Wisconsin General Land Office Survey Records (WIGLOSR)

Database Documentation

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Forest Landscape Ecology Lab
University of Wisconsin – Madison

Wisconsin State Cartographer's Office
University of Wisconsin – Madison

This documentation was compiled by:

v. 3: Ted Sickley
v. 4: Hayden Elza
Monika Shea

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Principal investigator: David J. Mladenoff
Department of Forest Ecology and Management
University of Wisconsin-Madison

Coordinators: Kristen L. Manies
Theodore A. Sickley

Data entry, quality control, patience, and sense of humor:

Shaun Anderson
Julie Block
Jon Boerner
Carrie Cash
Susan Crowley
Jennifer Dahms
Benjamin Ford
Nicholas Guries
Andrea Hildebrandt
Jason Jones
Thomas Katz
Daniel Kloiber
Rebecca Kurziak
Wendy Lai
Liang Li
Rhonda Mathison
Sheryl Moor
Etsuko Nonaka
Timothy Parshall
Heidi Platt
Jesse Ray
Stefania Rok
Erik Schuck
Nathan Schuck
Anna Scofield
Amy Sloane
Charles Staeven
Theran Stautz
Jedd Ungrodt
Hansheng Wang

Executive Summary

Between 1832 and 1866, contractors to the United States government surveyed the largely unsettled lands of what today constitute the State of Wisconsin for the purpose of subdividing and selling land to settlers moving west from the eastern states and from Europe. The survey was carried out in a systematic manner, with survey posts set every half mile along a grid of one mile square blocks of land called sections. Although this was a land survey rather than a botanical survey or inventory, the field notes recorded by the surveyors contain abundant vegetative information that represent the most complete picture we have today of how the landscape and flora of Wisconsin appeared before widespread European-American settlement and the accompanying clearing, logging, and agricultural activities.

We reviewed the entire set of field notes for the state of Wisconsin and compiled tabular databases of biological and ecological information contained in the notes. The following documentation provides a brief historical overview and description of the US public lands survey system (PLSS), its application to Wisconsin, an outline of our databases and their contents, and perhaps most importantly, a review of caveats and limitations to the use of the data. The databases we have compiled will be of enormous use to ecologists, foresters, planners, and land managers who are interested in the pre-European landscapes of Wisconsin and the subsequent changes to the land, but they must be approached with care and a full understanding of the inherent biases contained within the survey that will affect how the data are used.

Cumulatively, the databases contain over 300,000 records with information about 180,000 survey points, 450,000 individual trees, and 23,000 ecological boundaries between ecosystems, all of which can be explored and analyzed using conventional statistical methods. In addition, the Wisconsin Department of Natural Resources has produced a geographic information system (GIS) database of statewide PLSS corners, to which we are able to attach our tabular data. This then allows for the mapping and spatial analysis of the information.

General background and description

In 1785 the Continental Congress of the United States enacted the Land Ordinance which described a procedure for subdividing and disposing of the country's unsettled western territories. The federal government wanted to populate these territories and was already carrying a substantial debt from the Revolutionary War that it wished to retire with capital raised through the sale of land. The Surveyor General of the United States was appointed to supervise this survey and report to the Secretary of the Treasury. To further facilitate the survey, Congress established the General Land Office (GLO) within the Department of the Treasury in 1812. A method of rectangular land subdivision known as the public land survey system (PLSS) was developed in eastern Ohio in the late 1700s and applied westward across the country. The lands that are now within the State of Wisconsin were surveyed between 1832 and 1866, with 5 townships in Indian reservations completed in 1872, 1873, and 1891. Initially this area was part of the Northwest Territories, then part of the Michigan Territory, then the Wisconsin Territory, and ultimately in 1848 the State of Wisconsin. Surveys of the territories that comprise the remainder of what is today known as the lower 48 states were completed by the early 1900s.

Under the public land survey system, the subdivision of a given area began with the establishment of two surveyed lines: an east-west trending baseline and a north-south trending principal meridian. Land was first divided by surveying east-west township lines parallel to the baseline and north-south range lines parallel to the principal meridian at six mile intervals. This resulted in a grid of square areas called townships, each six miles on a side. Townships were subsequently subdivided into 36 sections, each 1 mile square. The location of a given township is identified as so many townships north or south of the baseline and so many ranges east or west of the principal meridian. The baseline for Wisconsin was established with the survey of the northern boundary of the Illinois territory in 1832. The 4th Principal Meridian, which had been used in the survey of Illinois, was extended north from the baseline to Lake Superior (Figure 1).

A district Land Office, overseen by the district Surveyor General, was established in each region that was to be surveyed. The work was conducted by Deputy Surveyors, who

contracted with the district Surveyor General to survey township lines or interior section lines for blocks of townships at a time. The Deputy Surveyor received instructions with the contract detailing the manner in which the survey was to be conducted. He was paid by the mile of survey, and with this money he hired a crew to assist him, purchased necessary supplies, and paid himself. In Wisconsin, the crew generally consisted of two chainmen who carried the chain used to measure distances, one or two axemen who constructed wooden survey posts and blazed and marked trees, and a flagman.

Distances along the survey lines were reported in chains and links. One chain equaled 66 feet (4 rods) and was comprised of 100 links. There were 80 chains or 8000 links to the mile. Survey posts were set along township and section lines every mile at locations designated as section corners. Additional survey posts were set at the midpoints between section corners at locations called quarter section corners (Figure 1). The presence of quarter section corners allowed for the future protraction of sections into quarter sections if desired. At each section and quarter section corner, a survey post was constructed of wood from the forest and set into the ground, and between 2 and 4 trees were identified as witness or bearing trees. The location of the corner, the type and diameter of each bearing tree as well as its compass bearing, or azimuth, and distance from the corner were recorded in the survey notebook. In areas without trees such as prairie and marshes, mounds of earth or stone were constructed to mark the location of the corners.

Where a section line intersected a navigable lake or river, the surveyor set a meander corner on the shore at the point of intersection, surveyed around the water body to the opposite shore along the same section line, set another meander corner, and continued surveying. Meander corners were also established when survey lines intersected boundaries of Indian reservations or preexisting private land claims, although the surveys did not generally extend into these areas. Meander corners resembled section corners: survey posts were set into the ground and bearing tree information (species, diameter, azimuth, and distance) was recorded in the notebooks.

