The Ordway Digital Database

Creating an archive of spatial information for continued exploration and research in The Katharine Ordway Natural History Study Area

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The authors of this report were enrolled in *GIS: Concepts and Applications* course in the Department of Geography at Macalester College during the fall semester of 2009.

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Acknowledgements

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Executive Summary

The report that follows is a description of work completed between September and December 2008 by students in the *GIS: Concepts and Applications* course in the Geography Department at Macalester College. Our primary task was to create the foundation for a living digital database of spatial information pertaining to the Katharine Ordway Natural History Study Area (Ordway). Ordway is a 300-acre plot owned by Macalester College and is nestled along the Mississippi River in Inver Grove Heights, Minnesota. Because it plays host to a diversity of plant and animal communities, it is an ideal location for environmental research and education. Our simple, yet important database is intended for use by researchers, educators, and students as a means to organize the growing amounts of data available for Ordway. Further, it offers a way of synthesizing that information for the purpose of furthering our understanding of Ordway and for guiding future research and policy decisions.

Creating this database entailed the fulfillment of several key objectives. First, it was necessary to collect all pertinent spatial data for Ordway. Modifications to the data were made in order to fit the spatial scope of our project and it was subsequently organized into a user-friendly database format and will be made available for general use. Finally, as a demonstration of the capabilities of our database, we constructed a series of informative maps and performed spatial analyses using the available data. To accomplish these objectives, students divided the labor of data acquisition by forming three working groups: Land Use, Vegetation, and Historical. Each group was responsible for their respective types of data and for showcasing its usefulness through maps and/or spatial analysis. The significant findings and recommendations of each working group are reported below.

The Land Use Working Group collected data pertaining to basic features in Ordway. One of our main goals was to create a digitized reference map that could be used as a base layer for any future mapping or data analysis. To collect this primary data we used Trimble GPS units to record waypoints, lines and polygons. Another of our main goals was to accurately collect data for trail locations. While recording the trails our group also sought to record different features in the landscape, so we could make a reference system for our partners and future classes to come back to. All of these points we collected with Garmin GPS units. One of our main goals was to record the locations of research flags. Other attributes we collected include: birdhouses, signs, fences, posts, and other points of interest. Our goals in collecting all these points was to give a bit more context to what can be found in the Ordway, for our class project as well as beyond.

The Vegetation Working Group had the responsibility of gaining a clearer understanding of existing plant communities and ecological habitats within Ordway. Information collected includes primary GPS data retrieved from Ordway pertaining to wetland and prairie plant communities, land use and land cover layers and the National Wetland Inventory. These data provide a valuable indication of the location and extent of prairies and wetlands. Our primary data are the most recent data set available, and our information is grounded in fieldwork conducted at Ordway, as opposed to being based on aerial photos, with the help of our partners who are familiar with the landscape. These data were collected and turned into cohesive layers and maps specifically with the goals of our partners in mind. Findings based on maps and spatial

analyses include the dramatic reduction in non-wooded areas over the period from 1974 -2008. It was also noted that Ordway is home to Sensitive Ecological Areas as determined by the Minnesota Department of Natural Resources.

The Historical Working Group was concerned primarily with gathering secondary data series for past time periods. Data collected include historic land use, aerial photographs, and the National Wetland Inventory. Spatial analysis of historical data revealed several trends in and around Ordway. First, maps of land use change from 1984-2005 reveal a loss of open space and the expansion of land areas used for commercial, residential, and transportation purposes. Next, aerial photo analysis indicates an overall increase in the size and stability of the surface area of River Lake--a backwater lake on Ordway property--from 1927-2008. Additionally, these surface area trends appear to be a likely cause of observed aquatic vegetation loss within the lake. While aerial photo interpretation is a valuable analysis tool, its limitations and uncertainty in regards to Ordway are discussed. Finally a temporal analysis of wetland changes within Ordway suggest possible differences in the overall composition and extent of those areas from 1984-2009.

Recommendations

Continuity of the Database as a Living Archive

Creating this database required substantial effort on the part of students in Macalester's *GIS: Concepts and Applications* course and their partners. Upon our release of database management responsibilities, we recommend that this resource would remain open and available to all parties who might benefit from its contents. Further, it is our hope that this archive represents a foundation upon which multidisciplinary workers will be capable of updating and adding to in the future.

Pursuing Relationships with Ordway's Neighbors

Given changes in land use, we recommend that our partners' effort to secure a conservation corridor along the riverfront should remain an immediate priority before continued development envelops the area. Furthermore, in light of the rapid pace of residential development, we stress the likelihood that Pine Bend Elementary will continue to grow. This should be considered in any plans to develop an educational partnership with the school.

Accessibility within Ordway

Accessibility of resources and research points within Ordway is currently restricted by outdated maps and unmanaged trails. Existing trails should be more clearly marked and future trails should be added to the database and reference maps. That way those unfamiliar with the landscape (especially if elementary students are going to have field trips here) can more easily find their way around. Another aspect of trail maintenance includes trail expansion along the corridors we suggested. These corridors haven't been assessed for the type of vegetation in these areas but based on elevation and steepness (slope); these areas would be improved by the addition of trails.

Lake Vegetation Restoration

Analysis of historical aerial photos revealed a striking loss of aquatic lake vegetation between 1927 and 2008. Because high river stage and surface-area stability seem be the likeliest causes of this loss within River Lake, we would endorse research proposals by Biology/ES Professor Dan Hornbach for vegetation reestablishment via lake draw-down. While costly and logistically complicated, the effort seems likely to succeed if those obstacles are overcome.

Terms

Trimble: A hand-held GPS unit used in this project with sub-foot accuracy.
Garmin: A hand-held GPS unit used in this project with sub three meter accuracy.

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Introduction and Objectives

In the Fall of 2009, the Macalester Geography Department partnered with the Macalester Biology and Environmental Studies Departments to create a digital database focused on the Katherine Ordway Natural History Study Area (KONHSA, from now on referred to as the Ordway). The primary objective of the project was to create a baseline digital database so that future research conducted at the Ordway can be added to it. Our intention is to continue to make this a living database that can be updated and edited in the future. To collect data, organize and release this database were the primary goals of the *GIS: Concepts and Applications* course this semester, under the instruction of Professor Holly Barcus. These goals were achieved through cooperation with our partners, Professors Mike Anderson and Jerald Dosch of the Biology Department, Professor Dan Hornbach of the Environmental Studies Department and Richard McCarthy, the on-site manager of the Ordway.

Ordway Background and the Need for Database

The Katherine Ordway Natural History Study Area was purchased by Macalester College in 1967 with a donation made by its namesake. The approximately three hundred acre property lies seventeen miles south-east of Macalester in Inver Grove Heights. Nestled along the Mississippi River, the Ordway covers most of the shoreline of River Lake, a backwater lake that is connected to the river. The Ordway boasts diverse plant and animal communities, allowing different types of research to be conducted through the years.[1] When the Ordway was first established, research was frequently conducted in the area, but as years went on, Macalester professors and students looked to new research areas. Now, with new professors coming into the Biology and Environmental Studies departments, a re-emerging enthusiasm for research at Ordway has led to the impetus for this project.

Our partners in the Biology and Environmental Studies departments saw a profound need for computer-based, digital information about the Ordway. Existing maps prior to this project were largely hand-drawn, and although they were intricate, they did not adequately meet the needs of researchers. Our partners are interested in pursuing a variety of research projects, as well as other collaborative efforts related to the Ordway which necessitates a more comprehensive and organized system for studying the Ordway. This database is the entry point to that effort. A few of the general goals of our partners include creating base maps to improve access and management. A recent NSF funded planning grant is allowing Macalester to assess the future uses of this property and this project provides information and data to assist with that process. Another goal was to look at changes in vegetation within Ordway as well as changes of the surrounding areas (Mississippi River and Inver Grove Heights) over time. Finally the partners wanted to have digital records of the locations of research flags, signs and other

[1] Paulson, Kelly, M., (2001) Macalester College Honors Thesis: *The History of Katharine Ordway Natural History Study Area, Inver Grove Heights, Minnesota*

attributes of the Ordway. With these goals in mind we set out to collect data and organize the database with a GIS framework.

Methodology

Based on the needs of our partners and our own capabilities and limitations in mind, we divided the workload among three working groups: Land Use, Vegetation, and Historical. The Land Use Working Group sought to gather information about existing land use at Ordway, with a particular focus on trails, built structures and the remnants of past research efforts, such as flags and other markers. This provides more information about how to navigate Ordway in the future and also gives researchers a sense of what improvements Ordway might need. The group collected primary GPS data and created layers based on points and attributes of interest around the property.

The Vegetation Working Group was given the responsibility of collecting primary and secondary data about existing and former plant communities within and around Ordway. During our time in the field, the group collected primary GPS data and created layers based on what plant communities currently exist in Ordway. Secondary data supplemented this by providing both a historical perspective to vegetation at Ordway and by giving added detail about areas we were unable to collect primary data from.

The Historical Working Group gathered secondary data on the history of Ordway over the past century. Most of this research concentrated on changes observed through aerial photographs focusing on vegetation change, development change and changes to River Lake. In this way they were able to add to the historical components of the other groups, as well as add important information.

Land Use Working Group

Introduction

The objective of our group was to collect data of basic features of Ordway. Because the only reference map available of Ordway was a hand drawn map (Figure 1) that was at least twenty years old, one of our main goals was to create a digitized reference map that could be used as a base layer for any future mapping or data analysis. To collect this primary data we used GPS units to record waypoints, lines and polygons. Another of our main goals was to accurately collect data for trail locations. We used Trimble GPS units to collect these data because of the higher accuracy that the Trimble units are able to give us. This task turned out to be a little more difficult than we first thought, mostly because the conditions of the trails system within Ordway left many of the trails indistinguishable from the surrounding landscape. With some help of our partners we were able to locate some of the main trails that have been used repeatedly through the years. That is not to say that there aren't many more trails within Ordway, they just have either fallen into disuse becoming overgrown or they were only used by a few individuals at a time.

While recording the trails our group also sought to record different features in the landscape, so we could make a reference system for our partners and future classes to come back to. All of these points we collected with Garmin GPS units. One of our main goals was to record the locations of research flags. Other attributes we collected include: birdhouses, signs, fences, posts, and other points of interest. Our goals in collecting all these points was to give a bit more context to what can be found in the Ordway, for our class project as well as beyond.

Figure 1: Existing hand-drawn map of Ordway kept on site. Predates 1989.

Layers

Water Features

Water Features is a polygon layer that shows the bodies of water around Ordway. It was taken from Metropolitan Council data found on MetroGIS Datafinder and clipped the extended boundary. Data from both Dakota and Washington Counties were combined to make this layer. The layer is based off aerial photographs taken in 2000.

Elevation

Elevation is a line layer depicting the elevation. It is based on data from the Metropolitan Council and was found on MetroGIS Datafinder. It is a combination of data from Dakota and Washington Counties and it was clipped to the extended boundary.

Roads

Roads is line layer based on a dataset from the Lawrence Group that was released in 2006 It shows all roads within the extended boundary. It was made by combining data from Dakota and Washington Counties and then clipped to the extended boundary.

Generalized Land Use

Generalized land use shows how the land around Ordway is being used. It is based on 2005 data from the Metropolitan council. Data from Dakota and Washington Counties were combined and then clipped to the extended boundary.

Steep Slopes

Steep Slopes is a polygon layer that shows areas where the slope is more than 12%. It is based on Metropolitan Council data from 2000 and was clipped to the extend boundary.

New Trails

The proposed new trials are based on a model which selects areas with high elevation but little land slope.

All of the following layers are based on primary data gathered by the Geography 364 class. These data were gathered over the course of three visits to the Ordway on Thursday October 8th, Tuesday October 13th, and Saturday October 17th using primarily Garmin GPS units, as well as occasionally Trimble units.

Signs

This layer contains the location of all signs that we encountered while gathering data. The type of sign is listed in the attribute table.

Fences
This layer contains the location of all fences that we encountered while gathering data. This includes various types of fences and roll of fencing.

Interesting Points
This layer contains all attribute points gathered where there were not enough of them to justify having their own layer, but still may be useful for future projects.

Birdhouses
This layer contains the location of all birdhouses that we encountered while gathering data. Some descriptions about the birdhouses' status can be found in the attribute table.

Posts
This layer contains all of the locations wooden or metal posts that we encountered while gathering data. Some details about the posts can be found in the attribute table.

Research Flags
This layer contains the location of all research flags we encountered while gathering data. A short description of the flag's setup and color is available in the attribute table.

Maps

Map 1: Katherine Ordway Natural History Area

The purpose of this map is to introduce the area of Ordway and to show some basic information that will help in understanding later maps. The map shows the entire boundary of Ordway, the trails that we collected, the location of the research center (as well as defining the symbol that will be used for the research center on other maps), the railways that run through Ordway, and the most recent aerial photo that we found of Ordway. This map will help readers get an idea of the major landmarks in Ordway, so that they can understand where other maps fit into the overall picture.

Map 2: Birdhouses and Research Flags

This map depicts the locations of birdhouses and flags left in Ordway to demarcate the locations of the various research projects. Those flags for which we recorded the color, the circle is the same color as the flags and the grey circles represent flags for which the color wasn't recorded. Circles with a black dot in the middle represent groups of flags; those without a dot are single flags. These are likely not all of the flags in Ordway – it only represents those flags which we encountered on our data gathering trips. We didn't do any kind of systematic sweep of Ordway for flags. Additionally, we do not know what the flags symbolize. We know their color and some information about their arrangement can be found in the attribute table for that layer, but the exact research projects that they correspond too is also unknown. Similarly, there is information that we don't know about the birdhouses, like the birds that they are intended for and

their quality. However, even with these limitations we can see that the research sites at Ordway are fairly clustered, mostly in one small part of the entire extent of Ordway.

Map 3: Collected Points

The *Collected Points* map shows the locations of those points that didn't fit onto any other maps. The purpose here is to showcase the other points which were gathered, so that if they become useful or interesting for any future projects, they'd know that they existed. For this reason, We've included some examples of the nature of the points. The full description of the points is available in the attribute table of the respective layers.

The collected points are divided into three categories. The orange octagons represent of the signs that we encountered while gathering data. The red squares cover both wooden and metal posts and the dark blue circles correspond to all of the fences that we encountered. These categories were selected based on the data collected. We went through all of the points collected and divided into logical categories which there were multiples of. All points which were documented a notable number of times are depicted here or in the Birdhouses and Research Flags map and any interesting points left over are depicted in the *Points of Interest* map.

Map **4: Trespassing Signs**

Trespassing Signs shows the locations and quality of all trespassing signs gathered in the course of the project. The quality of the signs is shown in the shade of grey – black signs are in the highest quality, dark grey signs are only rusted, and the light grey sign is both rusted and bent. This map only depicts the signs that we found, so any project working with the position of trespassing signs would be well served to go out and make a second pass of Ordway's boundaries to find additional signs.

Map 5: Points of Interest Along KONHSA Trails

This map was developed using a mixture of primary and secondary data sources. The points themselves as well as the location of the research center and the trails were collected using Garmin and Trimble GPS units, respectively, whereas the property boundary, railroads, roads, and water features were procured from secondary sources (e.g. the Minnesota Department of Transportation; details are available in the Technical Appendices). Decisions on which data layers to include or omit were made by considering the map's potential audiences: researchers, school groups, etc.

The main purpose of this map is to present notable landmarks accessible from recorded trails for both educational and practical use. Points 1, 3, 7 and 10 display historical attractions for informational purposes; points 5, 6 and 9 show fallen trees for accessibility planning. Perhaps most intriguing, though, are points 2 and 4: former drainage tunnels that should be converted to turtle crossings under the railroad tracks as suggested by our partners. Other recommendations include clean-up of historical sites and trails as well as better labeling and expansion of the latter to make Ordway's resources more useful.

Map 6 : Proposed Trails for Ordway, 2009

The *Proposed Trails* map suggests a possible development of the trails at the Ordway. The basic layers of the map were collected and edited by members of the Land Use Working Group. Then a model was created to find the best areas to expand the trails. The variables included were both made up of secondary data from the Metropolitan Council data from 2000. The first variable was elevation. The Ordway is very hilly, and the land slops down from the west to the Mississippi which is the eastern border. The second variable measured that slope and found locations were land slope was flat. Places where there is high elevation and flat land show on the map. The next step is to compare where the trails currently and the proposed new trail areas to determine the best areas to expand the trails. We suggest that the trails be completed so that they form two loops. These two loops should be named and marked clearly so that they are more accessible to people both in and outside of the Macalester Community.

Map 7 : Research Flags and Vegetation

This map shows the locations of research flags in relation to the vegetation landscape collected by the Vegetation Working Group for our project. It was never made clear to us what the research flags represented or what type of research was being conducted, so we wanted to make this map to see if any specific vegetation type overlapped with research sites. This map uses layers made available by the Vegetation Working Group: prairies, wetlands, and buckthorn. Through this map it is interesting to see that many of the buckthorn observation sites are the same as research flag sites. In the future, once an effective and all-encompassing system is in place for labeling the research flags, it will be clear if buckthorn is a major subject of study in the Ordway, as well as see if there are other plant communities that future classes can map

Recommendations Based on Maps and Analysis

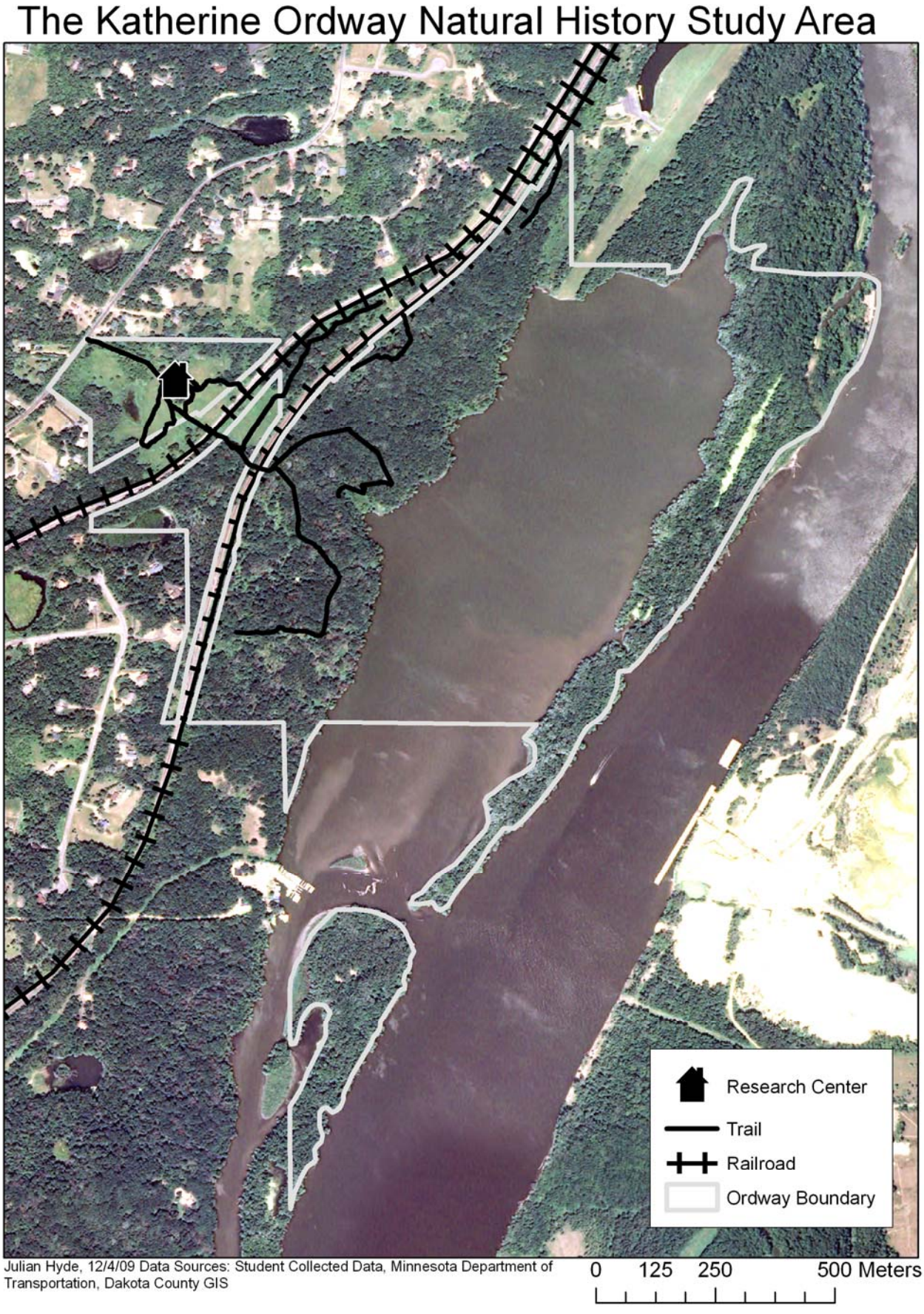
The first recommendation of our group for our partners continuing work in Ordway is to create and maintain an ongoing database for research being conducted at the Ordway. This was already a goal of our partners, but we want to stress the importance of sharing the locations, time-frame and extent of research being conducted at Ordway as delineated by research flags throughout the property. Our partners have thought about implementing a grid-system to systematically determine where research is being conducted and what type of research is underway (for instance if certain projects need to be isolated from other research or if it can have other research conducted nearby).

