



LIBRARIES

UNIVERSITY OF WISCONSIN-MADISON

Assessing the ecological status and vulnerability of springs in Wisconsin. [DNR-185] [2007]

Swanson, Susan K.; Bradbury, K. R.; Hart, David J. (Hydrogeologist)
[Madison, Wisconsin?]: [publisher not identified], [2007]

<https://digital.library.wisc.edu/1711.dl/QRB4KYQ3M2OPY9E>

<http://rightsstatements.org/vocab/InC/1.0/>

For information on re-use see:

<http://digital.library.wisc.edu/1711.dl/Copyright>

The libraries provide public access to a wide range of material, including online exhibits, digitized collections, archival finding aids, our catalog, online articles, and a growing range of materials in many media.

When possible, we provide rights information in catalog records, finding aids, and other metadata that accompanies collections or items. However, it is always the user's obligation to evaluate copyright and rights issues in light of their own use.

ASSESSING THE ECOLOGICAL STATUS AND VULNERABILITY OF SPRINGS IN WISCONSIN

Susan K. Swanson, Associate Professor, Department of Geology, Beloit College

Kenneth R. Bradbury, Hydrogeologist/Professor, Wisconsin Geological and Natural History Survey,
University of Wisconsin-Extension

David J. Hart, Hydrogeologist/Associate Professor, Wisconsin Geological and Natural History Survey,
University of Wisconsin-Extension

TABLE OF CONTENTS

Title Page	1
Table of Contents	2
List of Figures	3
Project Summary	4
Introduction	6
<i>Purpose and Scope</i>	6
<i>Study Areas</i>	6
Procedures and Methods	7
<i>Historical Surveys</i>	7
<i>Verification of Spring Locations</i>	7
<i>Selection of Representative Springs</i>	7
<i>Comprehensive Surveys</i>	7
<i>Bimonthly Surveys</i>	8
Results and Discussion	8
<i>Distribution of Springs</i>	8
<i>Physical Characteristics</i>	9
<i>Ecological Characteristics</i>	12
Conclusions and Recommendations	13
<i>Status of Spring Ecosystems</i>	13
<i>Conceptual Models and Vulnerability of Springs to Withdrawals</i>	13
References	15

Appendix A: Presentations and Awards

Appendix B: Field Survey Form from Springer et al. (in prep.)

Appendix C: Regional Information on the Distribution of Springs in Iowa County

Appendix D: Geochemistry Results and Charts

Appendix E: Vegetation Diversity Charts, Plant Species Lists, and Importance Values

Appendix F: Distribution of Springs and High-Capacity Wells in Iowa and Waukesha Counties

Appendix G: Acknowledgements

LIST OF FIGURES

Figure 1. Location of Iowa and Waukesha Counties.....	6
Figure 2. Distribution of a) historical, b) confirmed, and c) surveyed springs in Iowa County and d) historical, e) confirmed, and f) surveyed springs in Waukesha County.....	9
Figure 3. Distribution of springs within major stratigraphic units, Iowa County.....	9
Figure 4. Spring flow (cfs) in Iowa and Waukesha Counties June-August, 2006.....	10
Figure 5. Spring flow measurements for two springs in Iowa County.....	10
Figure 6. Concentrations of a) Chloride and b) Nitrate as N at springs near Highland, Otter Creek, and Governor Dodge State Park, Iowa County.....	11
Figure 7. Cluster analysis results, Waukesha County.....	11
Figure 8. Distribution of geochemical groups and bedrock geology (after Mudrey et al., 2007).....	12
Figure 9. Distribution of Group 3 springs relative to the Kettle Moraine (after Clayton, 2001).....	12
Figure 10. Distribution of Vegetative Strata Cover in a) Iowa County and b) Waukesha County.....	13

PROJECT SUMMARY

Title:	Assessing the Ecological Status and Vulnerability of Springs in Wisconsin
Project I.D.:	WR05R004
Investigator(s):	Susan K. Swanson, Associate Professor, Department of Geology, Beloit College Kenneth R. Bradbury, Hydrogeologist/Professor, Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension David J. Hart, Hydrogeologist/Associate Professor, Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension
Period of Contract:	07/01/05 – 06/30/07
Background/Need:	The need for a clear understanding of the range of physical and ecological characteristics of springs in Wisconsin provides the overall motivation for this project. The topic is relevant in Wisconsin because the Wisconsin Department of Natural Resources must evaluate whether groundwater pumping by new high-capacity wells will result in significant environmental impacts to springs that result “in a current of flowing water with flows of a minimum of one cubic foot per second at least 80% of the time (2003 WI Act 310, p.2)”. However, Wisconsin’s springs, irrespective of the flow criterion, are poorly studied, resulting in a lack of information for use in determining significance of impacts.
Objectives:	Our primary goal is to collect, classify, and evaluate baseline data on physicochemical characteristics and biological communities of Wisconsin’s spring resources. Using historical spring surveys and a comprehensive springs classification system developed by Springer et al. (in prep.), the physical, biological, and sociocultural characteristics of typical spring systems in two regions of the state were documented. The two regions differ in their topography, geology, land use, and development pressures. The approach allows the assessment of the physical and ecological status of spring systems and the formulation of hydrogeological conceptual models of springs in these settings.
Methods:	The methodology involves mapping springs in Iowa and Waukesha Counties, conducting surveys of representative springs in each county, building a database for the spring-related information, and interpreting these data in association with regional information on geology and topography to assess vulnerability to groundwater withdrawals. The study represents the first assessment of spring resources in these regions in approximately 50 years.
Results and Discussion:	Iowa County is rich in spring resources; any loss of spring resources over the last 50 years is minimal. Field data support conceptual models for springs in Iowa County that are based on a typical contact spring. Springs are associated with every major stratigraphic unit, but are most commonly found in association with the Sinnipee Group, near the upper contact of the St. Peter Fm., or near the upper contact of the Cambrian sandstones. Therefore, heterogeneities like vertical and horizontal fractures, both of which are prevalent in the Sinnipee Group rocks, or partings along major stratigraphic contacts may be particularly important in promoting discrete flow in the region. Spring waters discharging from different geologic units can be

distinguished on the basis of major ion geochemistry, and springs discharging from stratigraphically higher units have more variable flow.

In Waukesha County, much of the land that historically contained springs has been developed for residential or commercial purposes. The spatial distribution of springs was historically influenced by the glacial topography and the position of the Maquoketa shale subcrop. Geochemical groups of spring waters suggest that although flow paths originate in the unlithified aquifer, groundwater may flow through shallow bedrock before discharging as depression springs in low-lying wetlands or near streams.

Agricultural and historical uses of spring water have impacted the ecological status of springs in both regions. Plant diversity is somewhat higher at the Waukesha County springs, but the percent cover of native plants is lower and the percent cover of invasive plants is higher. Benthic fauna communities are dominated by non-insect taxa (Amphipoda, Isopoda, Gastropoda), although low numbers of aquatic insects (Tricoptera and Diptera) were found in most springs.

**Conclusions/
Implications/
Recommendations:**

Overall confidence in historical spring locations is high, which allows their use in association with patterns of regional geology and topography. This regional information is complemented by the depth of the site-specific information collected using the Springer et al. (in prep.) system. At least 20 springs were surveyed in each county. This number of springs provided sufficient data to develop conceptual models and preliminarily assess vulnerability to pumping, which suggests the overall approach may also be successful elsewhere in Wisconsin.

Springs discharging from stratigraphically higher units in Iowa County are likely to be vulnerable to pumping from wells along ridge tops that are installed in these aquifers or that span multiple aquifers. Because recharge areas for these springs are probably small and shallow, pumping could result in substantially reduced spring flow or complete loss of flow to small springs. Springs discharging from stratigraphically lower units are probably less vulnerable, due in part to broader contributing areas, but also because most high-capacity wells that pump water from the Cambrian sandstones are located in the floodplain of the Wisconsin River, where few springs exist. Because regional pumping in southeastern Wisconsin affects shallow flow patterns and downward flow from the shallow to the deep parts of the system occurs, springs in Waukesha County are vulnerable to additional groundwater withdrawals from both the shallow and deep parts of the system.

**Related
Publications:**

Bartkowiak, B.M. and Swanson, S.K., March 2007. Geochemical and flow characteristics of two contact springs in Iowa County, Wisconsin, American Water Resources Association - WI Section Annual Meeting, Wisconsin Dells, Wisconsin.

Swanson, S.K., March 2007. Assessing the ecological significance and vulnerability of springs in southern Wisconsin, American Water Resources Association - WI Section Annual Meeting, Wisconsin Dells, Wisconsin.

Key Words:

Springs, Iowa County, Waukesha County

Funding:

University of Wisconsin System; Wisconsin Department of Natural Resources; U.S. Geological Survey

INTRODUCTION

Purpose and Scope

The need for a clear understanding of the range of physical and ecological characteristics of springs in Wisconsin provides the overall motivation for this project. The topic is relevant in Wisconsin because the Wisconsin Department of Natural Resources (WDNR) must evaluate whether groundwater pumping by new high-capacity wells ($\geq 100,000$ gpd) will result in significant environmental impacts to springs that result “in a current of flowing water with flows of a minimum of one cubic foot per second at least 80% of the time (2003 WI Act 310, p.2)”. However, Wisconsin’s springs, irrespective of the flow criterion, are poorly studied, resulting in a lack of information for use in determining significance of impacts.

The primary goal of this investigation is to collect, classify, and evaluate baseline data on physicochemical characteristics and biological communities of Wisconsin’s spring resources. Using historical spring surveys and a comprehensive springs classification system developed by Springer et al. (in prep.), the physical, biological, and sociocultural characteristics of typical spring systems in two regions of the state were documented. The two regions differ in their topography, geology, land use, and development pressures. The approach allows the assessment of the physical and ecological status of typical spring systems and the formulation of hydrogeological conceptual models of springs in these settings, both of which are critical steps in assessing vulnerability to pumping. The methodology involves mapping springs in Iowa and Waukesha Counties, conducting surveys of representative springs in each county, building a database for the spring-related information, and interpreting these data in association with regional information on geology and topography to assess vulnerability to groundwater withdrawals. The study represents the first assessment of spring resources in these regions in approximately 50 years.

Study Areas

Iowa County is located in southwestern Wisconsin in the Driftless Area (Fig. 1). Land surface elevations range from 630 to 1720 feet above mean sea level (amsl), and the region is characterized by nearly horizontal, Cambrian and Ordovician sandstone and carbonate rocks that are exposed in steep and narrow valleys. Pleistocene deposits are absent except for thin layers of loess and/or hillslope sediments on valleys sides and stream sediment in valley bottoms (Clayton and Attig, 1998). The primary land uses in the county are agricultural (68%), followed by forested lands (20%), federal, state, and county lands (6%), and wetlands (5%). Urban land uses (residential, commercial, and manufacturing) account for less than 3% of the total land use. The population of Iowa County grew by 13% from 1993 to 2003, but as of 2000 the population was less than 23,000 (SWWRPC, 2005).



Figure 1. Location of Iowa and Waukesha Counties.

Land surface elevations in Waukesha County (Fig. 1) range from 700 to 1230 feet amsl, and the bedrock is composed of Cambrian, Ordovician, and Silurian sedimentary strata. Units older and deeper than the Ordovician Maquoketa Formation are often lumped together and referred to as the *deep sandstone aquifer* for purposes of describing and modeling regional groundwater flow (Feinstein et al., 2005). The bedrock is overlain by thick (up to 140m) Pleistocene deposits throughout much of the county. One of the most prominent glacial features in the county is the Kettle Moraine, which is an irregular ridge extending from the southwest corner to the northcentral edge of the county (Clayton, 2001). Waukesha County, along with much of southeastern Wisconsin, is one of the most rapidly developing regions of the state. The rate of land conversion from rural to urban uses during the 1990s was approximately 4.7 square miles per year, and the current population of Waukesha County is over 377,000. In 2000, agricultural (30%) and natural areas (27%) remained the largest land uses; however, urban land uses rose from 29% to 37% in the preceding ten years. Much of the increase in urban land uses is attributed to the area of land used for residential purposes (Waukesha County Department of Parks and Land Use, 2006).

PROCEDURES AND METHODS

Historical Surveys

Surveys that document spring locations in Wisconsin were conducted in the early 1800's (1834 to 1836) by the U.S. government and in 1937 by the U.S. Geological Survey (USGS), i.e., the Bordner Survey. These spring surveys were updated for fish management purposes by the Wisconsin Conservation Department (WCD) from 1956 to 1968 for about 60% of the counties in the state. The WCD gathered data on location, flow rate, land use, and a variety of other spring characteristics relating to the potential to support fisheries. These surveys serve as the basis for the historical information on spring locations in Iowa and Waukesha Counties and were supplemented by springs documented in the USGS Geographic Names Information System, WDNR Surface Water Resources reports, WGNHS publications for southwest Wisconsin (DeGeoffroy, 1969), and publications by local experts (Schoenknecht, 2003).

All historical data were converted to an electronic format by scanning, georeferencing, digitizing, and then saving spring positions as ArcGIS shapefiles. All of the spring attribute data in the WCD surveys were also transposed to a Microsoft Access database. Six-digit unique identifiers were assigned to each spring using the county code and by then numbering the springs in the order they appeared in the WCD surveys. ArcGIS shapefiles and the Access database are available at the UW-Water Resources Library.

Verification of Spring Locations

Spring locations were verified by identifying the current owners of properties that, according to historical data, contain springs. Property ownership was determined using land atlas plat books and geodatabases of tax parcels and ownership data supplied by local land information offices. Phone numbers for owners were determined using phone books and on-line resources. WDNR Land Managers were also identified for state lands. Contact information was found for approximately 68% of the relevant property owners in each county. Owners were contacted, asked whether a spring exists on the land today. If so, the owner was asked to describe the emergent setting, the volume of spring flow, and the persistence of spring flow.

Selection of Representative Springs

In Iowa County, the geographic positions of historical springs were used in association with property owners' descriptions and physical characteristics of the region to select a set of 24 representative springs to survey. The physical characteristics include elevation, slope, and aspect, as determined from a 10-meter digital elevation model, and stratigraphic position and position with respect to stratigraphic contacts, based on the state-wide geologic map of Wisconsin (Mudrey et al., 2007). Elevation and aspect can affect the development of microclimates, and slope and aspect can be valuable in predicting the distribution of biota due to variations in solar energy (Wadsworth and Treweek, 1999). Stratigraphic position may indicate the nature of aquifer heterogeneities that are responsible for springs. Historical spring locations were overlaid onto the regional datasets to determine if spatial relationships between spring position and the physical property exist. Where relationships are thought to exist, springs were selected so as to closely reproduce the distributions observed in the historical data. In Waukesha County, very few historical springs could be verified (see Results and Discussion). Therefore, 20 springs were selected primarily on the basis of property owners' descriptions, access to public or private property, and, to some degree, the geologic setting and geographic distribution of springs within the county.

Comprehensive Surveys

Springer et al. (in prep.) identify the need for an integrated springs classification system to further recognition, management, and conservation of springs ecosystems. They have developed a system that builds on the historical Meinzer (1927) spring discharge classification scheme by incorporating a comprehensive set of spring characteristics including information on spring location, weather conditions, site environmental conditions and land use, habitat, vegetation, wildlife, aquatic and terrestrial invertebrates, geomorphic conditions, geologic conditions, flow characteristics, and water quality. Surveys based on this classification system were conducted at the 24 representative springs in Iowa

County during June and July 2006 and the 20 representative springs in Waukesha County during July and August 2006. Teams of three or four spent two to four hours characterizing each spring. The classification system was modified slightly to reflect the expertise of the sampling team. For example, terrestrial invertebrates were not sampled. A copy of the field survey form is provided in Appendix B. All spring data are stored in the Access database.

Standard methods were applied for all field measurements and the collection of all field samples. Aquatic macroinvertebrates were collected prior to disturbance by site description and physicochemical sampling. The samples were collected using a 12-inch Surber net, a 6-inch Surber net, a D-net, or by hand-picking, where appropriate. Samples were transferred to plastic bags, kept cool, and preserved within 12 hours with 70% Ethyl Alcohol/H₂O solution prior to separation from substrate materials. Specimens were separated from substrate materials by hand-picking and suspension in freshwater, then returned to sealed glass vials for later identification. The number of samples collected at each spring location reflects the size and structural heterogeneity of the spring site. At a minimum, benthic fauna was sampled at the orifice of each spring; all but the smallest springs were also sampled at downstream locations, along springbrooks and, in some cases, at the spring channel/receiving waterbody confluence. Although detailed sampling was conducted, only qualitative analysis of these data was completed.

Water quality samples were collected at the orifice of each spring and analyzed for concentrations of major ions (calcium, magnesium, sodium, potassium, bicarbonate, sulfate, nitrate, and chloride), iron, phosphorous, total dissolved solids (TDS), and alkalinity. Samples were field-filtered, preserved with sulfuric (nutrients) or nitric (metals) acid, as appropriate, and processed at the Wisconsin State Laboratory of Hygiene. Dissolved oxygen (DO), pH, conductivity, temperature, and alkalinity were also measured in the field. Geochemical results were used to calculate charge balances to insure that errors were approximately $\pm 5\%$ or less.

Bimonthly Surveys

Three additional springs in Iowa County were monitored bimonthly in 2006 for the full suite of spring characteristics, including sampling for oxygen-18 and deuterium (Fig. 2). Flow was measured on a monthly basis. The three springs occur at different stratigraphic positions, elevations, and aspects. They also vary by level of disturbance. A spring near Highland is thought to discharge from the Prairie du Chien Group and occurs on a steep and wooded, south-facing slope. Another spring, near Otter Creek, is thought to discharge from the Jordan Formation. It is encased in a concrete spring pool, which occurs in an open setting, near a valley bottom. The third spring, in Governor Dodge State Park, discharges into a spring house, which is located near the upper contact of the St. Peter Formation with the Sinnipee Group. It was monitored in association with the WGNHS and UW-Madison (Carter, in prep.).

RESULTS AND DISCUSSION

Distribution of Springs

This investigation found approximately 407 and 282 historically documented springs in Iowa and Waukesha Counties, respectively (Fig. 2). Contact information was available for 274 property owners in Iowa County, of whom 190 could be reached. Property owners confirmed the presence of 175 of these springs, and access was granted to nearly all of them. Conversations with property owners and observations in the field suggest that many other springs that were not historically mapped also exist in Iowa County. Contact information was available for 193 property owners in Waukesha County, of whom 138 could be reached. Property owners confirmed the presence of approximately 43 of the historical springs, and access was granted to only 25. Conversations with property owners and observations in the field suggest that much of the land that historically contained springs has been developed for residential or commercial purposes. Ponds have also been created on at least six of the properties that once contained distinct springs. Because access was granted to only 25 springs, there was very little flexibility in the selection of springs for surveys in Waukesha County.

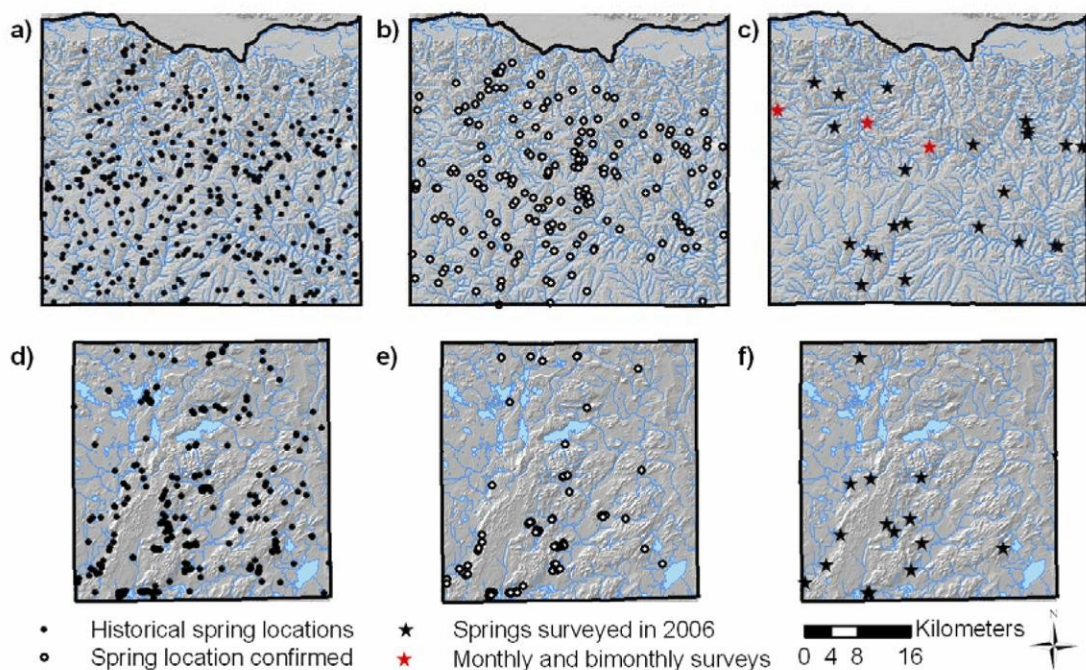


Figure 2. Distribution of a) historical, b) confirmed, and c) surveyed springs in Iowa County and d) historical, e) confirmed, and f) surveyed springs in Waukesha County.

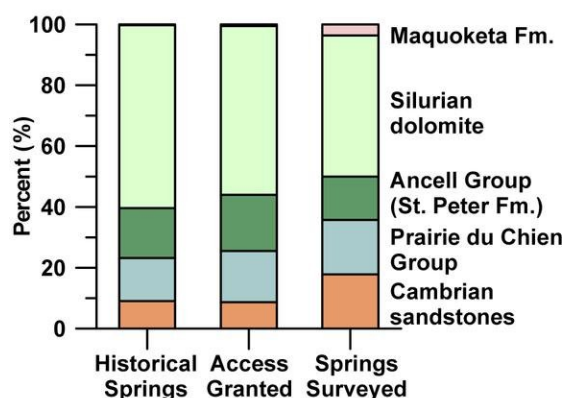


Figure 3. Distribution of springs within major stratigraphic units, Iowa County

Access was granted to nearly 175 springs in Iowa County, so the distribution of springs relative to regional physical conditions could be considered in selecting springs for surveys. On the basis of the historical data, springs are associated with every major stratigraphic unit in Iowa County; however, spatial overlays of the historical springs onto the regional bedrock map show that the springs are not distributed randomly across the landscape. They are most commonly found in association with the Sinnipee Group rocks, near the upper contact of the St. Peter Formation with the Sinnipee Group rocks, or near the upper contact of the Cambrian sandstones with the Prairie du Chien Group (Appendix C). The 24 springs selected for surveying closely resemble these relationships (Fig. 3). Springs

exist throughout the ranges of elevation, slope, and aspect in Iowa County. However, the distributions of springs relative to these properties do not differ significantly from the countywide distributions ($\alpha = 0.05$), so no distinct relationships between spring position and these three properties are thought to exist. However, in selecting representative springs, an effort was made to choose springs from a variety of elevations, slopes, and aspects, thus helping to insure that the springs surveyed are representative of the diversity of physical and ecological conditions in the county (Appendix C).

Physical Characteristics

Flow was measurable at 36 of the 47 springs that were surveyed. The mean discharge for all surveyed springs is 0.24 cfs, but the median is 0.08 cfs (Fig. 4). Among the springs that were monitored, there is no clear relationship between the magnitude of flow and the major stratigraphic unit from which the spring discharges. Three springs discharged at rates of 1 cfs or more at the time of monitoring; however,

one of these springs has been ponded, so the measurement probably includes a significant component of diffuse groundwater discharge. All three of these springs are located in Iowa County.

Fig. 5 shows spring flow hydrographs for two of the springs that were monitored on a monthly basis in Iowa County. The flow record for the third spring in Governor Dodge State Park is less complete and less reliable. Flow measurements are difficult at this site because the water depth is too low for a current meter and the bedrock channel hinders the use of a cutthroat flume. The records show that while the Otter Creek spring responds to seasonal patterns in precipitation, the response is damped, i.e., the total variation in flow throughout the period is relatively low. Discharge at the spring near Highland is more variable and may be more sensitive to storm events.

