An Ecological and Vegetative Overview of the Schmeeckle Reserve

by

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Abstract

Schmeeckle Reserve was officially established in 1976 as a cooperative effort between the University of Wisconsin-Stevens Point, the City of Stevens Point, and Sentry Insurance Corporation. Long before, in the 1950's, a nature preserve was envisioned by Fred J. Schmeeckle. It was his vision and that of his colleagues that the area north of campus be purchased and set aside as an outdoor classroom. Today the Reserve's three prioritized goals continue to reflect the ideas for the area:

1. To preserve and maintain native plant and animal communities of central Wisconsin;
2. To serve as a research and teaching facility for University faculty and students and for education of the public; and
3. To provide recreational opportunities for the community that are compatible with the preservation and education goals of the Reserve.

This project will identify past and present ecological communities, identify the greatest threats to the Reserve, and recommend methods for the management of these areas as needed. Most of the report will be based on qualitative evaluation. This will consist of reviewing historic data, past studies, and relevant literature to determine the most appropriate management practices. Baseline data were collected on the vegetation cover types using a stratified sampling technique. This data was used to support the classification of 13 current vegetation types.

The first report of plants and ecological communities in this area resulted from the Hathaway land survey begun in 1836. Hathaway's description of jack pine *(Pinus banksiana)*, birch *(Betula spp.)*, and aspen *(Populus spp.)* suggests this area was subject to disturbance early in the 19th century. Native Americans probably burned these lands to improve game habitat or to clear areas for the cultivation of crops. Following the logging that began in the 1840's, the land regressed ecologically to pasture and woodlots until its purchase by the Board of Regents. The latest vegetation study (Tesch 1982) is the most detailed compilation of vegetation descriptions known for Portage County, WI. In his study, he described the vegetation, focusing on the years 1839 - 1853. Tesch (1982) broke the vegetation types down into four broad categories and then 13 subdivisions (See page 28 - 33). In my study, the vegetation types were again reclassified into 13 current vegetation communities, not including one classification (type 5) to represent the developed areas of the Reserve.

Although several categories of management threats like habitat fragmentation, wetland and water quality, and lack of large scale disturbances were identified, two threats are thought to be of greatest concern. Invasive species such as glossy buckthorn *(Rhamnus frangula)* threaten to dominate the understory of the Reserve's woodlands. Without intervention, the long term goal of preserving the native communities will be compromised and future restoration will become progressively more difficult. Also of concern is the large number of white-tailed deer *(Odocoileus virginianus)* in the Reserve. This study found that deer populations are two to five times larger than recommended to maintain biodiversity and visitor satisfaction.

Statement of Objective: The purpose of this study is to assess the current ecological communities of the Schmeeckle Reserve and to make recommendations to restore, maintain, or replace them. Degraded units are defined as cover types that are regressing in terms of losing species or characteristics that define that type. The terms restoration and reconstruction will be used to refer to the management practices needed to reverse this process or guide succession toward a desired condition. Several steps are included:

1. Create through historic documents a picture of what the Reserve area might have looked like prior to European settlement.

2. Describe what is currently on the site. This will be done with a cultural map that shows buildings and trails, a topographic map, a soil map, a list of current cover types, and a list of birds, reptiles, amphibians, and mammals present in the Reserve.

3. Describe the trends and conditions that have driven the Reserve to its current state, focusing on the absence of fire, invasion of exotic species, and the abundance of white-tailed deer.

4. Define future desired conditions for the Reserve.

5. Recommend measures for land management.

Limitations: This study will not directly address the management of Lake Jonas, nor will it deal but marginally with the wetlands on the site. Finally, the land known as the Berard property that was purchased in 1998 is not included in this study.

Acknowledgements

I especially want to thank Ron Zimmerman and Dr. Alan Haney, my Graduate Committee Chairmen, for their continued patience as I completed my degree. There were times when I thought they would simply give up. Their persistence and patience shows a degree of commitment to the student that is admirable. I also would like to thank Dr. James Cook and Dr. Robert Brush for continuing to participate on my committee, even when I disappeared for long periods of time.

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Introduction

During the past two decades, several surveys, theses, and environmental impact assessments have focused on the Schmeeckle Reserve (Beyer 1995, Engel 1980, Strand and Associates 1974, Szewczykowski 1988, and Warzyn Engineering 1974). Most of these studies were in response to the numerous changes occurring in and around the Reserve. Many of the these directly impacted the Reserve's land base, animal populations, plant communities, and hydrology. Two especially significant changes were the construction of Michigan Avenue and the excavation of Lake Jonas. Both of these projects impacted the hydrology of the Reserve, which in turn affected everything from plant communities to the breeding of frogs (Engel 1980). Schmeeckle Reserve gained international attention when the Reserve and the City of Stevens Point installed "Frog Crossing" signs to help declining populations of wood frogs *(Rana pipiens)* crossing Michigan Avenue from breeding ponds to summer habitat.

Studies examined the effects of these disturbances on ground water levels, water quality, and wildlife populations. Until now, however, a vegetation management plan had not been completed. The importance of a management plan is particularly crucial today. Commercial and residential encroachment on the Reserve's boundaries continues. Developers have considered a housing addition on the Reserve's east boundary. Glossy buckthorn, which first appeared in the Reserve about 1986, now threatens many of the native plant communities. Plant and animal populations of the Schmeeckle Reserve are becoming isolated as corridors to other surrounding natural areas. Schmeeckle Reserve is becoming a natural island surrounded by urbanization (Zimmerman 1999).

Plant communities are also affected by the absence of fire. Evidence of old fire lines and large, open grown oaks testify to past disturbance by fire. A plan is critical to guide restoration of native plant communities already significantly altered by succession. Although natural succession is an important force that constantly shapes plant communities, the ability for vegetation to develop naturally has been lost in parts of the Reserve. In these areas, natural succession is altered by surrounding development, alteration of disturbance regimes, invasion of exotic plants, isolated populations, and increased herbivory by deer. Schmeeckle Reserve is an example of how small natural areas are becoming increasing difficult to manage using the laissez faire management style proposed by some.

Study Area

Schmeeckle Reserve is currently a 275 acre (111 ha.) nature preserve strategically located on the north edge of the University in the City of Stevens Point. Referred to as the "area north of campus" for many years, the Schmeeckle Reserve came into being in 1976, when a Federal Land and Water Conservation (LAWCON) grant enabled the University to purchase land, construct four miles of trails, revegetate disturbed areas, excavate a 24 acre lake, and build a shelter building. Additional land was added in December of 1998. This is the property known as the Berard property that is listed in the limitations section of this thesis. Management recommendations will focus on the 206 acres (83 ha.) that made up the Reserve when this project began.

The Reserve's boundaries are denoted entirely by roads, bordered on the north by North Point Drive, to the south by Maria Drive, to the west by Division Street (Business 51), and to the east by Wood Avenue (Fig. 1). Schmeeckle Reserve is in T.24N. - R.8E., sections 28 and 29 (Portage County Plat 1992). The highest point in the Reserve lies in the north-west corner (1123ft. or 342m.) and elevation drops only 33 feet to the south-east corner (1090ft. or 332m.) of the Reserve (Fig. 2).

Stevens Point lies just north of the Tension Zone described by Curtis (1956). Curtis described the tension zone as the area that separates Wisconsin into two distinct floristic provinces. The tension zone is the northern limit to the southern hardwood forest and the southern limit to the boreal forest. Because the Schmeeckle Reserve is near the tension zone, it contains a diverse set of plant and animal communities. For instance, in a study done in 1980, the Reserve was found to be the home of both the northern and southern species of flying squirrels (Engel 1980).

Many surveys of plant and animal populations in the Reserve have been made. The survey most often quoted was done by Dr. Freckmann and Dr. Hillier (Strand 1974), who described 14 different plant communities with 3 coniferous tree species, 10 deciduous tree species, 25 shrub species, and over 100 herbaceous species. It is an objective of this thesis to reclassify these communities into current cover types and to suggest a management plan to restore and/or maintain community diversity.

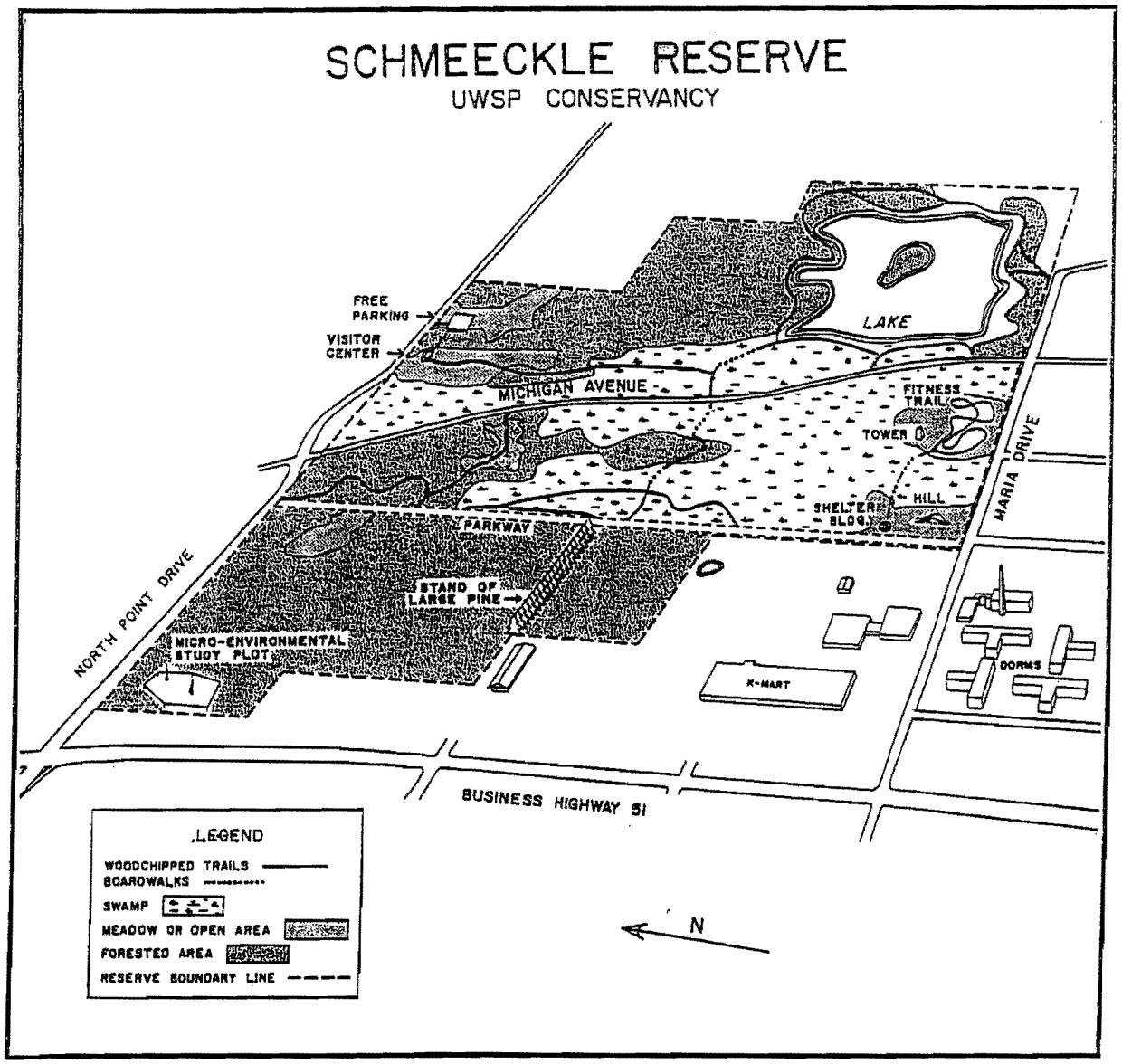

Fig. 1 Map of the Schmeeckle Reserve

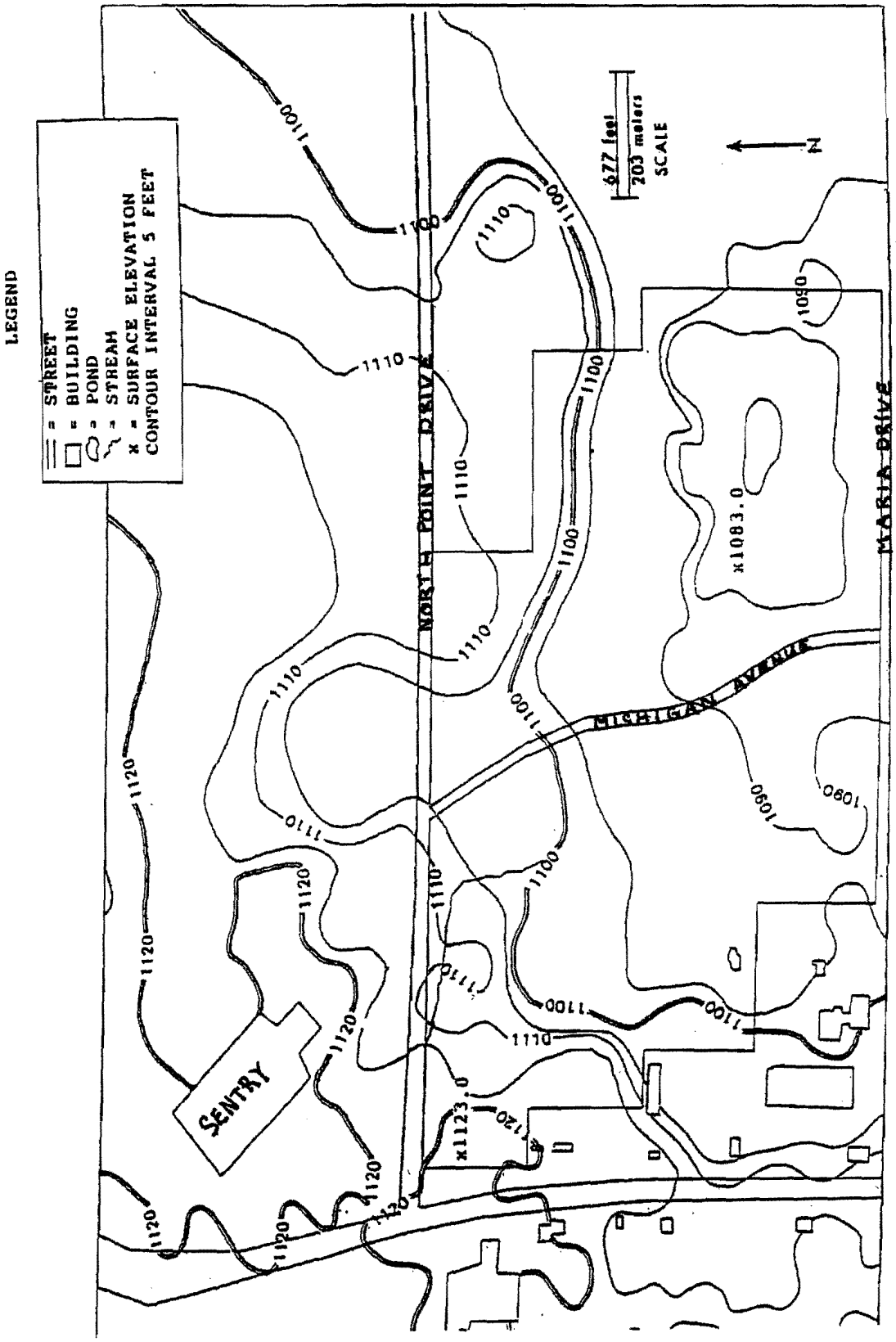

Fig. 2 Surface contour map of the Schmeeckle Reserve (Szewczykowski, 1988)

Methods

Most of this report will be of a qualitative nature. Historical data was located and reviewed, interviews were conducted with the Reserve's Director, Ron Zimmerman, and current literature was surveyed to determine the appropriate management practices. The objective is to collect and summarize information that will help guide the future management and use of the Reserve. Additional studies are needed to further document specific plant and animal populations in the Reserve. Permanent transects were installed to support the classifications of cover types and provide baseline data for future monitoring.

This study was based on the management needs of Schmeeckle Reserve, following the style of three similar studies: "Land Use Plan For Treehaven" (Payne and Harms 1994), "Long Range Management Plan, Arboretum Ecological Communities, Madison Wisconsin" (Kline 1992), and "Forest Vegetation: Inventory and Management Recommendations, Outer Island, Apostle Islands National Lake Shore, Wisconsin" (Fraundorf 1984). The latter is a thesis completed at the University of Wisconsin - Stevens Point and sets a precedent for this project. Field methods were adapted from Haney and Aptelbrum (1994) and their work on measuring changes in oak savannas. In general, the management plans have two things in common:

1. Determine what plant communities exist on the site ; and

2. Determine what actions, if any, are needed to preserve, maintain, or restore plant communities.

Although sample sizes are small, statistical data collected utilizing stratified sampling has been used to support the qualitative delineation of cover types in the Reserve.

Stratified Sampling

A stratified sampling technique was followed to collect baseline information. The Reserve was divided into cover types using aerial photographs supported by ground truthing. The proportional area of each was used to determine the number of transects to be placed in each cover type. This section along with the corresponding data will be reported in metric measurements only, however, basal area is calculated at mean square feet per acre using the standard 10x prism.

I. Cover type selection

Cover types were determined using a combination of the April 26, 1993 air photograph and ground truthing. Using a clear plastic overlay, cover types were outlined on the air photo with permanent marker. All the discernible areas were outlined in as much detail as possible. Alan Haney, Ron Zimmerman, and I performed ground truthing to verify what we had seen from the air photos and adjusted visible changes on the overlay. Vegetation types were then described.

II. Selection of transect locations

A. Weighting transects by cover type size. Each area of the Reserve was initially studied using available maps, soil surveys, original land surveys, aerial photographs, and any other descriptions or interpretations available. After the selection of cover types was completed, the area of each cover type was determined using a grid overlay. After the square meters for each patch of each cover type was determined, the total area of each cover type was tallied. Each individual cover type area was then divided by the total of all cover types and multiplied by 21, the total number of transects that were to be sampled. Each cover type, no matter how small, received at least one transect . The total area of cover types ranged from 1 to 4 ha.

B. Transect location. After determining the number of transects for each area, exact coordinates were located on the aerial photograph and grid sheet using a random numbers table. Coordinates were determined by assigning numbers to the X or Y axis. Points were accepted if they were more than 10m. from the edge of a cover type and if a 50m. transect could fit within the cover type. Transects were run due North (0^{o}), South (180^{o}), East (90^{o}), or West (270^{o}). The final direction of the transect was determined before going to the field by which direction would point most closely towards the center of the cover type. Lake Jonas and the Reserve's wetlands were not selected for sampling because they fell outside the scope of this thesis. Transects were given a specific number for permanent reference.

C. Location of transect starting points. Once all starting points were plotted on the air photo, a line was drawn between the starting point and a reference point on the air photo. This point was one that could both be seen on the air photo and

found on the ground. Using a 1° W declination, an azimuth was taken from the point on the map to the transect starting point, and the distance between the two points was scaled with a ruler and converted into meters.

D. Field location of transect starting points. Starting at the reference point on the ground, distance was measured in the direction chosen to locate transect starting points. After reaching the starting point, the cover type was verified. A metal stake was driven into the ground for permanent location. Only 10 to 15cm. were left above the ground to reduce the chance for vandalism. A metal detector may be needed to relocate the stakes in the future.

III. Establishment of transects

A. Field crews. The sampling crew was made up of graduate students with backgrounds in natural resources and biology. The crew consisted of members of the Legacy Vegetation Sampling Team, Dr. Haney, and myself. Supervision was provided by Dr. Haney.

B. Procedures. A 50m. tape was stretched taut at the ground to pass over the 25 and 50m. points. A compass was used to locate the line of the transect. Once the direction was determined, the starting point found, and 50m. tape stretched, an end point stake was driven in the ground for exact relocation of the 50m. line.

IV. Sampling and data summary

A. Trees

1. Cover. Tree cover by species was established by the line intercept method. Trees were defined as stems > 10cm. d.b.h. and greater than 1m. tall. Trees whose canopy intercepted the 50m. line were recorded by species to the nearest 0.1m. Percent cover was calculated for each species by adding the total intercept along each 50m. transect and dividing by 50 and multiplying by 100. Standard deviation was also calculated for each species by cover type.

2. Basal area. The basal area of all live and dead trees was recorded at the 0, 25, and 50m. points using a 10x prism, and averaged for the transect. Average basal area was found by summing the 0, 25, and 50m. numbers and dividing by 3. Where more than one transect occurred in a cover type, all the readings were used to find the average basal area and standard deviation. Density by diameter classes was expressed as trees per hectare. This was obtained by multiplying the number of trees in the $100m^2$ plot (2 x 50m.) by 100. If more than one transect was in a cover type average was calculated. Tree density by diameter classes is not included in the summary in Appendix C, but is on file, in a compiled form, in the Schmeeckle Reserve Visitor's Center.

B. Shrubs

1. Cover. Shrubs were defined as woody stems > 1m. tall and <10cm. d.b.h. Cover by species was estimated by line intercept method described above. Average percent cover and the standard deviation were calculated by species.

2. Dead and live shrub stems within 1m. of the right side of the tape were tallied by species. Stem numbers are expressed as stems per hectare basis. The number of stems in the $50m^2$ sample plot (1 x 50m) was multiplied by 200. If more than one transect was in a cover type, the average was calculated.

C. Herb layer

1. All living vegetation < 1m. tall was sampled in $1m.^2$ circular quadrats centered on 5, 15, 25, 35, and 45m. along each 50m. transect. Percent cover of each species was visually estimated. Percent cover of bryophytes and lichens was recorded as a single taxon.

2. Average percent cover and standard deviation, by species, was calculated for each cover type.

D. Litter and disturbance. The percent of each 1m.^{2} quadrat covered by fine litter (stem diameters < 2.54cm.) coarse litter and bare soil was visually estimated.

E. Photography. Photographs were taken of each cover type showing typical vegetation. These slides will be converted to digital images for storage in the Schmeeckle Reserve electronic files at the Visitor Center and at the CNR Schmeeckle office.

Historic Vegetation, Uses, and Significant Changes

To reconstruct a cover type, it is necessary to form a clear picture of what existed previously. Although the focus of this project is not solely on lost or degraded ecosystems, this information will help guide management decisions of the Reserve. There are many challenges in recreating an accurate picture of presettlement vegetation types. Without detailed descriptions of the vegetation, one must rely on a variety of information to compile a picture. The following types of data were evaluated to help reconstruct the historic scene:

1. Old land surveys and historic accounts;
2. Ownership maps, newspaper articles, owner occupations, past land uses, and deed descriptions;
3. Vegetation studies;
4. The 1938 air photo; and
5. Existing conditions: old trees, old fence rows, and existing cover types.

Pre-settlement Vegetation

Land survey descriptions of Portage County occurred as early as 1839. A survey completed by Joshua Hathaway was called the "Three mile survey" or "The Indian strip." This survey defined an area three miles wide on either side of the Wisconsin River for a 40 mile strip of land from Nekoosa to Wausau. Notes were made of major changes in vegetation, of trees intersected by the survey line, rivers, streams, ponds, lakes, marshes, and major changes in topography. A hand-written copy of these notes is available in the Stevens Point County - City Building and the originals are on file at the Wisconsin State Historical Society in Madison. The remainder of the county was surveyed later as the land surrounding Stevens Point was settled. The survey that was done in 1853 by Samuel P. Hicks describes the area now containing the Reserve (T.24N. - R.8E.). These notes, as well as the notes by Joshua Hathaway, were used to help reconstruct the 13 plant community types described by Tesch (1982) in his thesis, "Pre-settlement Vegetation of Portage County, Wisconsin."

Three other studies used by Tesch were (Hoyt 1860), (Roth 1898), and (Finely 1951, 1976). Hoyt (1860) based his descriptions on observations by other people. Vegetation types he recognized were: Pine and oak openings, heavy hardwoods, and blank areas, which Tesch concluded to be sections of prairie.

Roth (1898) compiled his information from testimonies given by experienced lumbermen. These indicated that near the close of the 19th century Portage County was covered with openings of jack pine or scrub oak woods, mixed hardwoods and pine forests, mixed forests of hardwood or pine that had been burned or largely cut over, and the southern extent of commercial hemlock.

