102 |
| 30E, | 10N | 1103 | 30E, | 10N | 2103 |
| 40E, | 10N | 1104 | 40E, | 10N | 2104 |
| 50E, | 10N | 1105 | 50E, | 10N | 2105 |
| 60E, | 10N | 1106 | 60E, | 10N | 2106 |
| 70E, | 10N | 1107 | 70E, | 10N | 2107 |
| 80E, | 10N | 1108 | 80E, | 10N | 2108 |
| 90E, | 10N | 1109 | 90E, | 10N | 2109 |
| 00E, | 40N | 1400 | 00E, | 40N | 2400 |
| 10E, | 40N | 1401 | 10E, | 40N | 2401 |
| 20E, | 40N | 1402 | 20E, | 40N | 2402 |
| 30E, | 40N | 1403 | 30E, | 40N | 2403 |
| 40E, | 40N | 1404 | 40E, | 40N | 2404 |
| 50E, | 40N | 1405 | 50E, | 40N | 2405 |
| 60E, | 40N | 1406 | 60E, | 40N | 2406 |
| 70E, | 40N | 1407 | 70E, | 40N | 2407 |
| 80E, | 40N | 1408 | 80E, | 40N | 2408 |
| 90E, | 40N | 1409 | 90E, | 40N | 2409 |

# Appendix H:

# Taxon Data Sheet Used to Keep Records on Voucher Specimens

No. ______

**VASCULAR PLANTS OF MIDLAND COUNTY, MICHIGAN**

Taxon: ______

Common Name: ______

Family: ______

Location: South 1/2 of the SE SW 1/4 of Section 25, Township 14 North, Range 2 West, Midland County, MI.

Voucher Specimen: Deciduous Forest Component of the Right-of-Way Research Program conducted by Argonne National Laboratory for the Gas Research Institute (Contract Number 5082-254-0690). Project Mgr: S.D. Zellmer .

Habitat: Secondary growth mixed deciduous forest on a poorly drained Lenawee soil.