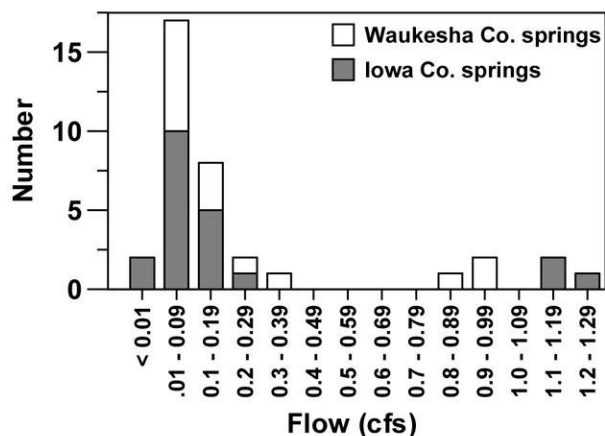


Figure 4. Spring flow (cfs) in Iowa and Waukesha Counties June-August, 2006.

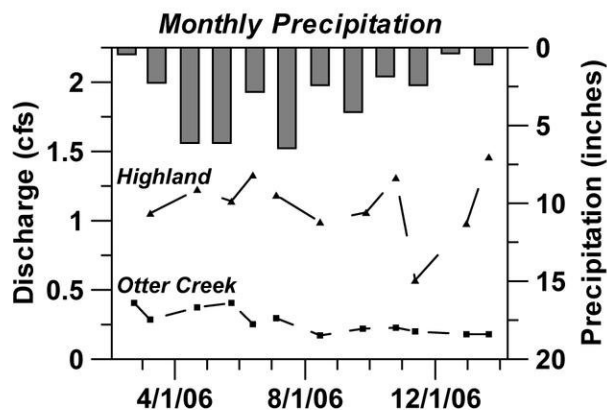


Figure 5. Spring flow measurements for two springs in Iowa County.

Piper diagrams, plots of ion concentrations, and plots of field parameters (Appendix D) show the overall similarity in geochemistry among spring waters in Iowa and Waukesha Counties. For example, water discharging from springs in both counties are a Calcium-magnesium Bicarbonate type. To differentiate possible groundwater flow paths to springs, concentrations of analytes were plotted according to the major stratigraphic unit from which the spring is thought to discharge. This approach assumes that the hydrogeologic properties of the units differ enough to treat each unit as a separate hydrostratigraphic unit. In Iowa County, mean TDS, pH, and nitrate concentrations in spring waters differ significantly ($\alpha = 0.05$) among major stratigraphic units. TDS concentrations in groundwater often increase along a flow path (Freeze and Cherry, 1979). Groundwater flowing along a simplified flow path in Iowa County might originate in a recharge area on a ridge and pass through the Sinnipee Group, the St. Peter Formation, the Prairie du Chien Group, and finally, the Cambrian sandstones. However, not all ridges are composed limestone and dolomite belonging to the Sinnipee Group, and groundwater is probably recharged along some slopes as well as ridge tops. In addition, flow through fractures may dominate in some units, whereas porous media flow dominates in others, resulting in a variety of possible flow paths and residence times. TDS is high in water discharging from the Sinnipee Group rocks and low in water discharging from the Cambrian sandstones. Therefore, TDS concentrations may be more representative of equilibrium conditions within particular units rather than the position along a simplified flow path.

Values of pH that are associated with the stratigraphic units in Iowa County are more indicative of a typical chemical evolution path for water dissolving calcite (Freeze and Cherry, 1979). The values increase from a mean pH of 6.9 for water discharging from the Sinnipee Group to a mean of 7.4 for water discharging from the Cambrian sandstones. Calcite saturation indexes (SI_{cal}) suggest the same chemical evolution path. They generally increase (become more saturated) along the simplified flow path; however, differences in the mean SI_{cal} among stratigraphic units are not significant.

Nitrate concentrations are highest and most variable in springs discharging from the Sinnipee Group. Concentrations are progressively lower and less variable in water discharging from the St. Peter Fm., the Prairie du Chien Group, and the Cambrian sandstones. These relationships are not surprising because many areas that are used for row crops coincide with the areas mapped as the Sinnipee Group.

Bi-monthly sampling results for the springs near Highland, Otter Creek, and Governor Dodge State Park show very little temporal variation in ion concentrations or in environmental isotopes (Appendix D). Even nitrate and chloride concentrations, which could vary in response to seasonal inputs of fertilizers or road salts, are relatively constant (Fig. 6).

Concentrations of both ions do vary at the Governor Dodge spring. However, samples collected from this spring are the only ones that were not analyzed at the WI State Laboratory of Hygiene and which have charge balance errors that are consistently greater than 5% (Carter, in prep.). Therefore, it is unclear if the variation in concentration is real or a result of inaccuracies in the analyses. Concentrations of both ions are consistently greater at the stratigraphically higher Highland and Governor Dodge springs.

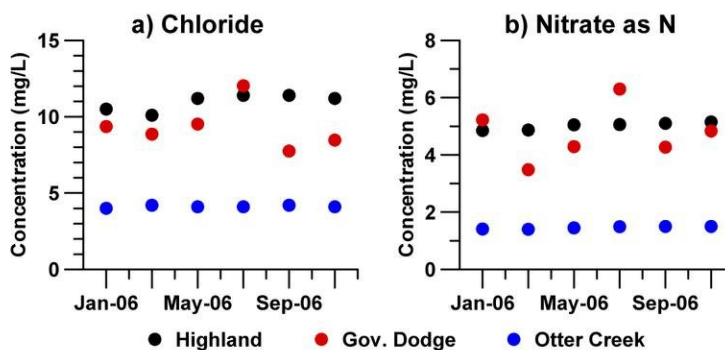


Figure 6. Concentrations of a) Chloride and b) Nitrate as N at springs near Highland, Otter Creek, and Gov. Dodge State Park.

In Waukesha County, relationships between major ion concentrations and stratigraphic units are less clear. Calcium, magnesium, and TDS concentrations appear to be related to stratigraphic units (Appendix D); however, differences in concentrations among the units are not significant ($\alpha=0.05$). This is not surprising because water discharging to springs in the region also flows through overlying glacial deposits; some springs may exist where groundwater flows exclusively through unconsolidated materials. Therefore, hierarchical cluster analysis of ion concentrations, which has been shown to be useful in discerning subtle geochemical differences among spring waters (Swanson et al., 2001), was used. Hierarchical clustering successively joins the most similar observations. Ward's hierarchical clustering method was chosen, and all analytical data were standardized prior to performing the analysis. Standardization is necessary because concentrations vary over a wide range among analytes. Readers are referred to Swanson et al. (2001) for further details of the approach. The analytes chosen for the cluster analysis are calcium, magnesium, TDS, and alkalinity, because these analytes were thought to be good indicators of aquifer materials. Fig. 7 shows that the cluster analysis results in four groups of springs, identified by spring number.

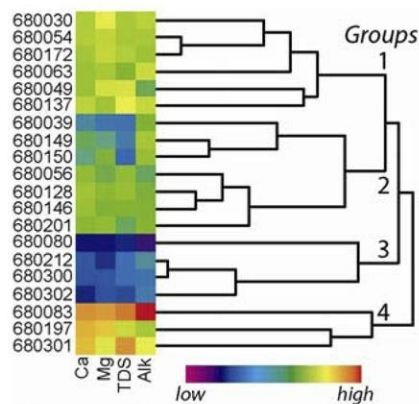


Figure 7. Cluster analysis results, Waukesha County.

Fig. 8 shows the spatial distribution of the four groups of springs overlaid onto a map of the bedrock geology in Waukesha County. Group 1 springs are broadly associated with areas mapped as Silurian dolomite, and Group 2 springs are broadly associated with areas mapped as the Sinnipee Group. Fig. 7 shows the similarity between these two groups of springs, which may help explain the position of one of the Group 2 springs (680056) in an area mapped as Silurian dolomite. Group 4 springs are broadly associated with areas mapped as Maquoketa Formation, but Group 3 springs do not appear to be associated with any of the mapped units. These springs have the lowest relative ion concentrations (Fig. 7), and when overlaid onto a digital elevation model (Fig. 9), it is clear that they align with the

Kettle Moraine, as do many other historical springs (Fig. 2). These observations, albeit preliminary, suggest that the Group 3 springs might be dominated by groundwater that flows primarily through unconsolidated deposits, whereas groundwater discharging to Groups 1, 2, and 4 springs may flow through bedrock somewhere along the flow path.

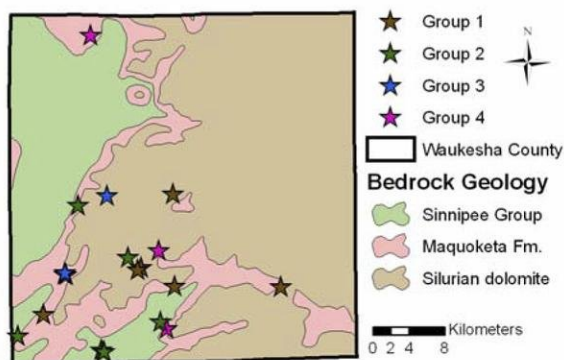


Figure 8. Distribution of geochemical groups and bedrock geology (after Mudrey et al., 2007).

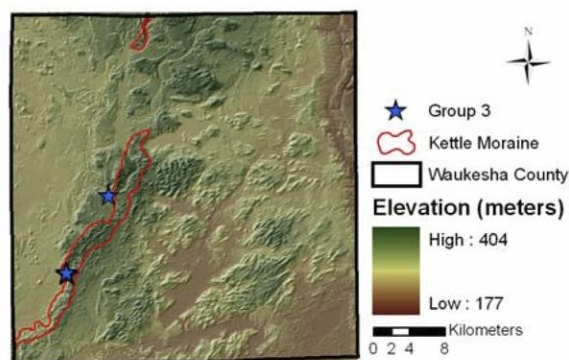


Figure 9. Distribution of Group 3 springs relative to the Kettle Moraine (after Clayton, 2001).

Ecological Characteristics

Ecological assessments of the 47 springs focus on qualitative descriptions macroinvertebrate diversity and quantitative measures of the diversity and distribution of vegetation. Invertebrates are widely used as indicators of water quality in streams, but no criteria currently exists for springs. Springer et al. (in prep.) state that a 95% inventory of aquatic macroinvertebrates may require five or more visits over two or more years. Even so, some general observations of macroinvertebrate diversity can be made on the basis of the sampling conducted during this study. Springs appear to support invertebrate communities that are similar to those observed in northwestern Illinois (Webb et al., 1998). Benthic fauna communities are dominated by non-insect taxa (Amphipoda, Isopoda, Gastropoda), although low numbers of aquatic insects (Tricoptera and Diptera) were found in most springs. Of note was the abundance of caddisfly larvae (Tricoptera) at the Highland spring and the prevalence of the terrestrial slug *Arion fasciatus*, which was found in many of the Iowa County springs. As in other studies of cold-water spring fauna in the region (Webb et al., 1998), benthic invertebrate diversity in spring pools appears to be relatively low compared to other cold-water lotic communities, and downstream changes in diversity are expected due to variations in water temperature and chemistry, substrate, and flow regime (McCabe, 1998).

Ecological surveys that use rapid inventory techniques like those used in this study often assume that native invertebrate diversity will be reflected by native plant diversity (Crisp et al., 1998). Thorough baseline inventories of plants also require far fewer site visits than those needed for aquatic invertebrate inventories (Springer et al., in prep.). Although each of the springs in this study was visited only once, detailed descriptions of the type and prominence of plants were made. The types and proportions of geomorphic surfaces (e.g., pool, colluvial slope) were recorded, and the prominence of vegetative strata classes (e.g., tall canopy, herbaceous) were estimated within each surface type. In addition, species lists were generated and the prominence of each plant in each geomorphic surface type was recorded. Using these data, importance values (IV) and importance percentages (IP) for vascular plants by growth habit were calculated. The IV is the sum of the relative frequency of a given species and the relative coverage for that species; the IP is the IV divided by 2 and expressed as a percentage. Species with higher IVs are considered more dominant. Species lists by site and calculations of IV/IPs are provided in Appendix E.

To determine if patterns of plant diversity exist among springs, the percent cover for six vegetative strata cover classes were plotted for springs grouped by major stratigraphic unit (Fig. 10). Note that total cover can exceed 100% because canopy can coincide with other cover classes. In Iowa County, springs discharging from the stratigraphically higher Sinnipee Group are dominated by herbaceous plants. These

springs exist near ridge tops and edges of valleys where tree cover is relatively low. Dominance by trees (tall and mid-canopy) increases along valley slopes, which are often composed of the St. Peter Fm., the Prairie du Chien Group, or the Cambrian sandstones. Herbaceous plants are more dominant near valley bottoms. Herbaceous plants tend to dominate in Waukesha County, regardless of stratigraphic unit.

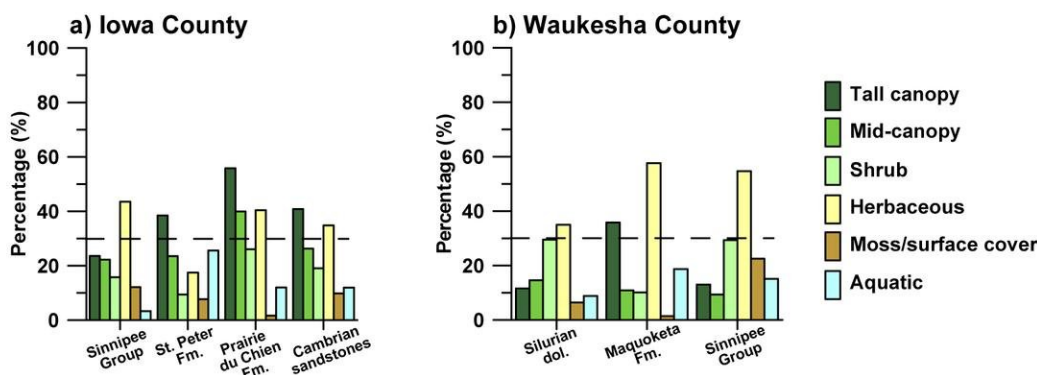


Figure 10. Distribution of Vegetative Strata Cover in a) Iowa County and b) Waukesha County.

For dominant vegetative strata cover classes within each stratigraphic group, i.e., those that exceed 30% cover (Fig. 10), Shannon's index of diversity (H'), the percent cover of native plants, and the percent cover of invasive plants were plotted (Appendix E). Results are similar among stratigraphic groups in Iowa County. Diversity ranges from 0.20 to 0.35 for trees (tall and mid-canopy) and herbaceous plants. The percent cover of native plants ranges from 65 to 100%, and the percent cover of invasive plants ranges from 10 to 38%. Results are also similar among stratigraphic groups of springs in Waukesha County, but diversity is generally higher for herbaceous plants (0.53 – 0.71). The percent cover of native plants ranges from 53 to 77%, and the percent cover of invasive plants is ranges from 21 to 52%.

CONCLUSIONS AND RECOMMENDATIONS

Status of Spring Ecosystems

Iowa County is rich in spring resources, and any loss of spring resources over the last 50 years is minimal. When compared to springs in northwestern Illinois (Webb et al., 1998), the species richness and diversity for plants at the Iowa County springs appears to be a bit lower. However, the percent cover of native species is relatively high and the percent cover of invasives is relatively low. Agricultural and historical uses of spring water clearly impact the ecological status of springs in this region. Cattle currently have or have recently had direct access to nearly 30% of the springs that were surveyed, and three of the springs emerge from spring houses that were originally built as part of a farmstead.

Plant diversity is somewhat higher at the Waukesha County springs, but the percent cover of native plants is lower and the percent cover of invasive plants is higher. The historical use of spring water and associated modifications to springs in the City of Waukesha are very well-documented (Schoenknecht, 2003). None of the springs within the City of Waukesha were surveyed, but results suggest that the ecological status of springs elsewhere in the county has been similarly compromised by historical uses of the water. Approximately 45% of the springs surveyed have been significantly modified in some way. Some springs have pipes that direct flow and others have concrete boxes or spring houses that fully encase the spring and hinder recovery of the natural system.

Conceptual Models and Vulnerability of Springs to Withdrawals

Field data support conceptual models for springs in Iowa County that are based on typical contact springs, where water emerges along slopes and at lithologic contacts with differences in hydraulic conductivity. Springs are associated with every major stratigraphic unit in Iowa County, but are most commonly found in association with the Sinnipee Group, near the upper contact of the St. Peter Fm., or near the upper

contact of the Cambrian sandstones (Fig. 3, Appendix C). This indicates that aquifer heterogeneities like vertical and horizontal fractures, both of which are prevalent throughout the Sinipee Group rocks, or partings along major stratigraphic contacts may be particularly important in promoting discrete flow in the region. There is some evidence that flow is more variable in springs discharging from stratigraphically higher geologic units, which supports a model that includes the influence of fractures. However, isotope levels and concentrations of most ions at these springs are relatively stable, indicating mixing along flow paths and/or a component of flow through porous media. In regions with high topographic relief, like Iowa County, groundwatersheds are more likely to coincide with surface watersheds (Toth, 1963). Therefore, stratigraphically higher springs may have small recharge areas that could be easily delineated by relying on topography. The wide range of nitrate concentrations in water discharging from these springs further supports the existence of small and shallow watersheds, where local land use influences geochemistry. There is also some evidence that flow is less variable in springs discharging from stratigraphically lower geologic units, which indicates longer or less direct flow paths. There is less variability in nitrate concentrations at these springs, and concentrations are generally lower. This indicates broader or deeper groundwatersheds, with a greater degree of mixing along flow paths.

The vulnerability to pumping of individual springs in Iowa County will require site-specific investigation because perched water tables and local aquitards are common in the Driftless Area (Krohelski et al., 2000). However, some generalizations can be made on the basis of the models presented above and the distribution of high-capacity wells in the county. Springs discharging from stratigraphically higher units are likely to be vulnerable to pumping from wells along ridge tops that are installed in these aquifers or that span multiple aquifers. Because recharge areas for these springs are probably small and shallow, pumping could result in substantially reduced spring flow or complete loss of flow to small springs. Springs discharging from stratigraphically lower units are probably less vulnerable, due in part to broader contributing areas, but also because most high-capacity wells that pump water from the Cambrian sandstones are located in the floodplain of the Wisconsin River, where few springs exist (Appendix F).

The spatial distribution of springs in Waukesha County is influenced by the glacial topography and the position of the Maquoketa shale subcrop. Springs were historically concentrated along the western margin of the Kettle Moraine and within the drumlinized zone to the east (Fig. 2). Very few springs were mapped northwest of the Maquoketa shale subcrop, which is recognized as an important recharge area for the deep sandstone aquifer (Feinstein et al., 2005). The four geochemical groups of springs presented above require more thorough testing; however, results suggest that while flow paths originate in the unlithified aquifer, groundwater may flow through shallow bedrock before discharging as depression springs in low-lying wetlands or near streams. Regional flow modeling for southeastern Wisconsin supports this conceptual model, and shows local, topographically-controlled flow systems near the Kettle Moraine and other areas of relief. Particle tracking shows that groundwater intersects shallow bedrock before discharging to surface water bodies or at the water table (Feinstein et al., 2005). Although they are not explicitly modeled, groundwater may flow along similar paths to springs.

Feinstein et al. (2005) conclude that the widespread regional pumping in southeastern Wisconsin (Appendix F) has affected some shallow flow patterns, especially those west of the Maquoketa shale subcrop, and that downward flow from the shallow to the deep parts of the system occurs. Furthermore, their work shows that shallow high-capacity wells derive water primarily from diverted baseflow or induced flow from streams. Therefore, springs in Waukesha County are likely to be vulnerable to additional groundwater withdrawals from both the shallow and deep parts of the system. However, Group 3 springs are probably most vulnerable to withdrawals from the unlithified aquifer, and Group 1, 2, and 4 springs are most vulnerable to withdrawals from the shallow bedrock aquifer.

The approach to developing conceptual models of springs and assessing their vulnerability to pumping relies on gaining confidence in the positional accuracy of historical springs, as well as interpreting the

site-specific geochemical and spring flow data that were collected as part of this study. In Iowa County, 92% of the property owners that were interviewed confirmed the location of one or more springs on their property. Fewer springs remain in Waukesha County, but many owners recall the existence of a spring on their property in the past. Therefore, the overall confidence in historical spring locations is high, which allows their use in association with patterns of regional geology and topography. These regional data are complemented by the depth of the site-specific information collected using the Springer et al. (in prep.) system. At least 20 springs were surveyed in each county. This number of springs provided sufficient data to develop conceptual models and preliminarily assess vulnerability to pumping, suggesting that the overall approach may also be successful elsewhere in the state.

REFERENCES

- Carter, J., in preparation, Investigation of perched and regional flow systems in bedrock aquifers, Iowa County, WI: Madison, WI, University of Wisconsin-Madison, M.S. Thesis.
- Clayton, L., and Attig, J.W., 1997, Pleistocene geology of Dane County, WI: WGNHS Bulletin 95, 64p.
- Clayton, L., 2001, Pleistocene geology of Waukesha County, WI: WGNHS Bulletin 99, 33p. plus map.
- Craig, H., 1961, Isotopic variations in meteoric waters: *Science*, v. 133, no. 3465, p. 1702-1703.
- Crisp, P.N., Dickinson, K.J.M., and Gibbs, G.W., 1998, Does native invertebrate diversity reflect native plant diversity?: *Biological Conservation*, vol. 83, no. 2, p.209-220.
- DeGeoffroy, J., 1969, Geochemical prospecting by spring sampling in the southwest Wisconsin zinc mining area: WGNHS Information Circular 10, 28p.
- Feinstein, D.T., Hart, D.J., Krohelski, J.T., Eaton, T.T., Bradbury, K.R., 2005, Simulation of regional groundwater flow in southeastern Wisconsin, Report 2: Model results and interpretation: U.S.G.S. and WGNHS Final Administrative Report to the Southeast WI Regional Planning Commission, 63p.
- Freeze, R.A., and Cherry, J.A., 1979, *Groundwater*: Englewood Cliffs, NJ, Prentice-Hall, Inc., 604p.
- Krohelski, J.T., Bradbury, K.R., Hunt, R.J., and Swanson, S.K., 2000, Numerical simulation of groundwater flow in Dane County, Wisconsin: WGNHS Bulletin 98, 31p.
- McCabe, D.J., 1998, Biological communities in springbrooks, *in* Botosaneanu, L., ed., *Studies in crenobiology: the biology of springs and springbrooks*: Leiden, Backhuys Publishers, p. 221-228.
- Meinzer, O.E., 1927, Large springs in the United States: U.S.G.S. Water-Supply Paper 557, 94p.
- Mudrey, M.G., Jr., Brown, B.A., and Greenberg, J.K., 2007, Bedrock geologic map of Wisconsin: WGNHS State Map 18-DI, version 1.0, 1 CD-ROM.
- Schoenknecht, J.M., 2003, The Great Waukesha Springs Era, 1868-1918: Waukesha, WI, , 322p.
- Springer, A.E., Stevens, L.E., Anderson, D.E., Parnell, R.A., Kreamer, D.K., and Flora, S.P., in prep., A comprehensive springs classification system: integrating geomorphic, hydrogeochemical, and ecological criteria, *in* Stevens, L.E., and Meretsky, V.J., eds., *Every last drop: ecology and conservation of springs ecosystems in North America*: Tucson, University of Arizona Press.
- Southwest WI Regional Planning Commission (SWWRPC), 2005, Iowa County Comprehensive Plan: SWWRPC Planning Report No. 05/188.
- Swanson, S.K., Bahr, J.M., Schwar, M.T., and Potter, K.W., 2001. Two-way cluster analysis of geochemical data to constrain spring source waters: *Chemical Geology* vol., 179, no. 1-4, p.73-91.
- Swanson, S.K., Bahr, J.M., and Potter, K.W., 2006. A local meteoric water line for Madison, Wisconsin: WGNHS Open File Report 2006-01, 4 p.
- Toth, J., 1963, A theoretical analysis of groundwater flow in small drainage basins: *Journal of Geophysical Research*, vol. 68, p.4795-4812.
- Wadsworth, R., and Treweek, J., 1999, *Geographical Information Systems for Ecology*: Essex, England, Addison Wesley Longman Limited, 184p.
- Waukesha County Department of Parks and Land Use, Land Resources Division, 2006, Waukesha County Land and Water Resource Management Plan 2006 – 2010: Waukesha, WI, 92p.
- Webb, D.W., Wetzal, M.J., and Phillippe, L.R., 1998, The aquatic biota and groundwater quality of springs in the Lincoln Hills, Wisconsin Driftless, and Northern Till Plains of Illinois: Illinois Natural History Survey, Center for Biodiversity Technical Report 1998 (6), 164p.

