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AN ECOLOGICAL APPROACH FOR HIGHWAY ROUTING IN MICHIGAN

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AN ECOLOGICAL APPROACH FOR HIGHWAY ROUTING IN MICHIGAN

By

Phillip Burton Davis

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ABSTRACT

AN ECOLOGICAL APPROACH FOR HIGHWAY
ROUTING IN MICHIGAN

By

Phillip Burton Davis

At the present time the Michigan Department of State Highways and Transportation does not have a procedure to evaluate before construction the potential impacts of that construction on existing or resultant environments. This study was performed to research methods to improve the route location process and assist highway planners, designers, and decision makers in objectively evaluating environments that may be impacted by future highway projects.

A holistic ecosystem approach is utilized to examine the relationships among soils, water, flora and fauna and the overall effects of highways on each. In this way physical and biological changes in natural systems can be analyzed before, during and after highway construction.

The Michigan Land Cover/Use Classification System was used as a framework to assemble existing information about associated soil groups, drainage regimes, wildlife species and endangered or threatened flora. To determine what resultant environments have to contain to support desired fauna, detailed information on specific species distributions, habitat requirements, status and food preferences were assembled. This compilation of information then serves as the basis for examining the effects of highway activities on the environment.

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Evaluation of how highway activities impact environmental conditions is facilitated by use of the Environment-Highway Interaction Matrix. The matrix provides a visual display of potentially impacted environmental characteristics and major actions causing impacts; its primary advantage being a gross screening technique for impact identification. Further advantages of this matrix are in its ability to be expanded or contracted in scope and to be modified in structure. Use of the matrix in highway decision making can be valuable in predicting the effects of highways on existing environments and to compare resultant environments created by highway related activities.

A guide for decision makers provides a procedure for directing the collection of data and organizing information needed in the route location decision making process. Decisions can then be made by following a step-by-step procedure on observations and inventories to compile, physical and biological aspects to consider, problems to avoid, and methods to use in predicting impacts.

The ecological approach presented provides a mechanism for more effectively and efficiently comparing potential impacts of alternative routes in a more analytical way before route selection which reduces reliance on personal opinions, is replicable, quantifiable and legally functional. Although this approach was developed for highway routing in Michigan with modifications it can be utilized for any type of corridor analysis.

To my mother

and in memory of my father

ACKNOWLEDGMENTS

This study was made possible through an agreement between Michigan State University and the Michigan Department of State Highways and Transportation in cooperation with the U.S. Department of Transportation and Federal Highway Administration. The assistance and cooperation offered by Mr. Jan Raad, Environmental Specialist of the MDSH&T assured the accomplishment of study goals.

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Particular gratitude is extended to my friend and colleague, Mr. Michael R. Thomas for providing intellectual stimulation and new insights which contributed to this study from its inception.

Support provided by my wife Deborah during this period of my life required understanding, patience and love that few are capable of giving. I proudly acknowledge her contribution.

Special thanks go to my major professor, Dr. Clifford R. Humphrys who successfully provided an atmosphere which fostered creativity and made learning fun by adhering to a philosophy that asserts the dignity and worth of any who wish to learn.

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LIST OF ABBREVIATIONS

CEC -- Cation Exchange Capacity

CEQ -- Council on Environmental Quality

DNR -- Department of Natural Resources

EIS -- Environmental Impact Statement

MATRIX -- Environment-Highway Interaction Matrix (Fig. 5)

MDSHT -- Michigan Department of State Highways and Transportation

MLCUCS -- Michigan Land Cover/Use Classification System

NEPA -- National Environmental Policy Act of 1969

pH -- Negative Log of the Hydrogen Ion Concentration

ROW -- Right-of-way

spp -- Species

MEASUREMENTS

a -- acre

cc -- cubic centimeter

cm -- centimeter

ft -- feet

gm -- gram

ha -- hectare

in -- inch

km -- kilometer

lb -- pound

m -- meter

mi -- mile

ml -- milliliter

yd -- yard

yr -- year

CHAPTER I

INTRODUCTION

Problem Statement

All highway projects require an impact assessment, National Environmental Policy Act (NEPA, 1969), before construction is authorized. Highway agencies have been acknowledged as being among the leaders in filing environmental impact statements (EIS). However, a major criticism of a large percentage of filed EIS's is that, while NEPA guidelines are followed sufficiently for legal purposes, the statements are inadequate in describing how the proposed project actually impacts the environment. For the most part, natural parameters are described mainly by extensive lists of inventories of all the species present in the affected area. As a result, the knowledge of actual environmental situations is never completely available.

Federal, state, county, and municipal highway agencies in the state of Michigan have frequently been accused of irreparably damaging the environment. The allegations made as to the insensitivity of highway agencies towards areas with high ecological values cannot at this time be adequately disproven. This is based on the fact that no studies presently exist that document in a scientific manner the actual direct and indirect physical impact of a highway facility upon an environment in a before, during, and after situation. Subsequently, planning for any highway proposal which impacts the environment often becomes a ready issue for public controversy and challenge; further, environmental impact statement requirements dictate that the potential negative and positive environmental effects be analyzed. By virtue of the lack of scientific data regarding these effects, the analysis tends to be based on incomplete data which detract from the intent and purpose of the environmental impact statement.

Thus, the lack of scientific data provides the primary basis for challenge and controversy. When these challenges are directed through established legal channels, the normal highway planning and construction schedules are either slowed down or abandoned.

At the present time the Michigan Department of State Highways and Transportation (MDSHT) does not have a procedure to evaluate before construction the potential impacts of that construction on existing or resultant environments. Environmental analysis done by or for the MDSHT now consists of inventorying existing fauna and flora at one point in time and space. This type of analysis does not provide sufficient information to plan for the wise use of the potentially impacted resources which are found in these environments. To improve the route location process with respect to the environment, information about the relationships among soils, drainage, vegetation, and wildlife impacted by highways needs to be assembled and presented in an easily understood, cohesive, and useable package.

Study Objectives

The primary objective of this research is to develop an ecological approach to assist highway planners, designers, and decision makers in objectively evaluating environments that may be impacted by future highway projects. When this approach is used, MDSHT personnel will be able to reduce reliance on personal opinions by using the developed procedures as a tool to aid in analyzing existing and resultant environments before highway construction.

To achieve the primary objective, three secondary objectives were established. The first of these is to adopt a problem-solving approach based on the holistic concept of ecosystems. Such a comprehensive approach requires the assemblage of information on soils, water, flora, and fauna to aid in evaluating environmental impacts of highway activities.

A second is to develop an environment-highway interaction matrix to provide a conceptual framework and visual tool to aid in examining how highway construction, operation and maintenance affects environmental conditions. Use of a matrix that can be expanded or contracted in scope allows decision makers prior to route selection to predict effects of highways on existing environments and to compare resultant environments that may be created.

The final objective is to develop an environmental guide for decision makers. Its basic function is to provide a set of information and procedures for highway routing that facilitates an evaluation capability which is replicable, quantifiable and legally functional.

Brief History of Highway Program

President Franklin D. Roosevelt appointed a National Interregional Highway Committee to examine the concept of a system of interregional superhighways in 1941. This committee in cooperation with the Public Roads Administration presented a report to Congress in 1944 entitled

"Interregional Highways." Acting on the basis of that report, the Congress in the Federal-Aid Highway Act of 1944 authorized a National System of Interstate Highways of 40,000 miles. Congress directed that these highways were to be

> so located as to connect by routes, as direct as practicable, the principal metropolitan areas, cities and industrial centers, to serve the national defense and to connect at suitable border points with route of continental importance.

By 1947 selection of 37,700 miles of the proposed 40,000-mile Interstate System were announced. During the next nine years the program was plagued with problems in establishing an acceptable method of financing. Congress reached a compromise in the Federal-Aid Highway Act of 1956 which authorized 25 billion dollars to be spent on 41,000 miles of Interstate from 1957 to 1969.

Highway personnel across the country were thereby given a legislative mandate to carry out the "prompt completion of Interstate by connecting routes as direct as practicable." To achieve such an objective, highway agencies attempted to find the most direct routes between the points they wanted to serve with the most economical procedure (from an engineering view) of building.

Impacts on the environment were therefore not considered when selecting, constructing, operating or maintaining routes. In 1968 the Federal-Aid Highway Act authorized an additional 2,500 miles, making the total system 42,500 miles in length. Passage of NEPA in 1969 required for the first time that consideration be given to the effects of highway activities on the environment. The effectiveness of NEPA in dealing adequately with highway impacts from the Interstate System were limited in two major ways.

First, over 39,000 miles of the system were already constructed or under construction when NEPA became law. The remaining mileage had already been routed which effectively removed the real potential of giving proper consideration to alternative routes that may have been less damaging to the environment.

Secondly, no methods or procedures for evaluating the impacts of highway activities were available to adequately evaluate and address the concerns of NEPA.

Past Work

Three complete and comprehensive efforts have been made to assemble published and unpublished materials pertaining to the impact of highways on the physical environment. As part of a study entitled Ecological Effects of Highway Construction Upon Michigan Woodlots and Wetlands, over 1,300 annotated citations of references that are specifically concerned with the effect of highways on soils, vegetation, water quality, wildlife and air quality were presented by Galin (1974). The references present information on topographic conditions in Michigan, wildlife, habitats, herbicides, pesticides, de-icing chemicals, runoff and spillage, erosion, highway drainage facilities, criteria for evaluating environmental impact, and methods which can be used to control the detrimental impacts of highways on the physical environment.

An updated version of the aforementioned annotated bibliography was produced during a second phase of the same study and is included in the final report by Davis, Thomas and Humphrys (1978). This effort redirected the literature search to focus on studies related to methods of identifying and evaluating the environmental impacts of highways on soils, water, flora and fauna.

Review of the references cited in these compilations reveals that research to date dealing with impacts of highway activities on the environment have been performed with a single disciplinary approach. The literature is replete with studies examining such topics as vegetation management, wildlife mortality, erosion, channelization, sedimentation, water quality, de-icing chemicals, herbicide use, etc. These references were drawn upon to assemble data on Michigan's soils, water, flora and fauna, which is needed by MDSHT personnel for an improved understanding of the relationships among these parameters.

Sufficient information was available to examine soils, water, flora and fauna independently but when confronted with developing a holistic approach to highway route selection, deficiencies in the literature were quickly apparent. Highways have been the direct focus of very little ecological research. Until the passage of NEPA, research of an ecological nature had no applied function in connection with highway agencies. Thus funding was not available for such research and none was done. The conclusion reached after examining the existing body of knowledge in this area is that research on methods of collecting, packaging and presenting ecological data dealing with impacts of highways on the physical environment are sorely needed. No studies to date are available on methods for obtaining ecological data in a form which can be incorporated into the decision-making process which involves lawyers, sociologists, engineers and others in selecting, constructing, operating and maintaining highway routes.

CHAPTER II

PROBLEM-SOLVING APPROACH

The Holistic Approach

An important role for highway decision makers is to ensure compatibility between the need for new and better highway facilities and the requirements for maintaining quality environments. Ecosystem management provides new methods of impact assessment and problem solving, presents innovative management tools, and outlines a framework for the rational use of physical and biological resources. A holistic, ecosystem approach is utilized to examine the relationships between soils, water, flora and fauna and the overall effects of highways on each. In this way, physical and biological changes in natural systems can be analyzed before, during, and after highway construction.

If existing and resultant environments impacted by highway activities are to be understood so that the information necessary to make wise resource decisions is possible, a more comprehensive approach must be adopted. It is important for highway personnel to become aware of the holistic concept of ecosystems. This concept is built upon ecological principles. The first of these is to protect critical environments and habitats. Habitat protection is often more crucial than protecting individual species, for more species have become rare or endangered through habitat reduction than from direct extermination. Maintaining the life support system provided by a habitat is necessary for the continuance of a species. Thus, analysis of existing and resultant environments should be made from an ecosystem and habitat perspective.

A second ecological principle is to adopt a long-term, carrying capacity approach to ecosystem management. This involves careful study of the habitat's ability to maintain populations based on the availability of resources. A population will tend to increase or decrease in response to the availability of food, water and shelter. Populations respond to changes in habitat. If one habitat is completely replaced by another due to either natural or artificial causes, the carrying capacity of that habitat for a particular composition of species is altered, while a new carrying capacity of the resultant environment is created for a new composition of species.

The third principle of ecosystem management, is to prevent irreversible changes in the environment. Critical to this principle is the knowledge that man is able to alter or disturb any ecosystem component and thereby affect environmental systems. Preventing irreversible changes requires that ecosystem managers recognize and understand how to avoid such disruptive actions.

The adoption of an ecological approach with the aforementioned principles can improve the analysis procedure and help assure that project impacts are evaluated in a more meaningful manner. The overall research effort provides a method whereby an environment can be evaluated for potential impacts from highway activities. This includes a guide for highway decision makers consisting of management tools. Decisions can then be made by following a step-by-step procedure on observations and inventories to compile, physical and biological aspects to consider, problems to avoid, and methods to use in predicting impacts.

Research Model

A major thrust of this study was to develop a framework to which existing information about soils, water, flora and fauna in Michigan could be assembled. These four parameters were targeted out for consideration as key components of the environments that are impacted by highway activities. Much work has been done on each of these parameters but prior to this study, no compilation of research findings has been presented which provides this information together.

The framework chosen to assemble this information was the Michigan Land Cover/Use Classification System (Michigan Land Use Classification and Referencing Committee, 1976). Rationale for using this system is that it is familiar to highway personnel, currently operating, and computer adaptable to the information assembled in this study. The system presents a standardized terminology for describing land cover/use. It is logical in construction and adaptable to uniform expansion for other uses. Improving the highway route location process is such a use (Fig. 1).

The major vegetative associations classified, defined and described in Michigan are presented in Appendix A. This system can supply information as to the size and type of vegetative communities that proposed corridors may traverse. This system was then expanded upon to include associated soil groups, drainage regimes, wildlife species and endangered or threatened flora. Appendix B presents this information so a determination of what characteristics an environment has can be easily made.

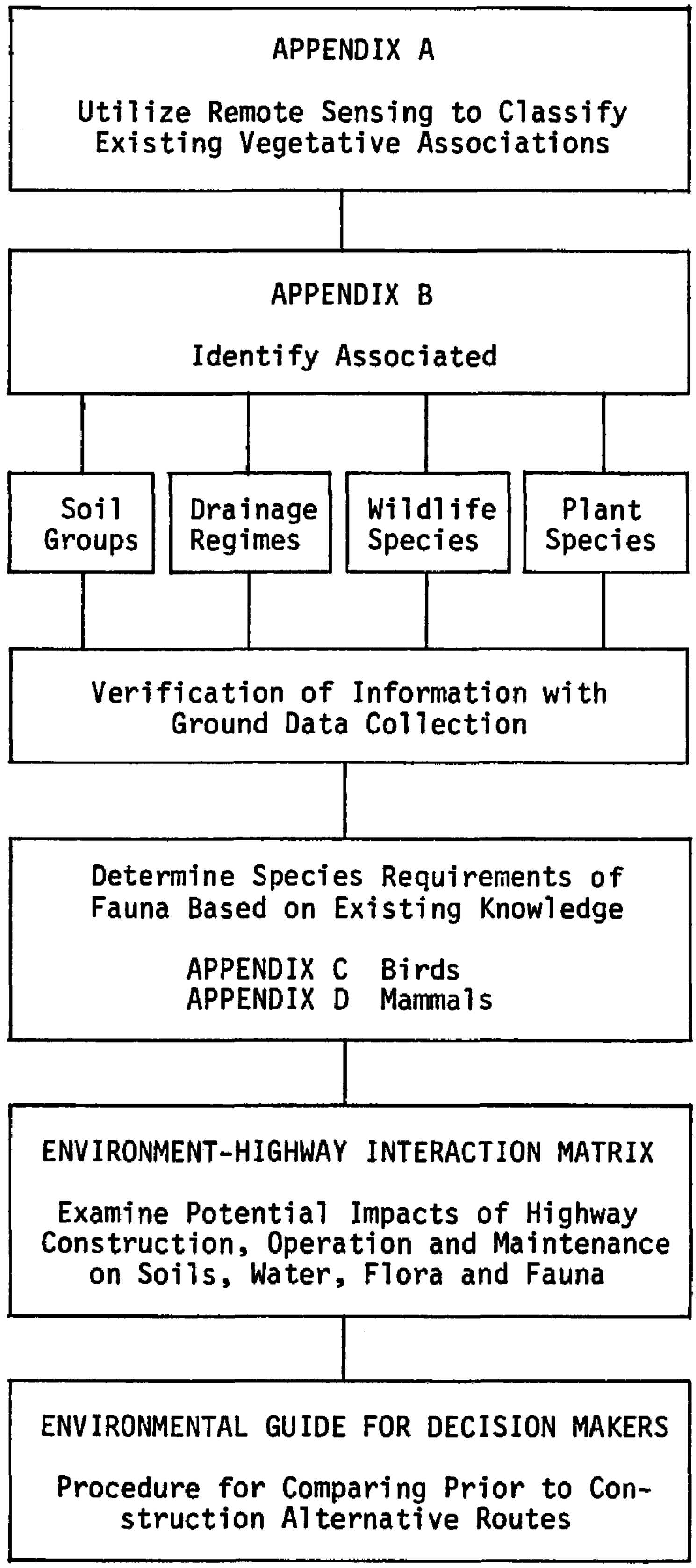

Figure 1. Environmental assessment framework for highway routing in Michigan.

To provide information on what resultant environments would have to contain to support desired fauna, all the detailed information available on specific species requirements was assembled. Habitat requirements, distribution and resident status of Michigan birds was compiled and is presented in Appendix C. Natural history information for Michigan mammals including distribution, status, food preferences and habitat requirements then follow in Appendix D.

This compilation of information serves as the basis for examining the effects of highway activities upon soils, water, flora and fauna (Chapter III). Evaluation of how highway activities impact environmental conditions can then be facilitated by the development of an environment-highway interaction matrix (Chapter IV). Since only portions of this information are needed at any point in the route selection process, a guide to decision makers is then presented. This guide provides a procedure for directing the collection of data and organizing information needed in the route selection decision-making process. Decisions can then be made by following a step-by-step procedure on observations and inventories to compile, physical and biological aspects to consider, problems to avoid, and methods to use in predicting impacts.

CHAPTER III

EFFECTS OF HIGHWAY ACTIVITIES UPON SOILS, WATER, FLORA, AND FAUNA

This framework serves to illustrate some of the important relationships among soils, water, flora, and fauna which are impacted by highway activities (Fig. 2). The initial step is to assess preconstruction parameters. This is important for two reasons. First, preconstruction conditions serve as a standard in monitoring changes. Second, if changes do occur, the kind and extent of change will partially be dependent upon pre-existing conditions. This operation would consist of collecting primary and secondary data related to the natural science parameters.

The second step is to utilize basic knowledge of parameter changes which may occur as a result of construction. This knowledge was obtained from data collected in Michigan during recent highway studies by Davis and Humphrys (1977), Krauss (1978) and Davis, Thomas and Humphrys (1978). Analysis of these studies in addition to those from the literature revealed that modification of hydrological parameters significantly affects the relationships among associated soils, flora and fauna. These changes can now be predicted and evaluated before highway construction.

