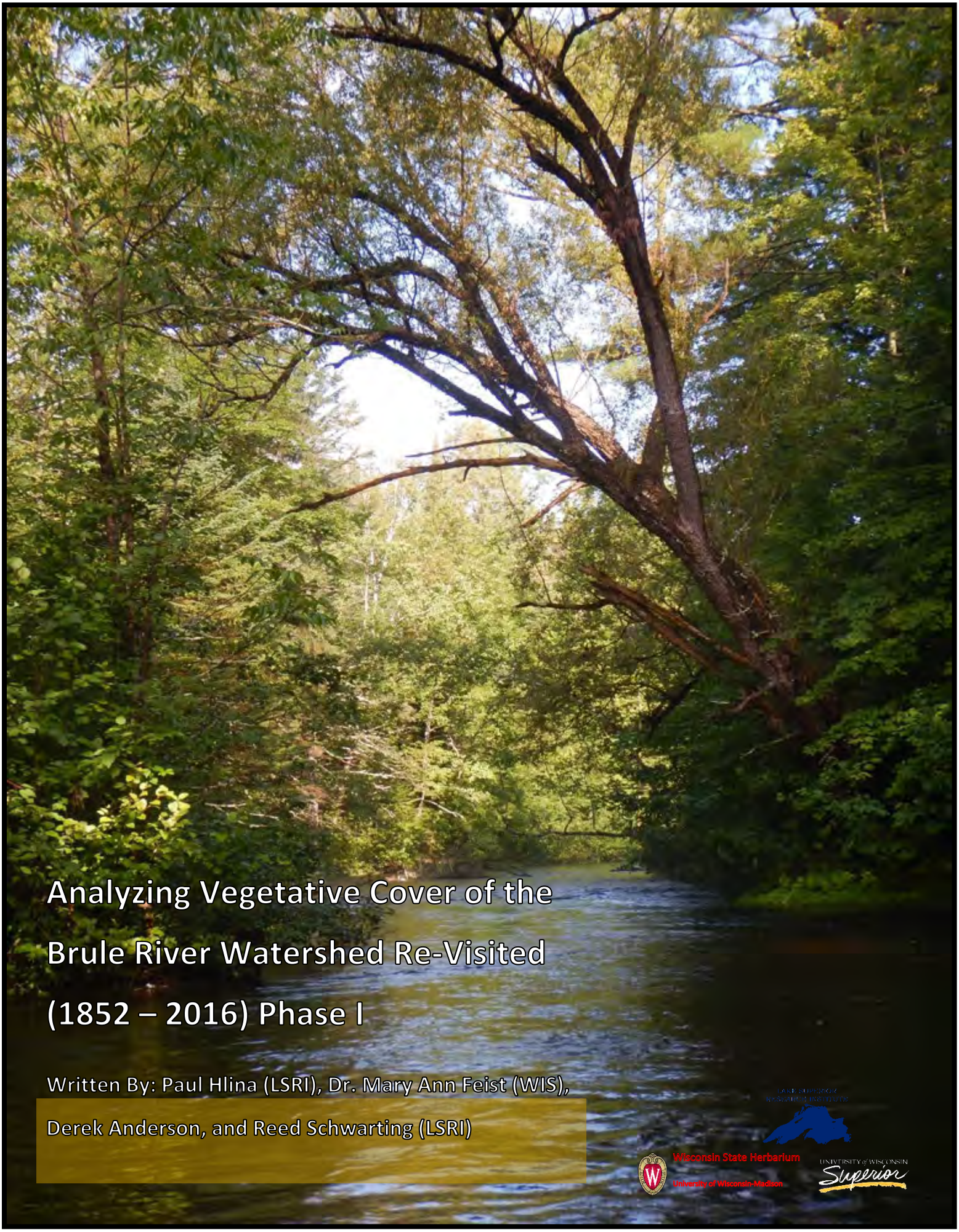

Analyzing Vegetative Cover of the Brule River Watershed Re-Visited (1852 – 2016) Phase I

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Table of Contents

EXECUTIVE SUMMARY

Prior to European settlement (1870's), the Bios Brule River served as a gateway between Lake Superior and the mighty Mississippi River and remained relatively unchanged subject to only natural forces. It was the early botany research scientists – Dr. Norman Fassett, UW-Madison and Dr. John W. Thomson II, State Teacher's College at Superior - interpreting the public land survey (PLS) data collected in (1852-56) that we get a holistic glimpse into the entire landscape of the Brule River watershed in all its diversity. The PLS data, although useful, wasn't meant to be used as a scientific survey let alone a vegetative survey of the landscape, but because of the relatively detailed notes taken by the surveyors some useful information can be gained.

By the mid 1930's land managers (Wisconsin Conservation Commission) and large land-holding private interests noticed a marked decrease in fish populations, especially trout, in the Brule River. The **Brule River Survey** was commissioned to understand the physical, chemical and biological factors in the ecosystem that may be effecting these fish populations. Fassett and Thomson were given the charge to describe vegetation changes that may be having an impact on the riverine environment. They created a series of vegetative cover maps for two time periods and vouchered more than 500+ plants from the watershed and deposited them in herbariums at Madison and Superior. The label information on these specimens along with studying the PLS data provided significant information to re-locate these sites in 2015-16.

This report only covers Phase 1 of the project and represents a partnership between the Wisconsin State Herbarium at UW-Madison, Brule River State Forest and UW-Superior Lake Superior Research Institute. Our objectives were to compare and contrast historical vegetation surveys of three major plant community types (boreal forest, northern wet-mesic forest and pine barrens) between four time periods for the Brule River watershed in northwest Wisconsin (1852-56, 1942-45, 1968-69 and 2015-16). A second objective was to re-survey 55 forest stands first surveyed in the 1960's by Dr. Donald W. Davidson, UW-Superior professor. Recently, a large box of Dr. Davidson's was uncovered at the Brule River State Forest office in Brule containing handwritten notes, data sheets and topographic maps of the Brule River watershed with locality information highlighted.

Research teams further refined the watershed boundaries, geo-referenced these earlier sites and conducted field studies in creating new inventories, gathering qualitative forestry data and describing plant community types. Biodiversity metrics were uses to gauge changes in species richness, percentage of introduced plants, prevalent species and Mean C values as a floristic quality assessment. Vegetative cover maps were created by re-creating GIS layers (i.e. community types) transposed over new land cover geographical datasets (WisLand 2.0) and noting the changes. These maps are valuable tools for scientifically based future studies and management plans.

The boreal forest was the most diverse with 351 species, though 50 are introduced, 4 rare, followed by the northern white cedar swamps with 261 species, 9 introduced, 6 rare and the pine barrens with 190 species, 26 introduced, 1 rare. Floristic quality measures in terms of *Mean C* are highest for the northern wet-mesic forest cedar swamps and lowest for the pine barren plant communities. The *Mean Ct* values have remained unchanged in the boreal forest, increasing slightly for the pine barrens. More than twenty rare and notable plants and forty new county records were found. Upon examination of all documented herbarium records in the

state, there were 36 new to the Brule River watershed and 90 species were underrepresented in the herbaria record.

In the Davidson data, we found a low number of stands for some forest community types (e.g. black ash swamps, white cedar swamps.) This factor along with a lack of access to some privately held stands restricted our ability to fully analyze these communities. Our six botany blitz surveys with expert botanists, provide some valuable information on some of these communities.

As a whole, the re-survey data discovered that the forest communities are multi-aged with high biodiversity of tree and sapling species. Data from the boreal forest depicts a forest in recovery from the initial harvest in the 1880's, with later successional forest with some stands becoming old growth. Many stands show an increase in balsam fir, white cedar and white pine trees and saplings, while paper birch and aspen are decreasing in density and dominance.

Paper birch has been declining throughout the northern portion of Wisconsin since the early 1980's. Our data confirms the continuing trend of the paper birch's precipitous decline, to dangerously low numbers today. Paper birch has been on the landscape for approximately 6,000 years following the retreating glacier which started 10,000 years ago. This once dominant iconic tree may disappear in the next 50 years resulting in a significant change on the landscape, effecting the areas' ecology, ecosystem functions, and its value to humans (i.e. birch bark canoes, containers and syrup).

A second species of concern in the watershed are black and green ash. These species are seriously threatened by the introduced emerald ash borer from China. Though not present in the stands we surveyed, the emerald ash borer creeps ever so closer to the Brule River watershed, as the pest was discovered 35 miles to the west in Superior, Wisconsin in 2014-15. What will replace these species? From our data, we can postulate that red maple and balsam fir may be the future benefactors. Red maple and balsam fir density continues to be strong across several forest community types and has increased in Importance Values in others that are adjacent to black ash swamps. Red maple and balsam fir have a high tolerance in terms of shade, moisture content and soil types.

Challenges exist for sustaining, maintaining and restoring the boreal forests, northern wet-mesic forests and pine barrens into the future. The boreal forest remains susceptible to severe erosion of clay banks as rain events and snow melts intensify under changing climate scenarios. The northern wet-mesic cedar swamps are even-aged and not re-generating. The pine barrens mosaic remains diminished and the area continues to be dominated by red and jack pine plantations with only small opportunities to expand.

INTRODUCTION

"The need for an intensive study on this stream became evident when it was realized that during a five-year period extending from 1937-1941, a total of $34,247.67 was expended for the planting of fish and that stocking was not bringing about the desired results of maintaining or improving fishing." – Schnerberger and Hasler, 1942

As early as the 1880's, the Bois Brule River was known as an outstanding cold water trout stream, attracting anglers from around the world, including presidents of the United States. By the 1930's landowners, visitors, and the Wisconsin Conservation Commission observed a serious decline in the rivers' fisheries, which five years (1937-1941) of expenditures did little to improve. In order to access the causes of this decline and determine how to halt it, a partnership was created through the Wisconsin Conservation Commission, the University of Wisconsin-Madison and the Superior State Teachers College (now UW-Superior) to begin the largest watershed study of its kind in the state of Wisconsin. The study brought together scientists and managers from Madison, Brule and Superior to study the hydrology, geology, topography, vegetation and fisheries of the river and surrounding landscape to ascertain ecological factors that may be causing declines in fish populations (e.g. brown trout, brook trout). Dr. Norman Fassett (University of Wisconsin-Madison) a renowned botanist and Dr. John W. Thomson Jr. (Superior State Teachers College), a young aspiring botany professor spearheaded the vegetative component of the study from 1942-1944. They produced three of the ten monographs that were published in the *Transactions of the Wisconsin Academy of Science, art and Letters* (volumes XXXVI and XXXVII) and collectively become known as **the Brule River Survey**.

The Analysis of the Vegetative Cover of the Brule River Watershed Re-Visited (1852 – 2016)- Phase I documents vegetation changes that have occurred since the early General Land Office (GLO) – Public Land Surveys (PLS) in the 1850's and today. These first surveys set township and section lines by marking trees (composition, size, distance from corner posts, habitat descriptions, soils, etc.) in order to "paint a picture" of the resources available for an expanding country and its pioneering settlers. Within a short period of time (≈20-30 years), Wisconsin no longer had a forest in the north, but an area termed "the cut-over" region that was sparsely populated. After this intensive logging period, agriculture was attempted throughout "the cut-over" areas, but in most cases these ventures failed. This was the backdrop for the next study of the vegetation on the Brule – the **Brule River Survey (Fassett 1944; Thomson 1944-45).** At the onset of the study, only remnants of multi-age and old growth forests existed on private property and most of the remaining landscape consisted of early successional forest or barrens. Using the PLS data (1852-1856 pre-European settlement), a vegetative cover map was created in coarse-scale depictions of forested and non-forested communities. A second vegetative cover map was produced in the 1940's, applying the Wisconsin Land Economic Inventory for Douglas and Bayfield County and verified by site visits to the watershed. Thomson further describes several forested and non-forested plant communities in terms of species richness, composition and dominance (Thomson 1945). Thomson vouchered more than 523 specimens representing 312 species from these communities in duplicate and they are **(Appendix A. Pg. A8)** deposited at the Wisconsin State Herbarium in Madison and a second set deposited at the newly created herbarium at the Superior State Teachers College.

This report has two major chapters. ***Chapter 1: Plant Community changes in Species Composition, Richness, Diversity and Floristic Quality of the Brule river watershed (1852,1944, 2016*)**, compares data from these two earlier studies with our present study and reports changes in species richness, biodiversity, introduced plants, floristic quality and rare plant findings. This section also includes a series of digital maps that delineates the vegetative cover type for the 1852-1856, 1932-1943, and 2014-2016 time periods and show the change through

time.