Another recommendation follows an idea of general upkeep. We as a group collected many data points of sites that were in need of removal or cleaning. There are many old rusty fences and signs on the property that should be removed or replaced. We also think that trail maintenance is very important. Especially if the partners want to expand Ordway's use beyond professor research, trails should be more clearly marked and future trails should be added to the database and reference maps. That way those unfamiliar with the landscape (especially if elementary students are going to have field trips here) can more easily find their way around. Another aspect of trail maintenance includes trail expansion along the corridors we suggested. These corridors haven't been assessed for the type of vegetation in these areas but based on elevation and steepness (slope) alone, these areas would be improved by the addition of trails.

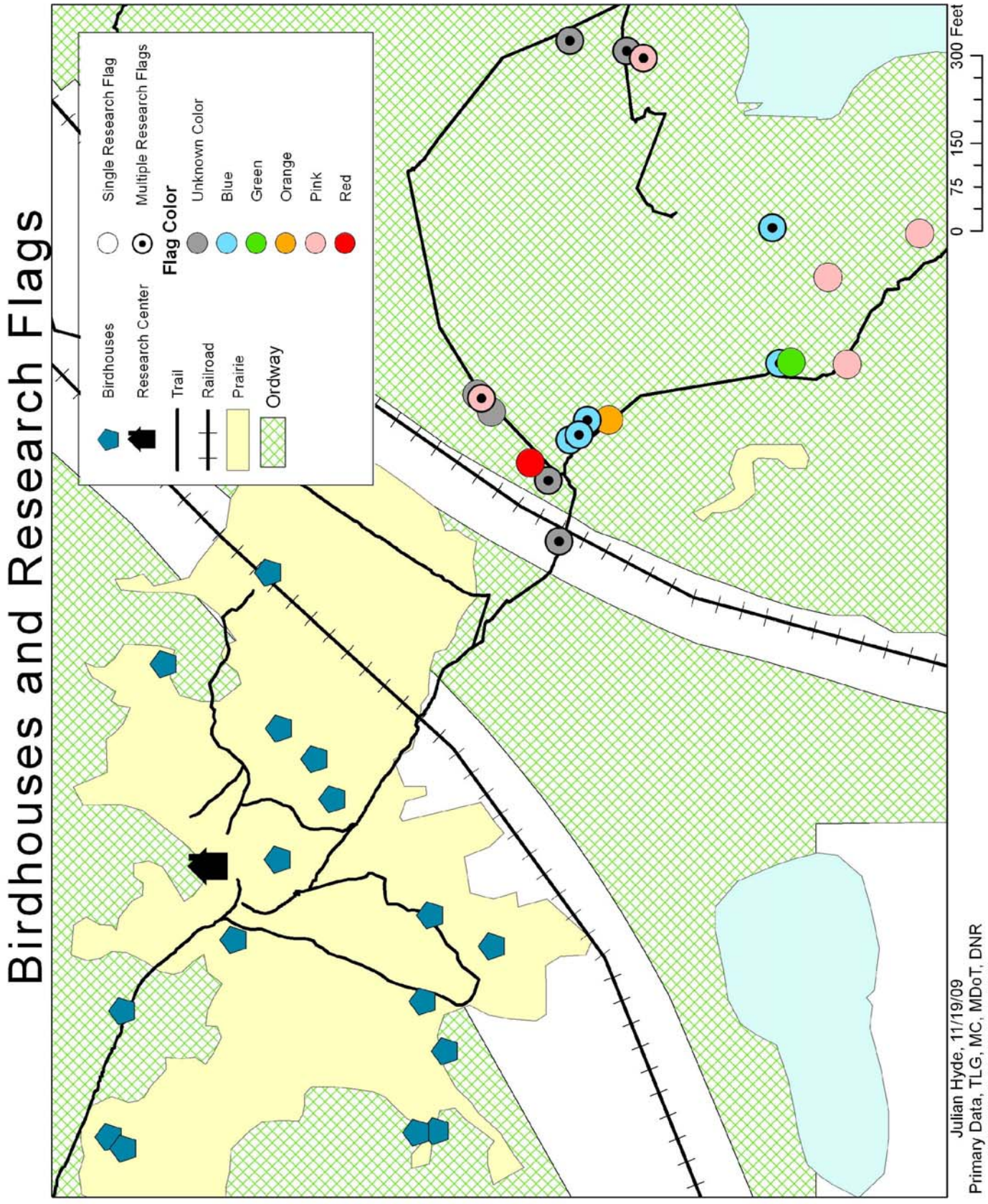
An additional recommendation is to add our support behind the proposed conversion of drainage tunnels into safe passageways for turtles underneath the train tracks. Even though this idea is in its nascent form, we'd like to put our support behind it, mostly because we think it's a really cool idea. Other than that, we think this is a project that would be very interesting for the local elementary students to get involved in, seeing as that was a goal of our partners.

Finally we want to stress our group's insistence that our data-set is used and added to in the future. We collected information on many different attributes within Ordway, but our collection was by no means all encompassing. We encourage our partners and future classes to add, edit and update the baseline data that we have put forward.

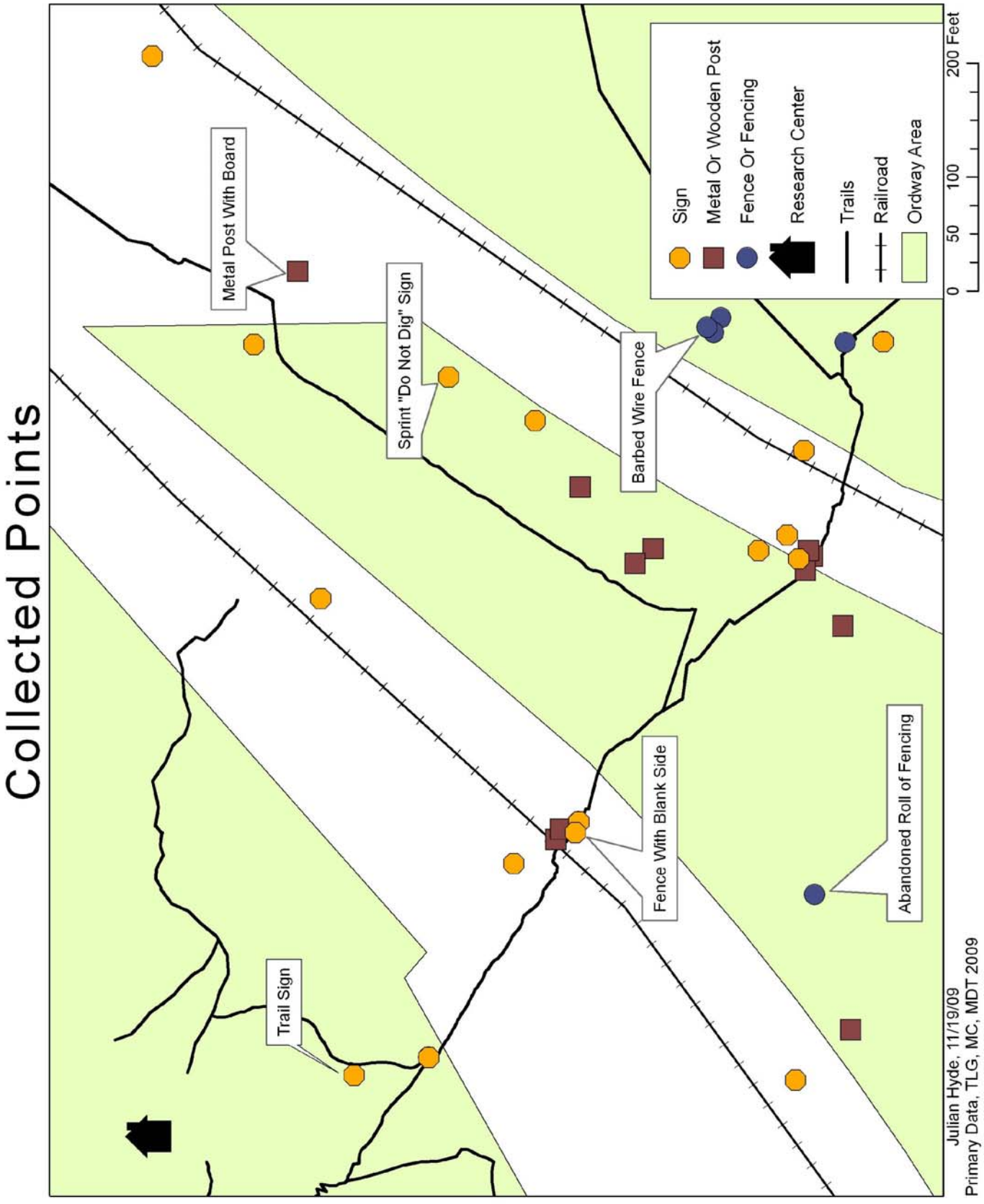
Map 1


The Katherine Ordway Natural History Study Area
Research Center
Trail
Railroad
Ordway Boundary
Julian Hyde, 12/4/09 Data Sources: Student Collected Data, Minnesota Department of Transportation, Dakota County GIS
0
125
250
500 Meters

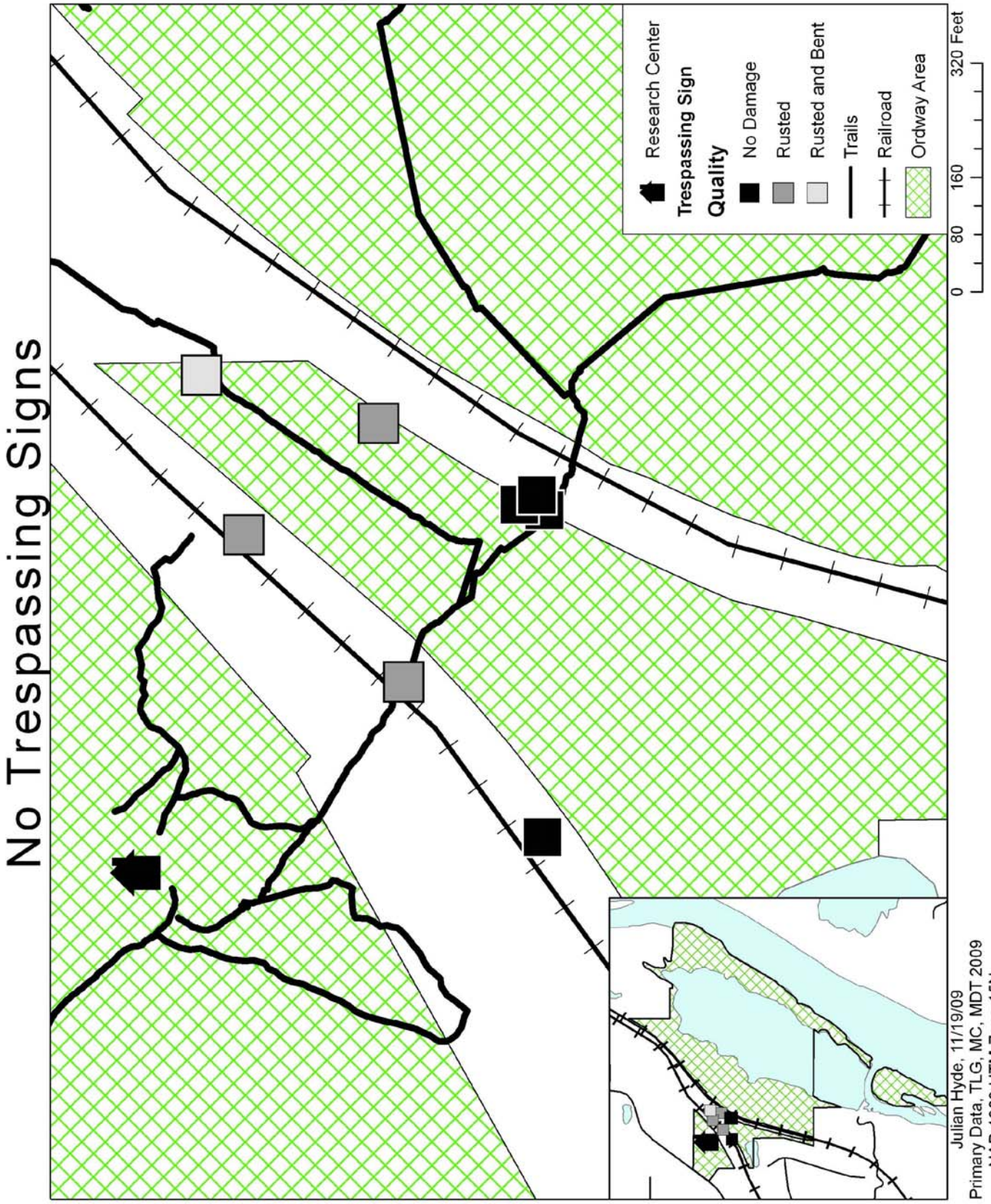
Map 2


Birdhouses and Research Flags
Birdhouses
Research Center
Single Research Flag
Multiple Research Flags
Flag Color
Unknown Color
Blue
Green
Orange
Pink
Red
Trail
Railroad
Prairie
Ordway
0 75 150 300 Feet
Julian Hyde, 11/19/09
Primary Data, TLG, MC, MDoT, DNR
NAD 1983 UTM Zone 15N

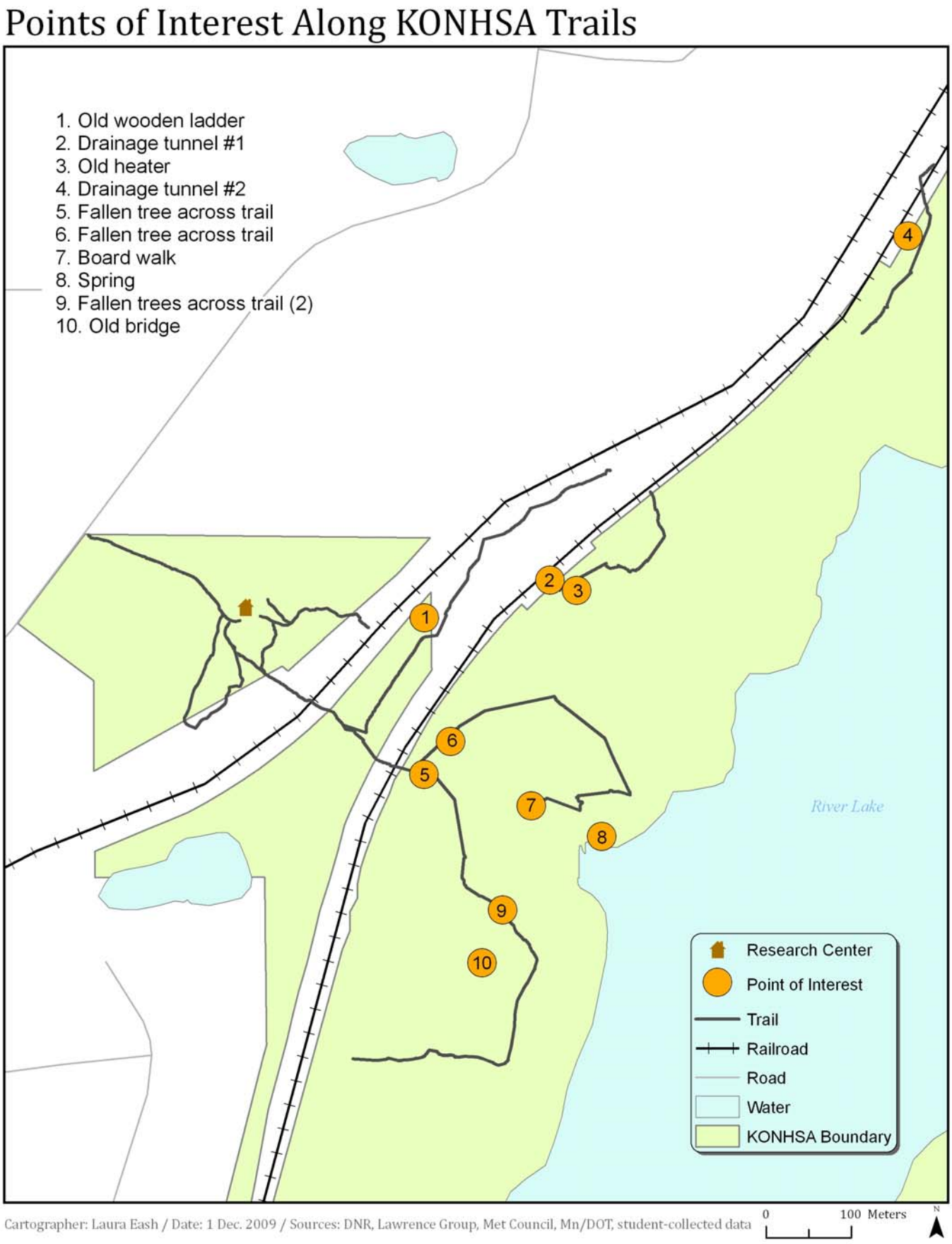
Map 3


Collected Points
Metal Post With Board
Sprint "Do Not Dig" Sign
Barbed Wire Fence
Trail Sign
Fence With Blank Side
Abandoned Roll of Fencing
Sign
Metal Or Wooden Post
Fence Or Fencing
Research Center
Trails
Railroad
Ordway Area
0
50
100
200 Feet
Julian Hyde, 11/19/09
Primary Data, TLG, MC, MDT 2009
NAD 1983 UTM Zone 15N

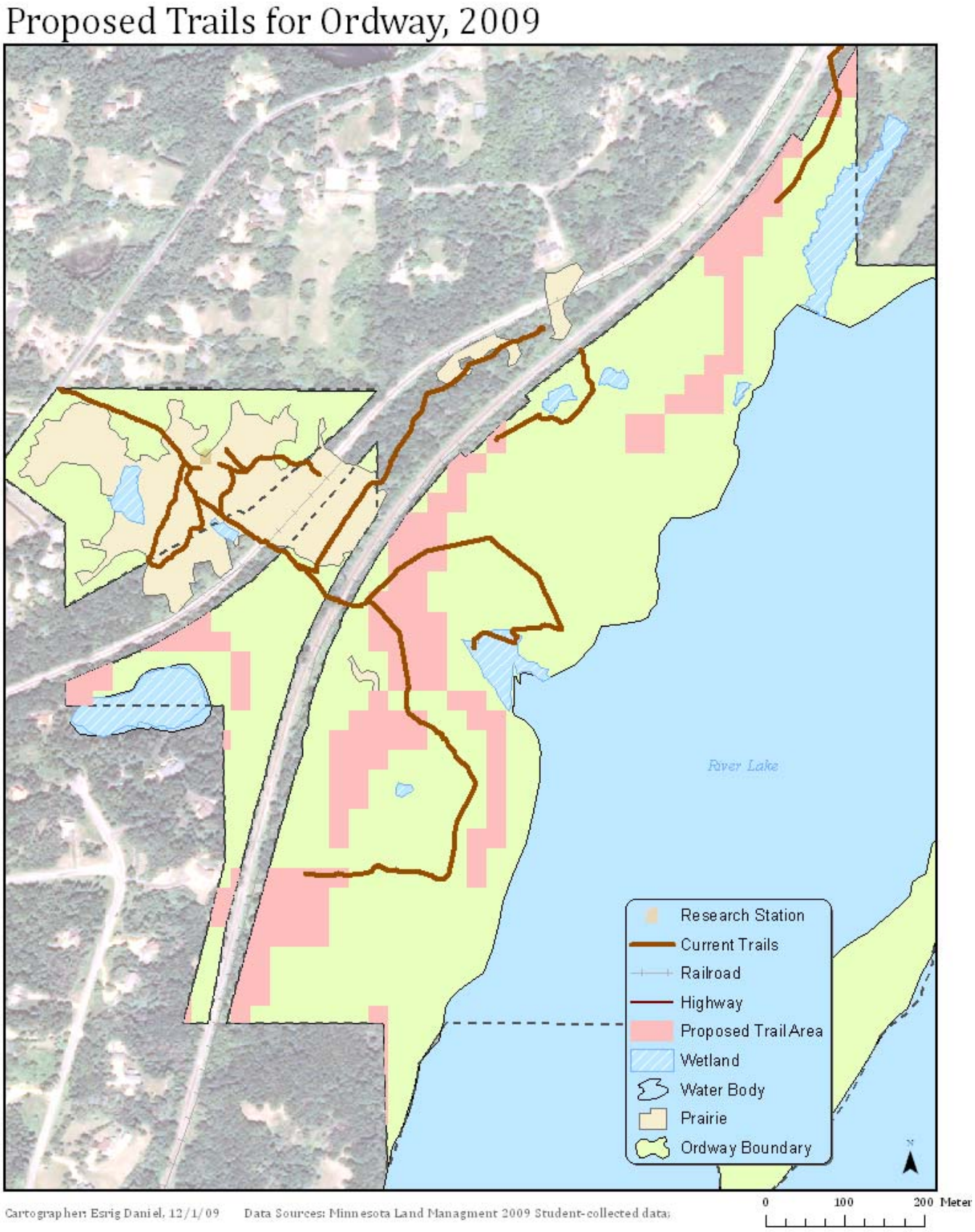
Map 4


No Trespassing Signs
Research Center
Trespassing Sign
Quality
No Damage
Rusted
Rusted and Bent
Trails
Railroad
Ordway Area
0
80
160
320 Feet
Julian Hyde, 11/19/09
Primary Data, TLG, MC, MDT 2009
NAD 1983 UTM Zone 15N