Effects of Construction Activities

The purpose of this section is to present effects of highway construction activities upon hydrologic systems which may also be evaluated

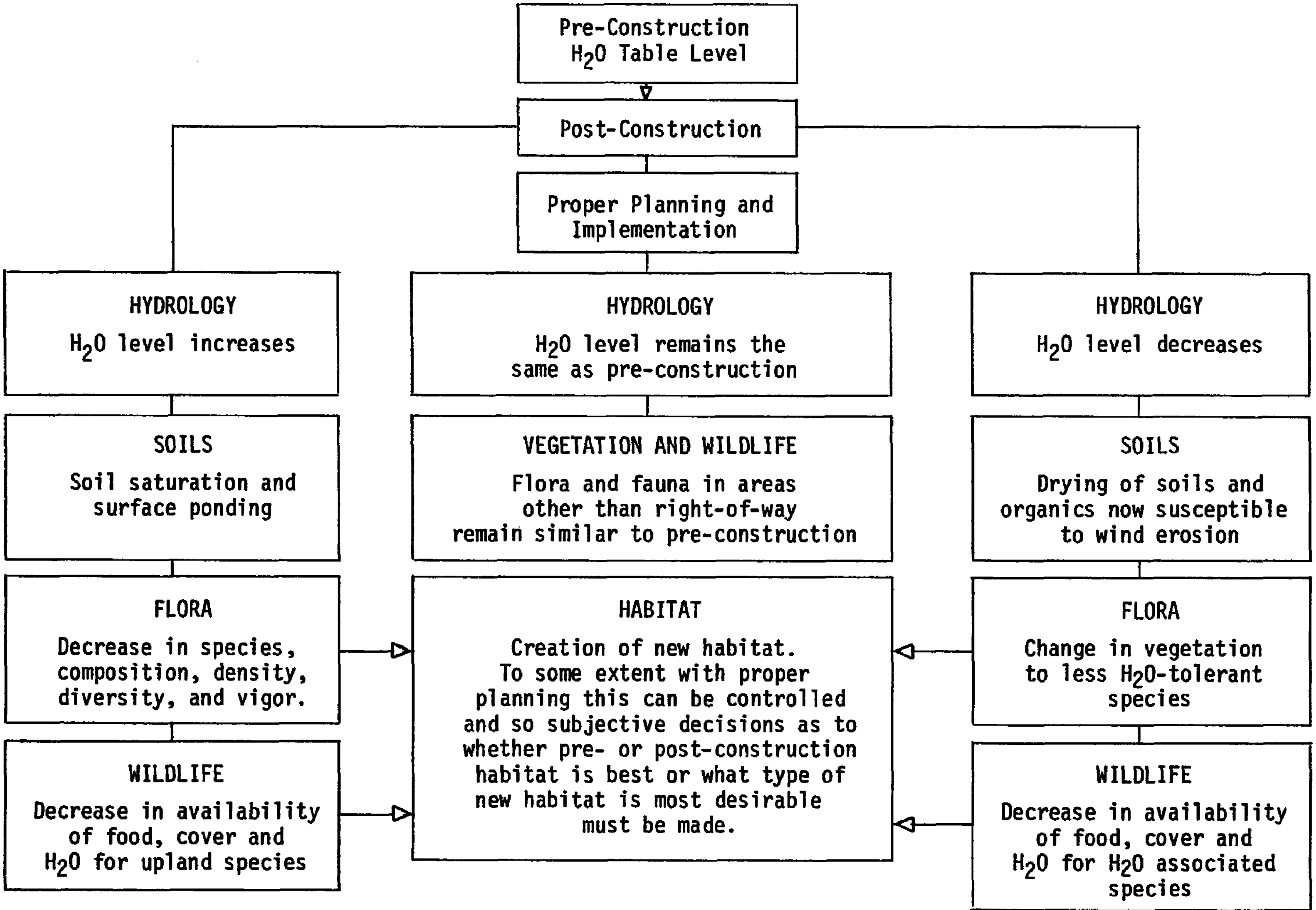

Figure 2.--Effects and ramifications resulting from the maintenance or alteration of existing water table levels.

in relation to impacts upon soils, flora and fauna (Fig. 3). This framework offers a means of assessing impacts in the context of an interdisciplinary model which will serve as a guide to planners involved in route location and construction processes.

This format includes a presentation of the impacts of particular construction activities in a manner which supplements the matrix. Each activity is presented in relation to impacts upon drainage regimes, soils, flora and fauna.

Surfacing

Surfacing involves the construction of a paved or otherwise hard, stable, and impermeable surface layer. This decreases infiltration and increases local runoff. Depending upon the permeability of adjacent soils, ground water recharge may be affected if rainfall rapidly flows off as surface flow.

For the safety of road users, the traffic surface must be kept as free of water as possible. This is accomplished by shaping the surface such that water will flow away to drainage ditches which are formed at the road edge by the curbs or in ditches at the outer edge of the shoulders (Batson, 1968). The flow of surface water adjacent to highways is frequently accompanied by detrimental soil erosion which may result in the destruction of productive soils, the creation of areas of unsightly appearance, and the clogging of ditches and drainage structures. Erosion may also endanger the stability of side slopes in embankment and cut sections (Ritter, 1951).

Not only does surfacing increase runoff, but the quality of the runoff, or effluent, may be affected as well. Both concrete and

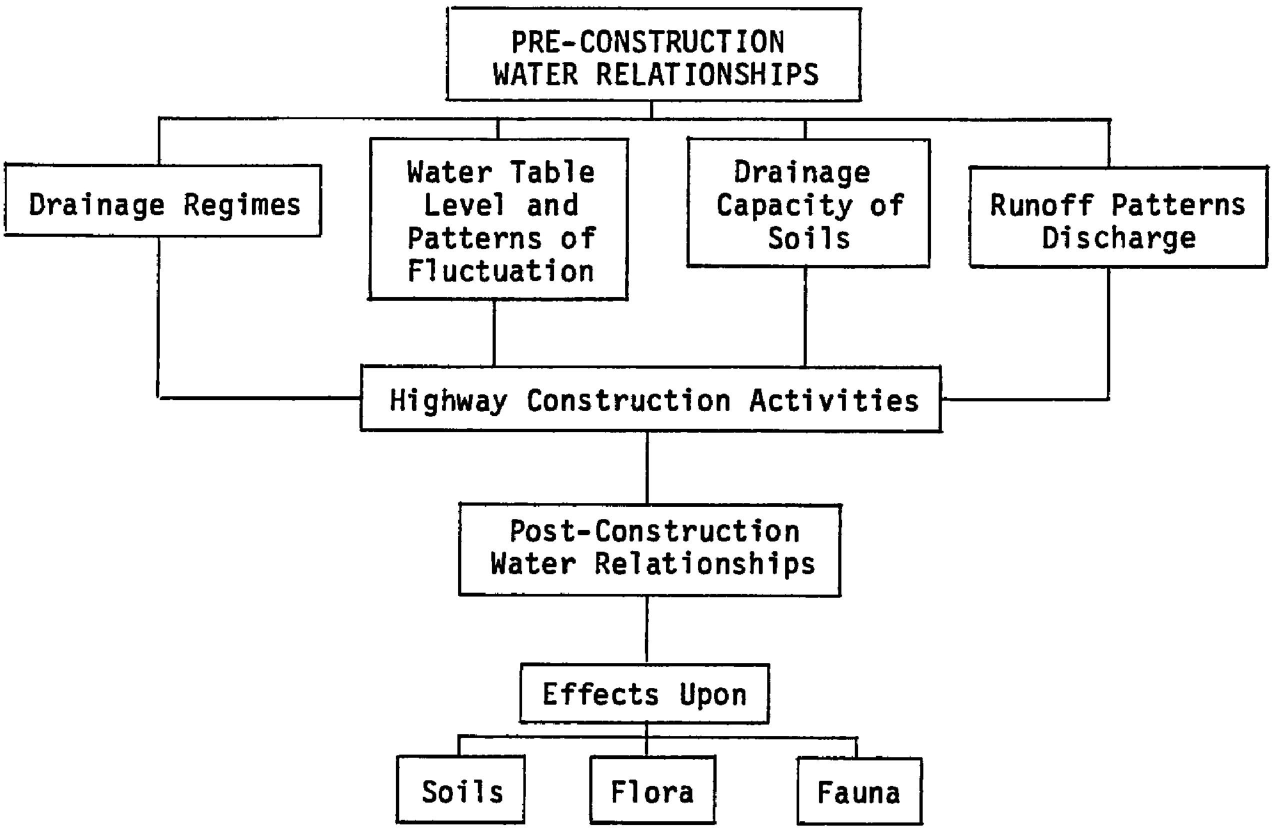

Figure 3.--Framework for studying water relationships.

bituminous surfaces leach out chemical substances which are eventually carried into adjacent watercourses. Mostly carbonates and hydroxides of calcium and magnesium come from cement plants and the concrete itself, but bituminous materials may provide a variety of organic coal-tar derivatives. The greatest leaching of these occurs during and after construction, but long-term leaching must also take place (Darnell, 1976).

Surfacing results in the destruction of the vegetation present prior to construction and precludes any future growth in the paved area. Destruction of vegetation results in a loss of wildlife habitat, which is accompanied with a decrease in the carrying capacity for both plant and wildlife species.

Cut and Fill

Fills for highways involve the placement of mineral material on stable substrates or the replacement of unstable substrates, such as peat or muck, with more stable mineral material. Both the displacement of unstable material and the filling affects surface and/or ground water movement in wetlands by providing an impermeable or less permeable medium.

Placing fill over peat or in place of peat will have an effect upon rates of runoff and ground water movement. Fill material will generally have larger interstitial pores than does peat and as these pores become clogged with organic material from the surrounding substrate, permeability decreases (Krauss, 1978).

Surface and ground water movements may also be affected by cut and fill operations, by either cutting into an aquifer which is under hydraulic pressure, or by possibly replacing an impermeable layer in the subsoil. This impermeable layer may cause an extensive ground water drain in that the water may become diverted from its original underground drainage flow pattern (Parizak, 1970). Changes in ground and surface water divides may also occur causing changes to distribution and quantity stream flow. Cut and fill operations may also cause increased sedimentation of streams which bisect or run adjacent to the operation, due to increased sediment loading of runoff.

Cut and fills which traverse vegetative communities usually result in the loss of existing habitat types and the creation of new ones. Cut and fill operations in Michigan often removed upland oak and lowland coniferous woodland (Davis, 1977). These habitats were lost and replaced with a forest field transition zone. Vegetative diversity, amount of edge, and amount of interspersion were all increased. Carrying capacity for some species such as songbirds and snowshoe hare was increased while for others, such as deer and bear, it was reduced.

Dredging

Regardless of the means of dredging, the primary results are the creation of depressions or ditches and the temporary suspension of particulate matter in a water body. If a sufficient amount of organic matter is available, depressions tend to become anaerobic in the lower strata, due to organic decomposition in the absence of light.

The cutting and digging action of dredging breaks through the oxidized layer of a submerged soil and exposes the deep unoxidized layer. Most of the sediments removed from this anoxic layer and placed in suspension are in a chemically reduced state. Materials removed from this layer generally have high chemical and biological oxygen demands. Often toxic materials such as hydrogen sulfide, methane, ketone, aldehydes, and heavy metals are released from anoxic sediment and subsediment material. Dredging increases turbidity which reduces light penetration, interferes with photosynthetic production of oxygen, and tends to elevate water temperature.

Eventually, the sediment is deposited creating modified bottom topography and obstructed patterns of water circulation elsewhere (Darnell, 1976).

Wetland Draining and Filling

Lowering of the water table in wetlands may result in more productive soils in the area by decreasing anaerobic soil conditions and increasing exposure to light (Darnell, 1976). Filling will cause some interference with existing surface flow patterns and possible creation of channel erosion. Temporary and possibly high permanent rates of sedimentation will also occur.

Dams and Impoundments

Productive soil may be lost due to inundation of wetlands. More water will be lost as a result of evaporation. Due to increased surface water, water-intolerant plants may experience severe die-off. Bank erosion may occur at the edges of the pond or in areas of relief which were formerly above water. Sediments from upstream will be deposited as water velocity decreases in the impoundment.

As water becomes impounded, temperature increases and thermal stratification may occur. Stratification and sedimentation may cause anoxic substrate conditions which result in the release of methane and hydrogen sulfate and a lowering of pH. Organic deposits may occur as abundant vegetative growth is created.

Downstream from the impoundments, flood damage is mitigated as peak flows are disrupted. However, there may be a loss of water, silt, and nutrients which would have been seasonally replenished. If impoundment water is relocated from the hypolimnion, it may be of lower pH and dissolved oxygen and of higher hydrogen sulfate concentration (Darnell, 1975).

Spoil Banks

Spoil banks exposed to runoff may add significantly to stream sedimentation of organic matter and minerals due to heavy leaching (Darnell, 1976). The heavy overburden causes soil compaction and integration of foreign soil particles at the soil surface which will alter infiltration capacity and permeability of the underlying soils.

Bridges

Construction of bridges will cause short-term erosion and sedimentation. Very little long-term effects are created by bridges proper, except possible channel scour and erosion influences by abutments (Parizek, 1974). Fills developed for approaches to bridges often act as dams. This damming effect causes the creation of backwater during flood stages, increasing the velocity of water moving through the bridge site. Such modifications in surface water patterns often cause a new set of downstream problems.

Burning and Removal of Vegetation

Both burning and removal of vegetation increased runoff and soil erosion causing increases sedimentation and turbidity of surface waters. Drainage patterns may also be altered due to changes in distribution or loss of flow-resistant materials. With increased rates of runoff, local stream levels will be less static. Soils become more susceptible to leaching. Some denuded areas have been shown to lose large quantities of dissolved minerals, particularly sodium, calcium, magnesium, iron, potassium nitrates, and phosphates. Leaching of highly alkaline ashes causes immediate increases in the pH of the waterways (Darnell, 1976).

Soil moisture may be increased or decreased depending upon the amount and type of matter removed. In a Missouri study (Fletcher, 1963), it was found that when litter was removed from a forest soil, soil drying increased by 10 percent. Tree removal decreased soil drying rates (by two-thirds), and removal of both trees and litter decreased drying rates by about one-third. A surface fire which destroyed only litter increased the drying rate by seven percent when moisture conditions were near field capacity and about 13 percent at lesser profile moisture contents. Thus, soil drying may increase as litter is removed but is offset by the loss of root absorption when trees are removed. If significant soil drying occurs, soil may be transported by wind erosion.

Borrow Pits

The excavation of borrow pits includes the removal or displacement of vegetation and topsoil. If the activity is subject to excessive runoff, erosion of exposed matter will cause sedimentation of adjacent streams. If excavation extends below the ground water table, the pit may fill with water and create a new aquatic habitat. If the excavation is above the water table, the exposure of coarse mineral material may facilitate an increase in local ground water recharge.

Borrow pits observed on the study area were all being utilized by waterfowl in the spring of the year. These pits provide habitat for species which prior to construction did not utilize the area. With proper planning and coordination between MDSHT and Michigan Department of Natural Resources (DNR) personnel, these pits are being built and managed to optimize their wildlife potential.

Fences and Barriers

Fences and barriers may restrict runoff by accumulating mulch and litter which will cause deposition of sediments from the runoff. Generally, fences have little effect on aquatic or hydrological systems unless a buildup of waterborne material occurs.

Separating a community into segments which are smaller than the home range of the species in question can result in animals avoiding an area which, prior to disturbance, was suitable habitat. Barriers such as the highway and related structures will also result in avoidance behavior. However, fencing has not proven to be an adequate deterrent for deer crossings.

Erosion, Sedimentation, and Siltation

If an activity increases erosion, there are significant impacts upon stream environments. Initially, a loss of soil and nutrients occurs on the eroded area at increasing rates. As the material becomes suspended in the waterway, increased turbidity reduces light available to aquatic vegetation, thereby lowering productivity. If velocity of flow is decreased, siltation will occur and cause the creation of anoxic conditions in the sediment, release of hydrogen sulfate and other toxins, and smothering of aquatic flora and fauna. Siltation may, however, add valuable minerals and nutrients which may increase floodplain productivity.

Culverts

Highway facilities can raise and/or lower the ground water table depending upon culvert placement and drainage design (Davis, 1977).

More than half of 70 wetland road crossings observed in a Minnesota survey showed timber killed or weakened by a rise in water table, which was caused by the damming effects of the roads and failure to provide adequate cross-drainage. The chief problems were the absence of culverts or other cross-drainage, discharge ditches or inadequate culverts, or some combination of the above (Fig. 4).

When culverts are set too high, ponding will occur, given an impermeable road grade. There may also be seasonal ponding or interference with seasonal water levels and ground water flow, which may have similar effects upon vegetation as ponding.

Ponding may naturally occur during periods of heavy precipitation, and the water table will decline during dryer months of the growing season. Trees and other vegetation may survive seasonal fluctuations, but if the fluctuations change such that the water table is higher during the growing season as a result of culvert placement, the vegetation may not withstand the higher seasonal water table (and resulting loss of aerobic soil). Subsurface drainage should be facilitated in such wetland sites to maintain natural water table fluctuations.

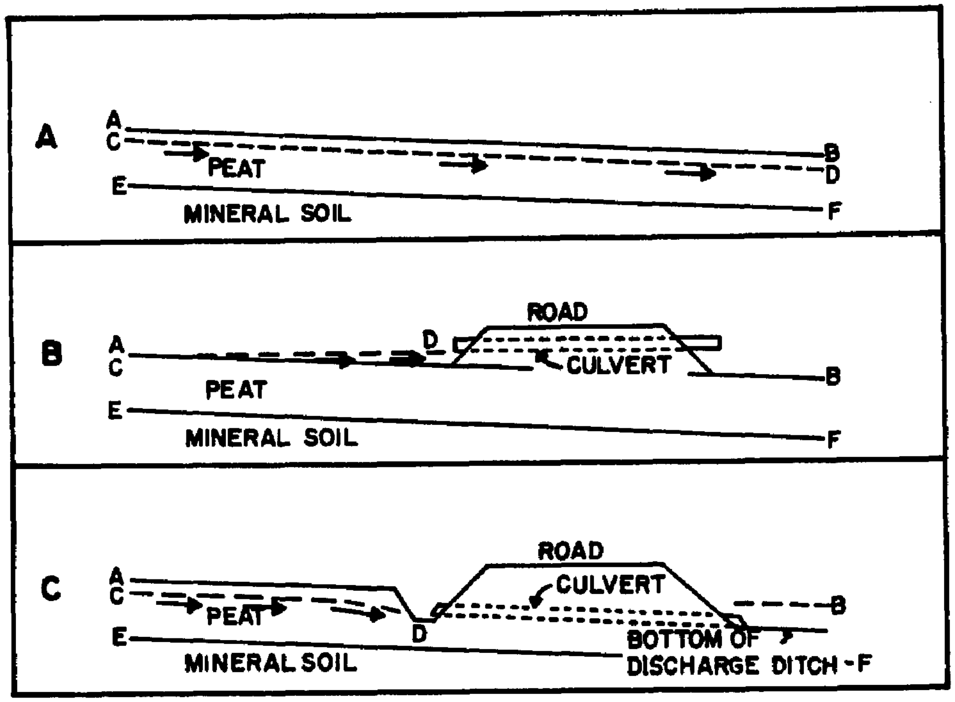

Figure 4.--Hydrologic problem and water table relations in roads crossing peatlands approximately parallel to the contour. Arrows indicate principal zone of water flow. A--Undisturbed swamp before road construction; B--Poorly sited culvert does not relieve damming action of road. Temporary or permanent pool of stagnant water results; C--Problem is solved when collector ditch is cut on upper side of the road and culvert is set with its bottom several feet below swamp surface. (Stoeckeler, 1965)

Culvert placement may also affect natural drainage patterns where laminar drainage has been altered to channelized drainage. Staggered culvert placement leads to a curvature flow of water in the median which results in ponding or stagnation. A comparison of drainage facilitation through culvert placement (Fig. 5) illustrates how surface flow and water levels may be affected. For a comparison of channelized and laminar drainage characteristics, see Figure 6.