By the late 1960's another young, aspiring botanist/forester Dr. Donald W. Davidson, two years into his tenure as a UW-Superior professor, learned of the **Brule River Survey** and began to re-visit the Thomson sites to conduct tree and sapling surveys of the upland forest communities. Davidson was unable to complete a ground and shrub cover analysis and his work remained unknown until the early phases of this project. A large box of topographic maps, with hand-written data and notes for 55 stands was discovered in 2013 at the Brule River State Forest office in Brule, Wisconsin**.** ***Chapter 2: Changes in Brule River Forests of the Brule (1968-2016*****)** compares changes in tree and sapling density, dominance and importance values (IV) by species and forest community types across these time periods.

Analysis of the Vegetative Cover of the Brule River Watershed Re-Visited (1852 – 2017)-Phase II was started during the summer of 2016. A second report will be drafted by December 31, 2017. This report will include further plant community descriptions, including assessments of species composition, dominance and floristic quality, thus completing this project (see below).

1) Davidson forest stands (48) – groundcover and shrub layer quantitative baseline results.
2) Northern mesic hardwoods, northern wet forests, northern dry forests, northern dry-mesic forests, northern hardwood swamps, and open bogs/muskegs community summaries.
3) Floristic quality assessment of randomly selected wetlands: black spruce swamps, alder thickets, open bogs/muskegs, northern sedge meadow, white cedar swamps and black ash swamps.
4) 1944 and 2016 Bois Brule River aquatic plant comparisons
5) Lake Minnesuing and Lake Nebagamon aquatic plant baseline inventories.

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You have all been so awesome, generous and kind and it has been a privilege and an honor to learn from you, guide you and share the diversity of one of the most pristine landscapes in Wisconsin. I'm sure our paths will cross again.

CHAPTER 1: PLANT COMMUNITY CHANGES IN SPECIES COMPOSITION, RICHNESS, DIVERSITY AND FLORISTIC QUALITY OF THE BRULE RIVER WATERSHED (1944 to 2016) written by Paul Hlina, Mary Ann Feist, Reed Schwarting and Derek Anderson.

During Phase I of the study, the three dominant forest types found on the Brule River watershed were surveyed. They are boreal forest, northern wet-mesic forest (white cedar swamps) and pine barren. Prior to European settlement in the mid-late 19th/early 20th century these native plant communities, had persisted for thousands of years, moving between successional seres as a result of natural disturbances like fires, catastrophic storms and periodic floods. In the descriptions that follow, the communities are depicted as they once existed after the retreat of the glacial ice during the last Ice Age (10,000 yrs. ago). Remnant tracts still exist in portions of the Brule River watershed to this day.

COMMUNITY DESCRIPTIONS

Boreal Forests of the Brule

The boreal forest is a circumpolar forest found from the arctic tundra south hugging the northern reaches of Eurasia and North America. This forest is represented in the Upper Midwest (Michigan, Minnesota and Wisconsin), the Adirondaks of New York, northern coastal Maine and west in high elevations in the Rockies. (Pastor and Mlandoff 1992). All tree species in this forest are adapted to cooler climates and may be susceptible to probable future climate change (Scheller and Mlandoff 2005); adding to its imperiled status in Wisconsin. The Wisconsin DNR ranks the boreal forest as (S2) imperiled in Wisconsin due to its restricted range, few occurrences, steep declines in recent decades and other factors (WDNR, 2016).

The boreal forests are currently, and have historically been, a small component of the forest types in Wisconsin, only garnering 1.92% of the land over (Curtis 1959). They are almost restricted to a few miles inland from either Lake Superior or Lake Michigan. Asaph Whittlesey (1852), a Wisconsin senator from Ashland, describes the interplay between these forests and the climatic forces of Lake Superior.

"The moist atmosphere next the water, and the increased circulation and force of the winds, together constitute a local climate, which is most favorable to the cedar, balsam, fir and birch" (Thomson, 1945).

Wisconsin's boreal forest is unique in the composition of the pine that is present and the pine that is missing. Jack pine (*Pinus banksiana*) is a co-dominant in the Canadian boreal forest but is absent in these forest. (Huang et.al. 2009). In contrast, white pine (*Pinus strobus)* historically has had the highest importance value of any tree in the Lake Superior region (GLO – PLS 1852-1856). It is in these boreal forests that we find the largest white pine in its greatest densities in the Brule River watershed (up to 30in dBh : diameter at breast height), with an average of 18in dBh (Fassett 1944). A summary in the 1850's of one of the Townships in the region stated:

"It is well timbered with White Pine in every part and Brule River offers every facility for a lumbering business" (Geo. Stuntz, GLO PLS 1852-1856).

It was these early descriptions of the land that brought the lumbering industry to the banks of the Bois Brule River in the 1880's changing the landscape forever. Prior to settlement the boreal forest was dominated by conifers such as white spruce, balsam fir, and white pine, while white cedars were restricted to steep river valley slopes. Deciduous species such as red maple, balsam poplar, trembling aspen, and paper birch were also present, and sometimes common. These deciduous trees, however, did not achieve the dominance over the conifers, which they now hold. (Epstein et. al 1999). Early surveyors recorded witness trees in the boreal forest as follows: white spruce, up to 16in, average 11in; balsam fir up to 12in, white birch up to 19in, average 11in and aspen up to 22in, red maple up to 12in and black ash up to 16in (Fassett, 1944).

Fassett and Thomson (1945) found small remnants of the boreal forest on the west side of the Bois Brule River, near the mouth during the time of their survey. The remaining historical boreal forest had been severely altered by lumbering, fires and clearings for agricultural purposes. Most of the area was cleared land with scatterings of swamp shrubs (willow, alders and red-osier dogwoods) found in the wettest and most poorly drained lands. Massive clear cutting exposed the poorly drained soils to winds and solar heat - thus desiccating slash and soils alike, igniting large wildfires that burned intensely even deep into the soil horizons (Ahlgren, 1960; Swain, 1973). Massive fires were recorded in the entire northern region of Wisconsin from 1930-1936 (Wisconsin Historical Society, 2016). Thomson (1945) observed numerous charred red and white pine stumps in the remaining forests during his surveys. The forests, alder thickets and scrub shrub swamps he found did not constitute a definition of the boreal forest he knew. He called this new landscape – the aspen association. He describes the area as an early successional forest.

White Cedar Swamps of the Brule

Commonly referred to as white cedar swamps, the northern wet-mesic forest communities can be easily recognized by their dominate canopy species, white cedar (*Thuja occidentalis*). White Cedar is a long-lived shade tolerant species with an average life-span of 200 years, though there have been records of 1,000 year old trees (Johnston 1990). These communities are contained mostly to the northern two thirds of Wisconsin. They are associated with the natural upwelling of ground water in the form of seepages and springs creating unique habitats with species found in no other community. Cedar swamps provide habitat for more than 80 wildlife species (Doepker and Ozoga 1991) and an abundance of rare species of orchids and lilies (USDA Forest Service 2004).

Much of the northern wet-mesic forest in the Brule River Watershed is located at its shared headwaters with the St. Croix River. This is the product of natural springs upwelling from the bottom of the ancient river valley in which the Bois Brule River resides. The springs are fed by the surrounding elevated glacial outwash sand plain laid down during the Pleistocene Ice Age (Clayton 1984). The PLS surveyor's notes (1856) recorded that every section line that crosses the Bois Brule River at it southern extent had them entering bog that was covered mainly with white cedar, tamarack, and black spruce. Several

other earlier written records (Owen 1848; Sweet 1880) describe similar conditions of the early "bog" forests as about a mile wide and ten miles in length spanning both sides of the river as it meanders to the northeast. The best remaining remnant in the watershed, if not the entire state of Wisconsin is an un-fragmented section of forest spanning more than 2,000 acres from the headwaters region to Winneboujou (O'Conner 2016). The valley floor in this forest type is dominated by sphagnum moss hummocks and small pool topography creating unique ecological conditions and providing niche habitats for many plants and animals. The sphagnum creates acidic conditions and several species grow directly out of the sphagnum (e.g. *Cornus canadensis, Coptis trifolia, Gaultheria hispidula, Cyprepedium parvilflorum* var*. makisin, Vaccinium macrocarpon, Clintonia borealis*, and more). The white cedar swamp stands (WisFIRS 2015) have a few trees with 24in dBh perhaps exceeding 400 years of age. These trees are deeply rooted in the alkaline sandy soils of the valley floor. As the land rises steeply above the valley floor, the forest transitions to small remnant stands of northern dry-mesic forest of old growth pines and, more often, mix-hardwood/conifer forest of younger-aged trees.

Having been protected in 1945 and thus having minimal logging activity, the northern wet-mesic forest of the Bois Brule River remains a testament to what the cedar swamp forests may have looked like prior to European settlement. The **Brule River Survey** results (Fassett 1944; Thomson 1945) provided the data and valuable information that preserved these forests for future generations. **Appendix A. pg. A3-A4** illustrates through photographs how little has changed in this area since the 1940's. The white cedar swamps along with numerous cold water seeps and springs reside in a valley that acts as a cold air sink possibly providing resistance to long-term climate change. However, long-term challenges continue to threaten this community, as re-generation has not occurred over the last several decades and will be discussed further in this report.

Pine Barrens of the Brule

With characteristics similar to that of oak savannas (Curtis 1959), pines barrens are a globally threatened ecological community and in decline due to fire suppression (Grossman 2008). NatureServe has ranked the pine barren community, (G2) imperiled globally due to a restricted range, few occurrences, and steep declines in recent decades along with other factors (WDNR 2016). In a protected state, pine barren are characterized by its open-air prairie like landscape with scatterings of red and jack pine savannas (*Pinus resinosa* and *Pinus banksiana*). Controlled mainly by naturally occurring frequent fires, this landscape historically lived up to its namesake, open barrens with the dominate species being grasses, shrubby jack pine (*Pinus banksiana*), and Hill's oak (*Quercus ellipsoidalis*). Pine barren communities were once widespread throughout the state of Wisconsin covering a total of 2.3 million acres, mainly occurring in the course sandy soils left behind by glacial outwash (Curtis 1959). Historical accounts and maps show a large portion of the entire southeast region of the Brule River watershed as pine barren on both sides of the Bois Brule River **(Appendix B. *Map 1.*)**. Early descriptions of the pine barren are stark indeed:

"*This is a township of barrens that is almost worthless for agricultural purposes or anything else; as there is very little Timber in it and this scrubby Black Pine (jack); and there is hardly a drop of water in the Township, in fact now, except for small ponds in the south end of it (outside the Brule watershed) the Prairie I have noted on the west side; can hardly be called a Prairie as no great time has elapsed since it was covered with small pine which has been blown down, and burned up, remnants of which still lie on the ground''.* (PLS, 1856).

The actual PLS data depicts some young even-aged jack pine trees (5-6in diameter) within thousands of acres of open barrens in several sections found in the southeast corner of the Brule River watershed (T45 9W,10W; T46 9W,10W). The even-aged jack pine and large tracts of open barrens provide evidence of the frequency of fires in this region (Fassett 1944). These natural wildfires were essential in maintaining the complex mosaic of burned and unburned patches typically found in naturally maintained pine barren (Radeloff 1999). Radeloff (1999) after further examination of the PLS data, states that red pine savannas were found on drier sites, white pine on

mesic sites, but that neither ever recovered after the initial "cut-over".


Botany blitz team in the pine barren assigning species abundance codes.

Logging of the original trees in the pine barren of northwest Wisconsin started in the 1880's and lasted about 20 years. Due to the soils being relatively easy to plow, settlers with the intent to farm, followed soon after (Vogl 1964). During this time, intense forest fires were common. The increased openings from fires, farming, and continued logging created even more open habitat, possible more then what was available previously (Radeloff 1998). The onset of an economic depression in the 1930's lead many farmers to abandon their land. This tax-delinquent land became the starting point for the creations of county and state forests, and timber industry holdings (Vogl 1964). The Civilian Conservation Corps once stationed at the present day Bois Brule River hatchery, planted these open barrens with red and jack pine. These plantations along with the State's fire suppression programs over the last 80 years, has led to a landscape dominated by forests and less and less by open barrens with more species of grasses and shrubs **(Appendix B. *Map 1.*)**. The red pine savannas of yesteryear have been mostly replaced with hardwood species (red oak and aspen) as fire suppression activities have increased.