The most detailed study was done by Finley (1951, 1976). Utilizing 30 years of survey records, Finley reconstructed the original vegetation for the entire state of

Wisconsin. In his study he described four broad categories of vegetation types for Portage County, which were broken down into 13 different cover types. These types were closely followed by Tesch (1980) in his study of Portage County vegetation seen on page 28 and following. See Figure 3 for Tesch's (1980) comparison of scientific names to historically used common names.

Mixed Coniferous - Deciduous Forest

A. Hemlock, sugar maple, yellow birch, white pine, red pine
B. Sugar maple, yellow birch, white pine, red pine
C. White pine, red pine
D. Jack pine, scrub (Hill's) oak forest and barrens
E. Aspen, white birch, pines, and soft maple

Deciduous Forest

A. Sugar maple, basswood, red oak, white oak, black oak
B. Oak - white, black, Hill's
C. Oak openings - bur, white, black, Hill's

Grassland and Brush

A. Prairie
B. Brush

Wetland Vegetation

A. Swamp conifers - white cedar, black spruce, tamarack, hemlock
B. Lowland hardwoods - willow, soft maple, box elder, ash, elm, cottonwood, river birch
C. Marsh and sedge meadows, wet prairies, lowland shrubs

Scientific name equivalence for common names referred to in text.

COMMON NAME	SCIENTIFIC NAME
Alder	Alnus rugosa (DuRoi) Spreng.
American Elm	Ulmus americana L.
Ash	Fraxinus spp.
Aspen	Populus spp.
Balsam	Abies balsamea (L.) Mill.
Basswood	Tilia americana L.
Beech	Fagus grandifolia Ehrh.
Birch	Betula spp.
Bitternut	Carya cordiformis (Wang.) K. Koch
Black Ash	Fraxinus nigra Marsh.
Black Birch	Betula nigra L.
Black Maple	Acer saccharum Marsh.
Black Oak	Quercus velutina Lam.
Black Pine	Pinus banksiana Lamb.
Black Spruce	Picea mariana (Mill.) BSP.
Black Willow	Salix nigra L.
Box Elder	Acer negundo L.
Bur Oak	Quercus macrocarpa Michx.
Butternut	Juglans cinerea L.
Cedar	Thuja occidentalis L.
Cottonwood	Populus deltoides Marsh.
Elm	Ulmus spp.
Fir	Abies balsamea (L.) Mill.
Hackberry	Celtis occidentalis L.
Hemlock	Tsuga canadensis (L.) Carr.
Hickory	Carya cordiformis (Wang.) K. Koch
Hill's Oak	Quercus ellipsoidalis E. J. Hill
Ironwood	Ostrya virginiana (Mill.) K. Koch
Jack Oak	Quercus ellipsoidalis E. J. Hill
Jack Pine	Pinus banksiana Lamb.
Linden	Tilia americana L.
Maple	Acer spp.
Northern Red Oak	Quercus borealis Michx. f.
Norway Pine	Pinus resinosa Ait.
Peach-leaf Willow	Salix amygdaloides Anderss.
Pin Oak	Quercus palustris Muenchh.
Pine	Pinus spp.
Pitch Pine	Pinus banksiana Lamb.

COMMON NAME	SCIENTIFIC NAME
Poison Ivy	Rhus radicans L.
Poison Sumac	Rhus vernix L.
Poplar	Populus spp.
Red Elm	Ulmus rubra Muhl.
Red Maple	Acer rubrum L.
Red Oak	Quercus borealis Michx. f.
Red Pine	Pinus resinosa Ait.
River Birch	Betula nigra L.
Scarlet Oak	Quercus coccinea Muenchh.
Scrub (Hill's) Oak	Quercus ellipsoidalis E. J. Hill
Scrub Pine	Pinus banksiana Lamb.
Scrub Pine (White)	Pinus strobus L.
Scrub White Oak	Quercus alba L.
Scrub White Pine	Pinus strobus L.
Silver Maple	Acer saccharinum L.
Soft Maple	Acer spp.
Southern Red Oak	Quercus falcata Michx.
Spanish Oak	Quercus sp.
Speckled Alder	Alnus rugosa (DuRoi) Spreng.
Spruce	Picea spp.
Sugar Maple	Acer saccharum Marsh.
Swamp Oak	Quercus bicolor Willd.
Swamp White Oak	Quercus bicolor Willd.
Tamarack	Larix laricina (DuRoi) K. Koch
Walnut	Juglans cinerea L.
White Ash	Fraxinus americana L.
White Birch	Betula papyrifera Marsh.
White Cedar	Thuja occidentalis L.
White Elm	Ulmus americana L.
White Maple	Acer spp.
White Oak	Quercus alba L.
White Pine	Pinus strobus L.
White Scrub Pine	Pinus strobus L.
Willow	Salix spp.
Yellow Birch	Betula lutea Michx. f.
Yellow Pine	Pinus banksiana Lamb., Pinus resinosa Ait.

Fig. 3. Tesch's (1982) scientific names for historic tree species

All descriptions that follow are summarized from the work of Tesch (1982). These are the most detailed compilations of vegetation descriptions known for Portage County, WI., during the years 1839 - 1853. Tesch used many of the same classifications that Finley used in his study. The following four major vegetation types are broken down by Tesch into 13 subdivisions or cover types. Binomials were not included in the body of Tesch's work. Figure 3 is his table for comparing scientific names to historically used common names. Each description included the following five categories:

1. Cover type name,
2. List of plants from highest cover to lowest,
3. Percent of county covered by type,
4. Ranking compared to other cover types in the county, and
5. Location in the county where it is most common.

The Schmeeckle Reserve is located in the north-central portion of the county. Many of these cover types would be found in or around the Reserve with the exception of those found solely in the southern or western portions of the county.

I. Mixed Coniferous - Deciduous Forest (5 cover types covering 22.64%)

A. Hemlock, Sugar maple, Yellow Birch, White Pine, Red Pine.

This cover type occupied 2.74% of Portage County, ranking tenth in coverage, and was found primarily in the north-western and west-central parts of the County. Curtis (1959) suspected that ground fires retrogressed similar communities to white pine only. This community was comprised of 51% hemlock, 11.50% birch, 7.00% maple,

6.50% white pine, 4.00% yellow birch, and 3.00% each for basswood and sugar maple. The remaining 14.00% (in decreasing order) consisted of ash, pine, red pine, elm, black oak, white maple, tamarack, fir, ironwood, butternut, soft maple, white oak, and river birch (Tesch 1982).

B. Sugar Maple, Yellow Birch, White Pine, Red Pine

This cover type occupied 3.01% of Portage County, ranking ninth in coverage, and was found in the northern one half and east-central parts. The composition of this community was: 16.77% white pine, 13.67% sugar maple, 9.94% each for white birch and aspen, 6.83 % soft maple, 5.59% each for birch and white maple, 3.11% each for white oak, maple, and northern red oak, and 2.48% individually for red pine, yellow birch, elm, and iron wood. The remaining 12.48% was represented by black oak, basswood, hemlock, river birch, bur oak, pine, hackberry, black ash, white ash,and tamarack (Tesch 1982).

C. White Pine, Red Pine

This cover type occupied 3.49% of the county, ranking eighth in coverage, and was found primarily in the north-central and north-east parts of Portage County. The composition of this community was: 40.97% white pine, 32.68% red pine, and 13.66% jack pine. The remaining 12.69% was occupied by aspen, pine, black oak, white oak, bur oak, hemlock, northern red oak, and Hill's oak (Tesch 1982).

D. Jack Pine, Scrub Oak Forest and Barrens

This cover type occupied 9.89%, ranking fourth in coverage, and was found primarily in the south-western and central parts of Portage County. The composition of this

community was: 79.65% jack pine, 6.26% red pine, 3.33% individually for bur oak and aspen, and 3.13% black oak. The remaining 6.30% was represented (in decreasing order) by white pine, tamarack, white oak, white maple, Hill's oak, northern red oak, black ash, and swamp white oak (Tesch 1982).

E. Aspen, White Birch, Pines, Soft Maple

This cover type occupied 3.51%, ranking seventh in coverage, and was found primarily in the north-east and south-west parts of Portage County. The composition of this community was: 50.20% aspen, 10.44% maple, 7.63% birch, 6.43% white birch, 4.02% white pine, 3.21% each for white oak and soft maple, and 2.41% each for pine and jack pine. The remaining 14.06% was tamarack, black oak, yellow birch, elm, river birch, white maple, swamp white oak, red pine, ash, white ash, and black ash (Tesch 1982).

II. Deciduous Forest (3 cover types, covering 46.74%)

A. Sugar Maple, Basswood, Red Oak, White Oak, Black Oak

This cover type occupied 10.41%, ranking third in coverage, and was found primarily in the northern half of Portage County. The composition of this community was: 13.86% black oak, 10.64% sugar maple, 8.73% birch, 6.63% white pine, 6.48% aspen, 6.33% white oak, 5.57% white birch, 4.97% basswood, 3.92% white maple, 3.31% white ash, 2.56% each for northern red oak, yellow birch, and pine. The remaining 14.60% consisted of elm, hemlock, tamarack, ironwood, soft maple, ash, black ash, bur oak, red pine, swamp white oak, bitternut, hackberry, white cedar, jack pine, willow, red elm, beech, spruce, American elm, and river birch (Tesch 1982).

B. Oak - White Oak, Black Oak, Bur Oak, Hill's Oak

This cover type occupied 7.56%, ranking fifth in coverage, and was found primarily in the eastern half of Portage County. The composition of this community was: 38.38% black oak, 23.29% white oak,19.41% bur oak, and 14.98% Hill's oak. The remaining 7.94% was comprised of maple, northern red oak, ash, birch, white pine, red pine, Spanish oak, and swamp white oak (Tesch 1982).

C. Oak Openings - Bur Oak, White Oak, Black Oak, Hill's Oak

This cover type occupied 28.77%, ranking first in coverage, and was found primarily in the eastern half of Portage County. The composition of this community was: 32.97% bur oak, 26.34% black oak, 23.79% white oak, and 12.37% Hill's oak. The remaining 4.56% was comprised of aspen, red pine, jack pine, white pine, northern red oak, maple, pine, soft maple, birch, and white birch (Tesch 1982). Irving (1880) noted that the oak openings of central Wisconsin quickly filled in once settlement began. Muir (1913) and Gleason (1922) depicted oak openings as a product of periodic burning. Stout (1944) and Cottam (1949) felt openings were derived from preexisting forests and not oak migrations across prairies.

III. Grassland and Brush (2 cover types and 2.11% coverage)

A. Prairie

This cover type occupied 1.60%, ranking twelfth in coverage, and was found primarily in the southern, east-central, and central parts of Portage County. Wright (1877) described prairies in northwestern Wisconsin as fire maintained. Gleason (1913) and Curtis (1959) attributed large tracts of prairie in the Midwest to burning by Native Americans (Day 1953, Tesch 1982).

B. Brush

This cover type occupied 0.51%, ranking thirteenth in coverage, and was found primarily in the south-western parts of Portage County. This community contained large amounts of oak grubs. Finley (1951, 1976) felt these areas were the result of fire.

IV. Wetland Vegetation (3 cover types, covering 27.51%)

A. Swamp Conifers - White Cedar, Black Spruce, Tamarack, Hemlock

This cover type occupied 18.20%, ranking second in coverage, and was found primarily in south-western portions through the central portion of the county, including smaller areas scattered throughout the northern half. The composition of this community was: 57.84% tamarack, 6.73% hemlock, 5.74% white pine, 4.86% spruce, 3.86% birch, 3.64% black ash, and 2.87% white ceder. The remaining 14.46% consisted of white birch, yellow birch, jack pine, aspen, red pine, maple, black oak, elm, sugar maple, white maple, soft maple, pine, fir, ash, willow, swamp white oak, basswood, and white oak (Tesch 1982).

B. Lowland Hardwoods - Willow, Soft Maple, Box Elder, Ash, Elm, Cottonwood, River Birch

This type occupied 2.00%, eleventh in coverage. It was found primarily along the Wisconsin River and along waterways in east-central Portage County. The community composition was: 17.34% elm, 13.87% white ash, 9.25% black ash, 6.94% white maple, 5.78% each of American elm, maple, and black oak, and 4.04% ash. The remaining 24.38% was comprised of hemlock, white pine, bur oak, aspen, basswood, birch, river birch, sugar maple, tamarack, white oak, white birch, Hill's oak, willow, red elm, soft maple, ironwood, black willow, butternut, and jack pine (Tesch 1982).

C. Marsh and Sedge Meadows, Wet Prairie, Lowland Shrubs

This cover type occupied 7.31%, ranking sixth in coverage, and was found primarily in south-western Portage County and along waterways. The composition of this community was: 38.46% tamarack, 15.38% individually for white pine and aspen, and 10.77% red pine. The remaining 20.01% consisted of birch, jack pine, speckled alder, willow, and black oak (Tesch 1982). Curtis (1959) felt that fire was critical to the maintenance of this type.

1977 Environmental Assessment Vegetation Study

In 1977 Hillier and Freckman did a vegetation study of Schmeeckle Reserve (University of Wisconsin Central Administration 1977). That provided an important reference point for evaluating how the vegetation has changed in the last 20 years. Cover types recognized by Hillier and Freckman are seen below (Fig. 4), many of which correspond well to current cover.

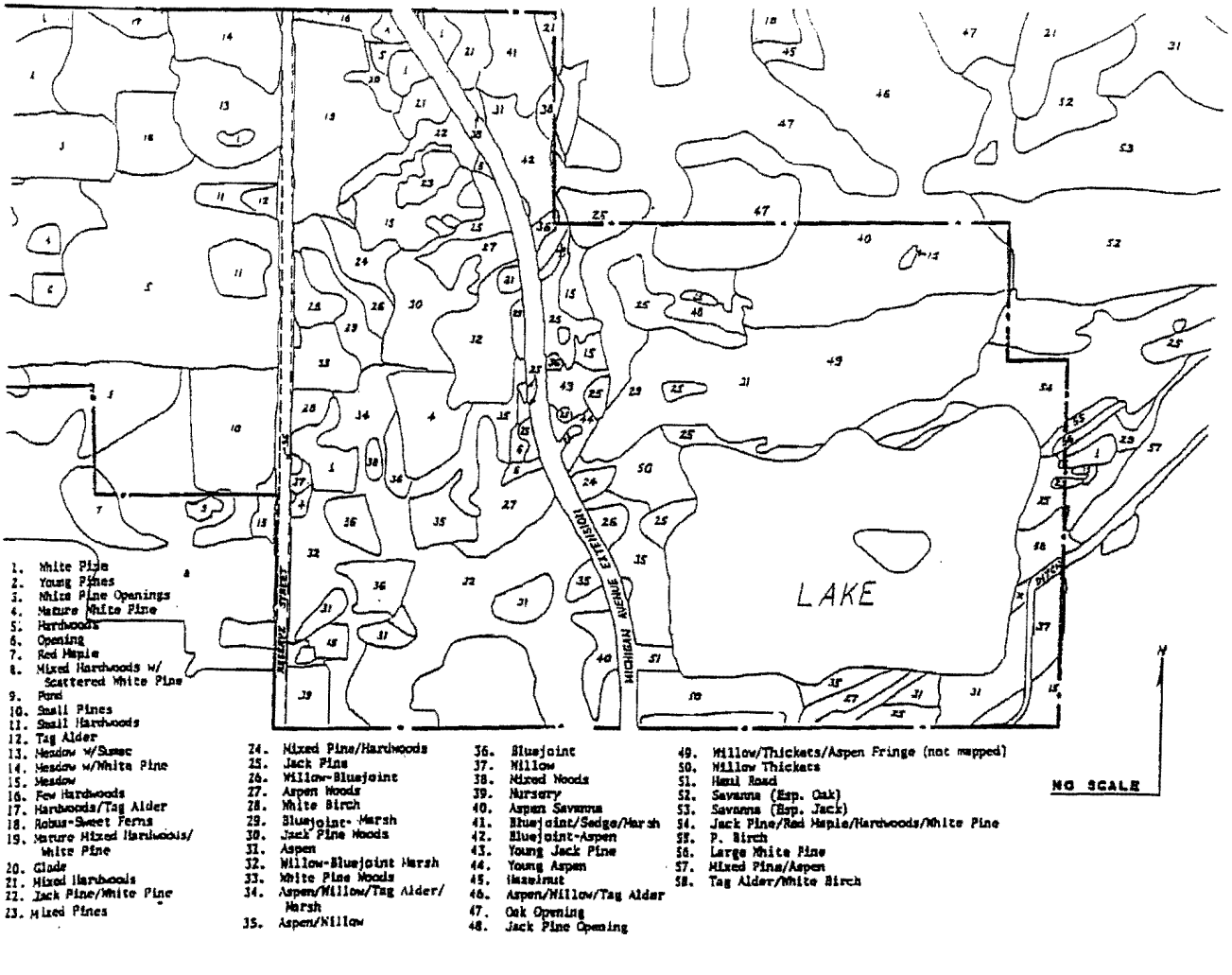

Fig. 4 Vegetation cover types of the Schmeeckle Reserve in 1977 (University of Wisconsin Central Administration 1977)

Land Uses and Significant Changes

Three sources were utilized to determine previous land uses: Past ownership, newspaper clippings, and deeds. The four most important land uses that impacted the vegetation in the Reserve were logging, cattle grazing, farming, and the construction of Michigan Avenue. The first three uses occurred prior to 1975, ending with the sale of Anton Mish's property to the University in 1976. This property was located on the north-east corner of Section 28, T.24N. - R.8E. (Schmeeckle Reserve Unit #5, page 82). This is believed to be the last working farm within the Reserve's boundaries. The Michigan Avenue construction combined with the creation of Lake Jonas was finished in 1979 and was the last major disturbance within the Reserve's boundaries.

Logging

All of the Reserve was logged. This is evident by the large stumps remaining throughout the Reserve. According to most "old-timers," even the Chilla Wood lot, which is currently classified as an old growth cover type, had selective timbering (Zimmerman 1999) . There are no pre-settlement white pines left on the Reserve, but some large second growth pine can be found throughout the property including the old Mish property, and several scattered pines near the "Trail of Reflections" tree house. Along with these large pines, several oaks, up to 41" dbh, (104cm.), still exist in the Berard land purchased in December of 1998.

In 1920, William Eichhorst's family began selling off their farm property to the North Boyington Company. This land was located on the area of the Reserve now containing Lake Jonas. The North Boyington Company was formed in 1893 for the purpose of "dealing in real estate, building dwellings, dealing in logs and lumber, and

carrying on a general mercantile business" (Portage County Law and Abstract Co., Stevens Point). Also in 1948, Frank Klicinski sold timber rights to Barney Omernick, D/B/A McDill Lumber Company. The deed reads: "All saw and pulp timber, 6 inches on the stump and up, except hardwood and tree tops, standing or growing on" (Anonymous Book "193" of Deeds, Page 512). This land was 5 acres (2ha.) located on the south-west corner of the south-west, north-west of Sec. 28 in T.24N. - R.8E. This location is north of the shelter area, west of where the old Reserve Street ran through the Schmeeckle Reserve. See Schmeeckle Reserve Unit #19 (page 82) for an exact location.

Grazing

Grazing occurred over much of the Reserve. The following evidence supports these claims. On October 22, 1903, William Eichhorst was killed by a bull on his property. Eichhorst owned a very large section of the land located in the south-central portion of the Reserve, on both sides of present day Michigan Avenue. In 1914, Theresa Green sold property to Martin Klecinski on the north-central portion of the Reserve. The deed reads: "Excepting that grantor reserves the right to use and occupy the slaughter house and buildings in connection therewith now located on above described premises and the right to pasture cattle for slaughter" (Anonymous Volume "102" of Deeds, Page 599). This was verified by Maurice Lolinski in 1980, when Reserve staff member Lori Landstrom conducted a telephone interview. Evidence of barbed wire fences can still be found transecting the property along with drainage ditches that channeled water from former pastures to Moses Creek. The 1938 aerial photograph also reveals pastures and cultivated fields.

Farming

Farming was practiced on at least one portion of what is now the Schmeeckle Reserve into the late 1950's on property then owned by Anton Mish. The open grassland on the north-east side of the parkway or Old Reserve Street (Schmeeckle Reserve Unit #5, page 82) is thought to be one of his fallow fields. The description of the North Boyington Company property states that when the lands were purchased they were fenced and had been used for agricultural purposes for many years (Anonymous Volume "185" of Misc., Page 149). The 1938 air photo also shows that selected areas were cultivated.

Michigan Avenue Construction

Michigan Avenue was constructed in 1976-77. Reserve Street, built in 1948, was abandoned in 1977 when Michigan Avenue was developed to take its place as a wider, safer road. This new road was controversial. Many people wrote to the campus and local papers voicing their opposition to the road. Several University library files are dedicated solely to Schmeeckle Reserve and its creation, much of which documents the building of Michigan Avenue.

At least two studies regarding the road were completed. One was an environmental impact assessment (Warzyn 1974) prior to road construction and another was a thesis (Engel 1980) on "The Effects of Urban Development on Vertebrate Wildlife Populations In Schmeeckle Reserve, University of Wisconsin - Stevens Point."

Present Conditions

The Schmeeckle Reserve is now a 275 acre (111 ha.) nature preserve. The excavation of Lake Jonas by Sentry Insurance on U.W. Foundation Land, allowed UWSP to accept the donation of the lake and land and apply it as a "match" for LAWCON funding. This enabled the University to purchase land, construct four miles (6 km.) of trails, and build a shelter building as shown on the Cultural Map (Fig. 1).

The highest point in the Reserve lies in the north-west corner and the elevation at its lowest point drops only 33 feet (10m.) to the south-east corner (Fig. 2). Five major soil types exist (Fig. 5). Although the soils listed are normally well drained at the surface, the high water table and shallow granite bedrock causes much of the Reserve to remain wet.

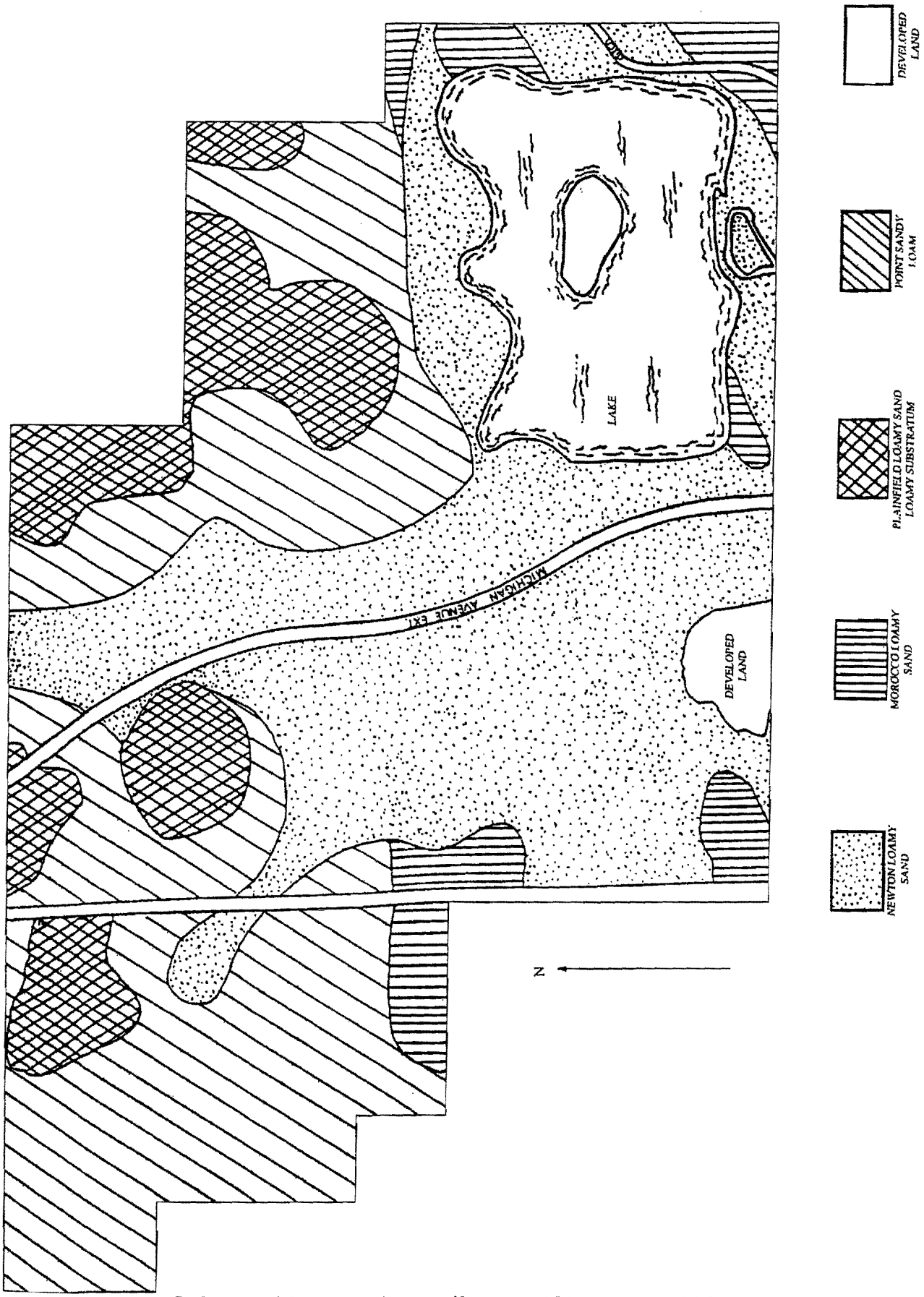

Fig. 5 Schmeeckle Reserve soil map (Chastain 2000)

Wildlife

Wildlife is abundant in the Reserve (appendix A). The bird species reported by Engel (1980) are listed in Appendix A. Engel (1980) observed 7 species of reptiles during his study. He could not verify four species that were listed by Warzyn (1974) or Strand (1974). These are noted with a (*) in appendix A.