If culverts are spaced evenly across the traversed wetland with channelization occurring in the median directly between paralleled

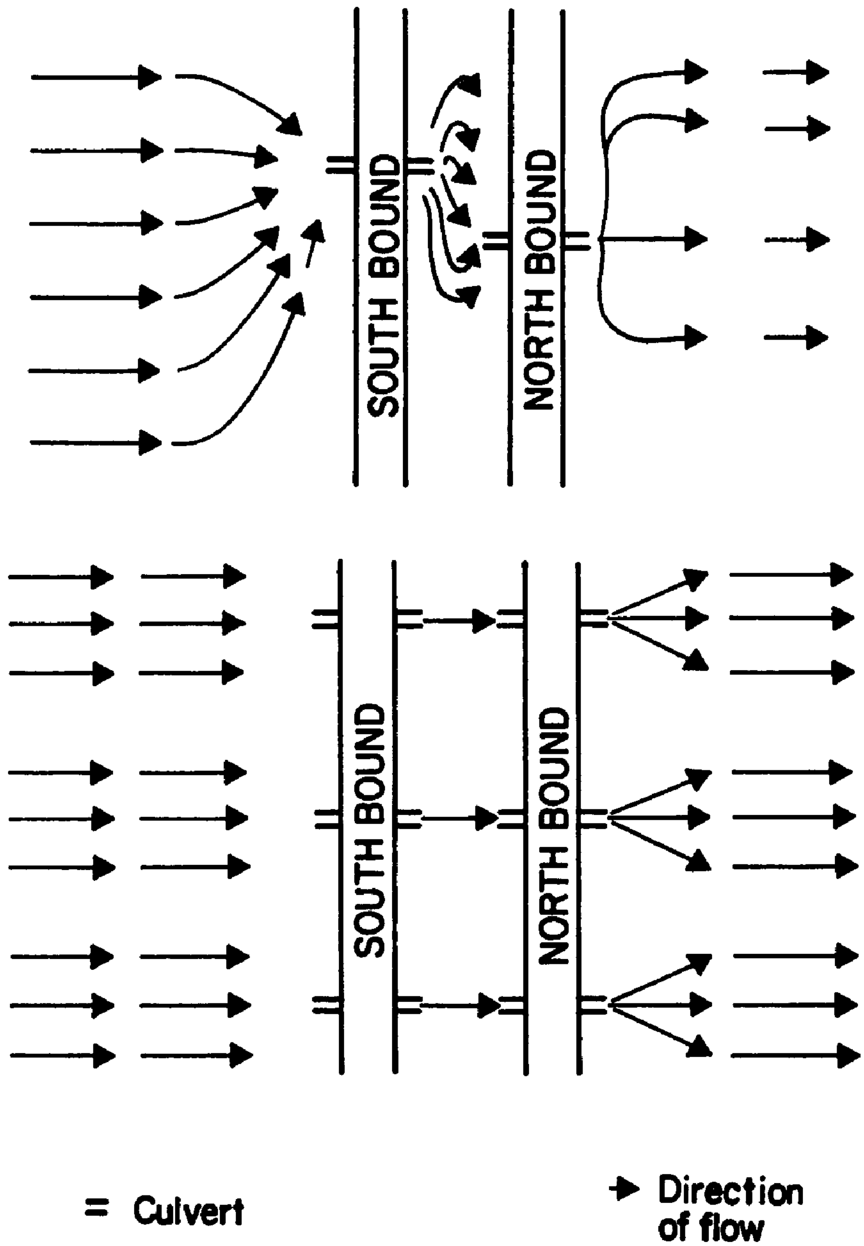

Figure 5.--Laminar flow in relation to culvert placement.

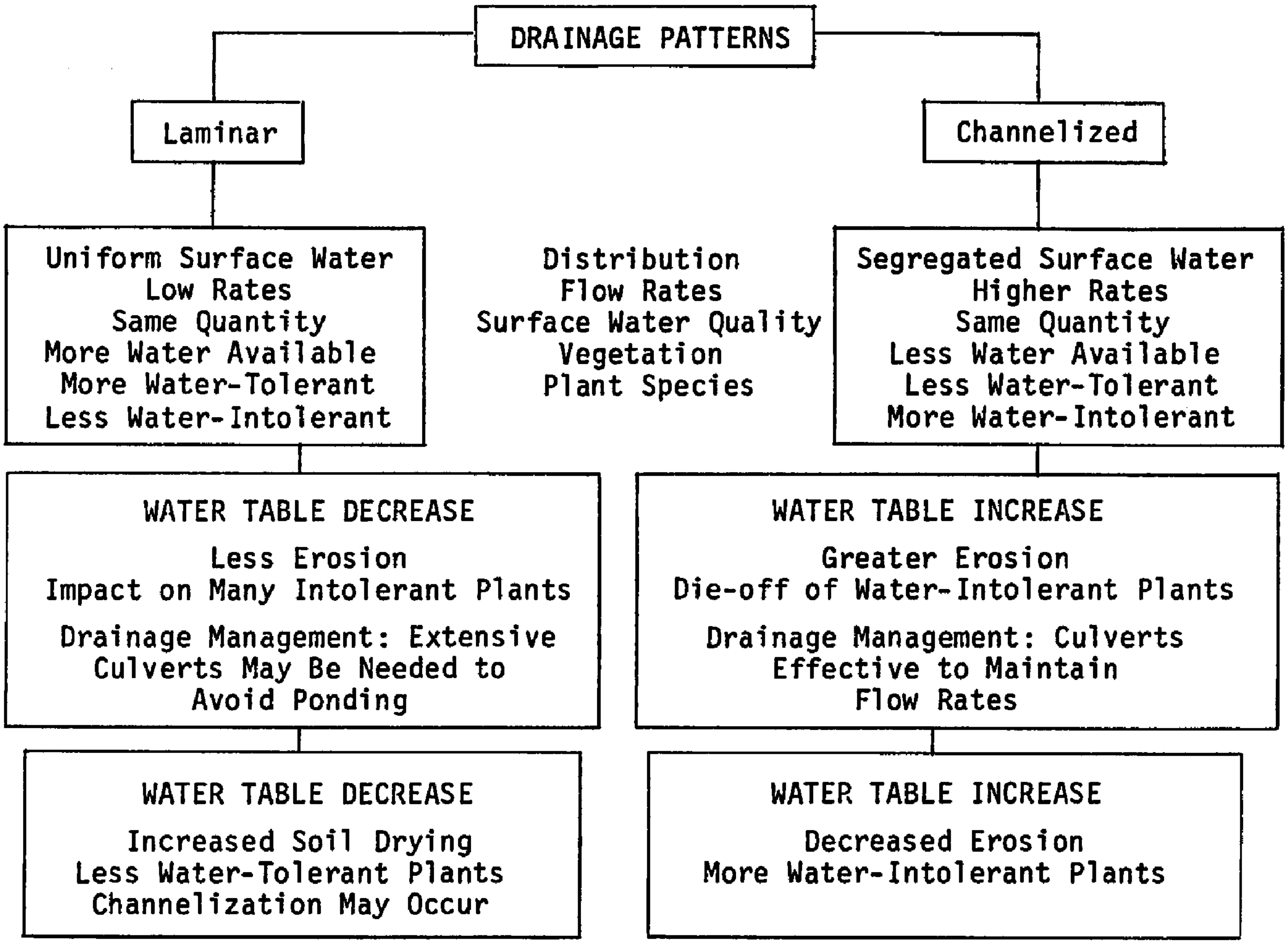

Figure 6.--A comparison of laminar and channelized drainage characteristics.

culverts, adequate drainage can be maintained with little or no vegetative die-off. However, when natural drainage patterns are not maintained, the resulting increases in water table levels caused by the impermeability of road fill material and inadequate artificial drainage results in vegetative die-off of water-intolerant species (Fig. 7). This comparison emphasizes the fact that the effect of highways on drainage may be minimized by proper culvert placement.

As high culverts may increase upstream water levels, likewise culverts placed too low may lower water tables, causing a loss of water-tolerant vegetation, possible erosion, and channelization of laminar flow (Stockeler, 1967).

Erosion Control, Landscaping, and Reforestation

These measures all decrease erosion and preserve local quantities of soil and mulch. Less damage is associated with peak flows, less sedimentation occurs in nearby streams, and infiltration and ground water recharge may be increased. Reforestation may create additional evapotranspiration losses which may decrease soil moisture. Erosion resulting from cuts and fills can be minimized or eliminated where adequate erosion control measures are taken.

Drainage and Water Table Alteration

Changes in flow patterns and water table appear to be the major hydrological impacts of highway construction. Stockeler (1951, 1965, and 1967) found that pipelines and roads caused timber die-off as a result of increased water table levels. A study in Michigan established that wetland areas and their associated surface and subsurface water movements are susceptible to alteration by highways (Davis,

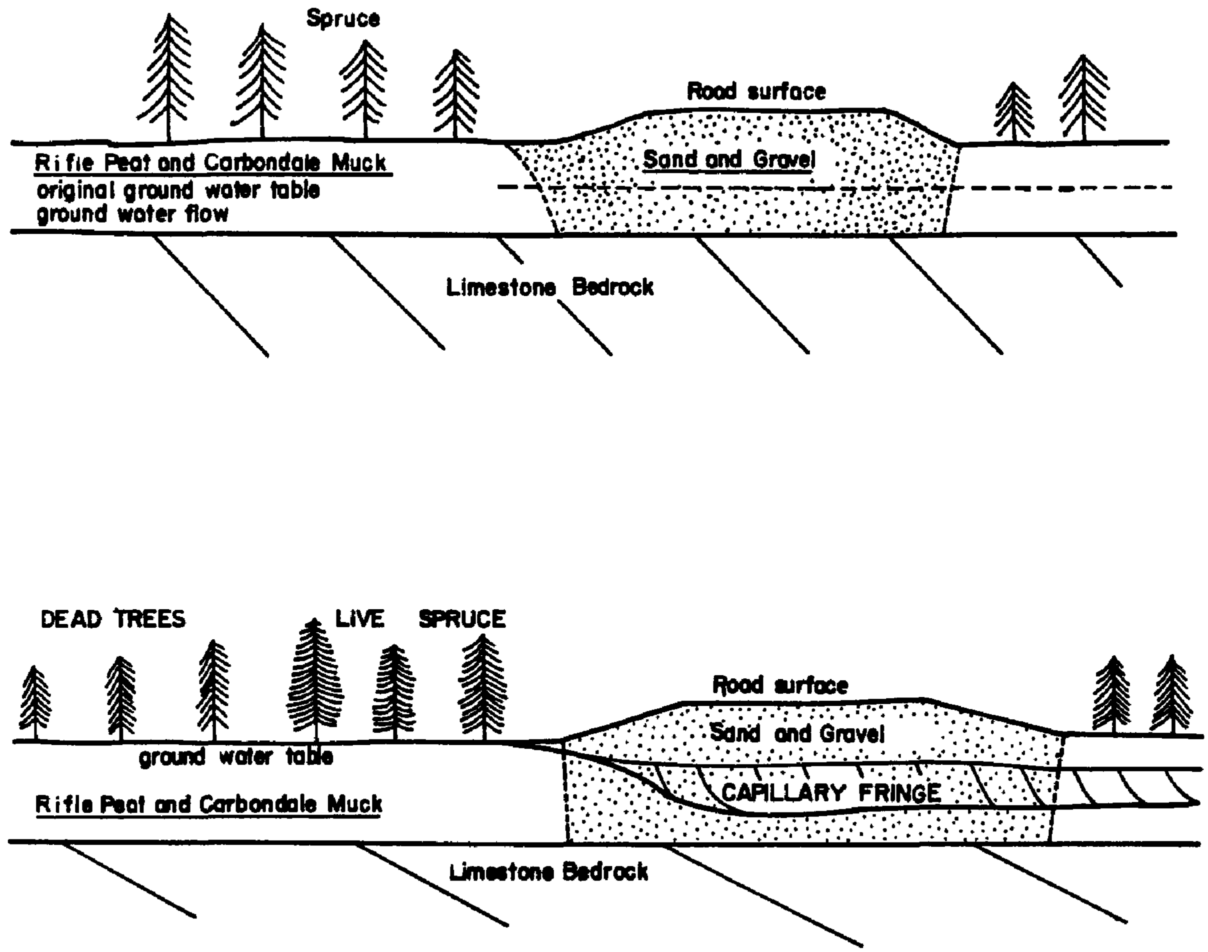

Figure 7.--Water table changes along I-75 north of St. Ignace causing flooded conditions and vegetative die-off.

1978; Krauss, 1978) found that due to soil compaction and changes in soil particle size, permeability changes occur among the organic soil and fill material. Furthermore, integration of organic matter into interstitial pores at the organic mineral fill interface causes a decrease in permeability sometimes greater than 50 percent. Based on these findings, highways are essentially dams which retard or prevent water movement in wetlands.

An increase or decrease in water table level is most likely caused by a combination of the following factors:

1. insufficient number of culverts;
2. improper culvert placement;
3. insufficient hydraulic capacity of culverts;
4. damming from highway fill;
5. reduced hydraulic conductivity of surface and ground water due to compaction of soils below the highway or a decline in porosity due to organic integration with mineral fill;
6. increased runoff due to: a) increased area of the ground or surface watershed due to highway location; b) less utilization of water by vegetation; c) decreased evapotranspiration; d) beheading of a spring or aquifer during construction; e) increased sealed surface in the watershed--decreased infiltration.

The above occurrences which increase or decrease water table levels may occur simultaneously such that a net increase or decrease results.

Factors exogenous to highway activities such as precipitation, land use in the watershed, or downstream damming cannot be controlled by highway personnel. However, factors which cause water table changes and result directly from construction activity may be controlled. Proper construction practices can mitigate water table changes resulting from inadequate planning. The following procedure could be taken in order to maintain pre-construction water table levels.

The first step involves the reconnaissance of pre-construction hydrological parameters including water table level; watershed size, shape, and runoff; runoff distribution; soil properties; and existing vegetation. This examination of pre-construction hydrologic parameters can then be used as standards with which to monitor changes during and after construction, and if desired, as a status quo to maintain.

If desired, personnel may apply construction techniques which would preserve the status quo reflected by watershed parameters. If the highway is to bisect a large portion of the watershed, flow patterns may change such that runoff is greatly increased at a culvert site. This would most likely occur in wetland areas of laminar flow, but may in other areas as well where channels, which originally traversed the corridor, have been rerouted to other culvert crossings.

It is essential to include the increased volume at a culvert site which occurs as a result of diversion by the highway. If the soils through which the water must detour are fairly permeable, additional transmissibility (larger or more culverts) at the site will enable sufficient drainage. On the contrary, if soil in the area is impermeable, conductivity of water may be too low to completely drain the additional input, and ponding will occur regardless of culvert size or the number of culverts at a single crossing. This occurs primarily in wetland areas of organic soils when laminar flow is restricted. The remedy is to place a sufficient number of culverts at close intervals across the transversed laminar drainage regime or to place culverts in areas of micro-drainage ways as well as at the lowest elevation of the wetland crossing.

Alteration of drainage regimes will affect the amount of flow at a given highway crossing and should be considered in an analysis of runoff prior to construction. Other activities, such as beheading of springs or aquifers and alteration or loss of vegetation, will also affect runoff and should be considered as well. Although highways do inhibit water movement and highway construction may alter runoff rates and volume, measures which provide sufficient drainage may minimize water table changes.

Potential impacts on vegetation are controlled by the major parameters affecting vegetative type (Fig. 8). Any highway activity that alters one of these parameters or some combination of them can result in vegetative changes. These changes, in turn, affect the wildlife habitat as illustrated in Figure 9. Thus, potential impacts of proposed highway activities cannot be dealt with independently. A potential change of one parameter, water table level, must be considered as an integral part of a complex system which, in turn, affects flora, soils, and fauna.

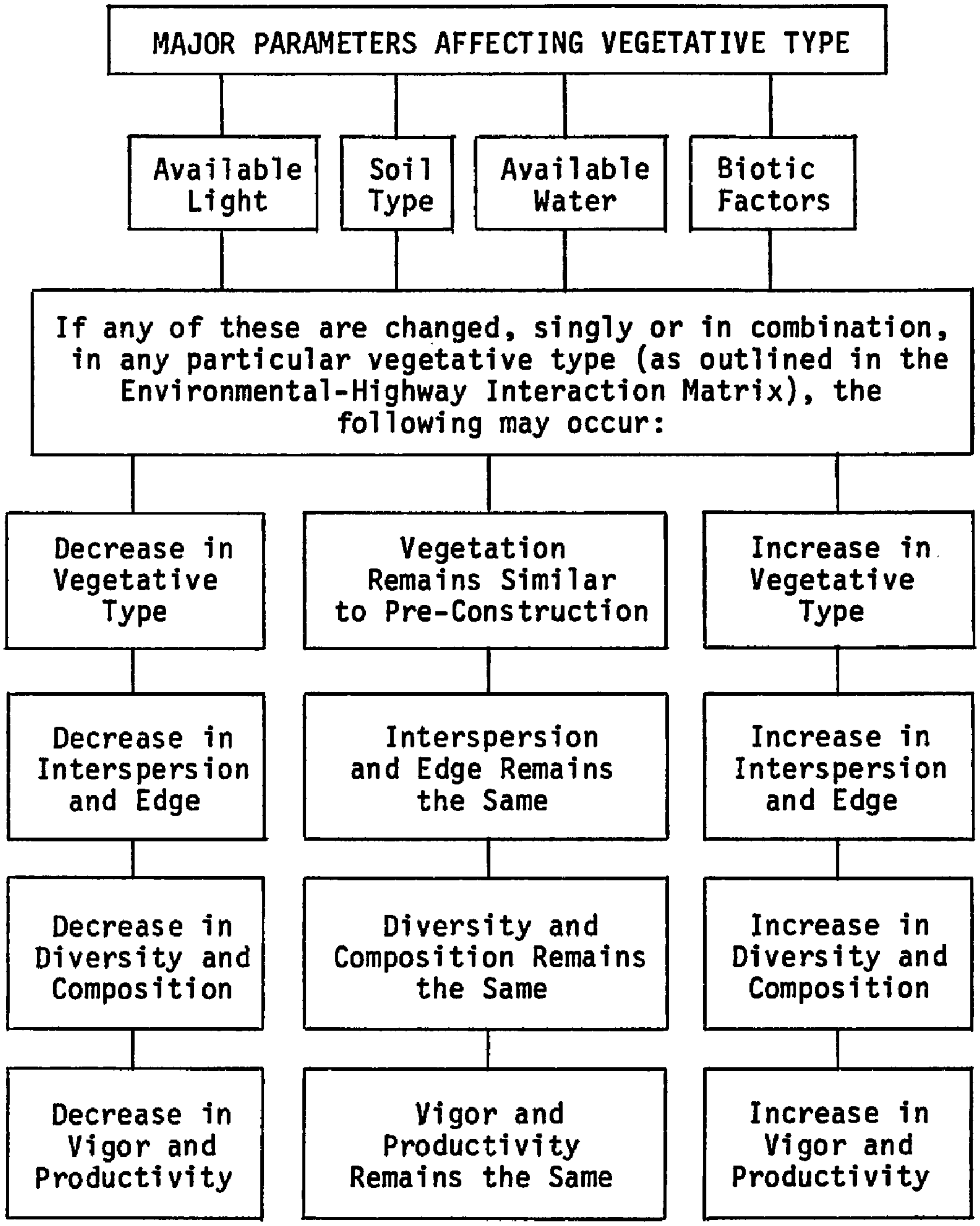

Figure 8.--Potential Impacts of highway activities on flora.