______ ______

Comments: ______

______

Collection No.: MI-______ Date: ______

Collected by: James R. Rastorfer and Gerrit D. Van Dyke

Voss 1: ______ Other Refs: ______

2: ______

3: ______

Gleason 1: ______

2: ______

3: ______

# Appendix I:
## Vascular Plants in Midland County

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Shr | Taxaceae | *Taxus canadensis* | W |
| Tre | Pinaceae | *Larix laricina* | W |
| Tre | Pinaceae | *Pinus strobus* | W |
| Tre | Pinaceae | *Pinus resinosa* | |
| Tre | Pinaceae | *Pinus banksiana* | D |
| Tre | Pinaceae | *Tsuga canadensis* | D |
| Tre | Cupressaceae | *Thuja occidentalis* | W |
| Hmc | Typhaceae | *Typha angustifolia* | |
| Hmc | Typhaceae | *Typha latifolia* | |
| Hmc | Sparganiaceae | *Sparganium eurycarpum* | |
| Hmc | Potamogetonaceae | *Potamogeton pectinatus* | |
| Hmc | Potamogetonaceae | *Potamogeton filiformis* | |
| Hmc | Potamogetonaceae | *Potamogeton richardsonii* | |
| Hmc | Potamogetonaceae | *Potamogeton nodosus* | |
| Hmc | Potamogetonaceae | *Potamogeton illinoensis* | |
| Hmc | Potamogetonaceae | *Potamogeton zosteriformis* | |
| Hmc | Potamogetonaceae | *Potamogeton foliosus* | |
| Hmc | Najadaceae | *Najas flexilis* | |
| Hmc | Alismataceae | *Sagittaria latifolia* | |
| Hmc | Alismataceae | *Alisma plantago-aquatica* | |
| Hmc | Hydrocharitaceae | *Vallisneria americana* | |
| Gra | Poaceae | *Schizachne purpurascens* | D |
| Gra | Poaceae | *Eragrostis hypnoides* | |
| Gra | Poaceae | *Eragrostis spectabilis* | |
| Gra | Poaceae | *Eragrostis pectinacea* | |
| Gra | Poaceae | *Poa saltuensis* | D |
| Gra | Poaceae | *Poa alsodes* | D |
| Gra | Poaceae | *Poa compressa* | |
| Gra | Poaceae | *Poa pratensis* | |
| Gra | Poaceae | *Poa palustris* | W |
| Gra | Poaceae | *Bromus tectorum* | |
| Gra | Poaceae | *Bromus latiglumis* | D |
| Gra | Poaceae | *Bromus pubescens* | D |
| Gra | Poaceae | *Festuca obtusa* | D |
| Gra | Poaceae | *Festuca ovina* | D |
| Gra | Poaceae | *Glyceria septentrionalis* | W |
| Gra | Poaceae | *Glyceria grandis* | |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Gra | Poaceae | *Glyceria striata* | W |
| Gra | Poaceae | *Triticum aestivum* | |
| Gra | Poaceae | *Elymus canadensis* | D |
| Gra | Poaceae | *Elymus virginicus* | W |
| Gra | Poaceae | *Elymus villosus* | W |
| Gra | Poaceae | *Hystrix patula* | W |
| Gra | Poaceae | *Hordeum jubatum* | |
| Gra | Poaceae | *Agropyron trachycaulum* | W |
| Gra | Poaceae | *Agropyron repens* | |
| Gra | Poaceae | *Sphenopholis intermedia* | D |
| Gra | Poaceae | *Danthonia spicata* | |
| Gra | Poaceae | *Brachyelytrum erectum* | W |
| Gra | Poaceae | *Oryzopsis asperifolia* | D |
| Gr | Poaceae | *Muhlenbergia mexicana* | D |
| Gra | Poaceae | *Phleum pratense* | |
| Gra | Poaceae | *Alopecurus aequalis* | |
| Gra | Poaceae | *Milium effusum* | D |
| Gra | Poaceae | *Sporobolus cryptandrus* | |
| Gra | Poaceae | *Calamagrostis canadensis* | |
| Gra | Poaceae | *Cinna latifolia* | W |
| Gra | Poaceae | *Agrostis gigantea* | W |
| Gra | Poaceae | *Agrostis stolonifera* | |
| Gra | Poaceae | *Spartina pectinata* | |
| Gra | Poaceae | *Phalaris arundinacea* | |
| Gra | Poaceae | *Leersia virginica* | |
| Gra | Poaceae | *Leersia oryzoides* | |
| Gra | Poaceae | *Cenchrus longispinus* | |
| Gra | Poaceae | *Echinochloa muricata* | |
| Gra | Poaceae | *Digitaria sanguinalis* | |
| Gra | Poaceae | *Panicum capillare* | |
| Gra | Poaceae | *Panicum latifolium* | D |
| Gra | Poaceae | *Panicum xanthophysum* | |
| Gra | Poaceae | *Panicum depauperatum* | |
| Gra | Poaceae | *Panicum linearifolium* | |
| Gra | Poaceae | *Panicum boreale* | |
| Gra | Poaceae | *Panicum columbianum* | D |
| Gra | Poaceae | *Panicum praecocius* | |
| Gra | Poaceae | *Panicum implicatum* | |
| Cyp | Cyperaceae | *Carex cephaloidea* | D |
| Cyp | Cyperaceae | *Carex sparganioides* | D |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Cyp | Cyperaceae | *Carex rosea* | D |
| Cyp | Cyperaceae | *Carex convoluta* | D |
| Cyp | Cyperaceae | *Carex muhlenbergii* | |
| Cyp | Cyperaceae | *Carex annectens* | |
| Cyp | Cyperaceae | *Carex vulpinoidea* | |
| Cyp | Cyperaceae | *Carex diandra* | |
| Cyp | Cyperaceae | *Carex alopecoidea* | D |
| Cyp | Cyperaceae | *Carex stipata* | D |
| Cyp | Cyperaceae | *Carex trisperma* | |
| Cyp | Cyperaceae | *Carex disperma* | |
| Cyp | Cyperaceae | *Carex brunnescens* | W |
| Cyp | Cyperaceae | *Carex canescens* | |
| Cyp | Cyperaceae | *Carex seorsa* | W |
| Cyp | Cyperaceae | *Carex interior* | |
| Cyp | Cyperaceae | *Carex atlantica* | |
| Cyp | Cyperaceae | *Carex bromoides* | W |