Engel (1980) observed 10 species of amphibians during his study, but could not verify one species that was reported by Warzyn (1974) or Strand (1974). It is noted with a (*) in appendix A. There is also an undocumented report of bullfrogs on site.

Engel (1980) observed at least 32 species of mammals during his study (seen in appendix A), with the exact number depending on the number of bat species he recognized. Two species, however, were the domestic dog and domestic cat. These are excluded from the list in appendix A. Also not included in this list are black bears *(Ursus americanus)*, which have been reported to the Reserve's Director, Ron Zimmerman, on three occasions.

Desired Future Condition

After reviewing past vegetation types, present conditions, and historic land uses, there is one other question to consider: What should the Reserve look like?

This question is addressed in two parts. First, what are the future uses of the Reserve, and second, how does this impact land management choices? Two primary sources have been pursued for answers: A Visitor Services Plan for the Reserve (Yarmark 1995), which includes interviews and opinions from private users and professors at the University, and the views of the current Director, Ron Zimmerman.

The mission of Schmeeckle Reserve is to preserve natural communities typical of central Wisconsin for scientific study, and for inspiration and enjoyment by the public (Yarmark 1995). To achieve this mission, three goals have been set. In order of importance, these are:

1. Preserve and maintain native plant and animal communities of central Wisconsin;

2. Serve as a research and teaching facility for faculty and students of numerous fields and for the education of the public; and

3. Provide recreational opportunities that are compatible with the preservation and education goals of the Schmeeckle Reserve.

Trail Use

Yarmark's (1995) market analysis showed that two areas of the Reserve were most heavily used, the Visitor Center and the trail system. Her survey showed that the trail users were, 60.3% UWSP students, 24% non-students from the Stevens Point area, and 15.5 % non-students from out of town. A summery of Visitor Center users showed that 50% are from the Stevens Point area, and of those 25.3% are students. This study also revealed that almost 40% were first time visitors.

The top three reasons people came to the Reserve were walking to relax, walking to exercise, and jogging (Fig. 6, Yarmark 1995).

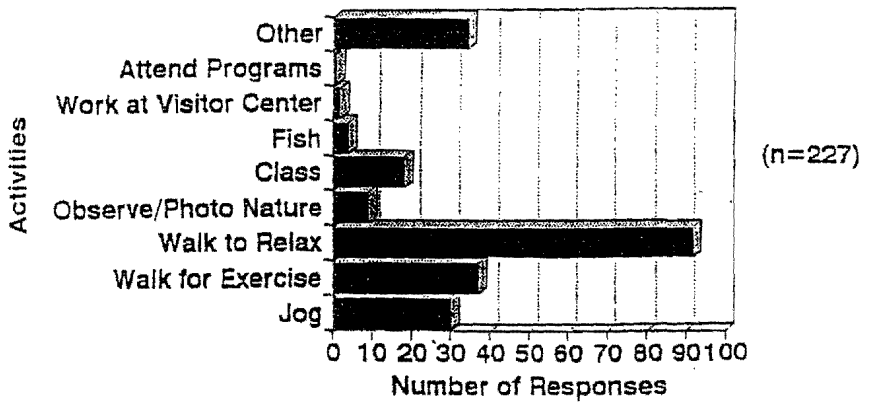

Fig. 6 "One thing you most often come to the Reserve to do?" (Yarmark 1995)

Watching wildlife and using trails are the two most appealing activities for Stevens Point residents (Fig. 7, Yarmark 1995). By visitor demand, trail use will continue to be an important activity at the Reserve, but may need to be controlled when it begins to directly compete with the Reserve's ability to maintain native ecosystems.

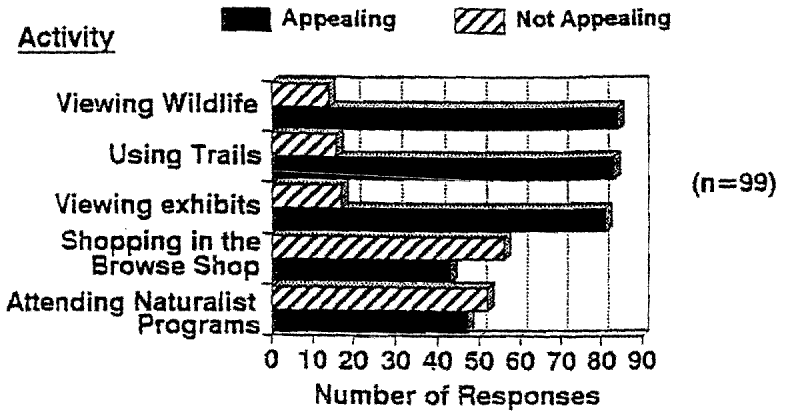

Fig. 7 "Ranking of favorite things to do at the Schmeeckle Reserve" (Yarmark 1995)

Educational Uses

Another segment of Yarmark's (1995) study was focused on the University's students and professors and how they use the Reserve. When the faculty and students were questioned regarding use of Schmeeckle Reserve, most use was for laboratory exercises such as radio telemetry, soil sampling, timber cruising, ground water measurement, plant identification, and environmental interpretation (Yarmark 1995). The Chilla Woodlot is used heavily for forestry studies and concern for the health of this area was mentioned. Other concerns were the confusion among different class projects and extensive plot marking in this area. Several other management issues also were cited: Invasion of sedge meadows by woody species, invasion by exotic species like glossy buckthorn, and the soil compaction and vegetation loss in heavily used areas. All of these are addressed in the discussion of vegetation management.

Vegetation and Habitat

The following information concerning the future of the Reserve, came from an interview with the Reserve's Director, Ron Zimmerman. When thinking about the future of the Reserve, it is important to revisit the pre-settlement vegetation. Four general vegetation categories can and should be displayed within the Reserve: Mixed coniferous - deciduous forests, deciduous forests, grasslands and brush, and wetland vegetation. Within these four categories there is, however, several cover types that will likely not be part of the Reserve's future. These types contain species that have all but disappeared from the Reserve and likely have been gone for some time now. The following list notes which of the 15 cover types, identified by Tesch (1985), could be represented. However, many of these cover types do not contain all of the species listed by Tesch (1985). Many of the more commercially valuable hardwoods have been selectively logged and are either uncommon or are not present in the Reserve. Therefore, many of the cover type names listed in the management section are different from those listed below.

Mixed Coniferous - Deciduous Forest

A. White pine, red pine
B. Jack pine, scrub oak forest and barrens
C. Aspen, white birch, pines, and soft maple

Deciduous Forest

A. Oak - white, black, Hill's
B. Oak openings - bur, white, black, Hill's

Grassland and Brush

A. Prairie

B. Brush

Wetland Vegetation

A. Lowland hardwoods - willow, soft maple, box-elder, ash, elm, cottonwood, river birch

B. Marsh and sedge meadows, wet prairies, lowland shrubs

Management Guidelines

To properly manage a natural area such as the Schmeeckle Reserve, it is important to understand its functions, goals, and expectations. Schmeeckle Reserve has three priorities that are mandated in its mission statement: Preservation, research and teaching, and recreation (see page 2 for a complete mission statement).

A managed forest is not necessarily an improvement over an unmanaged forest (Maser 1988). However, every forest and natural area should have an ecological landscape plan (Forman 1990). Schmeeckle Reserve has embarked on this project as an act of responsible land management. In a similar project, goals were established for the UWSP Treehaven property to emphasize five key landscape characteristics: Uncommon features, existing large patches, stream corridors, steep slopes, and links with other forests (Payne and Harms 1994). Payne and Harms stated that three additional characteristics needed further thought to tie the plan together into a basic spatial framework: Additional large patches, major natural land corridors, and main routes for people.

The size of Schmeeckle Reserve should enable it to fulfill the three primary objectives stated on page 2, but compromises must be made to successfully manage the area as a place for native plants, animals, and people. Evens (1974) said managing complex forest ecosystems requires flexibility and management practices that meet desired vegetation conditions.

To help reach a balanced management, four priorities have been set by the Reserve:

1. Further the three priority goals in the mission statement;
2. Control destructive species, especially buckthorn and deer;
3. Reintroduce fire to the Reserve where it is needed to maintain vegetation types; and
4. Encourage the Reserve's diversity and education goals by maintaining or restoring appropriate cover types.

To further aid in land management recommendations, the five general resource features described by Payne and Harms (1994) were considered:

1. Uncommon features,
2. Existing large patches,
3. Stream and wetland corridors,
4. Links with other natural areas, and
5. Aesthetic considerations.

One of Schmeeckle's greatest opportunities lies in its connection to education and serving as a corridor to other natural areas. These land bridges, called greenways or corridors, have become more important when talking about and planning environmentally sustainable urban areas. This next section looks briefly at restoration management, and then at the roles and functions of greenways. Aldo Leopold (1953) suggested that the first rule of intelligent tinkering is to save all the pieces. This is proving to be one of the great challenges for today's restorationists.

Restoration Management

There are several ways to approach ecosystem restoration. The first is to focus on natural processes. Often one of the greatest factors contributing to loss of diversity is the alteration or absence of key ecological processes, such as fires or floods. One goal of restoration management can be to simply reestablish these missing processes and restore them to the area. A good example of this is the periodic burning of prairie areas. In many instances we may not know the exact response that will follow, but we are sure that a process is underway (Boner and Heitlinger 1981).

The second approach is to focus on a particular natural element or feature that is significant at a given site (Boner and Heitlinger 1981). If, for example, surface filtration of runoff is a key function provided by a sedge meadow, then a good portion of the restoration and management could focus on maintaining the sedge meadow and restoring the land that has been claimed by invading shrubs. The focus of such a plan would need to center on the ecology of this ecosystem. Special attention would need to be paid to the relationship between runoff, contaminants, sedge, and management techniques like flooding.

The third approach is to actively restore lost or degraded components. While the disruption of natural processes, diseases, and/or contaminants may have been the cause of a lost ecosystem, simply restoring these processes and stopping the contaminants may not be enough to revive such an area. In these cases, techniques such as planting or seeding may be needed (Boner and Heitlinger 1981).

In Schmeeckle Reserve, it is possible to combine all the approaches or to use them independently. For example, the Reserve could choose to manage woodcock by focusing on open areas. Open areas could be restored by reintroducing fire, while manually pulling large shrubs that are invading open areas that are needed for breeding. In another part of the Reserve, fire could be used to control buckthorn, and

in another, one could remove buckthorn manually.

Another way to categorize restoration management is to divide the work into three phases: The recovery phase, the maintenance phase, and the experimental phase. The recovery phase can be thought of as the time when invasive species are brought under control, soil is stabilized, and the vigor of native species is improved. The prairie area around the Reserve's parking area can serve as our example. During the recovery phase, that area needed special attention to control weeds, encourage and introduce natives, and limit public use. This could have been accomplished by planting native species, seeding native species, fencing, and/or signage to keep public out. Exotics could have been controlled using such techniques as controlled spraying, hand digging or pulling, or frequent prescription burning. This example is in no way meant to reflect upon the actual process used, but only to demonstrate possibilities.

The second phase can be defined as processes needed to maintain an established ecosystem. For example, one of the main goals in establishing a prairie should be to control the invasion of woody species. This can be done by using fire at longer intervals than the initial frequency used to control cool season, herbaceous plants. The interval may go from every year to every third or fourth year during the dormant season. However, less is known about these longer term maintenance techniques than the shorter term recovery techniques.

Finally, If one of the Reserve's goals was to study these recovery or maintenance techniques, then the Reserve could use the experimental phase to explore such things as fire frequency, mowing, and grazing.

Greenways and Greenway Ecology

The Reserve's greatest opportunity to support a diverse plant and animal community may lie within its ability to serve as a greenway. Therefore, it is important to manage the Reserve as a larger part of the surrounding ecosystem. This becomes evident when managing concerns like deer control. It is useless to reduce deer numbers on the Reserve while ignoring the deer numbers and deer feeding programs in the surrounding area. Forman (1993) said "Greenways contribute to many ecological and societal goals. They help maintain biological diversity, protect water resources, conserve soil, support recreation, enhance community and cultural cohesion, and provide species dispersal routes during climate changes." The ecological structure and function of a greenway will depend largely on its location, shape, habitat, and the nature of human modification (Forman 1993). These factors will determine how well a greenway functions for plants, animals, water, and people.

From a community perspective, greenways can serve as a place for recreation, relaxation, and as a way to preserve the scenic qualities of an area. They can also serve as a way to create cohesiveness throughout the community. The Green Circle Trail is a good example. This trail system serves as travel corridors for people, animals, and plant movement. Trails are not only important to small towns like Stevens Point, but also have national impact. The President's Commission on Americans Outdoors (1987) stated, "We have a vision for allowing every American easy access to the natural world: Greenways. Greenways are fingers of green that reach out from and around and through communities all across America, created by local action. They will connect parks and forests and scenic countryside, public and private, in recreation corridors for hiking, jogging, wildlife movement, horse and bicycle riding." Although recreation may not be the loftiest ecological purpose of a greenway, incorporating this use into a greenway is the most tangible way to gain public support.

Even when used indirectly, for activities like running, walking, and biking, greenways are a place for people to interact with nature. Summarizing several studies, Rachel and Steven Kaplan (1989) wrote, "The immediate outcome of contacts with nearby nature include enjoyment, relaxation and lowered stress levels... People with access to nearby natural settings have been found to be healthier than other individuals."

Wildlife corridors are a major topic of research and discussion in landscape ecology (Forman and Godron 1986). In particular, habitat loss and fragmentation are often cited as the chief cause for wildlife decline. By using greenways to connect fragmented areas, some species can use several nearby land reserves to complete stages of their life cycle.

Noss (1993) summarized the relationship between wildlife and greenways like this: "The two major benefits of wildlife corridors in biological conservation are (1) providing dwelling habitat for plants and animals, and (2) serving as a conduit for movement. The conduit role can be further subdivided into several functions: (a) permitting daily and seasonal movements of animals; (b) facilitating dispersal, consequently gene flow between populations, and rescue of small populations from extinction; and (c) allowing long-distance range shifts of species, such as in response to climate change." It is possible for even a small strip of land to serve as both habitat and conduit. Plants are also affected by how well a greenway serves animals. With many plants, the main source of dispersal is by animals. An animal's ability to travel beyond its local habitat will directly affect the influx of new genetic material (Johnson and Adkisson 1985). Unfortunately, this also is true with invasive plant species, like the buckthorn in the Reserve.

Each of the following functions should be considered in regard to people, animals, and plants when designing or maintaining greenways: (1) habitat - where people, animals, and plants live, (2) conduit - areas where people, animals, and plants move, (3) barrier - how the design and/or integrity of an area may repel people, plants, and animals, (4) filter - how certain species will be filtered out or travel routes altered by the greenway, (5) source - how a greenway can offer a source of species or water to a surrounding area, and (6) sink - how an area acts as an attractant or storage area for polluted water, soil run off, nutrients, plant species, including invasives, and animals.

Because greenways are corridors, they can connect small, dysfunctional patches of land to larger, more functional wholes (Harris 1984). When designing greenways, consideration must be given to the total area needed for native communities. By linking different types of habitat together, an advantage can be given to plants or animals that need more than one type of habitat. Careful attention must be paid, however, to the possibility of creating an area that is so narrow that edge species or non-native species permeate the entire area. These areas, called line corridors, may create a travel path by which a potentially hazardous entity may be introduced. This may mean that native plants and animals are subjected to predation, parasitism, or competition from domestic or exotic plants and animals. If possible, every effort should be made to secure enough land so that the interiors of these greenways are wide enough so that a portion of the area will be free of these edge effects (Forman and Godron 1986). Most invasive species are fast-growing, resource-demanding, and thrive in disturbed and fragmented environments. Therefore, when areas are narrow and consist mostly of edge habitat (line corridors), they can be sources for these undesirable species. When areas provide good linkage of quality habitat they can function as sources of desired species (Henein and Merriam 1990).

Wetlands and Water Quality

Wetlands and stream-side forests make the Reserve even more valuable. Studies of riparian forests in Iowa showed such areas contain more species than other terrestrial ecosystems (Harris 1984). In Iowa, these systems supported an average of 506 breeding pairs of birds per 100 acres, compared to 339 pairs in upland forests (Stauffer and Best 1980). Besides the benefit to wildlife, riparian corridors are attractive to people for a variety of uses including recreation, relaxation, fishing, transportation, and agricultural uses. They also help in ways the average person does not see, including flood control and water purification. When human use is extensive in or around a waterway, such as at the Reserve, degradation can occur. Degradation may result from direct effects, such as damming or altering water flow, or from indirect effects such as disrupting riparian vegetation, which prevents the aquatic system from functioning properly. When vegetation is lost or invaded by exotics, siltation and pollutants will not be filtered. Water levels and water quality are also controlled by litter and soil characteristics. Litter and soil act as a sponge to hold water, releasing it slowly, creating a more stable water supply and aquatic environment. Water-holding ability is particularly important to maintain base flow for small streams during drier periods (Binford & Buchenau 1993), like the creek that feeds into the sedge meadows along the north-west side of Michigan Avenue. Riparian greenways also allow flood water to spread horizontally resulting in a slow release of water downstream.

In many cases the greatest threat to water quality may be large inputs of sediment and nutrients from adjacent areas. In the case of the Reserve, most of the surface water coming into the Reserve originates in developed areas, major roads, and parking lots on the north and west borders. Because human disturbance and pollution at headwaters cause a disproportionate amount of influence on down-stream areas, particular attention must be paid to these sections. Headwater areas also are

important because there is greater interface with the direct cause of the pollution. If contaminates can be filtered out, or their effects reduced early on, then downstream water quality can be substantially enhanced. This is particularly important at the Reserve's interface with developed areas north and west of the Reserve. Managers should pay close attention to the lowland vegetation that currently is filtering that run off. Regular checks of the area should be made to ensure the health of the vegetation. A study by Szewczykowski (1988) showed that contaminant levels are highest along this interface. This influx of the contaminants should be controlled through cooperation between the Reserve and the adjacent land owners by maintaining the health of the wetland vegetation along that interface.

Riparian vegetation is effective at reducing excessive inputs of nutrients. For example, cultural eutrophication can be caused when there is an excessive amount of phosphorus and nitrogen. Eutrophication causes a reduction in aquatic diversity, produces bad odor and taste, and brings about possible human health problems. Most phosphorus and much of the nitrogen that enters a system is attached to sediment (Cooper et al. 1987). Szewczykowski (1988) documented inputs of sediments into the Reserve from storm drains on the north and west sides of the Reserve. The storm drain on the north edge of the Reserve carries water from the Sentry Insurance golf course where large areas of grass are maintained through topical treatments of fertilizers and herbicides. Vegetation and soil can filter as much as 99 percent of total phosphorus mass and from 10 to 60 percent of total nitrogen (Karr and Schlosser 1977). Riparian forests retain other nutrients and contaminants such as calcium, potassium, magnesium, and lead. They also have been shown to filter oils and other pollutants such as insecticides and herbicides, although the degree of removal is not well documented (Lowrance et al. 1985). Therefore, water quality is easiest controlled by reducing inputs or by maintaining riparian vegetation.

The vegetation that traps nutrients may eventually decline or die as a result of the high level of pollutants. Szewczykowski (1988) concluded that storm sewer runoff was a concern for the Reserve's vegetation. The worst problem documented by Szewczykowski were salts, with a lesser concern from heavy metals and other hazardous waste. In a three-dimensional representation, Szewczykowski (1988) shows the areas of highest chloride concentrations in the Reserve are focused near roads and the storm drains (Fig. 8). These concentrations are up to eight times higher than the Wisconsin ground water enforcement standards. The lowest areas of contamination are dry areas not affected by runoff or wetland interiors.

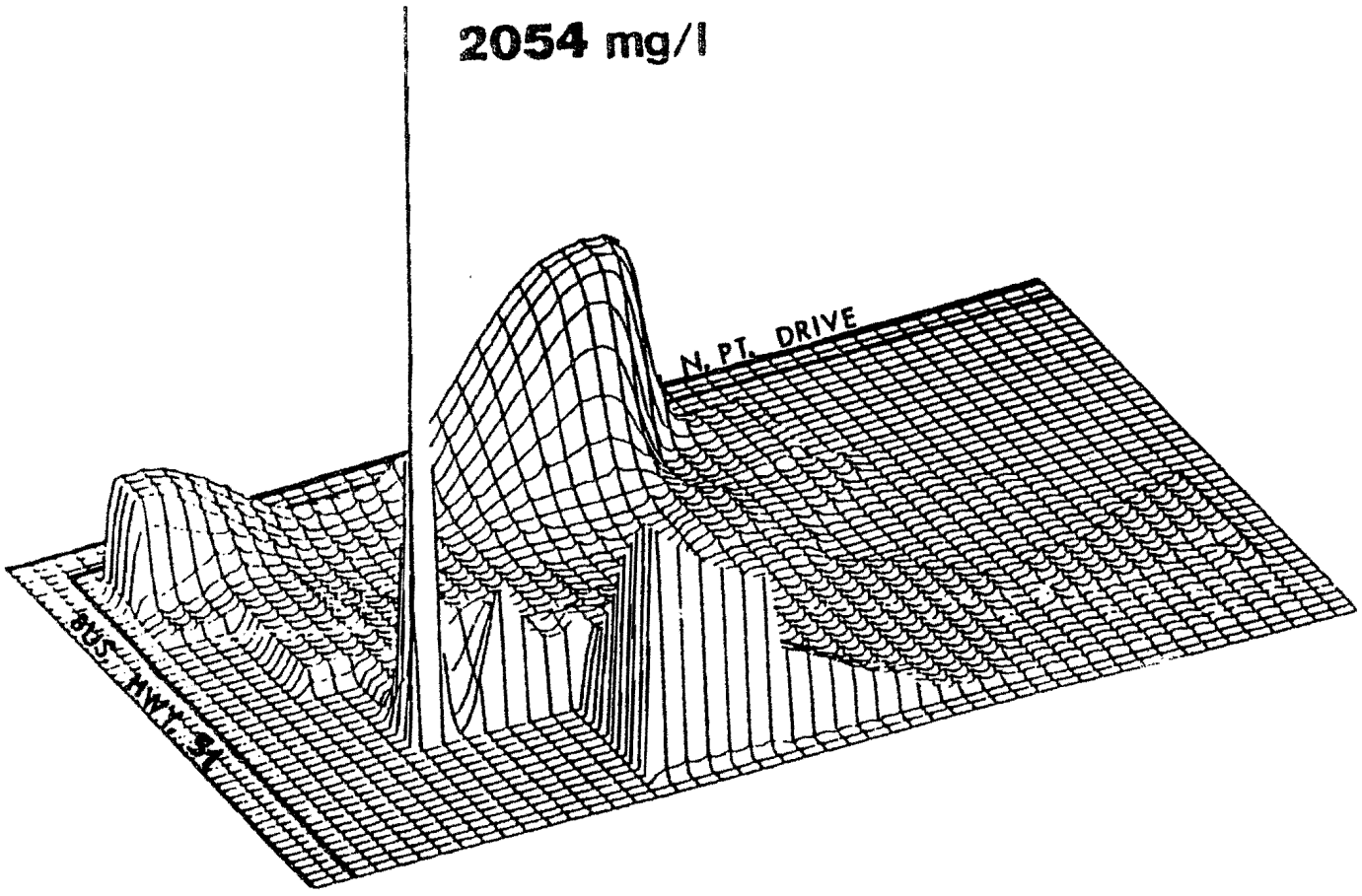

Fig. 8 Three dimensional representation of mean chloride concentrations in the ground water of the Schmeeckle Reserve (mg/l) (Szewczykowski 1988)

Area vegetation are less effective at filtering pollutants during the dormant season. Salts used for ice and snow removal can cause significant problems that riparian vegetation can not control (Binford & Buchenau 1993). Szewczykowski (1988) found that test wells registered the highest concentrations of chloride during peak winter road salting months and then decreased as salting lessened (Fig. 9). This seasonal fluctuation makes it particularly important to maintain the wetland plants on the west side of the Reserve near the shopping center parking area and on North Point Drive. Some effort should be made to work with land owners to encourage the use of alternative de-icing materials. There are many good non-toxic ice melt products on the market. It also may be possible to build a sediment retaining area with a highly absorbing clay to slow the release into wetland vegetation.