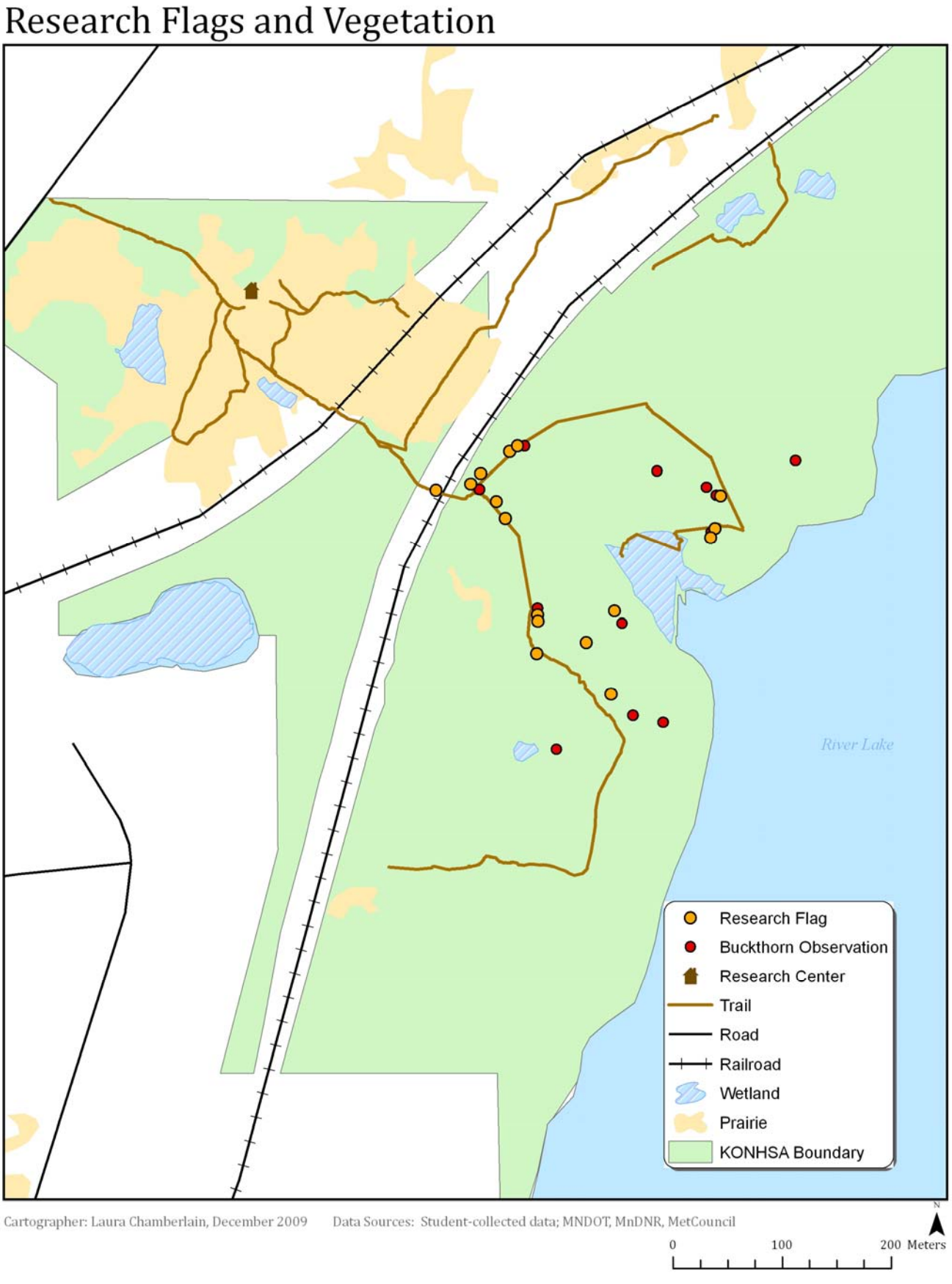
Map 5


Points of Interest Along KONHSA Trails
1. Old wooden ladder
2. Drainage tunnel #1
3. Old heater
4. Drainage tunnel #2
5. Fallen tree across trail
6. Fallen tree across trail
7. Board walk
8. Spring
9. Fallen trees across trail (2)
10. Old bridge
River Lake
Research Center
Point of Interest
Trail
Railroad
Road
Water
KONHSA Boundary
Cartographer: Laura Eash / Date: 1 Dec. 2009 / Sources: DNR, Lawrence Group, Met Council, Mn/DOT, student-collected data
0
100 Meters
N

Map 6


Proposed Trails for Ordway, 2009
River Lake
Research Station
Current Trails
Railroad
Highway
Proposed Trail Area
Wetland
Water Body
Prairie
Ordway Boundary
N
0
100
200 Meter
Cartographer: Esrig Daniel, 12/1/09
Data Sources: Minnesota Land Managment 2009 Student-collected data;

Map 7


Research Flags and Vegetation
River Lake
Research Flag
Buckthorn Observation
Research Center
Trail
Road
Railroad
Wetland
Prairie
KONHSA Boundary
Cartographer: Laura Chamberlain, December 2009
Data Sources: Student-collected data; MNDOT, MnDNR, MetCouncil
N
0
100
200 Meters

Vegetation Working Group

Introduction

The Vegetation Working Group was given the task of collecting primary and secondary data within and around Ordway. Our goal was to gain a clearer understanding of existing plant communities and ecological habitats. During the course of primary data collection, we focused primarily on wetland and prairie areas. This was for several reasons. First, our collective ecological knowledge was limited. Although we went out into the field with our partners, we were limited by time and technology in the level of detail we could collect. Therefore we used a fairly general level of classification for plant communities. The maps that we went on to create used this primary data in conjunction with primary data collected by the land use group, as well as existing secondary data from sources such as the Minnesota Department of Natural Resources. In compiling these data, our primary objectives were to contribute to the class database by making layers of these basic vegetation communities as well as related layers based on secondary source data (for example soil types, surrounding developments, and land cover. Another objective was to create maps synthesizing these data sets as well as data from other groups in order to increase our partners' spatial understanding of Ordway. And our final objective was to provide useful resources for our partners as they present the landscape at Ordway to third parties.

Overview of Data and Methods

One element of our work involved compiling both primary and secondary data about vegetation within and surrounding Ordway. During the primary data collection phase, we focused specifically on wetland and prairie areas, though we did little to create sub-classifications of the type of wetland or prairie, or to identify the diverse vegetation within these areas. We did this with the help of Richard McCarthy and Mike Anderson, the current and past resident naturalists at Ordway. Using handheld Garmin GPS units and Trimble units, we walked around the discernable boundaries of vegetation communities. Upon returning to the GIS lab, we were able to create data layers representing different plant communities: wetlands and prairies.

Our secondary data included aerial photos of the area as well as various land use and land cover layers. Much of this data came from the Minnesota Department of Natural Resources. These data are important as a way to contextualize what is happening with vegetation within Ordway and adding support and more detail to what we found during our primary data collection. Additionally, this information allowed us to compare images from multiple time periods, therefore adding a temporal as well as spatial perspective to our research.

Strengths

These data provide a valuable indication of the location and extent of prairies and wetlands. Our primary data are the most recent data set available, and our information is grounded in fieldwork physically done at Ordway, as opposed to being based on aerial photos, with the help of our partners who are familiar with the landscape. These data were collected and turned into cohesive layers and maps specifically with the goals of our partners in mind. They provide guidance for future development of Ordway and give a starting point for the living

database and as a baseline to continue to track changes (especially in relation to development and restoration projects. Finally these maps show visual representations of vegetation and related information that can be used as our partners work with outside groups to decide the future of Ordway. Our secondary data enhances this analysis, as it shows more detail in terms of vegetation classifications, gives an indication of other factors, such as soil types and development processes, which can influence vegetation. It also emphasizes the importance of evaluating vegetation within the Ordway boundaries by showing it in the context of the surrounding area. Though, as discussed below, these data are not comprehensive, we have included metadata that will allow these data to be added to in the future and to help solve problems not yet envisioned.

Limitations

Our primary data are not without error. We were unable to collect data on the peninsula, a key area of interest for our partners, as well as some wetland areas to the north of River Lake and those directly abutting the lake due to time limits. There is also some error as a result of impassable terrain, as we occasionally were unable to follow boundaries exactly due to thick bushes, fallen trees, etc. Finally, the accuracy of our units is also a source of error. As mentioned above, we used a Garmin with sub-3 meter accuracy and a Trimble unit with sub-food accuracy. However, two out of our three days of data collection were cloudy, which limits the accuracy of our units. It is therefore important to be cautious when using our estimates of the extent of these vegetation types and comparisons of these areas over time. We also were unable to account for the extent of the biodiversity in Ordway. Our classifications were limited to prairie and wetland areas due to a lack of time and ecological expertise among our group members. We hope that these data can be added to the database in the future. There are also sources of error in our secondary data. When aerial photos are used, error in digitizing is possible (see the Historical Working Group section) Some of the secondary data layers we obtained from other sources (e.g. the DNR, the National Wetlands Inventory) were originally created from digitized aerial photographs. These always contain a limit to resolution, and cannot perfectly match on-the-ground information. Some of the other secondary data are dated. For instance, the Dakota County Soil Survey was conducted in 1983, and some of the Minnesota County Biological Survey fieldwork took place as long ago as 1987. It is therefore important to continue to update this database and limit assumptions made when looking at the maps.

Layers

bearingtr.shp

This layer shows bearing trees as mapped by the Public Land Survey System in the late nineteenth century. The surveyors collected data on trees near each survey corner in case the corner marker might be lost. Data collected includes diameter, species, and distance from the survey corner. More information is available from Minnesota's Bearing Tree Database, linked in the metadata of this layer.

buckthorn.shp
This layer shows GPS data on the location of some buckthorn involved in an ongoing study at Ordway. The GPS points were collected by Jerald Dosch of the Biology Department during Summer 2009.

core_locations.shp
This layer shows GPS data on the location of core samples collected from River Lake on the KONHSA property. The GPS points were collected by Jerald Dosch of the Biology Department during Fall 2009.

digitized_prairies_2008.shp
This layer shows digitized areas that are not wooded, developed, or covered with wetland features within the close boundary extent. This layer was digitized off of a 2008 aerial photo from LMIC.

Digitized_Prairie_1974_Ordway
This layer shows digitized areas that are not wooded, developed, or covered with wetland features within the close boundary extent. This layer was digitized off of a 1974 aerial photo downloaded from Dakota County GIS.

Digitized_Prairie_1974_region
This layer shows digitized areas that are not wooded, developed, or covered with wetland features in the immediate area of Ordway. This layer was digitized off of a 1974 aerial photo downloaded from Dakota County GIS.

GPSprairies
This layer contains the primary data of prairies collected within the Ordway during October, 2009. Due to time constraints, we did not visit all areas of Ordway and therefore this layer may not be fully representative of prairies within Ordway.

GPSwetlands
This layer contains the primary data of wetlands collected within the Ordway during October, 2009. Due to time constraints, we did not visit all areas of Ordway and therefore this layer may not be fully representative of wetlands within Ordway.

karstfeat
This layer shows karst features, as mapped by the Minnesota Geological Survey and the Department of Geology and Geophysics at the University of Minnesota. Karst features include sinkholes, springs, and stream sinks. The four features within Ordway are all springs according to the attribute table and metadata.

landcover_cropland.shp
This layer contains the cropland in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System.

landcover_developed.shp
This layer contains the developed land in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. Developed land was defined as land with over 50% impervious cover.

landcover_exposed_earth.shp
This layer contains the exposed earth in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System.

landcover_grasses.shp
This layer contains the grasslands in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. Grasslands were defined as any type of grasses with less than 50% impervious cover.

landcover_mud_flats.shp
This layer contains the mud flats in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System.

landcover_sand_gravel.shp
This layer contains the sand and gravel in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System.

landcover_shrubs.shp
This layer contains the shrub-covered land in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. Shrub-covered areas were defined as any areas with shrubs with less than 50% impervious cover.

landcover_trees.shp
This layer contains the tree-covered land in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. Tree-covered land was defined as any land with trees with less than 50% impervious cover.

landcover_water.shp
This layer contains the water in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. This includes the Mississippi River, as well as numerous ponds and lakes.

landcover_wetlands.shp
This layer contains the wetlands in the area surrounding the Ordway, based on data from the Minnesota Land Cover Classification System. This included marshes, swamps, and other wetlands.

landtype.shp
This layer shows the most specific category, land type of the Ecological Land Type Associations of Minnesota. The attribute table also contains the corresponding provinces, sections, and subsections.

prairechange.shp
This layer is based off of layers Digitized_Prairie_1974_region and digitized_prairies_2008. A union was performed, and the areas included in this layer are those that were wooded, developed, or covered with wetland in 1974, but were not in the 2008 photo.

marschner.shp
This layer shows presettlement vegetation, as extrapolated from information collected by the surveyors of the Public Land Survey System in the late nineteenth century.

mcbs_npc.shp
This layer shows polygons representing high quality native plant communities remaining in surveyed counties, as determined by the Minnesota County Biological Survey since 1987.

mcbs_sbs.shp
This layer shows sites of biodiversity significance, as determined by the Minnesota County Biological Survey.

MeCC.shp
This layer shows Metro Conservation Corridors, determined by the DNR and originally hand-drawn in the late 1990's, using Regionally Significant Ecological Areas and Minnesota County Biological Survey data as guidance.

mlccs.shp
This layer shows the Minnesota Land Cover Classification System, determined by the DNR using a combination of aerial photos and field surveys.

mnSNA.shp
This layer shows Minnesota Scientific and Natural Areas as of 2007. These areas are owned by the DNR and protected.

mscriterea.shp
This layer shows the boundaries of the Mississippi River Critical Area, a DNR designation.

newprairie.shp
This layer is based off of layers Digitized_Prairie_1974_region and digitized_prairies_2008. A union was performed, and the areas included in this layer are those that were not wooded, developed, or covered with wetland in the 1974 photo, but were in the 2008 photo.

newprarie1.shp
This layer is based on layers Digitized_Prairie_1974_Ordway and GPSprairies. A union was performed, and the areas included in this layer are those that were not wooded, developed, or covered with wetland in the 1974 photo, but were found to be prairie during our field work.

ordwayprairiechange.shp
This layer is based on the layers Digitized_Prairie_1974_Ordway and GPSprairies. A union was performed, and the areas included in this layer are those that were wooded, developed, or covered with wetland in 1974, but that we did not find to be prairie during our field work.

plscorveg.shp
This layer shows vegetation at the Public Land Survey System corners, as recorded by surveyors in the late nineteenth century.

realponds.shp
This layer represents data collected at the Ordway of existing ponds. Due to the season and time constraints, the layer may not fully represent the full extent of ponds within Ordway.

REC08.shp
This layer shows potential ecological corridors connecting the MLCCS-derived patches (RSEA08 in this database) in the metro area, using the shortest route through the highest quality landcover types.

RSEA08.shp
This layer shows Regionally Significant terrestrial and wetland areas in the seven county metropolitan area. The patches were determined by examining ecological attributes with data gathered from the Minnesota Land Cover Classification system.

soilsland_CG.shp
This layer shows polygons of the Cummins and Grigal soil map, which incorporates the parent material, climate, landscape properties such as slope and aspect, plants and animals that can live on or in the material, and the length of time during which the above have interacted.

soilusda.shp
This layer shows soil data from the Washington and Dakota County Soil Surveys, as obtained from the Soil Survey Geographic Database. Soil series names and further details of their presence within a county can be found within the county soil surveys. Further descriptions of soil

series characteristics available from the US Department of Agriculture-Natural Resources Conservation Service. Links to these are in the metadata for the shapefile.

Maps

Map 8: Katharine Ordway Natural History Study Area, 2009

This map shows the general boundary of Ordway and includes primary vegetation and land use data. Our partners were interested in collecting primary data about existing plant communities at Ordway. This will aid in their future vegetation reconstruction efforts and serve as a baseline to future changes in vegetation. The map shows where wetland and prairie areas are in relation to existing trails. It also provides a good starting point for analysis with other maps. These data were also compared to past vegetation data. The data shown here are by no means comprehensive. We collected these data as a group during the month of October and were limited by time and ecological knowledge. Additionally, because there are seasonal variations in the vegetation, our data may not give an accurate representation of the Ordway at other times of the year.

Map 99: Presettlement Vegetation

This map shows vegetation in the area surrounding Ordway, as recorded by the surveyors of the Public Land Survey System in the late nineteenth century. The shapefile is available from the Minnesota DNR. This map provides historical background that will be useful to restoration ecologists and inform their efforts to recreate particular native plant communities within Ordway.

Map 10 : Native Plant Communities, 1987-1996

The *Native Plant Communities* map shows native plant communities of statewide significance, as determined by the Minnesota County Biological Survey. The polygons highlight areas within Ordway which have been evaluated by an ecologist as containing healthy native plant communities (as opposed to degraded or invasive-dominated communities). The diverse native plant communities within Ordway show that parts of the study area have been preserved at least to some degree. These portions of Ordway could be used as references for future restoration or sources for reseeding efforts in the future. In addition, as stakeholders try to balance restoration goals and research goals, it might be prudent to conduct research which involves disturbance in less-valuable parts of the property.

Map 11 : Regionally Significant Ecological Areas, 2008

This map shows high-quality ecological areas in and around Ordway. The RSEA layer was created with data from the Minnesota Land Cover Classification system. According to the metadata, "The scores are determined by examining important ecological attributes of the ecological patches including size, shape, cover type diversity, and adjacent land use. The results represent a probability that the modeled conditions exist in any given area, due to limitations of

the data layers".[2] The map demonstrates that major sections of Ordway have been ranked as highly significant. This ranking speaks to the relevance of current conservation efforts at Ordway and the importance of maintaining the corridor of high-quality land in the Pine Bend area, including the already-preserved Pine Bend Bluffs Scientific and Natural Area, also shown on this map

Map 12: Ordway Soils

This map shows soil types present within the Ordway boundaries. The soil classification layer came from the Soil Survey Geographic Database, with soil series names found in the Dakota County Soil Survey. Since the different soil types have different characteristics and support different types of land cover, knowledge of the soil types found within Ordway will be important to future restoration work.

Map 13: Comparison of Ordway Vegetation, 1974 and 2009

This map shows a comparison of vegetation coverage in Ordway between 1974 and 2009. The 1974 data are from a digitized aerial photo (see appendix____), and show areas that are non-wooded, not wetland or water features, and not obviously developed with structures, roads, or railroads, as in the map "Change in Area Vegetation, 1974-2008). The 2009 data show prairies that we identified and recorded during our fieldwork. All of these open areas in Ordway that we found and collected in 2009 were classified as prairies, so it is possible that prairie vegetation was present in the open areas shown from 1974 as well. However, as the data represent two different classifications of vegetation, it is difficult to draw any rigorous conclusions about the nature of the changes. However, 1) this map shows that within the boundaries of Ordway, the area that is open—not covered by trees, development, or wetland—is much smaller than it was in 1974 and 2) this map demonstrates of a useful way to make comparisons of vegetation over time as primary measurements are added to the database in the future.

Map 14: Comparison of Area Vegetation, 1974 and 2008

This map shows a comparison of vegetation coverage in Ordway and its immediate surroundings between 1974 and 2008. One goal was to show the change in the extent of prairies over time, However, as we found after looking at land use maps, prairies were not distinguishable from farmland and other open space, so no conclusions can be drawn about the extent of prairies. The areas that were digitized from 1974 and 2008 aerial photos (see appendices____) show areas that are non-wooded, not wetland or water features, and not obviously developed with structures, roads or railroads. This map shows that a significant decrease in these areas, some due to development (see Proximity of Inver Grove Heights Development, 2005) and likely some due to natural succession. It will be interesting to continue to track the changes in these areas as development continues.

Map 15 : Proximity to Inver Grove Heights Development, 2005

[2] Minnesota Department of Natural Resources (2008) Metadata for Layer: *Regionally Significant Ecological Areas - MLCCS derived 2008*, created Spring 2008, accessed Fall 2009 http://deli.dnr.state.mn.us/metadata.html?id=L390006470201

This land use map shows the proximity of Ordway vegetation communities to Inver Grove Heights development. The yellow areas on the map show single family residences abutting Ordway property. It is important to note that many of these residences may include large wooded sections. This map confirms the need to maintain communication with residents and businesses around Ordway because of the overlap of different ecological communities.

Map 16: Ordway Land Cover, 2008

This map shows the different vegetation types on the Ordway property and immediately surrounding area. With our limited time and ecological knowledge, the GIS class was not able to classify variations in trees, grasses and wetlands, so this data is very helpful for supplementing our knowledge of the area. Trees, Grasses and Wetlands are all respectively displayed in similar colors to show the general layout of the vegetation in addition to the specific categorization. This data can be used as a basis for comparison or spatial analysis with primary data that is collected in the future; additionally, this data can be used to add more detail on vegetation types at Ordway and allow future researchers to start with a more advanced knowledge of the vegetation at the site. For example, groups can verify their findings in the field with this existing secondary data.