The surveyor and his crew recorded other features that they encountered as they walked the section lines. The type and diameter of trees occurring along or very near sections

lines, called line or station trees, were noted, as were significant natural and cultural features such as swamps, marshes, ridges, ravines, meadows, thickets, prairies, lakes, ponds, rivers, river bottoms, streams, springs, windfalls, burned areas, homesteads, fields, villages, roads, trails, and many others. Figure 2 shows the field surveyors notes for several section lines in Township 35 North, Range 16 West.

At the end of every mile of survey completed, the surveyor recorded the nature of the land surface (e.g., level, rolling, broken) and soil (first, second, or third rate) as well as the dominant timber and understory species seen along that mile. The field notes for many townships are followed by a general description of the township regarding its current physical characteristics, the presence of settlement or improvements, and its economic potential for agriculture or timber production (Figure 3).

All field notes for the townships covered under a given contract were deposited with the Surveyor General at the district land office upon fulfillment of the contract. For Wisconsin, these offices were first in Cincinnati, Ohio, and later in Dubuque, Iowa. Government scribes and draftsmen in the district offices recompiled the notes into notebooks arranged in columns of townships and drafted accurate plat maps of each township at a scale of 1:63,360 (1 inch = 1 mile). Plat maps show the lengths of all township and section lines, the areas of each section and quarter section available for sale (with the area covered by meanderable bodies of water subtracted), water bodies, and some of the natural and cultural features mentioned in the notes (Figure 4). Wisconsin's field notes were compiled into 311 notebooks covering the subdivision of land into townships (called exterior surveys), and 360 notebooks covering the subdivision of townships into sections (interior surveys). The state Board of Commissioners of Public Lands maintains the notebooks and plat maps, which have been microfilmed and scanned into digital files.

More information regarding the General Land Office survey in the United States can be found in Stewart (1935) and White.

Error Assessment

Upon completion of data entry, 5% of all interior surveys and 5% of all exterior surveys were randomly chosen to quantify error rates. The contents of the database for these townships were printed out and compared to the original field notes, and errors introduced during data entry were tabuled by database field (see Appendix C). Error rates for all fields except Ecosystem were less than 2%, and the error rate for Ecosystem field was less than 3%.

Caveats to the database

The General Land Office Survey

There are numerous issues regarding this database that must be taken into account when using the data. Some of the issues are rooted in the original survey and how it was conducted, and other issues grew from the manner in which we constructed the database.

With respect to the General Land Office survey of Wisconsin, there is a great deal of variability seen in the field notes due to the long time period required to complete the survey and the number of individuals who worked on it. It took 34 years to complete the majority of the survey, as all but five townships were surveyed between 1832 and 1866 (Figure 7). The basic framework of the survey did not change over time, but the General Land Office issued new sets of instructions to be given to the deputy surveyors in 1833, 1846, 1851, and 1855. Prior to 1855, general instructions were published as circulars and included with all contracts. Special instructions pertaining specifically to that contract may have been included as well. The instructions of 1855 were published as a more formal handbook, The Manual of United States Surveying, thus standardizing the surveys in all parts of the country. The Manual was then updated and republished periodically, although most of these updates occurred after the completion of the survey of Wisconsin. Changes in the procedures affected the number of witness trees identified at a given section corner, the regularity with which line trees were noted, whether or not the surveyors subdividing townships into sections set posts when they

reached township boundaries, and other aspects. A review of surveyors' instructions and how the changes affected the survey in Wisconsin can be found in Onsrud (1979).

Over 100 surveyors worked in Wisconsin over this time period (Figure 8). There are many differences in the way individual surveyors conducted their surveys, beyond differences induced by changes in instructions. Many of these differences are obvious from looking at the data. Some surveyors consistently used genus names to identify certain trees (e.g., birch, pine) while most identified trees by species (e.g., yellow birch, red pine). Overall, 79% of birches, 16% of pines, 27% of maples, and less than 1% of oaks were identified in the notes only to the genus level.

The common names used to identify trees varied widely. What is called red pine today (Pinus resinosa) may have been called red, Norway, yellow, or sugar pine in the field notes. It appears that some common names migrated west with the surveyors and were applied to species in Wisconsin that resembled those known in the east. For example, pitch pines are noted throughout the survey although Pinus rigida is not found in Wisconsin. This common name was probably being applied to Pinus banksiana (jack pine), which ranges from New England to Minnesota. Some common names that appear in the notebooks are simply vague (e.g., yellow wilson, palm willow, blair). It is possible that these represent extremely obscure common names or typographic errors introduced during the transcription process, and overall they are very rare in the database.

Another obvious difference among surveyors is the volume of information they recorded. Some surveyors very regularly included one or two line trees between each section and quarter section corner and described in great detail the different ecosystems through which they passed. Some listed six, eight, even ten dominant timber species along a single mile. Others included no line trees, made no mention of changes in ecosystem, and listed one or two dominant timber species, if any. It is possible that these differences are due to real differences seen in the field or to the instructions the surveyors received, but it is equally probable that each surveyor had his own approach to surveying and his own interpretation of the instructions. For example, A. Millard subdivided Township 42 North, Range 9 East in 1861. He noted in addition to the 85 interior section and quarter section corners that are found in

every township 20 meander corners and 102 line trees. Four years later J. McBride surveyed the township immediately to the west. He noted 85 section and quarter section corners, 11 meander corners, and no line trees. Clearly these two surveyors had different opinions as to the importance of including line trees in their field notes.

There are also differences between surveyors that are not so apparent from casually looking at the data, but have been identified through statistical analysis. Numerous studies have found biases in the species, diameters, and compass quadrant of the trees chosen as witness trees as well as the distance the trees lay from the survey post (Bourdo, 1956; Delcourt and Delcourt, 1974). Manies (in press) reviewed many of these studies and found statistically significant bias in the species and diameters of witness tress in data contained in this database for northern Wisconsin. Surveyors in her study area favored some species over others and appeared to prefer trees of certain size classes. These biases will certainly affect analysis of forest composition and structure.

Although we extracted presettlement vegetation information from the field notes in order to compile this database, the original survey was not conducted as a biological or botanical inventory. It was primarily a land survey, and the biological content of the notebooks was collected and included in the notebooks to support the survey and otherwise secondary. It is crucial to remember when using this vegetation data that it was collected by surveyors rather than botanists, and done so neither systematically, consistently, nor objectively.