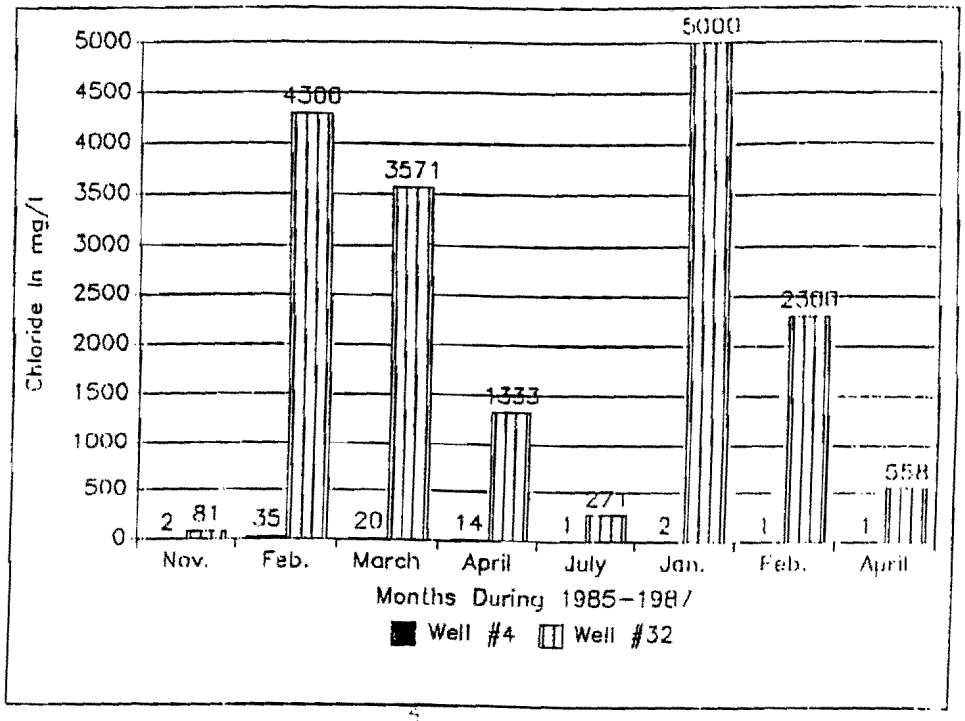

Fig. 9 Chloride concentration fluctuations in contaminated well #32 and control well #4 in the Schmeeckle Reserve (Szewczykowski 1988)

Fire History

Early incidents of fire in North America were believed to have come from three sources: Lightning, Native Americans, and white immigrants (Pyne 1984). It has long been accepted that the Native Americans used fire for reasons such as protection against enemies, hunting, preparing land for cultivation, and habitat management. Of all the Native American uses for fire, the most widespread was probably the most ancient: Fire for hunting. Native Americans recognized that new grass sprouting on a freshly burned site would attract grazers, allowing them to control large scale movement of herds by alternately firing and greening up sites. On a smaller scale, they could hunt individual animals by placing snare traps over burned plots. Fire hunting, the strategy of surrounding or driving the principal grazers of a region by fire, was universal. In the East it was used for deer; in the Everglades, for alligators; on the prairies, for buffalo; along the tules of the Colorado River, for rabbits and wood rats; in Utah and the Cordillera, for deer and antelope; in the Great Basin, for grasshoppers; in California and the Southwest, for rabbits; and in Alaska, for muskrats and moose. "It is, in fact, a remarkable coincidence that virtually all animals and birds prized as game come from environments that are sustained by periodic fire" (Pyne 1984). Maintaining the mosaic of vegetation that game animals need was an important practice, as well. By periodically burning their hunting grounds Native Americans could control successional forces that would ultimately produce a less fruitful, closed-canopy forest or a prairie overrun by shrubs.

The early European settlers used fire to make life easier and more productive. Many Native American fire practices were well-suited to settlement. Game was more abundant and grasslands made travel and homestead protection easier. As the European settlers made the transition from the nomadic farming practices of the Native Americans to their own sedentary style, fire use and vegetation changes began.

Prairies were converted to pasture grasses, forests to orchards, and deer and bear to hogs and cattle. Volunteer crews began suppressing wild fires and Native Americans were largely confined to reservations. Although the elimination of wildfires was considered impossible and in some cases undesirable, the change concerning fire use marked a time when fires in the East and Midwest became relatively infrequent.

Early Europeans brought with them a host of exotic plant and animal species. Some, like Kentucky bluegrass *(Poa pratensis)*, were not well adapted to fire but others, like cheat grasses (*Bromus spp.*), were extremely adaptive. Animals such as sheep, cattle, and hogs also had a great impact on the way land responded to fire. Although wildfire today looks and acts very similar to pre-settlement fires, the way in which it affects vegetation can be very different. Openings created by fire may facilitate pathways for the establishment of exotic plant species. Left unchecked, exotic species have the capability to change the way succession occurs. Likewise, an altered fire regime can facilitate the establishment of many exotic species. This is evident throughout the Reserve in the widely established presence of fire-sensitive buckthorn.

Fire Use

There are three distinct uses for fire at Schmeeckle Reserve: Maintenance of prairie, oak savanna, wetlands, and jack pine; fuel reduction; and buckthorn control. The Reserve maintains four separate grasslands. Two are restored prairies and two are grasslands with few prairie species except for some little bluestem *(Schizachyrium scoparium)*. Historically, grasslands were maintained by periodic fires started by lightning or Native Americans. Many grasses and forbs are not only fire adaptive but fire dependent. Although this is now well known, misunderstanding of fire led to the demise of vast grasslands after settlement began. Prescribed fire is now playing an increasingly important role in the reestablishment and restoration of these ecosystems.

Fire affects grasslands in three ways: Controlling the encroachment of woody plants, increasing biomass productivity, and favoring native species. The reasons why prairies are treeless has been the subject of much debate (Gleason 1913, Shimek 1948). Shimek felt that fire was a minor cause and emphasized the drying power of the wind and low soil moisture. Gleason emphasized the importance of fire. Shimek used observations of the Iowa prairie to support his argument, noting that trees had not dominated the prairie once fire was removed. Longer term observations have corrected that interpretation, especially in areas where seeds from trees are available.

Trees can invade even the driest tall grass prairie without fire intervention. Comparison of the area occupied by forest in 1856 with the forests in 1970 showed that in frequently burned areas the acreage is about the same, but on unburned areas forests had invaded half or more of the prairie (Bragg and Hulbert 1976). It is now clear that fire is essential to keeping woody plants from encroaching on the tall grass prairie, but it is equally clear the fire alone does not make a prairie. It is the combination of fire, soil, climate, and topography (Bell and Hulbert 1974). "Although the season of burning affects the results, most woody plants are reduced by most fires" (Adams et al. 1982). Autumn burning appears to be more effective than spring burning in Iowa (Hulbert 1984). In studies in the Flint Hills of Kansas, late spring burning was helpful only for trees and shrubs that leafed out early. Smooth sumac was less affected because of late leafing. Although burning kills the tops of sumac, stem density may increase (Adams et al. 1982). However, the amount of sumac on burned and grazed range was reduced in comparison to unburned Kansas sites (Owensby and Smith 1973). Fire should reduce the encroachment of sumac in the prairie near north end of old Reserve Street (Schmeeckle Reserve Unit 5, page 84).

In Missouri, a study showed 39% decrease in root and rhizome biomass in prairie unburned for 6 years compared to a prairie burned annually for 10 years

(Kucera and Dahlman 1968). A reduction in below ground biomass should reflect on the above ground biomass. While initially there may have been some misunderstanding about how fire affects biomass, data now show a clear benefit to burning prairies (Mitchell et al. 1996), although some short term studies (one or two years) did show a decrease in overall biomass (Gartner et al. 1984). "In the central Great Plains, overgrazing has caused a shift in species composition from warm season grasses to introduced cool season grasses, like Kentucky bluegrass and smooth brome grass (Mitchell et al. 1996). Cool season forbs, like sweet clover *(Melilotus spp.)*, also have become a problem for prairie managers. The Reserve's prairies have many of these same non-native species.

At Schmeeckle Reserve, managers are interested in the effects of fire on species composition, especially in regard to control of exotic species and development and maintenance of warm season prairie grasses and herbs. Numerous studies have shown the effectiveness of spring burning for reducing the vigor of cool season exotics, while stimulating the growth and increasing the flowering of prairie species (Diboll 1984). Gartner et al. (1984) found a decrease in Kentucky bluegrass and green needle grass *(Stipa viridula)* and an increase in warm season and short grasses the first year after a burn. There are two recognized reasons for the decrease in cool season grasses. First, the removal of dead mulch facilitates an earlier spring warm up and, second, direct damage to the cool season exotic occurs if burning is done after it sprouts, but before the flush of warm season plants. Peet et al. (1975) found daytime surface soil temperatures on a burned Wisconsin prairie to be as much as 20 C^{o} higher than on an adjacent unburned area in mid-May. Brown (1967) found temperatures in another Wisconsin prairie as much as 85% higher than unburned plots. Hulbert (1969) found April burned plots had big bluestem growth of 10 to 15 cm. (3.9 to 5.9 in.) and unburned sites with blades of 2 to 4 cm. (.8 to 1.6 in.).

Debate exists over the frequency in which a managed prairie should be burned. Kucera and Koelling (1964) reported that annual burning resulted in a uniform grass cover, while burning every other year resulted in a greater number of forbs. Burning every 5 years showed little difference from the unburned. In a study by Hulbert and Wilson (1983), early findings indicated there was a relationship between productivity and fire frequency. On ungrazed land that had been without fire for several years, flower stalks of big bluestem *(Andropogon gerardi)* and Indian grass *(Sorghastrum nutans)* were taller and denser the first season after burning than on areas burned annually. Flower stalk density and height were greater in areas burned every two years and greater still on areas burned every six as compared to annual burning. Indian grass response was different than big bluestem. On ungrazed areas in Kansas, Indian grass declined rapidly as the length of time since burning increased (Hulbert and Wilson 1984).

Annual burning in late spring favored warm season grasses but reduced diversity (Collins 1992). The diversity and abundance of forb species increased during the first 6 years following a fire in tall grass prairie and then began to decline (Gibson and Hulbert 1987). In general, the number of species in tall grass prairies is lowest with annual burning and increased as frequency of burning decreased to six years, and then diversity again began to drop off.

Burning times also affect species composition. In Kansas, early May burns were reported to be 10% better than April burns and 25% better than March burns for the production of big bluestem and Indian grass (Anderson & Valkenburg 1977). December and March were less productive times for grasses but good for the production of legumes. Owensby & Anderson (1967) reported March burns to be the best for diversity. Late spring burns also reduced exotic cool season grasses, both by physically damaging the early sprout and by encouraging an early spring warm-up

that allowed warm season grasses a competitive chance (Gartner et al. 1984).

Another system that is as dependent as grasslands on fire for many of the same reasons is oak savanna. Curtis (1959) described oak barrens as scattered trees with a canopy coverage of less than 50%, with the dominate tree species being black oak (*Quercus velutina*) and Hill's oak (*Q. ellipsoidalis*). Fire plays at least two main roles in this system: Maintaining fire tolerant grass and forb species and, maintaining the openness of the savanna. Schwegman and Anderson's (1984) study in Illinois documented the transformation of barrens to forest, stating that after an 11-year period without fire, both the herbaceous layer and canopy began to revert to forest species. Although there was not a significant increase in tree density, both basal area and shrub stem count increased. Much of the post-fire shrub stem count was attributed to the post-burn resprouting of trees.

The wetlands of the Reserve can benefit from a burn program in two ways. Fire can be used to manage shrubs in the wetland and increase sedge production. In a study on a Wisconsin sedge meadow, the Nature Conservancy burned the meadow in 1984 and 1985. Although this increased sedge (*Carex spp.*) and blue-joint grass *(Calamagrostis canadensis*), it did not significantly reduce the shrub cover. They did, however, note a change in composition from bog birch *(Betula glandulosa)* and poison sumac *(Rhus vernix)* to red-osier dogwood *(Cornus stolonifera)* (Warners 1987). A study in Nebraska showed a 187% increase in sedges that were burned in mid-spring (Mitchell et al.1996). Conversely, burning these meadows in late spring can cause a reduction in sedge by damaging newly emerging shoots. As with prairie ecosystems, if the only goal is to control woody encroachment, then a fall or winter burn may be best, thereby avoiding the possible disturbance of spring nesting birds (Linde 1983).

Controlling Exotic Species

Currently, over 2,100 foreign species exists in North America (Stevens 1990). Exotic or introduced species can quickly overtake a native ecosystem. Change in hydrology, fire, soil disturbance, and grazing can lead to the establishment of exotic species. The lack of natural predators or diseases can allow these introduced species to expand unchecked until conditions are no longer favorable or until people intervene. Two exotic species threaten Schmeeckle Reserve: Buckthorn and honeysuckle *(Lonicera spp.)*. A third, purple loosestrife *(Lythrum salicaria)*, is present in small numbers. Buckthorn is the most invasive species in the Reserve. Around the Midwest, land managers are now fighting buckthorn from Chicago's Highland Park to Pipestone National Monument in Minnesota (Boudreau and Willson 1992). Unless noted, the discussion on buckthorn control also will apply to the control of honeysuckle (Kline 1981).

Given the difficultly and/or expense in eradication, the key to controlling these species is early detection and swift countermeasures (Moody and Mack 1988). Stable plant communities have a greater ability to resist invasive species than do less stable communities. Ewel (1987) termed this "invasibility," and believed the ability to resist invasive species is a test for successful restoration. Ecosystems most susceptible to invasion are generally those with breaks in the native vegetation. These include overgrazed grasslands, riparian areas, waterways, roadsides, trodden paths, sand dunes, and some open forests (Baker 1986). Many of these breaks in native vegetation occur in the Reserve. Field observation confirm buckthorn's preference for wetland edges, as these are the most infested areas within the Reserve. Of the Reserve's 13 native plant communities, many already have well established buckthorn populations. However, buckthorn is just beginning to invade several of the least disturbed communities. These plant communities tend to be in the driest section

of the Reserve. In particular, these communities are in areas least effected by the change in hydrology that occurred during the construction of Michigan Avenue and occur most often in the north and north-west sections of the Reserve. One of the most resistant communities is the Chilla woodlot.

Invasive species often alter the conditions of an ecosystem to conditions less suitable for native species. For example, Kline (1995) suggested that buckthorn is capable of changing the local hydrology or soil conditions to favor its spread and reduce competition from other species. Although she provided no data to substantiate this, it is consistent with evidence for other exotics. For example, salt ceder *(Tamarisk spp.)* can dry up desert surface water through evapotranspiration (Vitousek and Walker 1989). A late and heavy leaf drop by buckthorn may produce a thick litter layer in which native seedlings fail to germinate.

Invading species also can use reproductive strategies to out-compete native vegetation. The ability to flower and fruit under lower light levels, prolific seeding, high seed viability, and effective seed dispersal by birds are a few of buckthorn's combined strategies that make it successful. Although birds eat the fruit, berries contain a mild poison that cause the bird's digestive track to expel the seed (Kingsbury 1964). Buckthorn is seen in the Reserve in dense colonies in both sun and shade. These dense colonies have become self-regenerative using the ability to resprout and seed themselves, even in the shade of the parent plant.

Current methods of control for buckthorn include pulling, cutting, and herbicide treatments, which are commonly used together for best results. Pulling of large trees can be extremely difficult. Buckthorn can reach 25 feet (8m.) with diameters of 5 inches (12.7 cm.). Levers and weed pulling devices can be used if this is the preferred method; there are many such devices on the market. Cutting can be performed quickly and easily, but stimulates resprouting from latent buds. This is best prevented

by a stump treatment with herbicide. There are several chemicals available for this purpose including a September mist of Krenite S (fosamine), or basal applications of a 2-4% solution of 2,4-D or 12.5% 2,4-D in diesel fuel during the early growing season. Basal applications of Tordon (picloram) or Velpar (hexazinone) also have been used. Round-up (glyphosate), however, is the most widely used and documented herbicide in use today and is generally not harmful to surrounding plants if used as a stump treatment (Kline 1981). Round-up is used by "painting" the stump immediately after cutting, but is ineffective if the stump is allowed to begin healing. Round-up is a systemic herbicide that needs to come in contact with green tissue to be translocated to the roots. Most techniques, including that used by the staff at the Madison Arboretum, call for cutting the stems to 3 to 6 inches (7.6 to 15.2cm.) and then treating them with a 1:5 mix (one part Round-up to 5 parts water). Kline (1992) did a study at the Madison Arboretum where she experimented with two ratios on both buckthorn and honeysuckle. Mortality was 94.6% and 100% on the buckthorn using 1:1 and 1:5 respectively. Mortality was 94.0% and 89.0% on the honeysuckle using 1:1 and 1:5 respectively. Kline also cut and left some stumps untreated. All of the stumps resprouted vigorously. Field observations reported no damage to surrounding plants.

Although mechanical methods of eradication are effective, they are labor intensive and can be difficult to use on a large scale. Unlike the use of herbicides and mechanical methods that most often target a single species for eradication, restoration techniques use strategic habitat modification to address not only the target species but also work to the benefit of the desired native community. Restoration techniques may be a useful alternative when such techniques can deprive the invading species of their competitive advantage in accessing light, moisture, and nutrients. Restoration techniques also may be used to interfere with a life-history stage such as reproduction,

seed production, germination, or growth (Berger 1993). Despite the prospects for using such techniques in controlling invasive species, restoration as currently practiced is almost always in addition to, rather than the exclusive means to control invasives (Caldwell & McDonald 1991). Although mechanical and chemical methods are most commonly used to prepare the way for community restoration, system approaches like burning, flooding, and shading appear to have promise for ongoing control (Caldwell and McDonald 1991). If successful restoration is to occur, eradication of invasive species must be accompanied by an ongoing management program such as prescribed burning or the restored native flora will remain at risk. Although the invaders may appear to be reduced, it is essential that a long term program of monitoring and prescriptions continue.

There are two circumstances in the Reserve where restoration techniques are best suited. First, restoration techniques are advantageous if the invading species, as with buckthorn, are not well adapted to deeper water levels, but have invaded a drained or silt-filled wetland. The simplest control method would be to restore the hydrologic regime, thereby giving the native wetland vegetation a competitive advantage. Second, restoration might be used in a grassland or other fire adapted ecosystem where the native species are fire adapted. Use of prescribed burns in the context of prairie restoration would then be a dependable way to control invasions.

Buckthorn is well adapted to the edges of wetlands. It thrives neither in the very deepest parts of the wetland nor in the dryer uplands. During the construction of Michigan Avenue, much of the surrounding land was converted to wetland edges. The flow of water was detained along the length of Michigan Avenue and these areas have become heavily infested with buckthorn. The areas along Michigan Avenue indicate some moderate change in vegetation (Beyer 1995). Beyer (1995) compared the work prepared by Hillier and Freckman (University of Wisconsin Central

Administration 1977) and the vegetation map prepared during this study to support his work. Although Beyer (1995), described these changes as inconclusive, he does not discuss the apparent change in species composition regarding the invasion by buckthorn. It may be possible to alter the Reserve's soil hydrology by either reestablishing the original drainage or somehow increasing water depth in the more sediment-filled wetlands.

The second idea that has merit is prescribed burning. Although literature clearly establishes the excellent resprouting ability of buckthorn (Berger 1993, Post and McCloskey 1990), burning, if done repeatedly (Boudreau and Willson 1992), can be effective. Problems associated with burning buckthorn include resprouting, lack of understory fuel, and wet habitats. Burning kills seedlings and top kills some smaller trees. Bark on larger trees can be injured, but trees resprout and releaf during the growing season. Highland Park authorities are recommending "burns when feasible" but caution that burns can trigger resprouting if performed at the wrong time of year (http://www.highland park.org/consoc/invaders.html. 1999). Late April and early May burns are prescribed when root reserves are low (http://www.npwrc.usgs.gov/resource/othrdata/exoticb/piperham.htm). These sites indicate that even though resprouting does occur, vigor is greatly reduced and subsequent fire can lead to the death of buckthorn. If cutting is used along with burning, limbs and brush should be removed to reduce fire hazards unless a prescribed burn is scheduled in the near future. These limbs and brush can then be used to supplement the fuel load in heavily infested areas, thereby addressing the lack of fuel. In heavily infested areas it would be worthwhile to experiment with cutting buckthorn during the summer and burning the brush and resprouts the following spring. There are several solid stands in the Reserve where this experiment could be conducted.

Effective control of buckthorn can be accomplished at the Reserve using a multi-faceted approach. In the management plan for the Madison Arboretum, Kline (1992) stated that all that is needed to successfully battle buckthorn is an army of well trained volunteers. At Schmeeckle Reserve this could be done with a College Work Day to cut and treat stumps. This type of program was underway in 1995 and should continue. The Reserve also should continue to apply for Wisconsin Conservation Corps Volunteers. Partnerships may be formed with youth organizations and some correction agencies. Contact should be made with city and county courts to check into community service programs. The Cheyenne Mountain Zoo, in Colorado Springs receives thousands of hours each year by facilitating the court appointed volunteers who choose volunteer hours for a reduction in fines, points, or jail time. Potential partnerships such as these abound and the effort should be made to search them out.

Deer Concerns

In Schmeeckle Reserve there is one species that everyone agrees has great impact. There is little agreement, however, on what, if anything, should be done about the white-tailed deer (*Odocoileus virginianus*) in the Reserve. Deer are not uniformly distributed across the land. As with most plants and animals, deer are found more frequently in habitats that best suit their needs, of food and cover. Likewise, deer do not use their habitat equally throughout the year. Deer density is measured by the number of deer per square mile of deer range or habitat. In the summer, deer may seek areas where sunlight can reach the forest floor. These areas are the best for rapid herbaceous growth, which is the deer's favorite summer forage. In the winter, however, deer may seek the thermal cover of dense evergreens. In northern

Wisconsin, these areas, known as yards, can have deer densities greater than 100 per square mile of deer habitat (Bartelt 1995). Quality of habitat also is important when considering deer impact. Again in northern Wisconsin, the impact of 20 deer per square mile of deer habitat is far greater than the same density of deer in the farmlands of southern Wisconsin where vegetation is more productive and farm crops supplement the deer's native food sources (Anonymous 1998). The Reserve falls somewhere in between these two habitat extremes. This chapter will look at four areas concerning deer management: Ecological effects of deer, current deer numbers in the Reserve, recommendations for deer numbers in the Reserve, and options for deer management.