APPENDIX A: Presentations and Awards

Swanson, S.K., March 2007. Assessing the ecological significance and vulnerability of springs in southern Wisconsin, American Water Resources Association - Wisconsin Section Annual Meeting, Wisconsin Dells, Wisconsin.

Outstanding Undergraduate Presentation Award:

Bartkowiak, B.M. and Swanson, S.K., March 2007. Geochemical and flow characteristics of two contact springs in Iowa County, Wisconsin, American Water Resources Association - Wisconsin Section Annual Meeting, Wisconsin Dells, Wisconsin.

APPENDIX B: Field Survey Form from Springer et al. (in prep.)

SITE INFORMATION /PHOTOS

CLIMATE

SITE ENVIRONMENTAL DESCRIPTION

Page - 1

SITE DESCRIPTION FORM

SITE CODE: -- S SITE NAME: DATE:

[illegible]

SITE CONDITION AND LAND USE

<p><u>Overall site condition and disturbance</u> (check appropriate boxes): <input type="checkbox"/> pristine <input type="checkbox"/> natural disturbance <input type="checkbox"/> anthropogenic disturbance</p>
<p><u>Natural Disturbance</u> (if box is checked above, then indicate the types of natural disturbance present on the site): <input type="checkbox"/> recent flooding <input type="checkbox"/> windthrow <input type="checkbox"/> native ungulate grazing <input type="checkbox"/> insect disturbance <input type="checkbox"/> other (describe): _____</p>
<p><u>Anthropogenic Disturbance</u> (if box is checked above, then indicate the types of anthropogenic disturbance present on the site): <input type="checkbox"/> roads/OHV trails <input type="checkbox"/> hiking trails <input type="checkbox"/> recreation use <input type="checkbox"/> flow modification <input type="checkbox"/> livestock grazing <input type="checkbox"/> historic human occupation/use <input type="checkbox"/> prehistoric human occupation/use <input type="checkbox"/> other (describe): _____</p>
<p>Site disturbance comments (use to describe all disturbance other than flow modification): </p>
<p><u>Flow Modification</u> (if box checked above, enter ‘PRE’ or ‘POST’ in applicable fields): <input type="checkbox"/> none ____ pipe diversion ____ dam diversion ____ open trough/tank ____ pumping ____ encasement ____ excavation ____ sealed cracks ____ other (describe in comments) -----</p>
<p><u>Impact on flow</u> (check appropriate box): <input type="checkbox"/> none <input type="checkbox"/> slowed <input type="checkbox"/> stopped <input type="checkbox"/> rerouted <input type="checkbox"/> increased -----</p>
<p>Flow modification comments: </p>

SITE DESCRIPTION FORM

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

AMPHIBIAN AND OTHER WILDLIFE OBSERVATION

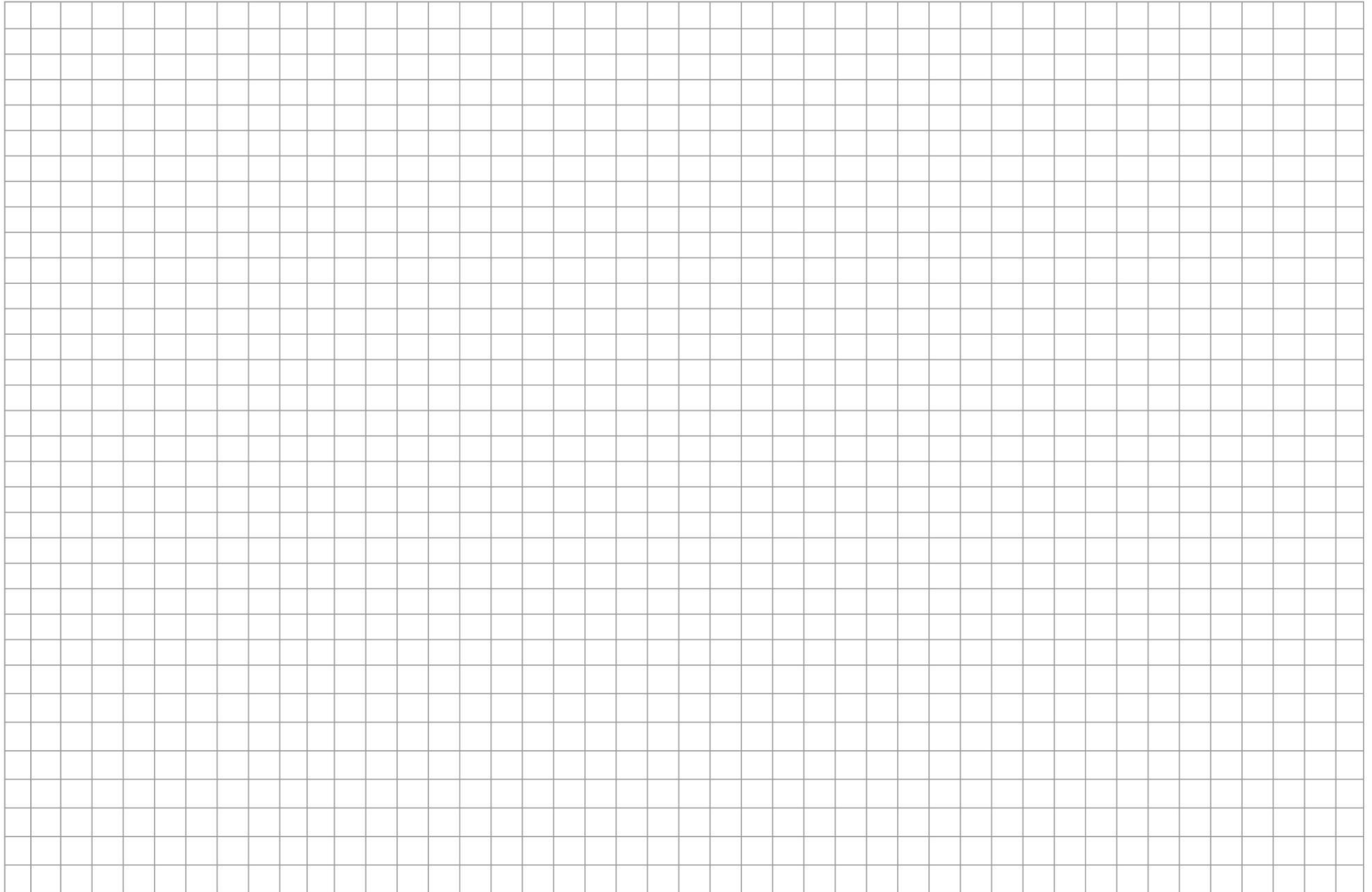
<u>Amphibians Survey Conducted:</u> <input type="checkbox"/> yes <input type="checkbox"/> no		
Scientific Names:		
Amphibian Comments:		
Wildlife Observations - (check which groups were <u>directly</u> observed on the site):		
<input type="checkbox"/> Bird <input type="checkbox"/> Mammal <input type="checkbox"/> Reptile		
Wildlife Comments (use this field to document species observed and indirect evidence of bird, mammal and reptile presence/use):		

SITE DESCRIPTION FORM

SITE SKETCH MAP

Site Code: _____ -- S _____

Site Name: _____



SKETCH MAP CODES: WQ = water quality measurement site PP = photopoint (w/#) OR = spring orifice PO = paleo-orifice CH = channel
DI = discharge measurement site GPS = GPS reading site PL = pool location FM = flow modification SR = solar radiation reading site

SITE DESCRIPTION FORM

EXTRA PHOTO LOG SHEET

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

Photo#	Photo Type*	Roll#	Frame#	Time	Hgt (cm)	Photographer	Caption
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
Photo Relocation Comments:							
* Note: Photo Type Choices: Site; Landscape, Feature, Fieldwork, Fauna, Vegetation, Disturbance, Other							

INVERTEBRATES FORM

SITE CODE: _____--S_____

SITE NAME: _____ **DATE:** _____

FORM: _____ **OF** _____

INVERTEBRATE SURVEYS CONDUCTED AT SITE (check all boxes that apply): ☐ T/spot ☐ T/sweep ☐ T/sheet ☐ A/spot ☐ A/kicknet ☐ A/D-net

TERRESTRIAL AND AQUATIC INVERTEBRATE SURVEY – QUALITATIVE SAMPLING

START TIME _____ END TIME _____

This datasheet is used to document terrestrial invertebrate species surveyed using a combination of sweep netting, spot collecting and beating/sheet methods and/or aquatic invertebrates using a spot sampling method.

[illegible]

INVERTEBRATES FORM

SITE CODE: _____ -- S _____

SITE NAME: _____ **DATE:** _____

FORM: _____ OF _____

AQUATIC INVERTEBRATE SURVEY – QUANTITATIVE SAMPLING

Use this datasheet to record aquatic invertebrate species observed and/or collected using quantitative methods (kick net and D-framed net).

[illegible]

Aquatic Habitat		Clay (not visible, smooth)		Fine Gravel (2-15mm, lady bug to marble)		Boulder (>250mm, basketball to car)		6	>95% cover	3	10-25%
Macrophyte % Cover		Silt (not visible to eye, but gritty)		Coarse Gravel (15-65mm, marble to tennis ball)		Bedrock (larger than a car)		5	50-95%	2	1-10%
Algal % Cover		Sand (0.06-2mm, visible to eye)		Cobble (65-250mm, tennis ball to basketball)		Wood (any size)		4	25-50%	1	<1%

VEGETATION SURVEY FORM

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

VEGETATION SPECIES FORM _____ OF _____ START TIME _____ END TIME _____

Species Cover Class: Starting with the uppermost stratum list all species with full scientific names, cover class for each species by geomorphic type. It may be helpful to group by lifeform, e.g. tree, shrub, graminoid, forbs, nonvascular. If the identification of a plant species is unknown please collect an ID sample and assign a unique unknown species code as described in the protocol. Use a check mark to indicate if ID collections or voucher collections were made.

[illegible]

Prominence scale for estimating vegetation and substrate cover					
Number	Class Name	Definition	Number	Class Name	Definition
6	Dominant	>95% cover	2	Uncommon	1-10% cover
5	Abundant	50-95% cover	1	Occasional	<1% cover
4	Common	25-50% cover	0	Rare	few individuals
3	Somewhat common	10-25% cover			

Geomorphic Surface Type Code			
Code	Name	Code	Name
BW	Backwall	SM	Spring Mound
SB	Sloping Bedrock	PL	Pool
CS	Colluvial Slope	TE	Terrace
C	Cave	TU	Tunnel
CH	Channel	MAD	Unfocused Madicolous Flow
HGC	High Gradient Cienega	OTH	Other
LGC	Low Gradient Cienega		

VEGETATION SURVEY FORM

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

Veg Strata Classes		Soil Moisture Classes (top 10 cm)			Substrate Classes		
Code	Class Name	Code	Class Name	Definition	Code	Class Name	Definition
T	tall canopy (>10 m)	6	inundated	standing water in soil	1	Clay	Not visible, smooth
C	mid-canopy (4-10 m)	5	saturated	completely wet, no standing water	2	Silt	Not visible, gritty
S	shrub (0-4 m)	4	wet	soil easily sticks together	3	Sand (0.06-2 mm)	Visible, gritty, up to ladybug size
H	herbaceous	3	damp	moderate moisture	4	Fine gravel (2-15 mm)	Ladybug to marble
M	moss/surface cover	2	moist	like after a light rain	5	Coarse gravel (15-65 mm)	Marble to tennis ball
A	Aquatic	1	dry	no moisture, soil easily separates	6	Cobble (65-250 mm)	Tennis ball to basketball
Prominence Scale					7	Boulder (>250 mm)	Basketball to car
Code	Class Name	Code	Class Name		8	Bedrock	Larger than a car
6	Dominant (>95%)	2	Uncommon (1-10%)		WD	Wood	Any size
5	Abundant (50-95%)	1	Occasional (<1%)		LI	Litter	Dead organic matter
4	Common (25-50%)	0	Rare (<<1%, few individuals)		SL	Soil	Mineral soil
3	< common (10-25%)				OT	Other	Use comments field

[illegible]

GPS AND GEOMORPHOLOGY DATASHEET

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

LOCATION - GPS (Take one reading at centroid of site)

START TIME _____

END TIME _____

UTM's from (check one) : <input type="checkbox"/> Map <input type="checkbox"/> GPS Datum NAD 83 Zone: _____ GPS Name and Model: _____					
GPS File Name	Field UTM X	Field UTM Y	PDOP	Error +/- (m)	3D Differential Y or N
	_____ mE	_____ mN			
GPS comments:					

GEOLOGIC UNIT DESCRIPTION

<u>Geologic Unit Name</u>		<u>Source Geologic Unit Code</u>		<u>Site Geologic Unit Code</u>		<u>Geologic Unit Comments:</u>	
Rock Sample Taken:		1		1			
<input type="checkbox"/> yes <input type="checkbox"/> no		2		2			
		3		3			
<u>Rock Type and Rock Subtype for Primary Geologic Unit</u> (check <u>one</u> box for primary type and <u>one</u> box for primary subtype)						<u>Rock Type Characterization for Primary Geologic Unit</u>	
<input type="checkbox"/> Sedimentary	<input type="checkbox"/> Igneous	<input type="checkbox"/> Metamorphic		<u>Percent Grain Size (total=100%)</u>		<u>Grain Shape</u>	
<input type="checkbox"/> shale	<input type="checkbox"/> granite	<input type="checkbox"/> marble		_____ Clay (not visible, smooth)		<input type="checkbox"/> spherical	
<input type="checkbox"/> mudstone	<input type="checkbox"/> granodiorite	<input type="checkbox"/> quartzite		_____ Silt (not visible to eye, but gritty)		<input type="checkbox"/> oblong	
<input type="checkbox"/> siltstone	<input type="checkbox"/> diorite	<input type="checkbox"/> slate		_____ Sand (0.06-2mm, visible to eye)		<input type="checkbox"/> other:	
<input type="checkbox"/> sandstone	<input type="checkbox"/> gabbro	<input type="checkbox"/> schist		_____ Fine Gravel (2-15mm, lady bug to marble)		<u>Grain Orientation</u>	
<input type="checkbox"/> conglomerate	<input type="checkbox"/> peridotite	<input type="checkbox"/> gneiss		_____ Coarse Gravel (15-65mm, marble to tennis ball)			
<input type="checkbox"/> limestone	<input type="checkbox"/> rhyolite	<u>Carbonate</u>		_____ Cobble (65-250mm, tennis ball to basketball)			
<input type="checkbox"/> dolomite	<input type="checkbox"/> dacite	<input type="checkbox"/> yes <input type="checkbox"/> no		_____ Boulder (>250mm, basketball to car)		<input type="checkbox"/> imbrication	
<input type="checkbox"/> evaporites	<input type="checkbox"/> andesite	Strike _____°		<u>Rock Color</u>		<input type="checkbox"/> random	
<input type="checkbox"/> coal	<input type="checkbox"/> basalt	Dip _____°		_____ / _____		<input type="checkbox"/> other	
Rock type comments:							

EMERGENCE ENVIRONMENT DESCRIPTION

<u>Emergence Environment</u> (check one): <input type="checkbox"/> cave <input type="checkbox"/> sub-aerial <input type="checkbox"/> subaqueous-lentic <input type="checkbox"/> subaqueous-lotic <input type="checkbox"/> other (describe in comments)
Emergence environment comments:
<u>Subaerial Emergence Setting</u> (ck one): <input type="checkbox"/> channel <input type="checkbox"/> floodplain <input type="checkbox"/> terrace <input type="checkbox"/> canyon wall <input type="checkbox"/> prairie <input type="checkbox"/> mountain side other (please describe)
<u>Emergence Substrate Character</u> (check one): <input type="checkbox"/> organic ooze <input type="checkbox"/> silt <input type="checkbox"/> sand <input type="checkbox"/> rock <input type="checkbox"/> other (describe): _____

FLOW FORCING MECHANISMS

<u>Flow Forcing Type</u> (check one): <input type="checkbox"/> gravity <input type="checkbox"/> artesian <input type="checkbox"/> geothermal <input type="checkbox"/> natural pressure <input type="checkbox"/> anthropogenic pressure <input type="checkbox"/> undetermined
Flow forcing mechanism comments:

GPS AND GEOMORPHOLOGY DATASHEET

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

SPRING TYPE AND ORIFICE CHARACTERIZATION

<u>Orifice Number</u> (check one): <input type="checkbox"/> single <input type="checkbox"/> multiple	
<u>Orifice Geomorphic Type</u> (check one): <input type="checkbox"/> seepage/filtration spring <input type="checkbox"/> fracture spring <input type="checkbox"/> tubular spring <input type="checkbox"/> contact spring	
<u>Spring Type</u> (check one): <input type="checkbox"/> cave <input type="checkbox"/> limnocrone <input type="checkbox"/> rheochrene <input type="checkbox"/> mound-form <input type="checkbox"/> heleocrone <input type="checkbox"/> hillslope <input type="checkbox"/> gushette <input type="checkbox"/> hanging garden <input type="checkbox"/> exposure <input type="checkbox"/> hypocrene	
<u>Spring type and orifice comments:</u> 	

SPRING CHANNEL CHARACTERIZATION

<u>Channel Present</u> (check one) : <input type="checkbox"/> yes <input type="checkbox"/> no	Number of Channels: _____	Meander Distance: _____ (m)
<u>Flow Type</u> (check one): <input type="checkbox"/> perennial <input type="checkbox"/> intermittent <input type="checkbox"/> ephemeral	<u>Channel Length</u> : _____ (m)	<u>Channel Slope</u> : _____ deg.
<u>Channel Width</u> (m) _____	<u>Channel Depth</u> (m) _____	
<u>Channel profile comments:</u> 		
<u>Channel substrate comments:</u> 		
Channel Type: <input type="checkbox"/> spring discharge dominated <input type="checkbox"/> run-off dominated <input type="checkbox"/> mixed		
<u>Channel Type Comments:</u> 		

WATER QUANTITY AND QUALITY DATASHEET

SITE CODE: _____ -- S _____ SITE NAME: _____ DATE: _____

START TIME _____ END TIME _____

WATER QUANTITY

Measurable Discharge (check one) : <input type="checkbox"/> yes <input type="checkbox"/> no		# Discharge Measurements: _____				
Instrument Type (check one):	Model Name	Serial Number	Description of where discharge measurement was taken:			
<input type="checkbox"/> weir (L/s)						
<input type="checkbox"/> current meter (m³/s)						
<input type="checkbox"/> cutthroat flume (m³/s)						
<input type="checkbox"/> volumetric (L/s)						
<input type="checkbox"/> other (L/s)						
WEIR MEASUREMENTS – STAGE		Weir Plate Size		Calculated Total Discharge (L/s)	Cumulative Discharge (L/s)	
_____		<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg		_____		
_____		<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg		_____		
_____		<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg		_____		
_____		<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg		_____		
_____		<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg		_____		
CUTTHROAT FLUME MEASUREMENTS – STAGE		Flume Size	Average Stage	% Flow	Calculated Total Discharge (L/s)	Cumulative Discharge (L/s)
_____		<input type="checkbox"/> 1 in <input type="checkbox"/> 8 in	_____	_____	_____	
_____		<input type="checkbox"/> 1 in <input type="checkbox"/> 8 in	_____	_____	_____	
_____		<input type="checkbox"/> 1 in <input type="checkbox"/> 8 in	_____	_____	_____	
_____		<input type="checkbox"/> 1 in <input type="checkbox"/> 8 in	_____	_____	_____	
_____		<input type="checkbox"/> 1 in <input type="checkbox"/> 8 in	_____	_____	_____	
CURRENT METER MEASUREMENTS					Calculated Total Discharge (L/s)	
VOLUMETRIC MEASUREMENTS – TIME TO FILL		Average Fill Time	Container Size	Calculated Total Discharge (L/s)	Cumulative Discharge (L/s)	
_____		_____	<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg			
_____		_____	<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg			
_____		_____	<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg			
_____		_____	<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg			
_____		_____	<input type="checkbox"/> sm <input type="checkbox"/> med <input type="checkbox"/> lg			
OTHER METHODS		Name of Method		Calculated Total Discharge (L/s)	Cumulative Discharge (L/s)	

Discharge comments:						

WATER QUANTITY AND QUALITY DATASHEET

SITE CODE: _____ -- S _____ **SITE NAME:** _____ **DATE:** _____

START TIME _____ **END TIME** _____

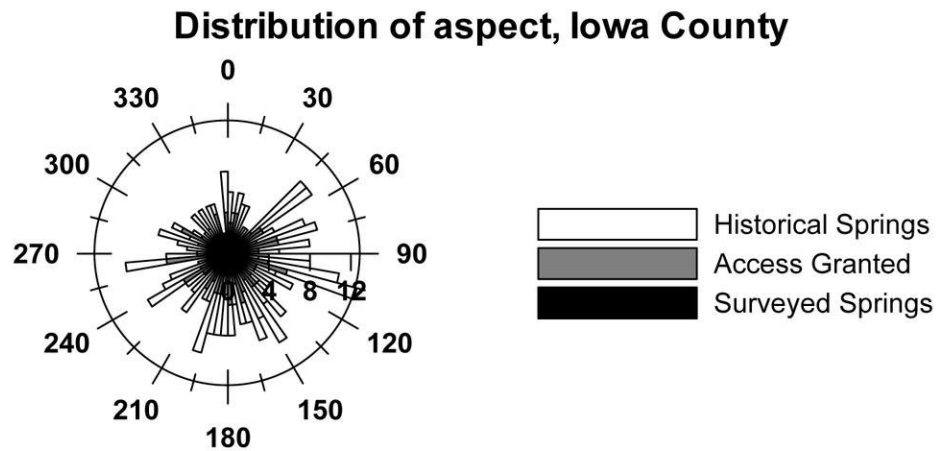
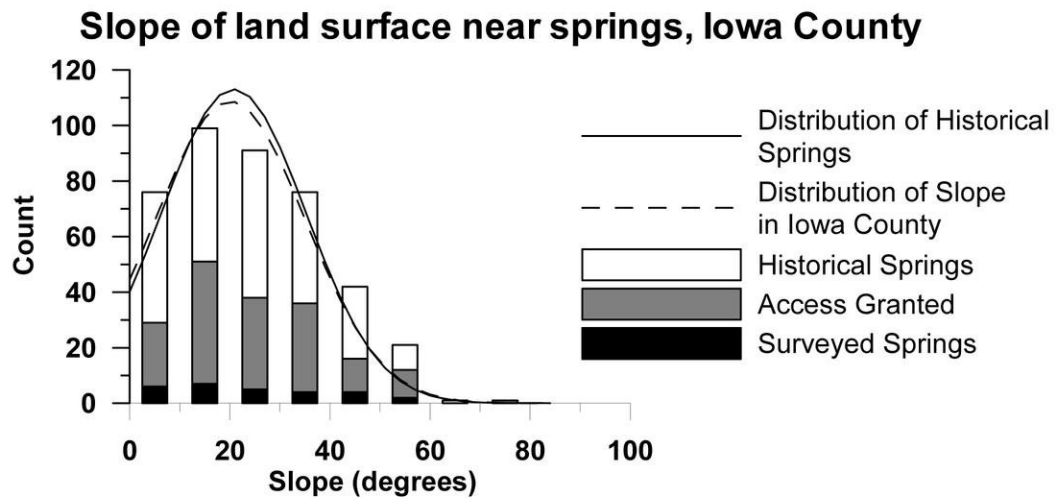
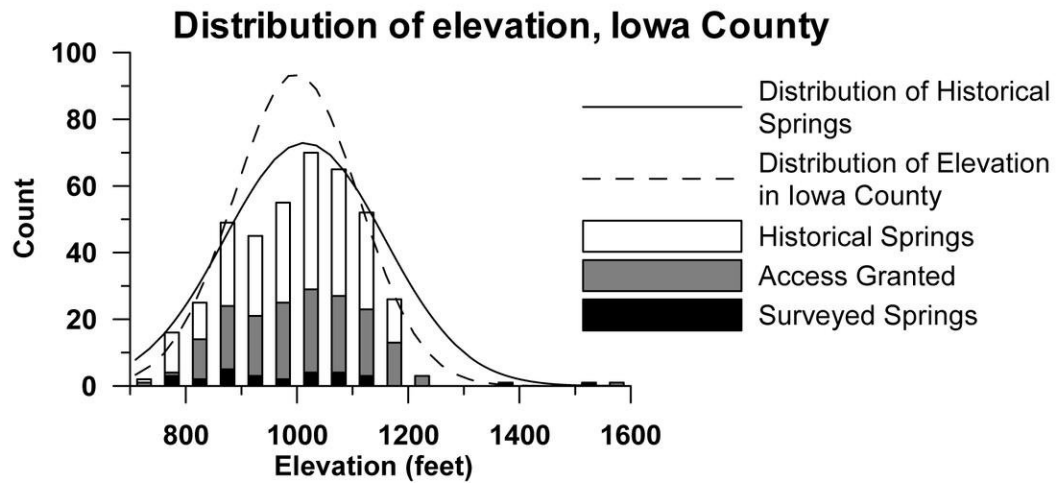
WATER QUALITY- FIELD BASED MEASUREMENTS