The Database Itself

Our goal was to capture as much of the vegetative and ecologically relevant information as possible from the notebooks, rather than to create a complete transcription of the field notes. To this end, we ignored certain elements of the survey records that were of little use or interest to us (see the list above in the general database description). There is however one significant natural feature that might be of interest to users of this database that was not captured. We did not create ecosystem point data records when the surveyors mentioned entering or leaving wetlands, such as swamps, marshes, and river bottoms, because

there were simply too many of them in northern Wisconsin. Any feature that occurs in these areas does have an ecosystem code that correctly reflects type of wetland in which the feature sits, but the actual location where the surveyor entered or left that wetland is not included in the database.

There exists in the notebooks a certain amount of ambiguity, confusion, and vagueness regarding ecosystems. For much of the state, there is no explicit mention of the type of ecosystem in which the surveyor was travelling. Ecosystem type may be surmised from the nature of the corners: those with trees nearby were likely to be in forests and those marked by mounds or boulders and lacking witness tree information were probably in prairie or very open savanna. Currently we use an ecosystem code of F, default or unmentioned, for these points. A user wishing to accurately map ecosystems based on the ecosystem codes assigned to each point may need to develop a methodology for defining ecosystem type more precisely when the code is F, based on other data included with these records.

In some cases, an ecosystem was explicitly entered but never left, or vice versa. Examination of adjacent section lines may explain where the other boundary of the ecosystem was, but if not, the ecosystem was assumed to end at the next section corner, after which the ecosystem code reverted to F. In other cases, a surveyor entered one ecosystem and then entered another without explicitly stating that he left the first. For example, the surveyor may have entered a barren at 2500 links and heavy timber at 4200. In a case such as this, the database will contain records for entering both ecosystems as well as a record for the implied leaving of the first ecosystem upon entering the second.

The description of the line reported at the end of the mile may include an indication of the ecosystem when there is no record of entering or leaving ecosystems along the survey line. For example, a section line may have been described as "land all swamp" or "oak openings." In these cases, all features found on that line will be coded as S (swamp) or O (oak openings). On other lines, the surveyor may have noted that he entered and/or left an ecosystem, and then at the end of the mile mentioned another ecosystem. For example, he may have entered a prairie at 6000 links and then described the mile as "scattering timber". In this case, any features occurring between 0 and 6000 links will have an ecosystem code 2 for scattered

timber, and all other features occurring between 6000 links and the end of the mile will have an ecosystem code P for prairie.

Data and Database Use

Early surveyors' records have been used for many years to study pre-European settlement forests and landscapes of North America. The nature of the surveys was quite different between the eastern United States, where metes and bounds surveys commonly followed settlement and were very irregular, and the territories west of the original 13 colonies, where the U.S. General Land Office surveys were conducted prior to widespread settlement. In both areas, the vegetative information contained in the survey records has been of great assistance to ecologists trying to better understand the natural history of the continent and the effects of European settlement on the land (see Siccama, 1971; Russell, 1981; Foster et al., 1998 for work in the eastern states; Bourdo, 1956; Iverson, 1988; Galatowitsch, 1990; for work in the midwestern and western public lands states; Kline and Cottam, 1979; White and Mladenoff, 1994; Radeloff et al., 1998; He et al., 2000 for work in Wisconsin).

Currently the database exists in tabular form and lends itself to statistical analysis. In order to display the data on a map, perform spatial analysis on it, or combine it with other geographic data such as soils, geology, landtype associations, or current land cover within a GIS, we have developed a procedure to attach the data to a geographic coverage of the section and quarter section corners called Landnet produced by the Wisconsin Department of Natural Resources (WDNR, 1996). Landnet contains the point locations for all corners, each uniquely identified by a code called corn-id, which is an 11 digit concatenation of range direction, township, range, section, and corner. For example, the section corner in the southeast corner of Township 35 North Range 15 East, section 36, has a corn-id value of 43515360000. Given the numbering conventions of Landnet outlined in its technical documentation, the identical corn-id values can be calculated for each section corner record in the presettlement vegetation database, and the data can then be attached to the Landnet's attribute table using standard relational database techniques. The x- and y-coordinates of any feature that occurs between

section and quarter section corners (meander corners, line trees, and ecosystem points) can be calculated by starting with the coordinates of the corner from which the feature was measured and adding or subtracting the distance contained in the Links field of the database (converted first to Landnet's geographic units, most likely meters) from the x- or the y-coordinate, depending on the direction from the corner the surveyor was traveling when he encountered the feature. Radeloff et al. (1998), Radeloff et al (1999), and He et al (2000) show examples of how this presettlement data was brought into a GIS and spatially analyzed.

Design of the Database

The first version of the database was created during the digitization process to store and later analyze the data. The design was a flat file database. This structure made it easy to write programs to store the information and was familiar to most users.

A flat file database is a database stored as an ordinary unstructured file such as a CSV.

Despite its portability and simplicity, a flat file falls short in several aspects. Immediately apparent to any user is that there are four species fields. This was to record each tree at a corner, but is problematic when trying to analyze the data. For instance, in order to get a count of each tree species one would need to summarize each species field, then combine the summaries.

Another shortcoming are the mixed fields. A tree in the *sp1* may be a witness tree or line tree or even not a tree at all but a feature such as a trail. This means a user needs to filter the field before it can be used. This problem and others can be alleviated by using an alternative to a flat file database, a relational database.

Witness trees bear witness to a corner or meander point. In areas where no trees were present sometimes rocks or boulders were used or mounds were erected. In comparison, line trees were marked and recorded when a surveyor encountered a tree while running a line and the tree was intersected by the line.

A relational database organizes data into one or more tables, or relations, comprised of columns and rows. In the relational data model, we can create a table for witness trees where multiple records, one for each tree, relate to a single corner record. Additionally, each type of observation can have a separate table. Now witness trees, line trees, and features no longer share the species field. To explore this further we can look at the conceptual design of the database.

Conceptual Design

The first step in designing a relational database is to create a conceptual model. An Entity-Relationship (ER) diagram or a UML class diagram can be used; below is the ER diagram for the GLO database.