Ecological Effects of Deer

When assessing the impact of deer on the ecosystem, it is important to consider that ecosystems are complex systems with many feedback loops. A single factor can seldom be singled out as the only factor affecting that system. Each factor has several conditions that may compound or lessen the effect it may have. However, it has long been understood that there are certain species, called keystones, that strongly influence the entire system (Anonymous 1998, Ricklefs 1997). Deer affect the environment in several ways. One of the greatest areas of interest to land managers is the deer impact on vegetation. Deer affect both herbaceous species and woody species.

There currently are about 1,300 species of native herbaceous plants in Wisconsin. Of the 1,300 species, 56 are listed as state-endangered, 55 state-threatened, and 172 as special concern (Martin 1995). White-tailed deer have both indirect and direct affects on herbaceous plants. Direct impacts include eating the

leaves, flowers, and seeds of certain plants. By doing this deer, also may help in the dispersal of seed by carrying it in their digestive tract. Other plants have evolved ways of attaching their seeds to animals, thereby dispersing them as they travel. Indirect effects can include such things as influencing species composition. Species composition also may be affected as deer selectively feed on plants, shifting the competitive edge to those less favored. Huntly (1991) summarized the dynamics of herbivory and concluded that herbivores influence growth, recruitment, and mortality rates of plants, affecting plant density, frequency, or with competitive abilities.

Deer have the ability to negatively impact highly favored plants, even to the point of producing local extinction. This effect is seen most commonly with herbaceous plants in the summer when forbs can account for as much as three-fourths of the deer's diet (Crawford 1982). Crawford also noted that certain species, in his case bluebead lily *(Clintonia borealis)* and false lily-of-the-valley *(Maianthemum canadense)*, accounted for more than 50% of the weight of all plants eaten during late spring. He also noted that deer in Maine favored bracken fern *(Pteridium aquilnum)*, bunchberry *(Cornus canadensis)*, broad-leaved cattail *(Typha spp.)*, graceful sedge *(Carex gracillima)*, and interrupted fern *(Osmunda claytoniana)*, several of which occur in the Reserve. At least two plant species should be of specific concern to land managers at the Reserve, because of their limited numbers. Marsh marigold (*Caltha palustris*) is listed by Paul Regnier, administrator and chief naturalist of the Ridges Sanctuary in Door County (Martin 1995), as a deer favorite. Showy lady's-slipper (*Cypripedium reginae*) is listed as a special concern species by the Wisconsin Department of Natural Resources. The latter is a highly preferred, slow growing member of the orchid family, found in wetlands and lowland forest (Martin 1995). Although showy lady's slipper is not known in the Reserve, the moccasin flower (*Cypripedium acaule)* is present, and these species are similar enough to warrant

concern.

Deer also have impact on woody vegetation. In the summer, forage may include 75 percent herbaceous plants, while in the winter browse shifts toward evergreens, twigs, and buds of trees and shrubs. In general, as deer numbers increase, native shrub populations tend to decrease (Anderson 1999). For example, Heart's Woods in Pennsylvania supported 27 woody tree and shrub species in the 1920's, when deer densities were less than 20 per square mile. More recently, with a herd of over 40 deer per square mile, only 11 woody species are left (Jones et al. 1993). Although browse species preferences can vary greatly depending on availability, age, abundance, distribution, and deer densities, almost any species can be severely impacted under certain conditions, even plants known to be low in palatability and nutrition. Favorite trees include hemlock *(Tsuga canadensis)*, northern white cedar *(Thuja occidentalis)*, basswood *(Tilia americana)*, white pine *(Pinus strobus)*, yellow birch *(Betula lutea)*, sugar maple *(Acer saccharum)*, red maple *(Acer rubrum)*, aspen *(Populus spp.)*, oaks *(Quercus spp.)* and white ash *(Fraxinus americana)* (Rodgers et al. 1981, Mladenoff 1995). Preferred shrubs include Canada yew *(Taxus canadensis)*, brambles *(Rubus spp.)*, mountain maple *(Acer spicatum.)*, alternate-leaved dogwood *(Cornus alternifolia)*, and hazel *(Corylus americana)* (Rogers et al. 1981). Of these species, white pine and oaks are important components of the Reserve's old growth type. Currently, the old growth type is the least infected with buckthorn and shows an intact example of what this cover type might have looked like in pre-settlement times.

Deer also may indirectly affect the animals living in the system. Deer can effect songbird populations, particularly ground and understory nesting birds, by altering the vertical structure in the forest (Anonymous 1998). Typically deer can reach browse to about 7 feet (2m.) and can adversely affect structure in this range. The structural

heterogeneity of the woody understory is directly related to bird diversity (Lynch and Whigham 1984).

Forest regeneration can be one of the greatest challenges facing land managers where high populations of deer occur. Diamond (1992) stated, "Closer examination of the forest showed that all the oaks, hickories, and lindens were mature trees: I saw no seedlings... The sight felt like visiting an apparently thriving country and suddenly realizing it was inhabited mainly by old people." Structural and species composition changes both appear to be occurring in the Reserve. This, along with many other factors previously discussed, could be contributing to the rapid spread of buckthorn throughout the Reserve.

Current Deer Numbers in the Reserve

Estimating the number of deer in the Reserve is tenuous at best. To provide an estimate, the following anecdotal evidence was considered. Schmeeckle Reserve lies close to the boundaries of Deer Management Units 57A and 57C. In these units the Wisconsin DNR estimated the deer populations at 36 and 42 deer per square mile of deer range in the summer of 1999 (Buchholz 1999). Total deer habitat is estimated by looking at the total land mass in a unit and then subtracting the non-usable portions like lakes, heavily urbanized areas, etc. By these calculations Schmeeckle Reserve has close to one-third of a square mile of deer habitat. Therefore, based on DNR estimates for adjacent units, it is possible to estimate the Reserve's deer herd between 13 to 14 deer.

By looking at the number of deer killed by automobiles on the roads surrounding the Reserve, one can guess that the number of deer still living in the Reserve will be greater than the number killed. According to Sargent Ron Carlson (1999), Stevens Point Traffic Bureau coordinator, there were four deer killed in 1997

and 1998. This information was determined by searching police records for deer killed on Division St., Maria Dr., North Point Dr., and Michigan Avenue. Sargent Carlson believes this number is low when one considers the unreported cases that happen in a given year. Even a high guess projecting 25% of Schmeeckle's deer being hit by cars would suggest at least 12 deer live on or pass through the Reserve.

When Ron Zimmerman (1999) was asked his opinion of the deer numbers he replied, "There have been reports of 5 resident deer in the summer and as many as 40 in the winter." These reports came from the student wildlife chapter at UWSP. Zimmerman thinks these winter numbers are high and estimates the deer population to be around 12 winter deer.

Personal studies of the Reserve collaborate Zimmerman's estimates of 8 to 12 deer, although I believe this to be a summer and winter population. In my vegetation studies, I have walked the Reserve's land base from start to finish in a few hours during both the summer and winter, and have rarely seen more or less than 8 to 12 deer. Although the deer population likely fluctuates, a reasonable estimate for the year-around resident deer population is approximately 10 deer. When translated to DNR terms this is approximately 30 deer per square mile of deer range.

Determining Recommended Deer Numbers

Three main goals should be considered when setting deer numbers for a unit or in this case, a landscape: The social carrying capacity, the biological carrying capacity, and the biodiversity carrying capacity (Anonymous 1998). The social carrying capacity is defined as the number of deer the people of a unit will tolerate. In this case, visitors to the Reserve and surrounding residents can be a bench mark to gauge social carrying capacity. The difficulty is balancing the difference between the

people for whom there can not be "too many" deer, the person who endangered the lives of their family by hitting a deer with their car, or the wildflower enthusiast who notices fewer and fewer of a certain flower every year. Many hunters do not realize how large numbers of deer impact the numbers set for harvest in any given year. In fact, results in studies by the Wisconsin DNR show that the greatest number of deer can be harvested when the population of deer is maintained at about 50% of the biological carrying capacity (Anonymous 1998). This number is typically defined as the maximum number of deer a given unit can support in good physical conditions. This number does not consider the ability of the system to withstand this pressure over a long period of time without significant damage to the native vegetation.

Agricultural damage also is a strong social carrying capacity consideration. Deer populations are responsible for 90% of the wildlife crop damage reported in Wisconsin. In 1993 corn damage in Wisconsin alone was estimated at $15 million. In most cases the agricultural concerns play a large part in deer population decision making (Anonymous 1998).

Another factor that normally is considered in the deer quota decision is deer-vehicle accidents. Again, this may be of little concern to the average visitor, but it is of concern to the people who drive by the Reserve and to decision makers in the community who see the repercussions of deer in urban areas. On average, there are about 4 reported deer collisions a year around the Reserve. Research by the DNR indicated that in 1976-78, an estimated 18,200 deer were killed in Wisconsin each year costing an estimated $7.4 million (Anonymous 1998). In 1997, more than 44,000 reported collisions occurred costing over $100 million, according to the Wisconsin Insurance Alliance (Anonymous 1998). Areas with high commuter traffic were the most likely to experience a car-deer collision. Estimations for central Wisconsin average about 0.5 vehicle-deer collisions per square mile (Anonymous 1998). Given

the Reserve's reported 4 killed deer per year, and the estimated 1/3 mile square of deer range, the collision rate associated with the Reserve is 24 times that of the normal average.

On the other hand, those who visit the Reserve enjoy seeing deer. Many, perhaps most visitors are unconcerned about high deer densities. Runners in New York's Allegany State Park counted 55 deer along a 3.5 mile loop (Jones et al. 1993). Instead of feeling concern at the incredibly high numbers, the runners reported a special kind of "runners high." Over two million Wisconsin residents participated in observing, feeding, or photographing wildlife in 1991, spending an estimated $482,754,900 (Judd 1995). At the Reserve, running, walking, and watching wildlife are common activities (Fig. 6 and 7). If densities were reduced to near biodiversity carrying capacity (described below), it is likely that people would see few deer in their casual travels.

Biological Carrying Capacity

The biological and biodiversity (see next section) carrying capacities are less dependent on the emotions of people and are based more on ecological knowledge. The biological carrying capacity has been calculated for the entire state based on quality and quantity of deer habitat. This can be more easily understood when one compares the capacities of the northern forests to the southern farmland. Deer densities of 20 per mile square have a far different impact in the north than in the food-abundant south. Stevens Point falls at the edge of what the Wisconsin DNR defines as the central forests. The overwintering goals for the two areas close to the Reserve are 30 deer per square mile of deer range. The biological carrying capacity of the central forest is estimated to be 50 to 60 deer per square mile of deer range (Rolley 1995). The Wisconsin DNR (Anonymous 1998) estimated the maximum biological carrying

capacity for management units 57A and 57C at 68 deer per square mile of deer range. Overwintering population goals for this part of Wisconsin are set at 50 to 60%. The above maximum biological carrying capacity is estimated by dividing the overwintering goals of 30 deer by the estimated 50% maximum biological carrying capacity. This gives an approximated maximum biological carrying capacity of 60 deer per square mile of deer range around the Reserve. Translating this to the Reserve, the maximum biological carrying capacity is estimated at 20 deer.

Biodiversity Carrying Capacity

Biodiversity carrying capacity numbers, however, are another matter. Much of the research on deer density and biodiversity comes from New York, Pennsylvania, Michigan, and Wisconsin. Biodiversity is considered when setting the state's goals for deer management units. The evidence will show that deer numbers set by the DNR are generally higher than what researchers believe is low enough to maintain a healthy forested ecosystem. However, most units do contain high forage areas like agricultural fields, relieving some pressure from native vegetation.

Bench mark deer density estimates have been made by researchers with biodiversity in mind. Most numbers suggested for maintaining biodiversity are below the average number of 20 to 30 deer per square mile of deer range set by the Wisconsin DNR. Martin (1995) summarized the results of several investigations and concluded that deer densities greater than 10 per square mile generally resulted in changes in relative abundance of some wildflowers. He recommended that deer populations should be maintained at no more than 10 to 15 per square mile. Mladenoff (1995) stated that, "In assessing deer effects on woody vegetation, differential habitat use and species preferences that change with seasons must be

considered." Ambient deer densities at the general Deer Management Unit scale do not account for these differences, or for the concentrations that may occur in winter. He suggested that at the DNR's low density alternative (less than 11 deer per square mile in the north, and less than 15 deer per square mile in the south), only negligible impacts would occur, even under winter concentrations.

Hoffman (1995) suggested that deer densities of 15 to 35 deer per square mile began to have adverse effects on some bird species. He went on to state that several Wisconsin bird species showed impacts at 35 deer per square mile, whereas they did not at 8 deer per square mile.

The deer numbers for biodiversity carrying capacity reported by Jones et al. (1993) were just slightly higher; they suggested that in eastern forests 20 deer per square mile is an acceptable number. Aaron Buchholz (1999) pointed out that deer densities for urban areas are targeted differently than rural settings. Currently, the target number for all urban areas in Wisconsin is 10 deer per square mile of deer range. Translating this number to the Reserve, the suggested target number would be approximately 3 to 4 deer.

Recommended Deer Density for Schmeeckle

Considering all information, I am recommending that managers target an overwintering deer population of between 10-15 deer per square mile of deer range to maintain biodiversity and visitor satisfaction. If 15 deer per square mile of deer range are targeted, the above research shows good plant biodiversity can be maintained. However, this is higher than the deer densities targeted for most urban areas. When translated to the Reserve's one-third of a square mile of deer range, this is approximately 2 to 5 deer in the Reserve. Currently, at the estimated 10 deer, the

population of the Reserve probably is between 2 to 5 times larger than this target.

Management Options

Deer density in the Reserve must be reduced. Most arboretums or forest preserves in the East and Midwest have come to the same conclusion. What is not clear is how this should be done. There are many ways that deer can be reduced. The first and most obvious is hunting. This has not been an easy decision for managers to make, however. Many parts of the country do not look favorably on hunting. Deer will continue to move into the Reserve, so any solution will need to be an on-going program, much as irradiation of exotic plant species will need to continue. A fall hunt could help to reach and sustain a target overwintering population of 2 to 5 deer.

An archery hunt makes the most sense. Many urban land managers have found success with this option. This could be a draw-style hunt for the residents of Stevens Point. Hunters would have to show high levels of competency with the bow. The Reserve could even run an archery tournament to determine which hunters get selected. The community should be involved early on, possibly even inviting an open debate or information session to help the public understand why a hunt is the best solution. Other organizations have opted to hire "sharp shooters" to reduce their deer populations. This would be easier to arrange and have less liability, but not as much community involvement. The hunt would need to be reevaluated every year. Harvest numbers would have to be reevaluated each year (Konopacki 2000).

Some institutions use fencing, vegetation protectors, and birth control programs to control deer populations. These solutions are expensive, as well as, not solving the problem of too many deer (Anderson 1999).

Regardless of what method is used, some intervention is necessary. Diamond (1992) warned, "Unfortunately we can not wriggle out of the odious task of managing nature reserves, even if all that we want to do is maintain their status quo. Smaller reserves are even more dependent on stewardship. For most of the earth there is no pristine state, unaffected by humans, to which we can use as a reference: None we could attain again, anyway. Instead, we must choose a human-altered state for our management efforts. We can not avoid the responsibility of managing reserves, because inaction is a management choice".

Deer management is not only highly emotional, it also is handicapped by the subtle ways in which deer change the environment. Many researchers note that if they were not diligently watching changes occur, changes might go unnoticed. As a final warning against laissez faire management of deer, consider Aldo Leopold's essay, "Wilderness," In which he stated, "This effect of too many deer on the ground flora of the forest deserves special mention because it is an elusive burglary of aesthetic wealth, the more dangerous because it is unintentional and unseen... One is put in mind of Shakespeare's warning that 'virtue, grown into a pleurisy, dies of its own too-much.' Be that as it may, the forest landscape is deprived of a certain exuberance which arises from a rich variety of plants fighting with each other for a place in the sun."

Management Recommendations

The following chapter summarizes each cover type and recommends specific management options. The first map shows cover types by the working number assigned to each type (Fig. 10). The next map (Fig. 11) is used to break Schmeeckle Reserve into individual patches so that specific areas can be discussed in the recommendations section. Throughout this paper specific areas have been referred to as Schmeeckle Reserve Unit #x, to give the reader an exact location to reference. Transect locations by cover type are found in Appendix B. Each cover type addresses:

1. A working name for the cover type;
2. A description of the cover type;
3. Similarities to pre-settlement cover types;
4. Relative size of that pre-settlement cover type; and
4. Management recommendations.

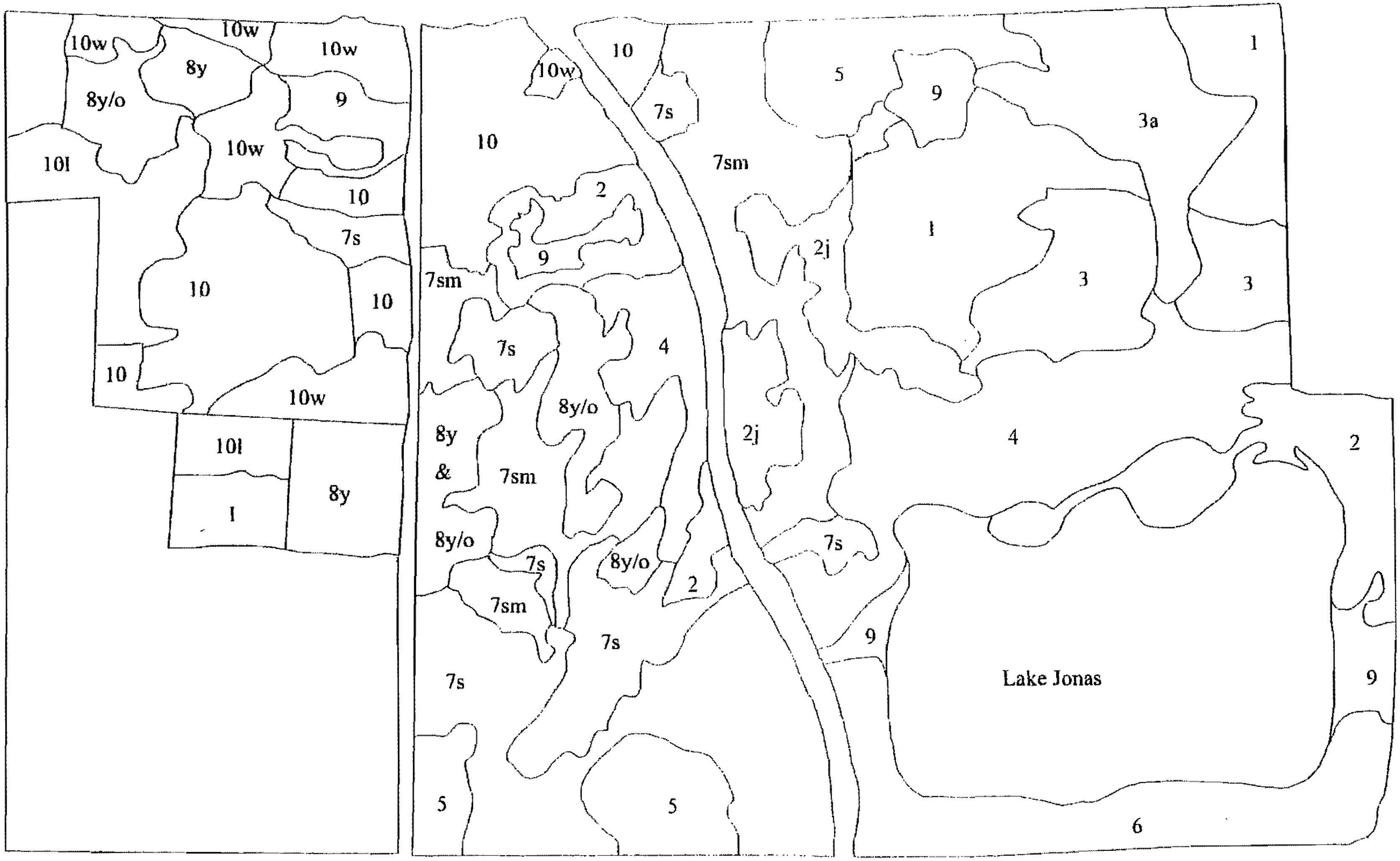

Fig. 10 A digitized map of the vegetation cover types at the Schmeeckle Reserve (Beyer 1995)

Key to Schmeeckle Covertype

Type 1 - Oak Barrens
Type 2 - Pine Barrens
Type 2j - Jack Pine Barrens
Type 3 - Birch, Maple, Oak
Type 3a - Maple, Birch, Rock & Pothole
Type 4 - Aspen, Birch, Deciduous

Type 5 - Developed Land
Type 6 - Aspen, Fern, Deciduous
Type 7s - Shrub Dominated Wetland
Type 7sm - Sedge Meadow
Type 8y - Young White Pine

Type 8y/o - Mixed Aged Pine
Type 9 - Meadow and Prairie
Type 10 - Old Growth
Type 10w - Old Growth-White Pine Dominated
Type 10l - Cut - Over Forest

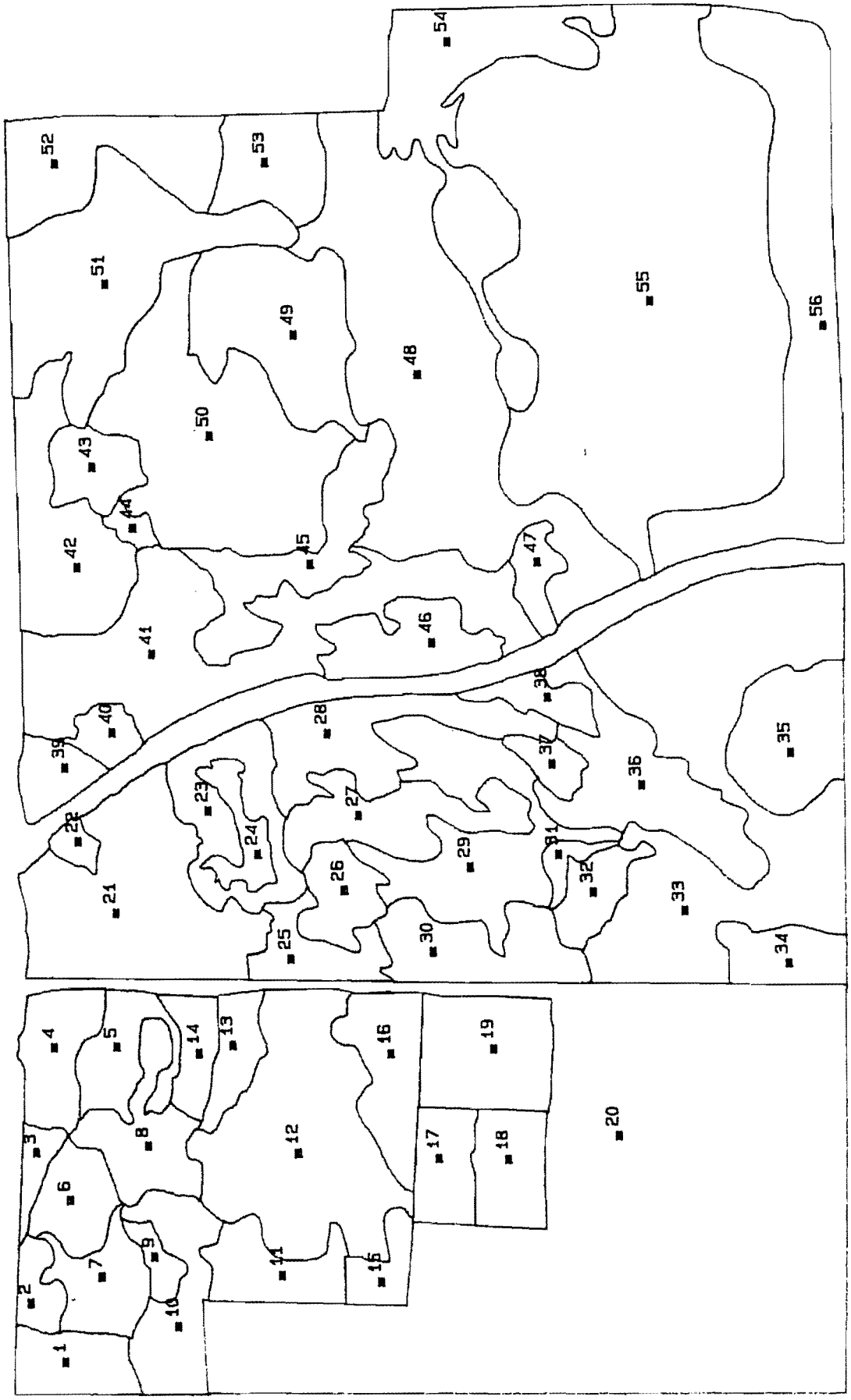

Fig.11 A digitized map of the vegetation cover types at the Schmeeckle Reserve. Recognized as exact "Schmeeckle Reserve units" (Beyer 1995)