| Cyp | Cyperaceae | *Carex deweyana* | D |
| Cyp | Cyperaceae | *Carex aenea* | |
| Cyp | Cyperaceae | *Carex muskingumensis* | W |
| Cyp | Cyperaceae | *Carex cumulata* | |
| Cyp | Cyperaceae | *Carex brevior* | |
| Cyp | Cyperaceae | *Carex bebbii* | D |
| Cyp | Cyperaceae | *Carex cristatella* | W |
| Cyp | Cyperaceae | *Carex projecta* | W |
| Cyp | Cyperaceae | *Carex tribuloides* | W |
| Cyp | Cyperaceae | *Carex scoparia* | |
| Cyp | Cyperaceae | *Carex normalis* | D |
| Cyp | Cyperaceae | *Carex tenera* | D |
| Cyp | Cyperaceae | *Carex leptalea* | D |
| Cyp | Cyperaceae | *Carex rugosperma* | |
| Cyp | Cyperaceae | *Carex communis* | D |
| Cyp | Cyperaceae | *Carex lucorum* | |
| Cyp | Cyperaceae | *Carex pensylvanica* | D |
| Cyp | Cyperaceae | *Carex peckii* | D |
| Cyp | Cyperaceae | *Carex emmonsii* | |
| Cyp | Cyperaceae | *Carex pedunculata* | D |
| Cyp | Cyperaceae | *Carex hirtifolia* | D |
| Cyp | Cyperaceae | *Carex aurea* | D |
| Cyp | Cyperaceae | *Carex woodii* | D |
| Cyp | Cyperaceae | *Carex tetanica* | D |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Cyp | Cyperaceae | *Carex plantaginea* | D |
| Cyp | Cyperaceae | *Carex careyana* | D |
| Cyp | Cyperaceae | *Carex albursina* | D |
| Cyp | Cyperaceae | *Carex laxiculmis* | D |
| Cyp | Cyperaceae | *Carex digitalis* | D |
| Cyp | Cyperaceae | *Carex leptonervia* | D |
| Cyp | Cyperaceae | *Carex laxiflora* | D |
| Cyp | Cyperaceae | *Carex blanda* | D |
| Cyp | Cyperaceae | *Carex granularis* | W |
| Cyp | Cyperaceae | *Carex hitchcockiana* | D |
| Cyp | Cyperaceae | *Carex amphibola* | W |
| Cyp | Cyperaceae | *Carex prasina* | D |
| Cyp | Cyperaceae | *Carex gracillima* | W |
| Cyp | Cyperaceae | *Carex arctata* | D |
| Cyp | Cyperaceae | *Carex debilis* | D |
| Cyp | Cyperaceae | *Carex sprengelii* | D |
| Cyp | Cyperaceae | *Carex lanuginosa* | |
| Cyp | Cyperaceae | *Carex scabrata* | W |
| Cyp | Cyperaceae | *Carex paupercula* | |
| Cyp | Cyperaceae | *Carex haydenii* | |
| Cyp | Cyperaceae | *Carex emoryi* | |
| Cyp | Cyperaceae | *Carex stricta* | |
| Cyp | Cyperaceae | *Carex crinita* | W |
| Cyp | Cyperaceae | *Carex folliculata* | W |
| Cyp | Cyperaceae | *Carex comosa* | |
| Cyp | Cyperaceae | *Carex pseudo-cyperus* | |
| Cyp | Cyperaceae | *Carex hystericina* | |
| Cyp | Cyperaceae | *Carex tuckermanii* | W |
| Cyp | Cyperaceae | *Carex retrorsa* | W |
| Cyp | Cyperaceae | *Carex rostrata* | |
| Cyp | Cyperaceae | *Carex grayi* | D |
| Cyp | Cyperaceae | *Carex intumescens* | W |
| Cyp | Cyperaceae | *Carex lupulina* | W |
| Cyp | Cyperaceae | *Cyperus rivularis* | |
| Cyp | Cyperaceae | *Cyperus aristatus* | |
| Cyp | Cyperaceae | *Cyperus houghtonii* | |
| Cyp | Cyperaceae | *Cyperus filiculmis* | |
| Cyp | Cyperaceae | *Cyperus strigosus* | |
| Cyp | Cyperaceae | *Cyperus esculentus* | |
| Cyp | Cyperaceae | *Eleocharis acicularis* | |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Cyp | Cyperaceae | *Eleocharis erythropoda* | |
| Cyp | Cyperaceae | *Scirpus validus* | |
| Cyp | Cyperaceae | *Scirpus paludosus* | |
| Cyp | Cyperaceae | *Scirpus atrovirens* | W |
| Cyp | Cyperaceae | *Scirpus cyperinus* | W |
| Hmc | Araceae | *Arisaema triphyllum* | W |
| Hmc | Araceae | *Arisaema dracontium* | D |
| Hmc | Araceae | *Acorus calamus* | |
| Hmc | Araceae | *Peltandra virginica* | |
| Hmc | Lemnaceae | *Spirodela polyrhiza* | |
| Hmc | Pontederiaceae | *Heteranthera dubia* | |
| Hmc | Juncaceae | *Luzula multiflora* | W |
| Hmc | Juncaceae | *Luzula acuminata* | D |
| Hmc | Juncaceae | *Juncus effusus* | |
| Hmc | Juncaceae | *Juncus marginatus* | |
| Hmc | Juncaceae | *Juncus bufonius* | |
| Hmc | Juncaceae | *Juncus tenuis* | |
| Hmc | Juncaceae | *Juncus dudleyi* | |
| Hmc | Juncaceae | *Juncus canadensis* | |
| Hmc | Juncaceae | *Juncus brachycephalus* | |
| Hmc | Juncaceae | *Juncus torreyi* | |
| Hmc | Juncaceae | *Juncus nodosus* | |
| Hmc | Juncaceae | *Juncus articulatus* | |
| Hmc | Liliaceae | *Asparagus officinalis* | |
| Hmc | Liliaceae | *Smilax tamnoides* | D |
| Hmc | Liliaceae | *Smilax illinoensis* | D |
| Hmc | Liliaceae | *Polygonatum biflorum* | W |
| Hmc | Liliaceae | *Polygonatum pubescens* | D |
| Hmc | Liliaceae | *Streptopus roseus* | D |
| Hmc | Liliaceae | *Trillium grandiflorum* | W |
| Hmc | Liliaceae | *Trillium cernuum* | D |
| Hmc | Liliaceae | *Medeola virginiana* | W |
| Hmc | Liliaceae | *Erythronium americanum* | D |
| Hmc | Liliaceae | *Erythronium albidum* | D |
| Hmc | Liliaceae | *Lilium michiganense* | W |
| Hmc | Liliaceae | *Hemerocallis fulva* | |
| Hmc | Liliaceae | *Clintonia borealis* | D |