RESEARCH METHODS

Geo-referencing Methods

Vegetation Cover Types Methods (Fassett 1944; Thomson 1945)

In 1942, John W. Thomson Jr. used aerial photographs taken by Abrams Aerial Corp. out of Lansing, Michigan in August of 1938. The photographs were developed at a scale of 3 inches =1 mile (1:21,120in). Using a stereoscope, the community boundaries were hand traced on the images using pencil. The boundaries were then transferred to a 1 inch to 1 mile (1:63,360) scale using a proportional glass grid placed over the photographs. The locations of the different community types were verified in the field and collections of vouchers specimens were made.

Each voucher specimen collected by Thomson from 1942 through 1944 was pressed, determined to species, mounted and stored at the Wisconsin State Herbarium (WIS) at UW-Madison, with duplicates being sent to the Donald W. Davidson Herbarium (SUWS) on the campus of UW-Superior. Each specimen collected was given a collection number and locality information was provided and often habitat were recorded. These voucher specimens provided most of the locality information for the 2015-2016 Botany Blitz re-survey sites. The locations could only generally be relocated, as Thomson used the PLS (Township Range Section) method of recording locational information, which was common at the time. Location was provided at the section level only; quarter section information was not recorded limiting the area of collection to a square mile. Studying the 1932-1943 Fassett maps **(Appendix B. *Map 1.*)** of forest and non-forested community types plus Thomson's habitat descriptions (when provided), the general location could be determined within the same or adjacent section lines. Most sites surveyed for the 2015 Botany Blitz were selected using this method (see below). Some sites could not be accessed due to private land ownership.

Some of the sites surveyed in 2015 were given a more accurate community type designation. Thomson could not distinguish the differences in some cover types because of the nature of the aerial photographs (black and white) and so the 1940's survey team grouped several of the more closely related communities as one (e.g. black spruce/tamarack swamps + white cedar swamps = coniferous bogs) **(Appendix C*. Table 1*.).** Using a planimeter to calculate area, a standard method in 1940's, Thomson calculated the area for each community type with an acceptable error of 7%. This resulted in a detailed map of vegetation cover in the watershed from aerial photographs from the 1938. This map is found in Thomson's Brule River Survey (Thomson 1944) and would be one of the tools utilized by Dr. Fassett to develop the final vegetative cover maps.

Digitizing Vegetative Cover Maps (Fassett 1944)

Thomson's vegetative cover map was used by Fassett along with Land Economic Survey data (1932-1943) for Douglas and Bayfield counties to create vegetative cover maps for the watershed for their time period (Fassett, 1944). Fassett also created a pre-settlement vegetation cover map using the notes taken by Hiram C. Fellows, George R. Stuntz and Albert C. Stuntz in 1852-1856 for the public land survey. These public land surveyors established corners for townships, sections and quarter sections and recorded from two-four trees ("witness trees") nearby and summarized each township with a detailed habitat description. The objectives of these surveys were to prepare maps and to indicate locations for land to be used for mining, timber and homesteader interests. However, these early records are often the starting point in describing vegetation prior to rapid settlement and exploitation of the natural resources of each area by European settlers. Fassett (1944) created the first vegetative cover maps for the Brule River watershed from these early surveyor's notes describing vegetative cover layers on a coarse scale for 1852-1856 **(Appendix B. *Map. 1*).** By the 1940's more refined maps were created through using better analytical tools to interpret and document in finer detail the differences in vegetative cover types between the two time periods **(Appendix B. *Map 1*.).**

Since the time of Fassett and Thomson, there has been substantial progress in the ability to intergrade theses historic maps using modern geographical system software. Part of the focus of this project was to reproduce the two maps by Fassett and convert them into a digital format. The process of digitizing Fassett's maps starts with using a light imaging scanner, hence creating a digital image that can be manipulated by computer software. The digital images are saved into a suitable format and uploaded into Geographic Information System (GIS) software. Using landmarks found on the map, the images are geo-referenced by matching those landmarks with existing spatial records within the GIS software until the most accurate overlay is achieved. Next, the entire watershed boundary is traced to create a vector based polygon layer file with spatial records. This layer file is than carefully "cut" using software tools into separate community types that are represented on Fassett's original map. Once completed, they are categorized by community type and calculated for area to compare with the whole forest. This process was repeated for each of the paper maps created by Fassett for the Brule River Report in the 1940's

Watershed Boundary Updated

As technology progresses so does our ability to more accurately describe and map our natural world. Using technological tools of today, like Geographic Information System (GIS) software, a more accurate account of the Brule River Watershed was created by Dr. William Bajjali, hydrogeologist from UW-Superior. Dr. Bajjali used the most recent elevation data available for Wisconsin. Software tools calculated possible direction lines of flow in the area surrounding the Bois Brule River. These directional lines can be used to create a boundary or dividing line between two paths of flow from which water may run in opposite directions. This method of technology based calculations gives us the current boundary of the Brule River Watershed we are using for the purposes of this study. It should be noted that as our ability to gather elevation data with higher resolution improves so will follow a further ability to map our natural world.

Vegetation Sampling Methods

Site Selection Criteria

a) Each site had to be in close proximity to Dr. Thomson's visits in 1942-44. Thomson only provided broad locational information – Township, Range and Section (TRS) as evident from herbarium labels on the 523 voucher specimens he collected.
b) The boreal forest sites had to have a strong conifer component in the understory and approaching a mid-successional sere.
c) The northern white cedar sites could either be upland or lowland forest types.
d) The pine barren sites had to be a mosaic of prairie-like openings, scrub oaks and stands of pines (today, mostly in plantation style growth).
e) All sites had to be larger than 5 acres in size for species composition and diversity to be documented.
f) Brule River State Forest compartment maps were consulted to verify stand types.
g) Ground-truthing was done through reconnaissance trips to each TRS site identified by geo-referencing Thomson's site visits.

Botany Blitz Meander Survey

A botany blitz week format was chosen as a primary method of documenting the flora of the boreal forest, northern wet-mesic forest, and pine barren. These botany blitzes were conducted in collaboration with expert botanist from agencies, universities and research organizations **(Appendix A. pg. A12)**. Field sheets for each community type were created using Thomson's species list in addition to "new" species more recently reported from other studies in the region (Hlina and Anderson 2008, Hlina and Anderson 2011) **(Appendix H.).**

Meander surveys were conducted in a minimum of five sites for each community type and continued until no new species were observed. Following the surveying for each site, the team would gather and agree on an abundance designation for each species. The four abundant codes used were: A: abundant; C: common: O: occasional; and R: rare. The abundance codes were applied subjectively by the team, but a conscientious effort was made for consistency. These descriptors should not be confused with cover values as they do not equate.

Teams also collected duplicate voucher specimens in each community to add to the archival Thomson collection presently housed at the Donald W. Davidson herbarium at the UW – Superior and the Wisconsin State Herbarium at UW-Madison. Nomenclature follows the Online Virtual Flora of Wisconsin (http://symbiota.botany.wisc .edu/index.php), 2016. A partial photographic record by community type and species was collected by botany blitz team members and shared with the Wisconsin State Herbarium wisflora database. Additional surveys were conducted at known and potential localities for rare and notable plants of the watershed. Photographs of each species were taken and new populations were shared with the Natural Heritage Inventory program at the Wisconsin Department of Natural Resources (WDNR).

Difficult to Identify Taxa

Both the Superior and Madison teams collected "difficult to identify" species for future taxonomic determinations back in the herbarium. When species were too immature or lacking the vegetative or reproductive parts needed to confirm identification, the specimens were discarded and removed from the data sheets and the databases. For some specimens, specialists of the Wisconsin flora, Dr. Robert Freckmann, emeritus and Dr. Emmet Judziewicz, emeritus of UW-Stevens Point, were consulted for final verification of the "difficult to identify species".

Biodiversity Metrics

Plant communities are dynamic, often shaped by time (succession), disturbance, or transitioning with other distinct communities (i.e. forests and riparian areas). From a bird's point of view, the Brule River watershed appears as a mosaic of evergreen and deciduous forests, wetlands, meadows, and barren areas interchanging frequently, often with distinct boundaries of different plant compositions. Plant assemblages can best be organized, understood and discussed by creating community categories, as we have done with the boreal forest, northern wet-mesic forest, and pine barren communities. In these distinct community types we measured biodiversity using the Sorensen's Similarity Index, α (alpha) species richness, γ (gamma) species richness, introduced species percentage, prevalent species based on abundance and frequency, and the *Mean C* metric of the floristic quality assessment (Swink and Wilhelm 1994).

Sorensen's Similarity Index for communities

The Sorensen's Coefficient provides a value from 0 – 1; a value closer to 1.0 indicates that most species are shared between sites, while a value closer to 0.0 indicates that most species are not shared between the two sites. The Sorensen's Coefficient was calculated to determine similarity of sites selected by community type. All sites within a community were compared and if the value = or >0. 50 they were lumped together as an aggregate. If the value = or <0.49 that site was considered dissimilar (i.e. not of the same community type) and dropped from further evaluations.

Species richness

This is a measure of the "richness" or diversity found within one site, considered alpha diversity (α). A second fuller diversity measurement known as gamma diversity (γ), calculates all species for the aggregate of "sites" of a singular similar community type (e.g. boreal forest sites). We created a Thomson species list using species lists in his two publications (Thomson 1944; Thomson 1945) and examining his herbarium specimens by community type. The two master lists were then compared.

Introduced species

These are species that have been introduced into the native plant communities that would not have been present prior to European settlement of the area. The Brule River watershed did not see substantial development until the logging period in the late 1870's and early 1880's. While introduced species will add to species richness values initially, they can often replace "natives", by occupying the same niches. Natural controls (e.g. insects, mammals and other browsers) are absent for these introduced species, allowing some species to spread rapidly (i.e. become invasive).

Groundcover and shrub layer prevalent species

Prevalent species were determined for groundcover and shrub layers for each forest community. A species must fall into one of two categories to be considered prevalent. The highest ranking category includes species receiving an abundance descriptor of (A=abundant or C=common) 75% of the time across all sites within one plant community plus a frequency of occurrence = or > 80%. A second and lower category includes those species receiving an abundance descriptor of (A=abundant or C=common) 50% of the time and having a frequency value = or >80%. Comparison measurements were made using Thomson's community descriptions of dominants, co-dominants, and associated species outlined in his paper (Thomson 1944). Furthermore, some of the herbarium specimens collected, were not listed in his papers, but were added to the appropriate community type, as part of Thomson's full species list. Thomson does not provide any quantitative data (i.e. cover values) for categorizing species as dominant or co-dominants. We assume he used subjective measures,

conscientious of consistency, in describing the vegetation of each community type.

*Tree and sapling data is not considered here, but will be discussed in **Chapter 2** of this report when comparing Dr. Davidson tree and sapling quantitative data from the late 1960's.*

Floristic Quality - Mean C

The Wisconsin floristic quality assessment (WFQA) requires a complete and accurate vascular plant inventory of each site (Bernthal 2003). The WFQA is based on the Coefficient of Conservatism (*C)*, which is a numerical rating (0-10), that was assigned in the early 2000's by a core of seven Wisconsin botanists, along with input from more than thirty other botanists from across the state (Bernthal 2003). Species that have narrow habitat requirements (habitat specialists) have high *C*-values, while species that are found across many habitats (habitat generalists) have low *C*-values. Introduced species and some invasive native species were assigned a zero. The *Mean C* is one of several metrics used in the Floristic Quality Assessment (FQA). Swink and Wilhelm (1994) created the floristic quality assessment method for prairie habitats in the Chicago region. It measures an ecological condition of the vascular flora of sites of the same community type. Due to several factors, great disparity between species richness values and no abundance data for Thomson, only the *Mean C* value will be compared. In examining both lists (1944 and 2016) representative species for each community were present, allowing *Mean C* values to be calculated. *Mean C* is the arithmetic average of the *C* values across the total number of plant species (*n*) observed in a plant community site.

$$\bar{C} = (C_1 + C_2 + C_3 + \cdots + C_n) \div n$$

When averaging all (*C*) values, a metric is created called the *Mean Cn* (natives only) and *Mean Ct* (all species).

Rare and Notable Plants

Rare plants may be scarce because the total population of the species may have just a few individuals, or be restricted to a narrow geographic range, or both. Some rare plants occur sparsely over a broad area. Other rare plants have many individuals, but these are crowded into a tiny area; in some cases, a single county or river channel. A third kind of rare plants are those with both few individuals and a narrow geographic range: these are the very rarest plants (USDA Forest Service,2016). To qualify as rare, the species had to be on the Wisconsin Natural Heritage Working List.

Rare plants populations were identified and documented by recording GPS coordinates and demographic data by taking a photo record. Notable plants were either rare plants in the Brule River watershed or new county records. Other rare plant populations from an earlier LSRI project conducted on the Brule River State Forest will be noted in our results.