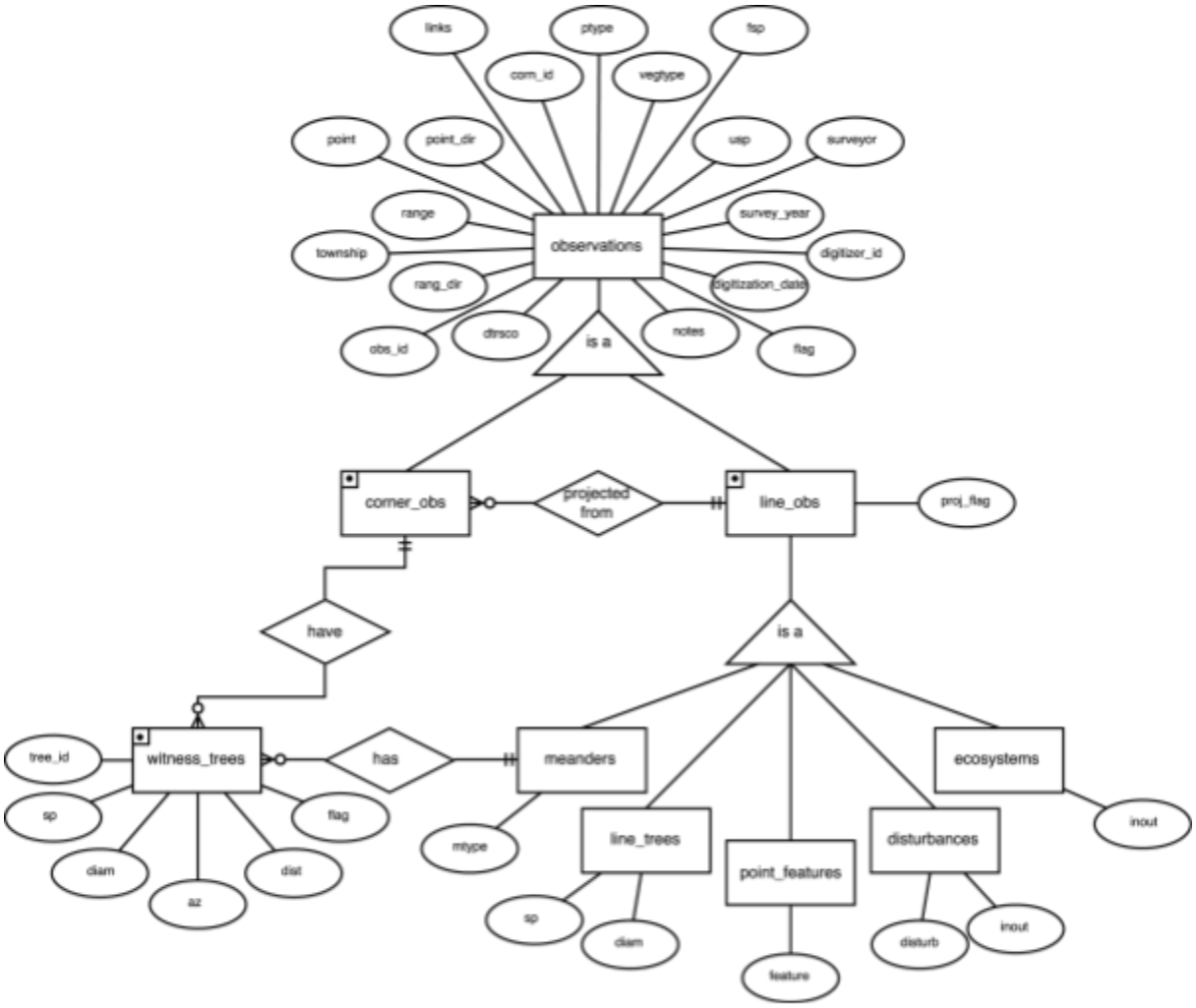

Figure 1. An entity relationship diagram for the GLO database.

In an ER diagram, the rectangles represent *entities*. An entity is something that exists either physically or logically, e.g. a tree or an observation. A triangle connecting entities shows the separation of an entity into subclasses. For instance there are two subclasses of

observations: *corner observations* and *line observations*. Ellipses are attributes of entities, for example, a witness tree can be described by its *species* or *diameter*. Entities connected by a diamond represent relationships. Corner observations *have* witness trees.

Relationships have cardinality, this is represented by the marks on the lines connecting relationships. For example, a corner observations has *zero to many* witness trees or conversely a witness tree is had by *one and only one* corner observation.

Observations

An observation is not a physical entity but a concept. Here we define it as an event when a surveyor stopped and recorded what they observed.

Each observation contains information to identify the township within the state as described by the: *township* (how many townships north of the state baseline), *range* (how many townships away from the fourth principal meridian), and *range direction* (west or east of the principal meridian). Location within the township was recorded in the *point* field; a number 1-126 representing every section and quarter section corner as demonstrated in figure 1 and shown fully in appendix D. Additionally, observations between corner points were represented using the direction from the corner, *point direction*, and the distance in *links*.

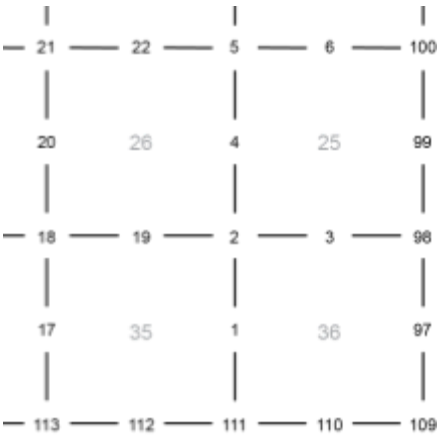

Figure 1. Township schematic showing point labels of section and quarter section corners for the sections 25, 26, 35, and 36.

The *point* field was easy to use during digitization but was later replaced with *section* and *corner number*. Sections are labeled 1-36 starting in the northeast corner and proceed in boustrophedon fashion. The section labels can be seen in Appendix D. *Corner number* comes from the Romportl numbering system and represents the location within a section. A *corner number* has two components: YY and XX. Both range from 00 to 40, 0000 being the bottom-right corner of the section and 4040 being the top-left corner of the section. Figure 2 shows three examples of *corner numbers*.

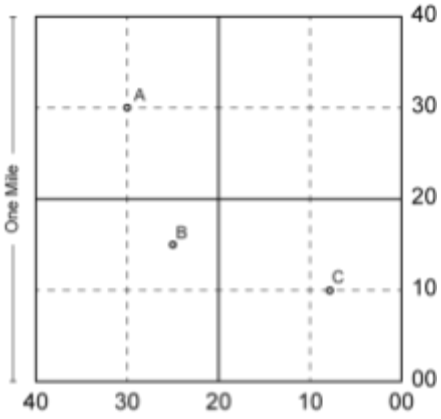

Figure 2. Corner id coding scheme, adopted from the WDNR 24k Landnet. Assuming Township 3N, Range 2 W, and Section 9: A=20302093030, B=20302091525, and C=20302091008.