| Hmc | Liliaceae | *Allium tricoccum* | D |
| Hmc | Liliaceae | *Allium canadense* | D |
| Hmc | Liliaceae | *Uvularia sessilifolia* | D |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Hmc | Liliaceae | *Uvularia grandiflora* | D |
| Hmc | Liliaceae | *Maianthemum canadense* | W |
| Hmc | Liliaceae | *Smilacina racemosa* | D |
| Hmc | Liliaceae | *Smilacina trifolia* | |
| Hmc | Liliaceae | *Smilacina stellata* | W |
| Hmc | Dioscoreaceae | *Dioscorea villosa* | D |
| Hmc | Amaryllidaceae | *Hypoxis hirsuta* | D |
| Hmc | Iridaceae | *Sisyrinchium angustifolium* | D |
| Hmc | Iridaceae | *Sisyrinchium atlanticum* | |
| Hmc | Iridaceae | *Sisyrinchium mucronatum* | |
| Hmc | Iridaceae | *Sisyrinchium montanum* | |
| Hmc | Iridaceae | *Iris virginica* | W |
| Hmc | Orchidaceae | *Cypripedium acaule* | |
| Hmc | Orchidaceae | *Cypripeduim calceolus* | D |
| Hmc | Orchidaceae | *Cypripedium arietinum* | |
| Hmc | Orchidaceae | *Habenaria psycodes* | W |
| Hmc | Orchidaceae | *Habenaria lacera* | |
| Hmc | Orchidaceae | *Habenaria hookeri* | D |
| Hmc | Orchidaceae | *Corallorhiza trifida* | D |
| Hmc | Orchidaceae | *Corallorhiza striata* | D |
| Hmc | Orchidaceae | *Epipactis helleborine* | D |
| Hmc | Orchidaceae | *Liparis loeselii* | W |
| Hmc | Orchidaceae | *Malaxis unifolia* | |
| Hmc | Orchidaceae | *Goodyera pubescens* | D |
| Hmc | Orchidaceae | *Spiranthes romanzoffiana* | |
| Hmc | Orchidaceae | *Spiranthes cernua* | |
| Hdc | Saururaceae | *Saururus cernuus* | W |
| Tre | Salicaceae | *Salix exigua* | |
| Tre | Salicaceae | *Salix nigra* | |
| Tre | Salicaceae | *Salix eriocephala* | |
| Shr | Salicaceae | *Salix bebbiana* | |
| Shr | Salicaceae | *Salix discolor* | |
| Tre | Salicaceae | *Salix humilis* | |
| Tre | Salicaceae | *Salix lucida* | |
| Tre | Salicaceae | *Salix amygdaloides* | |
| Tre | Salicaceae | *Salix pyrifolia* | |
| Tre | Salicaceae | *Salix petiolaris* | |
| Tre | Salicaceae | *Populus alba* | D |
| Tre | Salicaceae | *Populus balsamifera* | W |
| Tre | Salicaceae | *Populus deltoides* | W |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Tre | Salicaceae | *Populus tremuloides* | W |
| Tre | Salicaceae | *Populus grandidentata* | D |
| Shr | Myricaceae | *Comptonia peregrina* | |
| Shr | Myricaceae | *Myrica gale* | |
| Tre | Juglandaceae | *Juglans cinerea* | W |
| Tre | Juglandaceae | *Carya cordiformis* | D |
| Tre | Juglandaceae | *Carya ovata* | D |
| Shr | Betulaceae | *Alnus rugosa* | |
| Tre | Betulaceae | *Betula alleghaniensis* | |
| Shr | Betulaceae | *Betula pumila* | |
| Tre | Betulaceae | *Betula papyrifera* | D |
| Shr | Betulaceae | *Corylus cornuta* | |
| Tre | Betulaceae | *Carpinus caroliniana* | W |
| Tre | Betulaceae | *Ostrya virginiana* | D |
| Tre | Fagaceae | *Quercus velutina* | D |
| Tre | Fagaceae | *Quercus rubra* | |
| Tre | Fagaceae | *Quercus coccinea* | |
| Tre | Fagaceae | *Quercus alba* | D |
| Tre | Fagaceae | *Quercus bicolor* | W |
| Tre | Fagaceae | *Fagus grandifolia* | D |
| Tre | Ulmaceae | *Ulmus rubra* | D |
| Tre | Ulmaceae | *Ulmus americana* | W |
| Tre | Ulmaceae | *Celtis occidentalis* | D |
| Hdc | Ulmaceae | *Urtica dioica* | D |
| Hdc | Ulmaceae | *Boehmeria cylindrica* | W |
| Hdc | Santalaceae | *Comandra umbellata* | |
| Hdc | Aristolochiaceae | *Asarum canadense* | D |
| Hdc | Polygonaceae | *Rumex acetosella* | |
| Hdc | Polygonaceae | *Rumex obtusifolius* | |
| Hdc | Polygonaceae | *Rumex altissimus* | |
| Hdc | Polygonaceae | *Rumex verticillatus* | W |
| Hdc | Polygonaceae | *Rumex crispus* | |
| Hdc | Polygonaceae | *Fagopyrum esculentum* | |
| Hdc | Polygonaceae | *Polygonum virginianum* | W |
| Hdc | Polygonaceae | *Polygonum cilinode* | |
| Hdc | Polygonaceae | *Polygonum convolvulus* | |
| Hdc | Polygonaceae | *Polygonum scandens* | D |
| Hdc | Polygonaceae | *Polygonum amphibium* | |
| Hdc | Polygonaceae | *Polygonum pensylvanicum* | |
| Hdc | Polygonaceae | *Polygonum lapathifolium* | |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Hdc | Chenopodiaceae | *Salsola kali* | |
| Hdc | Chenopodiaceae | *Atriplex patula* | |
| Hdc | Chenopodiaceae | *Chenopodium hybridum* | |
| Hdc | Nyctaginaceae | *Mirabilis albida* | |
| Hdc | Portulacaceae | *Portulaca grandiflora* | |
| Hdc | Portulacaceae | *Claytonia virginica* | D |
| Hdc | Caryophyllaceae | *Spergula arvensis* | |
| Hdc | Caryophyllaceae | *Stellaria media* | D |
| Hdc | Caryophyllaceae | *Stellaria longifolia* | W |
| Hdc | Caryophyllaceae | *Cerastium arvense* | |
| Hdc | Caryophyllaceae | *Cerastium fontanum* | |
| Hdc | Caryophyllaceae | *Arenaria serpyllifolia* | |
| Hdc | Caryophyllaceae | *Dianthus armeria* | |