Measurements Taken: <input type="checkbox"/> yes <input type="checkbox"/> no		Troll9000 Serial # _____ Calibration Date: _____ Time: _____		
Water: flowing still/pooled				
<u>Depth (cm)</u>	<u>pH</u>	<u>Conductivity (µS/cm)</u>	<u>Dissolved Oxygen (mg O²/L)</u>	<u>Water Temperature (C⁰)</u>
Average:				
Field Water Quality Measurement Comments:				

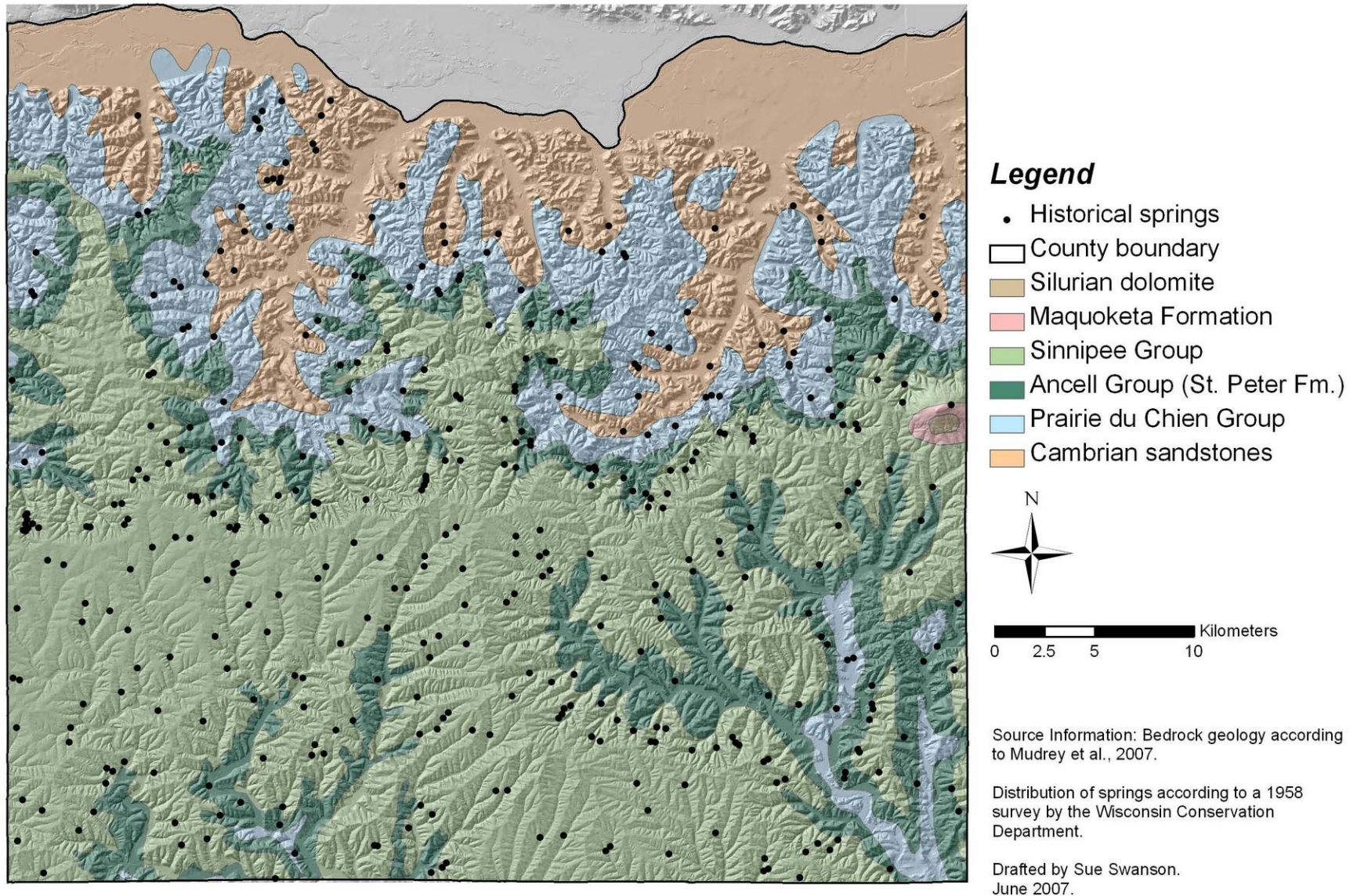
WATER QUALITY- SAMPLES COLLECTED FOR LABORATORY ANALYSIS

Water Quality Sample Type	Sample Taken (check box)	Duplicate Taken (check box)	
Alkalinity (250mL poly)	<input type="checkbox"/>	<input type="checkbox"/>	
Anions (250 mL poly, F)	<input type="checkbox"/>	<input type="checkbox"/>	
Cations (250 mL poly, F, HNO ³)	<input type="checkbox"/>	<input type="checkbox"/>	
Nutrients (60mL poly, F, H ₂ SO ⁴)	<input type="checkbox"/>	<input type="checkbox"/>	
¹⁸ O Isotope (60mL glass)	<input type="checkbox"/>	<input type="checkbox"/>	
² H Isotope (60mL glass)	<input type="checkbox"/>	<input type="checkbox"/>	
Comments on collection of water quality samples for laboratory analysis:			

APPENDIX C: Regional Information on the Distribution of Springs in Iowa County

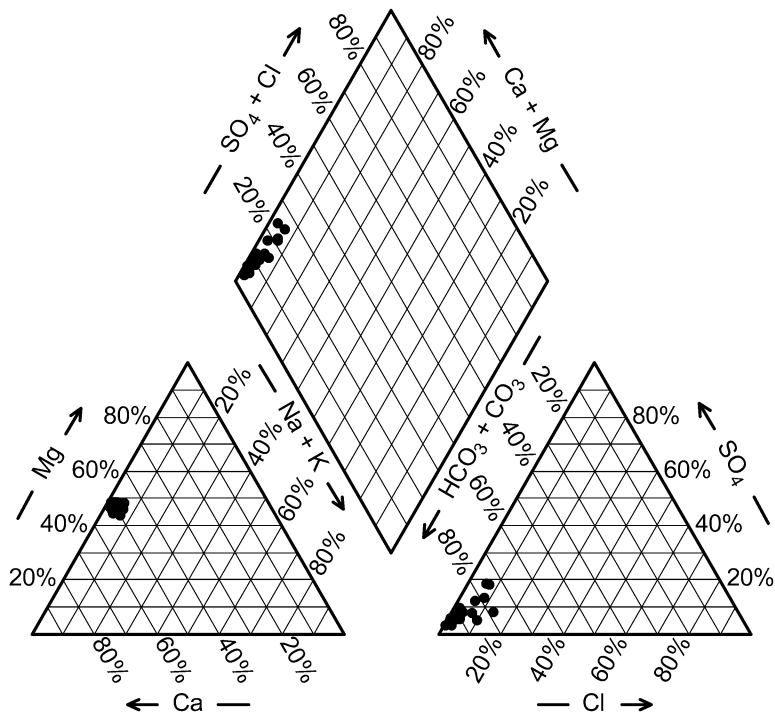


Distribution of Springs and Bedrock Geology in Iowa County, Wisconsin

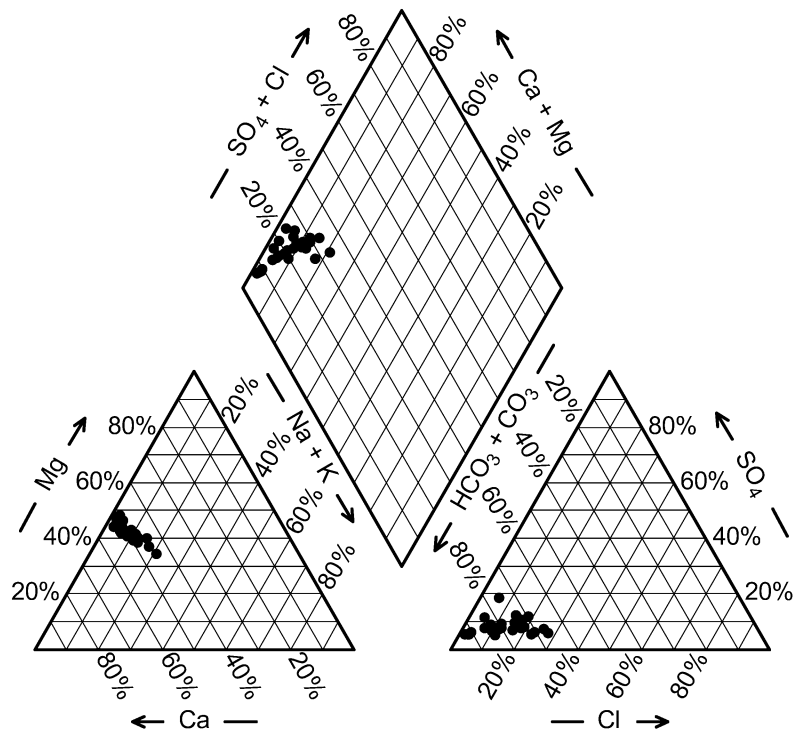


APPENDIX D: Geochemistry Results and Charts

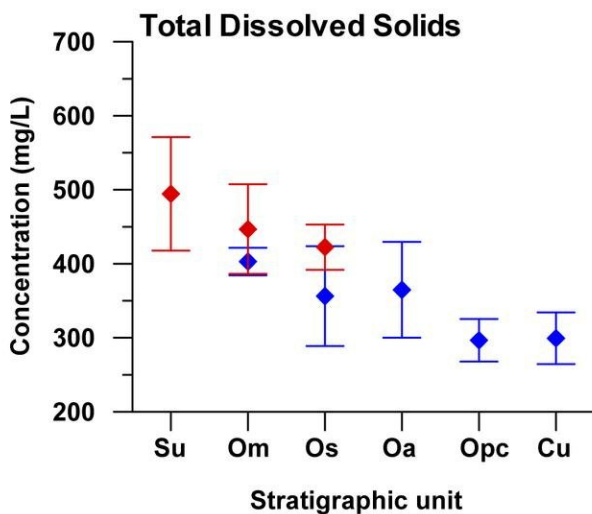
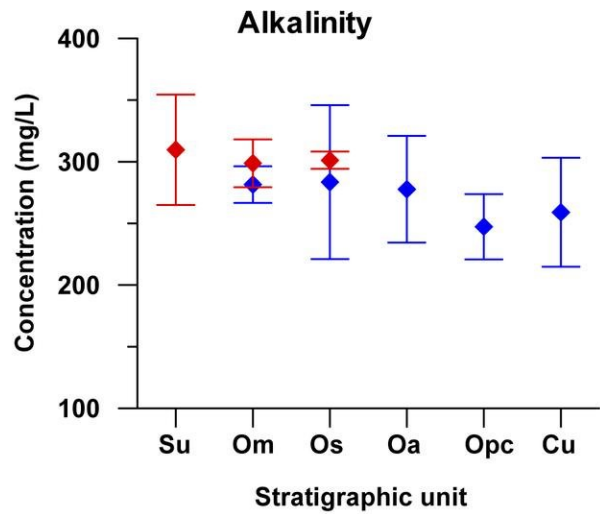
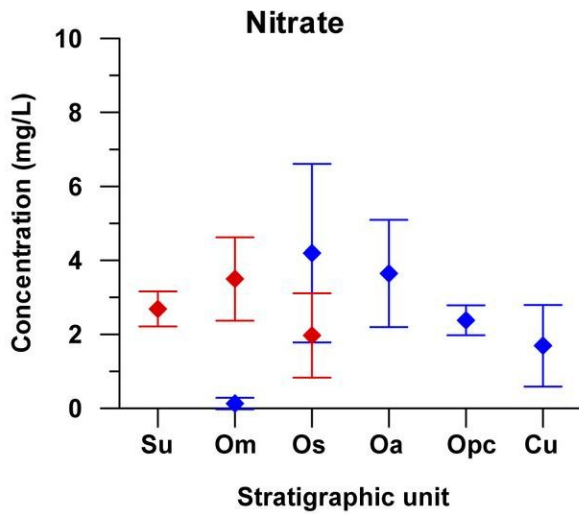
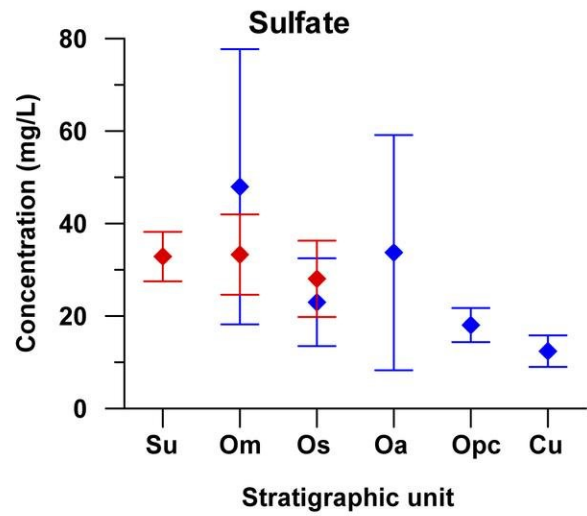
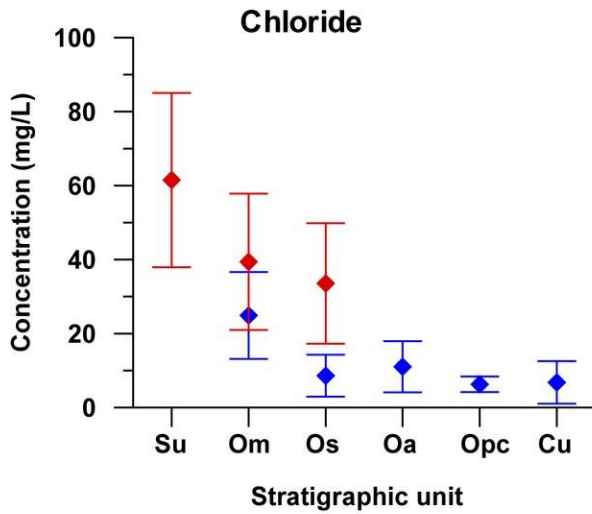
Piper Diagram for Iowa County Springs



Piper Diagram for Waukesha County Springs

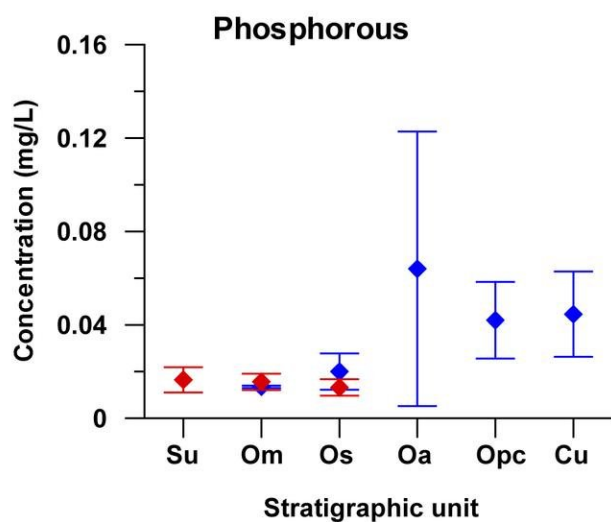
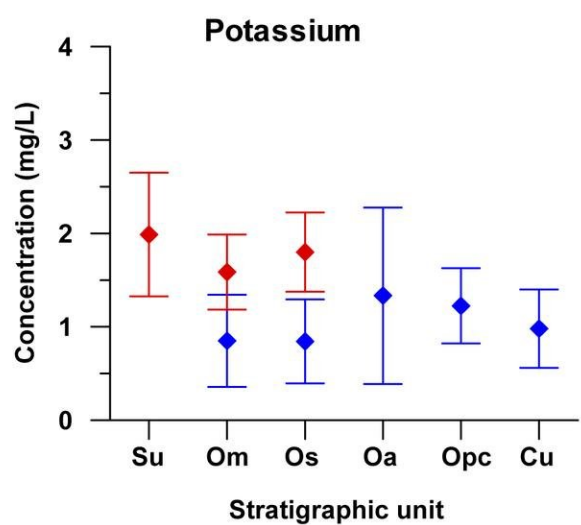
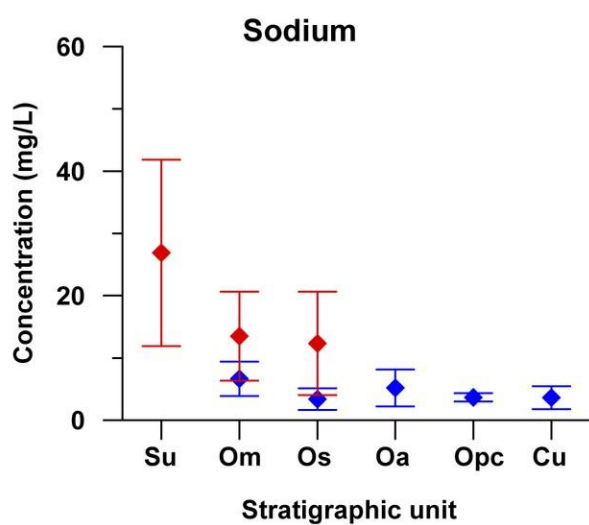
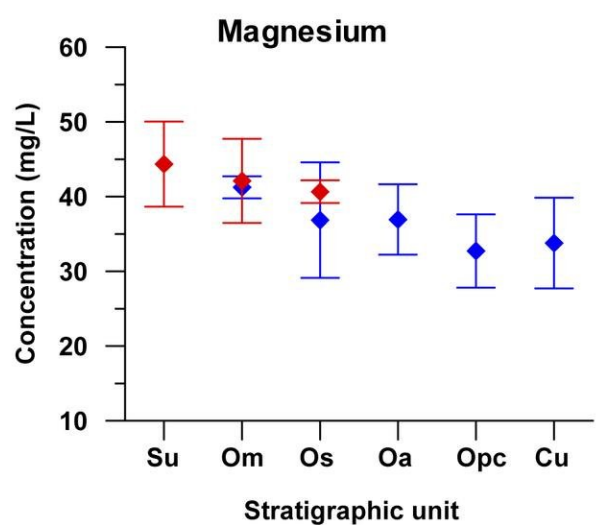
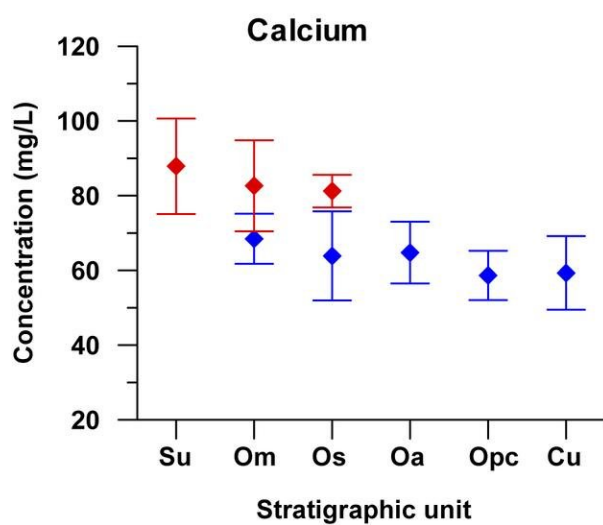


Geochemical Results for Spring Surveys in Iowa and Waukesha Counties



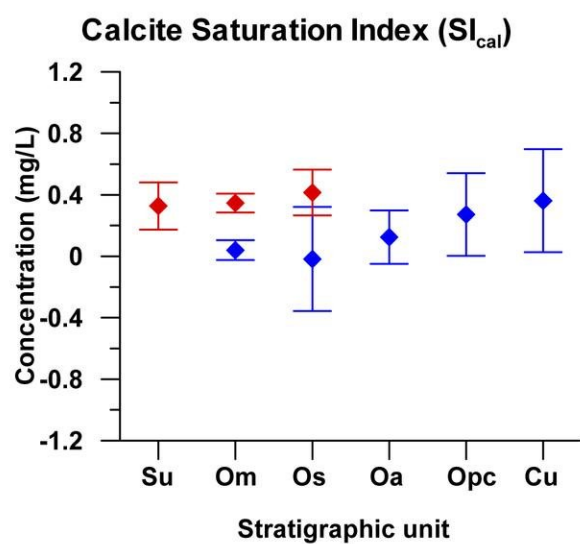
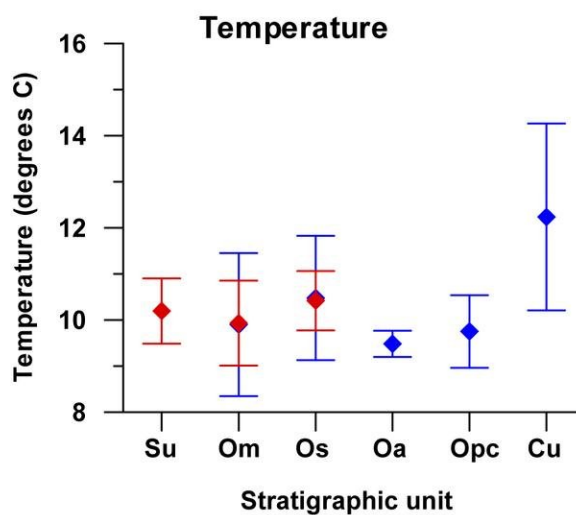
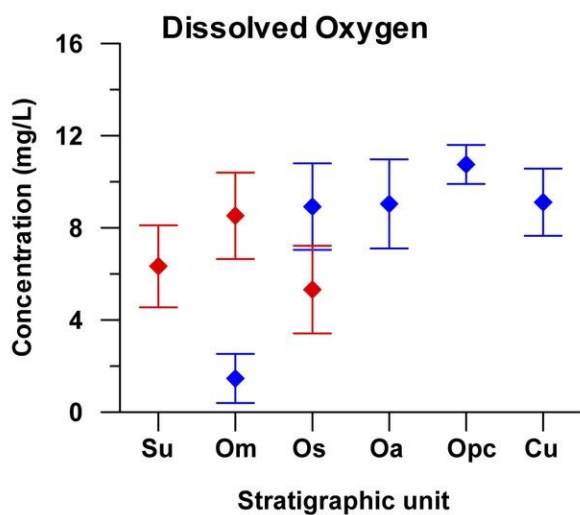
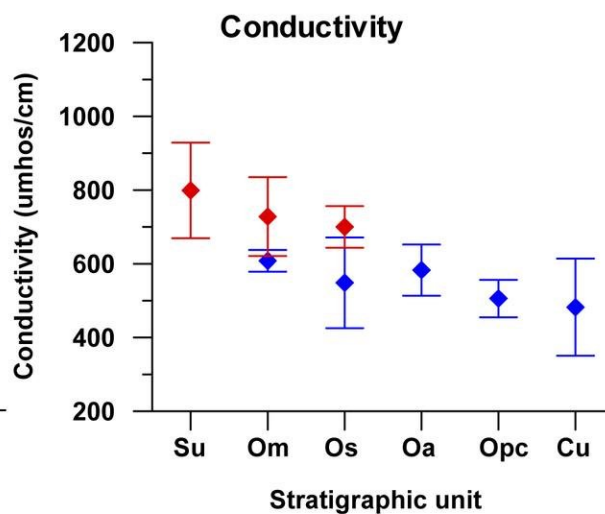
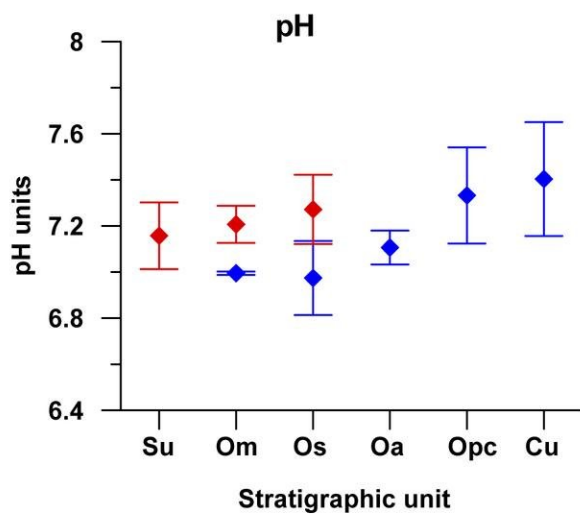
Mean concentration and standard deviation, Iowa County