Map 17: Ordway Area Land Cover, 2008

This map shows the land cover in the area surrounding the Ordway. Areas are classified based on the majority land cover, so, for example, an area with grasses and 40% impervious cover would be classified as grassland, while an area with grasses and 60% impervious cover would be classified as developed. This map shows that the areas immediately surrounding the Ordway are dominated by grasses and trees, but nearby areas are developed. This map helps demonstrate that although much of the land around Ordway is being used for residential or commercial purposes, there is still a good deal of grassland and tree covered areas in the vicinity. Moreover, this data has more specific categories in the attribute table, so researchers could use this data to compare the vegetation types at Ordway with vegetation in the surrounding area.

Recommendations Based on Maps and Analysis

Both primary and secondary data confirm that Ordway is a site of diverse and ecologically significant plant communities. This biodiversity includes native plant communities as well as invasive species such as buckthorn. Future ecological study in the area will provide more details about overlapping plant communities. It is important to note how preliminary this data is. There were areas within Ordway there were not explored during our field time, due to time constraints. These include areas on the peninsula and a section of land on the west side of the lake located between the collected wetland data. Therefore, vegetation data presented here only represents a portion of what may actually be there. Though the data here is not comprehensive, it provides an excellent starting point for future work at Ordway.

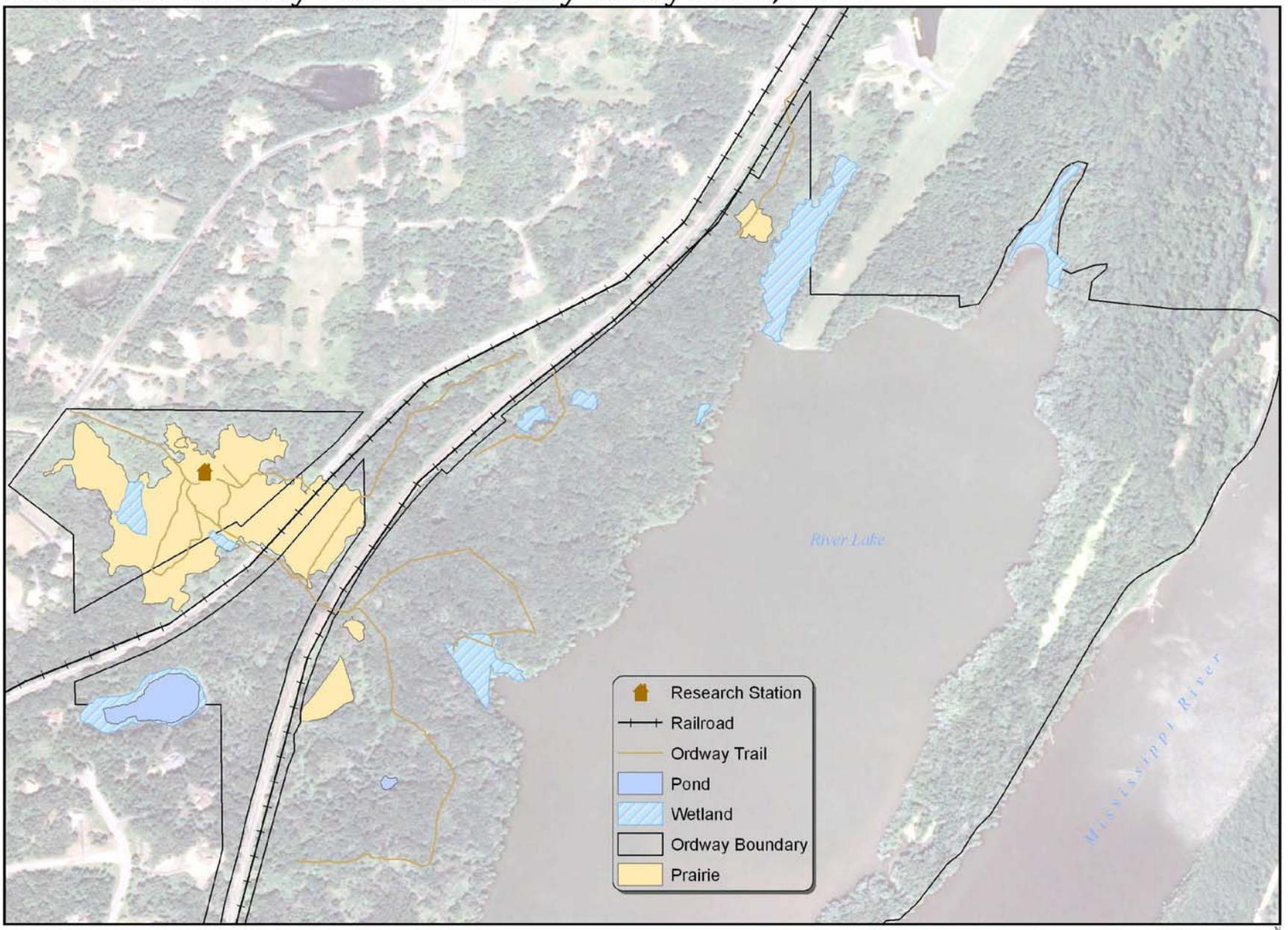
These maps and data act as a baseline of information about what plant communities exist in Ordway and where they are located. However, as our time and expertise was limited, there are definitely omissions in the primary data. We noticed while we were doing the fieldwork that there are diverse plant communities spread throughout the property, and though we gathered data on wetlands on prairies and wetlands, we have just scratched the surface in terms of documenting

biodiversity and valuable native plant communities. Therefore, we propose the following recommendations:

1) More work needs to be done to document these subtle changes and variations across the landscape. This will provide nuance to the existing data and allow ecologists to make more educated inferences about the land.
2) Data need to be collected in the parts of Ordway that we were not able to access, such as portions of the shore of River Lake and the peninsula of Ordway that we know have wetlands but that we were unable to collect. This will ensure we are fully aware of what types of vegetation exist within Ordway.
3) Individuals with some experience in plant identification or trained ecologists should perform further field work and add to this data set. This will add more detail about individual plant communities and where boundaries are.
4) Future uses of Ordway should take the data collected here into account. For example, environmental education outreach with elementary school students should explore diverse communities, but also avoid delicate ecosystems or areas where controlled research is being performed. If a group wants to begin agricultural operations in conjunction with Café Mac, it would be helpful to know underlying soil, and previously disturbed areas would serve as more suitable locations.

Map 8

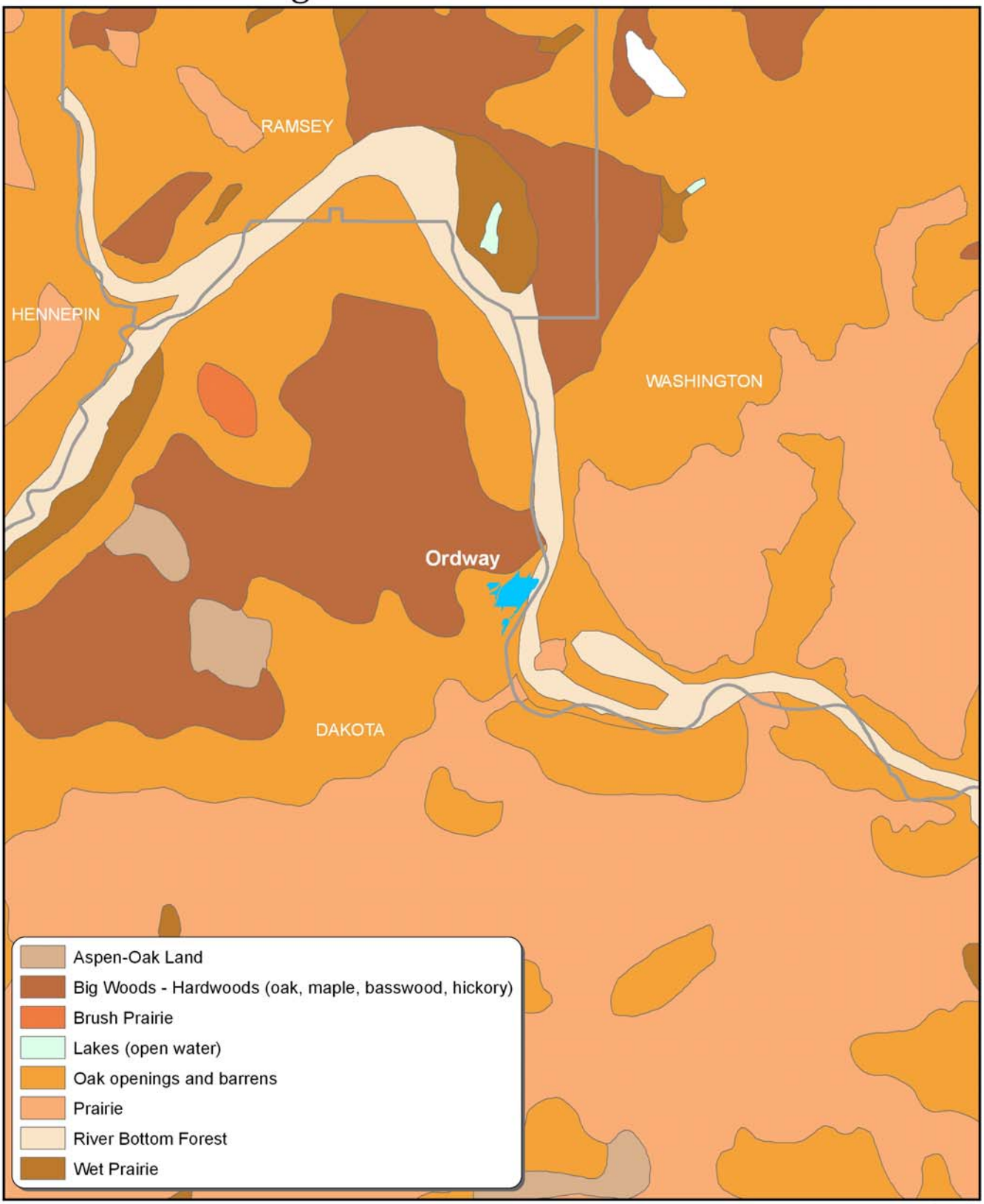
Katharine Ordway Natural History Study Area, 2009



Cartographer: Hannah Emple, 11/30/09 Data Sources: MN Dept of Natural Resources (2005), Student-collected data (2009)

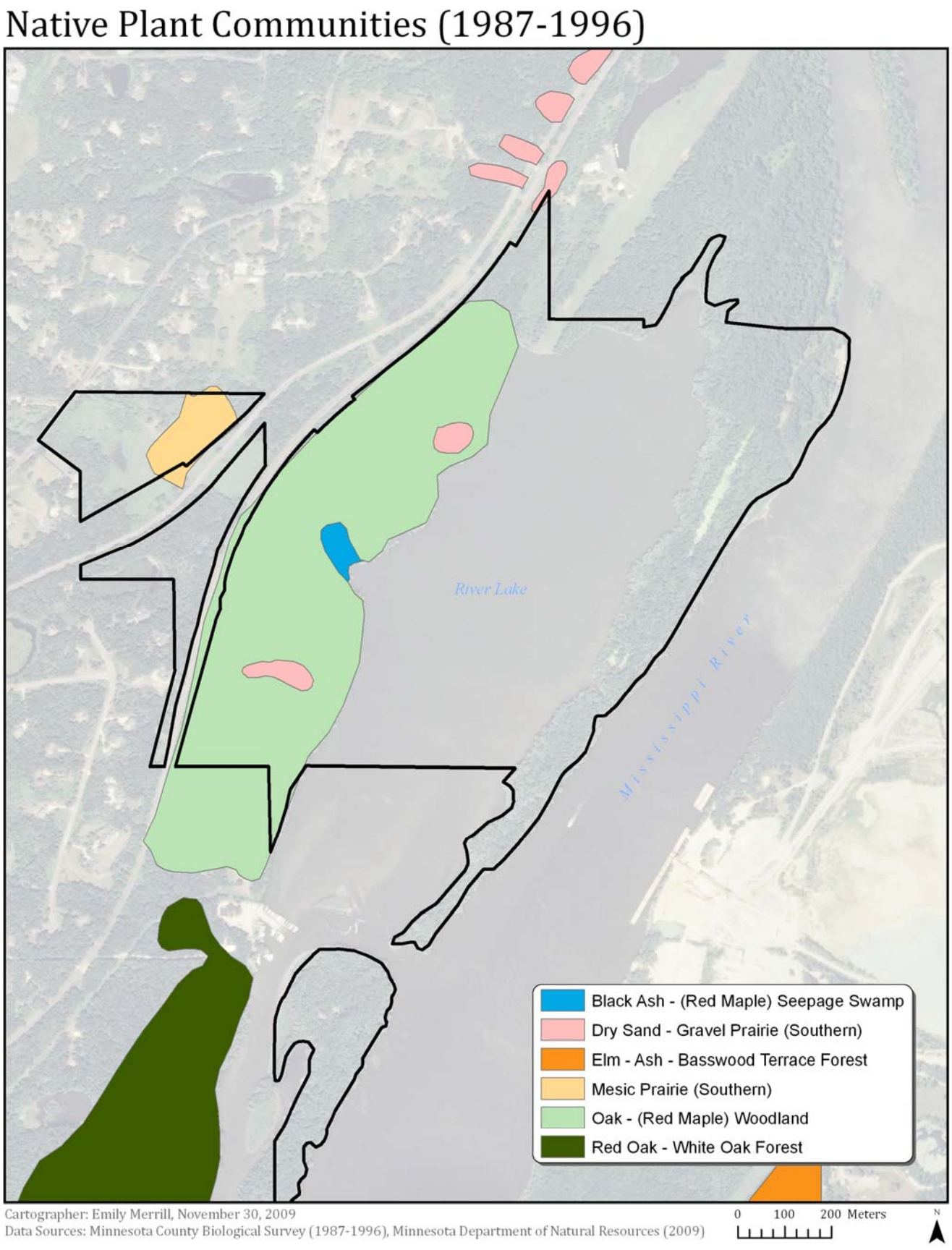
Map 9

Presettlement Vegetation



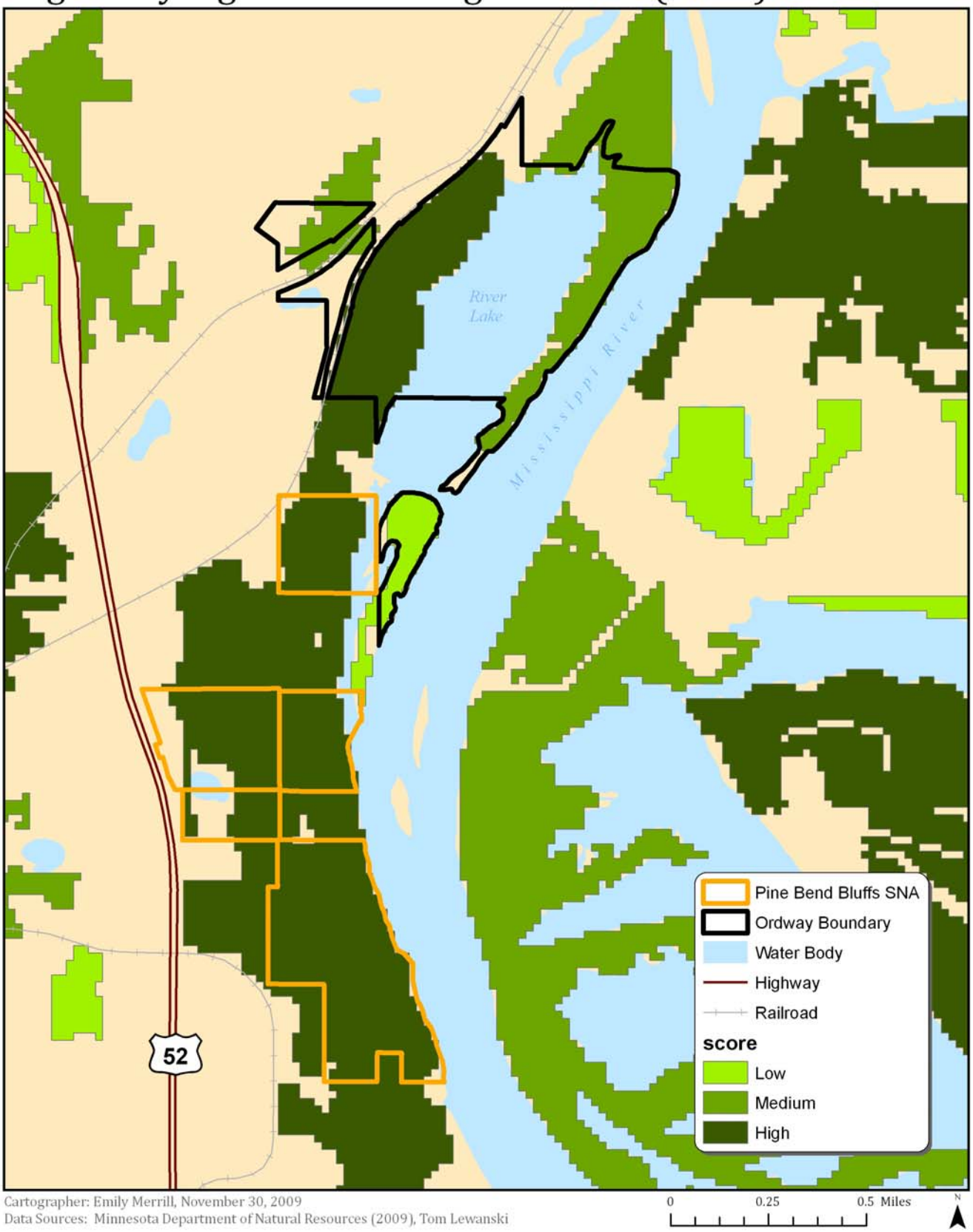
Cartographer: Emily Merrill, December 7, 2009 Data Sources: Minnesota Department of Natural Resources

Map 10


Native Plant Communities (1987-1996)
River Lake
Mississippi River
Black Ash - (Red Maple) Seepage Swamp
Dry Sand - Gravel Prairie (Southern)
Elm - Ash - Basswood Terrace Forest
Mesic Prairie (Southern)
Oak - (Red Maple) Woodland
Red Oak - White Oak Forest
Cartographer: Emily Merrill, November 30, 2009
Data Sources: Minnesota County Biological Survey (1987-1996), Minnesota Department of Natural Resources (2009)
0 100 200 Meters
N

Map 11

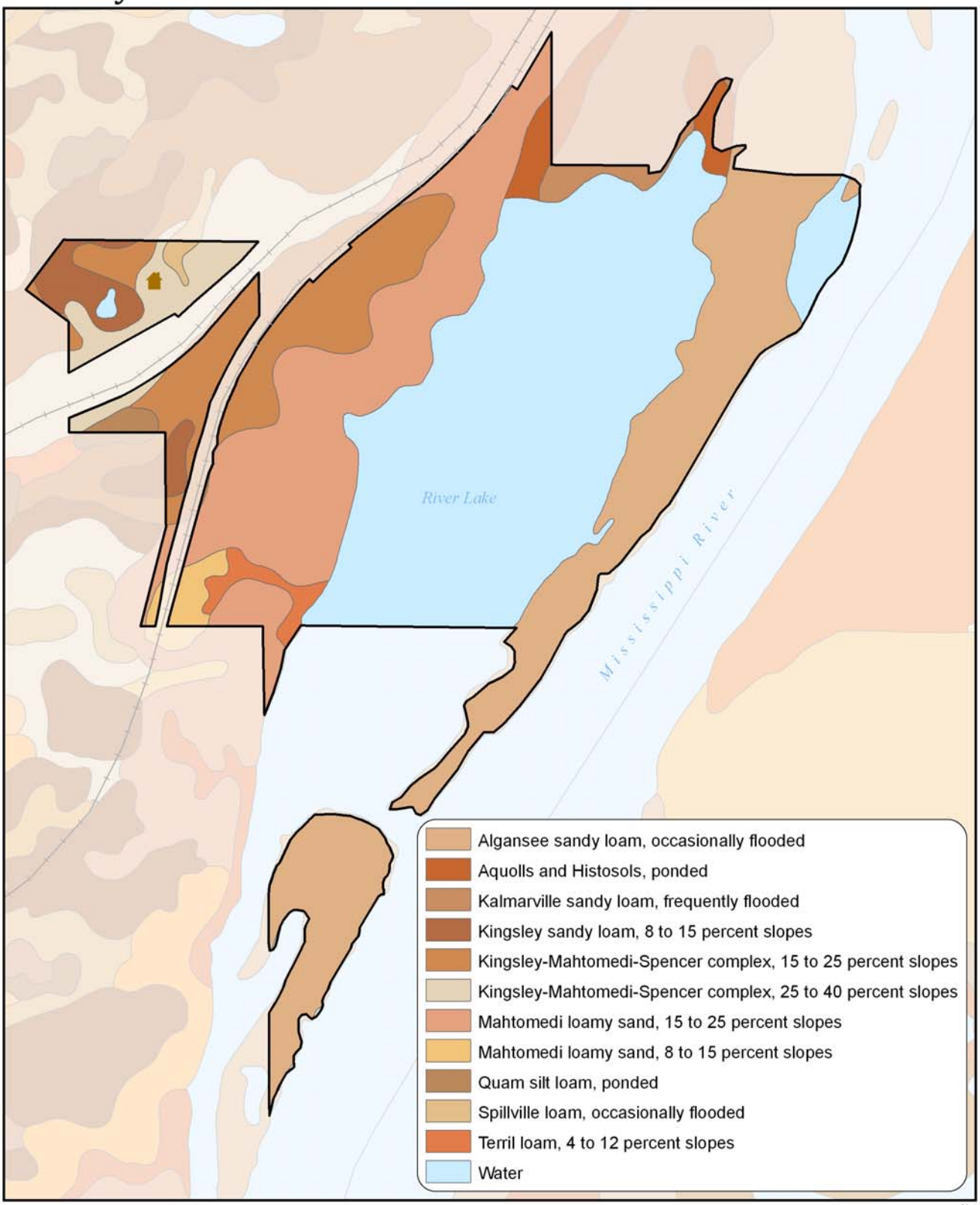
Regionally Significant Ecological Areas (2008)