| Hdc | Caryophyllaceae | *Saponaria officinalis* | |
| Hdc | Caryophyllaceae | *Silene antirrhina* | |
| Hdc | Caryophyllaceae | *Silene pratensis* | |
| Hdc | Caryophyllaceae | *Ceratophyllum demersum* | |
| Hdc | Ranunculaceae | *Clematis virginiana* | D |
| Hdc | Ranunculaceae | *Aquilegia canadensis* | D |
| Hdc | Ranunculaceae | *Thalictrum dioicum* | D |
| Hdc | Ranunculaceae | *Thalictrum dasycarpum* | |
| Hdc | Ranunculaceae | *Actaea rubra* | D |
| Hdc | Ranunculaceae | *Actaea pachypoda* | D |
| Hdc | Ranunculaceae | *Coptis trifolia* | |
| Hdc | Ranunculaceae | *Hepatica americana* | D |
| Hdc | Ranunculaceae | *Hepatica acutiloba* | |
| Hdc | Ranunculaceae | *Ranunculus longirostris* | |
| Hdc | Ranunculaceae | *Ranunculus flabellaris* | W |
| Hdc | Ranunculaceae | *Ranunculus recurvatus* | W |
| Hdc | Ranunculaceae | *Ranunculus sceleratus* | |
| Hdc | Ranunculaceae | *Ranunculus abortivus* | D |
| Hdc | Ranunculaceae | *Ranunculus pensylvanicus* | |
| Hdc | Ranunculaceae | *Ranunculus acris* | |
| Hdc | Ranunculaceae | *Ranunculus hispidus* | W |
| Hdc | Ranunculaceae | *Caltha palustris* | W |
| Hdc | Ranunculaceae | *Isopyrum biternatum* | D |
| Hdc | Ranunculaceae | *Anemone canadensis* | |
| Hdc | Ranunculaceae | *Anemone quinquefolia* | W |
| Hdc | Ranunculaceae | *Anemone virginiana* | D |
| Shr | Berberidaceae | *Berberis vulgaris* | D |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Hdc | Berberidaceae | *Caulophyllum thalictroides* | D |
| Hdc | Berberidaceae | *Podophyllum peltatum* | D |
| Vin | Menispermaceae | *Menispermum canadense* | W |
| Tre | Lauraceae | *Sassafras albidum* | W |
| Hdc | Papaveraceae | *Macleaya cordata* | |
| Hdc | Papaveraceae | *Sanguinaria canadensis* | D |
| Hdc | Fumariaceae | *Dicentra cucullaria* | D |
| Hdc | Fumariaceae | *Corydalis sempervirens* | |
| Hdc | Brassicaceae | *Barbarea vulgaris* | |
| Hdc | Brassicaceae | *Brassica kaber* | D |
| Hdc | Brassicaceae | *Rorippa palustris* | |
| Hdc | Brassicaceae | *Sisymbrium altissimum* | D |
| Hdc | Brassicaceae | *Camelina microcarpa* | |
| Hdc | Brassicaceae | *Erysimum cheiranthoides* | |
| Hdc | Brassicaceae | *Alyssum alyssoides* | |
| Hdc | Brassicaceae | *Dentaria laciniata* | D |
| Hdc | Brassicaceae | *Dentaria diphylla* | D |
| Hdc | Brassicaceae | *Armoracia rusticana* | |
| Hdc | Brassicaceae | *Cardamine douglassii* | D |
| Hdc | Brassicaceae | *Cardamine bulbosa* | D |
| Hdc | Brassicaceae | *Arabis glabra* | D |
| Hdc | Brassicaceae | *Arabis hirsuta* | |
| Hdc | Brassicaceae | *Arabis caucasica* | |
| Hdc | Brassicaceae | *Arabis laevigata* | D |
| Hdc | Brassicaceae | *Berteroa incana* | D |
| Hdc | Brassicaceae | *Lepidium densiflorum* | D |
| Hdc | Brassicaceae | *Lepidium virginicum* | D |
| Hdc | Droseraceae | *Drosera rotundifolia* | |
| Hdc | Saxifragaceae | *Chrysosplenium americanum* | W |
| Hdc | Saxifragaceae | *Mitella diphylla* | W |
| Hdc | Saxifragaceae | *Mitella nuda* | D |
| Brm | Grossulariaceae | *Ribes cynosbati* | W |
| Brm | Grossulariaceae | *Ribes hirtellum* | D |
| Brm | Grossulariaceae | *Ribes americanum* | W |
| Brm | Grossulariaceae | *Ribes glandulosum* | D |
| Brm | Grossulariaceae | *Ribes triste* | W |
| Shr | Hamamelidaceae | *Hamamelis virginiana* | D |
| Tre | Platanaceae | *Platanus occidentalis* | D |
| Brm | Rosaceae | *Rubus pubescens* | W |
| Brm | Rosaceae | *Rubus strigosus* | D |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Brm | Rosaceae | *Rubus hispidus* | W |
| Brm | Rosaceae | *Rubus allegheniensis* | D |
| Brm | Rosaceae | *Rosa eglanteria* | |
| Brm | Rosaceae | *Rosa cinnamomea* | |
| Brm | Rosaceae | *Rosa palustris* | |
| Brm | Rosaceae | *Rosa blanda* | |
| Tre | Rosaceae | *Prunus serotina* | D |
| Tre | Rosaceae | *Prunus virginiana* | D |
| Shr | Rosaceae | *Prunus pumila* | |
| Tre | Rosaceae | *Prunus pensylvanica* | D |
| Shr | Rosaceae | *Prunus americana* | D |
| Shr | Rosaceae | *Physocarpus opulifolius* | |
| Shr | Rosaceae | *Spiraea tomentosa* | |
| Shr | Rosaceae | *Spiraea alba* | |
| Shr | Rosaceae | *Aronia prunifolia* | D |
| Tre | Rosaceae | *Amelanchier arborea* | W |
| Shr | Rosaceae | *Amelanchier interior* | D |
| Tre | Rosaceae | *Crataegus calpodendron* | D |
| Tre | Rosaceae | *Crataegus punctata* | W |
| Tre | Rosaceae | *Crataegus brainerdii* | D |
| Tre | Rosaceae | *Crataegus mollis* | D |
| Tre | Rosaceae | *Crataegus coccinea* | D |
| Tre | Rosaceae | *Crataegus lucorum* | D |
| Tre | Rosaceae | *Crataegus flabellata* | D |
| Tre | Rosaceae | *Malus pumila* | D |
| Tre | Rosaceae | *Malus coronaria* | D |