Key to Digitized Map, Shown as Specific Vegetation Units

Unit Number	Cover Type Name	Cover Type Number
1	Micro-Plot	No Number assigned
2, 3, 4	Old Growth-White Pine Dominated	10w
5	Meadow and Prairie	9
6	Young White Pine	8y
7	Mixed Aged Pine	8 y/o
8	Old Growth-White Pine Dominated	10w
9	Mixed Aged Pine	8 y/o
10	Cut-Over Forest (Maple returning)	10l
11	Cut-Over Forest (Oak returning)	10l
12	Old Growth	10
13	Shrub Dominated Wetland	7 s
14, 15	Old Growth	10
16	Old Growth-White Pine Dominated	10w
17	Cut-Over Forest	10l
18	Oak Barrens	1
19	Young White Pine	8y
20	Non Reserve Property	No Number Assigned
21	Old Growth	10
22	Old Growth-White Pine Dominated	10w
23	Jack and White Pine Barrens	2
24	Meadow and Prairie	9
25	Sedge Meadow	7sm

Key to Digitized Map

Unit Number	Cover Type Name	Cover Type Number
26	Shrub Dominated Wetland	7 s
27	Mixed Aged Pine	8 y/o
28	Aspen, Birch Deciduous	4
29	Sedge Meadow	7sm
30	Includes Both 8 and 8 y/o	8y, 8 y/o
31	Shrub Dominated Wetland	7 s
32	Sedge Meadow	7sm
33	Shrub Dominated Wetland	7 s
34, 35	Developed Land	5
36	Shrub Dominated Wetland	7 s
37	Mixed Aged Pine	8 y/o
38	Jack and White Pine Barrens	2
39	Old Growth	10
40	Shrub Dominated Wetland	7 s
41	Sedge Meadow	7sm
42	Developed Land	5
43	Meadow and Prairie	9
44, 45, 46	Jack Pine Barrens	2j
47	Shrub Dominated Wetland	7 s
48	Aspen, Birch Deciduous	4
49	Birch, Maple, Oak Deciduous	3
50	Oak Barrens	1

Key to Digitized Map

Unit Number	Cover Type Name	Cover Type Number
51	Birch, Maple Rock and Pothole	3a
52	Oak Barrens	1
53	Birch, Maple, Oak Deciduous	3
54	Jack and White Pine Barrens	2
55	Lake Jonas	No Number Assigned
56	Aspen, Fern	6

Cover type descriptions

I. **Cover Type #1 - Oak Barrens** - This cover type contains three transects (1,6,14).

Description - The oak barren type of the Reserve ranges from nearly intact barrens with large, widely spaced oaks to very degraded and overgrown areas. Shrub understory in these areas is American hazelnut, blackberry, and cherry (Appendix D). Field observation shows that cherry is becoming thick in some areas. Edges of the area are aspen and red maple with more oak on the drier ground and more maple and aspen in the wetter areas (Appendix C). Some areas are moist but with little to no standing water. Water level is between the surface and 2 feet below ground (0 and .6 m.). This area is the fourth largest, occupying approximately 7.2 %.

Management Recommendations: If restoration were implemented, this area would be most similar to Tesch's (1982) "oak openings," although the canopy is now closed. I am not recommending that every area be restored to pre-settlement vegetation, but oak barren is an important type to maintain and restore. Tesch (1982) reported that oak openings were the most widespread cover type in Portage County covering 28.77%. Fire must be used to maintain an open understory. I recommend that fire be introduced in these areas with an interval of 3 to 5 years, depending on the need to control shrubs and the species that need either encouragement or eradication. Alan Haney (1999) also recommends that if an area is overgrown, with a canopy covering over 50%, that light fire should not be used until the canopy is thinned. Many of these areas will have limited seed reserves and these seeds should not be triggered until conditions are right, with a canopy coverage of under 50% and an

understory clear enough for a seed bed. The data from this area currently shows a canopy coverage of between 50.8% to 83.4%. Canopy reduction is best dealt with by either a selective harvest of invasive trees or by girding the trees that should be removed.

Unit 18, on the west side of the property (Fig. 11), appears to be a cut-over old growth forest and may revert back if left unmanaged. I would recommend letting it do so. The deed stated it was last logged in 1948, and white pines are beginning to become established. There is very little grass in the understory here, unlike the other barren units, and topography looks like the cradle-knoll topography that is demonstrated in nearby old growth. Several sensitive ferns also grow here, as well as on the nearby older growth.

II. **Cover Type #2 - Pine Barrens** - This cover type contains three transects (5,8,17). This type also has been sub-divided. The divisions are identified as 2 (Jack and White Pine Barrens) and 2j (Jack Pine Barrens).

Type 2 - Jack and White Pine Barrens

Description- This pine barren type is composed of both jack and white pine (Appendix C). This is the main difference between 2 and 2j. Both species appear to be similar in size, approximately 8 " dbh (20.3cm.) (Appendix C) and may be about the same age. The canopy has begun to open up and let sunlight down to the forest floor. The return of maple seedlings and developing shrub understory can be extremely thick in type 2. This area appears several years older than type 2j (Jack Pine Barrens). There is little standing water in this type with the exception of in the fire furrows where buckthorn is also very thick. Generally, ground water is between 1 and 2 feet below ground (.3 and .6m.). If left undisturbed, this type appears that it will go toward cover type 8y/o (Mixed Aged Pine).

Management Recommendations: If pre-settlement conditions were to be restored in this community, it will be most similar to Tesch's (1982) jack pine, scrub oak forests and barrens type. In pre-settlement times this type occupied about 9.8% of the county. It currently occupies about 5.2 % of the Reserve. Shrub data shows that no pines are reproducing (Appendix D). Buckthorn, most prevalent in the old fire furrows, is beginning to be a serious problem in this type (Appendix D) and should be eradicated. I believe that succession will cause this pine barren type to convert into type 8y/o (Mixed Aged Pine) and eventually to type 10 (Old Growth). I believe pine barrens should be preserved in the Reserve, but this is probably better done in type 2j (Jack

Pine Barrens). Natural succession should be allowed to continue in this type with special concern for the understory buckthorn.

Type 2j - Jack Pine Barrens

Description - The jack pine barren type is probably one of the youngest cover types in the Reserve. The lack of white pine in the canopy distinguishes this type from type 2 (Appendix C). The canopy is mostly composed of jack pine in dense stands with a closed canopy, including limited numbers of alder, white birch, aspen, and maple. Buckthorn is heavy in many parts of this type, especially the wetter areas and fire furrows. Water sometimes stands in this type, especially in the spring, and is either at the surface or about 1 foot below (.3m.). The area on the east side of Michigan Avenue seems to be the youngest and driest area of the jack pine barrens types. The canopy is crowded and die-out will begin soon. These crowded trees with low dead branches also present a substantial fire danger, acting as fuel ladders.

Management Recommendations: Restoration can reestablish this community to something similar to either Tesch's (1982) jack pine, scrub oak forest or pine barrens type. Since this composition could move toward either of these types, depending on the management recommendations, I recommend managing to continue a jack pine barrens type. This can be done with thinning and, eventually, fire introduction. Buckthorn is a serious problem and should be eradicated. In pre-settlement times this type occupied about 9.8% of the county. It currently occupies about 2.8 % of the Reserve. Along with the 5.2% coverage of the white and jack pine barrens, the Reserve still has good samples of this barrens type and managers should strive to maintain it for interpretation. Areas as small as one acre could be rejuvenated at a

time. Currently there is little or no jack pine reproducing in the understory (Appendix D). Fire will need to be prescribed to maintain these pine barrens. Ground fires alone will not rejuvenate this type. Haney (2000) suggested when it comes time to restore an area, the large trees and understory should be cut, followed by an aggressive fire to rejuvenate jack pine seedlings. By doing this, the Reserve could maintain an area of jack pine rejuvenation for instruction and interpretation. Fires in these areas would have to be hotter than a typical ground fire to open cones and clear the forest floor for a good seed bed.

III. Cover Type #3 - Birch, Maple Deciduous Type - This cover type contains two transects (3,2). This type also has been subdivided into two groups labeled 3 and 3a. These areas are similar, but are separated because of the clear division of these two subtypes on the air photo and the supporting data. Types 3, 3a, and 4 (Aspen, Birch Deciduous) also look very similar. They were separated with these three basic observations in mind. Type 3 has an even mix of birch, maple, and oak. Type 3a has many more red maples in the wetter areas (Appendix C), and type 4 (Aspen, Birch Deciduous) has mostly aspen (Appendix C) with a few birch.

Type 3 - Birch, Maple, Oak, Deciduous Type

Description - When observing this type in the field it appeared to contain approximately 45% white birch, 45% red maple, and 10 % oak. Transect data shows less white birch, 10.2 % (Appendix C), but this can easily be explained by the small sample size. Oaks tend to be more prevalent in the dryer spots. Some rock outcroppings are present, but not as prevalent as in 3a. This community has heavy amounts of large downed debris indicating the lack of recent fires, and/or a high mortality rate among middle-aged trees. This type is younger then type 10 (Old Growth), but will most likely not succeed toward the Reserve's old growth type because of the high water table. Both red and white pine are less common species in this cover type (Appendix C). Ground water levels range from standing surface water to 1 foot below ground (0 to .3m.). Water often stands in small depressions in spring.

Management Recommendations: This community most resembles Tesch's (1982) aspen, white birch, pines, and soft maple type. In pre-settlement times this type occupied about 3.5% of the county. Currently it occupies about 3.5%. If this type were

to be restored, white pines should be encouraged to reproduce. While my shrub and herb data do not show white pine seedlings (Appendix D and E), field observations indicate that many small seedlings are present. Shrub data show that maple and oaks are reproducing while birch is not (Appendix D). This area also lacks the cover and ground layer to support much wildlife. As with most wetter types in the Reserve, buckthorn is a problem here and should be removed. Fire should be kept from this area if the white pine seedlings are to get established. Care should also be taken while using chemical control of buckthorn in this area to avoid seedling damage. I believe this type will probably continue as is, with the high water table keeping longer lived species in limited numbers.

Type 3a - Maple, Birch, Rock, and Pothole Type

Description - Red maple dominates this type especially in the wet areas (Appendix C). The main difference between 3 and 3a is that 3a is wetter, and has more rock outcroppings; the two look very similar in the drier areas. These dry areas are also similar to oak barrens and often grade slowly into the oak barren type of the Reserve. Birch is abundant in some areas. Sedges and grasses are the primary ground cover in the wetter areas and edges. Many ferns and Pennsylvania sedge occupy the other areas. A possible explanation for how this herbaceous understory developed can be related to the change in hydrology. When Lake Jonas was excavated in 1976, the land around the lake became drier. I believe this change allowed wet-tolerant trees, like red maple, to begin to grow while the sedges continued to thrive in an area with a high water table. The shrub layer can be dense in some areas and includes maple, cherry, and buckthorn. The water level here ranges from significant standing water in potholes to just below the surface.

Management Recommendations: Again, this community is most similar to Tesch's (1982) aspen, white birch, pines, and soft maple type. This type historically occupied about 3.5% of the county and now occupies about 3.9% of the Reserve. Although this area is similar to type 3, the water table will guide the succession in this area. I believe that unless the water table changes, this area will continue to be dominated by red maple and other water-tolerant shrubs. Buckthorn should be quickly removed from this community because it will create an understory useless for deer forage. If this happens, deer will put more pressure on the Reserve's remaining cover types. Once buckthorn is removed, understory species (Appendix D) can utilize these areas. Currently there is very little reproduction of maple or birch in this area (Appendix D).

IV. Cover Type #4 - Aspen, Birch, Deciduous Type

Description - Aspen, birch, and red maple dominate this type with a ground cover of sedges (Appendix C and E). This cover type is similar to 3a (Birch, Maple, Rock and Pothole) but has even more standing water. I speculate that before Lake Jonas was dug and Michigan Avenue was built some of this was sedge meadow. Remnants of sedge meadow are left in areas where there is an opening. One difference between this type and the sedge meadows of the Reserve is the presence of hummocks. These hummocks contain many interesting plants such as blueberry, bunchberry, white birch, white pine, cherry, and oaks (Appendix D). Although this micro-community vegetation can be found in spots throughout the Reserve, they are usually not in such wet areas. The small change in elevation of about 1 foot (.3m.) seems to be enough to support their growth. These hummocks range from 5 $ft.^2$ to well over 200 $ft.^2$ ($.5m^2$ to $18m^2$).

Management Recommendations: This community is most similar to Tesch's (1982) aspen, white birch, pines, and soft maple type. What is most interesting about these types is the hummocks. It is my recommendation that these areas be protected for their plant diversity. I have also seen quite a few deer in this area and assume that it is a good feeding area due to the plant diversity and dense shrub undergrowth in places. Some areas are dense with buckthorn (Appendix D) and the primary management need is buckthorn removal. A fall cutting, followed by a spring prescribed burn (as suggested in the Fire Use section of this report) would not only help rid this area of the smaller sprouting buckthorn, but would be beneficial to the sedge ground layer as well. Efforts should be made to protect the hummocks from the burn by back burning around them first before running the fire through the main area. Once the buckthorn is under control, burns need not continue on a regular basis.

Water levels will continue to drive the succession in this area. This area should be monitored over the next 10 years to see which successional course it will take since it currently is unclear.

V. Cover Type #5 - Developed Land

Cover type 5 refers to any area that is heavily disturbed or maintained by constant human intervention. This is mainly confined to the area around the Reserve's Visitor Center. This would be an appropriate place to organize display gardens. These could range from composting demonstration areas, butterfly gardens, prairie restoration techniques, wildflower areas, etc. Focused thought should be given to what topics would best serve the community and visitors. Two topics that might be of interest are backyard wildlife gardens and/or a small sustainable backyard farm lot that could demonstrate how early land settlers in Portage County used subsistence farming. This working garden could be used as a discussion or educational tool. It could also be compared to or developed as a garden area using permiculture techniques. These techniques are based on using the land and living with the land in a way that supports sustainable land practices. This area would not need to be large, and in fact it would be most helpful to the typical home owner if it were not larger than a typical yard. I would suggest one acre or less confined to the area around the Visitor Center.

The second idea is perhaps better suited to the Reserve's mission of preservation. This suggestion would involve continuing efforts to restore examples of vegetation types around the Visitor Center. The prairie along the parking area is developing and efforts can now be turned towards the wooded area around the Visitor Center. Efforts to eradicate the buckthorn should continue, and selective cutting can help manage trees for large diameter trying to replicate what the old growth forest of Wisconsin might have looked like. The wildflower reproduction efforts should also continue in this area.

VI. Cover Type #6 - Aspen, Fern Deciduous Type

Description - This type is dominated almost solely by aspen (Appendix C), which are very dense. Downed woody debris is a result of the age of the aspen, which is near maturity. This area supports a carpet of sensitive fern. Upon investigation, box elder, American elm, paper birch, river birch, and cherry can be found. This may be an area as described in 3a (Jones et al. 1993) where deer exposure was very heavy at one time. Exposure has now lessened because of street traffic and trail use around Lake Jonas, allowing diverse shrubs and small trees to begin rejuvenating. Buckthorn is a real problem (Appendix D). This, along with an overcrowded stand of old aspen, pose serious threats to this unique community. The water level ranges from surface to 2 feet below ground (0 to .6m.). Currently this type occupies 4.7% of the Reserve.

Management Recommendations: This community is most similar to Tesch's (1982) lowland hardwoods, which only occupied 2% of early Portage County. Currently there is no such community represented. I would not, however, overlook the present uniqueness of this type considering the dense layer of sensitive fern. Field observations show that the hardwood species are present and will become a greater part of this community in the future. Efforts should now focus on the immediate threat of the large deer herd and large buckthorn trees. Water changes in the development of Michigan Avenue probably began the infestation of buckthorn in this type. Dense stands of buckthorn can be found along the road. This area should be considered a priority for eradication efforts because these large mature buckthorn will continue to overcrowd the area and provide seed for other infestations. In some cover types, cutting and stump treatments would be enough. I also would advocate removing the brush from this area to maintain its beauty and clean up the edges of the Reserve that

are most often seen by students and visitors walking over from the campus. Once the buckthorn is removed, observation of this area may show it moving more quickly toward the Tesch (1982) lowland hardwoods type. Many of the aspens are near maturity and if the buckthorn is not under control by the time they die, the hardwoods may not be able to compete successfully enough to form the next successional type.

VII. Cover Type #7 - Wetlands - This type was not sampled, and is outside the scope of this thesis. However, some generalizations will be made. In pre-settlement times wetlands accounted for 7.31% of the vegetation in the county. In the Reserve, wetlands account for 33.4%. Hydrology is the most important factor in determining this vegetation type. In the Reserve, the hydrology gradient starts with the wettest sedge meadow type and moves to the driest oak barrens and prairie sites. As the gradient goes from wet to dry, the vegetation changes from sedge to shrubs to short-lived trees like aspen and birch, and finally to pines and oaks. Two sub-populations occur.

Type 7sm - Sedge Meadow Type

Type 7 s - Shrubs Dominated Wetland

Management Recommendations: This community is most similar to Tesch's (1982) marsh and sedge meadow, wet prairie, and lowland shrub types. These areas are as close a match as any type, but the encroachment of shrubs into the sedge meadow will need to be addressed. Sedge meadows need periodic fire to control the encroachment of woody species. Research shows that infrequent fires do not control woody encroachment (Warners 1987), so several successive burns may be required. The Reserve should consider three to four successive burns and then wait 7 to 10 years before repeating. This can be done as a separate burn or as part of other burns in the general area. Burning should be done in the spring before new growth appears or sedge species may be harmed (Mitchell et al. 1996). As with prairie ecosystems, if the only goal is to control woody encroachment then a fall or winter burn may be best, thereby avoiding the possible disturbance of spring nesting birds (Linde 1983) and sprouting sedges.

VIII. Cover Type #8 - White Pine Dominated - Three transects (12,15,19). This type is broken down into two separate sub-populations. The differences can not be seen from the air photo, but ground truthing reveals two distinct populations. 8y is dominated by young white pines and 8y/o is dominated by a mix of both young and old pines, many in the 14" to 16" d.b.h. (35.6 cm. to 40.6 cm.) range (Appendix C).

Type 8y - Young White Pine Type

Description - This type is characterized as having dense young white pine (Appendix C), with very little understory (Appendix D). Some of the canopy has begun to open up to allow young red maple, oak, and birch to appear. Even though this is one of the least diverse communities in the Reserve, it contains one of the two known populations of moccasin flower. This population occurs in the section near the fenced-in plot across from Sentry (Reserve Vegetation Unit #6). There is also an occasional crabapple that probably came from Sentry. Water is standing at the surface to 2 feet below ground (0 to .6m.). This type currently occupies only 2.6% of the Reserve.

Management Recommendations: This community could match many of Tesch's (1982) mixed coniferous-deciduous types. The best choice for this area, however, would be to guide it toward the old growth type on the Reserve by controlling the two obstacles in this successional path. The first is a buckthorn problem that has become worsened from 1995 to 1998. As the area opens, more buckthorn is getting established in this type. After the buckthorn is under control, the area could be selectively thinned. If there are more moccasin flowers or other herbaceous plants that are in the seed bank, light would help them germinate. It is important that these plants be encouraged before the seed bank becomes depleted.

Type 8y/o - Mixed Aged Pine

Description - Type 8 y/o is a mix of young and old white pine (Appendix C). The understory (Appendix D) is more established than 8y. The canopy is somewhat open, but young white pine, birch, and maple are establishing themselves. Some old jack pines hint that 8y/o may come from cover type 2 (Pine Barrens). The ground layer is composed of 50 % pine needles and 50 % leaf forest litter. Some very large white pines suggest that this community may succeed to 10w (Old Growth - White Pine Canopy). Some areas already have very large white pine. Ground water is 1 to 2 feet (.3m. to .6m.) below ground, proving this to be one of the drier sites in the Reserve. Buckthorn continued to get worse here from 1995 to 1998. Currently this type occupies about 4.1% of the Reserve.

Management Recommendations: This community could match many of Tesch's (1982) mixed coniferous-deciduous types. I would not advise pursuing any of those type here but follow the same prescription as in 8y, which is to control the buckthorn and watch to see if this area moves toward the old growth type. It is possible that early fires set this once old growth vegetation back successionally. Many of the fire furrows are similar to those in the jack and white pine barrens type suggesting this is where 8 y/o successionally came from and toward which type 2 (Jack and White Pine Barrens) may succeed. Many older trees show that clear cutting was not done in this type, but some selective logging has occurred as evidenced by old stumps. It is also possible these trees were cut during the past fires to allow for fire furrows.

IX. Cover Type #9 - Meadow and Prairie Type

Description - The largest of these areas are more like disturbed meadows than prairies, but the two best prairie restorations are the patch near the Visitors Center parking lot (Schmeeckle Reserve Unit 43) and the patch near the west end of Lake Jonas (not numbered). Ground water level is 3 to 5 feet below ground (.9 to 1.5m.). The narrow section of grass on the north-west side of Michigan Avenue (Schmeeckle Reserve Unit 24) contains the least number of prairie grass, and is mostly made up of cool season grasses, sweet fern, and blackberries (Appendix E). Burning and possibly planting would need to be done in this area if a successful prairie restoration is to occur. On the other hand, the open grassland on the north-west side of old Reserve Street (Schmeeckle Reserve Unit 5) does have quite a few prairie indicators such as big and little bluestem. Efforts should be made to help this area by the use of prescribed fire. I would burn this area before any other in the Reserve. This area also contains sumac and sweet fern in some abundance. This type currently occupies about 2.8% of the Reserve.

Management Recommendations: This community is most similar to Tesch's (1982) Prairie. In pre-settlement times this type would have occupied approximately 1.6% of the county. Management for the two prairie areas (Schmeeckle Reserve parking lot and Lake Jonas) should be periodically burned on a 2 to 6 year interval. If species diversity is less important than the overall appearance of a tall grass prairie, biannual burning will stimulate the best "tall grass" stand. These burns should be done after the spring flush of cool season grasses but before the warm season grasses have more than 1in. (2.5cm.) of growth. If forb production and diversity is a priority then burns should be closer to a 4 to 6 year interval, with burns taking place in

early spring. This type of management may allow cool season grasses to persist and sporadic late spring burns can be intermixed.

The management plan for the two grass areas on the west side of Michigan Avenue should also include burning. It would be possible to substitute mowing early on in the transformation for grass to prairie species if time and resources are a problem (Diboll 1984). Since little bluestem is the most abundant prairie grass, mowing seems to be a easier alternative. Diboll (1984) stated that although big bluestem reacts better to burning, little bluestem and side oats gramma were both significantly increased by fire and mowing. He goes on to state that production of cool season grasses can be lower by about 55% with a mowing treatment as compared to the 75% reduction in burned sites. Although this appears to be a slower transformation process, it may make up for that by the ease of treatment. Mowing should occur in late spring and thorough raking and bagging must occur to accomplish the goal of removing the dead debris and allowing early spring warm up. I would suggest that a portion of the encroaching sumac be cut the year before a burn occurs, although leaving some would add both to the attractiveness of the area and the species richness. I recommend two or three burns in annual succession to reduce cool season grasses, sumac and sweet fern, as resprouting will undoubtably occur.