Cartographer: Emily Merrill, November 30, 2009
Data Sources: Minnesota Department of Natural Resources (2009), Tom Lewanski

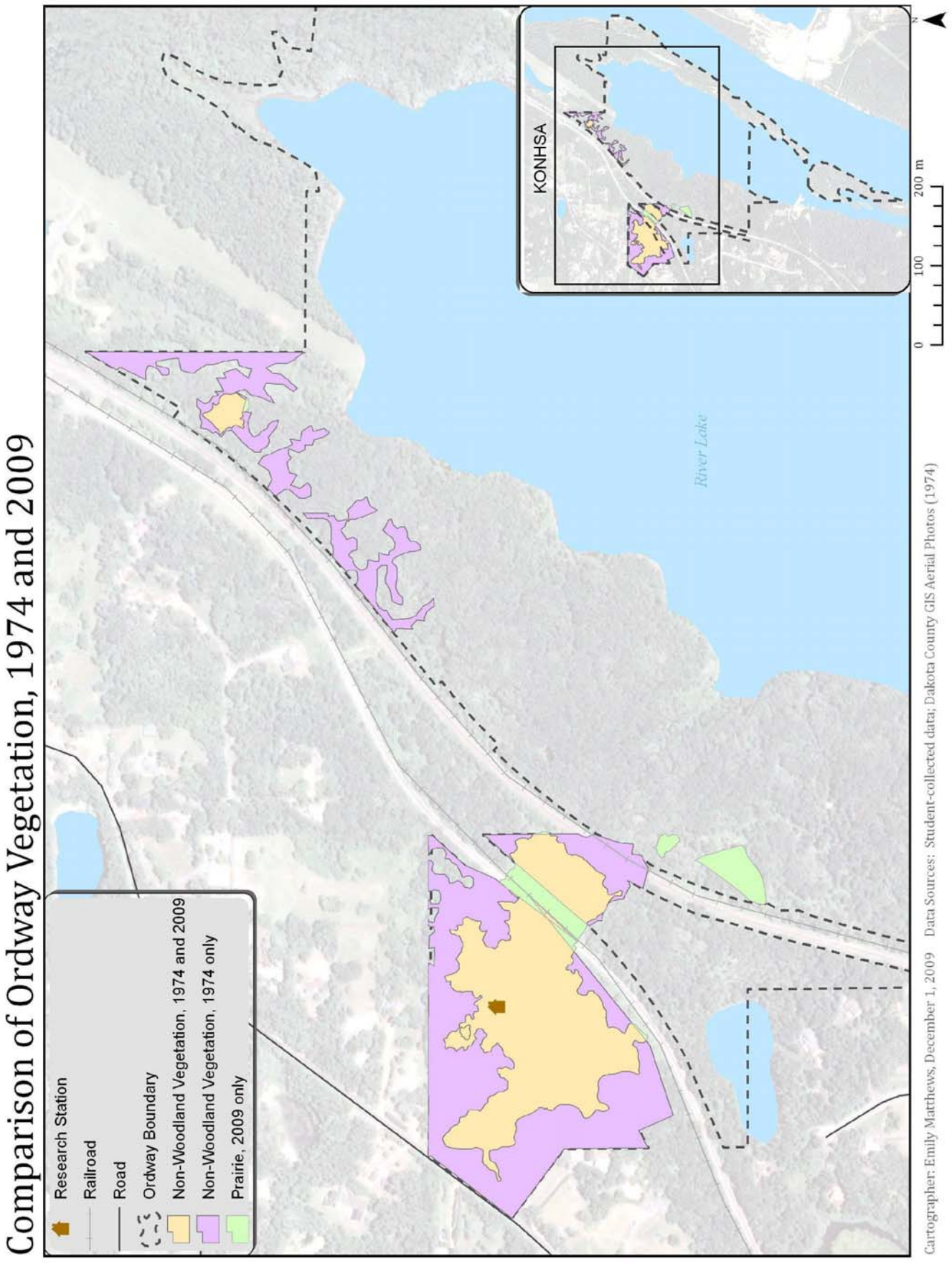
Map 12

Ordway Soils

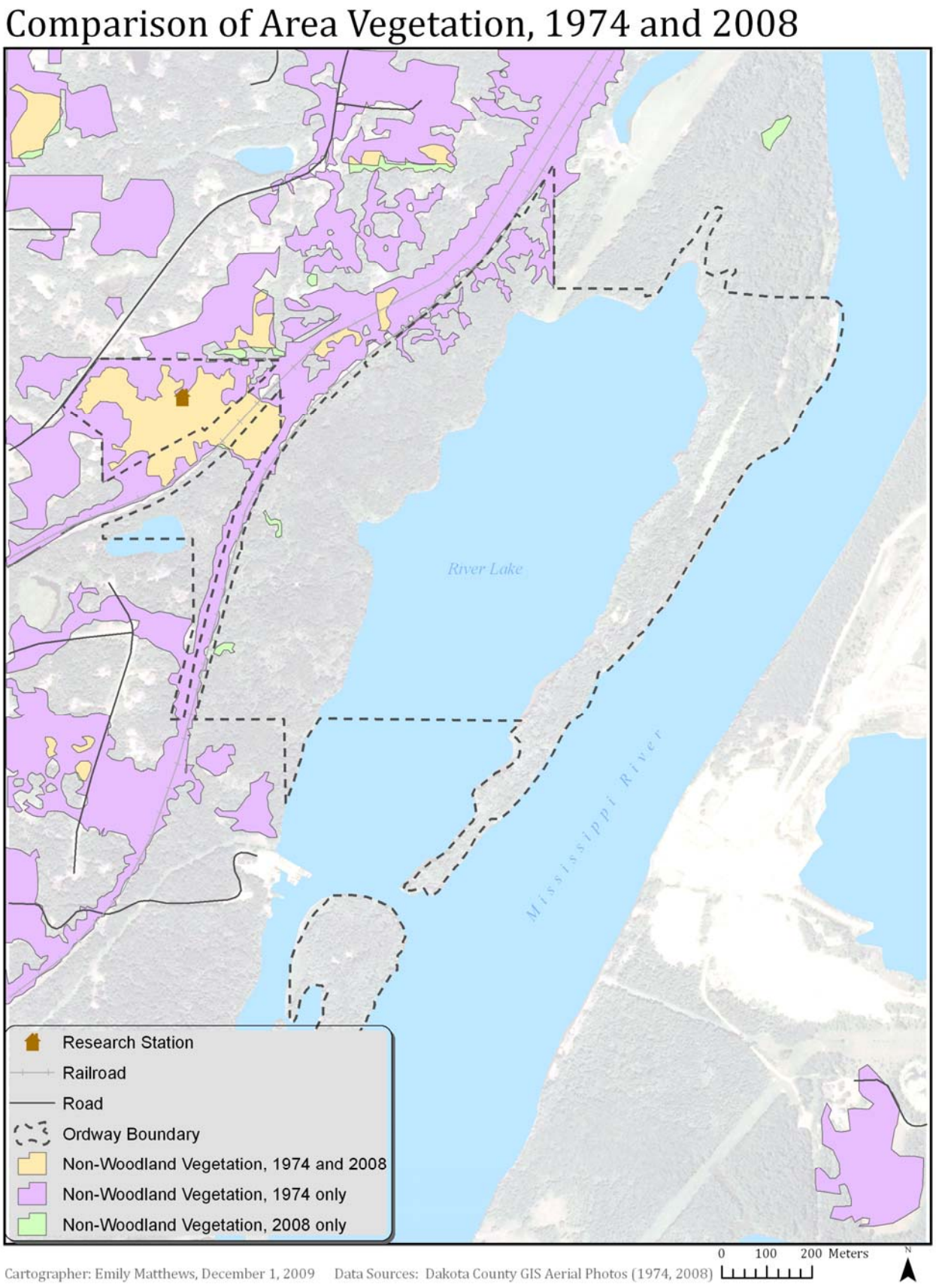


Cartographer: Emily Merrill, December 6, 2009;
Data Sources: US Soil Survey Geographic Database (USDA), Dakota County Soil Survey (1983)

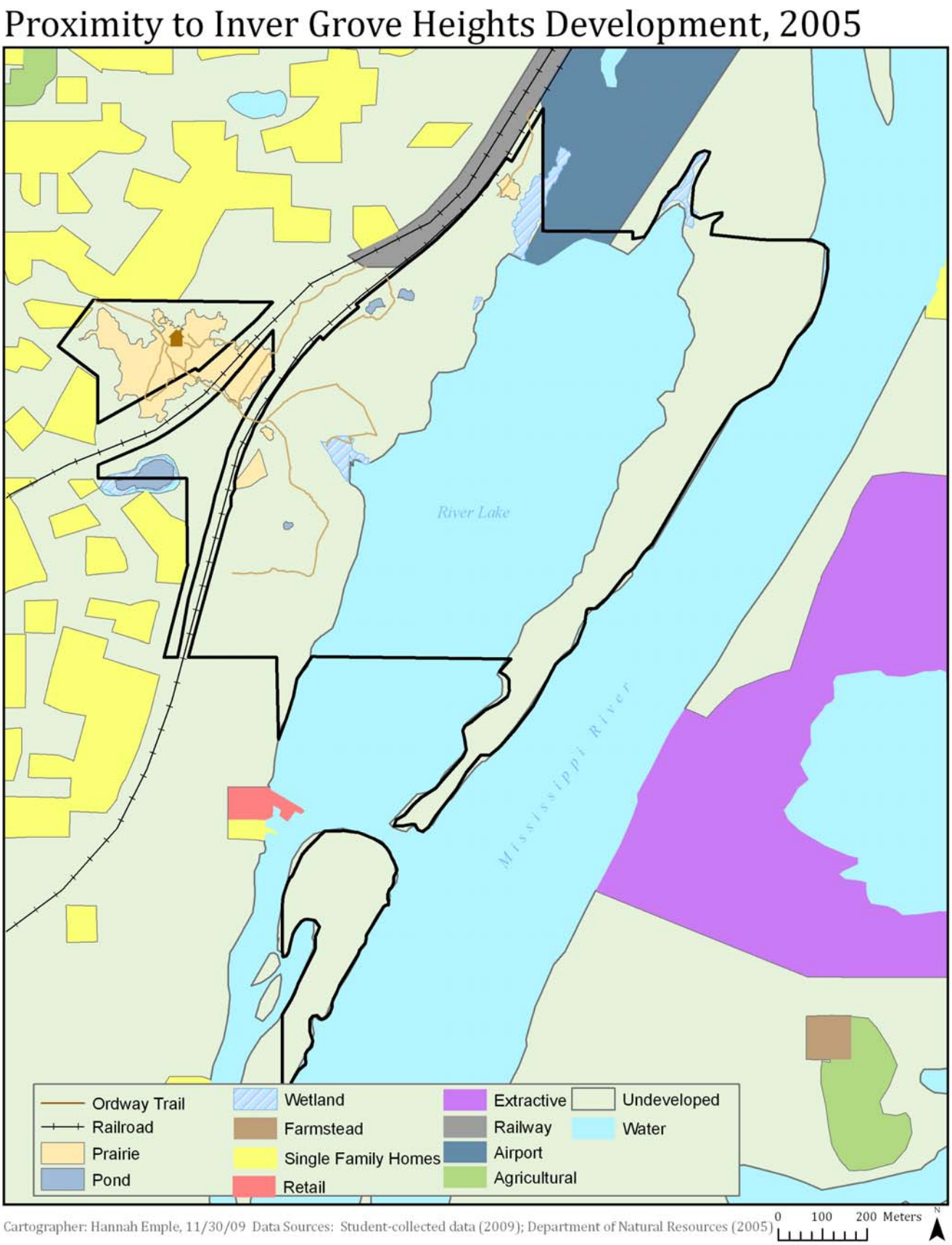
Map 13


Comparison of Ordway Vegetation, 1974 and 2009
Research Station
Railroad
Road
Ordway Boundary
Non-Woodland Vegetation, 1974 and 2009
Non-Woodland Vegetation, 1974 only
Prairie, 2009 only
River Lake
KONHSA
0
100
200 m
N
Cartographer: Emily Matthews, December 1, 2009 Data Sources: Student-collected data; Dakota County GIS Aerial Photos (1974)

Map 14

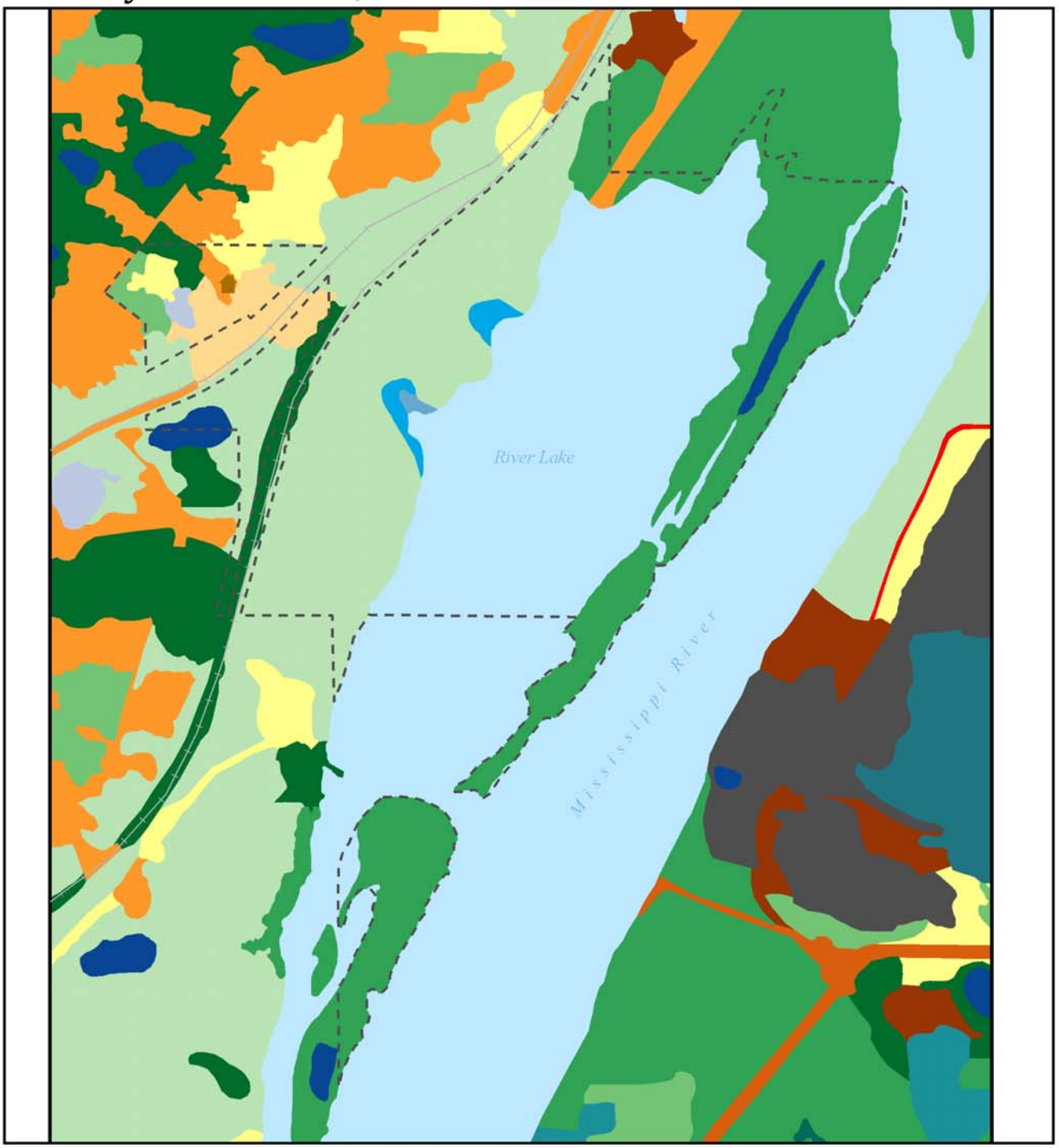

Comparison of Area Vegetation, 1974 and 2008
River Lake
Mississippi River
Research Station
Railroad
Road
Ordway Boundary
Non-Woodland Vegetation, 1974 and 2008
Non-Woodland Vegetation, 1974 only
Non-Woodland Vegetation, 2008 only
0 100 200 Meters
N
Cartographer: Emily Matthews, December 1, 2009
Data Sources: Dakota County GIS Aerial Photos (1974, 2008)

Map 15


Proximity to Inver Grove Heights Development, 2005
River Lake
Mississippi River
Ordway Trail
Railroad
Prairie
Pond
Wetland
Farmstead
Single Family Homes
Retail
Extractive
Railway
Airport
Agricultural
Undeveloped
Water
Cartographer: Hannah Emple, 11/30/09 Data Sources: Student-collected data (2009); Department of Natural Resources (2005)
0 100 200 Meters
N

Map 16

Ordway Land Cover, 2008



Trees
- Deciduous Trees with impervious cover
- Oak
- altered/nonnative deciduous forest/woodland
- floodplain forest

Grasses
- altered/nonnative dominated grasses
- mesic prairie
- perennial grasses w/sparse trees,impervious cover
- planted or maintained grasses
- short grasses with impervious cover

Wetlands
- Black Ash Swamp
- Mixed Emergent March
- Seepage Meadow
- Temp flooded nonnative grassland
- Willow Swamp

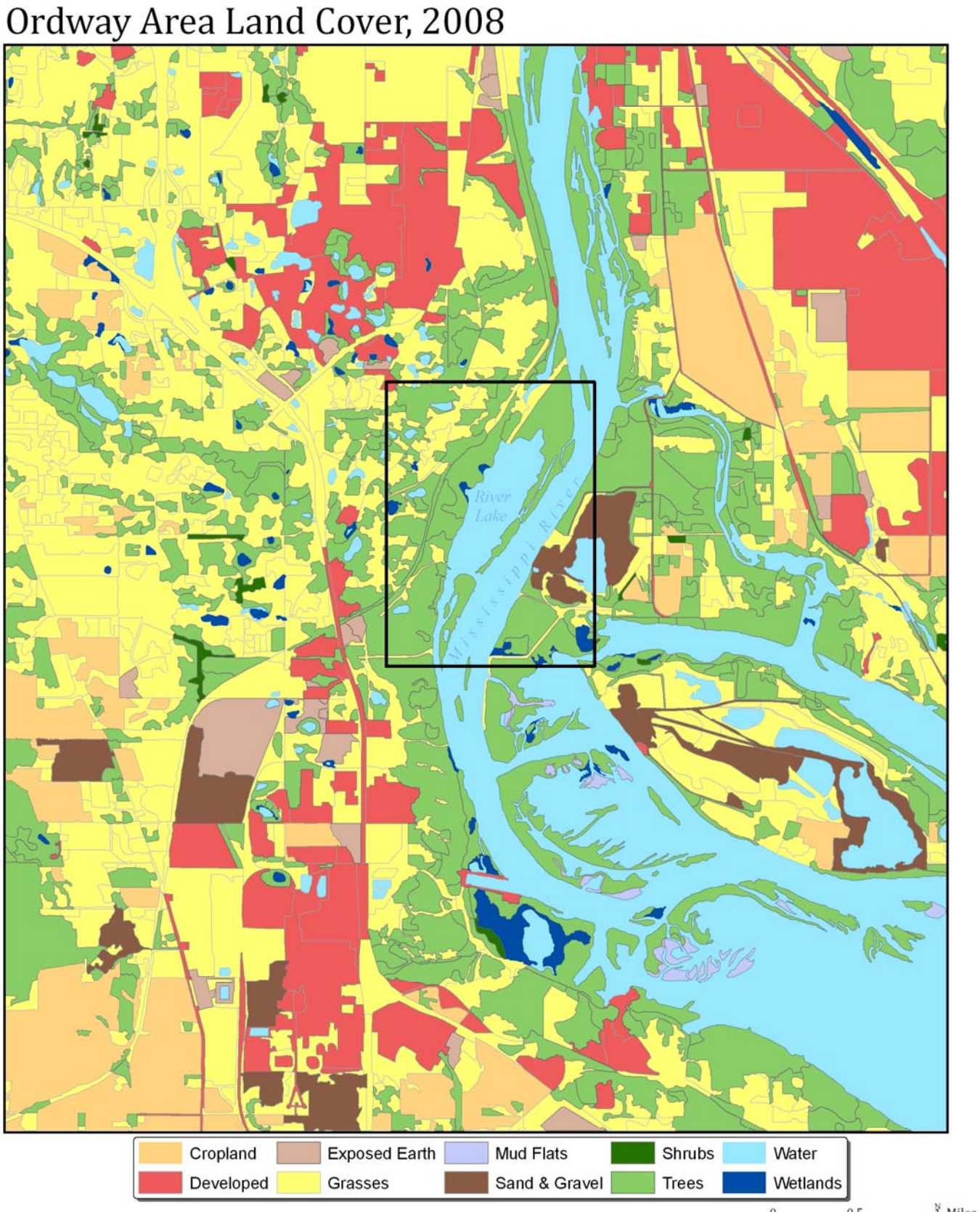
Water
- Littoral open water
- Palustrine open water
- Slow moving linear open water habitat
- Developed
- Sand & Gravel

Cartographer: Maggie Pearson, November24, 2009 Data Sources: Minnesota DNR

0 100 200 Meters

N

Map 17


Ordway Area Land Cover, 2008
River
Lake
Mississippi River
Cropland
Developed
Exposed Earth
Grasses
Mud Flats
Sand & Gravel
Shrubs
Trees
Water
Wetlands
Cartographer: Maggie Pearson, November 24, 2009
Data Sources: Minnesota DNR
0
0.5
Miles

Historical Working Group

The landscape surrounding Ordway has changed substantially over the past 80 years and continues to transform up to the present. An understanding of what change has occurred provides a context in which we can evaluate Ordway's current status as well as proposals for its future uses—including its role as a research station, community retreat center, or conservation corridor. The Historical Working Group was created to address this issue. Our primary tasks were to acquire existing (secondary) spatial information pertaining to KONHSA from previous time periods. We also wanted to modify and compile data sets to be consistent with project scope and guidelines. And finally we wanted to showcase our findings through a suite of maps which include trend analyses and comparisons of current data to previous periods.