Mean concentration and standard deviation, Waukesha County



Mean concentration and standard deviation, Iowa County

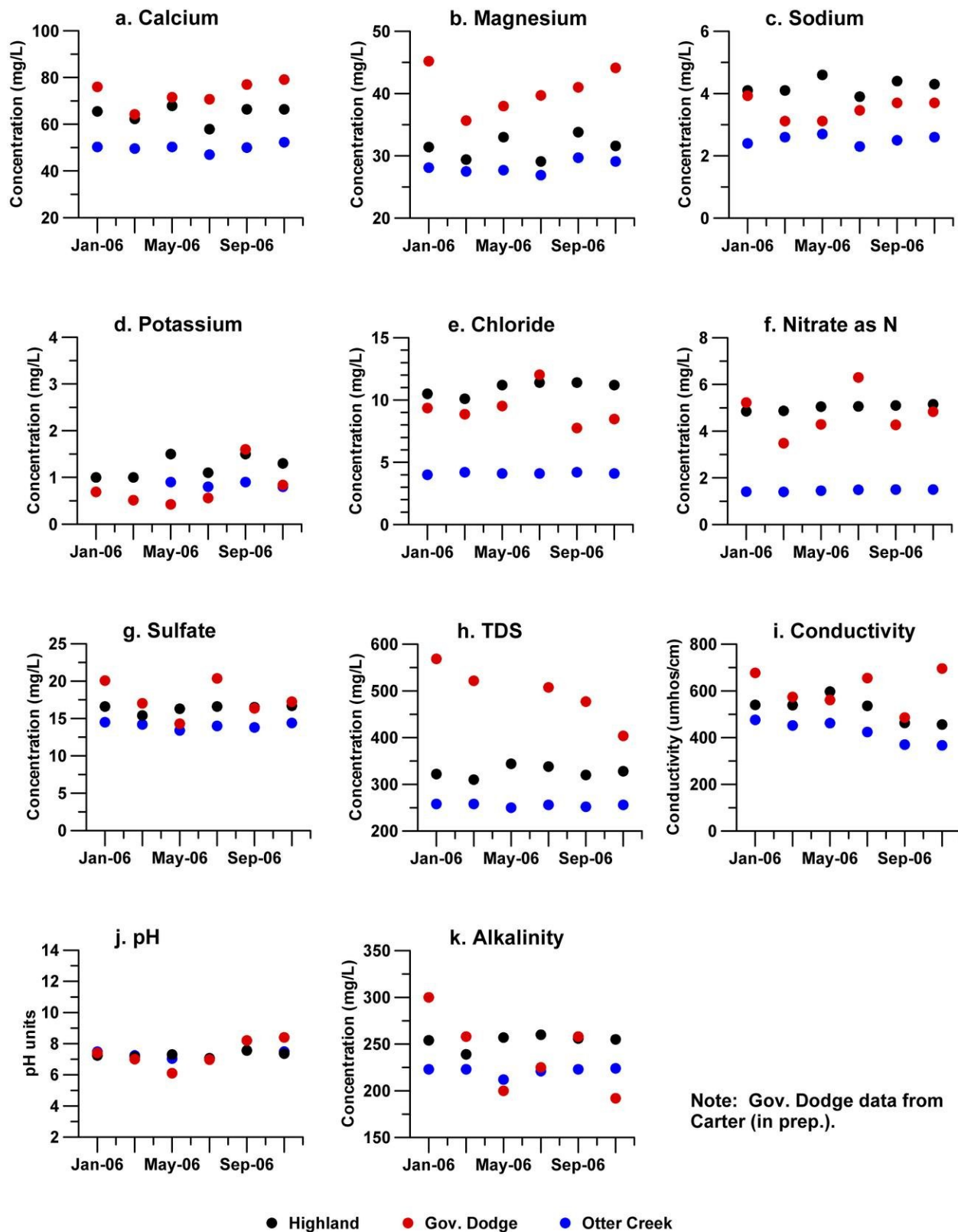
Mean concentration and standard deviation, Waukesha County



Mean concentration and standard deviation, Iowa County

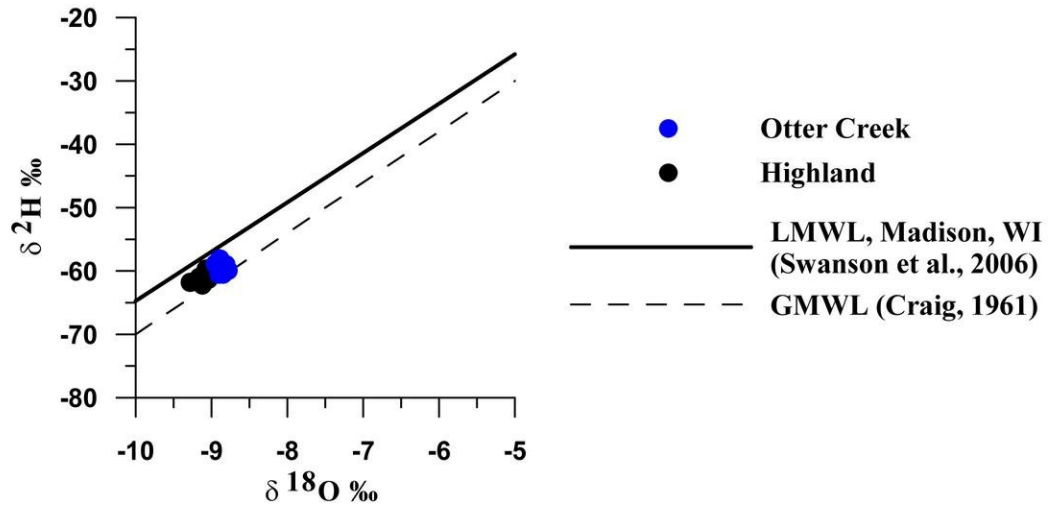
Mean concentration and standard deviation, Waukesha County

Geochemical Results for Springs near Highland, Otter Creek and Gov. Dodge State Park



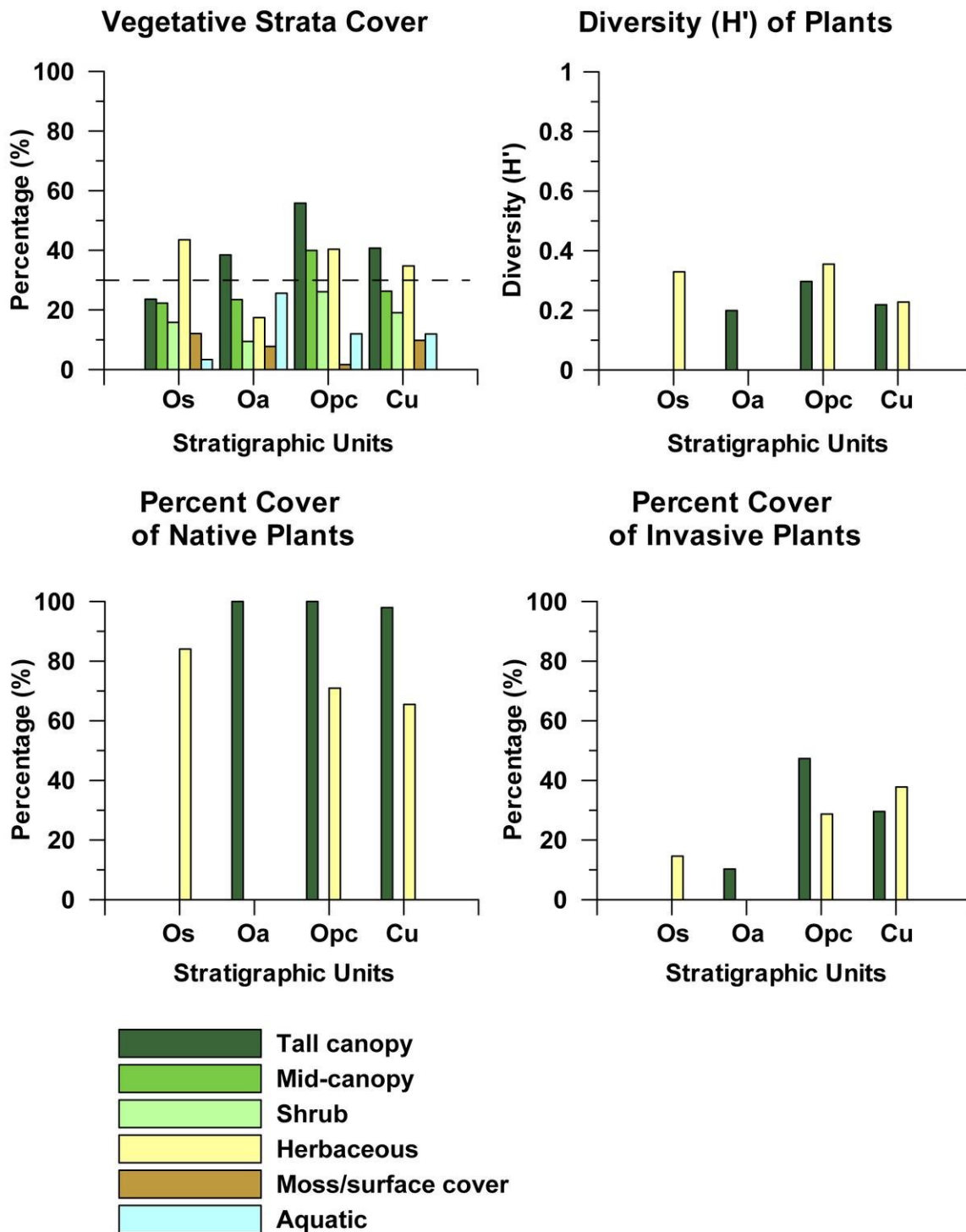
Note: Gov. Dodge data from Carter (in prep.).

Stable Isotope Results for Springs near Highland and Otter Creek, Iowa County



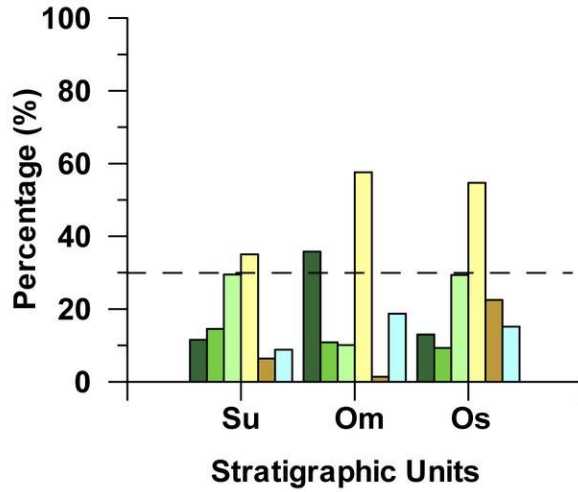
Appendix E: Vegetation Diversity Charts, Plant Species Lists, and Importance Values

Iowa Vegetation Diversity Charts

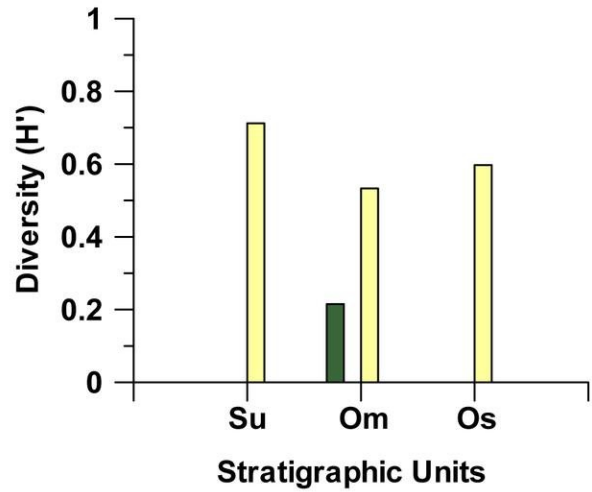


Waukesha Vegetation Diversity Charts

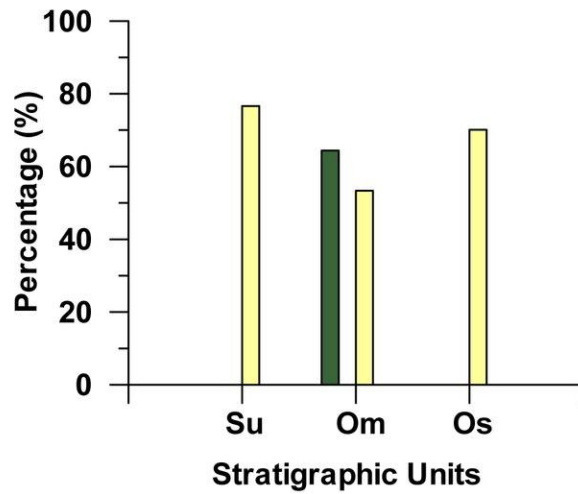
Vegetative Strata Cover



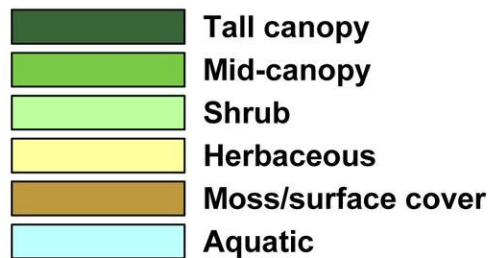
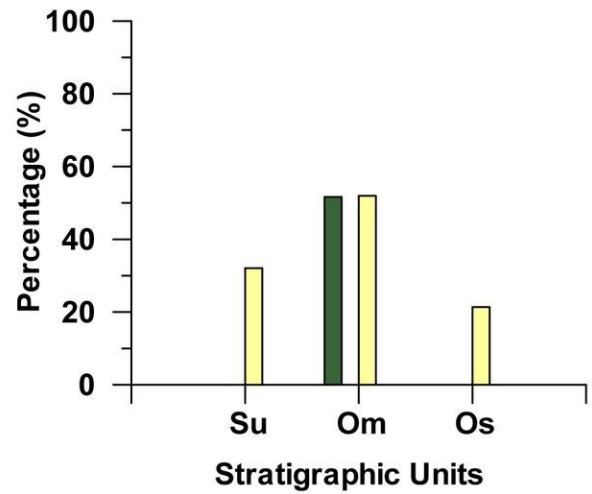
Diversity (H') of Plants