Records also contain *ptype*, or point type, which represents the type of point or observation. This includes: *corners*, *line trees*, *meanders*, *disturbances*, and *ecosystems*. These *ptypes* are subtypes of observations. In earlier versions of the database this field was required to differentiate the different subtypes, but in the current database each subtype gets its own table.

Surveyors noted the type of ecosystem they were in when recording a section corner or quarter section corner; this appears as *veg_type* in the database. They also noted the dominant timber species, *fsp*, and dominant understory species, *usp*, at the end of each section line. The surveyor did not always clearly distinguish which species were considered timber and which were understory. When this distinction was vague, all species were listed under *fsp* unless the species type was clearly undergrowth, such as prickly ash, vines, grass, etc.

Meta information such as *surveyor* and *survey_year* were also collected. The *surveyor* field is text and often includes multiple names, this makes it difficult to do things such as list all unique surveyors for the whole database. A surveyor may show up in multiple strings in conjunction with different names. An example of this phenomenon would be '*J. MULLETT & J. BRINK*' and '*J. MULLETT & J. H. MULLETT*' where *J. MULLETT* is a single surveyor that shows up in both of these values. In this case, there are at total of three surveyors, but if we were to count the distinct *surveyor* values we would only count two.

Additionally the database contains meta information on who digitized the record, *digitizer_id*, and when the record was digitized, *digitization_date*. Another meta field is *flag* which serves as a way to flag unique cases or errors.

To uniquely identify a record, *dtrsco* can be used. This field is a composite of others: *d* range direction, *t* township, *r* range, *s* section, *c* corner number, and lastly *o* observation id. Observation id, *obs_id*, is a code that uniquely identifies an observation when there are multiple that share a single *dtrsc*.

The *notes* field contains whatever does not fit into the other fields, often remarks by surveyors but also notes from digitizers. For example: '*S1/2 MILE THINLY TIMBERED*' or '*AZ2 RECORDED AS S72*'. The second example is the digitizer noting that the second azimuth was recorded as south 72 degrees. There is a wealth of

information in this field including cultural features such as sugar camps, mills, and even taverns, but this is often very difficult to extract.

Witness Trees

A witness tree is a tree that bears witness to the monumentation of a corner. In the absence of trees, a mound may be constructed or nearby rocks and boulders could also bear witness to a corner. Bearing witness means that an azimuth, *az*, and distance in links, *dist*, was recorded from the corner location to the witness. Witnesses were important because a wooden post marking the corner will eventually rot or otherwise be lost. Trees would long outlast the post, some even surviving to this day. Other attributes describing the witness trees include the species of a tree, *sp*, and diameter at breast height, *diam*.

The witness trees table also includes meta attributes such as the *tree_id* which indicates if a tree was first, second, third, or fourth to be listed at a corner. The *flag* field, similar to the flag in observations, indicates unique cases or errors.

Line Observations

An observation that occurs between corners, i.e. while traversing a section line, is a line observation. Line observations include meanders, line trees, point features, disturbances, and ecosystem points. The line observation table includes a meta attribute, *proj_flag*, which notes which projection case. See *WIGLOSR_projection_cases* in the associated documents.

Meanders

Meanders are locations where a surveyor met an impassable obstacle such as a large body of water or cultural boundary. They would meander around it recording measurements as they went. The reason for

meandering or meander type is recorded in the meander table as *mtype*.

Line Trees

As surveyors traversed a section line, they would record trees which intersected the line. Similar to witness trees, species, *sp*, and diameter at breast height, *diam*, were recorded. However, unlike witness trees, line trees were not recorded consistently; some surveyors did, others did not.

Point Features

If a surveyor recorded something other than a tree while traversing a section line, it is entered into the database as a point feature. Point features have a single attribute, *feature*, which records what type of feature it is. Examples of a point feature include: road, trail, field, home, and mill.

Disturbances

While traversing a section line surveyors sometimes recorded disturbances such as fire or windfall. These records appear in the disturbances table. Attributes of disturbances include: the disturbance type, *disturb*, and whether a surveyor was entering or leaving the disturbance area, *inout*.

Ecosystems

In the observations table *veg_type* notes the type of ecosystem in which an observation is made. However, while traversing a section edge surveyors sometimes recorded a change in ecosystem, noting whether they entered or left that ecosystem, *inout*. The *inout* field is stored in the ecosystems table, while the ecosystem type is stored in *veg_type* in the observations table.

Geometry and Geography

Geometry, *geom*, and geography, *geog*, are fields that store the location of an observation or feature. Geometry is the location represented in a projected coordinate reference system; in the case of this database, Wisconsin Transverse Mercator. Geography is the location represented as coordinates on a sphere; in the case of this database, WGS84.

Locations of observations are sourced from Landnet, geometry WTM. Witness trees and line observations have locations based on the corner locations. To obtain line observation locations the corner geometry is cast to geography, then projected to find the line observation geography, then the geography is casted back to geometry. This workflow is important to note as transformations are imperfect and allow for the introduction of error.

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Appendix A. Field Descriptions

dtrsco: a concatenation of *range_dir, township, range, sec, corner_num,* and *obs_id.*

range_dir: direction with respect to the 4th principal meridian

2 = west
4 = east

township: number of townships north of the base line.

range: number of townships east or west of the 4th principal meridian

sec: number identifying the section with a township 1-36. Section numbers start in the northeast corner and proceed in boustrophedon fashion (Appendix D).

corner_num: represents the location within a section.

- A corner number has two components: YY and XX. Both range from 00 to 40, increasing in the north and west directions, 0000 being the southeast corner of a section and 4040 being the northwest corner of a section. Figure 2 shows three examples of corner numbers.

obs_id: a code that uniquely identifies an observation when there are multiple that share a single *dtrsc.*

point: for the purposes of data entry, each possible section and quarter section corner in a given township has a number between 1 and 126 (Appendix D).

point_dir: direction the surveyor was traveling when marking the point (not used for quarter or section corners)

2 = south true line
3 = west true line
4 = east true line
6 = east corrected line
7 = north (true or corrected)
8 = west corrected line
9 = south (true or corrected)

links: distance away from section corner along section line, expressed as links (100 links = 1 chain).

- 1 mile = 80 chains; 1 chain = 66 feet; 1 link = 7.92 inches.

ptype: point type

P = section or quarter section corner
M = meander corner
L = line tree
E = ecosystem point
D = disturbance point

veg_type: code representing the ecosystem in which the point is located (see Appendix B1).

fsp: a list of the dominant timber species listed at the end of each section line, using the same genus and species codes as the *sp* field (see Appendix B2).