RESULTS

Vegetation Cover Map Analysis (1852-2016)

The two maps created by Fassett and Thomson in 1944 and 1945 can be compared to the present day vegetative cover map created using the Wiscland 2.0 data (2016). **(Appendix B. *Map 1. & 2.*)** These digital maps capture snapshots in time allowing a better visualization of changes that have occurred. There are slight variations in map resolution of community types because of technologies available to each research team at the time. Changes in land cover between time periods are summarized in **Appendix C. *Table 1***.

Listed below are four major vegetative cover changes observed between 1852 and 2016.

1) There was a shift from open pine barren to managed pine plantation in the southwestern extent of the watershed. These pine barren communities declined from 41,717 acres (1852-1856) to 30,355 acres (1932-43) to only 2,151 acres today.
2) The early surveys depict a narrow strip of northern wet-mesic forest surrounding the Bois Brule River from the headwaters area, extending to the northeast. Thomson noticed on-going harvesting in these forests in the 1940's with a substantial narrowing of the band of trees.
3) A large "Bog Conifer" complex north of Lake Nebagamon was depicted in the 1852-1856 maps. The second map depicts a substantial decline from cedar to a lower quality forests of norther hardwood swamps dominated by black ash (*Fraxinus nigra*) and alder thickets (*Alnus incana*). Remnants of the original forest are present, but in smaller acreages.
4) The boreal forest extending from the mouth of the river extending back towards the southwest has been greatly diminished, though recovery is occurring with some stands approaching old growth. Substantial acreage was initially cleared for farming (still active today), while thousands of acres have been placed in managed timber production lands of northern hardwoods consisting of aspen, oak and maple (*Populus tremuloides*, *Quercus rubra* and *Acer rubrum*).

Sorensen's Similarity Index

Ten sites were sampled in the boreal forest community. All ten were above the cut-off threshold to be considered for further evaluation **(Appendix C. *Table 3*.)**

Twelve sites were sampled in the northern wet-mesic communities. Two of these fell below the threshold of = or < .49 ; Leppala Cedars and Stone Chimney. The Leppala Cedars was an upland northern white cedar forest and the vegetation was not restricted by the acidic sphagnum moss that was evident at the other sites. A notable find – *Carex* X *knieskernii* was located at Leppala by Emmet Judziewciz who had made one of the first findings of this hybrid of *Carex arctata* and *Carex castanea* in Wisconsin several years ago (personal communication E. Judziewicz, 2016). Leppala Cedars will be removed from further consideration. The Stone Chimney site will remain in our evaluations, even though it fell slightly below the cut-off threshold. Species richness is lower, but it has a higher and richer array of habitat specialists. Also, the "Stone Chimney" area may be the last refuge in the Brule River watershed, if not the State of Wisconsin for the species *Ranunculus lapponicus* and *Calypso bulbosa* and many other rarer plant assemblages and for that reason will be considered in our evaluation **(Appendix C. *Table 4.*).**

Six sites were sampled in the pine barren community. One site was visited twice due to the low number of species discovered during the first visit (late May). It was sampled again in mid-July to capture the full array of species present. One site Moreland Barrens was below the cut-off threshold as the site had fewer large openings and a larger acreage of scrub oak and jack pine forests than the other sites. Five of the sites were above the threshold and were considered for further evaluation **(Appendix C. *Table 5.*).**

Species Richness and Introduced Species

Boreal forest α species richness averaged 132 species, with a range of 93-182. The γ species richness consisted of 63 families, 190 genera and 351 species, ranking highest of all of the communities. Of the γ richness, 14.2% are considered introduced. The five dominant families are Cyperaceae (10.1%), Asteraceae (9.6%), Rosaceae (8.0%), Poaceae (7.4%) and Ranunculaceae (5.3%). Thomson's γ species richness was 105 species with 5%

introduced (Thomson, 1945). Thomson recorded 24 additional species we did not observe **(Appendix E. pg. E3-E4).**

Northern wet-mesic forest α species richness averaged 98 species, with a range of 67-125. The γ species richness consisted of 68 families, 167 genera and 261 species with 3.4% introduced. The five dominant families are Cyperaceae (10.8%), Asteraceae (9.9%), Rosaceae (7.9%), Poaceae (5.8%) and Ericaceae (5.3%). Thomson's γ species richness was 83 species with 2.5% introduced (Thomson, 1945). Thomson recorded 4 additional species we did not observe **(Appendix E. pg. E3-E4).**

Pine barren α species richness averaged 84 species, with a range of 61-102. The γ species richness consisted of 59 families, 144 genera with 190 species with 13.7% introduced. The three dominant families were Asteraceae (17.8%), Poaceae (12.0%) and Rosaceae (11.6%). Thomson's γ species richness was 127 species with 17% introduced (Thomson, 1944). Thomson observed 24 species we did not observe **(Appendix E. pg. E3-E4).**

Groundcover and Shrub Prevalent Species

Boreal forest – 14 species are considered to be prevalent species. The four most prevalent species are *Eurybia macrophylla, Maianthemum canadense, Pteridium aquilinum* and *Aralia nudicaulis.* Comparing all of the prevalent species with the Thomson data, 79% of species are in common.

Northern white cedar swamps – 15 species are considered to be prevalent species. The five most prevalent species are *Rubus pubescens, Coptis trifolia, Maianthemum canadense, Trientalis borealis,* and *Cornus canadensis.* Comparing all of the prevalent species with the Thomson data, 80% of species are in common.

Pine barren - 16 species are considered to be prevalent species. Shrubs and scrub oaks make up 50% of the prevalent species. The eleven most prevalent species are *Comptonia peregrina, Corylus americana, Prunus pumila, Rubus flagellaris, Carex pensylvanica, Vaccinium angustifolium, Andropogon gerardii, Danthonia spicata, Quercus macrocarpa, Quercus ellipsoidalis*, and Monarda fistulosa. Comparing all of the prevalent species with Thomson data, 88% are in common.

Appendix C. *Table 9* for a full list of all prevalent species.

Mean Cn and *Ct*

Mean Cn and *Ct* values close to 0 indicate a poor quality plant community with a high proportion of the species at the site being habitat generalist including introduced species ; values from 4-6 indicate a moderate quality community and values greater than 7 indicate a good to high quality community with a large proportion of habitat specialist species present.

Boreal forest *Mean Cn* average across 10 sites is 5.3 today compared to 4.7 in 1945. *Mean Ct* is 4.7 today compared to 4.7 in 1944.

Northern wet-mesic forest *Mean Cn* average across 11 sites is 6.3 compared to 7.0 in 1945. *Mean Ct* is 6.2 today compared to 6.9 in 1944.

Pine barren *Mean Cn* average across 5 sites is 4.3 compared to 4.6 in 1945. *Mean Ct* is 4.0 today compared to 3.8 in 1944.

Appendix C. *Figure 5*

Online Virtual Flora of Wisconsin Collaborative

Our partnership with the Wisconsin State Herbarium allowed the project to upload 468 species (boreal forest, northern wet-mesic forest and pine barren) to the Online Virtual Flora of Wisconsin. The database was designed to mirror the conceptual structure of a traditional flora. This flora is exclusively web-based and employs a novel data model, information linking, and algorithms to provide highly dynamic customization. It enables meaningful access to biodiversity data for anyone from specialists to high school students. Records are mainly taken from preserved collections and more recently, from observational data such as that recorded in projects like this one. This open source database allows scientist from all over the globe to have access to the records collected by this project. Additional observational data will be added as more communities in the Brule River watershed are studied in Phase II of the project. For a complete species list see **Appendix D.**

Rare and Notable Plants

Eleven species were found in 2015 and 2016: *Calypso bulbosa, Cypripedium parviflorum var. makasin, Ranunculus lapponicus, Carex backii, Geum macrophyllum* var. *macrophyllum, Petasites sagittatus, Vaccinium vitis-idaea, Asclepias ovalifolia, Pyrola minor, Callitriche hermaphroditica,* and *Rychnospora fusca.* There were six rare species found in the northern wet-mesic forest, four in the boreal forest and one in the pine barren community. An additional nine notable species were also recorded.

Upon examination of databased herbarium records for Wisconsin, 40 new county records were found of which 25% are introduced species. Thirty-six species new to Brule River watershed, of which 6% are introduced species; and 90 species were underrepresented in Wisconsin herbarium records, of which 20% are introduced species **(Appendix F.).**

DISCUSSION

Forests are in a continual flux, from anthropogenic causes (i.e. logging, development) and/or natural disturbances such as fire, windstorms and catastrophic weather events (i.e. flooding). Within the forests on the Brule River watershed there are microclimates that dictate forest composition. In the lower reaches of the river where the forests are restricted to a narrow steep valley and are influenced by the cooler temperature of Lake Superior, boreal forest is found. The old growth coniferous bogs and swamps persist in the upper reaches of the river (headwaters), where hundreds of thousands of seepage springs deliver cool enriched mineral waters into a dense quagmire of cedars, black spruce, tamarack and alders. Due to foresight by early scientists and managers, large tracts of these forests have been protected. The landscape rising above the river to the southeast provides yet a third microclimate, consisting of nutrient poor, outwash glacial sand plains from the last glacial period (10,000 yrs. ago). In these pine barren communities, drought resistant, fire-dependent species continue to shift through a mosaic of dwarf pine trees, scrub oaks, and open prairie. Most of this land, however, has been converted into pine plantations (red and jack) and is managed by industrial, state and county forest departments. The research team examined Thomson's data and could not determine the methods he used in surveying the flora of each of these communities. Upon close examination of his herbarium specimens and subsequent papers, it appears that Thomson did not conduct exhaustive vegetation field surveys, but rather adhered to roadways or abandoned fields. Another caveat that makes comparison difficult is that he had 53 field days spanning a three-year period, while our research teams consisting of groups of surveyors and/or expert botanists (with sometimes up to seven individuals), collectively had the equivalency of 180 field days in two field seasons. One clearly sees our level of effort far exceeded Thomson's and is partially responsible for

the large discrepancy between the measurements (i.e. species richness, composition, etc.) of the two time periods **(Appendix C. *Figure 2* & *3*).**

When examining changes by function and growth an obvious pattern emerges that illustrates that the graminoids have become a more dominant feature throughout all forest types. Recent authors (Rooney 2009; Rooney and Waller 2003; Burton et.al. 2014) suggest that due to an increase of herbivory by ungulate mammals, graminoids are better able to recover from browsing pressure than most of the forbs leading to their increased dominance in today's forests. A second trend observed was an increase in the total number of tree species while tree percentages as a portion of forest composition remained the same across all community types. A likely explanation is the exhaustive nature of our studies and the large percentage of trees that were found at the seedlings stage – these seedlings may have been discounted or overlooked by Thomson and Fassett **(Appendix C. *Tables 6-8*).**

Species richness and abundance have changed with present day surveys showing a marked increase in overall species richness for each of the three communities **(Appendix C. *Figure 2*).** Level of effort between the two surveys best explains the increase. Introduced species increased in the boreal forest (5% to 13.7%) and white cedar swamp (2.5% to 3.4%) but not the pine barren (17% down to 14.2%). Pine barren had the lowest diversity with 190 species, 26 introduced. The decrease in introduced species is not likely a result of an ecological change in the community; instead a better explanation would be Thomson's' affinity of adhering to roadways and collecting from them. Boreal forest had the greatest diversity with 351 species, 50 of which are introduced, with buckthorn, honeysuckle and reed canary locally displacing the native flora. Rooney et. al (2004) and Hidding (2013) in historical studies and experimental exclosures found that in boreal forests species richness decreased, while introduced species increased along with graminoids and a denser shrub layer. This would suggest that the boreal forest of the Brule may be similarly impacted in the future. The northern wet-mesic forest had only a slight increase of introduced plants and most were found only along the edge of the Bois Brule River, as well as in gap openings (e.g. *Valeriana officinalis*, Angel Creek Swamp) and therefore may fare better.

Boreal Forest of the Brule

The present day boreal forest, north of the Copper Range, is characterized as gradually sloping to the northeast within a gentle terrain, bisected by numerous steep ravines. A contiguous 2nd and 3rd growth aspen forest continues to dominant the forest of today, with some balsam fir and spruce in the understory. Other areas have been lost to timber due to an alteration of the hydrology caused by heavy equipment resulting in "swamping" that favors thickets of alder and willow.