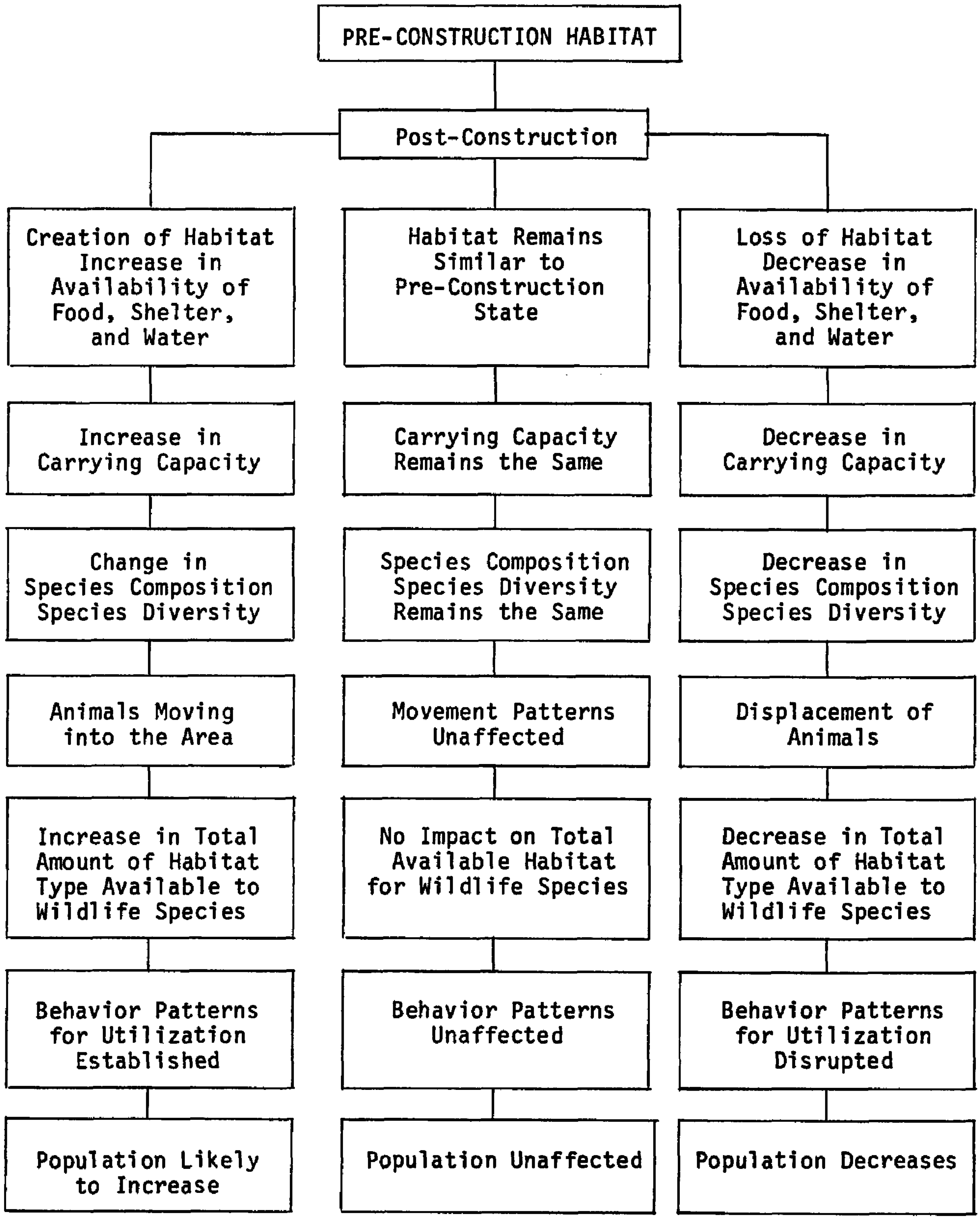

Figure 9.--Potential impacts of highway activities on wildlife habitats.

CHAPTER IV

ENVIRONMENT-HIGHWAY INTERACTION MATRIX

This matrix has been developed for use by MDSHT personnel as an aid to planning, designing, and constructing a highway in Michigan. The matrix is based on the Leopold Matrix (Leopold, 1971) and a shortened version of the Leopold Matrix developed and used by the Oregon Highway Department (Canter, 1977).

The matrix provides a visual display of potentially impacted environmental characteristics and major actions causing impacts; its primary advantage being a gross screening technique for impact identification. Further advantages of this matrix are in its ability to be expanded or contracted in scope and to be modified in structure. The matrix utilized information such as beneficial, neutral, or detrimental aspects of environment-highway interactions. Such a matrix can be a more useful decision-making tool.

The matrix includes three major interconnected sections:

1. Environmental Conditions--based on the four natural science parameters investigated in the study:
   a. Soils--mineral, organic, and made-land soils; drainage classes (Appendix B);
   b. Water--state, quality, drainage regime, and recharge potential (Appendix B);
   c. Flora--vegetation classes identified in the MLCUCS (Appendix A);

d. Fauna--major bird (Appendix C) and mammal groups (Appendix D).

2. Highway Activities--include actions which may impact the four natural science parameters at various stages or within spatial boundaries identified with a highway project. This section is divided into three parts:

   a. Activities occurring before, during, and after highway construction, including site preparation and restoration;

   b. Impacts of highway-related structures;

   c. Operational impacts induced by traffic, accidents, or maintenance.

The junction between Environmental Conditions (1) and Highway Activities (2) on the matrix grid allows a space or box where potential impacts can be listed. If the box is empty, there is either no change to that particular parameter or the interaction is of such a nature that impacts are minimal or extremely short-term. On the other hand, the presence of a code letter in the box indicates some type of interaction which must be examined. A large number of code letters tends to indicate that a highway activity has the potential to cause major changes in the environment.

3. Impacts--code letters present on the matrix represent significant interactions between the natural science parameters and highway activities. They are listed in a separate Table of Impacts which the user refers to. Letters <u>a-j</u> have been assigned to soils; <u>a</u> and <u>k-n</u> to water; <u>o-s</u> to flora; and <u>o, p</u>, and <u>t-v</u> to fauna.

Each code letter is further broken down to indicate in what ways a highway activity will affect the state or condition of a listed natural science parameter. In most cases, the interaction will result in either a beneficial (+) or detrimental (-) impact, or the increase (+) or decrease (-) of a particular condition, quantity, quality, etc. A code letter without a plus or minus would indicate an interaction which would benefit some aspects of a parameter while being detrimental to other aspects. A short description follows each code letter explaining the nature of the impact as well as its predicted magnitude and importance.

The use of the Environment-Highway Interaction Matrix in highway decision-making can be valuable in predicting the effects of highways on existing environments and to compare resultant environments created by highway-related activities. By evaluating various environmental parameters, alternate routes can be sufficiently analyzed prior to highway location and construction. The major function of the matrix is to present an objective list of potential impacts resulting from interactions between natural science parameters and highway activities. With this information, decisions can be based on research while reliance on personal opinions can be reduced.

<u>Impacts, Code Letters, and Definitions for Parameters</u>

a Soil quantity--the physical mass of soil present in a given locality

a+ Buildup or gain of productive soil through a practice which physically adds soil to an area, or reclamation practices, such as artificial drainage, which creates more productive soil although no new soil is deposited. It may also refer to erosion control practices as soil loss is mitigated.

a- Loss of soil quantity occurs as a result of the mechanical removal of the soil from a site through excavation or as a result of erosion.

Surfacing, cutting and filling, wetland fill, and bridges all may cause changes in quantity of soil to occur on all types of soil. Erosion control practices result in a build-up of productive soil while borrow pits, spoil banks, highways, and roads cause a loss of quantity of soil.

a Water quantity--refers to the mass of water present in a given water body, drainage regime, or aquifer.

a+ An increase in water.

a- A decrease in water.

Surface water quantity may be increased by highways and roads if water is dammed or by other dams or impoundments. It is decreased by surfacing and burning. Other factors which may affect quantity of surface water are drainage alteration, flow modification, and dredging.

Ground water may be increased by impoundments and erosion control and is decreased by surfacing, burning, highways, and roads which either increase runoff and/or decrease infiltration. Ground water quantity may also be affected by drainage alteration, flow modification, and removal of vegetation.

Quantity of recharge and runoff is affected by surfacing, drainage alteration, flow modification, burning, removal of vegetation, wetland fill, or draining, erosion control, landscaping, reforestation, highways and roads, dams, impoundments, fires, and mechanical weed control.

b Cation Exchange Capacity (CEC)--is a measure of the total amount of exchangeable cations that can be held by the soil. CEC is expressed as a milliequivalent per 100 grams of soil at neutrality (pH=7) or at some other stated pH values (Stefferud, 1957). Some factors which affect CEC are the amount of organic matter in the soil, soil particle size, and pH. In this context, changes in cation exchange will also occur as replacement of available exchange sites with undesirable cations.

b+ Improvement of CEC occurs as organic matter is added to the soil, the soil receives additional fine particles such as clay or silt or pH increases so that less sites are occupied by hydrogen ions.

b- Occurs as exchange sites are lost through removal of organic matter by burning or loss of vegetation or erosion. Sites may also be taken up by undesirable cations when calcium hydroxide ions are introduced to the soil during a chemical change, possibly as a result of chemical de-icing.

Chemical de-icing, burning, and surfacing are factors which contribute to the loss of cation exchange sites on all soil types. Organics, which improve cation exchange capacity, are removed from the soil during burning. Chemical de-icing may reduce cation exchange capacity as exchange sites become occupied by undesirable cations.

c Erosion refers to the movement of soil particles via wind or water flow such as splash, sheet, rill, bully or ice shove.

c+ Practices which cause a decrease in erosion by causing flow of water to slow.

c- An increase in erosion which may occur as a result of actions which expose the soil to erosive forces, such as removal of vegetation, burning, or drainage changes (i.e., laminar flow becomes channel flow) such that the velocity of water flow increases in a given locality.

Surfacing, burning, removal of vegetation, and mechanical weed control are factors contributing to erosion on all types of soils. Erosion control practices, landscaping, reforestation, and barriers help to reduce erosion.

d Leaching refers to the downward movement of elements or compounds through the soil. The rate of leaching relates to soil structure, texture, and profile, and to the rate of percolation of water through the soil.

d+ Increase in rate of leaching.

d- Decrease in rate of leaching.

Leaching is affected by surfacing, burning, removal of vegetation, landscaping, and reforestation, and with dams and impediments on all soil types.

e Mulch--accumulated organic matter at or near the surface in various stages of decomposition.

e+ The saving or buildup of mulch.

e- The removal of mulch or any practice which causes mulch to be removed.

Mulch builds up as a result of erosion control practices, landscaping, reforestation, and the construction of barriers on all types of soils.

Reduction of mulch occurs in cut and fill operations, burning, and removal of vegetation. Construction of dams and impoundments removes sites for mulch buildup due to the inundation of surface waters.

f Structure--the agglomerative formation of soil particles.

f+ An improvement in soil structure which is beneficial to plant growth.

f- The breakdown of agglomerates.

Surfacing causes a breakdown in soil structure, while drainage alteration, flow modification, landscaping, and reforestation contribute to beneficial soil structure.

g Infiltration and permeability refer to water entering the soil at the soil surface and the quality of the soil in terms of its ability to infiltrate water.

g+ An increase in infiltration.

g- A decrease in infiltration.

Infiltration may increase as a result of drainage alteration, flow modification, and burning on all soil types. Impermeable surfaces caused by surfacing decrease infiltration.

h Aerobic conditions refer to the amount of oxygen in the soil.

h+ Creation of aerobic conditions in the soil.

h- A loss of oxygen in the soil.

Dams and impoundments cause a decrease in the aerobic conditions of the soil.

i Soil and water quality--the summation of the properties imparted to the soil and water by the physical, chemical, and biological characteristics in consideration of the intended use of the soil and water.

i+ Increase in quality for intended use.

i- Decrease in quality for intended use.

Changes in soil quality occur during burning, removal of vegetation, erosion control practices, spills, and pollutions.

Changes in water quality occur as a result of drainage alteration, flow modification, dredging, burning, removal of vegetation, wetland filling, draining, borrow pits, erosion control, reforestation, landscaping, waste disposal, dams, impoundments, fires, spills, pollution, and chemical de-icing.

j Soil moisture refers to the amount of water in the soil including hygroscopic, capillary, and free water.

j+ An increase in soil moisture.

j- A decrease in water content of a soil.

Removal of vegetation affects soil moisture while landscaping and reforestation result in an increase in soil moisture. Drainage alterations, flow modifications, and culverts decrease the capacity of moisture for all soil types.

k Water table level is the upper surface of ground water or that level below which the soil is saturated with water; locus of points in soil water at which the hydraulic pressure is equal to atmospheric pressure.

k+ A raising of the water table level.

k- A lowering of the water table level.

The level of the water table is lowered as a result of filling and drainage alteration modifications. Dams and impoundments increase the water level adjacent to the body of surface water.

l Flow pattern refers to patterns or spatial distribution of migrating surface water.

Flow patterns are affected by surfacing, cutting and filling, drainage alteration modifications, dredging, burning, removal of vegetation, wetland fill or drainage, borrow pits, spoil banks, and erosion control practices in channel drainage and laminar drainage. Landscaping and reforestation, waste disposal, highways, roads, bridges, dams, and impoundments, culverts, barriers, pollution, and spills also contribute to changes in flow patterns in channel drainage and laminar drainage.

The flow patterns of surface water are changed as a result of bridges and culverts. Ground water flow patterns are affected by surfacing, cutting and filling, burning, and wetland fill or drainage.

m Flood probabilities or chances--that floods of various magnitude will occur.

m+ An increase in flood probabilities.

m- A decrease in flood probabilities.

Surface water flood probabilities are increased with surfacing land, burning, and removing vegetation. Dredging, erosion control, landscaping, and reforestation are factors which minimize flood probabilities of surface waters.

n Distribution refers to spatial location of water.

Surfacing, cutting and filling, drainage alteration modifications, burning, wetland fill or drainage, borrow pits, erosion control, highways and roads cause changes in spatial distribution of surface waters.

Ground water distribution is affected by drainage alteration or modification, burning, and the construction of highways and roads.

o Species diversity--the number of different species occurring in some location or under some conditions.

o+ Change results in an increase of species diversity.

o- Change results in a decrease of species diversity.

Highway activities can result in a + change when existing habitats are disturbed in a manner such that the resultant environment provides the necessary requirements to support a larger number of speices. An illustration of a + (increase) in diversity of both fauna and flora is when overstory species are removed in a forest producing a resultant environment of an earlier successional stage. A - (decrease) in species diversity of both fauna and flora is apparent when the soils surface is paved with concrete.

p Species composition--the kinds of species occurring in some location or under some conditions.

p+ Change results in an increase of the species desired by man.

p- Change results in a decrease of the species desired by man.

Avian diversity of a herbaceous rangeland could be comprised of between 25-30 species with 3-5 of these being upland game birds. If this habitat is disturbed so the resultant environment is a shallow pond (borrow pit), the avian diversity could remain between 25-30 species with 3-5 being waterfowl. Species composition, however, has changed from songbirds, birds of prey, and upland gamebirds to waterfowl marsh and shorebirds. Species composition of the vegetation present in an environment is affected in a similar manner. In this example, species in both the existing and resultant environments are desired by man. Thus, the question becomes which habitat or combination of habitats will be the most advantageous for the area in question?

q Interspersion--scattered among other things, located here and there; the act of diversifying with things scattered here and there.

q+ An increase in interspersion. An increase in interspersion is generally beneficial because it increases the diversity.

q- A decrease in interspersion. A decrease in interspersion is generally detrimental because it will reduce the plant diversity and thus plant habitat types available to a variety of fauna.

If a cut is excavated through an acre of land containing a mature broadleaf forest that has no openings, the effect of the cut will be to increase interspersion and thus diversity. Shrubs and herbaceous species will eventually move into the cut, and the acre will contain two habitat types rather than one. If a cut is conducted through an acre of land in such a way that the cut moves through a broadleaf forest, removes a small conifer stand, and cuts through shrub rangeland, the overall effect will be a decrease in interspersion. With the cut eventually supporting herbaceous and shrub rangeland, the habitat types in the acre of land will be changed from three to two. A single action may have two opposite effects, in one situation beneficial, in another detrimental.

r Edge--a special type of transition that refers to a very narrow or structurally abrupt juncture between seral communities; the classical example being the forest-field interface.

r+ An increase in edge. Edge is generally an area with high species diversity because two or more habitat types are in close proximity and animals move easily to and from various food, shelter, and/or water sites.

r- A decrease in edge. Edge is closely related to interspersion. An increase in edge is associated with an increase in interspersion and vice versa. In the previous example concerning interspersion, a cut which increases interspersion would increase edge as well. A cut producing a decrease in interspersion would produce a decrease in edge.

s Destruction--certain highway activities will result in total destruction and/or permanent removal of vegetation.

s- Obliteration of vegetation.

In an area which has been surfaced, the vegetation of the area has been completely and permanently removed.

t Habitat--the place where an organism lives, or the place where one would go to find it.

Each organism has a specific set of requirements essential to its survival and well-being which constitutes its habitat. Highway activities can result in an increase (t+) of available habitat for one species and a decrease (t-) of available habitat for another species simultaneously. Cut and fill operations through a northern white cedar swamp reduce the amount of wind-protected winter shelter for deer (t-) but increase (t+) the forage area for snowshoe hare.

t+ Change characteristics of habitat resulting in an increase in carrying capacity (creation).

t- Change characteristics of habitat resulting in a decrease in carrying capacity (destruction loss).

Characteristics--size, amount of edge, species composition, species diversity, interspersion, and production of food, shelter, and water.

u Carrying capacity is the number (or biomass) of organisms of a given species which can survive in, without causing deterioration of, a given ecosystem through the least favorable environmental conditions that occur within a stated interval of time.

u+ Change results in an increase in carrying capacity.

Highway activities can produce resultant environments that have more and/or improved habitat for a particular species. Edge habitat for low nesting birds, small mammals, and birds of prey is often created. When the amount of habitat available increases, the area's carrying capacity also increases.

u- Change results in a decrease in carrying capacity.

Destruction of habitat available to a species, such as occurs with surfacing, lowers the carrying capacity of the area.

v Behavior--the response of an individual, group, or species to the whole range of factors constituting its environment.

v+ Behavior changed results in an increase in carrying capacity.

Highway structures such as bridges and signs provide nesting sites for birds which would not have nested in an area where a highway is located. Barn swallows observed nesting on bridge structures illustrate how highway activities can increase the carrying capacity of an area for a given species.

v- Behavior changed results in a decrease in carrying capacity.

Separating a community into segments which are smaller than the home range of the species in question can result in animals avoiding an area which, prior to disturbance, was suitable habitat. Barriers such as the highway and related structures will also result in an avoidance behavior (v-).