- One word descriptions recorded with the timber species were sometimes included with the list (e.g., scattered oaks = SCAT OA; pine barrens = PI BARREN). Longer descriptions (e.g., pine on south ½ sugar & hemlock on north ½) are included in the *notes* field.

usp: a list of the dominant understory species listed at the end of each section line, using the same genus and species codes as the *sp* field (see Appendix B1).

- This information was quite commonly not included in the field notes, for which the code NL was used.
- The surveyor did not always clearly distinguish which species were considered timber and which understory. When this distinction was vague, all species were listed under *fsp* unless the species type was clearly undergrowth, such as prickly ash, vines, grass, etc.

surveyor: the first initial, middle initial (if present), and last name of the surveyor or surveyors.

survey_year: year the survey was conducted. If two years are listed (year contracted and year completed) the year the survey was completed was used.

digitizer_id: who digitized the record, initials.

digitization_date: the day the record was digitized.

flag: flag for unique cases or errors

XA = exists, not on film
XC = corner in private claim or Indian reservation
NM = no margin visible in scan
NL = no links
NV = not visible; ink blot
RV = repeat visit (corner was already surveyed)

notes: narrative information of interest recorded by the surveyor.

tree_id: indicates if a tree was first, second, third, or fourth to be listed at a corner.

sp: code representing the genus or species of the witness or line tree (see Appendix B2). Some codes also represent other objects noted in the survey, such as mounds, boulders, roads, trails, homes, etc.

- When the surveyor explicitly recorded "no trees" or none were listed we used the code NL.

diam: diameters of trees as listed in the field notes, in inches.

- If the surveyor listed a fraction for the diameter (e.g. 8½), which rarely happened, the fraction was dropped when the number was entered into the database.

az: the compass bearing of the witness tree from the corner.

- The values consist of three parts: a north or south bearing, a number of degrees between 1 and 89, and an east or west bearing. For example: N19E or S44W
- Fractions of degrees or seconds (e.g., N19½E or S44°30'W) were dropped from the bearing as it was entered into the database.

dist: the distance of the tree from the corner, in links.

mtype: code describing the reason meader

L = lake
R = river
P = pond
M = marsh
B = bayou
S = state line
C = private claim
I = Indian reservation

D = road
F = fractional section
E = special circumstances

The *E* code was used when surveyors recorded more than the normal quarter and section corners. This occured most frequently when errors in the survey of the township lines required tha some of the section lines were substantially longer than 1 mile, requiring the establishment of corners at the 1.5 mile point. In some townships within Indian reservations, extra corners were set on each section line to allow for the protraction of the section into 1/8 and 1/16 sections.

feature: a feature that surveyors took note of that does fall into the category of witness tree or line tree. Examples of a point feature include: road, trail, field, fence, house, cabin, and mill.

disturb: code representing the type of disturbance (see Appendix B1).

inout: code denoting whether the surveyor entered or left a certain ecosystem or disturbance
1 = enter
2= left

Appendix B1. Ecosystem and Disturbance Codes

Code	Ecosystem
A	Creek
B	Oak Barren
E	Meadow/not-man-made field
F	Default (unmentioned)
G	Grove
H	Bottom
I	Pine opening/barren
J	Pine grove
K	Scattered oak
L	Lake, pond
M	Marsh, wetland
N	Dry land
O	Oak opening
P	Prairie
Q	Barren (undifferentiated)
R	River, slough
S	Swamp
T	Thicket, brush
X	Forest/timber
Z	Wet prairie
2	Scattered timber
3	Opening (undifferentiated)
4	Dead forest
5	Sparse timber / little timber
7	low land, low wet area
8	Thinly timbered
9	Unknown

Code	Disturbance
2	Digging
3	Fire
4	Windfall
5	Man-made field
6	Sugar camp
7	Town, village
8	Farm
9	Slashing, old pinery, clearing

Appendix B2. Genus and Species Codes

Code	Species
AL	Alder, aldar
AN	Annis
AU	Annual plants
AP	Apple
AR	Arrow bush
AD	Arrow wood
AM	Artifical mounds
AH	Ash
AS	Aspen, Popple, Poplar
EB	B. Berry
LE	B. elm
LF	B. Leaf
BG	Balm of gilead, Balsam poplar
FI	Balsam, Balsam fir, Fir
BP	Bap
RY	Barberry
BN	Barn
BZ	Bars
LI	Basswood, Bass, Linden, Linn, Lynn, Lind
AZ	Bastard hazle
TP	Bastard pine
BE	Beech
BY	Berry
BI	Birch
SU	Bird's Eye maple, Hrd maple, Rock maple, Sugar, Sugar maple
IT	Bitternut
BQ	Bittersweet brier
BC	Black (undifferentiated)
LL	Black alder
BA	Black ash, B ash, Brown ash
BB	Black birch, B birch, Blk birch
LK	Black briers
CH	Black cherry, B cherry, Blk cherry, Cherry
BH	Black hase, Black hause
LA	Black haw
LJ	Black jack
KL	Black locust
LM	Black maple
LO	Black oak, B oak, Blk oak
JP	Black pine, Jack pine, J pine, Jk pine, Pitch pine, P Pine
BS	Black spruce, B spruce, Blk spruce
LT	Black thorn
BW	Black walnut, B walnut, Blk walnut, Walnut
KW	Black willow
LB	Blackberry

Code	Species
LR	Blair
LD	Blow Down
UA	Blue ash
BL	Blue beech
UB	Blue birch
BF	Blue grass
BJ	Blue joint grass
GG	Bog grass
IB	Bois blanc
BD	Boulder, rock (large stone used as a witness tree)
BX	Boxelder
BK	Brakes
RR	Briars
BR	Brush, bushes, underbrush
KB	Buck brush
BV	Buffalo clover
UG	Buffalo grass
RX	Bull rushes
BO	Bur oak, Br oak, Burr oak
BM	Burial mound
BU	Butternut, B'nut, White walnut, W walnut
BT	Buttonwood
CA	Cabin
CG	Cane grass
CT	Catbriers
CS	Cattails
CE	Cedar
CM	Cemetary
CH	Cherry, Black cherry, B cherry, Blk cherry
CC	Choke Cherry
XB	Corner does not exist, ie irregular township
XA	Corner exists but is missing on film, ie pages missing from notebook
XC	Corner in a private claim or Indian reservation
CO	Cottonwood, Cotton
CR	Crab apple, Crab
CB	Cranberry
CU	Current
DA	Dam
DK	Deer lick
DI	Diggings
DS	Dock
DG	Dogwood
DL	Dry elm
YP	Dry pine
DF	Dwarf fir
DM	Dwarf maple
DO	Dwarf oak
DP	Dwarf pine
ED	Elder (undifferentiated)