The above tasks led to several accomplishments. They include: analysis of land use changes over the period from 1984 to 2005. Specifically, we wanted to investigate the changes in developed land and open space for the full extent of our study area, as well as a more detailed analysis showing the types of land use in new developments in the immediate area neighboring Ordway. In addition to land use changes, we collected all available aerial photos for the site. A photo compilation of this sort is powerful because it documents first-hand, the variety of changes to the landscape around Ordway—visible changes pertain to hydrology (variations in the river and lake), development (suburbanization and expanded transportation corridors), and vegetation.

Finally, to compliment the work done by the Vegetation Working Group on the current status of wetland cover within Ordway, we searched for complimentary data from years past. Ideally, these data can be informative of the ways in which Ordway's wetlands have expanded, contracted, or changed in composition.

Secondary data were acquired primarily through sources such as the Minnesota Department of Natural Resources' Data Deli website (DNR Data Deli), the Minnesota Land Management Information Center (LMIC), and Dakota County GIS Services. Modifications to data were slight, often limited to the single clip to the Ordway extended boundary.

Layers

Aerial Photopraphs

Aerial photographs are raster files of scanned black-and-white aerial photographs provided by Dakota County GIS from years 1927, 1937, 1951, 1957 and 1974. A year 2008 digital color photograph was also obtained from the Minnesota Land Management Information Center. When necessary, photos were cropped to the Ordway extended boundary

US Geological Survey Topographic Maps

These files contain a raster graphic of USGS standard series topographic map, including all map collar information. They have been cropped to the Ordway extended boundary. The image inside the map neatline is geo-referenced to the surface of the earth and fit to the Universal Transverse Mercator projection. The horizontal positional accuracy and datum of the DRG matches the

accuracy and datum of the source map. The map was scanned at a minimum resolution of 250 dots per inch.

Historical Land Use

We acquired land use data from the Metropolitan Council which covers the years 1984, 1990, 1997, 2000, and 2005. The original data were for the entire seven-county metro area. There was a switch in the land use codes between 1997 and 2000, but both codes are detailed in the metadata for the shapefile. In order to prepare this data set for inclusion in the database, we cropped it to the extent of our study area.

Land Forms

These geomorphology data are polygons describing a wide variety of conditions related to surficial geology within a hierarchical classification scheme that was devised for use within Minnesota. Data created by the University of Minnesota—Duluth, the Minnesota Geological Survey, and the Minnesota Department of Natural Resources in 1997. Data were cropped to the Ordway extended boundary and exists as two files—one for Dakota County features and one for Washington County Features.

Lake Boundaries

Lake Boundary layers are polygons representing the extent of River Lake as digitized by Macalester Advanced GIS class from aerial photos taken in 1927, 1937, 1957, and 2008. Boundary layers include the full wet extent of the lake in a given year. When applicable, layers which represent lake areas characterized by dense aquatic vegetation versus open water were also created. For a discussion of the error and assumptions associated with aerial photo digitization, please see the description of Map XX TITLE HERE.

Outlet Boundaries

Outlet Boundary layers represent the outlet connecting River Lake to the Mississippi River as digitized by the Macalester Advanced GIS class from aerial photos taken in 1927, 1937, 1957, and 2008. Boundary layers include the full wet extent of the outlet in a given year. When applicable, layers which represent outlet areas characterized by dense aquatic vegetation versus open water were also created.

National Wetland Inventory

NWI is composed of polygons representing all wetlands digitized from a 1980 aerial photo by the South Dakota Cooperative Fish and Wildlife Research Unit at South Dakota State University. Data were cropped to the Ordway extended boundary.

Comparative Wetland Areas

These are a series of files containing polygons which describe the relationship of wetlands recorded during the 1980 National Wetland Inventory and those wetlands recorded during field visits in 2009 (e.g. Wetland Area in 1980, but not in 2009).

Maps

Map 18: Land Use Change, 1984-2005

This map shows the extensive development within our study area over the two decades from 1984 to 2005. Particularly, it focuses on the loss of open space by showing areas that were already developed in 1984, areas which have been developed since then, and areas which remain undeveloped. We kept parks and recreation areas separate as well because while they are not coded as "undeveloped," they obviously represent a form of open space that other development (i.e. industrial or residential) does not. A final important observation is the dramatic expansion of the highway running north-south through the area, which in many ways enabled the extensive suburban growth shown in the map.

Map 19**ap 19: Development and Land Use, 1984-2005**

This map shows in greater detail the expansion of development in the immediate area around Ordway. Again, it consolidates the areas that were already developed in 1984 as a single category. However, for areas which have developed since 1984, a simplified land use category is displayed. This reveals that the majority of development immediately next to Ordway has been residential, with some industrial expansion to the south and some commercial development along the highway corridor. Furthermore, this map shows Pine Bend Elementary in relation to the Ordway. It is important to note both the dramatic loss of open space in the area and the continuing availability of land along the riverfront.

Error! Reference source not found.**20: Aerial Photograph Series: 1927-2008**

This map displays the six aerial photos acquired by our work. Years include 1927, 1937, 1951, 1957, 1974 and 2008.[3] Note the many changes in development, hydrology, and vegetation that take place across the period.

Error! Reference source not found. **21: River Lake Historical Photos**

In 1930, the construction of Lock and Dam 2 upstream of Hastings, MN served to raise water levels along the 33 mile stretch of river from Hastings to Minneapolis.[4] The dam also acts as a buffer against high seasonal variability in the size of backwater lakes. To document this effect, photos from four years—1927, 1937, 1957, and 2008—were chosen to monitor trends in the shape and size of River Lake. They are shown here. All were taken during the mid-late summer season, allowing for meaningful comparisons of lake levels throughout time. Note the color-coded boundaries depicting lake surface area for that year.

It is important to note that for each of these four years, multiple layers were digitized from the visual data. These layers consist of a wet extent of the lake for each year, lake vegetation and standing water files (1927, 1937), a largest extent (1927), wing dams (1927), and outlet files (1937, 1957, 2008). The Wet extent for each year includes all area in the proximity of

[3] Five additional photos were viewed via the LMIC server for years 1991, 1996, 2000, 2004, and 2006, but copies were not obtained.

[4] US Army Corps of Engineers, St. Paul District, *Mississippi River Lock and Dam 2 (http://www.mvp.usace.army.mil/navigation/default.asp?pageid=145&subpageid=161)*

River Lake, which through examination of the digitized photo obviously contained standing water, aquatic vegetation, or both. The 1927 and 1937 lake boundaries are lined in areas with a white residue, due to assumptions that this is vegetation regrowth in areas where water has receded from spring flooding, this has been classified as aquatic vegetation and is included in both "wet" shape files and "vegetation" shape files. The definition of vegetation in terms of this analysis also includes any aquatic vegetation within the lake interior. These were also determined by shade of pixels with the lighter areas being considered vegetation. Standing water connotes area within the wet extent file for a given year that has not been classified as vegetation.

The peak seasonal extent was determined only for 1927 as all other files seem to be contained generally within a forested boundary while 1927 is surrounded by a non-wooded area which seems to be a saturated plain that does not allow for tree growth. In the 1927 photo, the area within the treeline is assumed to have been at least seasonally flooded and is thus considered the largest extent. Another 1927-only file is for Wing dams, were in place to regulate the flow of the Mississippi River before the introduction of large scale Lock and Dam systems like the one implemented in Hastings. Due to the widening of the river after the inception of the dam, these wing dams were only visible in 1927. In contrast to the largest extent and wing dam files, outlet files have been created for all years except 1927. The outlet is the water flow which connects River Lake to the Mississippi.

Error! Reference source not found.**22: Aerial Photograph Interpretation Errors**

This map was created as a visual representation of the errors encountered when digitizing shape file layers from digital orthoquarter quads (hereafter referred to as aerial photos). As described above, in order to analyze changes within the physical habitat and hydrology and aquatic vegetation over time it was essential to digitize layers from aerial photos. The majority of the photos viewed were black and white images and the digitized copies of these images become quite pixelated when zooming it to determine detail. Due to this pixelation as well as little knowledge of historical ground cover types a number of questions surfaced regarding how to classify different shades of pixels.

The extent rectangles in this map highlight areas that represented challenges for classification for aquatic vegetation. The top rectangle shows two areas of difficult categorization in terms of inner-lake vegetation. The one on left shows a space between two areas of vegetation where lighter pixels are still visible, but not as concentrated. The digitizers assumed this may be sumbmerged vegetation, but that it had not yet broken the surface water and was thus not included. The area on the right is a patch that does not seem to contain vegetation, but exists within a large island of vegetation. This was included to highlight the extent of the island. The lower rectangle highlights a region on the lake border with a large concentration of white pixels bordering what has been considered inner lake vegetation. As described in the previous map section, this white area has also been termed 'vegetation' due to assumptions about the rise and fall of water levels. Apparent in this analysis is a degree of uncertainty in what to consider vegetation, which is inherent to digital aerial photo analysis. As a number of the layers for this section have been digitized through photo interpretation, suggestions for improving this process are included in the recommendations for this section.

Map 23: Temporal Variation in the Surface Area of River Lake

This map shows all four digitized boundaries of River Lake (1927, 1937, 1957 & 2008) superimposed on the year 2008 photograph. It highlights key alterations in the surface area of River Lake; interesting details include: 1) a consistent generalized geometry of River Lake throughout the study period and 2) a dramatic increase in surface area after before the 1937 photograph was taken. In 1927, surface area was 300,523 m^2. This is only about 48.9% of the 2008 value, whereas the surface areas documented for 1937 and 1957 closely approximate the present day value (~90%, see Table 1). These data suggest that prior to dam construction, the extent of River Lake was subject to dramatic variations correlating to seasonal hydrologic differences. But because of the dam's ability to act as a buffer, the lake basin no longer experiences extensive area reductions in the late summer. This change has caused the many wetlands which are visible in the 1927 photograph (and to a lesser extent in 1937) to revert to open water conditions which persist to the present.

Year	Total Surface Area (sq. m)	Percent of 2008 Surface Area
1927	300,523	48.9
1937	564,950	91.9
1957	548,631	89.2
2008	615,011	100.0

Table 1
Total Surface Area of River Lake for years 1927, 1937 and 1957 compared with the present-day (2008) value. Values based on digitization from aerial photographs and digitization errors apply

Map 24: Open water as a percentage of River Lake's Total Area

This map contains the aerial photos from 1927, 1937, 1957 and 2008 with River Lake boundary layers superimposed. The thick outer boundary line defines the full wet extent of the lake at the time the photo was taken (early-late summer for all). The inner, thatched portions indicate areas of the lake characterized by open water conditions. For the purpose of this analysis, 'open water' is defined as *a lake surface observable in aerial photos in which aquatic vegetation is absent*. Note that in 1927, only 29.0% of River Lake's summer wet extent was actually characterized by open water (Table 2). This differs markedly from 1937 conditions, where open water accounted for 75.0% of total area. What's more, this value rose to full 100.0% by 1957 and 2008. The observed decline of vegetated areas within River Lake may be a drowning response to rising river stage and increased seasonal stability of lake area (see Map "Temporal Variation in the Surface Area of River Lake").

The Hastings dam's responsibility for these changes seems likely given river discharge data for the years straddling its construction (Table 2). For example, if vegetation changes were a response to only natural variations in river discharge, it might be expected that a year with high mean discharge (12,558 cfs is the mean for the 81 year period) would see fewer vegetated areas. Note however, that in 1927, when the Mississippi experienced a mean annual discharge of 10,170 cfs, lake vegetation was at its *most widespread*. While a decade later in 1937—a year with half that mean annual discharge, but higher lake levels due to pooling—vegetated areas had

decreased by 60.0%. This seems to suggest little linkage of vegetation changes caused by discharge. Instead, the 78 years of high river stage and surface-area stability due to the Hastings dam are the likeliest candidates responsible for the vegetation decline.

Year	Total Surface Area (sq. m)	Open Water (sq. m)	Percent Open Water	Mississipi River Mean Annual Q
1927	300,523	87,045	29.0	10,170
1937	564,950	423,893	75.0	5,379
1957	548,631	548,631	100.0	12,710
2008	615,011	615,011	100.0	14,469

Table 2

Open Water Area as a percent of Total Surface Area for years 1927,1937, 1957, and 2008 as digitized from aerial photographs. Values for Mean annual (Water Year, Oct 1-Sept 30) discharge in the Mississippi River at St. Paul, MN for these same years is shown at right. *Water discharge data courtesy USGS (waterdata.usgs.gov). Errors due to digitization apply.

Map 25: Wetlands in Ordway in 1980

This map is a simple illustration of the data from the National Wetland Inventory as it relates to Ordway. The data are derived from a digitization by the South Dakota Cooperative Fish and Wildlife Research Unit at South Dakota State University of a color-infrared photograph taken on May 1st, 1980 at a scale of 1:65,000.

Map 26: Wetlands in Ordway in 2009

A distinct issue with the data from the National Wetland Inventory is that 1980 data are the most current Wetland data available for the Ordway at a significant scale. However, due to our GPS work, we do have current primary data pertaining to Wetlands. These data are displayed here.

Map 27: Wetland Types in Ordway: 1980

This map is an effort to go beyond merely showing the location and extent of the wetlands identified in 1980, but to demonstrate the categories of wetlands as described by South Dakota Cooperative Fish and Wildlife Research Unit. In the Ordway they considered three areas Freshwater Ponds, two small areas Freshwater Emergent Wetland, and one large area at the North-end of River Lake a Freshwater Forested/Shrub Wetland.

Map 28: Comparison of Wetland Areas in Ordway: 1980 and 2009

Despite having different methods of retrieving data for each of the years (1980 and 2009), we still thought it would be helpful to create layers and maps comparing them. A union was performed which allowed us to note where the areas did and did not overlap. With the attribute table of the united layer available to illustrate these relationships, we exported the data as new layers in order to create maps depicting areas that were, according to the data sets, present in 1980 but not in 2009 (Union1_JUST_Wetlands1980), areas present in 2009 but not in

1980 (Union1_JUST_GPS), and areas present in both years (Union1_OverLapping_GPS_Wetlands 1980). The resulting map, "Comparison of Wetland Areas in Ordway: 1980 and 2009" overlays the data from these two years in order to quickly identify the areas in which both the data sets identify Wetland, while speaking to our inability to make significant conclusions regarding change over time.

Recommendations Based on Maps and Analysis

Our analyses revealed several important changes to the Ordway landscape. First, our maps of land use changes from 1984-2005 revealed a loss of open space and the expansion of land areas used for commercial, residential and transportation. Our analysis of aerial photos made it apparent that several sources of error are inherent in the process of photo interpretation. Despite these errors, River Lake surface area digitized from aerial photography suggests that two factors—high river stage and surface-area stability—are the likeliest causes of aquatic vegetation loss within River Lake. Additionally, a temporal analysis of wetland changes within the Ordway boundary revealed possible changes in the overall composition and extent of those areas.

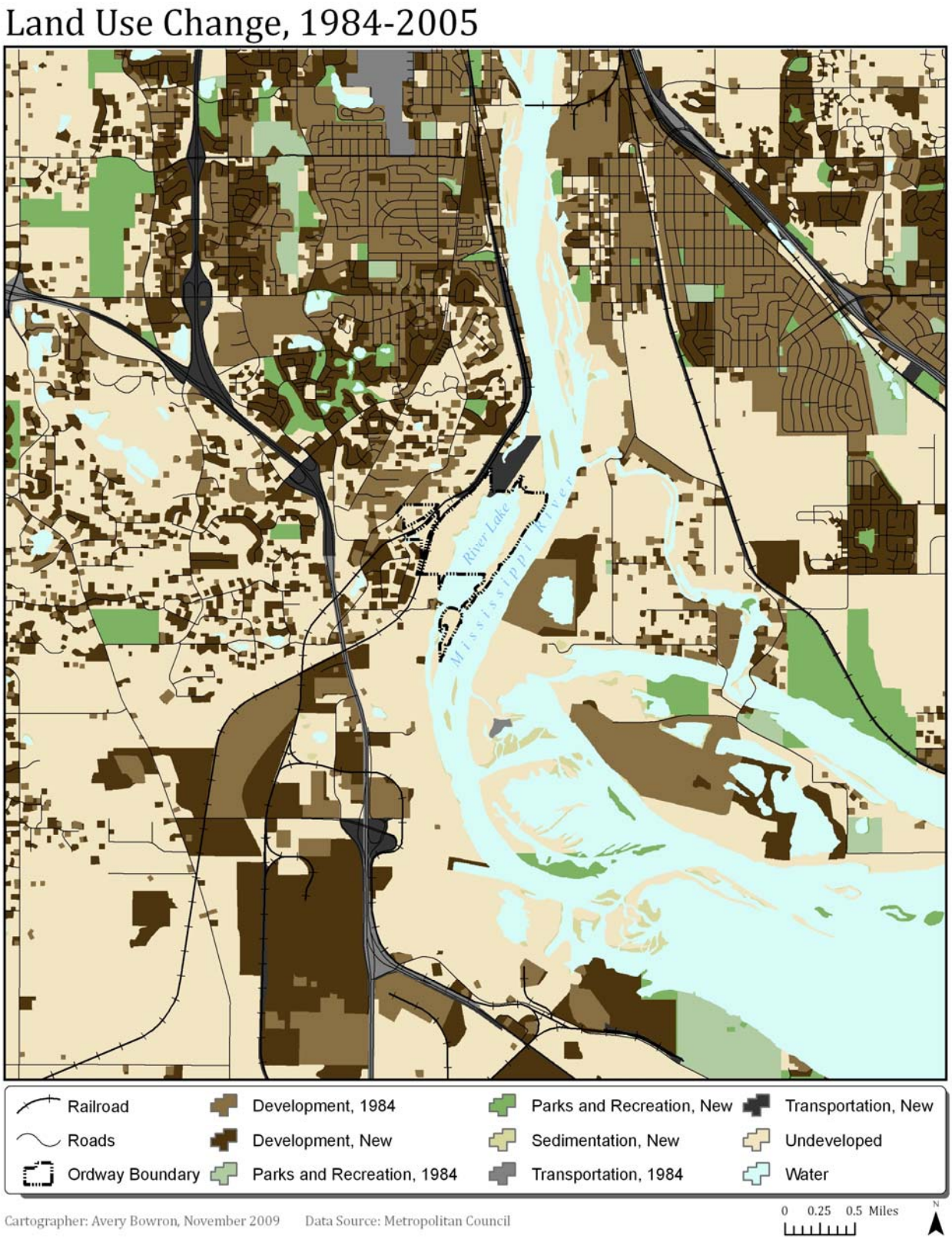
Based on these analyses, we would like to make several recommendations: Firstly, given changes in land use, we recommend that our partners' effort to secure a conservation corridor along the riverfront should remain an immediate priority before continued development envelops the area. Furthermore, in light of the rapid pace of residential development, we stress the likelihood that Pine Bend Elementary will continue to grow. This should be considered in any plans to develop an educational partnership with the school.

Photo interpretation of vegetated areas is complicated by the resolution of the images. To help clarify boundaries between vegetation types, we suggest that future researchers obtain hard copies of the original photographs. Additionally, we recommend that future interpretation is performed by someone with experience and demonstrated skills in aerial photo analysis.