| Hdc | Rosaceae | *Fragaria virginiana* | D |
| Shr | Rosaceae | *Potentilla fruticosa* | |
| Hdc | Rosaceae | *Potentilla palustris* | |
| Hdc | Rosaceae | *Potentilla arguta* | |
| Hdc | Rosaceae | *Potentilla norvegica* | D |
| Hdc | Rosaceae | *Potentilla simplex* | D |
| Hdc | Rosaceae | *Potentilla argentea* | D |
| Hdc | Rosaceae | *Potentilla recta* | D |
| Hdc | Rosaceae | *Geum canadense* | D |
| Hdc | Rosaceae | *Geum laciniatum* | W |
| Hdc | Rosaceae | *Geum aleppicum* | W |
| Hdc | Rosaceae | *Agrimonia gryposepala* | D |
| Hdc | Rosaceae | *Agrimonia pubescens* | D |
| Hdc | Fabaceae | *Melilotus alba* | |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Hdc | Fabaceae | *Melilotus officinalis* | D |
| Hdc | Fabaceae | *Trifolium pratense* | D |
| Hdc | Fabaceae | *Trifolium repens* | |
| Hdc | Fabaceae | *Trifolium hybridum* | |
| Hdc | Fabaceae | *Trifolium aureum* | D |
| Hdc | Fabaceae | *Trifolium campestre* | D |
| Hdc | Fabaceae | *Medicago lupulina* | D |
| Hdc | Fabaceae | *Amphicarpaea bracteata* | D |
| Hdc | Fabaceae | *Phaseolus vulgaris* | |
| Hdc | Fabaceae | *Desmodium glutinosum* | D |
| Hdc | Fabaceae | *Desmodium canadense* | |
| Hdc | Fabaceae | *Desmodium paniculatum* | D |
| Hdc | Fabaceae | *Lespedeza hirta* | D |
| Tre | Fabaceae | *Robinia pseudoacacia* | D |
| Hdc | Fabaceae | *Vicia americana* | W |
| Hdc | Fabaceae | *Vicia villosa* | D |
| Hdc | Fabaceae | *Apios americana* | D |
| Hdc | Linaceae | *Linum usitatissimum* | |
| Hdc | Oxalidaceae | *Oxalis fontana* | D |
| Hdc | Geraniaceae | *Geranium maculatum* | W |
| Hdc | Rutaceae | *Zanthoxylum americanum* | W |
| Hdc | Polygalaceae | *Polygala paucifolia* | D |
| Hdc | Polygalaceae | *Polygala verticillata* | D |
| Hdc | Polygalaceae | *Polygala polygama* | D |
| Hdc | Polygalaceae | *Polygala sanguinea* | |
| Shr | Anacardiaceae | *Toxicodendron vernix* | W |
| Vin | Anacardiaceae | *Toxicodendron radicans* | W |
| Shr | Anacardiaceae | *Rhus typhina* | D |
| Shr | Anacardiaceae | *Rhus x pulvinata* | |
| Shr | Aquifoliaceae | *Nemopanthus mucronatus* | |
| Shr | Aquifoliaceae | *Ilex verticillata* | |
| Vin | Celastraceae | *Celastrus scandens* | D |
| Vin | Celastraceae | *Euonymus obovata* | W |
| Vin | Celastraceae | *Euonymus atropurpurea* | D |
| Shr | Staphyleaceae | *Staphylea trifolia* | D |
| Tre | Aceraceae | *Acer saccharum* | D |
| Tre | Aceraceae | *Acer rubrum* | W |
| Tre | Hippocastanaceae | *Aesculus hippocastanum* | D |
| Shr | Rhamnaceae | *Rhamnus alnifolia* | D |
| Vin | Vitaceae | *Parthenocissus quinquefolia* | W |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Vin | Vitaceae | *Vitis riparia* | D |
| Tre | Tiliaceae | *Tilia americana* | D |
| Hdc | Clusiaceae | *Triadenum fraseri* | |
| Shr | Clusiaceae | *Hypericum prolificum* | D |
| Shr | Clusiaceae | *Hypericum kalmianum* | |
| Hdc | Clusiaceae | *Hypericum majus* | |
| Hdc | Cistaceae | *Lechea intermedia* | |
| Hdc | Violaceae | *Viola pubescens* | D |
| Hdc | Violaceae | *Viola striata* | D |
| Hdc | Violaceae | *Viola conspersa* | D |
| Hdc | Violaceae | *Viola adunca* | |
| Hdc | Violaceae | *Viola lanceolata* | |
| Hdc | Violaceae | *Viola blanda* | D |
| Hdc | Violaceae | *Viola sagittata* | D |
| Hdc | Violaceae | *Viola affinis* | W |
| Hdc | Violaceae | *Viola sororia* | D |
| Hdc | Lythraceae | *Lythrum alatum* | |
| Tre | Nyssaceae | *Nyssa sylvatica* | D |
| Hdc | Onagraceae | *Circaea alpina* | D |
| Hdc | Onagraceae | *Circaea lutetiana* | D |
| Hdc | Onagraceae | *Ludwigia polycarpa* | |
| Hdc | Onagraceae | *Epilobium angustifolium* | D |
| Hdc | Onagraceae | *Epilobium leptophyllum* | |
| Hdc | Onagraceae | *Epilobium ciliatum* | D |
| Hdc | Onagraceae | *Oenothera perennis* | |
| Hdc | Onagraceae | *Oenothera parviflora* | D |
| Hdc | Onagraceae | *Oenothera biennis* | |
| Hdc | Haloragaceae | *Myriophyllum heterophyllum* | |
| Hdc | Araliaceae | *Panax trifolius* | W |
| Hdc | Araliaceae | *Aralia racemosa* | D |
| Hdc | Araliaceae | *Aralia nudicaulis* | D |
| Hdc | Araliaceae | *Aralia hispida* | |
| Hdc | Araliaceae | *Panax quinquefolius* | |
| Hdc | Apiaceae | *Sanicula gregaria* | D |
| Hdc | Apiaceae | *Sanicula marilandica* | W |
| Hdc | Apiaceae | *Daucus carota* | D |
| Hdc | Apiaceae | *Osmorhiza longistylis* | W |
| Hdc | Apiaceae | *Osmorhiza claytonii* | D |
| Hdc | Apiaceae | *Angelica atropurpurea* | D |
| Hdc | Apiaceae | *Heracleum maximum* | D |
| Hdc | Apiaceae | *Pastinaca sativa* | D |
| Hdc | Apiaceae | *Erigenia bulbosa* | D |
| Hdc | Apiaceae | *Cryptotaenia canadensis* | W |
| Hdc | Apiaceae | *Zizia aurea* | W |