Percent Cover of Native Plants



Percent Cover of Invasive Plants



Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250009	<i>Populus deltoides</i> Bartr.	72.5%	68.4%	100.0%	20.0%	0.88	44.2%
250009	<i>Acer negundo</i> L.	27.5%	25.9%	100.0%	20.0%	0.46	23.0%
250009	<i>Salix nigra</i> Marsh.	3.5%	3.3%	100.0%	20.0%	0.23	11.7%
250009	<i>Rhamnus frangula</i> L.	2.0%	1.9%	100.0%	20.0%	0.22	10.9%
250009	<i>Ulmus americana</i> L.	0.5%	0.5%	100.0%	20.0%	0.20	10.2%
Shrubs							
250009	<i>Rosa multiflora</i> Thunb. Ex Murr	2.0%	80.0%	100.0%	50.0%	1.30	65.0%
250009	<i>Lonicera</i> sp.	0.5%	20.0%	100.0%	50.0%	0.70	35.0%
Herbaceous							
250009	<i>Nasturtium nasturtium-aquaticum</i>	72.5%	76.6%	100.0%	18.8%	0.95	47.7%
250009	<i>Pastinaca sativa</i> L.	17.5%	18.5%	100.0%	18.8%	0.37	18.6%
250009	<i>Alliaria petiolaris</i>	2.0%	2.1%	100.0%	18.8%	0.21	10.4%
250009	<i>Arctium</i> L.	0.5%	0.5%	100.0%	18.8%	0.19	9.6%
250009	<i>Cirsium arvense</i> L.	0.5%	0.5%	100.0%	18.8%	0.19	9.6%
250009	<i>Phalaris arundinacea</i> L.	1.7%	1.8%	33.3%	6.3%	0.08	4.0%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250022	<i>Vitis sp.</i>	0.1%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Trees</i>						
250022	<i>Prunus pennsylvanica L. fils</i>	0.3%	66.7%	66.7%	66.7%	1.33	66.7%
250022	<i>Juglans nigra L.</i>	0.2%	33.3%	33.3%	33.3%	0.67	33.3%
	<i>Shrubs</i>						
250022	<i>Cornus sp.</i>	6.0%	33.3%	66.7%	33.3%	0.67	33.3%
250022	<i>Lonicera sp.</i>	6.0%	33.3%	66.7%	33.3%	0.67	33.3%
250022	<i>Ribes sp.</i>	5.8%	32.4%	33.3%	16.7%	0.49	24.5%
250022	<i>Viburnum sp.</i>	0.2%	0.9%	33.3%	16.7%	0.18	8.8%
	<i>Herbaceous</i>						
250022	<i>Poaceae</i>	12.5%	78.5%	33.3%	25.0%	1.04	51.8%
250022	<i>Salix babylonica L.</i>	3.4%	21.5%	100.0%	75.0%	0.96	48.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250024	<i>Vitis sp.</i>	0.4%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Trees</i>						
250024	<i>Acer saccharum Marsh.</i>	7.5%	59.4%	100.0%	27.3%	0.87	43.3%
250024	<i>Prunus sp.</i>	3.9%	30.5%	66.7%	18.2%	0.49	24.3%
250024	<i>Carya sp.</i>	0.4%	3.2%	66.7%	18.2%	0.21	10.7%
250024	<i>Juglans nigra L.</i>	0.1%	1.0%	66.7%	18.2%	0.19	9.6%
250024	<i>Tilia americana L.</i>	0.4%	3.0%	33.3%	9.1%	0.12	6.0%
250024	<i>Ulmus rubra Muhl.</i>	0.4%	3.0%	33.3%	9.1%	0.12	6.0%
	<i>Shrubs</i>						
250024	<i>Lonicera sp.</i>	30.0%	46.9%	100.0%	33.3%	0.80	40.1%
250024	<i>Ribes sp.</i>	29.1%	45.5%	66.7%	22.2%	0.68	33.9%
250024	<i>Viburnum sp.</i>	3.9%	6.0%	66.7%	22.2%	0.28	14.1%
250024	<i>Rosa sp.</i>	1.0%	1.6%	66.7%	22.2%	0.24	11.9%
	<i>Herbaceous</i>						
250024	<i>Poaceae</i>	29.1%	54.0%	66.7%	11.8%	0.66	32.9%
250024	<i>Alliaria petiola</i>	13.2%	24.5%	66.7%	11.8%	0.36	18.1%
250024	<i>Impatiens capensis</i>	4.8%	8.9%	66.7%	11.8%	0.21	10.3%
250024	<i>Solidago sp.</i>	3.9%	7.1%	66.7%	11.8%	0.19	9.5%
250024	<i>Carex sp.</i>	1.4%	2.5%	66.7%	11.8%	0.14	7.2%
250024	<i>Aster sp.</i>	0.6%	1.2%	66.7%	11.8%	0.13	6.5%
250024	<i>Arctium L.</i>	0.5%	0.9%	66.7%	11.8%	0.13	6.3%
250024	<i>Phalaris arundinacea L.</i>	0.1%	0.2%	66.7%	11.8%	0.12	6.0%
250024	<i>Arisaema sp.</i>	0.4%	0.7%	33.3%	5.9%	0.07	3.3%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250028	<i>Acer negundo L.</i>	0.1%	50.0%	25.0%	50.0%	1.00	50.0%
250028	<i>Tilia americana L.</i>	0.1%	50.0%	25.0%	50.0%	1.00	50.0%
	<i>Shrubs</i>						
250028	<i>Diervilla lonicera</i>	0.5%	90.9%	25.0%	50.0%	1.41	70.5%
250028	<i>Rosa multiflora Thunb. Ex Murr</i>	0.1%	9.1%	25.0%	50.0%	0.59	29.5%
	<i>Herbaceous</i>						
250028	<i>Nasturtium nasturtium-aquaticum</i>	16.0%	49.7%	50.0%	8.7%	0.58	29.2%
250028	<i>Phalaris arundinacea L.</i>	11.3%	34.9%	100.0%	17.4%	0.52	26.2%
250028	<i>Impatiens capensis</i>	1.6%	5.0%	100.0%	17.4%	0.22	11.2%
250028	<i>Angelica atropurpurea L.</i>	1.6%	4.8%	100.0%	17.4%	0.22	11.1%
250028	<i>Solidago sp.</i>	1.5%	4.7%	100.0%	17.4%	0.22	11.0%
250028	<i>Alliaria petiola</i>	0.1%	0.3%	50.0%	8.7%	0.09	4.5%
250028	<i>Pteridophyta</i>	0.1%	0.4%	25.0%	4.3%	0.05	2.4%
250028	<i>Maianthemum racemosum</i>	0.0%	0.1%	25.0%	4.3%	0.04	2.2%
250028	<i>Solanum dulcamara</i>	0.0%	0.1%	25.0%	4.3%	0.04	2.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250030	<i>Quercus macrocarpa Michx.</i>	0.0%	1.7%	25.0%	20.0%	0.22	10.8%
250030	<i>Rhamnus frangula L.</i>	0.0%	3.4%	25.0%	20.0%	0.23	11.7%
250030	<i>Ulmus rubra Muhl.</i>	0.7%	94.9%	75.0%	60.0%	1.55	77.5%
	<i>Herbaceous</i>						
250030	<i>Angelica atropurpurea L.</i>	4.8%	6.4%	75.0%	27.3%	0.34	16.8%
250030	<i>Carex sp.</i>	0.5%	0.6%	75.0%	27.3%	0.28	14.0%
250030	<i>Nasturtium nasturtium-aquaticum</i>	65.3%	87.7%	50.0%	18.2%	1.06	53.0%
250030	<i>Pastinaca sativa L.</i>	0.3%	0.3%	25.0%	9.1%	0.09	4.7%
250030	<i>Poaceae</i>	3.7%	4.9%	50.0%	18.2%	0.23	11.5%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250045	<i>Parthenocissus quinquefolia</i>	0.5%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
250045	<i>Acer saccharum</i> Marsh.	72.5%	98.0%	100.0%	33.3%	1.31	65.7%
250045	<i>Ostrya virginiana</i> Koch.	1.0%	1.3%	100.0%	33.3%	0.35	17.3%
250045	<i>Prunus</i> sp.	0.5%	0.7%	50.0%	16.7%	0.17	8.7%
250045	<i>Ulmus</i> sp.	0.1%	0.1%	50.0%	16.7%	0.17	8.4%
	<i>Shrubs</i>						
250045	<i>Cornus</i> sp.	4.6%	47.6%	100.0%	40.0%	0.88	43.8%
250045	<i>Ribes</i> sp.	4.6%	47.6%	100.0%	40.0%	0.88	43.8%
250045	<i>Viburnum</i> sp.	0.5%	4.7%	50.0%	20.0%	0.25	12.4%
	<i>Herbaceous</i>						
250045	<i>Impatiens capensis</i>	16.3%	46.2%	100.0%	11.1%	0.57	28.6%
250045	<i>Geranium</i> L.	15.8%	44.9%	100.0%	11.1%	0.56	28.0%
250045	<i>Polygonatum biflorum</i>	1.0%	2.7%	100.0%	11.1%	0.14	6.9%
250045	<i>Adiantum pedatum</i> L.	0.5%	1.4%	100.0%	11.1%	0.13	6.3%
250045	<i>Pteridophyta</i>	0.5%	1.4%	100.0%	11.1%	0.13	6.3%
250045	<i>Trillium</i> sp.	0.5%	1.4%	100.0%	11.1%	0.13	6.3%
250045	<i>Poaceae</i>	0.3%	0.8%	50.0%	5.6%	0.06	3.2%
250045	<i>Viola</i> sp.	0.2%	0.6%	50.0%	5.6%	0.06	3.1%
250045	<i>Carex</i> sp.	0.1%	0.1%	50.0%	5.6%	0.06	2.8%
250045	<i>Cirsium</i> sp.	0.1%	0.1%	50.0%	5.6%	0.06	2.8%
250045	<i>Laportea canadensis</i>	0.1%	0.1%	50.0%	5.6%	0.06	2.8%
250045	<i>Streptopus</i> sp.	0.1%	0.1%	50.0%	5.6%	0.06	2.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
250101	<i>Acer negundo L.</i>	2.3%	87.0%	25.0%	33.3%	1.20	60.1%
250101	<i>Ulmus americana L.</i>	0.2%	8.7%	25.0%	33.3%	0.42	21.0%
250101	<i>Quercus velutina Lam.</i>	0.1%	4.3%	25.0%	33.3%	0.38	18.8%
	Shrubs						
250101	<i>Rosa multiflora Thunb. Ex Murr</i>	0.2%	100.0%	25.0%	100.0%	2.00	100.0%
	Herbaceous						
250101	<i>Impatiens capensis</i>	8.0%	50.9%	50.0%	18.2%	0.69	34.5%
250101	<i>Cirsium arvense L.</i>	2.4%	15.2%	50.0%	18.2%	0.33	16.7%
250101	<i>Galium sp.</i>	2.3%	14.3%	25.0%	9.1%	0.23	11.7%
250101	<i>Geranium L.</i>	2.3%	14.3%	25.0%	9.1%	0.23	11.7%
250101	<i>Urtica L.</i>	0.4%	2.4%	50.0%	18.2%	0.21	10.3%
250101	<i>Pteridophyta</i>	0.3%	1.6%	50.0%	18.2%	0.20	9.9%
250101	<i>Carex sp.</i>	0.2%	1.4%	25.0%	9.1%	0.11	5.3%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250106	<i>Acer negundo L.</i>	12.8%	69.8%	100.0%	60.0%	1.30	64.9%
250106	<i>Salix nigra Marsh.</i>	5.6%	30.2%	66.7%	40.0%	0.70	35.1%
	<i>Herbaceous</i>						
250106	<i>Poaceae</i>	49.3%	60.6%	100.0%	17.6%	0.78	39.1%
250106	<i>Asclepias sp.</i>	22.3%	27.4%	100.0%	17.6%	0.45	22.5%
250106	<i>Phalaris arundinacea L.</i>	8.3%	10.2%	100.0%	17.6%	0.28	13.9%
250106	<i>Achillea sp.</i>	0.5%	0.6%	100.0%	17.6%	0.18	9.1%
250106	<i>Cirsium sp.</i>	0.5%	0.6%	100.0%	17.6%	0.18	9.1%
250106	<i>Solidago sp.</i>	0.5%	0.6%	66.7%	11.8%	0.12	6.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
250174	<i>Quercus velutina</i> Lam.	50.5%	52.1%	100.0%	20.0%	0.72	36.0%
250174	<i>Acer saccharum</i> Marsh.	39.5%	40.7%	100.0%	20.0%	0.61	30.4%
250174	<i>Ulmus</i> sp.	0.5%	0.5%	100.0%	20.0%	0.21	10.3%
250174	<i>Fraxinus nigra</i> Marsh.	3.0%	3.1%	50.0%	10.0%	0.13	6.5%
250174	<i>Fraxinus pennsylvanica</i> Marsh.	3.0%	3.1%	50.0%	10.0%	0.13	6.5%
250174	<i>Prunus pennsylvanica</i> L. fils	0.3%	0.3%	50.0%	10.0%	0.10	5.2%
250174	<i>Crataegus</i> sp.	0.2%	0.2%	50.0%	10.0%	0.10	5.1%
	Shrubs						
250174	<i>Ribes hirtellum</i>	0.3%	50.0%	50.0%	50.0%	1.00	50.0%
250174	<i>Rosa multiflora</i> Thunb. Ex Murr	0.3%	50.0%	50.0%	50.0%	1.00	50.0%
	Herbaceous						
250174	<i>Poaceae</i>	0.3%	33.3%	50.0%	20.0%	0.53	26.7%
250174	<i>Cirsium arvense</i> L.	0.2%	16.7%	50.0%	20.0%	0.37	18.3%
250174	<i>Impatiens capensis</i>	0.2%	16.7%	50.0%	20.0%	0.37	18.3%
250174	<i>Plantago major</i> L.	0.2%	16.7%	50.0%	20.0%	0.37	18.3%
250174	<i>Urtica</i> L.	0.2%	16.7%	50.0%	20.0%	0.37	18.3%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250195	<i>Quercus velutina</i> Lam.	17.5%	41.8%	100.0%	16.7%	0.58	29.2%
250195	<i>Tilia americana</i> L.	17.5%	41.8%	100.0%	16.7%	0.58	29.2%
250195	<i>Ribes americanum</i>	4.5%	10.8%	50.0%	8.3%	0.19	9.5%
250195	<i>Ulmus rubra</i> Muhl.	1.0%	2.3%	100.0%	16.7%	0.19	9.5%
250195	<i>Acer negundo</i> L.	0.5%	1.2%	100.0%	16.7%	0.18	8.9%
250195	<i>Acer saccharum</i> Marsh.	0.5%	1.1%	100.0%	16.7%	0.18	8.9%
250195	<i>Ribes sp.</i>	0.5%	1.1%	50.0%	8.3%	0.09	4.7%
	<i>Herbaceous</i>						
250195	<i>Gernanium maculatum</i> L.	15.8%	68.5%	50.0%	10.0%	0.78	39.2%
250195	<i>Laportea canadensis</i>	5.0%	21.7%	100.0%	20.0%	0.42	20.9%
250195	<i>Adiantum pedatum</i> L.	0.5%	2.0%	50.0%	10.0%	0.12	6.0%
250195	<i>Alliaria petiola</i>	0.5%	2.0%	50.0%	10.0%	0.12	6.0%
250195	<i>Poaceae</i>	0.5%	2.0%	50.0%	10.0%	0.12	6.0%
250195	<i>Anemone sp.</i>	0.2%	1.0%	50.0%	10.0%	0.11	5.5%
250195	<i>Galium sp.</i>	0.2%	1.0%	50.0%	10.0%	0.11	5.5%
250195	<i>Osmorhiza sp.</i>	0.2%	1.0%	50.0%	10.0%	0.11	5.5%
250195	<i>Smilacina stellata</i>	0.2%	1.0%	50.0%	10.0%	0.11	5.5%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
250200	<i>Quercus sp.</i>	12.1%	72.6%	100.0%	25.0%	0.98	48.8%
250200	<i>Acer negundo L.</i>	0.5%	3.0%	100.0%	25.0%	0.28	14.0%
250200	<i>Malus sp.</i>	1.8%	10.8%	66.7%	16.7%	0.28	13.8%
250200	<i>Robinia pseudoacacia L.</i>	1.8%	10.8%	66.7%	16.7%	0.28	13.8%
250200	<i>Ulmus sp.</i>	0.5%	2.7%	66.7%	16.7%	0.19	9.7%
	Shrubs						
250200	<i>Rosa multiflora Thunb. Ex Murr</i>	8.3%	100.0%	66.7%	100.0%	2.00	100.0%
	Herbaceous						
250200	<i>Poaceae</i>	47.4%	97.2%	100.0%	23.1%	1.20	60.1%
250200	<i>Cirsium sp.</i>	0.5%	1.0%	100.0%	23.1%	0.24	12.1%
250200	<i>Dalea candida</i>	0.5%	1.0%	100.0%	23.1%	0.24	12.1%
250200	<i>Taraxacum sp.</i>	0.2%	0.5%	66.7%	15.4%	0.16	7.9%
250200	<i>Phalaris arundinacea L.</i>	0.2%	0.3%	66.7%	15.4%	0.16	7.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250205	<i>Vitis sp.</i>	0.2%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
250205	<i>Acer negundo L.</i>	12.9%	55.8%	100.0%	30.0%	0.86	42.9%
250205	<i>Ribes sp.</i>	6.8%	29.2%	66.7%	20.0%	0.49	24.6%
250205	<i>Rhamnus frangula L.</i>	1.7%	7.1%	66.7%	20.0%	0.27	13.6%
250205	<i>Ulmus rubra Muhl.</i>	1.5%	6.5%	33.3%	10.0%	0.16	8.2%
250205	<i>Quercus velutina Lam.</i>	0.2%	0.6%	33.3%	10.0%	0.11	5.3%
250205	<i>Tilia americana L.</i>	0.2%	0.6%	33.3%	10.0%	0.11	5.3%
	<i>Herbaceous</i>						
250205	<i>Poaceae</i>	11.4%	49.4%	66.7%	20.0%	0.69	34.7%
250205	<i>Impatiens capensis</i>	5.4%	23.4%	66.7%	20.0%	0.43	21.7%
250205	<i>Galium sp.</i>	3.0%	13.0%	66.7%	20.0%	0.33	16.5%
250205	<i>Cirsium arvense L.</i>	1.7%	7.1%	66.7%	20.0%	0.27	13.6%
250205	<i>Pastinaca sativa L.</i>	1.7%	7.1%	66.7%	20.0%	0.27	13.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250210	<i>Ulmus sp</i>	34.9%	45.8%	100.0%	15.8%	0.62	30.8%
250210	<i>Ribes sp.</i>	15.8%	20.7%	66.7%	10.5%	0.31	15.6%
250210	<i>Quercus sp.</i>	5.0%	6.6%	100.0%	15.8%	0.22	11.2%
250210	<i>Carya ovata Koch.</i>	4.8%	6.3%	100.0%	15.8%	0.22	11.0%
250210	<i>Acer negundo L.</i>	5.4%	7.1%	66.7%	10.5%	0.18	8.8%
250210	<i>Tilia americana L.</i>	5.4%	7.1%	66.7%	10.5%	0.18	8.8%
250210	<i>Acer saccharinum</i>	4.5%	5.9%	66.7%	10.5%	0.16	8.2%
250210	<i>Juglans nigra L.</i>	0.5%	0.6%	66.7%	10.5%	0.11	5.6%
Herbaceous							
250210	<i>Poaceae</i>	4.8%	35.6%	66.7%	25.0%	0.61	30.3%
250210	<i>Smilacina stellata</i>	4.5%	33.7%	33.3%	12.5%	0.46	23.1%
250210	<i>Impatiens capensis</i>	1.3%	9.9%	66.7%	25.0%	0.35	17.5%
250210	<i>Nasturtium nasturtium-aquaticum</i>	1.9%	14.0%	33.3%	12.5%	0.27	13.3%
250210	<i>Arisaema sp.</i>	0.5%	3.4%	33.3%	12.5%	0.16	7.9%
250210	<i>Trillium sp</i>	0.5%	3.4%	33.3%	12.5%	0.16	7.9%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250215	<i>Acer negundo L.</i>	37.5%	46.4%	100.0%	25.0%	0.71	35.7%
250215	<i>Populus deltoides Bartr.</i>	37.5%	46.4%	100.0%	25.0%	0.71	35.7%
250215	<i>Fraxinus sp.</i>	0.5%	0.6%	66.7%	16.7%	0.17	8.6%
250215	<i>Juglans nigra L.</i>	0.5%	0.6%	66.7%	16.7%	0.17	8.6%
250215	<i>Ribes sp.</i>	4.5%	5.6%	33.3%	8.3%	0.14	6.9%
250215	<i>Prunus sp.</i>	0.5%	0.6%	33.3%	8.3%	0.09	4.4%
Herbaceous							
250215	<i>Impatiens capensis</i>	41.0%	54.0%	100.0%	25.0%	0.79	39.5%
250215	<i>Angelica atropurpurea L.</i>	17.5%	23.1%	100.0%	25.0%	0.48	24.0%
250215	<i>Poaceae</i>	16.0%	21.1%	66.7%	16.7%	0.38	18.9%
250215	<i>Carex sp.</i>	0.5%	0.6%	66.7%	16.7%	0.17	8.6%
250215	<i>Geranium L.</i>	0.5%	0.6%	33.3%	8.3%	0.09	4.5%
250215	<i>Urtica L.</i>	0.5%	0.6%	33.3%	8.3%	0.09	4.5%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
<i>Trees</i>							
250235	<i>Crataegus sp.</i>	9.8%	99.5%	66.7%	66.7%	1.66	83.1%
250235	<i>Robinia pseudoacacia L.</i>	0.1%	0.5%	33.3%	33.3%	0.34	16.9%
<i>Herbaceous</i>							
250235	<i>Nasturtium sp.</i>	22.0%	59.2%	66.7%	28.6%	0.88	43.9%
250235	<i>Poaceae</i>	14.8%	39.7%	66.7%	28.6%	0.68	34.1%
250235	<i>Solidago sp.</i>	0.4%	0.9%	66.7%	28.6%	0.30	14.8%
250235	<i>Solanum sp.</i>	0.1%	0.1%	33.3%	14.3%	0.14	7.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
<i>Trees</i>							
250240	<i>Ulmus americana L.</i>	2.1%	50.3%	100.0%	30.8%	0.81	40.5%
250240	<i>Salix nigra Marsh.</i>	1.4%	33.9%	100.0%	30.8%	0.65	32.4%
250240	<i>Prunus serotina Ehrh.</i>	0.5%	12.1%	100.0%	30.8%	0.43	21.4%
250240	<i>Quercus macrocarpa Michx.</i>	0.2%	3.6%	25.0%	7.7%	0.11	5.7%
<i>Herbaceous</i>							
250240	<i>Poaceae</i>	25.3%	64.5%	100.0%	25.0%	0.89	44.7%
250240	<i>Pastinaca sativa L.</i>	5.6%	14.3%	100.0%	25.0%	0.39	19.6%
250240	<i>Carex sp.</i>	5.6%	14.2%	100.0%	25.0%	0.39	19.6%
250240	<i>Barbarea sp.</i>	2.8%	7.0%	100.0%	25.0%	0.32	16.0%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250248	<i>Juglans nigra L.</i>	0.5%	100.0%	66.7%	100.0%	2.00	100.0%
	<i>Shrubs</i>						
250248	<i>Ribes sp.</i>	4.8%	90.9%	66.7%	50.0%	1.41	70.5%
250248	<i>Ribes hirtellum</i>	0.5%	9.1%	66.7%	50.0%	0.59	29.5%
	<i>Herbaceous</i>						
250248	<i>Carex sp.</i>	29.3%	43.3%	100.0%	17.6%	0.61	30.5%
250248	<i>Poaceae</i>	27.5%	40.7%	100.0%	17.6%	0.58	29.2%
250248	<i>Impatiens capensis</i>	5.0%	7.4%	100.0%	17.6%	0.25	12.5%
250248	<i>Pastinaca sativa L.</i>	4.8%	7.1%	100.0%	17.6%	0.25	12.4%
250248	<i>Juncus sp.</i>	0.5%	0.7%	100.0%	17.6%	0.18	9.2%
250248	<i>Equisetum sp.</i>	0.5%	0.7%	66.7%	11.8%	0.12	6.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250259	<i>Juniperus virginiana L.</i>	21.5%	41.6%	100.0%	37.5%	0.79	39.5%
250259	<i>Ribes sp.</i>	14.9%	28.9%	66.7%	25.0%	0.54	26.9%
250259	<i>Prunus sp.</i>	14.9%	28.8%	33.3%	12.5%	0.41	20.6%
250259	<i>Quercus sp.</i>	0.2%	0.4%	33.3%	12.5%	0.13	6.5%
250259	<i>Tilia americana L.</i>	0.2%	0.4%	33.3%	12.5%	0.13	6.5%
Shrubs							
250259	<i>Lonicera sp.</i>	15.2%	100.0%	100.0%	100.0%	2.00	100.0%
Herbaceous							
250259	<i>Poaceae</i>	31.9%	41.9%	66.7%	14.3%	0.56	28.1%
250259	<i>Urtica L.</i>	16.7%	21.9%	100.0%	21.4%	0.43	21.6%
250259	<i>Pastinaca sativa L.</i>	16.6%	21.8%	66.7%	14.3%	0.36	18.1%
250259	<i>Arctium L.</i>	4.8%	6.3%	100.0%	21.4%	0.28	13.8%
250259	<i>Impatiens capensis</i>	4.0%	5.3%	66.7%	14.3%	0.20	9.8%
250259	<i>Phalaris arundinacea L.</i>	2.2%	2.9%	66.7%	14.3%	0.17	8.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250296	<i>Malus sp.</i>	33.3%	73.9%	100.0%	30.0%	1.04	52.0%
250296	<i>Acer negundo L.</i>	3.4%	7.6%	100.0%	30.0%	0.38	18.8%
250296	<i>Juglans nigra L.</i>	4.8%	10.6%	66.7%	20.0%	0.31	15.3%
250296	<i>Rhamnus sp.</i>	3.3%	7.2%	33.3%	10.0%	0.17	8.6%
250296	<i>Robinia pseudoacacia L.</i>	3.3%	7.2%	33.3%	10.0%	0.17	8.6%
250296	<i>Populus deltoides Bartr.</i>	0.2%	0.4%	33.3%	10.0%	0.10	5.2%
250296	<i>Quercus velutina Lam.</i>	0.2%	0.4%	33.3%	10.0%	0.10	5.2%
250296	<i>Ulmus sp.</i>	0.2%	0.4%	33.3%	10.0%	0.10	5.2%
Shrubs							
250296	<i>Viburnum sp.</i>	12.9%	29.7%	100.0%	33.3%	0.63	31.5%
250296	<i>Lonicera sp.</i>	12.9%	29.7%	66.7%	22.2%	0.52	25.9%
250296	<i>Ribes sp.</i>	12.9%	29.7%	66.7%	22.2%	0.52	25.9%
250296	<i>Rosa sp.</i>	4.8%	10.9%	66.7%	22.2%	0.33	16.6%
Herbaceous							
250296	<i>Poaceae</i>	0.5%	74.5%	66.7%	66.7%	1.41	70.6%
250296	<i>Leonurus cardiaca L.</i>	0.2%	25.5%	33.3%	33.3%	0.59	29.4%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
250309	<i>Ostrya virginiana Koch.</i>	0.1%	50.0%	50.0%	50.0%	1.00	50.0%
250309	<i>Tilia americana L.</i>	0.1%	50.0%	50.0%	50.0%	1.00	50.0%
	<i>Shrubs</i>						
250309	<i>Rosa multiflora Thunb. Ex Murr</i>	5.0%	64.5%	100.0%	50.0%	1.15	57.3%
250309	<i>Lonicera sp.</i>	2.8%	35.5%	100.0%	50.0%	0.85	42.7%
	<i>Herbaceous</i>						
250309	<i>Nasturtium nasturtium-aquaticum</i>	38.8%	55.8%	100.0%	16.7%	0.72	36.2%
250309	<i>Poaceae</i>	17.5%	25.2%	100.0%	16.7%	0.42	20.9%
250309	<i>Phalaris arundinacea L.</i>	5.0%	7.2%	100.0%	16.7%	0.24	11.9%
250309	<i>Scirpus sp.</i>	5.0%	7.2%	100.0%	16.7%	0.24	11.9%
250309	<i>Cirsium arvense L.</i>	2.8%	4.0%	100.0%	16.7%	0.21	10.3%
250309	<i>Solanum sp.</i>	0.5%	0.7%	100.0%	16.7%	0.17	8.7%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
250331	<i>Carya ovata</i> Koch.	8.5%	26.9%	75.0%	17.6%	0.45	22.3%
250331	<i>Fraxinus</i> sp.	6.9%	21.8%	75.0%	17.6%	0.39	19.7%
250331	<i>Populus deltoides</i> Bartr.	0.3%	0.9%	50.0%	11.8%	0.13	6.4%
250331	<i>Quercus alba</i> L.	6.8%	21.3%	50.0%	11.8%	0.33	16.5%
250331	<i>Quercus velutina</i> Lam.	7.3%	22.9%	75.0%	17.6%	0.41	20.3%
250331	<i>Robinia pseudoacacia</i> L.	1.7%	5.2%	50.0%	11.8%	0.17	8.5%
250331	<i>Ulmus</i> sp.	0.3%	0.9%	50.0%	11.8%	0.13	6.4%
Shrubs							
250331	<i>Ribes</i> sp.	3.2%	31.3%	75.0%	50.0%	0.81	40.7%
250331	<i>Rosa multiflora</i> Thunb. Ex Murr	6.9%	68.7%	75.0%	50.0%	1.19	59.3%
Herbaceous							
250331	<i>Laportea canadensis</i>	3.0%	5.4%	50.0%	33.3%	0.39	19.4%
250331	<i>Poaceae</i>	52.6%	94.6%	100.0%	66.7%	1.61	80.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
<i>Herbaceous</i>							
250334	<i>Carex sp.</i>	34.3%	49.9%	100.0%	16.7%	0.67	33.3%
250334	<i>Impatiens capensis</i>	20.3%	29.5%	100.0%	16.7%	0.46	23.1%
250334	<i>Lemna sp.</i>	7.3%	10.6%	100.0%	16.7%	0.27	13.6%
250334	<i>Poaceae</i>	5.4%	7.9%	100.0%	16.7%	0.25	12.3%
250334	<i>Eupatorium perfoliatum</i>	0.5%	0.7%	66.7%	11.1%	0.12	5.9%
250334	<i>Eupatoriadelphus maculatus</i>	0.5%	0.7%	33.3%	5.6%	0.06	3.1%
250334	<i>Phalaris arundinacea L.</i>	0.3%	0.4%	33.3%	5.6%	0.06	3.0%
250334	<i>Solidago sp.</i>	0.3%	0.4%	33.3%	5.6%	0.06	3.0%
250334	<i>Scirpus sp.</i>	0.0%	0.0%	33.3%	5.6%	0.06	2.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
250380	<i>Salix sp.</i>	0.1%	50.0%	50.0%	50.0%	1.00	50.0%
250380	<i>Tilia americana L.</i>	0.1%	50.0%	50.0%	50.0%	1.00	50.0%
	Shrubs						
250380	<i>Ribes americanum</i>	0.1%	33.3%	50.0%	33.3%	0.67	33.3%
250380	<i>Rosa multiflora Thunb. Ex Murr</i>	0.1%	33.3%	50.0%	33.3%	0.67	33.3%
250380	<i>Rubus occidentalis L.</i>	0.1%	33.3%	50.0%	33.3%	0.67	33.3%
	Herbaceous						
250380	<i>Carex sp.</i>	0.5%	18.3%	50.0%	8.3%	0.27	13.3%
250380	<i>Impatiens pallida</i>	0.5%	18.3%	50.0%	8.3%	0.27	13.3%
250380	<i>Poaceae</i>	0.5%	18.3%	50.0%	8.3%	0.27	13.3%
250380	<i>Angelica atropurpurea L.</i>	0.5%	16.5%	50.0%	8.3%	0.25	12.4%
250380	<i>Lemna sp.</i>	0.5%	16.5%	50.0%	8.3%	0.25	12.4%
250380	<i>Alliaria petiola</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Arctium minus</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Dioscorea villosa</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Galium aparine</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Laportea canadensis</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Taraxacum sp.</i>	0.1%	1.8%	50.0%	8.3%	0.10	5.1%
250380	<i>Solanum sp.</i>	0.0%	0.9%	50.0%	8.3%	0.09	4.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250407	<i>Parthenocissus quinquefolia</i>	5.8%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Trees</i>						