Boreal forest *Mean Ct* values illustrate an identical floristic quality at 4.7 for both time periods. This is somewhat surprising as species richness was three times greater in 2015 than in the 1940's, with a large percentage of habitat generalists **(Appendix C. *Figure 5*).** Moreover, Thomson classified the boreal forest as "The Aspen Association" since the boreal forest composition was greatly compromised from early logging activities. Thomson did not discover as many introduced plants in this early successional forest (only 5%) as we did in today's boreal forest (14.2%). Family dominance have changed from Rosaceae, Asteraceae, Ranunculaceae and Salicaceae in the 1940's to Cyperaceae, Asteraceae, Rosaceae, Poaceae and Ranunculaceae today. The graminoids represent almost 20% of the boreal forest flora of today, when they were only 7% in the 1940's. Another observation was that insect pollinated dependent families have declined (Rosaceae and Ranunculaceae), while wind-pollinated species have substantially increased (Cyperaceae and Poaceae). These findings are consistent with the trends found during a re-survey of the Curtis plots for randomly selected northern forests in Wisconsin (Rooney et. al 2004). To further the point, one of those grasses, *Calamagrostis*

canadensis, a prevalent species of today, was not even found by the Thomson survey. In addition, *Equisetum arvense* (habitat generalist) has displaced *Equisetum sylvaticum* (habitat specialist); while *Alnus incana* has become a prevalent species and again was not noted in the Thomson survey.

The best examples of remnant boreal forest stands are along steep ravines near the mouth of the river and extending inland for several miles. The cooler climate and soils (red clay) dictate the species that can be sustained in this part of the watershed. In these areas we see the returning prominence of white pine, balsam fir and white spruce, while paper birch is dwindling to extremely low numbers **(Appendix C. Chapter 2. *Figure 13.*)**. In the deep tributary creek ravines of this area, dominant trees include northern white cedar, balsam fir, white spruce, and aspen. The boreal forest on the Brule is slowly recovering and opportunities for restoration activities are high. O'Connor (2016) in the Biotic Inventory of the Brule River State Forest states: ***"The Brule River State Forest offers the single best opportunity for clay plain Boreal Forest Restoration on state-owned land on the entire Superior Coastal Plan Ecological Landscape and possibly North America."*** Doing so will insure the continued biodiversity, complexity and health of this rare plant community in Wisconsin for future generations.

White Cedar Swamps of the Brule

The northern wet-mesic forest's 2,252 acres are dominated by old growth even-aged white cedar swamps in the headwaters region of the Bois Brule River. From 1942-44 Thomson observed harvesting in the headwaters' northern wet-mesic forest and recommended that all cutting cease (Thomson, 1945). Area residents and farmers were harvesting the cedar for fence posts and exposing the sphagnum hummocks and pools to wind and sun resulting in severe desiccation, thereby creating a wasteland **(Appendix A. pg. A2).** Thomson recognized the importance of this area and the direct influence it had on sustaining water quality, water flow and stable temperatures needed to support brown, brook and rainbow trout populations in the river. The white cedar swamps are approaching 200 years of age, with no record of regeneration in the last 70-80 years. Beals (1960) and others (Alverson 1988; Van Deelen;1999; Rooney 2002; Forrester 2014) have all documented the impact of deer populations on the ability of northern white cedars to regenerate. Due to the lack of regeneration, the Brule Spillway cedar swamps (the largest in the State) are vulnerable to disappearance in the next 50 years (Bushman 2006; Scheller and Mlandeoff 2005; Scheller and Mlandeoff 2008). Matula (2014) reported on a study conducted by Johnston and Puettman in late 1970's, and early 1980s' in the Brule Spillway cedar swamps. They designed experimental plots to assess white cedars ability to re-generate by creating three rectangular experimental plots, some with exclosures, in this area. The result of their study was that seed production was adequate in the remaining forests to re-establish a cedar stand, but after 3- and 5-year intervals, cedar regeneration was only present in deer browse protected exclosures. Outside the exclosures, balsam fir, alder and willow colonized the area. Our research teams visited these rectangular shaped study plots and verified this colonization by balsam, willow and alder.

Northern wet-mesic forest *Mean Ct* values depict a decrease in floristic quality from 6.9 to 6.2. Introduced species slightly increased temporally (2.5% – 3.4%), but this alone does not explain the large discrepancy between the two time periods. As was standard in the 1940's, Thomson classified both the northern wet (black spruce/tamarack) and northern wet-mesic forest (cedar swamps) as one community type – "coniferous bogs", with the former having a greater percentage of habitat specialist species. In Vegetation of Wisconsin, Curtis (1959) compares these two types and finds only a 50% similarity between the communities and separates them into northern wet-mesic forest and northern wet forest, perhaps explaining the wide differences in *Mean C* values. Family dominance has also changed from Cyperaceae, Orchidaceae, Caprifoliaceae, Rosaceae and

Ericaceae to Cyperaceae, Asteraceae, Rosaceae, Poaceae and Ericaceae. The graminoid dominance has increased from 11% to 17% since the 1940's. Surprisingly *Maianthemum canadense, Aralia nudicaulis* and *Acer spicatum,* highly prevalent today, were not recorded in the 1940's. Another substantial decline we find is in the Orchid family from 6.0% to 2.9%. **(Appendix E. pg. E3)**. *Calypso bulbosa*, a state threatened orchid, is probably near extinction in the Brule River watershed (personal communication, E.J. Judziewicz, 2016). Judziewicz studied the same cedar swamps in the mid to late 1990's and found hundreds of individual *Calypso bulbosa* plants. During the field seasons of 2015 and 2016 (Judziewicz was in attendance) only four plants were found (2 sterile, 2 in flower – see rare plant section). Lastly, Rooney and Waller (2003) and Rawiniski (2008) described the effects of high deer densities on the understory flora of forested ecosystems, which may explain some of this decline, as well as a drop in the *Mean Ct* values of these northern wet-mesic forests.

Pine Barrens of the Brule

Pine Barren remained frequently burned and mostly treeless at the time of the Brule River surveys of the 1940's; the last big fire occurring in 1936 (Fassett 1944). Thomson (1945) and Fassett (1944) documented a much more intact pine barren than we find today, noting many characteristics such as shrubby jack pine, scattered red pine savannas and vast open barrens.

They reported that the pine barren community covered 24.3% of the total watershed in 1938; today it covers less than 2% (see Table 13). Lost to history is the full extent of the flora of these pine barrens as less than 2% of this community exists as it did in 1854 in the Brule river watershed. The land that was historically pine barren is managed by private timber companies, the Brule River State Forest and Douglas and Bayfield counties as pine plantation monocultures. This reduction and replacement of native plant populations and available wildlife habitat is reflected in the *Mean C* values.

Pine barren *Mean Ct* values illustrate a slight increase in floristic quality from 3.8 to 4.0. These numbers indicate an overabundance of habitat generalists (Asteraceae and Poaceae) which accounts for more than 30% of the flora and the lower *Mean Ct* values as compared to the other two community types. This community is embedded in large acreages of pine plantation, resulting in the second highest percentage of introduced species (13.7%) and the lowest *Mean Ct* of all the communities. Family dominance has remained the same with the Astereaceae, Poaceae and Rosaceae leading the way. *Hieracium aurantiacum* (orange hawkweed) is the only introduced species that ranked high enough to make the prevalent list for any community in the Brule. *Carex pensylvanica* (a native sedge) has successfully spread to this community and was not recorded by Thomson, though it is present in other adjacent forested communities.

Due to the smaller open areas (>1000 acres) and savanna-like conditions, the globally rare pine barren community is a magnet for wind-dispersed introduced plants (e.g. *Agrostis gigantea*, *Centaurea stoebe and Cirsium arvense*). Radeloff (2000) notes that fire suppression activities have altered the pine barren landscape by eliminating large patches of open habitat (1,000 – 1,500 acres). It is doubtful that the shifting mosaic of oak and pine savannah surrounded by large open patches will be achieved without further use of fire by land managers. *Open barren areas are only in the 100's of acres today, not the thousands required by numerous wildlife species such as sharp-tailed grouse, bobolink, and savannah sparrows to name a few* (Radeloff 1999). ***The best remaining examples of the pine barren habitat in the Brule River watershed are found at Mott's Ravine State Natural Area and in patches between forests or recent harvest events. There are plans in the 2003 Brule River State Master Plan to modestly increase the acreage of pine barren found at Mott's Ravine.***

SUMMARY

Near pristine conditions still exist within the Brule River watershed and continue to support a diverse array of animal and plant life (albeit not as abundantly) as depicted in the Biotic Inventory Report for the Brule River State Forest (2016) and this report. Today, the Brule River watershed continues to exhibit an exceptionally diverse array of habitat types with outstanding water resources supporting fish and wildlife species and numerous rare flora and fauna. The consistent flow of cold waters of the Bois Brule river are a product of the headwaters cedar swamps and groundwater connected springs, moving through hundreds of feet of outwash sand plans, arising on the valley floor. The vegetative cover of the Brule is exceptionally unique with large tracks of lowland forest at the headwaters region to old growth pine forest extending to Winneboujou and rare plants found throughout. The narrowing lower reaches of the watershed consist of boreal forest heavily influenced by Lake Superior. The boreal forest pines were some of the first to be cut at the turn of the 20th century. Boreal forests are recovering with several stands approaching old growth status (120 years old) and there are long-term goals to further expand these forests as stated in the 2003 Brule River State Forest Master Plan. Today, there are four state natural areas that offer further conservation potential for all three communities types discussed earlier: Brule Glacial Spillway (2,642 acres); Mott's Ravine (655 acres), Brule River Boreal Forest (652 acres) and Brule Rush Lake (22 acre), when there were no protected lands prior to the Brule River Survey in 1945.

The Analysis of the Vegetative Cover of the Brule River Watershed Re-Visited (1852-2016) – Phase 1 re-kindled a relationship between scientists and resource managers from Madison to Superior, re-surveying plant communities in the Brule River watershed. The first study was conducted between 1942-1944 by leading botanists in the State of Wisconsin at the time –Norman Fassett (Madison), John T. Curtis (Madison) and John W. Thomson Jr. (Superior). They provided vegetative cover maps dating back to the first surveys by the General Land Office, Public Land Survey in 1852-1856 and again for their time period 1932-1943 using the Wisconsin Land Economic Inventory for Douglas and Bayfield counties and their own personal observations. They further described the species composition of most of the plant communities in the watershed, along with duplicate voucher specimens housed in herbaria at Superior and Madison. Results and recommendations from these earlier floristic studies protected all the remaining headwater swamp forest areas as well as the alder thickets growing along the river corridor; and they recommended the cessation of all timber harvesting from crest to crest along the Brule River valley, which continues to this day.

We georeferenced Thomson's survey sites from locational information found on herbarium labels. This report covers the floristic composition of the three principal communities of the watershed– boreal forest, pine barren and northern wet-mesic cedar swamps. A series of botany blitzes were conducted by expert botanist from around the state. A minimum of five separate sites, at least 5 acres in size, were sampled for each type. The boreal forest was the most diverse with 351 species, 50 introduced, 4 rare followed by the northern wet-mesic forest with 261 species, 9 introduced and 6 rare, and the pine barren with 190 species, 26 introduced, 1 rare. Floristic quality measures in terms of *Mean C* are highest for the northern wet-mesic forest and lowest for the pine barren. The *Mean Ct* values have remained unchanged in the boreal forest, increasing slightly for the pine barren. The northern wet-mesic forest *Mean C* values are not as comparable due to the common practice in the 1940's of lumping two communities into one type (black spruce swamp + northern cedar swamp). Dominant family and prevalent species were also compared and it was learned that graminoid families of Cyperaceae, Poaceae and Juncaceae increased (wind-pollinated), while flowering plant families declined (pollinator dependent species). More than twenty rare and notable plants and forty new county records were found.

Upon examination of all documented herbarium records in the state, there were 36 new to the Brule River watershed and 90 species were underrepresented in the Wisconsin herbaria record for the watershed.

Still challenges exist for sustaining, maintaining and restoring these three communities into the future. The boreal forest remains susceptible to severe erosion of clay banks as rain events and snow melts intensify under changing climate scenarios. The cedar swamp is even-aged and not re-generating. The pine barren mosaic remains diminished and the area continues to be dominated by red and jack pine plantations with only small opportunities to expand. Habitat loss, deer herbivory, insect-pollinator damage, exotic plant invasion and a rapidly changing climate will continue to shift species - some to extinction, especially rare plants. If species are lost here, genetic potential of that species is lost for other populations nearby.

Two rare species, *Calypso bulbosa* (calypso orchid) and *Callitriche hermaphroditica* (autumnal water star-wort), stand out as harbingers of the change. *Calypso bulbosa* populations are substantially diminished since the 1990's and may disappear in the next decade from unknown causes. *Callitriche hermaphroditica*, a diminutive aquatic plant, has the narrowest of conditions to survive. *Callitriche* populations are present and substantial, but only within close proximity to the coldest groundwater springs of the river. If there are hydrological disturbances or warming waters, this is the species that will disappear before all others, acting like a "canary in the mine" for the river's health and the health of the fish and wildlife species.