| Plant Type[a] | Family | Species | Where Found[b] |
|---|---|---|---|
| Hdc | Apiaceae | *Cicuta bulbifera* | |
| Htc | Apiaceae | *Cicuta maculata* | W |
| Shr | Cornaceae | *Cornus canadensis* | D |
| Shr | Cornaceae | *Cornus alternifolia* | D |
| Shr | Cornaceae | *Cornus stolonifera* | |
| Shr | Cornaceae | *Cornus amomum* | W |
| Shr | Cornaceae | *Cornus foemina* | D |

[a]Brm = brambles, Cyp = sedges, Gra = grasses, Hdc = herbaceous dicots, Hmc = herbaceous monocots, Shr = shrubs, Tre = trees, and Vin = vines.

[b]W = wet deciduous woods, D = deciduous woods.

Source: Voss (1972, 1985).

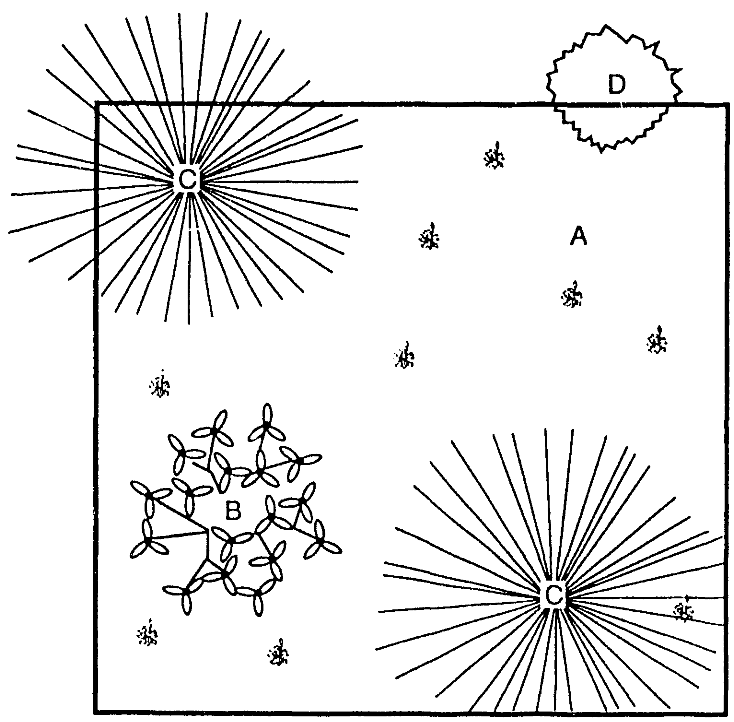
# Appendix J:

## Cover-Class Values and Frame Used in Cover Estimation Sampling*

TABLE J.1 Values for Cover Estirı.ıtions

| Cover Class | Range of Cover (%) | Midpoint of Cover Class (%) |
|---|---|---|
| 1 | 0-5 | 2.5 |
| 2 | 5-25 | 15.0 |
| 3 | 25-50 | 37.5 |
| 4 | 50-75 | 62.5 |
| 5 | 75-95 | 85.0 |
| 6 | 95-100 | 97.5 |

FIGURE J.1 Diagram of the 1 x 1-Meter Frame Used for Cover Estimation Sampling




**Cover Class:** A - 1 B - 2 C - 3 D - 1

*Source: Adapted from Daubenmire (1968).

# Appendix K:

## Sample Data Collected and Calculated for Sensitive Fern

Here is a sample of data (cover-class number per plot) collected in the field and average coverages and frequencies calculated for the species *Onoclea sensibilis.*

```
FILENAME - b:ONOSE025                    DATE - 11 August 1989
TAXON - Onoclea sensibilis - Sensitive fern
FAMILY - Polypodiaceae

SITE - 1(one)  TRANSECT (OR MACROPLOT) NUMBER - 505
NUMBER OF COVERAGE PLOTS -  40
SIZE OF COVERAGE PLOT - 1x1 meter
DATA COLLECTORS - J.R.R.  G.V.D.  M.S.
-----------------------------------------------------------------
RESULTS----AVERAGE COVERAGE -  .6875 %

           FREQUENCY -  27.5 %
-----------------------------------------------------------------

DECIDUOUS FOREST - R O W RESEARCH PROJECT - MICHIGAN - GAS
RESEARCH INSTITUTE/ARGONNE NATIONAL LABORATORY - Project Manager
STANLEY D. ZELLMER - Plant Ecologists  JAMES R. RASTORFER and
GERRIT D. VAN DYKE - Computer Programmer  JUDITH B. RASTORFER

          PLOT 1  -  0
          PLOT 2  -  1
          PLOT 3  -  0
          PLOT 4  -  0
          PLOT 5  -  0
          PLOT 6  -  0
          PLOT 7  -  1
          PLOT 8  -  1
          PLOT 9  -  0
          PLOT 10  -  1
          PLOT 11  -  0
          PLOT 12  -  0
          PLOT 13  -  0
          PLOT 14  -  0
          PLOT 15  -  1
          PLOT 16  -  0
          PLOT 17  -  0
          PLOT 18  -  0
          PLOT 19  -  0
          PLOT 20  -  0
          PLOT 21  -  0
          PLOT 22  -  0
          PLOT 23  -  0
          PLOT 24  -  1
          PLOT 25  -  1
          PLOT 26  -  0
          PLOT 27  -  0
          PLOT 28  -  0
          PLOT 29  -  1
          PLOT 30  -  0
          PLOT 31  -  1
          PLOT 32  -  0
          PLOT 33  -  0
          PLOT 34  -  0
          PLOT 35  -  0
          PLOT 36  -  0
          PLOT 37  -  1
          PLOT 38  -  0
          PLOT 39  -  0
          PLOT 40  -  1
```

FILENAME - b:ONOSE024 DATE - 11 August 1989
TAXON - Onoclea sensibilis - Sensitive fern
FAMILY - Polypodiaceae

SITE - 1(one) TRANSECT (OR MACROPLOT) NUMBER - 101
NUMBER OF COVERAGE PLOTS - 40
SIZE OF COVERAGE PLOT - 1x1 meter
DATA COLLECTORS - J.R.R. G.V.D. M.S.

---

RESULTS----AVERAGE COVERAGE - 3.5 %

FREQUENCY - 45 %

---

DECIDUOUS FOREST - R O W RESEARCH PROJECT - MICHIGAN - GAS RESEARCH INSTITUTE/ARGONNE NATIONAL LABORATORY - Project Manager STANLEY D. ZELLMER - Plant Ecologists JAMES R. RASTORFER and GERRIT D. VAN DYKE - Computer Programmer JUDITH B. RASTORFER

PLOT 1 - 3
PLOT 2 - 2
PLOT 3 - 1
PLOT 4 - 0
PLOT 5 - 0
PLOT 6 - 0
PLOT 7 - 0
PLOT 8 - 0
PLOT 9 - 0
PLOT 10 - 1
PLOT 11 - 0
PLOT 12 - 0
PLOT 13 - 0
PLOT 14 - 0
PLOT 15 - 0
PLOT 16 - 1
PLOT 17 - 1
PLOT 18 - 1
PLOT 19 - 1
PLOT 20 - 3
PLOT 21 - 1
PLOT 22 - 1
PLOT 23 - 0
PLOT 24 - 0
PLOT 25 - 0
PLOT 26 - 1
PLOT 27 - 1
PLOT 28 - 1
PLOT 29 - 1
PLOT 30 - 1
PLOT 31 - 1
PLOT 32 - 2
PLOT 33 - 0
PLOT 34 - 0
PLOT 35 - 0
PLOT 36 - 0
PLOT 37 - 0
PLOT 38 - 0
PLOT 39 - 0
PLOT 40 - 0

FILENAME - b:ONOSE021 DATE - 8 August 1989
TAXON - Onoclea sensibilis - Sensitive fern
FAMILY - Polypodiaceae

SITE - 1(one) TRANSECT (OR MACROPLOT) NUMBER - 105
NUMBER OF COVERAGE PLOTS - 40
SIZE OF COVERAGE PLOT - 1x1 meter
DATA COLLECTORS - J.R.R. G.V.D. M.S.