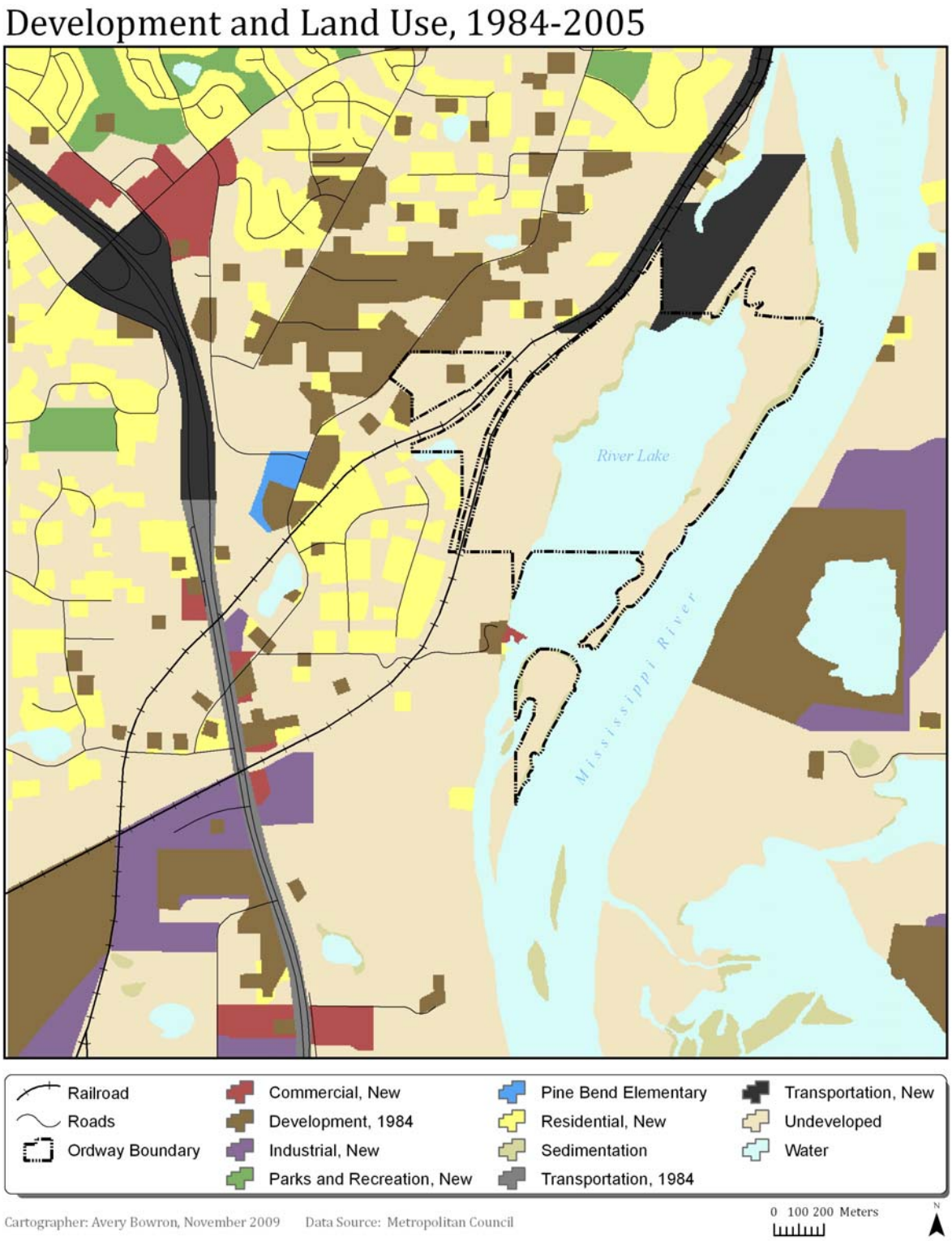
Because high river stage and surface-area stability seem be the likeliest causes of aquatic vegetation loss within River Lake, we would endorse research proposals for vegetation reestablishment via lake draw-down. While costly and logistically complicated, the effort seems likely to succeed if carried out appropriately.

Finally, the evolution of the wetlands in Ordway is a primary concern for our partners, and despite our attempts to draw conclusions concerning the area's change over time we were limited by the data itself. For this reason it is important that future investment in the database should include more systematized and extensive mapping through collecting GPS data points as well as professional analysis of current digitized photos.

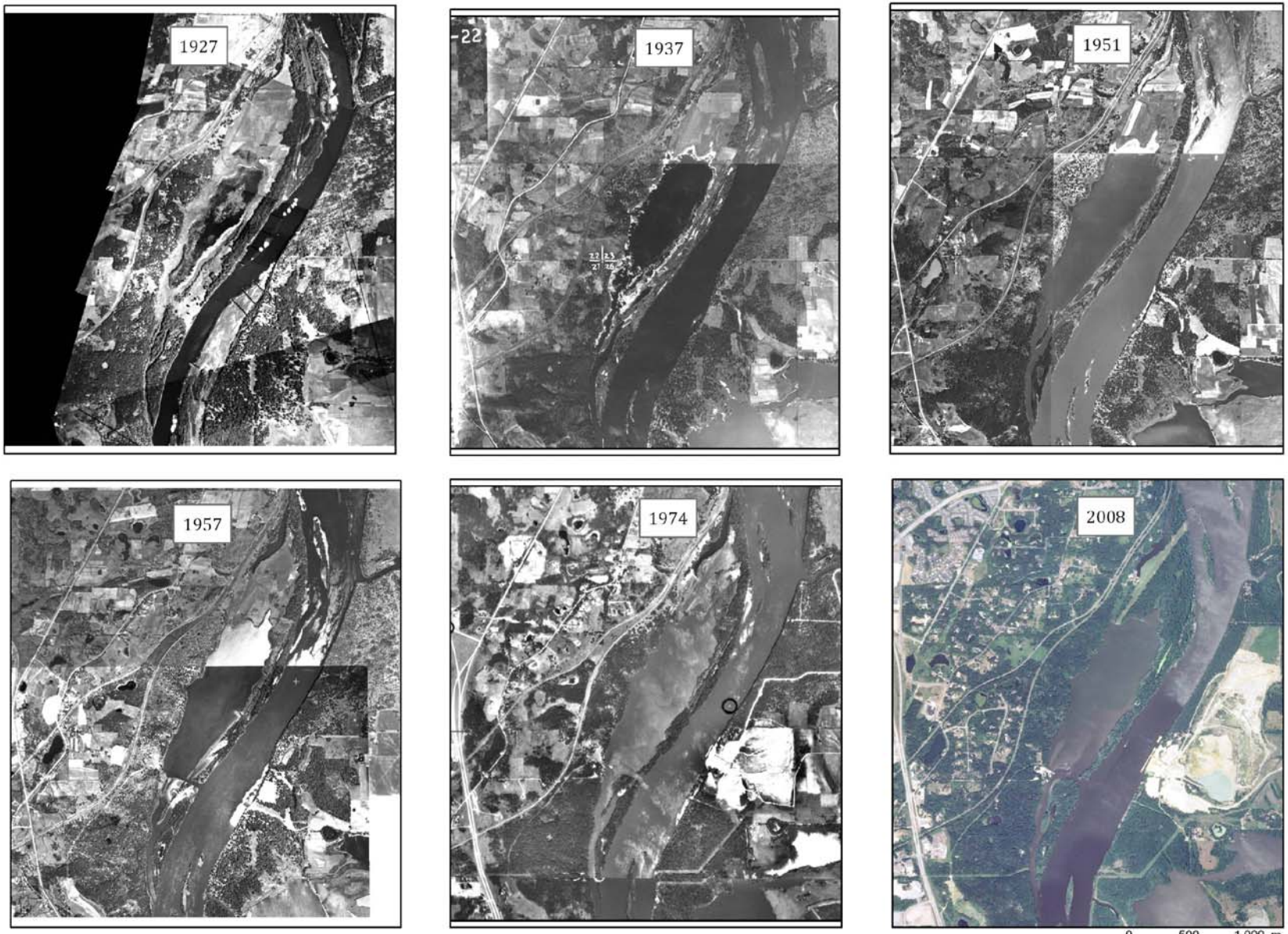
Map 18


Land Use Change, 1984-2005
River Lake
Mississippi River
Railroad
Roads
Ordway Boundary
Development, 1984
Development, New
Parks and Recreation, 1984
Parks and Recreation, New
Sedimentation, New
Transportation, 1984
Transportation, New
Undeveloped
Water
Cartographer: Avery Bowron, November 2009
Data Source: Metropolitan Council
0 0.25 0.5 Miles
N

Map 19


Development and Land Use, 1984-2005
River Lake
Mississippi River
Railroad
Roads
Ordway Boundary
Commercial, New
Development, 1984
Industrial, New
Parks and Recreation, New
Pine Bend Elementary
Residential, New
Sedimentation
Transportation, 1984
Transportation, New
Undeveloped
Water
Cartographer: Avery Bowron, November 2009
Data Source: Metropolitan Council
0 100 200 Meters
N

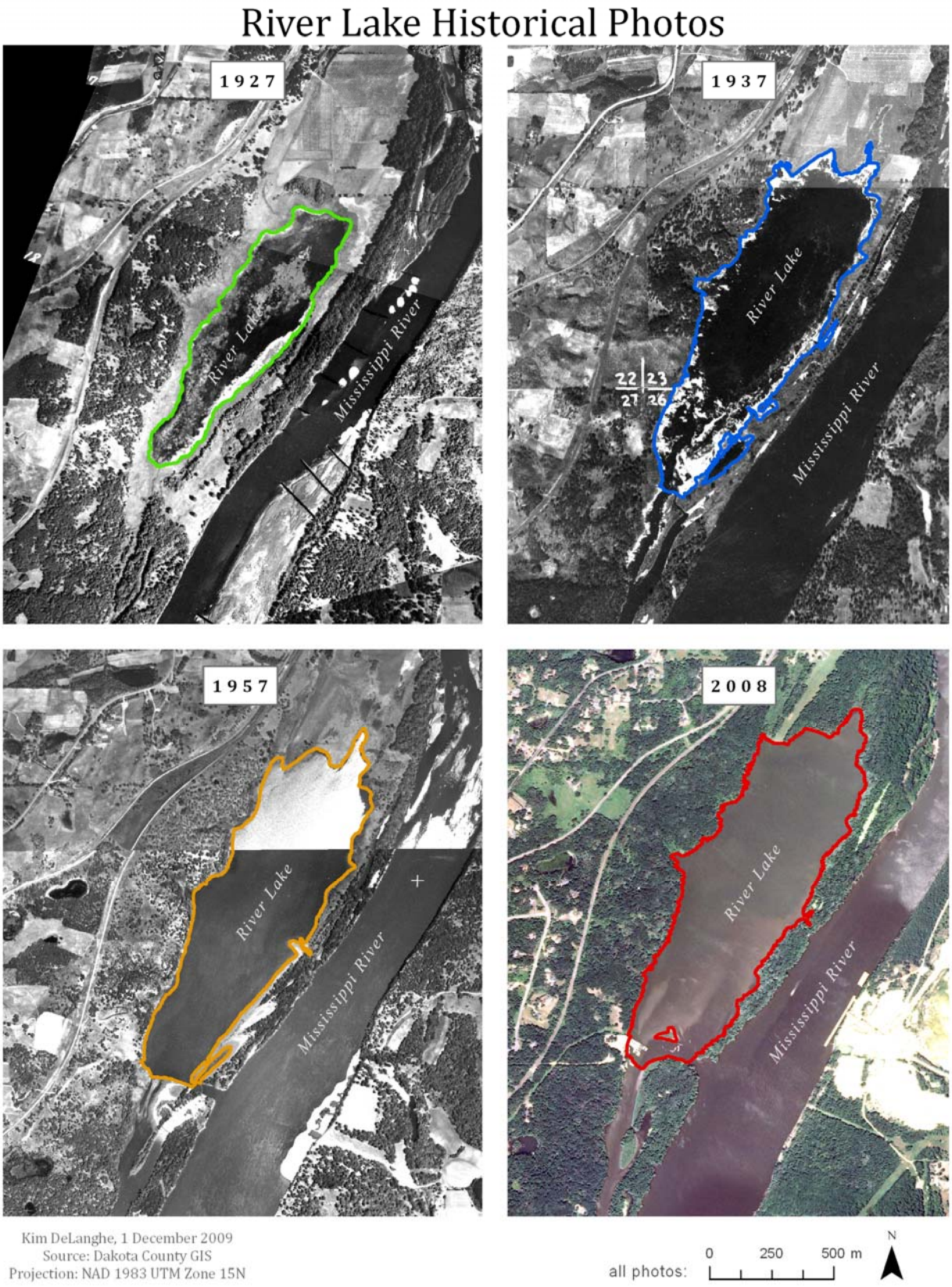
Aerial Photo Series: 1927-2008



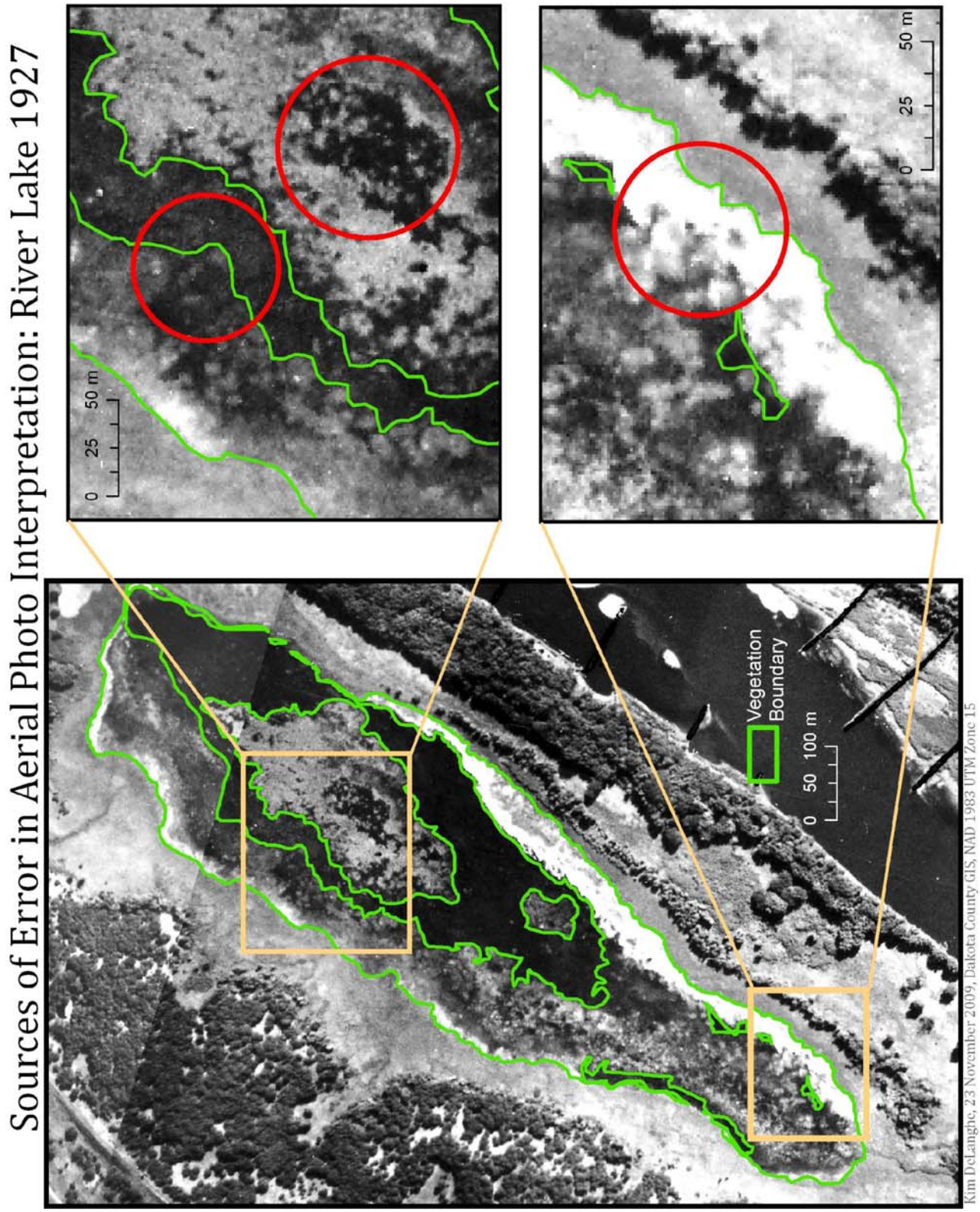
Kim DeLanghe, 1 December 2009, Source: Dakota County GIS, Projection: NAD 1983 UTM Zone 15N

Map 20

Map 21

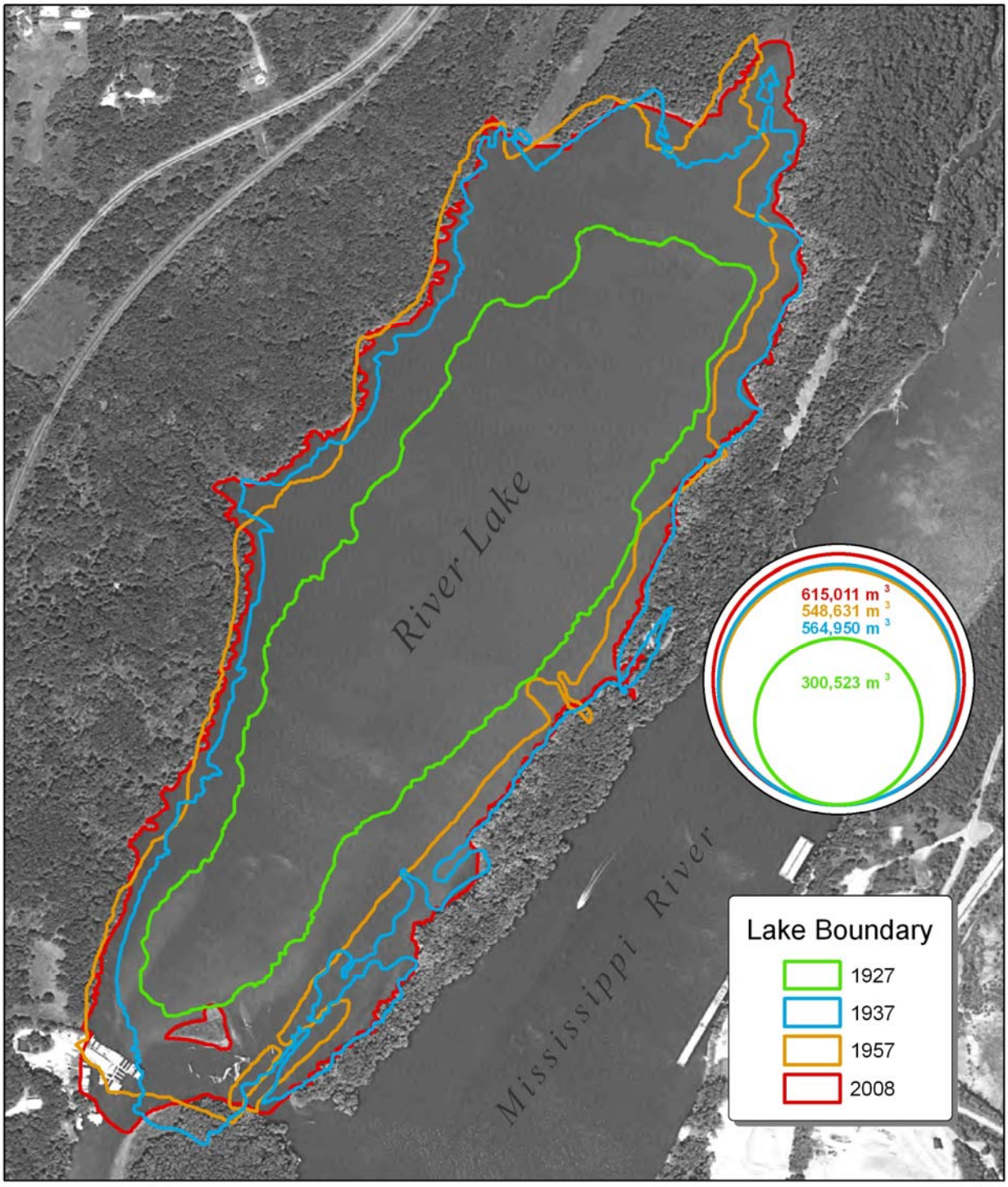

River Lake Historical Photos
1927
River Lake
Mississippi River
1937
River Lake
22
23
27
26
Mississippi River
1957
River Lake
Mississippi River
2008
River Lake
Mississippi River
Kim DeLanghe, 1 December 2009
Source: Dakota County GIS
Projection: NAD 1983 UTM Zone 15N
all photos:
0
250
500 m
N

Map 22


Sources of Error in Aerial Photo Interpretation: River Lake 1927
Vegetation Boundary
0 50 100 m
0 25 50 m
0 25 50 m
Kim DeLanghe, 23 November 2009, Dakota County GIS, NAD 1983 UTM Zone 15