ACTIONS THAT MAY IMPACT SOILS, WATER, FLORA, AND FAUNA

ENVIRONMENTA

			SOILS					WATER							
			WELL DRAINED MINERAL SOILS	MODERATELY DRAINED MINERAL SOILS	POORLY DRAINED MINERAL SOILS	ORGANIC SOILS	MADE LAND	SURFACE WATER	GROUND WATER	RUNOFF	RECHARGE	CHANNELIZED DRAINAGE	LAMINAR DRAINAGE	CROPLAND ROTATION & PERMANENT PASTURE	ORCHARDS, BUSH-FRUITS VINEYARDS AND
HIGHWAY CONSTRUCTION ACTIVITIES	LAND TRANSFORMATION AND CONSTRUCTION	SURFACING	a-b-c- d-f-g-	a-b-c- d-f-g-	a-b-c- d-f-g-	a-b-c- d-f-g-	a-b-c- d-f-g-	a-n l m+	a- l	a	a	l	l	s-	s-
		CUT	a- e-	a- e-	a- e-	a- e-	a- e-	n k	a k l	a	a	l	l	s-	s-
		FILL	a- e-	a- e-	a- e-	a- e-	a+ e-	n k	a k l	a	a	l	l	q r s-	q r
		DRAINAGE ALTERATION FLOW MODIFICATION	f g+k- j-	f g+k- j-	f g+k- j-	k- j-	f g+k- j-	a i n	a n	a	a	l	l	o p	o p
		DREDGING	a-	a-	a-	a-	a-	a i m-			a	l	l		
		BURNING	b-c-d+e- g+i k-j-	b-c-d+e- g+i k-j-	b-e-d+ e-j+i	b-c-d+ e-g+i	b-c-d+e- g+i k-j-	a-i m+ n	a-i l n	a+		l	l	s-	s-
		REMOVAL OF VEGETATION	c d e i j	c d e i j	c d e i j	c d e	c d e i j	i m+	a	a+	a	l	l	o p q r s-	o p r s-
		WETLAND FILL OR DRAINING			a h k	a h k	a h k	i n	l	a+	a-	l	l		
		BORROW PITS	a-	a-	a-	a-	a-	i n	i		a	l	l	s-	s-
		SPOIL BANKS	a	a	a	a	a			j		l	l	s-	s-
	RESTORATION & PROTECTION	EROSION CONTROL	a+e+i+	a+e+i+	a+e+i+	a+e+i+	a+e+i+	i m-n	a+	a-	a+	l	l	o p	o p
		LANDSCAPING REFORESTATION	c+d+e+ f+j+	c+d+e+ f+j+	c+d+e+ f+j+	c+d+e+ f+j+	c+d+e+ f+j+	i m-		a-	a+	l	l	o p q r	o p r
		WASTE DISPOSAL	i	i	i	i	i	i	i					s-	s-
RELATED STRUCTURES		HIGHWAYS AND ROADS	a e-g-	a e-g-	a e-g-	a e-g-	a e-g-	a+n	a-n	a+	a-	l	l	s-	s-
		BRIDGES	a	a	a	a	a	m n l				l	l	s-	s-
		DAMS-IMPOUNDMENTS	a-d-e- h-k+	a d e- h-k+	a-d-e- h-k+	a-d-e h-k+	a-d-c- h-k+	a+i l m	a+k+l		a	l	l	s-	s-
		CULVERTS	j-	j-	j-		j-	j n	k			l	l	s-	s-
		BARRIERS; FENCING	e+	e+	e+	e+	e+						l		
		SIGNS, MARKERS													
HIGHWAY OPERATION	TRAFFIC	AUTOMOBILE													
		TRUCKING													
	ACCIDENTS	VEHICLE COLLISION WITH WILDLIFE													
		FIRES	b-c-d+e- g+i k-j-	b-c-d+e- g+i k-j-	b-c-d+ e-j-i	b-c-d+ e-g+i	b-c-d+e- g+i k-j-	a-i m+ n	a-i l n	a+		l	l	s-	s-
		SPILLS	i	i	i	i	i	i	i					o-p-s-	o-p-
		POLLUTION AIR, LAND, WATER	i	i	i	i	i	i	i					o-p-s-	o-p-
	MAINTENANCE	CHEMICAL DE-ICING	b-	b-	b-	b-	b-	i	i						
		MECHANICAL WEED CONTROL	c-g+j	c-g+j	c-g+j	c-g+j	c-g+j			a+					
		VEHICLE DISRUPTION													

KEY
a quantity b cation exchange c erosion (water) d leaching e mulch (litter) f soil structure g infiltration-
m flood probabilities n distribution o diversity p composition q interspersion r edge s destruction
(+ beneficial impact; increase of a condition, quantity, quality, etc.) (-detrimental impact; decrease of a condition, q

Figure 10 Environment-Highway Interaction Matrix

ENVIRONMENTAL CONDITIONS

WATER				FLORA									FAUNA						
RUNOFF	RECHARGE	CHANNELIZED DRAINAGE	LAMINAR DRAINAGE	CROPLAND ROTATION & PERMANENT PASTURE	ORCHARDS, BUSH-FRUITS VINEYARDS AND HORTICULTURAL AREAS	HERBACEOUS RANGELAND	SHRUB RANGELAND	BROADLEAF FOREST	CONIFEROUS FOREST	MIXED CONIFER-BROADLEAF FOREST	FORESTED WETLANDS	NON-FORESTED WETLANDS	WATERFOWL	MARSH AND SHORE BIRDS	UPLAND GAMEBIRDS	BIRDS OF PREY	SONGBIRDS	FURBEARING AND GAME MAMMALS	SMALL MAMMALS
[illegible]	a	l	l	s-	s-	s-	s-	s-	s-	s-	s-	s-	t- u-	t- u-	t- u-	t- u-	t- u-	t- u-	t- u-
	a	l	l	s-	s-	s-	s-	s-	s-	s-	s-	s-				t u	t u	t u	t u
	a	l	l	q r s-	q r s-	opqrs-	opqrs-	opqrs-	opqrs-	opqrs-	opqrs-	opqrs-	t- u-	t- u-	o+p+t+u+	o p t u	o p t u	o p t u	o p t+u+
	a	l	l	o p	o p	o p	o p	o p	o p	o p	o p	o p	o p t u	o p t u	o p t u	t u	o p t u	t u	t u
	a	l	l								o p q r s-	o p q r s-	o-p-t- u-	o-p-t- u-	t-u-	t u	o p t u	o p t u	o p t u
+|		l	l	s-	s-			o p q r s-	o p q r s-	o p q r s-					t u	t u	o p t u	o p t u	o p t u
+	a	l	l	o p q r s-	o p q r s-	o p q	o p q	o p q r s-	o p q r s-	o p q r s-	o p q r s-	o p q r s-			o p t u	o p t u	o p t u	o p t u	o p t u
+	a-	l	l								o p q r s-	o p q r s-	t-u-	t-u-	o+p+t+ u+	o p t u	o p t u	o p t u	o p t u
	a	l	l	s-	s-	o p q r s-	o p q r s-	o p q r s-					o+p+t+ u+	o+p+t+ u+	t-u-	t u	o p t u	t u	t u
		l	l	s-	s-	o p s-	o p s-									t u		t u	t u
-	a+	l	l	o p	o p			o p q r	o p q r	o p q r			t+u+	t+u+	t+u+	t+u+	t+u+	t+u+	t+u+
-	a+	l	l	o p q r	o p q r	o p q r	o p q r	o p q r	o p q r	o p q r					t+u+	t+u+	o+p+t+ u+	t+u+	o p t+ u+
				s-	s-	o-p-s-	o-p-s-	o-p-q r s-	o-p-q r s-	o-p-q r s-	o-p-q r s-	o-p-q r s-	t-u-	t-u-	t-u-	t-u-	t-u-	t-u-	t-u-
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tter) f soil structure g infiltration-permeability h aerobic conditions i quality j soil moisture k water table level l flow patterns
erspersion r edge s destruction t habitat u carrying capacity v behavior
mental impact; decrease of a condition, quantity, quality, etc.)

CHAPTER V

ENVIRONMENTAL GUIDE FOR DECISION MAKERS

The objectives of this guide are to provide a set of information and procedures that can aid decision makers in evaluating environments that may be impacted by highway activities. This guide is presented here as a tool for highway personnel to examine both existing and resultant environments. However, the information and procedures have broad applicability to other corridor analyses performed in Michigan. Impacts of corridors have similar effects on the environments they traverse, be they transmission lines, pipelines, fire lanes or highways. Degree of impacts often will vary but the ecological parameters and the relationships among them are the same. Adoption of these procedures reduces reliance on personal opinion and facilitates an information-gathering capability which is replicable, quantifiable and legally functional (Fig. 11).

The first step in determining effects of highway activities is to quantify the size and type of vegetative communities the proposed corridor will traverse. Since NEPA directives require examination of alternatives, this will necessitate examination of several potential routes. Information on vegetative types is available for areas of the state where imagery has been flown and photo interpreters have classified the vegetation using the MLCUCS. This information is currently available for highway planning regions where future construction is being considered.

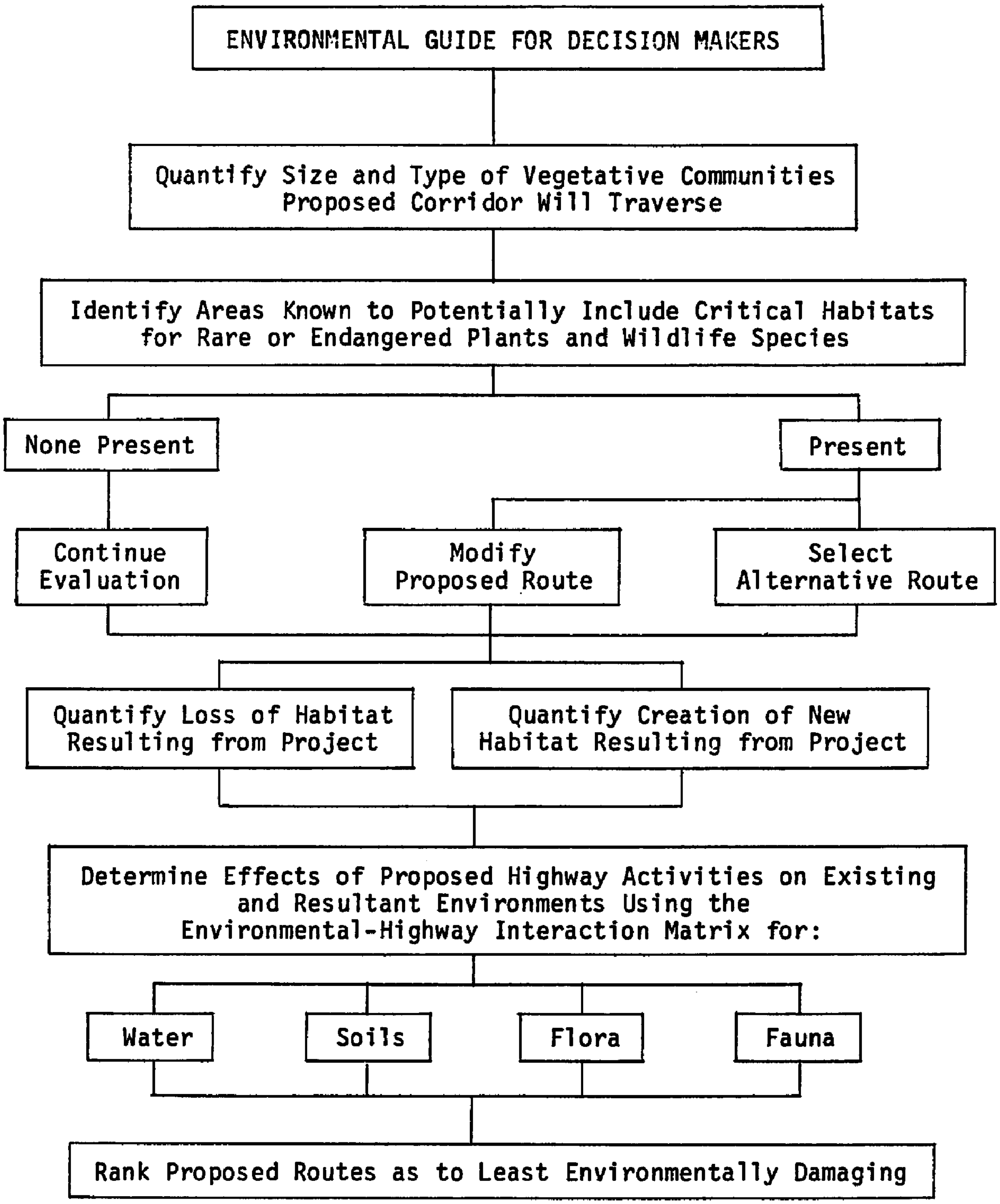

Figure 11.--Decision-making process to select least environmentally damaging route.

Once quantification of the size and type of existing vegetative communities is determined, highway planners have assembled the basic information necessary to begin an assessment of potential environmental impacts. This is the point at which many environmental assessments in the past have been considered complete.

Since no project receives approval if endangered species will be adversely impacted by the proposed project, unacceptable routes from a legal viewpoint can be quickly ruled out by identifying areas known to include critical habitats for endangered flora or fauna.

A procedure for considering endangered and/or threatened flora during the route location process is indicated in Figure 12. By utilizing the habitat type and distribution information which follows in conjunction with the procedure outlined in Figure 12, highway planners can quickly determine if proposed corridors traverse counties that contain critical habitats for endangered or threatened flora. The vegetative types and associated soils, water, flora and fauna contained in Appendix B indicate what species are likely to be present with the vegetative type being considered.

Field surveys to determine if any of these species are present and how the total amount of critical habitat will be impacted can then be conducted. This procedure is much more efficient than suggesting a corridor and then sending staff out into the field to inventory flora and to determine if any endangered or threatened species are present. By utilizing the aforementioned procedure, the species which field staff will be looking for are known in advance. This allows for full consideration of what stage of development the plant is in, time of the year most easily observed in the field, associated

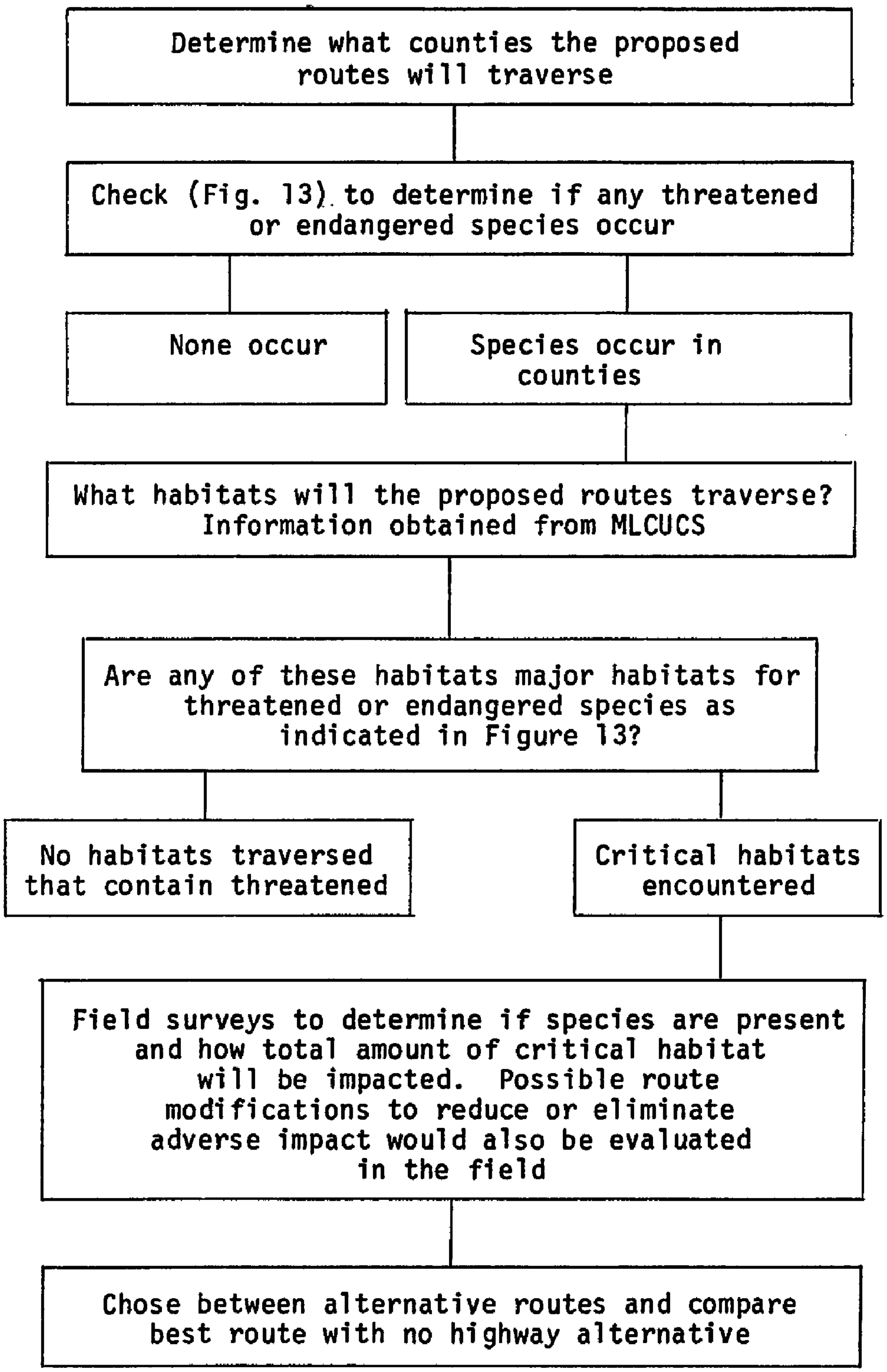

Figure 12.--Procedures for considering threatened or endangered flora during the route location process.

plant species, soils and drainage regimes, thereby decreasing the likelihood of overlooking important flora.

Habitat type and distribution of endangered and threatened flora are presented here to augment Figure 13. Greater numbers of rare species are found in the southeastern and southwestern corners of the state and the northern tip of the Lower Peninsula (Fig. 13). The smallest number of rare species are found in the central areas of the state.

Endangered and threatened aquatic and wetland species are concentrated in several areas of the state. Some are in the southeastern corner of the state, others in the southwest, and still others have a distribution in the Upper Peninsula and northern Lower Peninsula. Species occurring in rangeland habitats generally show a southern distribution. Woodland species show the least characteristic patterns because woodland is well represented throughout the state. Although not discussed in this report, endangered and threatened species also occur on rock outcrops, bluffs, dunes, and other sandy areas. Species for which good habitat data are lacking or which occur in more than one type of habitat are also excluded. For a complete list of endangered, threatened or rare vascular plants in Michigan, users are referred to Wagner (1977).

Appendix B also provides the status and distribution of endangered and/or threatened fauna so that habitats important to these species can be identified. Once established, modifications, if necessary, to avoid such areas can be made and the evaluation of other potential corridors continued.

A. Counties with a triangle have 24 to 69 endangered or threatened species; those with a solid circle have 15 to 22.

B. Counties with a triangle have 3 to 5 threatened species; those with a solid circle have from none to 2.

Habitat Type	Endangered Species	Threatened Species	Total Species
Water (5)* and Wetlands (6)	3	79	82
Rangeland (3)	3	30	33
Woodlands (4)	4	25	29
Total	10	134	144

*Numbers correspond to those in MLCUCS.

Figure 13.--Habitat type and distribution of endangered and threatened plants in Michigan (Beaman, 1977).

Knowing what soils, vegetation, drainage regimes, and wildlife are associated with the vegetative cover types provides useful information about what resultant environments will be like after construction. To provide detailed information on what resultant habitats would have to contain to support desired plant and wildlife species, requirements for each were examined. Habitat requirements, food preferences, home range, status, and distribution for mammals (Appendix B) and birds (Appendix C) found in Michigan were assembled.

With the use of the information assembled on associated soils, drainage, vegetation, wildlife, and the data available from the MLCUCS (Appendix B), highway planners can quickly determine the nature of environments to be traversed.

Highway corridors may result in either loss of existing habitat or creation of new habitat types. Exact figures of such acreage may be difficult to calculate in the pre-construction stage due to unknown parameters. Such parameters include varying techniques used by contractors, time of construction, existing weather conditions, and ability of contractors to ensure personnel follow stated plan specifications. However, an attempt should be made to quantify these changes in order to determine overall impacts of highway activities.

Once the requirements for flora and fauna are established, it is possible to identify how highway activities may impact the relationships among water, soils, flora, and fauna in existing and resultant environments. To determine the effects of proposed highway activities on existing and resultant environments, the matrix can serve as a useful tool (Fig. 10). This matrix provides a visual display of potentially impacted environmental characteristics and major actions causing impacts. Once potential impacts are identified, examples of such impacts and how they are related can be found presented in Chapter III.

The final step in the route location process involves weighing of alternatives and trade-offs among possible impacts and mitigation processes. Ultimately, planners must make value judgements and trade-offs in determining whether a change should be avoided.

It was not the aim of this project to provide a means of deciding where a highway should be located. Rather it was to provide methods for an objective evaluation of the environment in question, based on natural science parameters that are measurable. The relationships among natural science parameters are described and evaluated to compare highway routes in a more analytical way. Thus, a proposed change and final impact can be objectively evaluated, making it possible to compare several existing and resultant environments <u>before</u> route selection.

CHAPTER VI

SUMMARY AND CONCLUSIONS

All highway projects require an environmental impact assessment before construction is authorized. Highway agencies have been acknowledged as being among the leaders in filing environmental impact statements. However, a major criticism of a large percentage of filed EIS's is that, while NEPA guidelines are followed sufficiently for legal purposes, the statements are inadequate in describing how the proposed project actually impacts the environment.

If existing and resultant environments impacted by highway activities are to be understood so that the information necessary to make wise resource decisions is possible, an ecological approach for highway routing must be adopted. It is important for highway personnel to become aware of the holistic concept of ecosystems which is built upon three major ecological principles. They are: 1) to protect critical environments and habitats; 2) to adopt a long-term, carrying capacity approach to ecosystem management; and 3) prevention of irreversible changes in the environment.

The adoption of an ecosystem approach with the aforementioned principles can improve the analysis procedure and help assure that project impacts are evaluated in a more meaningful manner. By referring to the matrix, a highway decision maker can readily see the far-reaching environmental impacts resulting from the construction, operation, and maintenance of highways and related structures. Each activity presents the potential for impact in all natural systems. On the matrix, the interactions illustrated are, generally, of a primary nature and can be dealt with as such. For example, by allowing for an adequate number of properly installed culverts, water impoundment can be avoided. These considerations are economic and engineering in nature, and can be derived by hydraulic research of the area traversed by the highway, calculating the amount of water to be drained, and ensuring that there are sufficient funds available for the required number of culverts.