Code	Species
EL	Elm (undifferentiated)
EV	Evergreens
FM	Farm
FN	Fence
FE	Ferns
FR	Ferry
FD	Field
FI	Fir, Balsam, Balsam fir
FG	Flagg grass
FL	Flagstaff
FB	Flat blade grass
FO	Formation (bed or range of rocks)
FT	fort/fortification
FU	furnace
GA	Garden
GS	ginseng
GB	Gooseberry
GE	Grape
GR	Grass
GV	graveyard
GY	Gray ash
GP	Gray pine
RA	Green ash, Red ash
NB	Green briars
GX	Green bush
GO	Green osier
GZ	Ground hazel
GH	Ground hemlock
GI	Ground pine
GU	Grubs
HA	Hackberry, H'berry
HH	Hard hack
SU	Hard maple, Rock maple, Sugar, Sugar maple, Bird's Eye maple
HK	Hard oak
HP	Hard pine
HD	Hardwood
HF	Haw
HW	Hawthorn
HY	Hay
HZ	Hazelnut, Hazel
HE	Hemlock
HR	Herbs
HL	Hickory elm
HI	Hickory, Hick, H'ory, Hkry
HM	Home, House
HS	Hops
HO	Hornbeam
HU	Huckleberry
HC	Hunters camp

Code	Species
XX	Illegible, indeterminable
IW	Indigo weed, Indigo plant
IR	Ironwood, Iron, I'wood
IV	Ivy vines
JO	Jack oak, J oak Jk oak, Yellow oak, Pin oak, Spanish oak
JP	Jack pine, J pine, Jk pine, Black pine, Pitch pine, P Pine
JU	Juniper, Red cedar
KI	Kinnikinick
TA	Larch
DR	Lead running
LW	Leatherwood
LI	Linden, Linn, Lynn, Lind, Basswood, Bass
LN	Line
OC	Locust
LG	Lodge
LC	Lumbering camp
LY	Lynch
MA	Maple
MG	Marsh grass
MH	Marsh hay
ME	Masonic weed
YC	May cherry
ML	Mill
MB	Moose brush
MW	Moosewood
MR	Morel grass
MO	Moss
MD	Mound
MT	Mountain ash
MI	Mountain willow
MP	Muskrat swamps
NE	Nettles
NJ	New Jersey tea
NO	No tree around or similar quotation in place of species listing
NL	None listed-no trees are listed in notes
RP	Norway pine, N pine, Yellow pine, Y pine, Sugar pine, Red pine, R pine
OA	Oak (undifferentiated)
OB	Oak Bushes
OO	Osier (undifferentiated)
OV	Overcup
AW	Palm willow
WB	Paper birch, White birch, W birch, Wht birch
PV	Pea vines
JO	Pin oak, Yellow oak, Jack oak, J oak Jk oak, Spanish oak
PI	Pine (undifferentiated)
PD	Pinewood
JP	Pitch pine, P Pine, Black pine, Jack pine, J pine, Jk pine
PL	Plum
PR	Poison elder

Code	Species
OI	Poison ivy
PC	Poison sumac
AS	Popple, Poplar, Aspen
PT	Post (a post is used as a witness tree)
PO	Potato patch
AC	Prairie Cane
CK	Prairie dock
PG	Prairie grass
PW	Prairie willow
PE	Prickles
PA	Prickley ash
PP	Princess pine
RL	Railroad
RS	Raspberries
RQ	Rattlesnake weed
RA	Red ash, Green ash
JU	Red cedar, Juniper
RC	Red cherry
RE	Red elm
RH	Red haw
DZ	Red hazle
RI	Red indigo
RM	Red maple, R maple
RO	Red oak, R oak
RP	Red pine, R pine, Norway pine, N pine, Yellow pine, Y pine, Sugar pine
RT	Red root
RG	Red top grass
RW	Red willow
RB	Reeds
RV	River maple
RD	Road (used only in association with the line tree option)
RK	Rock elm
SU	Rock maple, Hrd maple, Sugar, Sugar maple, Bird's Eye maple
BD	Rock or boulder
RZ	Rose
OW	Rose willow, roze willow
RN	Rosin weed
RU	Rushes
SL	S Maple
PN	S Pine
AG	Saplings
SX	Sassafrass
UO	Scrub oak, Shrub oak
SC	Scrub pine
SB	Serviceberry
AO	Shamrock
LH	Shilbark hickory
MK	Shoe make
SN	Shop