What these two species remind us of with their presence, are the diversity, uniqueness and richness of the floristic composition of the Brule River watershed. Time will tell and it is for the next generation of botanists to gauge and evaluate how well we all have done in protecting this floral record.


Calypso bulbosa (L.) Oakes


Callitriche hermaphroditica L.

"If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."
— Aldo Leopold, Round River: From the Journals of Aldo Leopold

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CHAPTER 2: CHANGES IN THE FOREST OF THE BRULE RIVER WATERSHED (1968-2016) written by Paul Hlina, Reed Schwarting, Statistical Analysis by Nick Danz.

FOREST BACKGROUND

At the end of the 19th and early 20th century, most of the Brule River watershed (BRW) was harvested (Wisconsin Department of Natural Resources (WDNR 2015). The tall straight pines were first harvested for building projects throughout the upper Midwest. This initial harvest was thorough with woody debris left behind. Once dried out, this debris was a catalyst for fires which were commonplace for decades after the initial harvest. Many of these early fires burned hot and destroyed the fragile topsoil in some areas, restricting the land in supporting new forests (Wisconsin State Forests Web 2016). Some of the upland flat areas in the boreal forest and the pine barren were further cleared for agricultural purposes. Most of the pine barren farms were short-lived and public and private pine plantations were planted (Wisconsin Natural Communities Web 2015).

In the 1920's the forest industry turned its attention to the northern hardwoods of oak, maple, basswood, white ash and yellow birch. This harvest would continue sporadically through the 1930's and early 1940's (WDNR 2015).

The Brule River State Forest (BRSF) was officially declared a state forest in 1936. The idea for a state forest on the Bois Brule River began in 1907 when timber baron Frederick Weyerhauser gifted over 4,000 acres to the state of Wisconsin (WDNR, 2015). The BRSF is mainly located in a narrow band of the BRW from glacial ridge to glacial ridge and 27% of the state forest is actively managed for harvest (Wisconsin State Forests Web 2016) **(Appendix B. *Map 5*)**. The BRSF is comprised of more than 50% of the forested land in the watershed. The remaining 50% of land in the BRW is privately owned, county forest and a mixture of agricultural, river, wetlands, forest and residential development, mainly near lakes and the Bois Brule River. Other significant areas in protective status are the steep sides of the Brule River Valley along with several State Natural Areas comprising the headwaters area cedar swamps (2,642 acres) ,a boreal forest approaching old growth status (652 acres), the pine barren (655 acres) and a small sandy shore alkaline seepage lake, Rush Lake (22 acres). The remaining acreage of the BRSF is either protected for its size, age, species diversity, and/or erosion control. The BRW does not include the Gordon Annex area, the newly acquired forested land on Lake Superior, and the St. Croix Creek area that empties into the Upper St. Croix Lake, near Solon Springs.

RESEARCH METHODS

Forest Compartments and Stands in the Brule River State Forest.

We examined public forestry records from the Wisconsin Department of Natural Resources forest stand database (WisFIRS 2016). This database describes the forest composition in the Brule River State Forest (BRSF), the Douglas County Forest and the Bayfield County Forest within the Brule River watershed. We were able to use this data to compare forest community percentage with the stands we re-surveyed in 2015. We were able to re-survey all of the stands studied in 1968-69 on public and private lands and will return to survey ground cover and shrub layers during the 2016 field season **(Appendix C. *Table 11,* pg. C13).** The forest community types are: boreal forest (spruce/fir), northern dry-mesic forest (red/white pine), northern hardwood forest (aspen dominated), northern hardwood forest (oak, maple), northern hardwood swamp (black ash), northern mesic forest, (black spruce/tamarack) northern wet-mesic forest, (white cedar) and the pine barren (jack/red pine).

Geo-Referencing 1968-1969 Davidson Maps

The Davidson forestry data was recently rediscovered in the fall of 2014, and locations of each stand were geo-referenced using geographical information system (GIS) software ArcMaps 10.3.1. Hand-drawn rectangles with stand numbers were found on the Davidson topographic maps. (GIS) assisted our field survey teams in re-locating the original stands, which were all adjacent to a road. Hand-held global positioning system (GPS) were used to identify our re-surveyed stands. The boundaries of the watershed has also been updated with modern geographical elevation data using advanced ground hydrological modeling in ArcMap 10.3.1.

Point Centered Quarter (PCQ) Forest Sampling Method

The point-centered quarter method is one of the most frequently used distance methods employed to sample forest communities (Johnson et. al., 2008). Stearns (1949) notes that this method dates back a least 150 years and was used by earlier surveyors. Cottam and Curtis (1956) evaluated several forestry sampling methods in quantifying forests and stated that the point-centered quarter method was deemed the best method in terms of distance determinations and the amount of tree species data at each point, while minimizing biases. Dr. Davidson chose this method for his forest inventory of the Brule River watershed in 1968-1969 which consisted of 55 stands, with one stand (#47) outside the watershed **(Appendix B. *Map 5*)**.

Both the 1968 and 2015 studies used the point centered quarter method in sampling trees and saplings in each stand. Sampling points in 1968 consisted, on average, of 20 points. In 2015, points were chosen within the Davidson stands and were plotted at regular 20 m (65.5ft) intervals along one to five transects spaced 25m(82ft) apart in each surveyed stand within a homogeneous community type. At each interval, the survey team randomly diverted 90° either left or right 5m (16.4ft) from the transect to reduce surveyor biases. Once the survey point was established the closest tree and sapling were recorded for every quarter based on proximity to the point. The quarters where divided along the cardinal directions. For trees/saplings to be considered, the majority of its base had to fall within the quarter. If no trees/saplings were present within 12.2m (40ft) of the survey point that quarter was marked as NONE. Trees are defined as 10.16cm (4in) in diameter or greater, while saplings ranged in size from 2.54cm – 9.90cm (1.0in – 3.9in). Distances were measured in feet to each tree/sapling from the survey point. Diameter at breast height dBh was recorded in inches. Species were recorded by taxonomic code **(Appendix C. pg. C15-16).**

Forest Importance Value Method

Importance values (IV) for each tree species were calculated in all the stands commonly surveyed between the two surveys. Different importance values were calculated by species within each forest community type and compared between the two surveys spanning 47 years. The importance values are a summary of the relative frequency of occurrence, relative density and relative dominance by species in each stand.

Bray-Curtis Distance

We used the Bray–Curtis distance as a measure of the "ecological distance" or dissimilarity between the same stands, but at different time periods. The Bray-Curtis index was first described in 1957 when comparing upland forested sites in southern, Wisconsin (Bray and Curtis, 1957). Values nearer 1 indicate samples more unlike each other (greater distance) and values nearer 0 indicate samples more like each other. The index is a way of quantifying differences in species composition using one number.

ANALYSIS AND RESULTS

Forest Composition in the Watershed

Through our geographical analysis, the Brule River watershed encompasses 124,702 acres of forests, wetlands, fields, lakes, and a 44 mile riparian corridor. Aspen and pine plantations make-up a vast majority (>58%) of the forested land cover in public ownership today **(Appendix C. *Figure 8.*).** Aspen (*Populus tremuloides*) dominated forests are found throughout the BRW but the species is also common in the pine barren, northern hardwood, and boreal forest community types. Jack pine (*Pinus banksiana*) and red pine (*Pinus resinosa*) are the dominant trees in pine plantations interspersed with Hill's oak (*Quercus ellipsoidalis*). Pine barren is primarily located southeast of the Bois Brule River Headwater's area. More than 6,500 acres of the swamp and uplands are in the southern reaches of the river and are protected by the WDNR and several private entities. These stands include the largest intact white cedar (*Thuja occidentalis*) swamp in Wisconsin, with some areas aged 150 and 200 years (WDNR, WisFIRS, 2016).

Absolute Density and Absolute Dominance

In selecting forest stands to survey, Davidson achieved a geographic distribution throughout the watershed, as well as an equitable number of private versus public stands. Twenty-eight stands are represented by the northern hardwood forests (including mixed hardwoods/conifers), while four types – Northern Wet Mesic Forests, Northern Hardwood Swamps, Northern Wet Forest, and Pine Barren had only one or two representative stands each. All other forest types had four (4) or more representative stands **(Appendix C. *Table 11,* pg. C13).** In 1968 the average absolute density was 326 trees/per acre and 111ft^2/per acre. In 2015, our surveys found 243 trees/acre and 104 ft^2/acre. The sapling data indicates an increase in earlier successional forests than during the 1968-69 time period. Five stands (11%) have been clear-cut or partially cut in the last decade. Another six (13%) stands had larger amounts of saplings to trees. Notable changes in sapling data is found in three species; paper birch (*Betula papyrifera*), balsam fir (*Abies balsamea*), and red maple (*Acer rubrum*). We will discuss these changes in the next section.

Brule River Watershed Forest Tree Species

Aspen *(Populus tremuloides* and *Populus grandidentata)* were 29.5% of the forest in 1968, today they have decreased to 23.4%. Aspen are declining in density 25% and dominance 60%. Saplings have increased from 10.7% to 17.3%.

Paper Birch (*Betula papyrifera*) were 15% of the forest in 1968, today they have decreased to 3.3%. Paper birch is dominant only in older stands, but density has dramatically shifted to extremely low numbers. Sapling data illustrates that birch saplings are decreasing 225% in density and dominance. As with trees, sapling numbers are decreasing from 10.6% to 3.8%.

Balsam Fir (*Abies balsamea*) was 7% of the forest in 1968, today balsam fir has increased to 13.8%. Balsam fir has increased in density by 135%, while decreasing in dominance by 25%. Balsam fir is germinating well across all community types as our sapling data indicates, 35% in density and 35% in dominance.

White Spruce (*Picea glauca*) is increasing in density, while there has been a slight decrease in dominance. When comparing harvesting data provided by the Brule River State Forest, (WisFIRS 2016) selective cutting of larger trees has occurred in some of the boreal stands surveyed, potentially reducing the spruces' dominance. Sapling data depicts an increased presence of white spruce in future forests. Sapling density and dominance has increased by 400% and 100% respectively.

White Pine (*Pinus stobus*) increased in density by 100% and dominance by 30%. Old Growth pine trees cover the steep river valleys and estimates based on landowner knowledge, places these trees at 250 -400 years old on two stands and 125 -200 years at two other stands.

Jack Pine (*Pinus banksiana*) was not represented in its natural pine barren community in the Davidson data. Instead both stands were pine plantations or on the edge of a plantation and could not be adequately compared.

Red Pine (*Pinus resinosa*) is an important component of the Old Growth forest on northern dry and northern dry-mesic stands. In these old growth areas both density (300%) and dominance (25%) have increased. Most of the increase in dominance can be attributed to an average increase of dBh (17.7 in 1968, 20.1 in 2015), in which the canopy trees are better represented by red pine than white pine.

Black Ash (*Fraxinus nigra*) trees and sapling have slightly increased in density and dominance.

Red Maple (*Acer rubrum*) were 9% of the forest in 1968, today they have increased to 13.4%. Red Maple is increasing in presence and size and replacing habitat niches in both upland and lowland forests. In the past 47 years red maple has increased its presence in the northern hardwood and mixed conifer forest communities. Red Maple sapling density have decreased from 34% to 16.3%, but dominance has remained constant.

Northern Red Oak (*Quercus rubra*) were 12.9% of the forest in 1968, today they have decreased to 10.7%. Density has decreased while dominance has slightly increased to 35%. Sapling numbers are increasing from 3.1% to 6%.

Sugar Maple (*Acer saccharum*) were 4.8% of the forest in 1968, today they have increased to 6.6%. Sugar Maple has increased slightly in density and dominance from 1968 to 2015. Sapling numbers are decreasing from 14.9% to 5.4%.

For a comparison of species by total count, relative density, relative dominance and relative importance values consult **Appendix C. *Figure 22 & 23.***

Bray- Curtis Dissimilarity Distance

Species composition was calculated by relative importance value (IV) of each species within each forest community type and then compared between the two time periods **(Appendix C. *Table 12,* pg. C23*)***.