---

RESULTS----AVERAGE COVERAGE - 36.4375 %

FREQUENCY - 70 %

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DECIDUOUS FOREST - R O W RESEARCH PROJECT - MICHIGAN - GAS RESEARCH INSTITUTE/ARGONNE NATIONAL LABORATORY - Project Manager STANLEY D. ZELLMER - Plant Ecologists JAMES R. RASTORFER and GERRIT D. VAN DYKE - Computer Programmer JUDITH B. RASTORFER

PLOT 1 - 3
PLOT 2 - 4
PLOT 3 - 4
PLOT 4 - 4
PLOT 5 - 0
PLOT 6 - 2
PLOT 7 - 4
PLOT 8 - 5
PLOT 9 - 5
PLOT 10 - 5
PLOT 11 - 5
PLOT 12 - 3
PLOT 13 - 3
PLOT 14 - 0
PLOT 15 - 0
PLOT 16 - 0
PLOT 17 - 0
PLOT 18 - 3
PLOT 19 - 1
PLOT 20 - 0
PLOT 21 - 2
PLOT 22 - 0
PLOT 23 - 0
PLOT 24 - 0
PLOT 25 - 2
PLOT 26 - 3
PLOT 27 - 2
PLOT 28 - 4
PLOT 29 - 4
PLOT 30 - 5
PLOT 31 - 5
PLOT 32 - 5
PLOT 33 - 3
PLOT 34 - 4
PLOT 35 - 5
PLOT 36 - 3
PLOT 37 - 0
PLOT 38 - 2
PLOT 39 - 0
PLOT 40 - 0

FILENAME - b:ONOSE022 DATE - 9 August 1989
TAXON - Onoclea sensibilis - Sensitive fern
FAMILY - Polypodiaceae

SITE - 1(one) TRANSECT (OR MACROPLOT) NUMBER - 113
NUMBER OF COVERAGE PLOTS - 40
SIZE OF COVERAGE PLOT - 1x1 meter
DATA COLLECTORS - J.R.R. G.V.D. M.S.

---

RESULTS----AVERAGE COVERAGE - 34.625 %

FREQUENCY - 80 %

---

DECIDUOUS FOREST - R O W RESEARCH PROJECT - MICHIGAN - GAS RESEARCH INSTITUTE/ARGONNE NATIONAL LABORATORY - Project Manager STANLEY D. ZELLMER - Plant Ecologists JAMES R. RASTORFER and GERRIT D. VAN DYKE - Computer Programmer JUDITH B. RASTORFER

PLOT 1 - 2
PLOT 2 - 1
PLOT 3 - 0
PLOT 4 - 0
PLOT 5 - 0
PLOT 6 - 0
PLOT 7 - 1
PLOT 8 - 0
PLOT 9 - 0
PLOT 10 - 0
PLOT 11 - 2
PLOT 12 - 3
PLOT 13 - 3
PLOT 14 - 0
PLOT 15 - 3
PLOT 16 - 3
PLOT 17 - 2
PLOT 18 - 3
PLOT 19 - 2
PLOT 20 - 1
PLOT 21 - 1
PLOT 22 - 2
PLOT 23 - 1
PLOT 24 - 4
PLOT 25 - 3
PLOT 26 - 2
PLOT 27 - 4
PLOT 28 - 5
PLOT 29 - 4
PLOT 30 - 5
PLOT 31 - 3
PLOT 32 - 4
PLOT 33 - 5
PLOT 34 - 5
PLOT 35 - 2
PLOT 36 - 5
PLOT 37 - 5
PLOT 38 - 5
PLOT 39 - 6
PLOT 40 - 4

FILENAME - b:ONOSE.023 DATE - 10 August 1989
TAXON - Onoclea sensibilis - Sensitive fern
FAMILY - Polypodiaceae

SITE - 1(one) TRANSECT (OR MACROPLOT) NUMBER - 141
NUMBER OF COVERAGE PLOTS - 40
SIZE OF COVERAGE PLOT - 1x1 meter
DATA COLLECTORS - J.R.R. G.V.D. M.S.

---

RESULTS----AVERAGE COVERAGE - 5.875 %

FREQUENCY - 22.5 %

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DECIDUOUS FOREST - R O W RESEARCH PROJECT - MICHIGAN - GAS RESEARCH INSTITUTE/ARGONNE NATIONAL LABORATORY - Project Manager STANLEY D. ZELLMER - Plant Ecologists JAMES R. RASTORFER and GERRIT D. VAN DYKE - Computer Programmer JUDITH B. RASTORFER

PLOT 1 - 0
PLOT 2 - 0
PLOT 3 - 0
PLOT 4 - 0
PLOT 5 - 0
PLOT 6 - 0
PLOT 7 - 0
PLOT 8 - 0
PLOT 9 - 0
PLOT 10 - 0
PLOT 11 - 0
PLOT 12 - 0
PLOT 13 - 0
PLOT 14 - 0
PLOT 15 - 1
PLOT 16 - 3
PLOT 17 - 3
PLOT 18 - 3
PLOT 19 - 4
PLOT 20 - 3
PLOT 21 - 0
PLOT 22 - 0
PLOT 23 - 0
PLOT 24 - 0
PLOT 25 - 0
PLOT 26 - 0
PLOT 27 - 0
PLOT 28 - 0
PLOT 29 - 0
PLOT 30 - 0
PLOT 31 - 0
PLOT 32 - 0
PLOT 33 - 0
PLOT 34 - 0
PLOT 35 - 0
PLOT 36 - 1
PLOT 37 - 1
PLOT 38 - 0
PLOT 39 - 0
PLOT 40 - 2

END

DATE FILMED

11/14/91

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