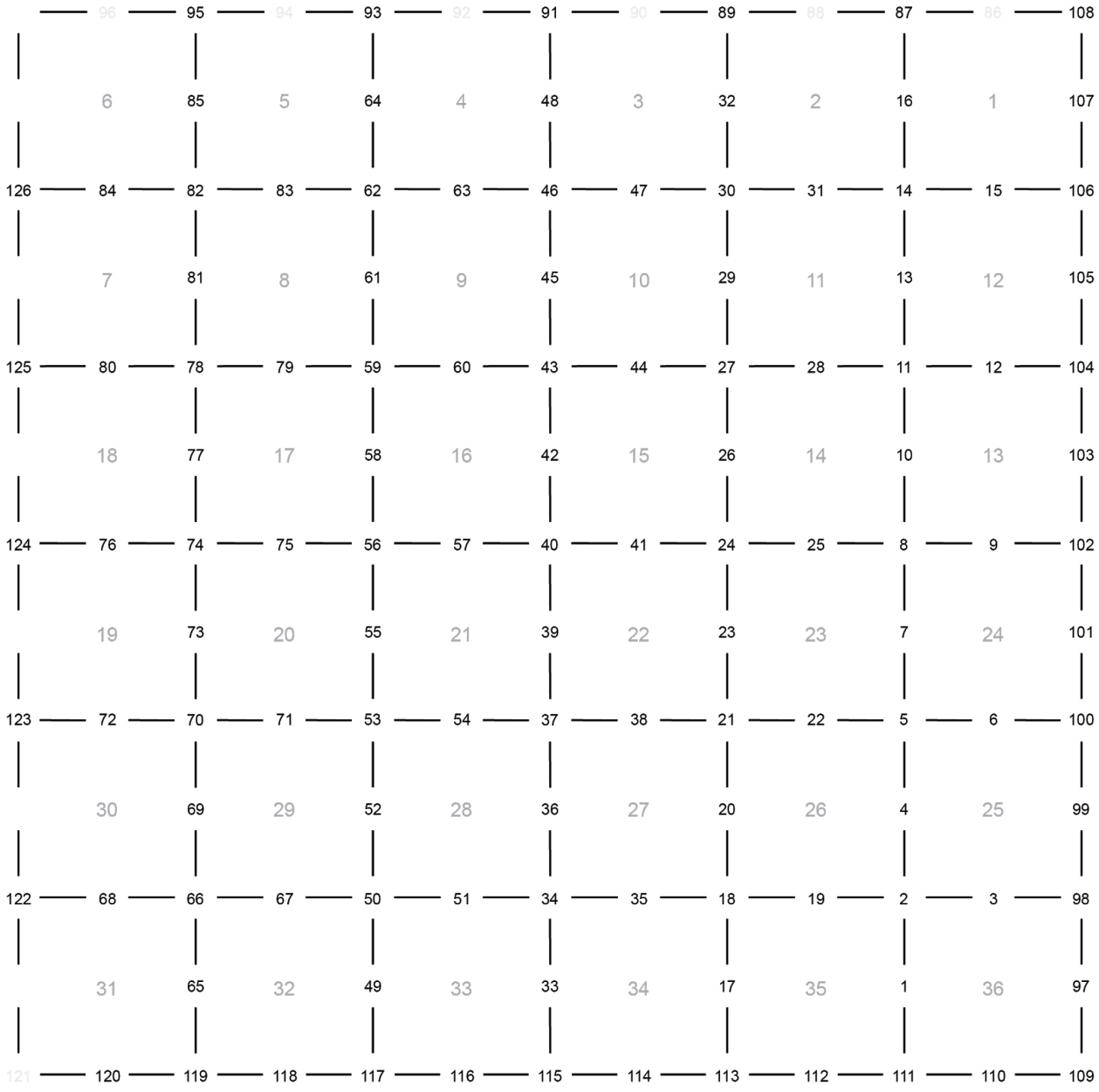
Code	Species
SJ	Shrubs
UM	Shumach
KO	Sinkhole
ES	Slippery elm
FC	Smelting furnace
SM	Soft maple
JO	Spanish oak, Yellow oak, Jack oak, J oak Jk oak, Pin oak
SI	Spice
SK	Spikenard
MS	Spotted maple
SG	Spring of pure water
SP	Spruce (undifferentiated)
PS	Spruce pine (one case of spruce fir)
QP	Squaw pine
SV	Squaw vine
SD	Station
SY	Strawberry
ST	Street
UC	Sugar camp
SS	Sugar house
RP	Sugar pine, Norway pine, N pine, Yellow pine, Y pine, Red pine, R pine
SR	Sugar tree
SU	Sugar, Sugar maple, Hrd maple, Rock maple, Bird's Eye maple
MC	Sumac
SA	Swamp ash
PH	Swamp beech
PB	Swamp birch
PK	Swamp burr oak
SQ	Swamp elder
SE	Swamp elm
XG	Swamp grass
SH	Swamp hazel
PM	Swamp maple
SO	Swamp oak, S oak
SZ	Swamp pine
SW	Swamp white oak
CI	Sweet cisily
WN	Sweet fern
YS	Sycamore
TA	Tamarack, Tam'k, Tamarac,Larch
TV	Tavern
TK	Thicket
TS	Thistle
TH	Thorn
TN	Thorn apple
TT	Thorn tree
RR	Thornbriars, Briars
TB	Thornbush
DE	Timber all dead or similar notation in place of species listing

Code	Species
TR	Trail (used only in association with the line tree option)
TU	Turpentine weed
VL	Village, Town
VI	Vines, Hop vines
BW	Walnut, Black walnut, B walnut, Blk walnut
QQ	Water
AA	Water ash
WU	Water beech, Water beach
WY	Water birch
AB	Water bush
AE	Water elm
TO	Water oak
WV	Water willow
WD	Weeds
WA	White ash
WB	White birch, W birch, Wht birch, Paper birch
WC	White cedar
WE	White elm, W elm
WF	White fir
HV	White haw (was WH-now HV eff 2-23-1999)
WK	White hickory
WM	White maple, W maple, Wht maple
OG	White oak grubs
WO	White oak, W oak, Wht oak
WP	White pine, W pine Wht pine
WJ	White poplar
WS	White spruce, W spruce, Wht spruce
WT	White thorn, W thorn
BU	White walnut, W walnut, Butternut, B'nut
WW	Whitewood
WH	Whortleberry
DC	Wild cherry
WL	Wild current
PY	Wild pears
PX	Wild peas
WR	Wild rice
YR	Wild rye
IG	Wild sage
XT	Wild tea
WI	Willow
WG	Wintergreen
IS	Wire grass
WZ	Witchhazel
WQ	Woodbine
YB	Yellow birch, Y birch
JO	Yellow oak, Jack oak, J oak Jk oak, Pin oak, Spanish oak
RP	Yellow pine, Y pine, Norway pine, N pine, Sugar pine, Red pine, R pine
YW	Yellow willow
YN	Yellow wilson

Appendix C. Error Assessment

Field	Interior surveys			Exterior surveys			Total		
	Values checked	Errors found	Error percent	Values checked	Errors found	Error percent	Values checked	Errors found	Error percent
Point	12230	12	0.1	3251	0	0.0	15481	12	0.1
Pointdir	5492	27	0.5	1336	0	0.0	6828	27	0.4
Links	5228	110	2.0	1336	6	0.4	6564	116	1.8
Ecosystem	12230	350	2.9	3254	81	2.5	15484	431	2.8
Disturbed	217	0	0.0	51	0	0.0	268	0	0.0
InOut	788	2	0.3	207	0	0.0	995	2	0.2
Mtype	572	0	0.0	135	0	0.0	707	0	0.0
Sp1-4	18458	61	0.3	6237	19	0.3	24695	80	0.3
Diam1-4	18457	64	0.3	6237	17	0.3	24694	81	0.3
Az1-4	13395	166	1.2	4657	42	0.9	18052	208	1.2
Dist1-4	13395	143	1.1	4657	34	0.7	18052	177	1.0
Fsp	14630	206	1.4	3343	30	0.9	17973	236	1.3
Usp	6270	74	1.2	1293	8	0.6	7563	82	1.1

Appendix D.



Township schematic showing point labels for every section and quarter section corner within a township.