X. **Cover Type 10 - Old Growth Type** - This type has five transects (4,9,13,16,18), and is divided into three sub-populations: One in which the canopy is mixed hardwoods and pine (10), one in which the canopy is mainly white pine (10w), and one that looks to be a logged version of once old growth (10l).

Cover type 10 - Mixed Canopy Old Growth

Description - This area contains several large trees including oak, white pine, and maple (Appendix C). Some spots have abundant red maple ranging from small trees to 18" dbh (45.7cm.). There are many red oaks over 18" (45.7 cm.) and several white pines in the 2-10" dbh range (5.1cm -25.4cm.). Many of the oaks and white pines are over 20" dbh (50.8 cm.). In the understory, there is some grass, blueberry, and lady ferns. In the area on the west side of the Reserve by the Road Star Inn, the plant diversity is very good. Species include sensitive fern, bracken fern, blueberry, witch-hazel, American hazelnut, blue-beech, ironwood, white ash (Appendix D and E), and all of the other major tree species that are common for this type. Boulder outcroppings are present, as well as persistent ponds in the plot by Michigan Avenue. An abundance of ferns exist in the understory. Water levels range from standing surface water to 5 feet (1.5m.) below ground. Red maples are dense in some wetter areas. This type currently occupies 10.5 % of the Reserve and ranks second only to the entire wetland type which occupies 33.4%.

Management Recommendations: This community could resemble many of the Finely/Tesch mixed coniferous-deciduous types. Restoration is not necessary. This is a healthy representation of what an old growth forest might have looked like. It appears that although this type is young compared to pre-settlement forest, it is

apparently stable with all major species reproducing. This area is least affected by buckthorn (Appendix D) and what little there is should be removed immediately. This area could be controlled by hand pulling utilizing a group of volunteers. Perhaps a scout or business group could adopt this area and volunteer a couple of times a year for an afternoon. However, land managers should not underestimate the spreading ability of buckthorn if left unchecked.

Cover Type 10w - Old Growth - White Pine Dominated

Description - The description for this area is very similar to that of the generic type 10. The main difference is that the canopy is dominated by large white pines (Appendix C). This type has a somewhat less developed understory (Appendix D) and does not contain the frog pond areas like type 10. Water level is 1 to 5 feet below ground (.3 to 1.5m.). This type currently occupies about 4.1% of the Reserve.

Management Recommendations: This community could resemble many of the Tesch's (1982) mixed coniferous-deciduous types, but seems closer to the white pine, red pine type. Again, restoration is not necessary. It should be managed similar to type 10 (Old Growth). Data support the observations that as white pine coverage is increased in this type, species diversity drops. Species are still reproducing in the shrub layer, although no oaks were present in our sample. It seems evident that white pines and some red maple will continue to dominate this type in the near future. Again, careful attention should be given to the buckthorn problem. With effort, total eradication should be obtainable.

Cover Type 10l - Cut-Over Forest

Description - This type is either dominated by mid-sized oaks or mid-sized maple (Appendix C), depending on the area. Still very healthy, these areas seem to be missing the large trees. Water levels range from standing surface water to 5 feet below ground (1.5m.). This type currently occupies 3.1%.

Management Recommendations: This community could resemble many of the Tesch's (1982) mixed coniferous-deciduous types. Again, it is not important to restore this type. It should be managed similar to type 10 (Old Growth). One obstacle with this area is that there is no oak and pine reproducing in the shrub layer (Appendix D). If this trend continues, effort will be required to reintroduce these species to the understory. It is also interesting that although some oaks show up in the species composition, there are very few mature white pine trees. It seems white pine was selectively cut. These areas are on the west side of the Reserve near housing. This is property that was purchased later in the Reserve's history and would seem to correlate roughly to the last known logging dates. Buckthorn is also just beginning in this area and should be hand pulled immediately to stop its spread.

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Appendix A- Wildlife species observed at the Schmeeckle Reserve in 1977 or 1978.

Bird Species

Family	Species
Gaviidae	(Loons)
	Common loon (*Gavia immer)*
Podicipediadae	(Grebes)
	Horned grebe (*Podiceps niqricollis)*
	Pied-billed grebe *(Podilymbus podiceps)*
Ardeidae	(Herons)
	Great blue heron *(Ardea herodias)*
	Green heron (*Butorides striatus)*
	American bittern (*Botaurus lentiginosus)*
Anatidae	(Waterfowl)
	Canada goose *(Branta canadensis)*
	Mallard *(Anas platyrhynchos)*
	Black duck *(A. rubripes)*
	Pintail *(A. acuta)*
	Green-winqed teal *(A crecca)*
	Blue-winged teal *(A. discors)*
	Wood duck *(Aix sponsa)*
	Lesser scaup *(Aythya affinis)*
	Common goldeneye *(Bucephala clangula)*
	Bufflehead *(B. albeola)*
	Common merganser *(Mergus merganser)*
Sarthartidae	(Vultures)
	Turkey vulture *(Cathartes aura)*
Tetraonidae	(Grouse)
	Ruffed grouse *(Bonasa umbellus)*
Phasianidae	(Quails, Partridges, Pheasants)
	Ring-necked pheasant *(Phasianus colchicus)*
Rallidae	(Rails, Gallinules, Coots)
	American coot *(Fulica americana)*

Charadriidae	(Plovers)
	Killdeer *(Charadrius vociferus)*
Accipitridae	(Hawks, Falcons, Eagle)
	Northern goshawk *(Accipiter gentilis)*
	Cooper's hawk *(A. coopeni)*
	Sharp-shinned hawk *(A. striatus)*
	Red-tailed hawk *(Buteo jamaicensis)*
	Red-shouldered hawk *(B. lineatus)*
	Broad-winged hawk *(B. platypterus)*
	Rough-legged hawk *(B. lagopus)*
	Bald eagle *(Haliaeetus leucocephalus)*
	Northern harrier *(Circus syaneus)*
	Osprey *(Pandion haliaetus)*
	Merlin *(Falco columbarius)*
	American kestrel *(F. sparerius)*
Scolopacidae	(Sandpipers)
	Spotted sandpiper *(Actitis macularia)*
	Short-billed dowitcher *(Limnodromus griseus)*
	American woodcock *(Philohela minor)*
	Common snipe *(Cappella gallinago)*
Laridae	(Gulls)
	Herring gull *(Larus argentatus)*
	Ring-billed gull *(L. delawarensis)*
Columbidae	(Pigeons, Doves)
	Rock dove *(Columba livia)*
	Mourning dove *(Zenaida macroura)*
Strigidae	(Owls)
	Common screech owl *(Otus asio)*
	Great horned owl *(Bubo virginianus*
	Barred owl *(Strix varia)*
	Saw-whet owl *(Aegolius acadicus)*
Caprimulgidae	(Goatsuckers)
	Whip-poor-will *(Caprimulgus voci ferus)*
	Common nighthawk *(Chordeiles minor)*

Apodidee	(Swifts) Chimney swift (Chaetura pelagica)
Trochilidae	(Hummingbirds) Ruby-throated hummingbird *(Archilochus colubris)*
Alcedinidae	(Kingfishers) Belted kingfisher *(Megaceryle alcyon)*
Picidae	(Woodpeckers) Common flicker *(Colaptes auratus)* Pileated woodpecker *(Dryocopus pileatus)* Red-bellied woodpecker *(Centurus carolinus)* Yellow-bellied sapsucker *(Sphyrapicus varius)* Hairy woodpecker *(Picoides villosus)* Downy woodpecker *(P. pubescens)*
Tyrannidae	(Tyrant Flycatchers) Eastern kingbird *(Tyrannus tyrannus)* Great-crested flycatcher *(Myiarchus crinitus)* Eastern phoebe *(Sayornis phoebe)* Willow flycatcher *(Empidonax traillii)* Least flycatcher *(E. minimus)* Eastern peewee *(Contopus virens)* Olive-sided flycatcher *(Nuttallornis borealis)*
Alandidee	(Larks) Horned lark *(Eremophila alpestris)*
Hirundinidae	(Swallows) Tree swallow *(Iridoprocne bicolor)* Bank swallow *(Riparia riparis)* Barn swallow *(Hirundo rustica)* Purple martin *(Progne subis)*
Corvidae	(Crows) Blue jay *(Cyanocitta cristata)* Northern raven *(Corvus corax)* American crow *(C. brachyrhynchos)*
Paridae	(Chickadees, Titmice) Black-capped chickadee *(Parus atricapillus)* Boreal chickadee *(P. hudsonicus)* Eastern tufted titmouse *(P. bicolor)*

Sittidae	(Nuthatches) White-breasted nuthatch *(Sitta carolinensis)* Red-breasted nuthatch *(S. canadensis)*
Certhiidae	(Creepers) Brown creeper *(Certhia familiaris)*
Troglodytidae	(Wrens) House wren *(Troglodytes aedon)*
Mimidae	(Thrashers) Gray catbird (*Dumetella carolinensis* Brown thrasher *(Taxostoma rufum)*
Turdidae	(Thrushes) American robin *(Turdus migratorius)* Wood thrush *(Hylocichla mustelina)* Hermit thrush *(Catharus guttatus)* Swainson's thrush *(C. ustulatus)* Veery *(C. fuscescens)* Eastern bluebird *(Sialia sialis)*
Sylviidae	(Gnatcatchers, Kinglets) Blue-gray gnatcatcher *(Polioptila caerulea)* Golden-crowned kinglet *(Regulus satrapa)* Ruby-crowned kinglet *(R. calendula)*
Bombycillidae	(Waxwings) Cedar waxwing *(Bombycilla cendrorum)*
Laniidae	(Shrikes) Northern shrike *(Lanius excubitor)*
Ploceidae	(Weaver, finches) House sparrow *(Passer domesticus)*
Icteridae	(Blackbirds) Eastern meadowlark *(Sturnella magna)* Western meadowlark *(S. neglecta)* Red-winged blackbird *(Agelaius phoeniceus)* Northern oriole *(Icterus glabula)* Brewer's blackbird *(Euphagus cyanocephalus)* Common grackle *(Quiscalus quiscula)* Brown-headed cowbird *(Molothrus ater)*

Thraupidae	(Tanagers) Scarlet tanager *(Piranga olivacea)*
Fringillidae	(Finches, Sparrows) Northern Cardinal *(Cardinalis cardinalis)* Rose-breasted grosbeak *(Pheucticus ludovicianus)* Indigo bunting *(Passerina cyanea)* Evening grosbeak *(Hesperiphona vespertina)* Purple finch *(Carpodacus purpureus)* Pine grosbeak *(Pinicola enucleator)* Hoary redpoll *(Carduelis hornemanni)*
Sturnidae	(Starlings) European starling *(Sturnus vulgaris)*
Vireonidae	(Vireos) Yellow-throated vireo *(Vireo flavifrons)* Solitary vireo *(V. solitarius)* Red-eyed vireo *(V. olivaceus)* Philadelphia vireo *(V. philadelphicus)* Warbling vireo *(V. gilvus)*
Parulidae	(Wood Warblers) Black and white *warbler (Mniotilta varia)* Blue-winged warbler *(Vermivora pinus)* Tennessee warbler *(V. peregrina)* Nashville warbler *(V. ruficapilla)* Yellow warbler *(Dedroica petechia)* Magnolia warbler *(D. magnolis)* Cape May warbler *(D. tigrina)* Black-throated blue warbler *(D. caerulescens)* Yellow-rumped warbler *(D. dominica)* Black-throated green warbler *(D. virens)* Blackburnian warbler *(D. fusca)* Chestnut-sided warbler *(D. pensylvania)* Bay-breasted warbler *(D. castanea)* Blackpoll warbler *(D.striata)* Pine warbler *(D.pinus)* Palm warbler *(D. palmarum)* Ovenbird *(Seiurus aurocapillus)* Kentucky warbler *(Oporornis formosus)* Common yellowthroat *(Geothlypis trichas)* Canada warbler *(Wilsonia canadensis)* American redstart *(Setophaga ruticilla)*

Reptile Species

Brown snake - *Storeria dekayi*

Common snapping turtle - *Chelydra serpentina*

Eastern fox snake - *Elphe picta*

Eastern garter snake - *Thamnophis sirtalis*

* Eastern hognosed snake - *Heterodon platyrhinos*

* Five-lined skink - *Eumeces faciatus*

* Northern ringneck snake - *Diadophis punctatus*

Painted turtle - *Crysemys picta*

Red-bellied snake - *Storeria Occipitomaculata*

Smooth green snake - *Opheodrys vernalis*

* Wood turtle - *Clemmys insculpta*

Salamander species

Blue-spotted salamander - *Ambystoma laterale*

Red-backed salamander - *Plethodon cinereus*

Spotted salamander - *Ambystoma maculatum*

Tiger salamander - *Ambystoma tigrium*

Frog and Toad Species

American toad - *Bufo americanus*

Chorus frog - *Psewdacris triseriata*

Gray treefrog - *Hyla versicolor*

*Green frog - *Rana clamitans*

Northern leopard frog - *Rana pipiens*

Spring peeper - *Hyla crucifer*

Wood frog - *Rana pipiens*

Mammal species

Masked shrew - *Sorex cinereus*

Arctic shrew - *Sorex arcticus*

Short-tailed shrew - *Blariana brevicauda*

Bats - *Chiroptera spp.*

Eastern cottontail - *Sylvilagus floridanus*

Snowshoe hare - *Lepus americanus*

Woodchuck - *Marmota monax*

Eastern chipmunk - *Tamias striatus*

13-lined ground squirrel - *Spermophilus tridecemlineatus*

Gray squirrel - *Sciurus carolinensis*

Red squirrel - *Tamiasciurus hudsonicus*

Southern flying squirrel - *Glaucomys volans*

Northern flying squirrel - *Glaucomys sabrinus*

Beaver - *Castor canadensis*

White-footed mouse - *Peromyscus leucopus*

Red-backed vole - *Clethrionomys gapperi*

Meadow vole - *Microtus pennsylvanicus*

Muskrat - *Ondatra ziebethicus*

Norway rat - *Rattus norvegicus*

House mouse - *Mus musculus*

Meadow jumping mouse - *Zapus hudsonius*

Porcupine - *Erethizon doratum*

Red fox - *Vulpes vulpes*

Short-tail weasel - *Mustela erminea*

Long-tailed weasel - *Mustela frenata*

Mink - *Mustela vison*

Stripped skunk - *Mephitis mephitis*

River otter - *Lutra canadensis* - Unconfirmed reports from several observers

Bobcat - *Felis rufus* - Unconfirmed reports from two observers

White-tailed deer - *Odocoileus virginianus*

Appendix B - Cover type transect locations

I. Cover Type 1 Transects - Oak Barrens

Transect 1W - Transect 1 is located 110° E-SE and 99m. from the center of the planting bed located on the south-east side of the Road Star Inn parking lot. Start from the crabapple tree planted in a small bed near the edge of the blacktop.

Transect 6W - Transect 6 is located 358° N-NW and 111m. from the split-trunked white pine near the Schmeeckle and Hatch Berard property line. There is a 7" oak near the pin. With your back against the tree the pin is 1m. @ 206°.

Transect 14N - Transect 14 is located 353° N-NW and 60m. from the treehouse white pine. There is a double-trunked oak near the pin. With your back against the tree the pin is 1m. @ 300° .

II. Type 2 Transects - Jack and White Pine Barrens

Transect 8E - Transect 8 E is located 89° E-NE and 111m. from transect #21. It can also be located by walking 12.5 paces at 70° from the drain tile that is in the fire furrow at the trail's edge. There is a double-trunked aspen, with a 4" dead trunk and a 7" live trunk, near the pin. With your back against the tree the pin is 1m. @ 202° .

Transect 17W - Transect 17 is located 293° W-NW and 45m. from the wetland's overlook platform. Start where the platform meets the sidewalk. There is a 7" aspen and a 6" jack pine near the pin. With your back against the tree the pin is 1m. @ 264°.

III. Type 2j Transect - Jack Pine Barrens

Transect 5E - Transect 5 is located 174° S-SE and 81m. from the south end of the trail of Reflection's boardwalk. This is the first boardwalk (long) leaving the Visitors Center. The far pin is located 1m. at 264° from the north end of a boardwalk.

IV. Type 3 Transect - Birch, Maple, Oak, Deciduous Type

Transect 3N - Transect 3 is located 96° E-SE and 57m. from the treehouse pine. There is a 4-5" aspen near the pin. With your back against this tree the pin is 1m. at 138°.

V. Type 3a Transect - Maple, Birch, Rock, and Pothole

Transect 2W - Transect 2 is located 288° W-NW and 75m. from the split-trunked white pine near the Hatch Berard and Schmeeckle Property line. There is a 10 -12" aspen near the pin. With your back against the tree the pin is 1m. at 10°.

VI. Cover Type 4 Transects - Aspen, Birch, Deciduous Type

Transect 10N - Transect 10 is located 21^{o} N-NE and 72m. from transect #8 starting point. There is a double-maple with two 5" trunks near the pin. With your back against the tree the pin is 3m. at 22^{o}.

Transect 21N - Transect 21 is located 156 S-SE and 135m. from the treehouse white pine. There is an aspen near the pin that is 7" and very straight. With your back against the tree, the pin is 3-4m. at 256^{o}.

VII. Cover Type 6 Transect - Aspen, Fern Deciduous Type

Transect 7E - Transect 7 is 81^{o} E-NE and 105m. from the intersection of Maria and Michigan. Start from the north-east corner in the grass inside of the sidewalk.

VIII. Type 8y Transect - Young White Pine Type

Transect 15S - Transect 15 is located 96^{o} E-SE and 162m. from the north-east corner of the Road Star Inn parking lot. It can also be reached from the University Trail fire hydrant by going 267^{o} for 60m.

Transect 19E - Transect 19 is located 159^{o} S-SE and 84m. from the west point of the longest median in front of the Sentry Insurance Building on North Point Dr.

IX. Type 8y/o Transect- Young and Old Mixed Pine Type

Transect 12S - Transect 12 is located 336^{o} N-NW and 78m. from the west end of the first boardwalk after crossing Michigan Ave. going west, away from the lake.

X. Cover type 9 Transects - Meadow and Prairie Type

Transect 11S - Transect 11 is located 173^{o} S-SE and 90m. from the starting stake of transect #4. Also, there is a large 18 - 21" white pine near the starting pin. There also is a large patch of briars near the tree. With your back against this tree the pin is 4.5 paces at 198^{o}. This tree also can be seen on the air photo.

Transect 20S - Transect 20 is located 109^{o} E-SE and 36m. from the center of the gazebo near the Visitor Center parking lot.

XI. Cover Type 10 Transects - Mixed Canopy Old Growth

Transect 4W - Transect 4 is located 129^{o} E-SE and 129m. from the east side of the Granite Trail and the intersection of North Point Dr. A multi-trunked red maple is located near the pin. With your back against the tree the pin is 1m. at 293^{o}.

Transect 9E - Transect 9 is located 1^{o} N-NE and 54m. from the north-east corner of Road Star Inn parking lot.

Transect 16W - Transect 16 is located 48^{o} E-NE and 186m. from the north-east corner of Road Star Inn parking lot. This transect was at one time named 22W. The original 16W was too close to the property line.

XII. Cover Type 10w Transect - White Pine Canopy Old Growth

Transect 18W - Transect 18 is located 240^{o} SW-W and 63m. from the north-east corner where the Granite Trail intersects North Point Dr.

XII. Cover Type 10l Transect - Logged Old Growth

Transect 13N - Transect 13 is located 343^{o} N-NW and 147m. from the north-east corner of the Road Star Inn parking lot.

Appendix C- Tree Data (Stems > 10cm. d.b.h.) Showing Basel Area and Percent Cover Based on a 50m. Transect Recorded May 19-20, 1995

		Type 1 - Oak Barrens				Type 2-Pine Barrens				Type 2j-Jack Pine Barrens				Type 3-Birch, Maple, Oak				Type 3a-Birch, Maple, Rock				Type 4-Aspen,Birch				Type 8-Aspen, Fern			
		Basel		Average		Basel		Average		Basel		Average		Basel		Average		Basel		Average		Basel		Average		Basel		Average	
Scientific Name	Common name	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.
Acer rubrum	Red Maple																												
Alive		3.33	7.07	5.14	8.9	0		9.2	9.34	0		2.8		30	10	49.8		3.33	32.15	82		6.67	8.16	1	1.42				
Dead		0		0						0		0		0		0		0		0		1.67	4.08	0					
Alnus rugosa	Speckled Alder																												
Alive																						1.67	4.08	0					
Dead																						1.67	4.08	0					
Amelanchier spp.	Serviceberry																												
Alive																													
Dead																													
Betula papyrifera	Paper Birch																												
Alive						23.3	5.78	11.8	16.68	3.33	5.77	21.4		26.67	20.82	10.2		0		0		1.67	4.08	15	21.22	3.33	5.77	0	
Dead						0		0		0		0		0		0		10	17.32	0		5	12.25	0		0		0	
Carpinus caroliniana	Hornbeam																												
Alive																													
Dead																													
Corylus americana	Hazelnut																												
Alive																		0		0.8									
Dead																		0		0									
Fraxinus americana	American Ash																												
Alive																													
Dead																													
Fraxinus penn.	White Ash																												
Alive																		3.33	5.77	3		1.67	4.08	0					
Dead																		0		0		0		0					
Hamamelis virginiana	Witch Hazel																												
Alive																													
Dead																													
Malus spp.	Crabapple																												
Alive																													
Dead																													
Ostrya virginiana	Ironwood																												
Alive																		3.33	5.7	7.2									
Dead																		0		0									
Pinus banksiana	Jack Pine																												
Alive						60	55.67	59.5	10.88	160	55.68	51.6										6.67	10.33	20	28.28				
Dead						3.33	5.78	0		20	14.14	0										1.67	4.08						
Pinus Resinosa	Red Pine																												
Alive														3.33	5.77	0													
Dead														0		0													
Pinus strobus	White Pine																												
Alive		0		1.88	1.62	8.33	16.02	6.8	9.62					3.33	5.77	15.4													
Dead		0		0		0		0						0		0													
Populus trem.	Aspen																												
Alive		2.22	6.67	4.74	8.2	10		4.3	1	6.67	11.55	18.4		26.67	23.09	24.2		53.33	46.19	24.4		30	30.98	46.2	51	63.33	5.77	90.2	
Dead		0		0		0		0		0		0		0		0		13.33	15.28			1.67	4.08			20	10	0	
Prunus serotina	Black Cherry																												
Alive		0		0		0		0						0		2.2						0		0					
Dead		0		0		0		0						6.67	5.77	0						0		0					
Quercus alba	White Oak																												
Alive		10	16.5	6.08	8.84													3.33	5.7	0									
Dead		1.11	3.33	0														0		0									
Quercus ellip.	Hill's Oak																												
Alive		48.88	48.07	50.8	23.8	0		2.1	2.98					16.67	20.82	14.8						5	8.37	19.3	10.6				
Dead		5.56	16.67	0		0		0						0		0						0		0					
Quercus rubra	Red Oak																												
Alive		21.44	43.55	14.8	25.64																								
Dead		1.11	3.33	0																									
Ulmus americana	American Elm																												
Alive																													
Dead																													

Appendix C- Tree Data (Stems > 10cm. d.b.h.) Showing Basel Area and Percent Cover
Based on a 50m. Transect Recorded May 19-20, 1995