A highway decision maker, thinking in terms of an ecosystem approach to problem solving, will also consider the areas adjacent to the right-of-way (ROW) where the secondary impacts of highway activities occur. For example, too much drainage will cause a drying of organic soils resulting in a loss of soil, vegetation dependent on the soil, and a change in water table levels. Not enough or interrupted drainage will cause a loss of water-intolerant plant species. Some swamp species, on the other hand, are tolerant to a high water table but are sensitive and perhaps intolerant to an extended period of excessive flooding. In such cases, wildlife are also affected by habitat alteration.

A major problem encountered by decision makers is determining which impacts are important. It is at this point in an analysis that subjectivity is introduced (Canter, 1975). Whether an impact is important or not depends to a great extent on who the investigator or observer is. This shows the significance of an interdisciplinary and holistic "team" approach to analysis and problem solving. The data provided by many disciplines can be integrated more objectively, but the importance of impacts must be weighted in each case to add objectivity to the final analysis.

Thus, the types of resultant environments created from highway activities can be viewed either as desirable or undesirable based on value judgements of the decision makers.

Van Winkle and others (1976) discuss the role of ecologists in determining the acceptability of environmental impacts. Their framework charges the ecologist or ecosystem manager to be aware of certain constraints:

a. knowledge limitations in assessing impacts accurately and with some degree of certainty;

b. the role of value judgements in decision making; and

c. the interface between progress and environmental protection.

The size and complexity of an ecosystem along with a lack of knowledge on the part of investigators introduces a set of compromises which ecosystem managers must consider in assessing project impacts.

Andrews (1973) proposes a new thought process for predicting the consequences of alternative actions. Basic to this approach is the realization that impacts affect whole systems, whether natural or artificial. Highway activities can cause both gross and subtle effects: a change in wildlife species composition is much less dramatic than widespread vegetation alteration or die-off. Also the complex interrelationships among ecosystem components may not always be quick to show that an impact has occurred. Thus, an understanding of natural systems and how they can be altered is necessary to make valid predictions and conscientious decisions.

Assessment of highway impacts should be an on-going process from the initial planning stages until after construction is completed. All stages of planning, construction, operation and maintenance should be flexible enough to allow for modification as new impacts are discovered during and after construction. Once the approach in this study for analyzing highway-environment relationships has been utilized, monitoring and management programs should be developed. Project impacts should be continuously observed to determine if current practices are adequate for future highway projects.

The ecological approach developed in this study provides the basis for improved environmental assessment and more informed decision making. The framework of the MLCUCS was expanded to include associated soil groups, drainage regimes, wildlife species and endangered or threatened flora. To provide information on what resultant environments would have to contain to support desired fauna, detailed information on habitat requirements, distribution, resident status, and food preferences of Michigan birds and mammals was compiled. This compilation of information serves as the basis for examining the effects of highway activities upon the relationships among soils, water, flora and fauna. Use of the species requirements, matrix, assessment framework and guide for decision makers provides a mechanism for more efficiently and effectively comparing potential impacts of alternative routes in a more analytical way <u>before</u> route selection. The ecological approach presented was developed for highway routing in Michigan. However, with modifications this approach can be utilized for any type of corridor analysis in Michigan. This approach reduces reliance on personal opinions, is replicable, quantifiable and legally functional.

APPENDICES

APPENDIX A

CLASSIFICATION, DEFINITION, AND DESCRIPTION OF MICHIGAN VEGETATIVE ASSOCIATIONS

3 RANGELAND*

Rangeland is defined as areas supporting early stages of plant succession consisting of plant communities characterized by grasses or shrubs. In cases where there is obvious evidence of seeding, fertilizing or other cultural practices, these areas should be mapped as rotation or improved pasture (Agricultural Land, 2122 and 2123).

31 Herbaceous Rangeland

Herbaceous rangelands are dominated by native grasses and forbs. Such areas are often subjected to continuous disturbance such as mowing, grazing or burning to maintain the herbaceous character. Typical plant species are quackgrass, Kentucky bluegrass, upland and lowland sedges, reed canary grass, clovers, etc.

311 Upland Herbaceous Rangeland

312 Lowland Herbaceous Rangeland

32 Shrub Rangeland

Shrub rangelands are dominated by native shrubs and low woody plants. If left undisturbed, such areas are soon dominated by young tree growth. Typical shrub species include blackberry and raspberry briars, dogwood, willow, tag alder, etc.

321 Upland Shrub Rangeland

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*Rangelands, forest lands, and wetlands are classified according to plant associations as they are identified with the various stages of ecological succession in Michigan. Definitions for wetlands were extracted from Golet, Francis C. and Larson, Joseph S. (G/L), "Classification of Freshwater Wetlands in the Glaciated Northeast," U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife Resource Publication 116, 1974, modified for Michigan conditions (Michigan Land Use Classification and Referencing Committee, 1976).

4 FOREST LAND

Forest lands are lands that are at least 10 percent stocked by trees producing an influence on the climate or water regime. Forest land can generally be identified rather easily from high-altitude imagery.

Lands from which trees have been removed to less than 10 percent stocking but which have not been developed for other use are also included. For example, lands on which there is forest rotation, involving clear-cutting and block planting, are part of Forest Land. On such lands, when trees reach marketable size, which for pulpwood in the Southeastern United States may occur in two to three decades, there will be large areas that have little or no visible forest growth. The pattern can sometimes be identified by the presence of cutting operations in the midst of a large expanse of forest. Unless there is evidence of other use, such areas of little or no forest growth should be included in the Forest Land category. Lands that meet the requirements for Forest Land and also for a higher use category should be placed in the higher category. Shrub communities will be mapped under Rangeland (upland) and Wetland (lowland).

41 Broadleaved Forest (generally deciduous)

In Michigan typical species are oak, maple, beech, birch, ash, hickory, aspen, cottonwood, and yellow poplar.

411 Upland Hardwoods

412 Aspen, White Birch, and Associated Species

413 Lowland Hardwoods

42 Coniferous Forest

Coniferous forests include all forested areas in which the trees are predominantly those with needle foliage. In Michigan these would include species such as pine, spruce, balsam, larch, hemlock, and cedar.

421 Upland Conifers

422 Lowland Conifers

43 Mixed Conifer-Broadleaved Forest

Mixed forest land includes all forested areas where both broadleaved and coniferous trees are growing.

431 Upland Hardwoods and Pine Associations

432 Aspen, Birch with Conifer Associations

433 Lowland Hardwoods with Cedar, Spruce, Tamarack, Etc. Associations

434 Upland Conifers with Maple, Elm, Ash, Aspen, and Birch, Etc. Associations

435 Lowland Conifers with Maple, Elm, Ash, Aspen, Birch, Etc. Associations

6 WETLANDS

Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation usually is established, although alluvial and tidal flats can be non-vegetated. Wetlands are frequently associated with topographic lows, even in mountainous regions. Examples of wetlands include marshes, mudflats, wooded swamps, and floating vegetation situated on the shallow margins of bays, lakes, rivers, ponds, streams, and man-made impoundments such as reservoirs. They include wet meadows or perched bogs in high mountain valleys and seasonally wet or flooded basins or potholes with no surface water outflow. Shallow water areas with submerged aquatic vegetation are classed as Water and are not included in the Wetlands category.

Wetland areas drained for any purpose belong to other land use categories, whether it be Agricultural Land, Rangeland, Forest Land, or Urban and Built-Up Land. When the drainage is discontinued and such use ceases, classification reverts to Wetlands after characteristic vegetation is re-established. Wetlands managed for wildlife purposes may show short-term changes in vegetative type and wetness condition as different management practices are used, but are properly classified Wetlands.

Two separate boundaries are important with respect to wetland discrimination: the upper wetland boundary above which practically any category of land cover may exist, and the boundary between wetland and open water beyond which the appropriate Water category should be employed.

Forested Wetland and Non-Forested Wetland are the Level II categories of Wetlands.

61 Forested (wooded) Wetlands

Forest wetlands include seasonally flooded bottomland hardwoods, shrub swamps, and wooded swamps including those around bogs. Because forested wetlands can be detected and mapped using seasonal (winter/summer) imagery, and because delineation of forested wetland is needed for many environmental planning activities, they are separated from other forest land. Wooded swamps and floodplains contain primarily oak, red maple, elm, ash, alder, and willow. Bogs typically contain larch, black spruce, and heath shrubs. Shrub swamp vegetation includes alder, willow, and buttonbush.

(611) Wooded swamps (mapped under forestry categories 413, 422, 433, 435)

This class applies to wetlands dominated by trees. The soil surface is seasonally flooded with up to one foot of water. Several levels of vegetation are usually present, including trees, shrubs, and herbaceous plants. Broadleaved swamps would be placed in the forestry category 413 and 433; coniferous swamps are placed in forestry category 422 and 435. Wooded bogs are placed in forestry category 422 and 435

612 Shrub Swamps

This class applies to wetlands dominated by shrubs where the soil surface is seasonally or permanently flooded with as much as 12 inches of water. Characteristic emergent plants providing cover beneath the shrubs are the sedge and sensitive fern. Meadow or marsh emergents occupy open areas.

62 Non-Forested (non-wooded) Wetlands

Non-forested wetlands are dominated by wetland herbaceous vegetation. These wetlands include inland non-tidal fresh marshes, freshwater meadows, wet prairies, and open bogs. The following are examples of vegetation associated with non-forested wetland. Narrow-leaved emergents such as cordgrass and rush are dominant in coastal marshes. Both narrow-leaved emergents such as cattail, bulrush, sedges and other grasses, and broad-leaved emergents such as water lily, pickerelweed, arrow arum, and arrowhead are typical of fresh water locations. Mosses and sedges grow in wet meadows and bogs.

(621) Marshland Meadow

This class applies to wetlands dominated by meadow emergents, with up to six inches of surface water in the late fall, winter and early spring. During the growing season, the soil is saturated and the surface exposed, except in shallow depressions and drainage ditches. Meadows occur most commonly on agricultural land where periodic grazing or mowing keeps shrubs from growing.

622 Mudflats

Mudflats include areas supporting little or no vegetation exposed during periods of low water.

623 Shallow Marshes

This class applies to wetlands dominated by robust or marsh emergents, with an average water depth of less than six inches during the growing season. Surface water may be present throughout the year or absent during the late summer and abnormally dry periods. Floating leaved plants and submergents are usually present in open areas. Duckweed is often abundant in quiet water. Submergents are primarily shallow-water species like coontail, bladderwort, and waterweed. Cover plants generally occupy 50 percent of the marsh area.

624 Deep Marshes

This class applies to wetlands with an average water depth between six inches and three feet during the growing season. Emergent marsh vegetation is usually dominant, with surface and submergent plants present in open areas. Cover plants generally occupy less than 50 percent of the marsh area.

APPENDIX B

VEGETATIVE TYPES AND ASSOCIATED SOILS, WATER, FAUNA AND FLORA

RANGELAND--Areas supporting early stages of plant succession consisting of plant communities characterized by grasses or shrubs. Vegetative types identified within this classification are Upland Herbaceous Rangeland, Lowland Herbaceous Rangeland, and Upland Shrub Rangeland. Each of these vegetative types provide habitat for several endangered and/or threatened plant species that are associated with rangelands. The primary endangered plants include Baptisia leucophaea (cream wild indigo), Gentiana saponaria (soapwort gentian), and Petalostemon purpureum (red prairie clover). Families which contain one or more threatened species in rangeland habitat are Cyperaceae (1 species), Poaceae (4), Acanthaceae (1), Apiaceae (1), Asclepiadaceae (3), Asteaceae (10), Convolvulaceae (1), Fabaceae (1), Gentianaceae (1), Lamiaceae (1), Rosaceae (3), Schrophulariaceae (1), Violaceae (1) (Beaman, 1977).

Soils, drainage and fauna associated with rangelands vary from one vegetative type to another and are therefore described for each of the classifications.

Upland Herbaceous Rangeland--Dominated by native grasses and forbs.

Soils and Water. Soils are well drained to moderately well drained with channelized surface drainage patterns. Laminar drainage will occur only occasionally over flat, uniform areas during or after heavy precipitation. The mineral nature of the soil facilitates high rates of infiltration preventing severe erosion when vegetative cover is present. Surface waters migrate toward lower elevations when geological characteristics of the subsoil prevent vertical movement.

Wildlife. Wildlife species associated with Upland Herbaceous Rangeland are waterfowl (nesting), marsh and shore birds, upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

Lowland Herbaceous Rangeland--Dominated by native grasses and forbs.

Soils and Water. Soils are moderately well drained to somewhat poorly drained with channelized surface drainage patterns. Laminar flow occurs over flat, uniform areas during or after periods of heavy or frequent precipitation. Usually high infiltration rates depending upon distance to water table from the soil surface. Little damage from erosion occurs given vegetative cover exists. Ground water may be near the soil surface at various times of the year, but is usually found beneath the soil surface. Soil profiles are well developed with colloidal material being leached from the A horizon.

Wildlife. Wildlife species associated with Lowland Herbaceous Rangeland include waterfowl (nesting), upland game birds, songbirds, fur and game mammals, and small mammals.

Upland Shrub Rangeland--Dominated by native shrubs and low wood plants.

Soils and Water. Soils are well drained to moderately well drained with channelized surface drainage patterns. The mineral nature of the soil with weakly developed profiles facilitates high rates of infiltration. Little erosion occurs unless heavy precipitation causes splash erosion on sloping areas without vegetative cover. Such conditions may result in gulley erosion.

Wildlife. Upland Shrub Rangeland provides habitat for waterfowl, upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

FOREST LAND--Lands that are at least 10 percent stocked by trees producing an influence on the climate or water regime. Vegetative types identified within this classification are Broadleaved Forest, Coniferous Forest, and Mixed Conifer-Broadleaved Forest. Each of these vegetative types is further divided into subgroups based on the topography where they are present (upland or lowland). Each of these vegetative types provide habitat for several endangered and/or threatened species of plants. The primary species found in woodlands are Arnica cordifolia (heart-leaved arnica), Castanea dentata (American chestnut), Isotria medeoloides (smaller whorled pogonia), and Polygonatum biflorum var. melleum (Solomon-seal). Families which contain one or more threatened species in woodland habitats are Cyperaceae (1 species), Liliaceae (4), Orchidaceae (4), Araliaceae (1), Aristolochiaceae (1), Asteraceae (1), Boraginaceae (1), Caprifoliaceae (2), Ericaceae (1), Fabaceae (1), Hippocastanaceae (1), Polemoniaceae (1), and Ranunculaceae (1) (Beaman, 1977).

Soils, drainage and fauna associated with Forest Land vary from one vegetative type to another and are therefore described for each of the classifications.

Upland Hardwoods--Deciduous species including sugar maple, red maple, elm, beech, yellow birch, cherry, red oak and white oak.

Soils and Water. Soils are well drained to moderately well drained with channelized surface drainage patterns. Usually little damage from erosion with high infiltration rates on level ground, however, heavy runoff may cause gulley erosion as surface waters migrate to lower elevations over exposed soil surfaces. Soils are mineral with generally thicker A horizons in maple and beech associations than in oak or birch areas. Soils in maple or beech associations are likely to be loams or sandy loams whereas birch or oak associations are sands or loamy sands.

Wildlife. Wildlife species associated with Upland Hardwoods are upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

Aspen, White Birch and Associated Species

Soils and Water. Soils are moderately well to somewhat poorly drained with channelized drainage patterns. Soils are mineral and sandy in texture, with weakly developed horizons and high infiltration rates. Little damage from erosion occurs given adequate ground cover and level ground. Sloping areas with exposed soils are subject to gulley erosion during periods of precipitation and heavy surface runoff.

Wildlife. Wildlife species found in Aspen and White Birch Associations are upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

Lowland Hardwoods--Deciduous species including ash, elm and maple.

Soils and Water. Soils are moderately well drained to somewhat poorly drained but may frequently be poorly drained in elm or ash associations. Both laminar and channelized drainage patterns are found depending upon the depth to the water table. Little damage from erosion occurs as a result of surface runoff in these lowland areas. Siltation from overflow of adjacent waterways may alter textural composition of the soil. Soils are predominantly mineral but may have a high percentage of organic matter in the A horizon. Ground water may occur at the surface during most periods and some laminar flow will move water horizontally at very slow rates.

Wildlife. Lowland Hardwoods provide habitat for birds of prey, songbirds, fur and game mammals, and small mammals.

Upland Conifers--Coniferous species including white pine, red pine, jack pine, scotch pine and white spruce.

Soils and Water. Soils are well drained to moderately well drained with channelized drainage patterns. High infiltration rates facilitate the vertical movement of water through the mineral, usually sandy spodosols or podzols which have weakly developed profiles. Thus erosion is only a problem when vegetative cover is lacking or heavy runoff over slopes causes the formation of gullies.

Wildlife. Wildlife species associated with Upland Conifers include upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

Lowland Conifers--Coniferous species including cedar, black spruce, tamarack and balsam fir.

Soils and Water. Soils are somewhat poorly drained to poorly drained in cedar or tamarack associations and moderately well drained to well drained in balsam-fir and spruce associations. The water table may be near or at the soil surface where cedar and tamarack predominate, whereas water tables will be further below the soil surface in spruce and fir areas. Laminar drainage will occur depending upon the level of the water table and uniformity of soil elevation. Infiltration rates will depend upon the depth to the water table and amount of organic accumulation on the soil. Generally there is little or no erosion damage unless severe flooding occurs. Soils are mineral, or mineral with a significant overburden of organic matter.

Wildlife. Wildlife species found in Lowland Conifers are birds of prey, upland game birds, songbirds, fur and game mammals, and small mammals.

Upland Hardwoods and Pine Associations--Both broadleaved and deciduous trees are growing together including pines found in Upland Conifers and deciduous species found in Upland Hardwoods.

Soils and Water. Soils are well drained to moderately well drained with channelized surface drainage patterns. Infiltration rates due to the mineral nature of the soil are generally higher in birch, cherry, and oak sites, and lower in maple, elm, and beech areas. Little damage from erosion occurs when the ground surface and slopes are vegetated. Significant splash erosion can occur if precipitation is not intercepted by the overstory canopy. Large amounts of precipitation may migrate over the soil surface and result in gulley erosion particularly on slopes. In maple, elm or beech areas soils are likely to be loamy with well developed profiles, whereas in birch, oak or cherry areas soils are likely to be sandy with weakly developed horizons.

Wildlife. Upland Hardwoods and Pine Associations provide habitat for upland game birds, birds of prey, songbirds, fur and game mammals, and small mammals.

Aspen, Birch and Conifer Associations

Soils and Water. Soils are moderately well drained to somewhat poorly drained with channelized surface drainage. Infiltration rates are high which prevents damage from erosion by surface runoff when vegetative cover is present. If ground cover is sparse (<30%), gulley erosion may occur during periods of heavy runoff. Soils are mineral and sandy in texture with weakly developed horizons.

Wildlife. Birds of prey, songbirds, fur and game mammals, and small mammals are found in Aspen, Birch and Conifer Associations.

Lowland Hardwoods with Cedar, Spruce, Tamarack, Etc.

Soils and Water. Soils are somewhat poorly drained to poorly drained. Both channelized and laminar surface drainage may occur. Rate of infiltration will depend upon depth to water table and texture at soil surface which may be altered by siltation. Small areas of lowland provide efficient sediment traps for flowing surface water where deposition occurs. Soil may be mineral, or mineral with a significant organic overburden with high cation exchange capacities for short periods of time.

Wildlife. Wildlife species found in Lowland Hardwood with Cedar, Spruce, Tamarack, Etc. Associations are birds of prey, songbirds, fur and game mammals, and small mammals.

Upland Conifers with Maple, Elm, Ash, Aspen, Etc.

Soils and Water. Soils are generally well drained to moderately well drained with channelized surface drainage. Erosion damage may occur on slopes and areas with sparse vegetative cover. Soils are mineral, sandy textured with low cation exchange capacity and high infiltration rates. A horizons are thin and soil profiles are weakly developed.

Wildlife. Birds of prey, songbirds, fur and game mammals, and small mammals are associated with this habitat type.