In *Table 12* we compared 1968 Davidson Trees to 2015 Trees[1]; 1968 Davidson saplings to 2015 trees[2]; and 2015 Trees to 2015 saplings[3]. Values across all the 1968 and 2015 comparisons showed displacement of some species between time periods. The northern hardwood forests (aspen, oak and mixed conifer) on the BRW fluctuate between 8-10 species being dominant at any one time period across even-age and multi-age stands. The disappearance of paper birch is occurring across all northern hardwood types widening the ecological distance between the two time periods. In comparing, northern hardwoods forest community types in the third analysis, *Table 12 column* 3, species composition is shown to have smaller differences than between the earlier forest comparisons. The most notable species to see an increase in importance are red maple and balsam fir. The remaining species in the northern hardwood stands exhibited both rising and declining IV values equally.

Further examination of the data shows that the boreal forest and the northern dry-mesic forest had the smallest differences between species composition in the first analysis. In 60% of these stands, the largest living birch were recorded, with the old growth forest serving as a possible refuge to the paper birch, found mainly in the sub-canopy. In the second column of *Table 12*, forest community types are widening their ecological distance, suggesting a greater change in species composition in the forest today, than expected from the saplings of 1968. One community that has remained consistent through the time comparison is the northern mesic forest in which sugar maple, yellow birch, basswood and red maple were present in all stands of this type. These four species IV dominance shift based on successional stage and stand location (i.e. Sugar Camp Hill (#4) continues to have high Sugar Maple IV, while stands (#22) near Lake Minnesuing have a various species with higher IV's). When examining all of the forest types' 2015 sapling to 2015 trees, results depict a future forest with a similar species composition, except in the Old Growth Forests. Saplings in this forest showed a marked departure from the pines that dominant the forests of today.

The Ten Forest Communities of the Brule River Watershed

Boreal Forest

Four stands were re-visited, representing 8% of the forest surveyed in 2015. Balsam fir and quaking aspen continue to have the highest relative importance value (IV) in the forest, but IV has declined as natural succession has occurred creating a later successional forest in which white spruce is slowly increasing, both in terms of trees and saplings. As discussed earlier white birch continues to decline in both the tree and sapling category. White pine and quaking aspen IV values are slightly down from 1968, while sapling data suggests that regeneration in the future forest will remain low. For more information on old growth boreal forest stand (#35) see **Appendix G. *Figure 32***.

Species Code	Count		R.Frequency		R.Dominance		R.Density		R.Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ABAL Balsam Fir	4	4	0.28	0.29	0.27	0.15	0.38	0.32	0.31	0.25
BPAP Paper Birch	4	4	0.12	0.05	0.06	0.02	0.09	0.03	0.09	0.03
PGLA White Spruce	4	4	0.09	0.17	0.11	0.13	0.07	0.15	0.09	0.15
PSTR White Pine	4	4	0.15	0.10	0.18	0.20	0.11	0.09	0.15	0.13
PTRE Quaking Aspen	4	4	0.33	0.25	0.37	0.40	0.34	0.29	0.34	0.31

Northern Dry-Mesic Forest

The northern dry-mesic forest is considered an old growth forest of red and white pines. Old growth forests are defined as trees that exceed 120 years of age (WDNR, 2001). Two stands are estimated to be 250-400 years old and were re-visited, representing 4% of the forest surveyed in 2015. Two 125-200 years old stands were re-visited, representing an additional 4% of the forest surveyed in 2015. Stands exceeding economic rotation age are rare statewide, but are represented in the Davidson data. Red pine has the highest IV in the canopy of this forest community. White pine remains stable with some sapling recruitment to the sub-canopy. Natural mortality of the largest white pine trees (>36 dBh) was 100% on the oldest stands. There were no red pine saplings in 2015, while white pine had a few saplings. The IV for balsam fir is higher than for white pine due to the relative density of the tree in pockets of the stands. It is in these communities that we see the only increase in paper birch IV values due to increases in basal area, not density. As stated earlier, these old growth stands may serve as refuges for aging paper birch. For further information on the old growth pine forests see **Appendix G. *Figures 28, 29, 30, and 31***.

Species Code	Count		R.Frequency		R.Dominance		R.Density		R.Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
PRES Red Pine	4	4	0.26	0.24	0.59	0.50	0.30	0.24	0.39	0.32
PSTR White Pine	4	4	0.16	0.12	0.23	0.27	0.13	0.11	0.17	0.17
ABAL Balsam Fir	3	4	0.27	0.23	0.10	0.07	0.32	0.29	0.23	0.20
BPAP Paper Birch	3	4	0.15	0.15	0.02	0.06	0.11	0.13	0.09	0.11
PGLA White Spruce	3	2	0.07	0.04	0.02	0.01	0.05	0.03	0.04	0.03

Northern Hardwood Forest, Aspen Dominated

Nine aspen (quaking or big tooth) dominated hardwood forest stands were re-visited, representing 19% of the forest surveyed in 2015. These forests (private and public) are maintained as short-lived early successional forests and are represented throughout the watershed. Quaking aspen has remained stable, while big-tooth aspen and northern red oak reached harvestable age during the 47 years interval between surveys and will likely recover in future forests. Paper birch, as found in the boreal forest, has experienced a steep decline in IV values. Red maple relative frequency has nearly doubled and its IV value is rising when moisture conditions and shade tolerance favors the species.

Species Code	Count		Frequency		Dominance		Density		Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
BPAP Paper Birch	8	9	0.15	0.05	0.08	0.03	0.13	0.03	0.12	0.03
PGRA Asp, Big Tooth	9	6	0.51	0.26	0.64	0.24	0.61	0.32	0.59	0.27
PTRE Aspen, Quaking	8	9	0.31	0.30	0.33	0.26	0.32	0.34	0.32	0.30
ARUB Red Maple	4	9	0.10	0.17	0.03	0.16	0.07	0.15	0.07	0.16
QRUB Red Oak	5	6	0.12	0.11	0.06	0.20	0.08	0.10	0.09	0.14

Northern Hardwood Forest (Oak, Maple)

Eleven oak/maple dominated hardwood forest stands were re-visited, representing 23% of the forest surveyed in 2015. This forest type shares many similarities with its' aspen-dominated counterpart. In these stands, red maple and northern red oak have rising IV values and usually exceed the two aspen species IV values, while the reverse is true in the aspen dominated northern hardwood forests. Further differences will be recorded when reviewing other forest layers (i.e. groundcover layers). Paper birch relative IV values have decreased in all categories, most notably in density.

Species Code	Count		Frequency		Dominance		Density		Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ARUB Red Maple	12	11	0.18	0.30	0.09	0.24	0.14	0.29	0.14	0.28
BPAP Paper Birch	12	7	0.24	0.07	0.20	0.02	0.27	0.05	0.24	0.05
QRUB Red Oak	12	10	0.29	0.28	0.30	0.42	0.29	0.30	0.29	0.33
PGRA Big Tooth Asp.	7	8	0.25	0.19	0.40	0.16	0.29	0.22	0.31	0.19
PTRE Quaking Aspen	8	4	0.09	0.19	0.15	0.16	0.08	0.20	0.10	0.18

Northern Mixed-Conifer/Hardwood Forest

Eight northern mixed-conifer/hardwood forest stands were re-visited, representing 17% of the forest surveyed in 2015. The conifer with the highest IV in this forest type is balsam fir. Its relative IV has increased five-fold since the late 1960's and is responsible for the mixed nature of these forest communities. There is a balance amongst the broad leaved deciduous trees IV values with a slight shift favoring red maple, while northern red oak is slightly declining. Once again, we see a sharp decline in paper birch IV values (both as trees and saplings) in this forest community type.

Species Code	Count		R.Frequency		R.Dominance		R.Density		R.Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
BPAP White Birch	8	7	0.24	0.05	0.19	0.03	0.21	0.04	0.20	.04
ARUB Red Maple	8	8	0.15	0.18	0.09	0.13	0.18	0.21	0.13	0.17
QRUB North. Red Oak	5	8	0.25	0.20	0.41	0.36	0.30	0.20	0.32	0.25
ASAC Sugar Maple	4	6	0.13	0.11	0.07	0.04	0.09	0.09	0.10	0.09
ABAL Balsam Fir	5	5	0.06	0.30	0.03	0.19	0.05	0.33	0.05	0.27

Northern Hardwood Swamp

One northern hardwood swamp forest stand was re-visited, representing 2% of the forest surveyed in 2015. With only one sample in the survey, there are no trends we can point to with any level of confidence. Species and numbers are different in this comparison, as geo-referencing on this stand was problematic because of the large expanse of this forested wetland mosaic **(Appendix C. *Table 11,* pg. C13)**.

Species Code	Count		R.Frequency		R.Dominance		R.Density		Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ABAL Balsam Fir	1	0	0.24		0.11		0.13		0.16	
FNIG Black Ash	1	1	0.62	0.48	0.79	0.68	0.81	0.60	0.74	0.58
TOCC White Cedar	1	1	0.14	0.26	0.10	0.24	0.06	0.21	0.10	0.24
ARUB Red Maple	0	1		0.02		0.00		0.01		0.01
BALL Yellow Birch	0	1		0.19		0.07		0.15		0.14

Northern Mesic Forest

Five northern mesic forests stands were re-visited, representing 10% of the forest surveyed in 2015. This type is common in northern Wisconsin, but not in the BRW. These stands represent its westernmost range in the state. Sugar maple and yellow birch IV values have remained stable in these stands while basswood IV values have more than doubled reflecting on its rapid growth patterns. Northern red oak has declined as the canopy has become denser. At Sugar Camp Hill (#4), sugar maple average dBh has increased fomr 5.5 in. to 8.2 in. 2015, with largest trees averaging 13.4 to 20.6 today. Hemlock and white ash are present in most stands, but IV values are lower than the other major species.

Species Code	Count		R.Frequency		R.Dominance		R.Density		Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ARUB Red Maple	5	5	0.14	0.11	0.08	0.08	0.12	0.07	0.11	0.09
ASAC Sugar Maple	5	5	0.25	0.26	0.30	0.24	0.30	0.30	0.28	0.27
QRUB Northern red oak	5	4	0.16	0.08	0.23	0.08	0.19	0.04	0.20	0.07
TAME Basswood	5	3	0.11	0.20	0.08	0.26	0.08	0.20	0.09	0.22
BALL Yellow Birch	4	2	0.05	0.06	0.09	0.05	0.04	0.04	0.06	0.05

Northern Wet Forest

One black spruce/tamarack swamp was re-visited, representing 2% of the forest surveyed in 2015. Within the Brule river watershed, this community is relatively rare. Stands are small and when away from the river corridor, often isolated. These stands are dominated by either black spruce or tamarack growing in a thick layer of sphagnum moss and ericaceous shrubs. Davidson had only visited one stand and we are unable to identify trends in this community during the first phase of the project. Black spruce swamps will be surveyed in the next phase of the project to assess floristic quality and will be reported in a subsequent report.

Species Code	Count		R.Frequency		R.Dominance		R.Density		Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ABAL Balsam Fir	1	1	0.04	0.08	0.02	0.06	0.01	0.08	0.03	0.08
LLAR Tamarack	1	1	0.09	0.29	0.02	0.22	0.03	0.27	0.04	0.26
PMAR Black Spruce	1	1	0.87	0.17	0.96	0.08	0.96	0.21	0.93	0.16
PSTR White Pine	0	1		0.21		0.51		0.20		0.30
PTRE Quaking Aspen	0	1		0.12		0.08		0.11		0.10

Northern Wet-Mesic Forest

One white cedar swamp was re-visited, representing 2 % of the forest surveyed in 2015. More than 6,500 acres spanning the upper reaches of the watershed consists of the northern wet-mesic forest type. The conifer swamps of the upper Brule are generally mature, with some stands in or approaching old-growth condition. The forest understory is floristically rich, especially in orchids and sedges. Cedar seedlings are rare and reproductive success has been low.

Species Code	Count		R.Frequency		R. Dominance		R. Density		R.Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
ABAL Balsam Fir	1	1	0.37	0.32	0.15	0.07	0.21	0.19	0.24	0.19
TOCC White Cedar	1	1	0.63	0.65	0.85	0.93	0.79	0.80	0.76	0.79
FNIG Black Ash	0	1		0.03		0.00		0.01		0.02

Pine Barren

Two "pine barren like stands" were re-visited, representing 4% of the forest surveyed in 2015. Due to the small number of stands surveyed and paucity of the pine barren community types in the watershed we were unable to compare this community type. These two Davidson stands were located in a pine plantations and on the fringe of one **(Appendix B. *Map 5,* Appendix C. *Table 11*)**.