250407	<i>Tilia americana</i> L.	30.8%	70.6%	100.0%	30.0%	1.01	50.3%
250407	<i>Fraxinus nigra</i> Marsh.	9.2%	21.0%	100.0%	30.0%	0.51	25.5%
250407	<i>Rhamnus cathartica</i> L.	1.8%	4.2%	66.7%	20.0%	0.24	12.1%
250407	<i>Carya ovata</i> Koch.	1.7%	3.8%	33.3%	10.0%	0.14	6.9%
250407	<i>Acer saccharum</i> Marsh.	0.2%	0.4%	33.3%	10.0%	0.10	5.2%
	<i>Shrubs</i>						
250407	<i>Ribes</i> sp.	3.5%	51.2%	100.0%	60.0%	1.11	55.6%
250407	<i>Lonicera</i> sp.	3.3%	48.8%	66.7%	40.0%	0.89	44.4%
	<i>Herbaceous</i>						
250407	<i>Impatiens capensis</i>	26.0%	90.2%	100.0%	27.3%	1.17	58.7%
250407	<i>Toxicodendron radicans</i>	1.8%	6.4%	66.7%	18.2%	0.25	12.3%
250407	<i>Asparagus</i> L.	0.2%	0.6%	33.3%	9.1%	0.10	4.8%
250407	<i>Carex</i> sp.	0.2%	0.6%	33.3%	9.1%	0.10	4.8%
250407	<i>Podophyllum peltatum</i>	0.2%	0.6%	33.3%	9.1%	0.10	4.8%
250407	<i>Polygonatum biflorum</i>	0.2%	0.6%	33.3%	9.1%	0.10	4.8%
250407	<i>Sanguinaria canadensis</i> L.	0.2%	0.6%	33.3%	9.1%	0.10	4.8%
250407	<i>Trillium</i> sp.	0.2%	0.6%	33.3%	9.1%	0.10	4.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250408	<i>Vitis sp.</i>	0.1%	100.0%	50.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
250408	<i>Acer saccharum Marsh.</i>	72.5%	99.3%	100.0%	50.0%	1.49	74.7%
250408	<i>Ulmus americana L.</i>	0.5%	0.7%	100.0%	50.0%	0.51	25.3%
	<i>Herbaceous</i>						
250408	<i>Impatiens capensis</i>	6.3%	98.4%	100.0%	50.0%	1.48	74.2%
250408	<i>Poaceae</i>	0.1%	0.8%	50.0%	25.0%	0.26	12.9%
250408	<i>Taraxacum sp.</i>	0.1%	0.8%	50.0%	25.0%	0.26	12.9%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
250409	<i>Vitis sp.</i>	0.2%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Trees</i>						
250409	<i>Acer negundo L.</i>	18.3%	41.2%	66.7%	25.0%	0.66	33.1%
250409	<i>Quercus macrocarpa Michx.</i>	18.3%	41.2%	66.7%	25.0%	0.66	33.1%
250409	<i>Ulmus sp.</i>	7.5%	16.9%	66.7%	25.0%	0.42	20.9%
250409	<i>Juglans nigra L.</i>	0.2%	0.4%	33.3%	12.5%	0.13	6.4%
250409	<i>Prunus serotina Ehrh.</i>	0.2%	0.4%	33.3%	12.5%	0.13	6.4%
	<i>Shrubs</i>						
250409	<i>Ribes sp.</i>	6.0%	47.4%	66.7%	33.3%	0.81	40.4%
250409	<i>Cornus sp.</i>	3.3%	26.3%	66.7%	33.3%	0.60	29.8%
250409	<i>Lonicera sp.</i>	3.3%	26.3%	66.7%	33.3%	0.60	29.8%
	<i>Herbaceous</i>						
250409	<i>Nasturtium nasturtium-aquaticum</i>	36.7%	75.0%	100.0%	18.8%	0.94	46.9%
250409	<i>Impatiens capensis</i>	7.5%	15.3%	66.7%	12.5%	0.28	13.9%
250409	<i>Poaceae</i>	2.0%	4.1%	100.0%	18.8%	0.23	11.4%
250409	<i>Solidago sp.</i>	1.8%	3.7%	66.7%	12.5%	0.16	8.1%
250409	<i>Pastinaca sativa L.</i>	0.3%	0.7%	66.7%	12.5%	0.13	6.6%
250409	<i>Phalaris arundinacea L.</i>	0.3%	0.7%	66.7%	12.5%	0.13	6.6%
250409	<i>Arctium L.</i>	0.2%	0.3%	33.3%	6.3%	0.07	3.3%
250409	<i>Polygonatum biflorum</i>	0.1%	0.2%	33.3%	6.3%	0.06	3.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680030	<i>Salix sp.</i>	1.0%	71.4%	33.3%	33.3%	1.05	52.4%
680030	<i>Robinia pseudoacacia L.</i>	0.4%	28.6%	66.7%	66.7%	0.95	47.6%
	<i>Shrubs</i>						
680030	<i>Cornus racemosa</i>	4.6%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680030	<i>Carex sp.</i>	4.1%	16.1%	100.0%	13.6%	0.30	14.9%
680030	<i>Juncus sp.</i>	4.1%	16.1%	100.0%	13.6%	0.30	14.9%
680030	<i>Scirpus sp.</i>	4.1%	16.1%	100.0%	13.6%	0.30	14.9%
680030	<i>Dalea candida</i>	4.0%	15.7%	66.7%	9.1%	0.25	12.4%
680030	<i>Solidago sp.</i>	4.0%	15.7%	66.7%	9.1%	0.25	12.4%
680030	<i>Silphium terebinthinaceum Jacq.</i>	3.5%	13.8%	33.3%	4.5%	0.18	9.1%
680030	<i>Typha L.</i>	0.5%	2.0%	100.0%	13.6%	0.16	7.8%
680030	<i>Coreopsis sp.</i>	0.4%	1.6%	66.7%	9.1%	0.11	5.3%
680030	<i>Monarda fistulosa L.</i>	0.4%	1.6%	66.7%	9.1%	0.11	5.3%
680030	<i>Caltha L.</i>	0.4%	1.4%	33.3%	4.5%	0.06	3.0%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
680039	<i>Ulmus sp.</i>	12.8%	29.4%	100.0%	30.8%	0.60	30.1%
680039	<i>Quercus sp.</i>	10.9%	25.0%	50.0%	15.4%	0.40	20.2%
680039	<i>Prunus sp.</i>	6.0%	13.6%	75.0%	23.1%	0.37	18.4%
680039	<i>Salix sp.</i>	5.7%	13.1%	50.0%	15.4%	0.28	14.2%
680039	<i>Rhamnus sp.</i>	5.6%	12.9%	25.0%	7.7%	0.21	10.3%
680039	<i>Tilia americana L.</i>	2.6%	6.0%	25.0%	7.7%	0.14	6.9%
	Shrubs						
680039	<i>Cornus sp.</i>	25.9%	100.0%	75.0%	100.0%	2.00	100.0%
	Herbaceous						
680039	<i>Impatiens capensis</i>	37.9%	30.4%	100.0%	17.4%	0.48	23.9%
680039	<i>Caltha L.</i>	25.9%	20.8%	100.0%	17.4%	0.38	19.1%
680039	<i>Carex sp.</i>	12.2%	9.8%	75.0%	13.0%	0.23	11.4%
680039	<i>Nasturtium nasturtium-aquaticum</i>	17.0%	13.6%	50.0%	8.7%	0.22	11.2%
680039	<i>Juncus sp.</i>	12.1%	9.7%	50.0%	8.7%	0.18	9.2%
680039	<i>Phalaris arundinacea L.</i>	12.1%	9.7%	50.0%	8.7%	0.18	9.2%
680039	<i>Eupatoriadelphus sp.</i>	4.0%	3.2%	75.0%	13.0%	0.16	8.1%
680039	<i>Scirpus sp.</i>	3.3%	2.7%	50.0%	8.7%	0.11	5.7%
680039	<i>Poaceae</i>	0.1%	0.1%	25.0%	4.3%	0.04	2.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680049	<i>Rhamnus sp.</i>	78.1%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680049	<i>Phalaris arundinacea L.</i>	13.3%	32.2%	100.0%	15.8%	0.48	24.0%
680049	<i>Impatiens capensis</i>	12.4%	30.0%	100.0%	15.8%	0.46	22.9%
680049	<i>Poaceae</i>	3.7%	8.8%	100.0%	15.8%	0.25	12.3%
680049	<i>Solidago sp.</i>	3.7%	8.8%	100.0%	15.8%	0.25	12.3%
680049	<i>Nasturtium nasturtium-aquaticum</i>	4.0%	9.7%	66.7%	10.5%	0.20	10.1%
680049	<i>Cirsium sp.</i>	0.5%	1.2%	100.0%	15.8%	0.17	8.5%
680049	<i>Carex sp.</i>	3.5%	8.5%	33.3%	5.3%	0.14	6.9%
680049	<i>Equisetum sp.</i>	0.4%	0.8%	33.3%	5.3%	0.06	3.1%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680054	<i>Salix sp.</i>	5.0%	60.6%	100.0%	75.0%	1.36	67.8%
680054	<i>Rhamnus sp.</i>	3.3%	39.4%	33.3%	25.0%	0.64	32.2%
	<i>Shrubs</i>						
680054	<i>Rosa sp.</i>	0.3%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680054	<i>Aster sp.</i>	13.3%	13.4%	100.0%	9.7%	0.23	11.5%
680054	<i>Eupatoriadelphus sp.</i>	11.6%	11.7%	100.0%	9.7%	0.21	10.7%
680054	<i>Impatiens capensis</i>	13.1%	13.2%	66.7%	6.5%	0.20	9.8%
680054	<i>Carex sp.</i>	11.9%	12.0%	66.7%	6.5%	0.18	9.2%
680054	<i>Eupatorium perfoliatum</i>	11.4%	11.5%	66.7%	6.5%	0.18	9.0%
680054	<i>Nasturtium nasturtium-aquaticum</i>	9.8%	9.8%	33.3%	3.2%	0.13	6.5%
680054	<i>Equisetum sp.</i>	3.8%	3.8%	66.7%	6.5%	0.10	5.1%
680054	<i>Juncus sp.</i>	3.8%	3.8%	66.7%	6.5%	0.10	5.1%
680054	<i>Solidago sp.</i>	3.8%	3.8%	66.7%	6.5%	0.10	5.1%
680054	<i>Angelica atropurpurea L.</i>	3.3%	3.3%	66.7%	6.5%	0.10	4.9%
680054	<i>Phalaris arundinacea L.</i>	3.3%	3.3%	66.7%	6.5%	0.10	4.9%
680054	<i>Poaceae</i>	3.3%	3.3%	66.7%	6.5%	0.10	4.9%
680054	<i>Symplocarpus sp.</i>	3.3%	3.3%	66.7%	6.5%	0.10	4.9%
680054	<i>Scirpus sp.</i>	0.4%	0.4%	66.7%	6.5%	0.07	3.4%
680054	<i>Verbena hastata L.</i>	3.3%	3.3%	33.3%	3.2%	0.07	3.3%
680054	<i>Allium schoenoprasum L.</i>	0.1%	0.1%	33.3%	3.2%	0.03	1.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680056	<i>Rhamnus sp.</i>	27.8%	51.2%	100.0%	50.0%	1.01	50.6%
680056	<i>Salix sp.</i>	26.4%	48.8%	100.0%	50.0%	0.99	49.4%
	<i>Herbaceous</i>						
680056	<i>Phalaris arundinacea L.</i>	56.0%	40.8%	100.0%	7.7%	0.49	24.3%
680056	<i>Poaceae</i>	27.8%	20.2%	100.0%	7.7%	0.28	14.0%
680056	<i>Nasturtium nasturtium-aquaticum</i>	25.3%	18.4%	100.0%	7.7%	0.26	13.0%
680056	<i>Carex sp.</i>	5.0%	3.6%	100.0%	7.7%	0.11	5.7%
680056	<i>Juncus sp.</i>	5.0%	3.6%	100.0%	7.7%	0.11	5.7%
680056	<i>Eupatorium perfoliatum</i>	3.7%	2.7%	100.0%	7.7%	0.10	5.2%
680056	<i>Lemna sp.</i>	1.9%	1.3%	100.0%	7.7%	0.09	4.5%
680056	<i>Angelica atropurpurea L.</i>	0.5%	0.4%	100.0%	7.7%	0.08	4.0%
680056	<i>Eupatoriadelphus sp.</i>	0.5%	0.4%	100.0%	7.7%	0.08	4.0%
680056	<i>Impatiens capensis</i>	0.5%	0.4%	100.0%	7.7%	0.08	4.0%
680056	<i>Pastinaca sativa L.</i>	0.5%	0.4%	100.0%	7.7%	0.08	4.0%
680056	<i>Potentilla sp.</i>	3.5%	2.6%	50.0%	3.8%	0.06	3.2%
680056	<i>Solidago sp.</i>	3.5%	2.6%	50.0%	3.8%	0.06	3.2%
680056	<i>Symplocarpus sp.</i>	3.5%	2.6%	50.0%	3.8%	0.06	3.2%
680056	<i>Verbena L.</i>	0.2%	0.1%	50.0%	3.8%	0.04	2.0%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
680063	<i>Rhamnus sp.</i>	15.0%	74.9%	100.0%	50.0%	1.25	62.5%
680063	<i>Salix sp.</i>	5.0%	25.1%	100.0%	50.0%	0.75	37.5%
	Shrubs						
680063	<i>Cornus racemosa</i>	15.0%	63.8%	100.0%	50.0%	1.14	56.9%
680063	<i>Ribes sp.</i>	4.3%	18.1%	50.0%	25.0%	0.43	21.6%
680063	<i>Rosa sp.</i>	4.3%	18.1%	50.0%	25.0%	0.43	21.6%
	Herbaceous						
680063	<i>Solidago sp.</i>	62.4%	27.7%	100.0%	7.4%	0.35	17.6%
680063	<i>Impatiens capensis</i>	32.6%	14.5%	100.0%	7.4%	0.22	11.0%
680063	<i>Eupatoriadelphus sp.</i>	32.0%	14.2%	100.0%	7.4%	0.22	10.8%
680063	<i>Juncus sp.</i>	15.6%	6.9%	100.0%	7.4%	0.14	7.2%
680063	<i>Cirsium arvense L.</i>	15.0%	6.6%	100.0%	7.4%	0.14	7.0%
680063	<i>Lythrum salicaria</i>	15.0%	6.6%	100.0%	7.4%	0.14	7.0%
680063	<i>Mentha arvensis L.</i>	15.0%	6.6%	100.0%	7.4%	0.14	7.0%
680063	<i>Phalaris arundinacea L.</i>	15.0%	6.6%	100.0%	7.4%	0.14	7.0%
680063	<i>Carex sp.</i>	5.0%	2.2%	100.0%	7.4%	0.10	4.8%
680063	<i>Cirsium muticum</i>	4.3%	1.9%	100.0%	7.4%	0.09	4.7%
680063	<i>Scirpus sp.</i>	4.3%	1.9%	100.0%	7.4%	0.09	4.7%
680063	<i>Symplocarpus sp.</i>	4.3%	1.9%	100.0%	7.4%	0.09	4.7%
680063	<i>Angelica atropurpurea L.</i>	4.3%	1.9%	50.0%	3.7%	0.06	2.8%
680063	<i>Mimulus sp.</i>	0.4%	0.2%	50.0%	3.7%	0.04	1.9%
680063	<i>Typha L.</i>	0.0%	0.0%	50.0%	3.7%	0.04	1.9%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680080	<i>Rhamnus sp.</i>	16.6%	47.7%	66.7%	33.3%	0.81	40.5%
680080	<i>Acer saccharium</i>	13.5%	38.7%	66.7%	33.3%	0.72	36.0%
680080	<i>Salix nigra</i> Marsh.	4.8%	13.6%	66.7%	33.3%	0.47	23.5%
	<i>Shrubs</i>						
680080	<i>Rosa sp.</i>	3.5%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680080	<i>Impatiens capensis</i>	72.6%	74.7%	66.7%	50.0%	1.25	62.4%
680080	<i>Nasturtium nasturtium-aquaticum</i>	24.4%	25.1%	33.3%	25.0%	0.50	25.0%
680080	<i>Equisetum sp.</i>	0.2%	0.2%	33.3%	25.0%	0.25	12.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
680083	<i>Vitis sp.</i>	4.8%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
680083	<i>Rhamnus sp.</i>	22.9%	40.1%	100.0%	23.1%	0.63	31.6%
680083	<i>Fraxinus pennsylvanica Marsh.</i>	11.7%	20.4%	100.0%	23.1%	0.43	21.7%
680083	<i>Populus grandidentata</i>	11.7%	20.4%	100.0%	23.1%	0.43	21.7%
680083	<i>Acer negundo L.</i>	10.7%	18.7%	100.0%	23.1%	0.42	20.9%
680083	<i>Thuja occidentalis</i>	0.2%	0.4%	33.3%	7.7%	0.08	4.0%
	<i>Shrubs</i>						
680083	<i>Viburnum sp.</i>	4.8%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680083	<i>Juncus sp.</i>	16.6%	28.9%	66.7%	12.5%	0.41	20.7%
680083	<i>Liliaceae sp.</i>	11.6%	20.2%	66.7%	12.5%	0.33	16.4%
680083	<i>Solidago sp.</i>	11.6%	20.2%	66.7%	12.5%	0.33	16.4%
680083	<i>Aster sp.</i>	4.8%	8.3%	66.7%	12.5%	0.21	10.4%
680083	<i>Iris sp.</i>	4.8%	8.3%	66.7%	12.5%	0.21	10.4%
680083	<i>Poaceae</i>	4.8%	8.3%	66.7%	12.5%	0.21	10.4%
680083	<i>Eupatoriadelphus sp.</i>	0.5%	0.8%	66.7%	12.5%	0.13	6.7%
680083	<i>Symplocarpus sp.</i>	2.8%	4.8%	33.3%	6.3%	0.11	5.5%
680083	<i>Lythrum salicaria</i>	0.1%	0.2%	33.3%	6.3%	0.06	3.2%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680128	<i>Rhamnus sp.</i>	17.5%	75.3%	100.0%	25.0%	1.00	50.1%
680128	<i>Salix sp.</i>	5.0%	21.5%	100.0%	25.0%	0.47	23.3%
680128	<i>Betula sp.</i>	0.5%	2.2%	100.0%	25.0%	0.27	13.6%
680128	<i>Rhus sp.</i>	0.3%	1.1%	100.0%	25.0%	0.26	13.0%
	<i>Shrubs</i>						
680128	<i>Ulex sp.</i>	0.5%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680128	<i>Equisetum sp.</i>	5.0%	46.5%	100.0%	25.0%	0.72	35.8%
680128	<i>Plantago major L.</i>	5.0%	46.5%	100.0%	25.0%	0.72	35.8%
680128	<i>Poaceae</i>	0.5%	4.7%	100.0%	25.0%	0.30	14.8%
680128	<i>Solidago sp.</i>	0.3%	2.3%	100.0%	25.0%	0.27	13.7%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680137	<i>Acer negundo L.</i>	5.2%	91.6%	100.0%	60.0%	1.52	75.8%
680137	<i>Salix sp.</i>	0.5%	8.4%	66.7%	40.0%	0.48	24.2%
	<i>Shrubs</i>						
680137	<i>Rosa sp.</i>	0.03%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680137	<i>Phalaris arundinacea L.</i>	97.5%	70.0%	100.0%	21.4%	0.91	45.7%
680137	<i>Nasturtium nasturtium-aquaticum</i>	35.9%	25.7%	100.0%	21.4%	0.47	23.6%
680137	<i>Impatiens capensis</i>	5.0%	3.6%	100.0%	21.4%	0.25	12.5%
680137	<i>Urtica L.</i>	0.5%	0.4%	100.0%	21.4%	0.22	10.9%
680137	<i>Cirsium arvense L.</i>	0.5%	0.3%	66.7%	14.3%	0.15	7.3%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680146	<i>Rhamnus sp.</i>	32.0%	93.3%	100.0%	50.0%	1.43	71.6%
680146	<i>Alnus sp.</i>	2.3%	6.7%	100.0%	50.0%	0.57	28.4%
	<i>Herbaceous</i>						
680146	<i>Potentilla sp.</i>	15.3%	26.6%	100.0%	10.5%	0.37	18.6%
680146	<i>Carex sp.</i>	15.0%	26.1%	50.0%	5.3%	0.31	15.7%
680146	<i>Phalaris arundinacea L.</i>	10.0%	17.4%	100.0%	10.5%	0.28	14.0%
680146	<i>Poaceae</i>	7.3%	12.7%	100.0%	10.5%	0.23	11.6%
680146	<i>Cirsium arvense L.</i>	2.3%	4.0%	100.0%	10.5%	0.15	7.3%
680146	<i>Impatiens capensis</i>	2.0%	3.5%	50.0%	5.3%	0.09	4.4%
680146	<i>Juncus sp.</i>	2.0%	3.5%	50.0%	5.3%	0.09	4.4%
680146	<i>Mentha arvensis L.</i>	2.0%	3.5%	50.0%	5.3%	0.09	4.4%
680146	<i>Iris sp.</i>	0.3%	0.5%	50.0%	5.3%	0.06	2.9%
680146	<i>Nasturtium sp.</i>	0.3%	0.5%	50.0%	5.3%	0.06	2.9%
680146	<i>Sagittaria sp.</i>	0.3%	0.5%	50.0%	5.3%	0.06	2.9%
680146	<i>Symplocarpus sp.</i>	0.3%	0.5%	50.0%	5.3%	0.06	2.9%
680146	<i>Eupatoriadelphus sp.</i>	0.2%	0.3%	50.0%	5.3%	0.06	2.8%
680146	<i>Mimulus ringens L.</i>	0.1%	0.2%	50.0%	5.3%	0.05	2.7%
680146	<i>Ranunculus sp.</i>	0.1%	0.2%	50.0%	5.3%	0.05	2.7%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
680149	<i>Rhamnus sp.</i>	48.3%	67.4%	100.0%	33.3%	1.01	50.4%
680149	<i>Fraxinus sp.</i>	20.8%	29.1%	100.0%	33.3%	0.62	31.2%
680149	<i>Alnus sp.</i>	2.3%	3.1%	66.7%	22.2%	0.25	12.7%
680149	<i>Quercus sp.</i>	0.3%	0.3%	33.3%	11.1%	0.11	5.7%
	Shrubs						
680149	<i>Cornus sp.</i>	0.5%	52.6%	100.0%	60.0%	1.13	56.3%
680149	<i>Ribes sp.</i>	0.5%	47.4%	66.7%	40.0%	0.87	43.7%
	Herbaceous						
680149	<i>Poaceae</i>	35.5%	40.4%	100.0%	9.1%	0.50	24.8%
680149	<i>Symplocarpus sp.</i>	10.8%	12.2%	66.7%	6.1%	0.18	9.2%
680149	<i>Phalaris arundinacea L.</i>	7.5%	8.5%	66.7%	6.1%	0.15	7.3%
680149	<i>Carex sp.</i>	4.6%	5.2%	100.0%	9.1%	0.14	7.1%
680149	<i>Laportea canadensis</i>	4.6%	5.2%	100.0%	9.1%	0.14	7.1%
680149	<i>Scirpus sp.</i>	2.3%	2.6%	100.0%	9.1%	0.12	5.9%
680149	<i>Aster sp.</i>	4.5%	5.1%	66.7%	6.1%	0.11	5.6%
680149	<i>Equisetum sp.</i>	2.7%	3.1%	66.7%	6.1%	0.09	4.6%
680149	<i>Eupatoriadelphus sp.</i>	2.3%	2.6%	66.7%	6.1%	0.09	4.3%
680149	<i>Eupatorium perfoliatum</i>	2.3%	2.6%	66.7%	6.1%	0.09	4.3%
680149	<i>Geranium L.</i>	2.3%	2.6%	66.7%	6.1%	0.09	4.3%
680149	<i>Impatiens capensis</i>	2.3%	2.6%	66.7%	6.1%	0.09	4.3%
680149	<i>Verbena L.</i>	2.3%	2.6%	66.7%	6.1%	0.09	4.3%
680149	<i>Angelica atropurpurea L.</i>	2.0%	2.3%	33.3%	3.0%	0.05	2.7%
680149	<i>Solidago sp.</i>	2.0%	2.3%	33.3%	3.0%	0.05	2.7%
680149	<i>Mentha arvensis L.</i>	0.2%	0.2%	33.3%	3.0%	0.03	1.6%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680150	<i>Rhamnus sp.</i>	32.6%	90.9%	100.0%	80.0%	1.71	85.5%
680150	<i>Salix sp.</i>	3.3%	9.1%	25.0%	20.0%	0.29	14.5%
	<i>Herbaceous</i>						
680150	<i>Solidago sp.</i>	15.0%	16.9%	100.0%	10.5%	0.27	13.7%
680150	<i>Scirpus sp.</i>	14.9%	16.9%	75.0%	7.9%	0.25	12.4%
680150	<i>Cirsium arvense L.</i>	12.5%	14.1%	100.0%	10.5%	0.25	12.3%
680150	<i>Nasturtium nasturtium-aquaticum</i>	14.7%	16.6%	75.0%	7.9%	0.25	12.3%
680150	<i>Phalaris arundinacea L.</i>	4.8%	5.4%	100.0%	10.5%	0.16	8.0%
680150	<i>Symplocarpus sp.</i>	6.8%	7.7%	75.0%	7.9%	0.16	7.8%
680150	<i>Equisetum sp.</i>	4.3%	4.9%	75.0%	7.9%	0.13	6.4%
680150	<i>Eupatorium perfoliatum</i>	3.4%	3.8%	75.0%	7.9%	0.12	5.9%
680150	<i>Caltha L.</i>	1.0%	1.1%	100.0%	10.5%	0.12	5.8%
680150	<i>Potentilla sp.</i>	4.3%	4.8%	50.0%	5.3%	0.10	5.0%
680150	<i>Cirsium muticum</i>	3.3%	3.7%	25.0%	2.6%	0.06	3.2%
680150	<i>Eupatoriadelphus sp.</i>	3.3%	3.7%	25.0%	2.6%	0.06	3.2%
680150	<i>Mentha arvensis L.</i>	0.4%	0.5%	50.0%	5.3%	0.06	2.9%
680150	<i>Juncus sp.</i>	0.1%	0.1%	25.0%	2.6%	0.03	1.3%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
680172	<i>Tilia americana</i> L.	90.1%	75.3%	75.0%	18.8%	0.94	47.0%
680172	<i>Rhamnus</i> sp.	10.8%	9.0%	100.0%	25.0%	0.34	17.0%
680172	<i>Prunus</i> sp.	7.9%	6.6%	75.0%	18.8%	0.25	12.7%
680172	<i>Ulmus rubra</i> Muhl.	3.8%	3.2%	50.0%	12.5%	0.16	7.8%
680172	<i>Fraxinus</i> sp.	3.8%	3.1%	50.0%	12.5%	0.16	7.8%
680172	<i>Juglans nigra</i> L.	3.3%	2.8%	50.0%	12.5%	0.15	7.6%
Shrubs							
680172	<i>Rosa</i> sp.	15.4%	45.0%	100.0%	36.4%	0.81	40.7%
680172	<i>Lonicera</i> sp.	15.0%	43.7%	100.0%	36.4%	0.80	40.0%
680172	<i>Ribes</i> sp.	3.9%	11.3%	75.0%	27.3%	0.39	19.3%
Herbaceous							
680172	<i>Impatiens capensis</i>	47.8%	77.9%	100.0%	28.6%	1.06	53.2%
680172	<i>Juncus</i> sp.	4.3%	7.0%	75.0%	21.4%	0.28	14.2%
680172	<i>Urtica</i> L.	3.4%	5.5%	75.0%	21.4%	0.27	13.5%
680172	<i>Podophyllum peltatum</i>	3.5%	5.7%	25.0%	7.1%	0.13	6.4%
680172	<i>Arisaema</i> sp.	1.0%	1.6%	25.0%	7.1%	0.09	4.4%
680172	<i>Parthenocissus quinquefolia</i>	1.0%	1.6%	25.0%	7.1%	0.09	4.4%
680172	<i>Mimulus</i> sp.	0.3%	0.5%	25.0%	7.1%	0.08	3.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
680197	<i>Vitis sp.</i>	0.4%	100.0%	100.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
680197	<i>Rhamnus sp.</i>	14.0%	97.2%	50.0%	50.0%	1.47	73.6%
680197	<i>Ulmus americana L.</i>	0.4%	2.8%	50.0%	50.0%	0.53	26.4%
	<i>Herbaceous</i>						
680197	<i>Impatiens capensis</i>	31.0%	17.4%	100.0%	8.0%	0.25	12.7%
680197	<i>Carex sp.</i>	30.1%	16.9%	100.0%	8.0%	0.25	12.4%
680197	<i>Solidago sp.</i>	30.1%	16.9%	100.0%	8.0%	0.25	12.4%
680197	<i>Juncus sp.</i>	14.1%	7.9%	100.0%	8.0%	0.16	8.0%
680197	<i>Poaceae</i>	14.1%	7.9%	100.0%	8.0%	0.16	8.0%
680197	<i>Nasturtium nasturtium-aquaticum</i>	19.5%	10.9%	50.0%	4.0%	0.15	7.5%
680197	<i>Aster sp.</i>	14.0%	7.9%	50.0%	4.0%	0.12	5.9%
680197	<i>Angelica atropurpurea L.</i>	4.1%	2.3%	100.0%	8.0%	0.10	5.2%
680197	<i>Cirsium muticum</i>	4.1%	2.3%	100.0%	8.0%	0.10	5.2%
680197	<i>Phalaris arundinacea L.</i>	4.1%	2.3%	100.0%	8.0%	0.10	5.2%
680197	<i>Typha L.</i>	4.1%	2.3%	100.0%	8.0%	0.10	5.2%
680197	<i>Verbena L.</i>	4.1%	2.3%	100.0%	8.0%	0.10	5.2%
680197	<i>Eupatoriadelphus sp.</i>	4.0%	2.2%	50.0%	4.0%	0.06	3.1%
680197	<i>Panicum virgatum</i>	0.4%	0.2%	50.0%	4.0%	0.04	2.1%
680197	<i>Toxicodendron radicans</i>	0.4%	0.2%	50.0%	4.0%	0.04	2.1%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
Trees							
680201	<i>Quercus macrocarpa</i> Michx.	12.4%	59.8%	100.0%	27.3%	0.87	43.5%
680201	<i>Rhamnus</i> sp.	4.0%	19.3%	66.7%	18.2%	0.37	18.7%
680201	<i>Salix babylonica</i> L.	4.0%	19.3%	66.7%	18.2%	0.37	18.7%
680201	<i>Larix laricina</i> Koch	0.2%	0.7%	66.7%	18.2%	0.19	9.5%
680201	<i>Acer saccharinum</i>	0.1%	0.5%	33.3%	9.1%	0.10	4.8%
680201	<i>Pinus strobus</i> L.	0.1%	0.5%	33.3%	9.1%	0.10	4.8%
Herbaceous							
680201	<i>Nasturtium nasturtium-aquaticum</i>	20.0%	73.9%	66.7%	20.0%	0.94	47.0%
680201	<i>Impatiens capensis</i>	3.6%	13.1%	66.7%	20.0%	0.33	16.6%
680201	<i>Poaceae</i>	1.4%	5.0%	66.7%	20.0%	0.25	12.5%
680201	<i>Arctium</i> L.	0.2%	0.6%	66.7%	20.0%	0.21	10.3%
680201	<i>Cirsium arvense</i> L.	1.0%	3.7%	33.3%	10.0%	0.14	6.8%
680201	<i>Eupatoriadelphus</i> sp.	1.0%	3.7%	33.3%	10.0%	0.14	6.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	Trees						
680212	<i>Quercus alba L.</i>	18.0%	53.4%	100.0%	37.5%	0.91	45.5%
680212	<i>Carya ovata Koch.</i>	15.3%	45.4%	100.0%	37.5%	0.83	41.5%
680212	<i>Alnus sp.</i>	0.2%	0.6%	33.3%	12.5%	0.13	6.5%
680212	<i>Robinia pseudoacacia L.</i>	0.2%	0.6%	33.3%	12.5%	0.13	6.5%
	Shrubs						
680212	<i>Ribes sp.</i>	15.0%	100.0%	33.3%	100.0%	2.00	100.0%
	Herbaceous						
680212	<i>Alliaria petiolaris</i>	29.0%	71.4%	33.3%	5.9%	0.77	38.7%
680212	<i>Symplocarpus sp.</i>	1.4%	3.4%	100.0%	17.6%	0.21	10.5%
680212	<i>Impatiens capensis</i>	1.2%	3.0%	66.7%	11.8%	0.15	7.4%
680212	<i>Caltha L.</i>	0.3%	0.7%	66.7%	11.8%	0.13	6.3%
680212	<i>Nasturtium nasturtium-aquaticum</i>	0.3%	0.7%	66.7%	11.8%	0.13	6.3%
680212	<i>Polygonatum biflorum</i>	0.2%	0.5%	66.7%	11.8%	0.12	6.1%
680212	<i>Erigeron sp.</i>	2.0%	4.9%	33.3%	5.9%	0.11	5.4%
680212	<i>Galium sp.</i>	2.0%	4.9%	33.3%	5.9%	0.11	5.4%
680212	<i>Geranium L.</i>	2.0%	4.9%	33.3%	5.9%	0.11	5.4%
680212	<i>Poaceae</i>	2.0%	4.9%	33.3%	5.9%	0.11	5.4%
680212	<i>Aquilegia sp.</i>	0.2%	0.5%	33.3%	5.9%	0.06	3.2%