Lowland Conifers with Maple, Elm, Ash, Aspen, Birch, Etc.

Soils and Water. Soils are moderately well drained to poorly drained where cedar and tamarack predominate. Moderately well drained soils occur where spruce and balsam predominate. Both channelized and laminar surface drainage may occur. Rates of infiltration will depend upon depth to water table and soil texture. Little erosion occurs given abundant plant growth unless flooding occurs. Soils are mineral or mineral with a significant organic overburden.

Wildlife. Wildlife species associated with this habitat type include birds of prey, songbirds, fur and game mammals, and small mammals.

WETLANDS--Wooded swamps, shrub swamps, marshland meadows, mudflats, shallow marshes, and deep marshes. Wetlands provide habitat for many endangered and/or threatened plant species. Endangered species associated with wetlands and water habitats are *Chelone obliqua* (purple turtlehead), *Nelumbo pentapetala* (American lotus), and *Scirpus hallii*. Families which contain one or more threatened species in wetlands and water habitats include Araceae (1 species), Cyperaceae (14), Juncaceae (3), Lemnaceae (1), Liliaceae (3), Orchidaceae (4), Poaceae (10), Potamogetonaceae (5), Ruppiaceae (1), Acanthaceae (1), Apiaceae (1), Asteraceae (3), Brassicaceae (2), Convolvulaceae (3), Ericaceae (1), Gentianaceae (2), Haloragaceae (1), Lentibulariaceae (1), Malvaceae (1), Nymphaeaceae (2), Onagraceae (2), Polemoniaceae (1), Polygonaceae (1), Salicaceae (1), Sarraceniaceae (1), Scrophulariaceae (5), Valerianaceae (1), and Violaceae (1) (Beaman, 1977).

Soils and Water. Wetlands are those areas where the water table is at, near or above the land surface for a significant part of most years. Since these areas are all saturated as a result of high water tables, soils associated with these vegetative types are predominately poorly drained organics and minerals. Erosion damage is very limited since most wetland areas are in low elevations and are receiving sediments rather than losing soil materials. Some soil removal may occur on mudflats when mineral material with little or no profile development is exposed during periods of low water.

Wildlife. Wetlands provide habitat for waterfowl, marsh and shore birds, birds of prey, songbirds, fur and game mammals, and small mammals.

APPENDIX C

DISTRIBUTION, HABITAT REQUIREMENTS AND RESIDENT STATUS OF MICHIGAN BIRDS

Waterfowl

Michigan provides habitat for 29 species of waterfowl (Swans, Geese, Ducks) which are members of the order Anseriformes and the family Anatidae. All of these species occur in Michigan at some time of the year except for the European Widgeon which is a rare visitor.

The two species of swans occurring in Michigan are the Whistling Swan which passes through lower Michigan during migration, and the introduced Mute Swan which nests in northern lower Michigan. The Mute Swans nest in cattail or bulrush marshes where they feed upon the leaves, stems, and tubers of submergent and emergent vegetation. Some of these swans have been able to overwinter where feeding programs were initiated.

Among the geese, only certain introduced Canada Geese breed in the state (McWhirter, 1977). Most Canada Geese and all Snow Geese are migrants. Some Canadas do overwinter in the eastern and southwestern sections of the state. Numbers of geese peak during the months of October-November and March-April.

Geese feed in shallow water to obtain roots, tubers, and shoots of aquatic plants. However, they prefer cereal and feed grains found on agricultural uplands.

The 25 species of ducks that occur regularly in Michigan may be divided into dabblers and divers. Some species nest in Michigan, some overwinter, some occur all year, and others are transients. Peak populations for all species usually occur in October-November and March-April.

Species that do not nest in Michigan select sites in marshes, hardwood, conifer and shrub swamps, grassy and shrub uplands, tree cavities in wooded uplands, and on rock ledges.

Food habits vary from species to species but for the dabblers as a group, important foods are seeds, roots, tubers, stems, and leafy parts of submergent and emergent vegetation, berries, waste corn, phytoplankton (Shoveler), acorns (Wood Duck), insects (dabbler chicks) and mollusks. Dabblers find their food in shallow waters of marshes, swamps, ponds, lakes, mudflats and uplands.

Diving ducks as a group are more likely to eat animal matter. Their food consists of insects (adult and larvae), clams, snails, fish, and fish eggs. Plant materials eaten are the seeds, roots, tubers, stems, and leafy parts of submergent and emergent plants. Divers are known to feed both in shallow or deep areas of marshes, ponds, lakes, and streams.

Marsh and Shore Birds

For the purposes of this report, five orders including 14 families and 73 species will be considered as marsh and shore birds.

The Gaviiformes (loons) are diving birds found on lakes and along coasts where they feed on fish. Only the Common Loon nests on Michigan lakes. Nests are built in the water on piles of vegetation among weeds and brush. Fish make up the diet. The Common Loon is considered a common summer resident of the north and a transient in southern Michigan (Wallace, 1977). Some loons are found on the Great Lakes in winter.

Among the Podicipediformes (grebes) only one is a summer resident, others are transients. Grebes are found on the Great Lakes, inland lakes, ponds and potholes near shore (Wallace, 1977). A floating nest is constructed in thickets. Grebes feed on fish, frogs, invertebrates, insects, seeds and other vegetable matter (Wallace, 1977). They are considered common (Wallace, 1977).

Pelicans and cormorants belong to the order Pelicaniformes. The White Pelican is considered accidental in Michigan (McWhirter, 1977). The Double-Crested Cormorant is transient, though occasionally nests in the state and is considered rare (Wallace, 1977). It is found on islands, along coasts and on lakes close to its primary food source fish (Wallace, 1977).

The order Ciconiiformes (herons, bitterns, egrets and ibises) are wading birds found along the edges of lakes, ponds, rivers and streams and in marshes. They nest in trees. Fish, frogs and invertebrates are the main food items. These birds are summer residents and are common, rare (Wallace, 1977), or irregular (McWhirter, 1977).

Cranes, rails and coots are all members of the order Gruiformes. They are either summer residents or transients. Sandhill Cranes are found in grain fields and marshes where they eat grain, vegetation, frogs, crayfish and other invertebrates (Wallace, 1977). Wallace (1977) states they are increasing in numbers.

The rail and coot are found in marshes and swamps where they construct a floating nest among bulrushes. Their diet consists of seeds and insects. These species range from common to uncommon (Wallace, 1977).

The order with the largest number of species in their group is the Charadriiformes (gulls, terns, sandpipers, plovers). Most of these species are transient but some are summer residents and others are permanent. Habitat ranges from coastal areas, lakes, rivers and marshes to meadows and upland fields. Nesting areas are gravel and sand beaches, rocks, marshes, and upland pastures. Foods consumed are fish, carrion, insects, mollusks, crustacea, seeds, berries, algae, and other plant material. Species range from common to rare (Wallace, 1977; McWhirter, 1977). The Piping Plover, a transient occurring along beaches, is listed as threatened (Wallace, 1977).

Upland Game Birds

There are 10 psecies of upland game birds in Michigan; eight nonmigratory species of the order Galliformes (gallinacious birds), and two migratory species of the order Charadriiformes (shore birds). All 10 species are ground nesters.

The gallinacious game birds include grouse, quail, pheasant, partridge, and turkey. The ruffed grouse (Bonasa umbellus) is common in northern Michigan, but exists only in small pockets in southern Michigan (Wallace, 1977). Although it utilizes different seral stages of hardwoods, the species is primarily associated with second-growth hardwoods, notably aspen (Populus spp.). A variety of buds, twigs, leaves, fruits and berries comprise its diet.

The spruce grouse (Canachites canadensis) is scarce, occurring in the Upper Peninsula and in scattered areas of the northern Lower Peninsula (Wallace, 1977). The species inhabits spruce (Picea spp.) forests and swamps. It nests under spruce trees and in heavy brush. Conifer buds, twigs, fruits, leaves and insects constitute its food.

The sharp-tailed grouse (Pedicetes phasianellus) is scarce today in Michigan (Stearns and Lindsley, 1977). The species is associated with prairie and brushland habitats. It nests in tall grass, shrubby uplands, or in vegetation along streams. In winter it may utilize wooded areas. Shoots, twigs, leaves, and buds make up most of its diet.

The greater prairie chicken (Tympanchus cupido) has been nearly extirpated from Michigan (Wallace, 1977). Prairie lands and marsh lands are its preferred habitats. It nests in grass, low shrubs, and occasionally in woodlands. Seeds and berries comprise its diet.

The bob-white quail (Colinus virginianus) is common in southern Michigan (McWhirter, 1977). The species nests in tall grass found in shrubby fields and fence rows. Seeds, grains and insects are its major food source.

The ring-necked pheasant (Phasianus colchicus) is a successful, introduced species which is common in Michigan (Wallace, 1977). The species is most abundant where lands are heavily cultivated in row crops. It nests in grass, shrubby edges, fence rows and in roadside vegetation. Seeds and grains are its main food items.

The wild turkey (Meleagris gallopavo) is associated with open, mature hardwood forests interspersed with grassy openings. Lindsay (1967) estimates the species requires from 5,000 to 15,000 acres to be successfully managed. Once removed from Michigan, it has been successfully reintroduced. It is now common in some parts of the state. Hardwood mast is its most important food. Seeds, grasses, berries, fruits, and grasshoppers are also eaten.

The American woodcock (Philohela minor) and the common snipe (Capella gallinago) are classified taxonomically as shore birds, but are considered as upland game birds for management purposes. Both utilize upland areas for part of their habitat.

The woodcock, or timber doodle, is a common migrant present in Michigan from spring to fall (Wallace, 1977). The species utilizes bogs, shrublands, pastures, old fields and woody areas. Alder (Alnus spp.) swales are used for daytime cover; old fields are used for nighttime roosting. Nests usually are in swamps, brushlands, or more commonly, in field edges. The woodcock feeds by probing moist, soft soils for earthworms and insects.

The common snipe, also called Wilson's snipe, or jack snipe, is another common migrant to Michigan present from spring to fall (Wallace, 1977). Bogs, marshes, and mudflats are its preferred habitats. Shallow fringe areas of peat bogs are excellent breeding habitats and need to be preserved (Fogarty and Arnold, 1977). Insects, earthworms, crustaceans and mollusks comprise its diet.

Birds of Prey

Birds of prey belong to two orders: Falconiformes, comprised of the vultures, hawks, falcons, and eagles; and Strigiformes, made up of owls. In Michigan there occur one species of vulture, 14 species of hawks, falcons and eagles, and 11 species of owls. Not all of these species reside in the state. The Peregrine falcon and the Merlin or Pigeon hawk are transients, while among the owls the Great Gray and the Hawk owl are listed as accidentals, occurring only very rarely. The others are either summer, winter, or permanent residents.

Nesting and habitat requirements are varied. Turkey vultures nest on the ground in dense brush, on cliffs, in caves, and in rotted stumps. Most of the hawks, falcons, and eagles nest in trees in deciduous, coniferous or mixed woods. Exceptions are the Rough-legged hawk which also nests on cliffs or along river banks and the Marsh hawk which nests on or near the ground in marshes, swamps, sloughs, wet meadows, and grassy and brushy uplands. Bald eagles and Osprey usually nest in trees near water. General habitat requirements range from marshes and coastal areas to meadows, woodland edges, and forests.

Carrion is the food of Turkey vultures and may be a major portion of the diet for Bald eagles. Bald eagles and Osprey are primarily fish eaters. Small mammals, birds, frogs, snakes, and insects are the major prey for the other birds of prey.

Wallace (1977) names only the Turkey vulture, Red-tailed hawk, Broad-winged hawk, Marsh hawk, and Kestrel (Sparrow hawk) as common. Thus the majority of birds of prey in Michigan are considered threatened, scarce or rare.

Among the owls, most nest in woodlands or forests in constructed nests or tree cavities. The Barn owl may also nest underground, along banks and even in buildings. Short-eared owls nest on the ground in fields and marshes. Habitat requirements include parks and suburbs, open country such as meadows, fields and marshes, woodlots, and hardwood and coniferous forests.

Rabbits, squirrels, other small mammals, birds, and insects are the major prey species of owls. Wallace lists only the Great Horned owl and the Screech owl (rare in northern Michigan) as common. Other owls are uncommon, rare or scarce.

Songbirds

For the purposes of this report, seven orders will be considered as songbirds. These orders are Columbiformes (doves), Cuculiformes (cuckoos), Caprimulgiformes (whip-poor-wills), Apodiformes (swifts and hummingbirds), Caraciiformes (kingfishers), Piciformes (woodpeckers), and Passeriformes (flycatchers, swallows, wrens, thrushes, vireos, warblers, finches, etc.). Within the seven orders are 28 families and 161 species. For the names of each species and its residency status, refer to the following list of "Resident Status of Michigan Birds."

There is virtually no land habitat in which songbirds do not occur in Michigan. A change in any habitat will have some impact on the diversity and composition of species in that area. Due to the large number of species, diversity of habits and habitats required and the limited scope of this essay, the highway developer is referred to Bent (1919-1968), Wallace (1977), McWhirter (1977), Wood (1951), and Zimmerman (1959), for detailed natural history information.

RESIDENT STATUS OF MICHIGAN BIRDS*

Key:			
T	= Transient	(UP)	= Upper Peninsula
SR	= Summer Resident	(N)	= North
WR	= Winter Resident	(S)	= South
PR	= Permanent Resident	(SW)	= Southwest
Acc	= Accidental or Rare Visitor	(GL)	= Great Lakes

Waterfowl	Status
Mute Swan	PR
Whistling Swan	T
Canada Goose	T SR PR
Brant	Acc
Snow Goose	T
Mallard	PR
Black Duck	PR (S)
Gadwall	T
Pintail	T
Green-winged Teal	T
Blue-winged Teal	SR
European Widgeon	Acc
American Widgeon	T
Shoveler	T SR (UP)
Wood Duck	SR
Redhead	T
Ring-necked Duck	SR (N)
Canvasback	T
Greater Scaup	T
Lesser Scaup	T WR (GL)
Common Goldeneye	WR
Bufflehead	T WR (S)
Oldsquaw	WR (GL)
Eider (spp.)	Acc
White-winged Scoter	T WR (GL)
Surf Scoter	Acc
Common Scoter	Acc

*Compiled by Michael Thomas in Davis (1978).

Waterfowl	Status
Ruddy Duck	T
Hooded Merganser	SR
Common Merganser	WR
Red-breasted Merganser	WR

Birds of Prey	
Turkey Vulture	SR
Goshawk	WR
Sharp-shinned Hawk	SR PR (S)
Cooper's Hawk	SR PR (S)
Red-tailed Hawk	SR PR (S)
Red-shouldered Hawk	SR
Broad-winged Hawk	SR
Rough-legged Hawk	WR
Golden Eagle	WR
Bald Eagle	PR
Marsh Hawk	SR PR (S)
Osprey	SR
Gyrfalcon	Acc
Peregrine Falcon	T
Merlin	T SR (N)
Kestrel	SR PR (S)
Barn Owl	PR (S)
Screech Owl	PR
Great Horned Owl	PR
Snowy Owl	WR
Hawk Owl	Acc
Barred Owl	PR
Great Gray Owl	Acc
Long-eared Owl	PR
Short-eared Owl	PR
Boreal Owl	WR
Saw-whet Owl	PR

Marsh and Shore Birds	
Common Loon	SR (UP)
Red-throated Loon	T
Red-necked Grebe	T
Horned Grebe	T
Pied-billed Grebe	SR
White Pelican	Acc
Double-crested Cormorant	SR (UP)
Great Blue Heron	SR
Green Heron	SR
Little Blue Heron	Acc
Cattle Egret	SR (S)
Common Egret	Acc

Marsh and Shore Birds	Status
Snowy Egret	Acc
Black-crowned Night Heron	SR
Yellow-crowned Night Heron	Acc
Least Bittern	SR
American Bittern	SR
Glossy Ibis	Acc
Sandhill Crane	SR
King Rail	SR (S)
Virginia Rail	SR
Sora	SR
Yellow Rail	T
Black Rail	SR
Common Gallinule	SR (S)
American Coot	SR
Semipalmated Plover	T
Piping Plover	SR (GL)
Killdeer	SR
American Golden Plover	T
Black-bellied Plover	T
Ruddy Turnstone	T
Whimbrel	T
Upland Plover	SR
Spotted Sandpiper	SR
Solitary Sandpiper	T
Willet	Acc
Greater Yellowlegs	T
Lesser Yellowlegs	T
Knot	T
Ruff	Acc
Purple Sandpiper	Acc
Pectoral Sandpiper	T
White-rumped Sandpiper	T
Baird's Sandpiper	T
Least Sandpiper	T
Dunlin	T
Short-billed Dowitcher	T
Long-billed Dowitcher	T
Stilt Sandpiper	T
Semipalmated Sandpiper	T
Western Sandpiper	T
Buff-breasted Sandpiper	Acc
Marbled Godwit	Acc
Hudsonian Godwit	Acc
Sanderling	T
American Avocet	Acc
Red Phalarope	Acc
Wilson's Phalarope	Acc
Northern Phalarope	Acc
Parasitic Jaeger	Acc (GL)
Glaucous Gull	Acc
Iceland Gull	Acc

Marsh and Shore Birds	Status
Great Black-backed gull	WR
Herring Gull	PR (GL)
Ring-billed Gull	PR (GL)
Franklin's Gull	Acc
Bonaparte's Gull	T
Little Gull	Acc
Forster's Tern	T
Common Tern	T SR (GL)
Caspian Tern	T
Black Tern	SR

Upland Game Birds	
American Woodcock	SR
Common Snipe	SR
Turkey	PR
Spruce Grouse	PR (N) (Non-game)
Ruffed Grouse	PR
Sharp-tailed Grouse	PR (N) (Non-game)
Greater Prairie Chicken	PR (N) (Non-game)
Bobwhite	PR (S)
Ring-necked Pheasant	PR (S)
Gray Partridge	PR (S) (Non-game)

Songbirds	
Rock Dove	PR
Mourning Dove	SR PR (S)
Yellow-billed Cuckoo	SR
Black-billed Cuckoo	SR
Whip-poor-will	SR
Common Nighthawk	SR
Chimney Swift	SR
Ruby-throated Hummingbird	SR
Belted Kingfisher	SR
Yellow-shafted Flicker	SR PR (S)
Pileated Woodpecker	PR
Red-bellied Woodpecker	PR (S)
Red-headed Woodpecker	SR
Yellow-bellied Sapsucker	SR PR (S)
Hairy Woodpecker	PR
Downy Woodpecker	PR
Black-backed Three-toed Woodpecker	PR (N)
Northern Three-toed Woodpecker	Acc
Eastern Kingbird	SR
Western Kingbird	Acc
Great Crested Flycatcher	SR
Eastern Phoebe	SR
Yellow-bellied Flycatcher	SR (N)

Songbirds	Status
Acadian Flycatcher	SR (S)
Traill's Flycatcher	SR
Least Flycatcher	SR
Eastern Wood Pewee	SR
Olive-sided Flycatcher	SR (N)
Horned Lark	PR
Tree Swallow	SR
Bank Swallow	SR
Rough-winged Swallow	SR
Barn Swallow	SR
Cliff Swallow	SR
Purple Martin	SR
Gray Jay	WR (N)
Blue Jay	PR
Common Raven	PR (N)
Common Crow	PR
Black-capped Chickadee	PR
Boreal Chickadee	PR (UP)
Tufted Titmouse	PR (S)
White-breasted Nuthatch	PR
Red-breasted Nuthatch	SR PR (S)
Brown Creeper	SR (N), WR (S)
House Wren	SR
Bewick's Wren	SR (S)
Winter Wren	T SR (N)
Carolina Wren	PR (S)
Long-billed Marsh Wren	SR
Short-billed Marsh Wren	SR
Mockingbird	SR (S)
Catbird	SR
Brown Thrasher	SR
Robin	SR PR (S)
Varied Thrush	Acc
Wood Thrush	SR
Hermit Thrush	SR (N)
Swainson's Thrush	SR (UP)
Gray-cheeked Thrush	T
Veery	SR
Eastern Bluebird	SR
Blue-gray Gnatcatcher	SR
Golden-crowned Kinglet	SR (UP)
Ruby-crowned Kinglet	T
Water Pipit	T
Bohemian Waxwing	Acc
Cedar Waxwing	PR
Northern Shrike	SR
Loggerhead Shrike	SR
Starling	PR
White-eyed Vireo	SR (S)
Yellow-throated Vireo	SR
Solitary Vireo	SR (N)