	Type 8y-Young White Pine				Type8 y/o-Mixed Aged Pine				Type8-Meadow and Prairie				Type 10-Old Growth Type				Type 10-White Pine Dominated				Type 10-Cut Over Forest			
	Basel		Average		Basel		Average		Basel		Average		Basel		Average		Basel		Average		Basel		Average	
Scientific Name	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.	Area	S.D.	% covr	S.D.
Acer rubrum																								
Alive	16.67	18.62	38.1	37.2	10	10	21.6						31.11	36.21	39.4	8.58	20	20	70.8		30	10	44.2	
Dead	0		0		0		0						0		0		0		0		0		0	
Alnus rugosa																								
Alive																								
Dead																								
Amelanchier spp.																								
Alive	0		0																					
Dead	0		0																					
Betula papyrifera																								
Alive	0		3.2	4.52	0		12.2						1.11	3.33	0		0		3					
Dead	0		0		0		0						0		0		6.67	11.54						
Carpinus caroliniana																								
Alive													0		8	13.86								
Dead													0		0									
Corylus americana																								
Alive																								
Dead																								
Fraxinus americana																								
Alive													0		0.8	1.38								
Dead													0		0									
Fraxinus penn.																								
Alive																								
Dead																								
Hamamelis virginiana																								
Alive													0		1.4	2.42								
Dead													0		0									
Malus spp.																								
Alive	0		0.1	1.4																				
Dead	0		0																					
Ostrya virginiana																								
Alive													0		3.54	6.12								
Dead													0		0									
Pinus banksiana																								
Alive					83.33	40.41	21.2		6.67	11.55	3.7	5.24	0		3.2	5.54								
Dead					0		0		3.33	5.77	0		0		0									
Pinus Resinosa																								
Alive																								
Dead																								
Pinus strobus																								
Alive	111.67	49.97	64.2	14.7	33.33	23.09	39.6		30	17.32	2.4	3.4	33.33	22.91	34	13.44	140	100	94.2		37.33	62.94	5	
Dead	20	8.94	0		3.33	5.77			3.33	5.77	0		0		0		1.11	3.33	0		0		0	
Populus trem.																								
Alive	10	10.95	16	15	3.33	5.77	0														3.33	5.77	4	
Dead	1.67	4.08	0		0		0														0		0	
Prunus serotina																								
Alive									3.33	5.77	10.4	14.7												
Dead									0		0													
Quercus alba																								
Alive													14.44	13.33	12.06	13.34	1.11	3.33	20		70	40	77	
Dead													2.22	6.67	0		0		0		0		0	
Quercus ellip.																								
Alive																								
Dead																								
Quercus rubra																								
Alive					0		3						30	15	41.14	26.16					10	17.32	0	
Dead					0		0						0		0						0		0	
Ulmus americana																								
Alive													0		0									
Dead													1.11	3.33	0									

Appendix D- Shrub Data (Stems > 1m. tall and < 10 cm. d.b.h.) Showing Stems Per Hectare and Average Percent Cover. Based on a 50m. Transect Recorded May 19-20, 1995

		1 - Oak Barrens			2-Pine Barrens			2j-Jack Pine Barrens			3-Birch, Maple, Oak			3a-Birch, Maple, Rock			4-Aspen,Birch			6-Aspen, Fern		
Scientific Name	Common name	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover
Acer negundo	Boxelder																					
Alive																				200	0	0.2
Dead																				0	0	0
Acer rubrum	Red Maple																					
Alive					1000	1132	0	200	0	6.6	600	0	0				400	566	0.4	200	0	0
Dead					0	0	0	0	0	0	0	0	0				0	0	0	0	0	0
Alnus rugosa	Speckled Alder																					
Alive					0	0	0	0	0	0.2							100	142	9.2	600	0	3.4
Dead					100	142	0	0	0	0							0	0	0	0	0	0
Betula papyrifera	Paper Birch																					
Alive								0	0	1.8							100	142	2.3			
Dead								0	0	0							0	0	0			
Carpinus caroliniana	Hornbeam																					
Alive																						
Dead																						
Corylus americana	Hazelnut																					
Alive		7200	12470	12.8	1130	0	1.9	200	0	0				4600	0	0	0	0	0.6			
Dead		0	0	0	0	0	0	0	0	0				0	0	0	0	0	0			
Corylus cornuta	Beaked Hazelnut																					
Alive																						
Dead																						
Crataegus spp.	Hawthorn																					
Alive		134	230	2.66							0	0	0.8									
Dead		0	0	0							0	0	0									
Fraxinus americana	American Ash																					
Alive																						
Dead																						
Fraxinus penn.	White Ash																					
Alive														0	0	2.2	100	142	0			
Dead														0	0	0	0	0	0			
Hamamelis virginiana	Witch Hazel																					
Alive																						
Dead																						
Lonicera tatarica	Honeysuckle																					
Alive		0	0	0.32																		
Dead		0	0	0																		
Nemopanthus mucr.	Mountain Holly																					
Alive					2100	2970	1.3	4000	0	5	800	0	2.2	0	0	0.8	4600	7100	0			
Dead					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Ostrya virginiana	Ironwood																					
Alive																						
Dead																						
Pinus strobus	White Pine																					
Alive																						
Dead																						

Appendix D- Shrub Data (Stems > 1m. tall and < 10 cm. d.b.h.) Showing Stems Per Hectare and Average Percent Cover. Based on a 50m. Transect Recorded May 19-20, 1995

		1 - Oak Barrens			2-Pine Barrens			2j-Jack Pine Barrens			3-Birch, Maple, Oak			3a-Birch, Maple, Rock			4-Aspen,Birch			6-Aspen, Fern		
Scientific Name	Common name	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover
Populus trem.	Aspen																					
Alive					100	142	0	200	0	0	0	0	0				100	1420	0	600	0	0.8
Dead					0	0	0	0	0	0	200	0	0				0	0	0	400	0	0
Prunus serotina	Black Cherry																					
Alive		534	576	2.14	2600	3673	11.2										200	0	0			
Dead		0	0	0	0	0	0										0	0	0			
Prunus virginiana	Chokecherry	66	116	0																		
Alive		0	0	0										200	0	0	100	142	0			
Dead														0	0	0	0	0	0			
Quercus alba	White Oak																					
Alive											200	0	2.4									
Dead											0	0	0									
Quercus ellip.	Hill's Oak																					
Alive					900	1272	0	0	0	0.2	0	0	2.4				0	0	0			
Dead					0	0	0	0	0	0	0	0	0				100	142	0			
Quercus rubra	Red Oak																					
Alive																						
Dead																						
Rhamnus cathartica	Common Buckthorn																					
Alive					100	142	0										200	282	1.4			
Dead					0	0	0										0	0	0			
Rhamnus frangula	Glossey Buckthorn																					
Alive		200	200	3.66	2400	1698	7.7	200	0	0	6000	0	8.4	4600	0	1	800	0	5.9	6200	0	41.2
Dead		0	0	0	0	0	0	0	0	0	2000	0	0	0	0	0	0	0	0	0	0	0
Rosa caroina	Carolina Rose																					
Alive																	100	142	0			
Dead																	0	0	0			
Sambucus canadens	Elderbery																					
Alive																				400	0	1.4
Dead																				1200	0	0
Spirea spp.	Steeple Bush																					
Alive								400	0	0												
Dead								0	0	0												
Spirea tomentosa	Steeple Bush																					
Alive																	600	848	0			
Dead																	0	0	0			
Ulmus americana	American Elm																					
Alive																						
Dead																						
Unknown																						
Alive								200	0	0												
Dead								0	0	0												

Appendix D- Shrub Data (Stems > 1m. tall and < 10 cm. d.b.h.) Showing Stems Per Hectare and Average Percent Cover. Based on a 50m. Transect Recorded May 19-20, 1995

	8y-Young White Pine			8 y/o-Mixed Aged Pine			9-Meadow and Prairie			10-Old Growth Type			10-White Pine Dominated			10l-Cut-Over Forest		
Scientific Name	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover	Stems / Hectare	N-1	Average % cover
Acer negundo																		
Alive																		
Dead																		
Acer rubrum	0	0	8.4															
Alive	0	0	0	2000	0	10.8				0	0	1.4	200	0	5	0	0	8
Dead				0	0	0				200	200	0	0	0	0	0	0	0
Alnus rugosa																		
Alive																		
Dead																		
Betula papyrifera																		
Alive										200	346	0						
Dead										0	0	0						
Carpinus caroliniana																		
Alive										534	612	13.74						
Dead										0	0	0						
Corylus americana																		
Alive				1800	0	6.4												
Dead				0	0	0												
Corylus cornuta																		
Alive										66	114	0.4						
Dead										0	0	0						
Crataegus spp.																		
Alive																		
Dead																		
Fraxinus americana																		
Alive										0	0	0.6						
Dead										0	0	0						
Fraxinus penn.																		
Alive										66	116	0						
Dead										0	0	0						
Hamamelis virginiana										134	230	3.14				600	0	1.4
Alive										134	116	0				0	0	0
Dead																		
Lonicera tatarica																		
Alive																		
Dead																		
Nemopanthus mucr.																		
Alive																400	0	1.6
Dead																0	0	0
Ostrya virginiana																		
Alive										0	0	2.4						
Dead										0	0	0						
Pinus strobus																		
Alive	100	142	0	200	0	1.8				334	556	0.06	400	0	5			
Dead	500	142	0	0	0	0				0	0	0	0	0	0			

Appendix D- Shrub Data (Stems > 1m. tall and < 10 cm. d.b.h.) Showing Stems Per Hectare and Average Percent Cover. Based on a 50m. Transect Recorded May 19-20, 1995

	8y-Young White Pine			8 y/o-Mixed Aged Pine			9-Meadow and Prairie			10-Old Growth Type			10-White Pine Dominated			10l-Cut-Over Forest		
	Stems /		Average	Stems /		Average	Stems /		Average	Stems /		Average	Stems /		Average	Stems /		Average
Scientific Name	Hectare	N-1	% cover	Hectare	N-1	% cover	Hectare	N-1	% cover	Hectare	N-1	% cover	Hectare	N-1	% cover	Hectare	N-1	% cover
Populus trem.																		
Alive				600	0	0.6												
Dead				0	0	0												
Prunus serotina																		
Alive																		
Dead																		
Prunus virginiana																		
Alive																		
Dead																		
Quercus alba																		
Alive																		
Dead																		
Quercus ellip.																		
Alive																		
Dead																		
Quercus rubra																		
Alive										66	116	2.66						
Dead										334	416	0						
Rhamnus cathartica																		
Alive																		
Dead																		
Rhamnus frangula																		
Alive	200	228	0	2000	0	4.4												
Dead	0	0	0	0	0	0												
Rosa caroina																		
Alive																		
Dead																		
Sambucus canadens																		
Alive																		
Dead																		
Spirea spp.																		
Alive																		
Dead																		
Spirea tomentosa																		
Alive																		
Dead																		
Ulmus americana																		
Alive										0	0	0						
Dead										66	116	0						
Unknown																		
Alive																		
Dead																		

Appendix 5- Herb Data (Vegetation >1m.) Showing Average Percent Cover
Based on a 50m. Transect Recorded May 19-20, 1995

Scientific Name	Common name	Type 1		Type 2		Type 3j		Type 3		Type 3e		Type 4		Type 6		Type 8y		Type 8 y/o		Type 9		Type 10		Type 10W		Type 10l	
		Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.	Aver.	St. Dev.
Achillea millefolium	Common Yarrow																										
Acer negundo	Boxelder																			0.3	0.6749						
Acer rubrum	Red Maple	0.8	0.6761	7.1	9.3387	4	6.245	2.2	2.1679			0.9	1.5239			0.8	0.4216	8.4	10.31			0.67	0.488	1	0.7071	1.2	0.8367
Agropyron repens	Quack Grass																			33.3	30.941						
Alnus regosa	Speckled Alder											3.5	8.182														
Amelanchier spp.	Serviceberry	0.1	0.6164			0.6	0.8944					0.2	0.6325			0.1	0.3162							0.4	0.8944	0.4	0.8944
Anemone quinquefolia	Wood Anemone	0.4	0.7589			2.4	4.3359	11	7.4162	5.6	6.6558					0.1	0.3162	3	4.4721			1.2	2.569	1.2	1.7889	0.4	0.8944
Aralia nudicaulis	Wild Sarsaperilla			0.2	0.6325																	0.93	3.1045				
Artemisia amb.																				0.1	0.3162						
Artemisia absinthium																						2.4	5.7793			0.4	0.5477
Aster macrophyllus	Heat-leaved Aster	0.1	0.3519	0.1	0.3162																						
Aster spp.	Aster					0.2	0.4472																				
Calamagrostis canadensis	Canadian Reed-Grass			1	3.1623	8.2	7.328	0.2	0.4472	2.8	1.4832	32.5	38.774	0.8	1.7889												
Carex #1	Sedge									0.4	0.5477																
Carex #2	Sedge									5.8	10.872																
Carex #3	Sedge									0.2	0.4472																
Carex #4	Sedge					2.4	2.881																				
Carex pensylvanica	Pennsylvania Sedge	30.3	22.279	4.1	12.618			13.4	14.163	0.4	0.8944	0.7	2.2136			0.2	0.6325	2.4	4.3359	6	12.649	4.07	6.8501	17.4	21.835	13	11.958
Carex sp.	Sedge			0.3	0.6749	11	13.304	0.2	0.4472			4.6	8.1541	0.2	0.4472	1.3	1.8886							0.4	0.8944		
Carpinus caroliniana	American Hornbeam	0.3	1.291																			1.4	3.501			1	2.2361
Cerastium spp.	Chickweed																			0.1	0.3162						
Chrysanthemum spp.	Daisy																			0.2	0.6325						
Corrysia canadensis																				0.2	0.4216						
Cornus alternifolia	Alternate-leaved Dogwood																										
Cornus canadensis	Canadian Dogwood											1.3	3.199														
Cornus racemosa	Grey Dogwood									1	2.2361																
Corylus americen	Hazel-nut	0.8	1.5523							1	2.2361																
Corylus cornuta	Beaked Hazel-nut\																										
Crataegus sp.	Hawthorn					0.2	0.4472	1.2	0.8367																		
Cucumber Root like?						0.4	0.8944																				
Danthonia spicata	Oat Grass			0.1	0.3162			0.4	0.8944			2	6.3246			0.2	0.6325										
Dennstaedtia punctilobula										2.4	3.3615							0.2	0.4472								
Dryopteris spinulosa														0.4	0.8944			3	6.7082								
Erigeron spp.	Fleabane																			0.4	0.8433						
Erythronium albidum	White Adder's Tongue															0.4	0.8433					0.07	0.2582				
Fragaria americana	Wild Strawberry																										
Fragaria virginiana	Duchesne			0.2	0.4216	1.4	2.1909																				
Galium aparine	Goosegrass													0.2	0.4472												
Galium trifloriom	Bedstraw spp.			0.1	0.3162					0.8	0.8367																
Galtheria procumbens		0.3	0.6936					0.2	0.4472													0.07	0.2582	0.2	0.4472	0.8	0.8367
Geum triflola	Prairie Smoke																										
Hamamelis virginiana	Witch hazel	0.1	0.5164																			0.07	0.2582			0.4	0.8944
Hepatica acutiloba																								0.6	1.3416		
Heracium spp.	Hawkweed																			3.8	6.957						
Impatiens biflora	Jewelweed									0.4	0.8944																
Impatiens capensis	Jewelweed													13.8	11.606												
Lactuca spp.	Lettuce													1	2.2361					0.1	0.3162						
Lepidium spp.	Peppergrass																			0.3	0.6749						
Lithospermum canescens	Hoary Puccoon																							0.4	0.8944		
Lonicera spp.	Honeysuckle																					0.07	0.2582			0.8	1.3038
Luzula acuminata		0.3	0.7888	0.1	0.3162																			0.2	0.4472		
Lysimachea sp.	Loosestrife	0.1	0.2582											1	2.2361	0.1	0.3162										
Lysimachia quadrifolia	Whorled Loosestrife			0.4	1.2649																						
Lysimachia thyrsiflora	Tufted Loosestrife					0.8	0.4472	0.8	1.3038																		
Maianthemum canadense	Canada Mayflower	2.2	3.4476	15.1	16.569	14.4	14.467	3.4	1.5166	4.2	1.9235	10.2	13.473			10.8	13.473	8.2	7.225			3.4	3.4393	9.2	12.276	3.4	4.0989
Melilotus spp.	Sweet Clover																			0.1	0.3162						
Mentha spp.	Mint					0.4	0.8944			1	1.7321					0.6	1.5811										
Mitchella repens	Partridge Berry	0.1	0.2582	0.3	0.483											0.1	0.3162	2	4.4721			0.73	1.0328	0.6	1.3416		
Monarda fistulosa	Horse Mint																			0.6	1.2649						
Nemopanthus mucronatus	Mountain Holly	0.3	1.291			1.2	2.1679	2	4.4721	0.8	1.7889															1	2.2391
Onoclea sensibilis	Sensitive Fern													10.4	1.6733												
Onoclea spp						0.2	0.4472			0.2	0.4472					0.6	1.5811										
Oryzopsis asperifolia	Rough-leaved Ricegrass																							0.2	0.4472		
Osmunda cleytoniana	Cinnamon Fern	4.7	9.6914																			6.8	13.945			14.2	12.677
Osmunda regalis	Regal Fern																										

Appendix 5- Herb Data (Vegetation >1m.) Showing Average Percent Cover
Based on a 50m. Transect Recorded May 19-20, 1995

Scientific Name	Common name	Type 1		Type 2		Type 2j		Type 3		Type 3e		Type 4		Type 6		Type 6y		Type 6 y/o		Type 9		Type 10		Type 10W		Type 10l	
Panax trifolius	Dwarf Ginseng	3.0	6.6869					0.4	0.8477									0.2	0.4472			2.73	6.3411	0.2	0.4472	8.4	9.99
Panicum spp	Swithch Grass							3.2	6.6106	0.2	0.4472																
Pinus strobus	White Pine	0.1	0.3519	0.6	1.5776	0.8	1.3038	0.4	0.8477							0.5	0.527	1	1.4142	0.4	1.2649	1.73	6.4417	0.4	0.5477	0.2	0.4472
Poa compressa	Canada Bluegrass																			0.1	0.3162						
Poa pratensis	Kentucky Bluegrass																			17	23.944						
Poa. Spp.	Bluegrass			0.1	0.3162	0.2	0.4472			0.2	0.4472																
Podofilium pallatum	Mayapple																										
Populus trambuloides	Trembling Aspen			0.3	0.6749									2.2	4.3818	0.1	0.3162										
Potentilla simplex	Old-Field Cinquefoil	0.1	0.2582	1.9	1.8379							0.9	1.7288	0.6	1.3416			1.4	0.5477	0.4	0.9661						
Potentilla spp.	Cinquefoil	0.3	1.0466																	0.1	0.3162						
Prenanthes alba	White-Lettuce	0.3	0.6172																			0.07	0.2582	0.4	0.8944	0.8	0.8944
Prunus serotina	Black Cherry	0.8	1.5675	2.6	3.7478	0.2	0.4472			1.4	3.1305	1.6	3.3747			0.3	0.6749	0.4	0.8944					0.4	0.5477		
Prunus virginiana	Chokecherry			0.1	0.3162							0.3	0.9487									0.13	0.5164				
Pteridium aquilinum	Bracken Fern	0.5	1.2459			1	2.2361									1	3.1623					2.2	3.4898	3.4	4.4497	1.4	1.9494
Pyrola elliptica	Shinleaf			0.2	0.6325																			0.2	0.4472		
Pyrola rotundifolia	Swealfern			0.7	1.3376											0.1	0.3162										
Quercus alba	White oak									0	0	0.4	1.2649									0.07	0.2582				
Quercus ellipsidalis	Hill's Oak	0.5	0.8339	0.7	1.4944	0.2	0.4472			0.2	0.4472	0.5	1.5811									0.07	0.2582				
Quercus rubra	Red Oak	0.1	0.2582	0.3	0.483																	0.4	0.7368	0.4	0.5477	0.2	0.4472
Rhamnus cathartlcus	Common Buckthorn	2.0	7.746									1.6	3.34														
Rhamnus frangula	Glossy Buckthorn	1.3	3.8631	5.6	6.3593			1.0	1.9235	5	7.0711	0.6	1.075	1.4	2.1909	1.4	3.0984	3	1.5811			0.2	0.5806	0.2	0.4472		
Rosa carolina	Carolina Rose	0.1	0.6164			0.4	0.5477					4.7	6.6668							0.5	1.5811						
Rubus allegheniensis	Blackberry	4.7	12.932	4.5	10.124							0.3	0.9487	2	4.4721			0.6	1.3416	9.2	21.607						
Rubus hispidus	Dewberry			8.7	16.945	1.4	0.8944					5.4	6.7198	3.6	5.5038			3.5	4.3359			0.2	0.5606				
Rubus idaeus	Red Raspberry											0.9	2.5298					1.8	2.49								
Rubus spp.										1	0.7071	0.1	0.3162														
Rudbeckia spp.	Black-eyed Susan			0.2	0.6325																						
Rumex acetosella	Sheep Sorrel			0.1	0.3162															2.8	5.2662						
Sambucus canadensis	Elderberry													0.4	0.8477												
Smilacina racemosa	False Solomon's Seal							0.4	0.8944																		
Smilax lamnoides?	Greenbrier									0.4	0.8944																
Solanum dulcamara ?	Greenbrier													0.4	0.8944												
Solidago spp.	Goldenrod			0.4	0.9661	1	1.4142					3	9.4868	5.2	5.5857			0.2	0.4472								
Sorbus americana	Mountain Ash			0.1	0.3162																			0.2	0.4472		
Spirea alba	Meadowsweet			0.7	1.3375	4.6	6.7676					0.2	0.8325														
Spirea tomentosa	Steeplebush					2	4.4721					0.8	1.2293														
Stereptopus roseus												#####	#DIV/0!									0.07	0.2582				
Taraxacum officinale	Dandelion			0.1	0.3162	0.2	0.4472																				
Tilia americana	Basswood	0.1	0.2582																								
Trientalis borealis	Starflower	0.3	0.488	1	2.5386			1.4	1.1402	0.4	0.5477	0.2	0.4216			1.1	2.4244	1.8	1.4832			1.4	1.1832	2.2	1.9235	0.6	0.5477
Trifolium repens	White Clover																			3.1	9.4569						
Trillium spp.	Trillium																										
Ulnus american	American Elm																										
Unknown grass				0.1	0.3162													0.2	0.4472	3	6.7495	0.13	0.3519				
Unknown spp.						0.2	0.4472									0.8	2.5298										
Uvularia sessilifolia	Bellwort	0.3	0.7237			0.8	0.4472															0.93	1.6242	1.6	1.5166	0.8	0.8944
Vaccinium angustifolium	Early Blueberry	1.0	2.6458	2.7	3.4335	16	17.889	4.4	5.9833			7.2	13.967			0.6	1.2649	0.4	0.5477					0.2	0.4472	0.4	0.8944
Vaccinium myrtilloides	Velvet-leaved Blueberry																										
Veronica serpyllifolia	Thyme-leaved Speedwell																			0.1	0.3162						
Viburnum acerifolium	Arrowwood	0.1	0.2582																			0.67	1.0466			0.2	0.4472
Viola macloskeyi	Violet			8	13.375											0.2	0.4216	2	2.7386					0.2	0.4472		
Viola pedata	Bird's Foot Violet																										
Fine litter		93.4	10.636	87	20.44	73	33.466	242	342.79	91.2	4.4385	86.4	22.177	81	7.4162	97.5	6.3465	97	2.7386	86	23.19	87.6	23.625	87.6	26.623	92.2	4.5497
Course litter		2.3	3.2834	7	9.7753	1.2	2.1679	7.6	4.3359	2	1.8708	2.2	2.2804	7	3.7417	3.2	4.8628	4	6.2849	0.2	0.6325	5	7	12	26.833	5	4.6904
Bare soil		5.3	10.048	0.7	1.6364	0		0		0		0.5	0.8498	11.6	8.0808	0.2	0.6325	1	1.4142	4.2	7.2847	8.67	22.853	0.4	0.8944	4.4	3.5071
Bryophytes		0.7	1.2799	18.5	26.227	1.2	1.8432	5.4	2.1909	5.4	2.51	14.6	21.025	4.8	5.933	3	6.2539	4.8	4.8683	15.9	27.902	3.2	4.3128	8	17.889	1.6	1.5166
Lichens		1.0	3.1623	0		0.2	0.4472	0		0		0		0		0		0.2	0.4472	0		0		0		0	