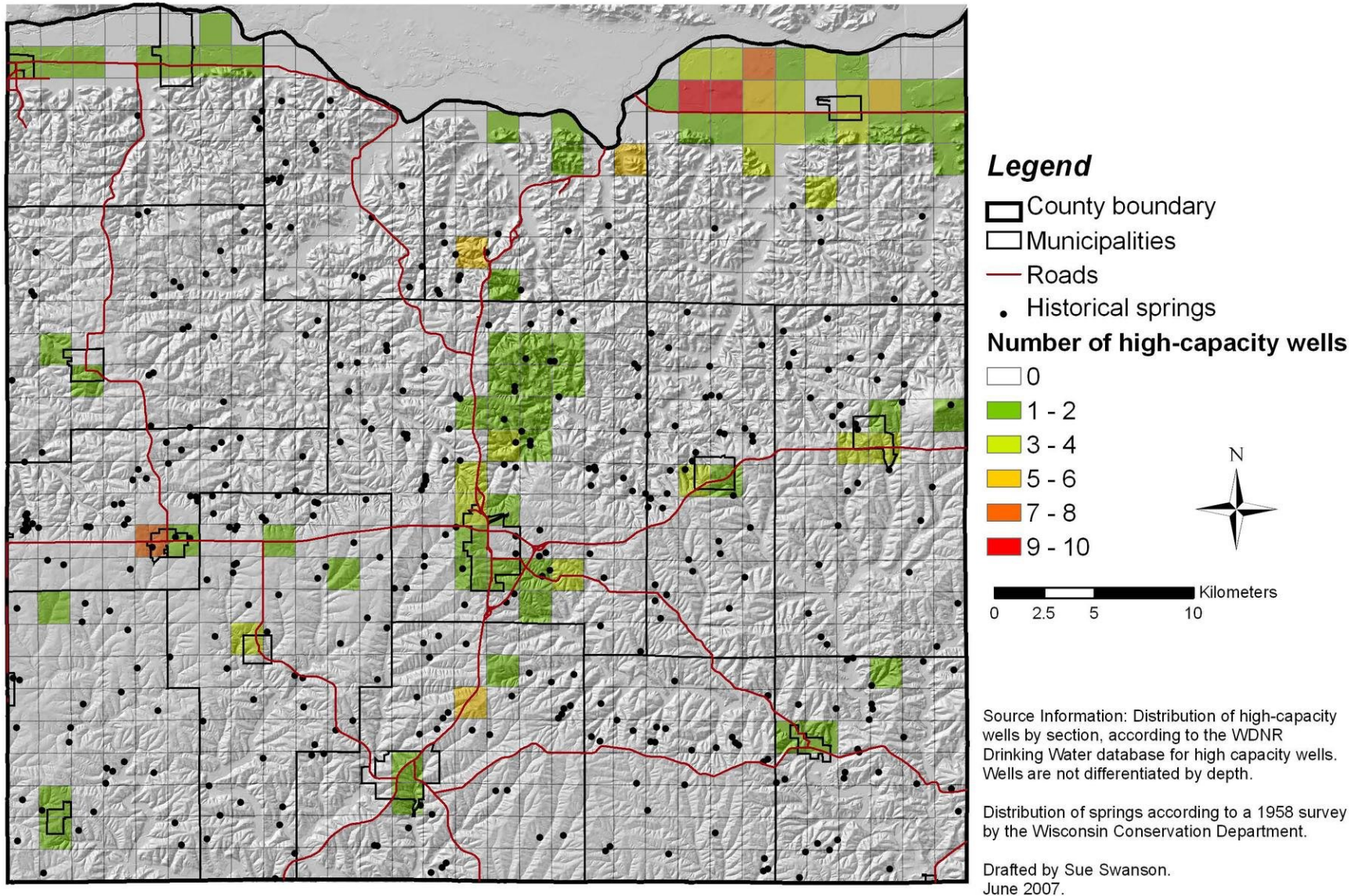
Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
680300	<i>Vitis sp.</i>	0.3%	100.0%	33.3%	100.0%	2.00	100.0%
	<i>Trees</i>						
680300	<i>Rhamnus sp.</i>	46.8%	81.4%	100.0%	60.0%	1.41	70.7%
680300	<i>Prunus pennsylvanica L. fils</i>	10.7%	18.6%	66.7%	40.0%	0.59	29.3%
	<i>Shrubs</i>						
680300	<i>Ribes sp.</i>	10.7%	100.0%	66.7%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680300	<i>Symplocarpus sp.</i>	43.7%	50.9%	100.0%	15.8%	0.67	33.3%
680300	<i>Impatiens capensis</i>	12.5%	14.6%	100.0%	15.8%	0.30	15.2%
680300	<i>Nasturtium nasturtium-aquaticum</i>	15.0%	17.5%	66.7%	10.5%	0.28	14.0%
680300	<i>Poaceae</i>	6.1%	7.0%	100.0%	15.8%	0.23	11.4%
680300	<i>Caltha L.</i>	4.6%	5.3%	100.0%	15.8%	0.21	10.5%
680300	<i>Solidago sp.</i>	3.2%	3.7%	66.7%	10.5%	0.14	7.1%
680300	<i>Equisetum sp.</i>	0.3%	0.3%	33.3%	5.3%	0.06	2.8%
680300	<i>Liliaceae sp.</i>	0.3%	0.3%	33.3%	5.3%	0.06	2.8%
680300	<i>Parthenocissus quinquefolia</i>	0.3%	0.3%	33.3%	5.3%	0.06	2.8%

Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Trees</i>						
680301	<i>Rhamnus sp.</i>	15.1%	92.8%	100.0%	50.0%	1.43	71.4%
680301	<i>Salix sp.</i>	1.2%	7.2%	100.0%	50.0%	0.57	28.6%
	<i>Herbaceous</i>						
680301	<i>Juncus sp.</i>	6.9%	66.7%	100.0%	18.2%	0.85	42.5%
680301	<i>Equisetum sp.</i>	1.2%	11.4%	100.0%	18.2%	0.30	14.8%
680301	<i>Phalaris arundinacea L.</i>	1.2%	11.4%	100.0%	18.2%	0.30	14.8%
680301	<i>Carex sp.</i>	0.5%	4.9%	100.0%	18.2%	0.23	11.5%
680301	<i>Pteridophyta</i>	0.5%	4.9%	100.0%	18.2%	0.23	11.5%
680301	<i>Rudbeckia hirta</i>	0.1%	0.7%	50.0%	9.1%	0.10	4.9%

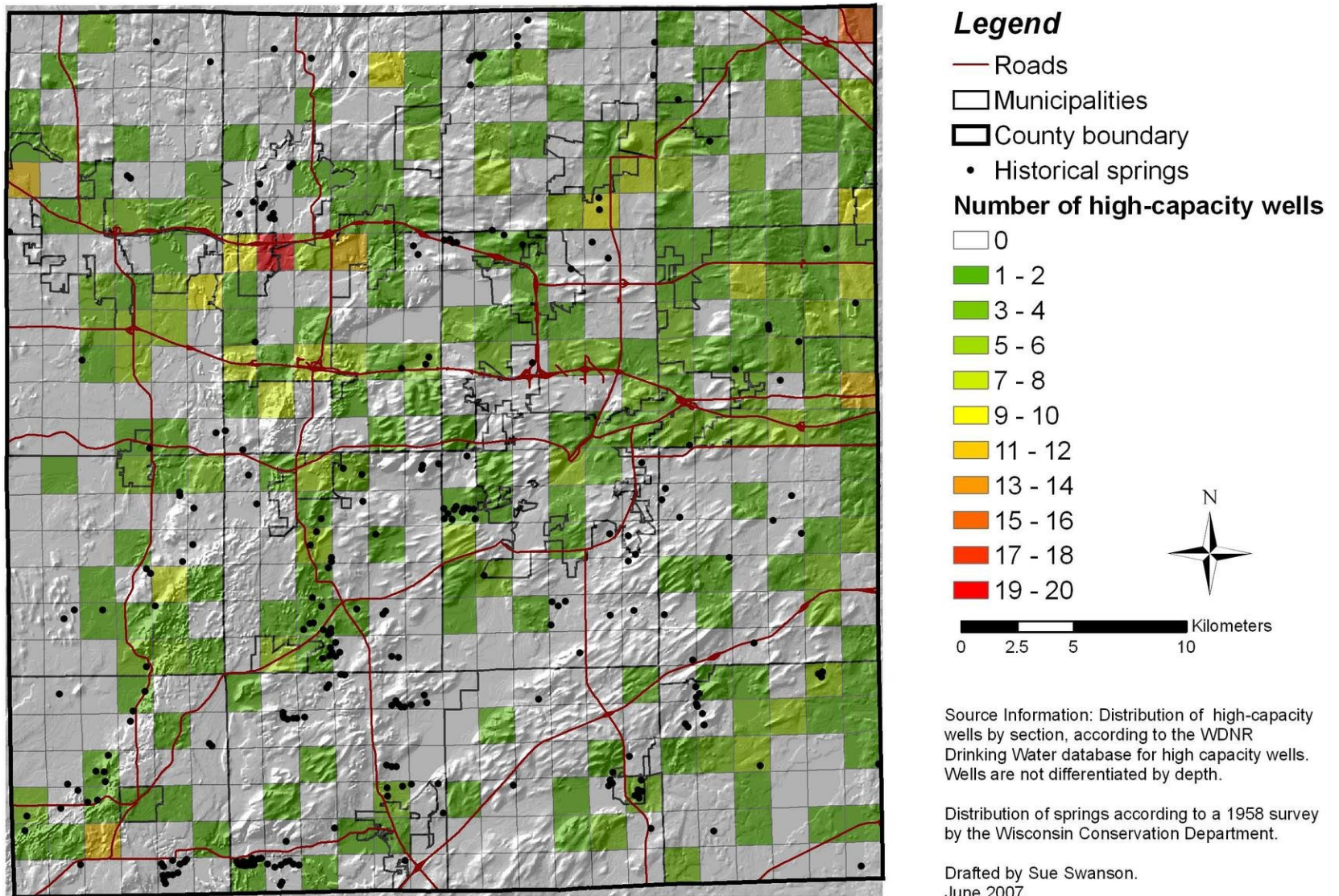
Site Code	Plant Name	Average Coverage	Relative Coverage	Frequency	Relative Frequency	Importance Value	Importance Percentage
	<i>Vines</i>						
680302	<i>Vitis sp.</i>	1.0%	100.0%	25.0%	100.0%	2.00	100.0%
	<i>Trees</i>						
680302	<i>Rhamnus sp.</i>	16.7%	31.5%	100.0%	20.0%	0.52	25.8%
680302	<i>Quercus macrocarpa Michx.</i>	16.6%	31.3%	75.0%	15.0%	0.46	23.2%
680302	<i>Salix nigra Marsh.</i>	8.2%	15.5%	100.0%	20.0%	0.35	17.7%
680302	<i>Populus deltoides Bartr.</i>	5.7%	10.8%	100.0%	20.0%	0.31	15.4%
680302	<i>Salix sp.</i>	2.1%	4.0%	75.0%	15.0%	0.19	9.5%
680302	<i>Carya ovata Koch.</i>	3.7%	7.0%	50.0%	10.0%	0.17	8.5%
	<i>Shrubs</i>						
680302	<i>Ribes sp.</i>	1.0%	100.0%	25.0%	100.0%	2.00	100.0%
	<i>Herbaceous</i>						
680302	<i>Typha L.</i>	15.7%	33.4%	75.0%	10.7%	0.44	22.1%
680302	<i>Poaceae</i>	10.6%	22.6%	100.0%	14.3%	0.37	18.4%
680302	<i>Juncus sp.</i>	4.8%	10.2%	100.0%	14.3%	0.24	12.2%
680302	<i>Impatiens capensis</i>	4.6%	9.8%	75.0%	10.7%	0.21	10.3%
680302	<i>Phalaris arundinacea L.</i>	3.8%	8.1%	75.0%	10.7%	0.19	9.4%
680302	<i>Eupatoriadelphus sp.</i>	2.2%	4.7%	75.0%	10.7%	0.15	7.7%
680302	<i>Solidago sp.</i>	1.2%	2.6%	75.0%	10.7%	0.13	6.6%
680302	<i>Carex sp.</i>	2.0%	4.3%	50.0%	7.1%	0.11	5.7%
680302	<i>Cirsium arvense L.</i>	1.0%	2.1%	25.0%	3.6%	0.06	2.8%
680302	<i>Scirpus sp.</i>	1.0%	2.1%	25.0%	3.6%	0.06	2.8%
680302	<i>Urtica L.</i>	0.1%	0.2%	25.0%	3.6%	0.04	1.9%

APPENDIX F: Distribution of Springs and High-Capacity Wells in Iowa and Waukesha Counties

Distribution of Springs and High-Capacity Wells in Iowa County, Wisconsin



Distribution of Springs and High-Capacity Wells in Waukesha County, Wisconsin



APPENDIX G: Acknowledgements

This work was supported by the UW-Water Resources Institute, the USGS, and the WDNR. We thank the many property owners who assisted in this effort by sharing information and allowing access to their springs. We also thank Paul Ohlrogge (UW-Extension) and the many other county and state personnel who contributed background information. Sincere thanks to Dr. Yaffa Grossman (Beloit College), who provided assistance with interpretation of ecological data. Brandon Bartkowiak, Becky Carvin, Natalie Hunt, and David Zaber also provided valuable assistance in the field.