Songbirds	Status
Red-eyed Vireo	SR
Philadelphia Vireo	T
Warbling Vireo	SR
Black-and-white Warbler	SR
Prothonotary Warbler	SR (S)
Worm-eating Warbler	Acc
Golden-winged Warbler	SR
Blue-winged Warbler	SR
Tennessee Warbler	SR (UP)
Orange-crowned Warbler	T
Nashville Warbler	SR (N)
Parula Warbler	SR (N)
Yellow Warbler	SR
Magnolia Warbler	SR (N)
Cape May Warbler	T
Black-throated Green Warbler	SR
Cerulean Warbler	SR
Blackburnian Warbler	SR (N)
Chestnut-sided Warbler	SR
Bay-breasted Warbler	SR (UP)
Blackpoll Warbler	SR (UP)
Pine Warbler	SR (N)
Kirtland's Warbler	SR
Prairie Warbler	SR
Palm Warbler	T
Ovenbird	SR
Northern Waterthrush	SR
Louisiana Waterthrush	SR
Kentucky Warbler	SR (SW)
Connecticut Warbler	SR (N)
Mourning Warbler	SR
Yellowthroat	SR
Yellow-breasted Chat	SR
Hooded Warbler	SR (SW)
Wilson's Warbler	T
Canada Warbler	SR
American Redstart	SR
House Sparrow	PR
Bobolink	SR
Eastern Meadowlark	PR (S)
Western Meadowlark	SR (UP)
Yellow-headed Blackbird	SR (UP)
Red-winged Blackbird	SR
Orchard Oriole	SR
Northern Oriole	SR
Rusty Blackbird	SR (UP)
Brewer's Blackbird	SR (UP)
Common Grackle	SR
Brown-headed Cowbird	SR
Scarlet Tanager	SR
Cardinal	PR (S)

Songbirds	Status
Rose-breasted Grosbeak	SR
Indigo Bunting	SR
Dickcissel	SR
Purple Finch	PR (N), WR (S)
House Finch	Acc
Evening Grosbeak	PR (N), WR (S)
Pine Grosbeak	WR
Hoary Redpoll	WR
Common Redpoll	WR
Pine Siskin	WR
American Goldfinch	PR
Red Crossbill	PR (N)
White-winged Crossbill	PR (N)
Rufous-sided Towhee	SR
Savannah Sparrow	SR
Grasshopper Sparrow	SR
LeConte's Sparrow	T
Henslow's Sparrow	SR
Sharp-tailed Sparrow	T
Lark Bunting	Acc
Vesper Sparrow	SR
Lark Sparrow	SR (S)
Dark-eyed Junco	SR (N), WR (S)
Oregon Junco	Acc
Tree Sparrow	WR
Chipping Sparrow	SR
Clay-colored Sparrow	T
Field Sparrow	SR
Harris' Sparrow	Acc
White-crowned Sparrow	T
Golden-crowned Sparrow	Acc
White-throated Sparrow	SR (N)
Fox Sparrow	T
Lincoln's Sparrow	T
Swamp Sparrow	PR (S)
Song Sparrow	PR (S)
Lapland Longspur	WR
Snow Bunting	WR

APPENDIX D

DISTRIBUTION, HABITAT REQUIREMENTS, STATUS AND FOOD PREFERENCES OF MICHIGAN MAMMALS

SPECIES: Didelphis marsupialis

Common Name: Opossum

STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Carrion, fruits, nuts, poultry, insects (Burt, 1972); mostly animal food in all seasons: winter--83%, spring--95%, summer--87%, fall--83% (Martin, 1961); from 52 stomachs 80% was animal matter--carrion; plants eaten were grapes, pokeweed, elderberries, and ground cherries (Phygalis sp.) (Taube, 1947).

HABITAT REQUIREMENTS: Wooded areas; almost any shelter it can find; it may use deserted dens of other animals, under buildings, brush piles, or use tree dens (Burt, 1972).

HOME RANGE: Mean distance--697 ft (212.5 m) (Holmes, 1965); 1680 ft (512 m) (Verts, 1963).

SPECIES: Ursus americanus

Common Name: Black bear

STATUS: Rare, protected (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Berries and other fleshy fruits, as well as acorns, beechnuts, and pine seeds are staples. Serviceberry also consumed; animal food consists of insects, fish, and small mammals (Burt, 1972).

HABITAT REQUIREMENTS: Preferred denning sites in Michigan are holes beneath logs or fallen trees or in hillsides (Erickson, 1964). Upland hardwoods are favored during all seasons, but conifer swamps are also heavily utilized (Erickson, 1964).

HOME RANGE: Normal movements of marked bears average less than 5 mi (8.1 km) (Erickson, 1964); and minimum summer and annual home ranges were estimated as approximately 6 and 15 mi^2 respectively (Erickson, 1964).

SPECIES: Procyon lotor

Common Name: Raccoon

STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Mostly animal matter: winter--58%, spring--96%, summer--82%, fall--58%; frogs, crayfish, grasshoppers, insects (Martin, 1961); plant foods: fall and winter mainstay is acorns, corn, and fleshy fruits also favorites (Martin, 1961); corn, hay, and fruit most preferred, also mice, insects, oats, soybeans, seeds, and grass (Fisher, 1977).

HABITAT REQUIREMENTS: Tree dens are much more common than ground dens (Berner, 1965); prefer hollow trees for dens. Resting sites are usually tree dens (Fisher, 1977).

HOME RANGE: 89-380.5 a (36-154 ha), averaging 136 a (55 ha) (Fisher, 1977). Range from 1000-7000 ft (304.8-2133.6 m), averaging 3194 ft (973.5 m); home ranges vary from 20 to 83 a (8-34 ha) (Stromberg, 1970).

SPECIES: *Mustela erminea*

Common Name: Shorttail weasel; ermine

STATUS: Protected--more abundant than *M. frenata* (Long, 1974)

CONSUMER: Carnivore

FOOD PREFERENCES: Small mammals and birds (Burt, 1972).

HABITAT REQUIREMENTS: Woodlands (Burt, 1972), marshes and mesic forests (Long, 1974); cavity or burrow beneath rockpile, woodpile, or building (Burt, 1972).

HOME RANGE: 30-40 a (12.1-16.2 ha) (Burt, 1976).

SPECIES: *Mustela frenata*

Common Name: Longtailed weasel

STATUS: Protected; uncommon, perhaps rare (Long, 1974)

CONSUMER: Carnivore

FOOD PREFERENCES: Rabbits, mice (Long, 1974; Burt, 1972).

HABITAT REQUIREMENTS: Forest, brushland, prairie (especially near water); cavities, burrows as with *M. erminea* (Burt, 1972).

HOME RANGE: 30-40 a (12-16 ha) (Burt, 1976).

SPECIES: Mustela rixosa

Common Name: Least weasel

STATUS: Rare and perhaps threatened (Long, 1974)

CONSUMER: Carnivore

FOOD PREFERENCES: Mice, insects, and possibly small birds (Burt, 1972).

HABITAT REQUIREMENTS: Meadows, fields, and possibly woodlands (Burt, 1972); marshes and wet prairies (Long, 1974).

HOME RANGE: Male in winter about 2 a (0.8 ha) (Burt, 1972).

SPECIES: Mustela vison

Common Name: Mink

STATUS: Uncommon, protected (Long, 1974)

CONSUMER: Carnivore

FOOD PREFERENCES: Fish, mice, rabbits, birds, turtle eggs, and frogs (Burt, 1972).

HABITAT REQUIREMENTS: Wooded streams; burrow in bank of lake or stream or beneath stump or log (Burt, 1972).

HOME RANGE: For male, greater than 1100 a (445.2 ha) (McCabe, 1949); for female, 19.4 to 50.3 a (7.8-20.3 ha) (Mitchell, 1961); about 20 a (8 ha) (Marshall, 1936).

SPECIES: Lutra canadensis

Common Name: River otter

STATUS: Protected, fairly common (Long, 1974)
Threatened (Stearns and Lindsley, 1977)

CONSUMER: Carnivore

FOOD PREFERENCES: Forage fish most important (Knudsen and Hale, 1968); amphibians, crayfish, insects, snails (Burt, 1972).

HABITAT REQUIREMENTS: Bank burrows along stream or lake (Burt, 1972).

HOME RANGE: 15 mi (24 km) or more (Burt, 1976).

SPECIES: Mephitis mephitis

Common Name: Striped skunk

STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Mostly animal food: adult and larval insects, grasshoppers, grubs, beetles, wasps, spiders, toads, frogs, lizards, mice; plant food: fleshy fruits principally (Martin, 1961).

HABITAT REQUIREMENTS: Ground dens (Storm, 1966). They do not hibernate but stay inactive for extended periods within dens (Sunquist, 1974). Skunks shift from above ground and hollow log nest sites to underground dens in the fall (Houseknecht, 1969). Summer nest sites change almost daily and do not cache food in dens but depend on fat reserves (Sunquist, 1974).

HOME RANGE: 31-114 a (12-46 ha); daily activity for males is 0.5 mi (0.8 km), for females 0.2 to 0.4 mi (0.32-0.64 km) (Baily, 1971). For rabid skunks it was found to be 990 x 880 yds (804.7 x 905.3 m); 98.5% of 321 radio positions were within a 1 mi (1.6 km) radius (Storm, 1966).

SPECIES: Vulpes fulva

Common Name: Red fox

STATUS: Abundant (Long, 1974)

CONSUMER: Carnivore

FOOD PREFERENCES: Chiefly meat with berries and fruits in season, bulk of food is small mammals (Burt, 1972). Mice, rabbits, birds, insects; fresh fruits and seed average about 25% of the summer and fall diet (Martin, 1961). Chief prey species are cottontails, Microtus pennsylvanicus and Peromyscus spp. (Ables, 1969).

HABITAT REQUIREMENTS: Not markedly different for red or gray fox (Follman, 1973); rest at midday (Storm, 1965).

HOME RANGE: 18.4 mi (31 km) (Phillips, 1972). 955 a or 1.9 x 1.4 mi wide (386 ha) (Storm, 1965). 142 to 400 a (57.5-161.9 ha) (Ables, 1969).

SPECIES: Urocyon cinereoargenteus

Common Name: Gray fox

STATUS: Rarer than Red fox and possibly threatened (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Animal food: birds, mice, rabbits; plant food: fruit and other plant products constitute a small but fairly consistent part of diet (Martin, 1961). Cottontail, arthropods, small mammals and birds constitute 84% of the diet (Yoho, 1972).

HABITAT REQUIREMENTS: Forests and fairly open brushland, den may be in hollow logs or trees, or under a rock pile. Gray foxes are arboreal (Burt, 1972).

HOME RANGE: 0.25 to 0.5 mi (0.4-0.8 km) radius (Long, 1974).

SPECIES: Lynx rufus

Common Name: Bobcat

STATUS: Uncommon (Long, 1974)
Threatened (Stearns and Lindsley, 1977)

CONSUMER: Carnivore

FOOD PREFERENCES: Rabbits, mice, birds (Long, 1974).

HABITAT REQUIREMENTS: Swamps and broken country with adequate brush cover; cavities in trees, and logs for dens (Burt, 1972).

HOME RANGE: Usually within 2 mi (3.2 km) radius of den (Burt, 1976).

SPECIES: Marmota monax

Common Name: Woodchuck

STATUS: Neither abundant nor rare (Long, 1974)

CONSUMER: Herbivore

FOOD PREFERENCES: Eats green vegetation in summer and hibernates in winter; food consists of clover, grasses, and vegetables (Burt, 1972). The woodchuck eats only green food--grasses, leaves, and buds (Fall, 1971).

HABITAT REQUIREMENTS: Digs complicated burrow systems, makes dens in fields, fence rows and woodlands bordered by clearings (Burt, 1972).

HOME RANGE: 0.25 to 0.5 mi (0.4-0.8 km) in diameter (Burt, 1972). 200 to 300 ft (61.0-91.4 m) radius (Long, 1974).

SPECIES: Tamias striatus

Common Name: Eastern chipmunk

STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

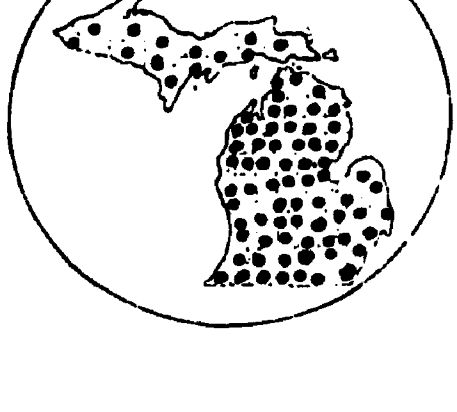
FOOD PREFERENCES: Seeds or nuts of woody plants; also corn, wheat, and other crop plants as well as seeds of weedy plants; animal matter includes insects, young birds, eggs, and snails (Martin, 1961). Summer--87% plant material, fall--91% plant material.

HABITAT REQUIREMENTS: Hardwood forests, semi-open brushland; rarely in swamps (Burt, 1972); mostly a ground dweller, uses trees only occasionally (Burt, 1972).

HOME RANGE: Seldom more than 100 yd (91.4 m) diameter (Burt, 1972). 200 ft (61 m) radius (Long, 1974).

SPECIES: Tamiasciurus hudsonicus

Common Name: Red squirrel



STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Nuts, pine cones, mushrooms, birds' eggs, nestlings, meat, sap (Burt, 1972). Plant food: seeds and fruits of both conifers and hardwoods; animal food: carrion, insects, young birds, and eggs (Martin, 1961).

HABITAT REQUIREMENTS: Coniferous and hardwood forests (Burt, 1972).

HOME RANGE: Probably less than 200 yd (183 m) (Burt, 1972). 500 to 600 ft (152-183 m) (Long, 1974).

SPECIES: <u>Sciurus carolinensis</u>

Common Name: Gray squirrel

STATUS: Abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Animal food: insect larvae, birds' eggs, nestings; plant food is by far the most important: winter--98%, spring--100%, summer--87%, fall--98% (Martin, 1961).

HABITAT REQUIREMENTS: Hardwood forests, nests are either in hollow trees or constructed leaf nests (Burt, 1972).

HOME RANGE: Males: 1.3 a (0.5 ha); females: 1 a (0.4 ha) (Doebel, 1974).

SPECIES: <u>Sciurus niger</u>

Common Name: Fox squirrel

STATUS: Abundant, spreading (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Oak acorns, hickory nuts, mushrooms, birds' eggs, young birds, insects, fruit, and corn (Martin, 1961).

HABITAT REQUIREMENTS: Tree cavities or will construct leaf nests; small areas of hardwoods interspersed with open farm land, and wooded streams (Burt, 1972).

HOME RANGE: About 400 ft (122 m) (Trippensee, 1948).

SPECIES: Castor canadensis

Common Name: Beaver

STATUS: Numbers declining due to habitat loss, absent from southern Michigan (Long, 1974)

CONSUMER: Herbivore

FOOD PREFERENCES: Aspen--bark and twigs 840 kcal/day (1.5 lbs aspen) for maintenance of 26 lb yearling. 2040 kcal/day (3.6 lbs aspen) for maximum growth (Brenner, 1967).

HABITAT REQUIREMENTS: Forest stands of aspen, poplar, birch, maple, or willow by a lake or stream; builds lodge in the lake or stream bed or has bank burrow where water too swift for lodge (Burt, 1972).

HOME RANGE: (Feeding range) 1.0 a to 1.8 a (0.4 ha-0.7 ha) (Brenner, 1967).

SPECIES: Ondatra zibethica

Common Name: Muskrat

STATUS: Fairly abundant (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Aquatic and marsh plants--cattails, bulrush, some clams, snails, and crayfish (Burt, 1972).

HABITAT REQUIREMENTS: Marshes, ponds, lakes, and streams; heavy growth of rush or cattails; builds "houses" or bank burrows with entrance usually below water (Burt, 1972).

HOME RANGE: 50 to 100 yd (45.7-91.4 m) radius from den (Errington, 1961).

SPECIES: <u>Erethizon dorsatum</u>

Common Name: Porcupine

STATUS: Never abundant, but not rare (Long, 1974)

CONSUMER: Omnivore

FOOD PREFERENCES: Almost any plant species, bark and wood, and some meat (Burt, 1972); deciduous leaves in summer (Brander, 1973).

HABITAT REQUIREMENTS: Forest dweller--arboreal, cavity dweller (logs, hollow trees, caves) (Burt, 1972).

HOME RANGE: Females in summer: 32 to 36 a (13-14.6 ha) (Marshall, 1962). Mean cruising radius of 492 ft (150 m) in summer for all animals (Brander, 1973).

SPECIES: <u>Lepus americanus</u>

Common Name: Snowshoe hare

STATUS: Abundant in appropriate habitat (Long, 1974)

CONSUMER: Herbivore

FOOD PREFERENCES: Succulent vegetation during summer months, and twigs, buds, and bark of small trees during winter (Burt, 1972). White cedar, speckled alder, black spruce, balsam fir, winterberry, and sugar maple twigs browsed (Bookhout, 1965). Also, quaking aspen, raspberry, and hazelnut (Bider, 1961).

HABITAT REQUIREMENTS: Spruce and cedar swamps, and nearby wooded areas (Burt, 1972); "edge" areas are highly used (Bookhout, 1965). Rest in "forms" by logs or beneath trees in areas of dense cover during the day (Burt, 1972).

HOME RANGE: Males in winter--19 a (7.6 ha); males in summer--26 a (10.5 ha); females in winter--16 a (6.4 ha); females in summer--15.4 a (6.3 ha) (Bookhout, 1965).

SPECIES: Sylvilagus floridanus

SPECIES: Sylvilagus floridanus

Common Name: Cottontail

STATUS: Abundant (Long, 1974)

CONSUMER: Herbivore

FOOD PREFERENCES: Summer--tender, herbaceous plants; winter--twigs and bark of young trees: sumac, dogwood (Martin, 1961).

HABITAT REQUIREMENTS: Brushy areas, edges of swamps, open woods (Burt, 1972); primarily nocturnal, rabbits spend the day in some sheltered spot, either in heavy grass, ground burrows, or brush piles. Agricultural lands with croplands, grassland, woodland, and brushland equally represented and distributed; old woodchuck burrows are preferred over vegetative cover and brush piles are also used (Trippensee, 1948).

HOME RANGE: Males: 8 to 20 a (3.2-8.1 ha); females: about 3 a (1.2 ha) (Burt, 1972).

SPECIES: Odocoileus virginianus

Common Name: White-tailed deer

STATUS: Abundant, throughout the region (Long, 1974)

CONSUMER: Herbivore

FOOD PREFERENCES: Spring--graminids, evergreen ground plants (barren strawberry, strawberry, blue-bead lily, wintergreen); early summer--aspen leaves, graminids, bush honeysuckle; late summer--aspen leaves, bush honeysuckle, asters; fall--grasses and sedges, acorns, asters, aspen leaves, mushrooms (McCaffrey, 1974). Winter--northern white cedar (preferred), sugar maple, willows, beaked hazelnut, swamp birch, speckled alder, winterberry (Bookhout, 1965). Grasses and forbs when available, woody browse with snowcover (red and ground cedar) (Coblentz, 1970). Acorn availability probably has effect on winter survival (more acorns, better survival) (Duvendeck, 1962).

HABITAT REQUIREMENTS: Winter--low, coniferous areas from mid-December to first of April (Bookhout, 1965). High carrying-capacity winter yard characterized by large (40-160 a), fully stocked, even-aged stands, interspersion on small tracts leads to overuse, therefore, large tracts of different-aged classes best (Verme, 1965).

HOME RANGE: Rarely more than a mi (1.6 km) across (Burt, 1976). May be found several mi from traditional wintering yard in November (Verme, 1973).

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