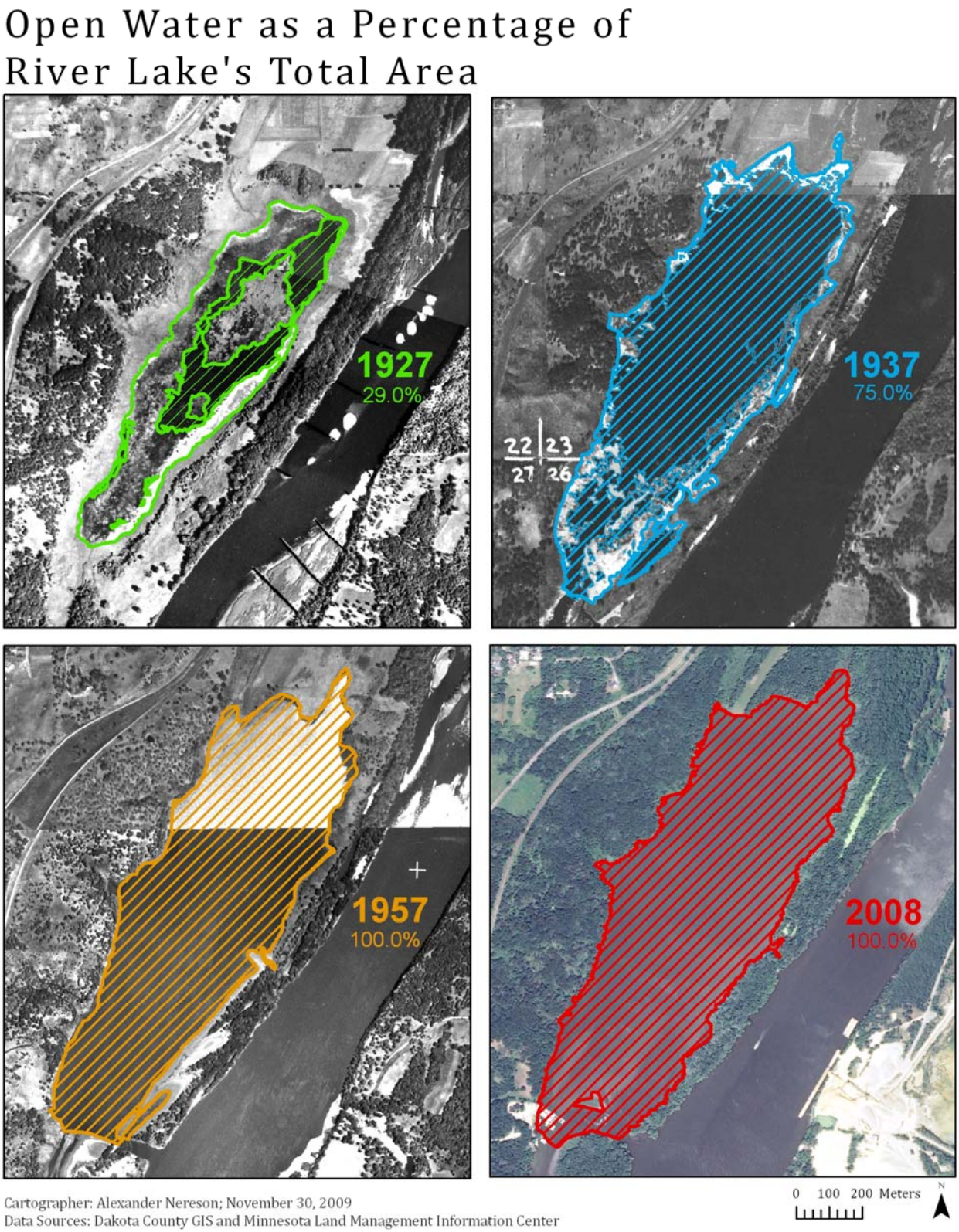
Map 23

Temporal Variation in the Surface Area of River Lake

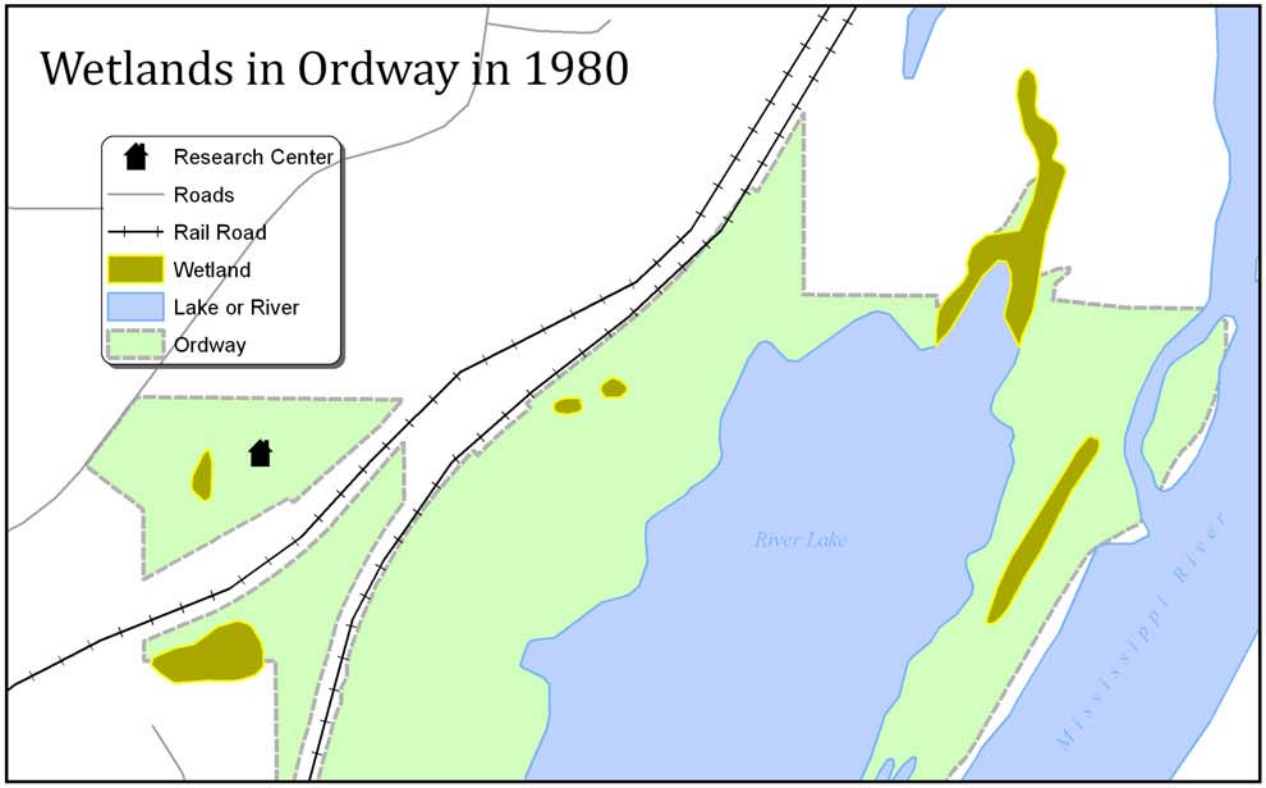


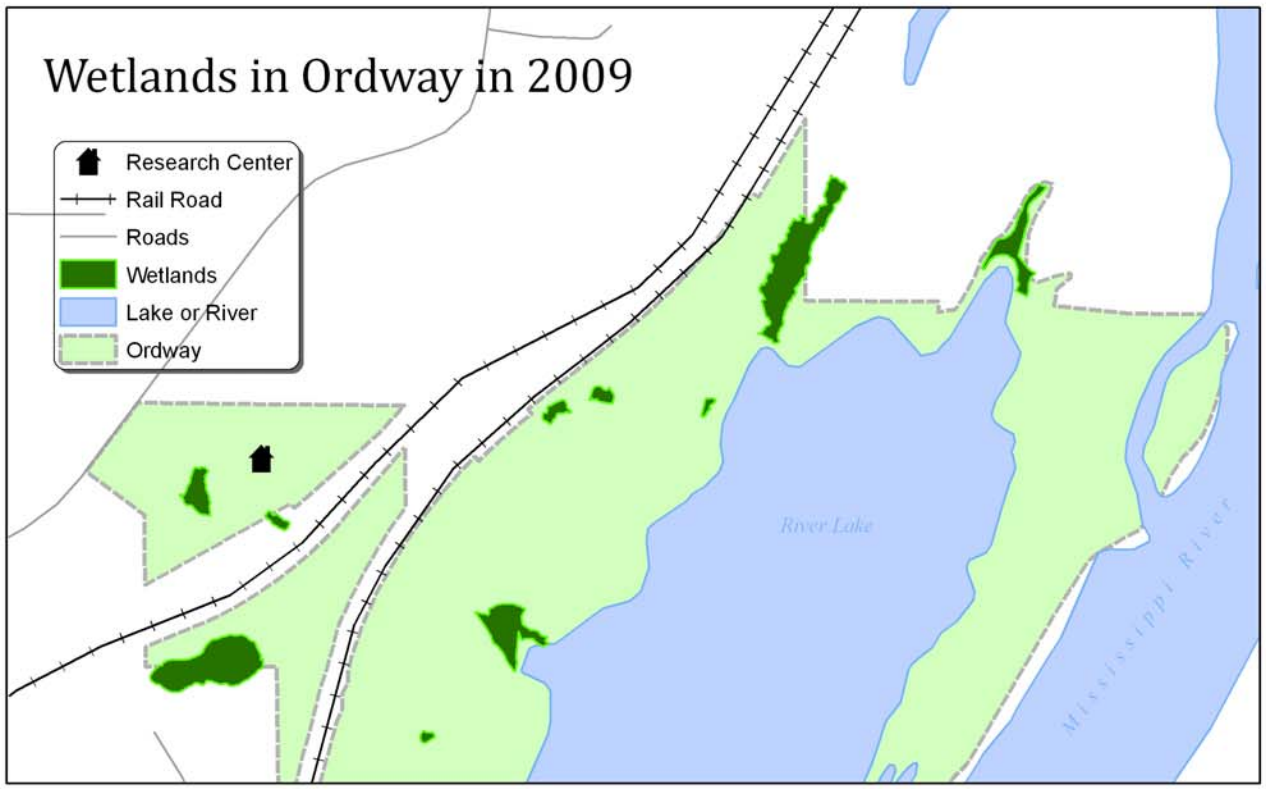
Cartographer: Alexander Nereson; November 30, 2009
Data Sources: Dakota County GIS and Minnesota Land Management Information Center

Map 24


Open Water as a Percentage of
River Lake's Total Area
1927
29.0%
1937
75.0%
22
27
23
26
1957
100.0%
2008
100.0%
0 100 200 Meters
N
Cartographer: Alexander Nereson; November 30, 2009
Data Sources: Dakota County GIS and Minnesota Land Management Information Center

Map 26 and Map 26

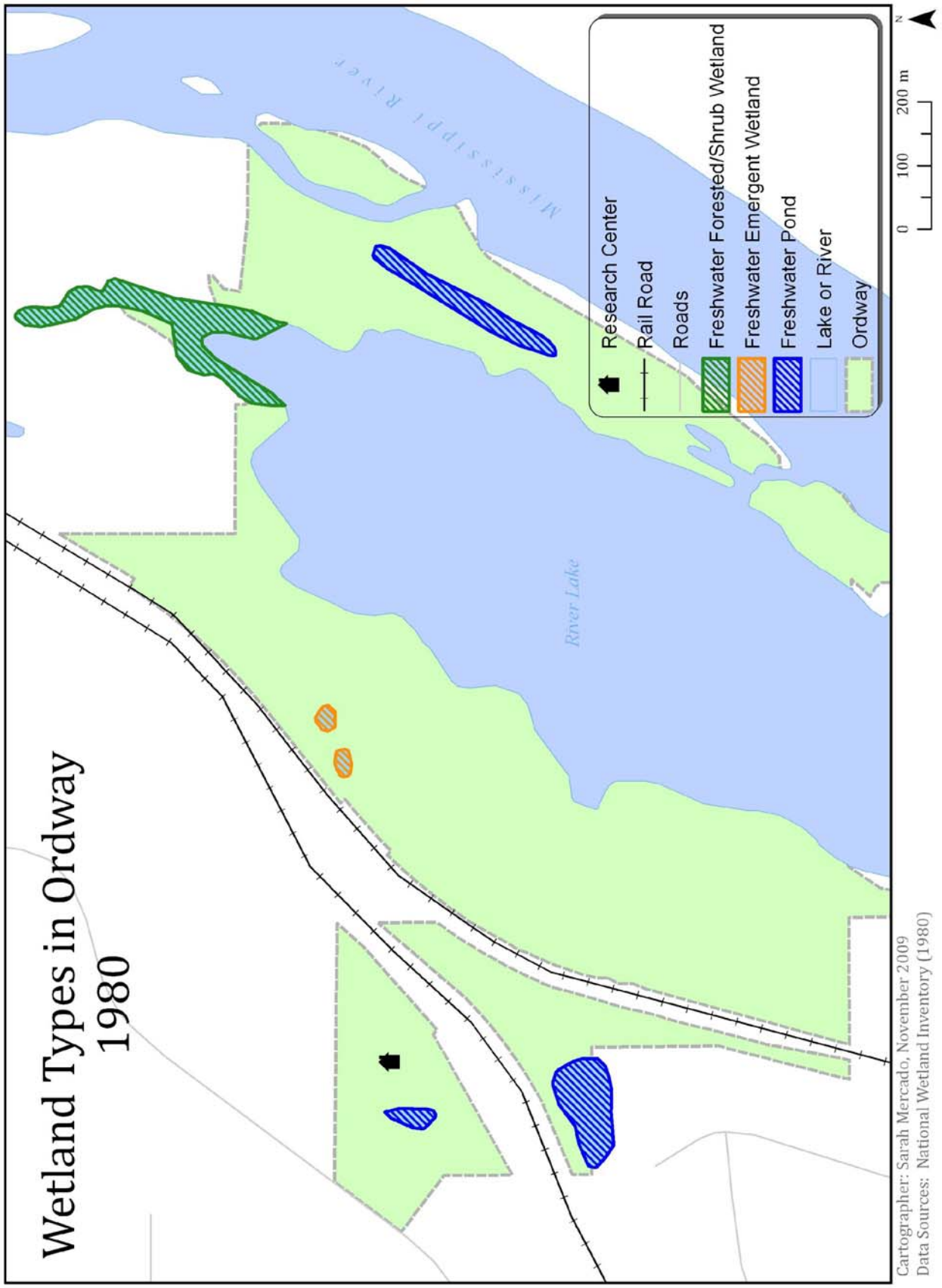




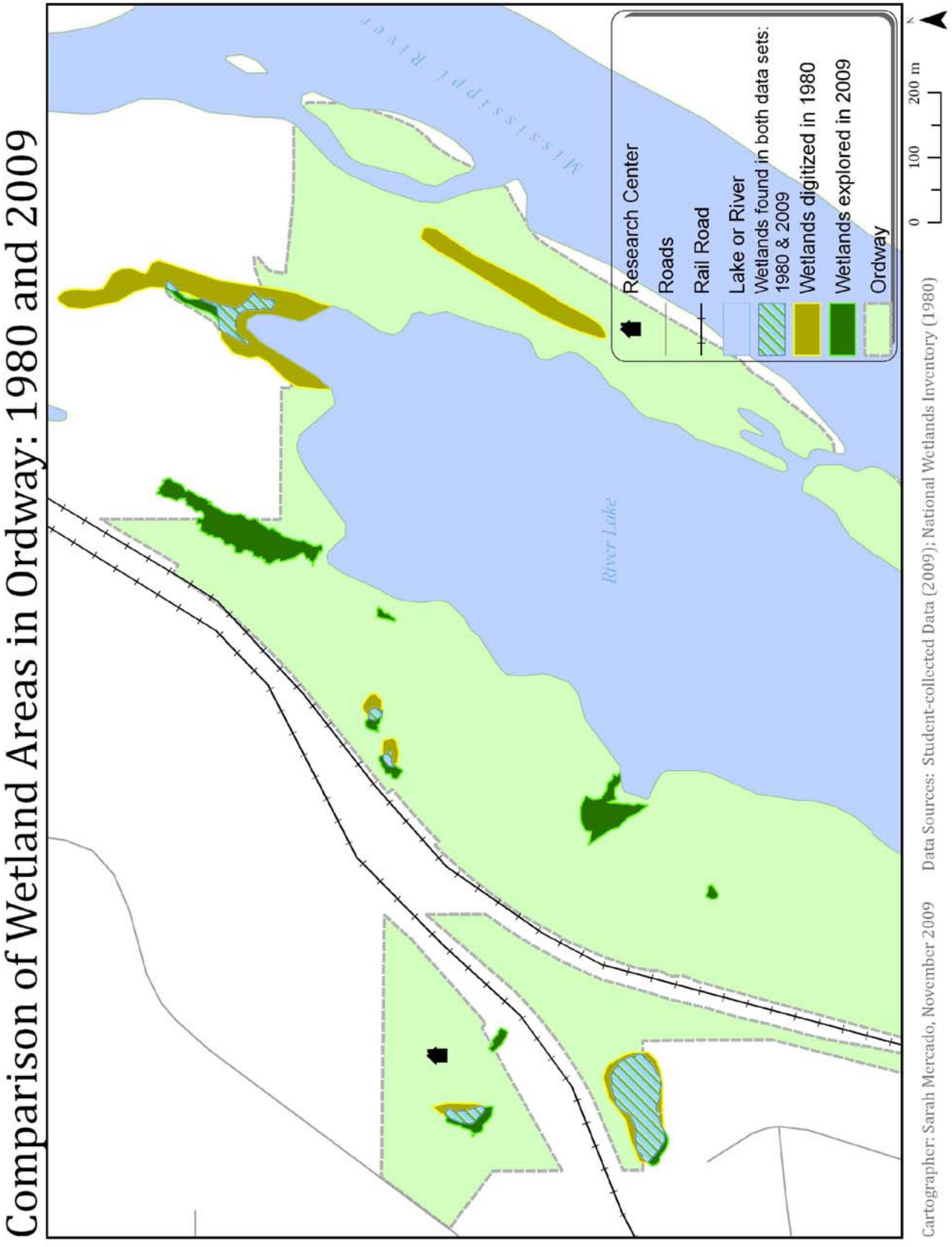
Cartographer: Sarah Mercado, November 2009
Data Sources: Student-collected data; National Wetlands Inventory (1980)

0 100 200 m N

Map 27


Wetland Types in Ordway
1980
Mississippi River
River Lake
Research Center
Rail Road
Roads
Freshwater Forested/Shrub Wetland
Freshwater Emergent Wetland
Freshwater Pond
Lake or River
Ordway
N
0
100
200 m
Cartographer: Sarah Mercado, November 2009
Data Sources: National Wetland Inventory (1980)

Map 28


Comparison of Wetland Areas in Ordway: 1980 and 2009
Mississippi River
River Lake
Research Center
Roads
Rail Road
Lake or River
Wetlands found in both data sets: 1980 & 2009
Wetlands digitized in 1980
Wetlands explored in 2009
Ordway
0
100
200 m
N
Cartographer: Sarah Mercado, November 2009
Data Sources: Student-collected Data (2009); National Wetlands Inventory (1980)

Concluding Remarks

Ordway's diversity of biological communities makes it ideally suited for environmental research and education. Due to the increasing amounts of information being generated as a result of these uses, a comprehensive digital database is ever more important because it provides a means for organizing it all. Moreover, a digital database built within a GIS framework allows for the synthesis of that information for the purpose of furthering our understanding of Ordway and for guiding future research and policy decisions. This report described the work completed between September and December 2008 by students in the *GIS: Concepts and Applications* course at Macalester College. Our primary task was to create the foundation for a living digital database of spatial information pertaining to Ordway. This simple, yet important tool will be available for use by researchers, educators, and students alike for years to come.

In the creation of this database, we fulfilled several key objectives. First, we collected all pertinent spatial data for Ordway. Modifications to the data were made in order to fit the spatial scope of our project and it was subsequently organized into a user-friendly database format. Finally, as a demonstration of the capabilities of our database, we constructed a series of informative maps and performed spatial analyses using the available data. We accomplished these objectives by dividing the labor of data acquisition among three working groups: Land Use, Vegetation, and Historical. Each group was responsible for their respective types of data and for showcasing its usefulness through maps and/or spatial analysis. Based on those findings, our class provides several significant recommendations to future users/contributors to Ordway and this database. They are detailed below.

Continuity of the Database as a Living Archive

Creating this database required substantial effort on the part of students in Macalester's *GIS: Concepts and Applications* course and their partners. Upon our release of database management responsibilities, we recommend that this resource would remain open and available to all parties who might benefit from its contents. Further, it is our hope that this archive represents a foundation upon which multidisciplinary workers will be capable of updating and adding to in the future.

Pursuing Relationships with Ordway's Neighbors

Given changes in land use, we recommend that our partners' effort to secure a conservation corridor along the riverfront should remain an immediate priority before continued development envelops the area. Furthermore, in light of the rapid pace of residential development, we stress the likelihood that Pine Bend Elementary will continue to grow. This should be considered in any plans to develop an educational partnership with the school.

Accessibility within Ordway

Accessibility of resources and research points within Ordway is currently restricted by outdated maps and unmanaged trails. Existing trails should be more clearly marked and future trails should be added to the database and reference maps. That way those unfamiliar with the landscape (especially if elementary students are going to have field trips here) can more easily

find their way around. Another aspect of trail maintenance includes trail expansion along the corridors we suggested. These corridors haven't been assessed for the type of vegetation in these areas but based on elevation and steepness (slope) alone, these areas would be improved by the addition of trails.

Lake Vegetation Restoration

Analysis of historical aerial photos revealed a striking loss of aquatic lake vegetation between 1927 and 2008. Because high river stage and surface-area stability seem be the likeliest causes of this loss within River Lake, we would endorse research proposals by Biology/ES Professor Dan Hornbach for vegetation reestablishment via lake draw-down. While costly and logistically complicated, the effort seems likely to succeed if those obstacles are overcome.