Species Code	Count		R.Frequency		R.Dominance		R.Density		R.Importance Value	
	1968	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**	**1968**	**2015**
PBAN Jack Pine	2	2	0.93	0.43	0.99	0.51	0.98	0.44	0.97	0.46
PRES Red Pine	1	2	0.04	0.35	0.01	0.41	0.01	0.44	0.02	0.40
QELL Hill's Oak	1	2	0.09	0.03	0.01	0.01	0.03	0.01	0.04	0.02
ABAL Balsam Fir	0	1		0.13		0.04		0.08		0.08
PGLA Big Tooth Aspen	0	1		0.10		0.02		0.05		0.06

DISCUSSION

The forest composition we describe here in 2015 is similar to the one presented in the 1999 Biotic Inventory and Analysis of the Brule River State Forest) in preparation for the 2003 Brule River State Forest Master Plan (Epstein et. al. 1999). As a general rule, in 1968 across all Davidson forest stands in the BRW there was a greater number of trees/acre than today, (326 down to 243), and a slightly greater basal area of trees ($111ft^2$ down to $104ft^2$). The forest has more trees (absolute density) and some of them are larger (absolute dominance) indicating a larger and older forest, with some reaching maturity and dying (i.e. old growth white pine, white cedar and birch). An alternative explanation may be that harvesting has increased in several stands with increased density following, hence the new forest has yet to obtain its pre-harvest conditions **(Appendix C. *Figures 6 & 7*)**. Sapling numbers have increased with density change per species fluctuating based on natural succession, harvesting, fire and/or wind damage between the two time periods. In the Upper Great Lakes forests today, the greatest ecological driver in forest structure and function change is caused by wind damage. (Stueve et.al 2011).

Forest Trees of the Brule River Watershed

Aspen are short-lived trees reaching 60-70 years of age (Burns and Honkala 1990). They are early successional trees and are often represented in young upland forests of northern Wisconsin. Aspen is a shade intolerant species, has low nutrient needs and reproduces by extensive rhizomes. It is the most common species to dominant an upland area after a clear-cut. It quickly dominates the canopy, excluding other tree seedlings from these stands. After the third rotation of an aspen clear-cut in a boreal forest community (120 - 135 years), natural succession will lead to a spruce/fir dominated boreal forest (D. Schutz personal communication, 2015).

Paper birch is a cold climate and short-lived species reaching 60-80 years old (Burns and Honkala 1990). Since 1983 paper birch mortality has been exceeding annual growth throughout Wisconsin (Wisconsin State Forests, Web, 2016). Paper birch is likely to play a decreasing role in structure and function in the early successional forests of the BRW in the future. Observation suggests that saplings and trees (up to 6in dBh) are still present, but middle-aged trees have either fallen or are dead snags. In older forests stands, the canopy is well-developed; cutting off light required for birch regeneration. Birch was well represented across all size classes in 1968. However, today all size classes have seen a significant decline (**Appendix C. *Figure 13***). Larger birch >8in dBh are only alive on a handful of stands in which the tree was a sub-canopy species of a later successional boreal or northern dry-mesic forest. Most paper birch in this size class are their later stages of life. Scheller and Mladenoff (2005) using climate change models predict the localized extinction of five tree species (including paper birch) in northern Wisconsin by 2190.

Balsam fir is germinating well across all community types. Balsam fir is best represented at the 4in and 6in pole size indicating that it may be replacing aspen now and into the future, especially in the boreal forest community type. Pole size (dBh > 6in) trees are declining most likely due to density, disease and harvesting (**Appendix C. *Figure 9*).**

White spruce is a long-lived species reaching 150-200 years old (Burns and Honkala 1990). When examining harvesting data of the Brule River State Forest, selective cutting of larger trees has occurred in some of the boreal stands surveyed, potentially reducing the spruces' dominance (WisFIRS 2016). White spruce thrives best after a disturbance (i.e. harvest, wind throw, blow-down, etc.) that allows an increase in light reaching the forest floor. White spruce can remain suppressed for many years as a seedling in the shade before obtaining the sapling threshold of >1in dBh (Burns and Honkala 1990). The stands with multi-age populations of white spruce have a significant moss component (as exhibited in stand #35) that changes the mineral soils favoring the spruce/fir boreal species (Wisconsin State Forest Web 2016) **(See Appendix G. *Figure 32*).**

White pine is a long lived species reaching 200-450 years old (Burns and Honkala 1990). The largest white pines have been in private ownership as early as the 1870's and have been managed as no-cut zones, except for selective cutting for building projects. It was near these Old Growth stands on the slopes of the steep river valley that five presidents (1880 – 1928) visited, trying their fishing luck on the famous Bois Brule River. On the oldest stands, the largest white pines (>36in dBh) were only recorded as snags. Many of these same white pines were alive in 1968. White pine seedlings and saplings were sparse and infrequent.

The white pines found in the boreal forest are a unique feature of the Wisconsin boreal forests. (WDNR -Endangered Resources Web 2015). They are a product of the mixed conifer/hardwood forest to the south. In the BRW they are between 100 -125 years old (WisFIRS 2016) and are often larger than the smaller spruce, fir, aspen and birch. It is in this area we see the greatest potential for regeneration of white pine as the sapling data suggests, though deer herbivory may continue to be a serious problem with their survival (Rooney 2004).

Red pine and jack pine in the BRW have historically been used in plantation style plantings in the southern upland areas on the west and east side of the Bois Brule River. These areas in 1850's were sparse landscapes with oak and pine savannas before conversion to plantations. Red pine and jack pine are not well represented as natural communities, but serve a very important role for both the private and public forest industry. There were two stands chosen by Dr. Don Davidson in 1968, one was a pine plantation and the other one was on the edge of a plantation. Dr. Davidson recorded

only one or two trees species in these stands, with no saplings **(Appendix C. *Table 11*, pg. C13 Stands 19 & 20)**. These stands do not reflect the conditions first described by Fellows in 1856.

Red pine is an important component of the Old Growth forest on northern dry and northern dry-mesic stands. The challenge in maintaining future old growth red pines are that the standing trees are not reflected as seedling or saplings in today's understory. Instead shade tolerant red maple and balsam fir will possibly replace these Old Growth forests if a natural or anthropogenic disturbance were to occur. Examples of balsam thickets can be observed in small patches under open canopies where the dominant tree(s) have fallen or died. As openings occur in the canopy, exposing the land to sunlight and planting red and white pine may sustain these rare forest types.

Black ash is the dominant tree species in the northern hardwoods swamp community. This forest community type is best represented in the northern third of Wisconsin, though black ash is present statewide. The emerald ash borer is a serious threat to the black ash's survival. In 2002, the emerald ash borer was introduced to the United States through a shipment of goods in Chinese crates sent to Detroit, Michigan (Emerald Ash Borer Information Network Web 2015). After only a little more than a decade, the beetle spread to twelve states from Wisconsin (near Superior) to Louisiana. In 2014, the emerald ash borer was discovered in the city of Superior (35 miles west of Brule, Wisconsin). Soon afterwards, Superior started an ash tree removal project, which includes the ash trees on the UW-Superior campus.

Red maple is a "super-generalist" due to its low resource requirements. It shows characteristics of both an early and a late successional species (Abrams 1998). Red maple grows on diverse stands, from dry ridges and southwest slopes to peat bogs and swamps. (Burns and Honkala 1990). It commonly grows under the more extreme soil-moisture conditions either very wet or quite dry. Red maple is a likely tree to become dominant in many forest communities and may replace black ash in lowland northern hardwood swamps.

Northern red oak and sugar maple are long-lived hardwood species reaching 300-400 years old, but are often harvested between 80-100 years. Northern red oak is intermediate in shade tolerance but generally unable to establish beneath its own canopy. (Burns and Honkala 1990). Seedlings usually do not reach sapling or pole size unless gaps are created in the canopy, and it's often surpassed by the more shade tolerant sugar maple or basswood. Sugar maple are slow-growing when in the understory or groundcover layer and typically respond vigorously and rapidly following a natural or anthropogenic disturbance outcompeting northern red oak (Burns and Honkala 1990). In 1968-69, northern red oak IV values for trees was greater than in 2015, but sapling IV were less. Conversely, in 2015 sugar maple IV values for trees was greater than in 1968-69, but sapling IV values are now less. In another 50 years it is possible to see the reverse in the two hardwood species as they move through one succession sere to another. Sugar maple is becoming a late-successional (climax) dominant tree on dry-mesic to wet-mesic stands found on Sugar Camp Hill in the BRW (WisFIRS 2016).

Forest Communities of the Brule River Watershed

Boreal Forest

Mostly all of Wisconsin's boreal forests are associated with the Great Lakes, especially within the Lake Superior red clay plains, and the northeastern side of the Door Peninsula on Lake Michigan. (WDNR 2015). Prior to European settlement, white pine had the largest importance value in the boreal forest closely followed by white spruce, balsam fir, aspen and paper birch, according to public land records. (WDNR -Endangered Resources Web 2015). The boreal forest is transitionally between the mixed deciduous-conifer forests to the south and the spruce-fir dominated forests of Canada. These boreal forests have higher species richness values. In the BRW, boreal forests are found north of the Town of Brule to the mouth of the river. In 2015, balsam fir is increasing in density and replacing older paper birch and aspen which had higher IV values in 1968. Paper birch had a precipitous drop in density and dominance and if trends continue it is predicted to become extinct in the boreal forest of Wisconsin (Scheller and Mlandenoff 2005).

Northern Dry-Mesic Forest

In the BRW, northern dry-mesic forests have declined greatly because of the conversion of pine forests to plantation monocultures along with fire suppression over the years. These communities are fire dependent for seed release and growth. Red pine has the highest IV values with white pine, birch and balsam fir being associate species. Fire, at infrequent intervals, remains evident on red pine trunks and was the primary disturbance responsible for regenerating these stands. Today, these old growth stands are <1% of the forest **(Appendix G. *Figures 28, 29, 30, and 31*).**

Northern Hardwood Forest – Aspen

In 1968, the northern hardwood forest that were dominated by aspen also consisted of associates of other hardwoods - northern red oak, sugar and red maple, and paper birch with lower IV values. These are early successional forests and are often represented in young upland forests of northern Wisconsin.

Northern Hardwood Forest – Oak/Maple

In this forest type northern red oak and red maple are the dominant species, with aspen, birch and sugar maple as common associate species. The vast majority of these stands are managed as shelter wood and strip clear-cuts to encourage acorn germination and seedling growth for the future oak forests. The canopy trees are then harvested at 80-100 years. This management method may explain why oak sapling IV values are higher today then in 1968-69.

Northern Hardwood Swamp

Northern hardwood swamps are lowland forests dominated by black ash. In the Davidson data there was only one stand represented and trees were alive and healthy. However, the northern hardwood swamps are threatened by an introduced insect pest – the emerald ash borer, which was discovered in 2014, 35 miles to the west in Superior, Wisconsin. Red maple, balsam fir and tag alder may be the species posed to occupy this vacant forest community in the future. Northern hardwood swamps will be surveyed during Phase II as a wetland forest to assess floristic quality and will be reported.

Northern Mesic Forests

The northern mesic forests in the BRW are comprised of sugar maple, yellow birch, basswood, and to a lesser degree hemlock, (Stearns 1951). The Sugar Camp Hill stand area, north of Brule, Wisconsin is best represented by this forest community type. The Sugar Camp Hill stand is managed as a shelter wood forests by the BRSF and was last harvested in 1933 (WisFIRS 2016). The forest will be thinned to allow new seedling to grow and thrive. In 100 years (2033) the canopy of older trees will be removed, while a younger forest will then stand in its place. The stands near Lake Minnesuing have hemlock (Tsuga canadensis) as a frequent associate in the northern mesic forest. Dr. Davidson (1973) authored a report describing hemlock in these stands as the westernmost record in the United States at the time. Subsequent reports now place the hemlock range into northeastern, Minnesota (Little 1999).

Northern Wet Mesic Forest

The northern wet mesic forest are dominated by white cedar with balsam fir, black spruce, black ash and tamarack being common associates. Dr. Davidson data recorded one stand in this forestry community type. This stand is an old growth forest dating back to 1838. Deer herbivory is a major problem affecting forest regeneration in these important northern wet mesic forests on the Brule as observed by survey teams. The northern wet mesic forest on the Brule have been recognized for their significance for decades (Fassett 1944; Thomson 1945). As early as 1945 the area was purchased by the Wisconsin Conservation Commission, following recommendations by John W. Thomson (Superior State Teachers College, professor) to halt all harvesting activity in these forests (Thomson 1945). The same area would receive further protective status in the 1980's and was designated as a State Natural Area in 2003.

Pine Barren

The pine barren region was once widespread throughout northwestern Wisconsin covering 2.3 million acres. Today, only one percent remains in heavily managed and protected areas (U.S. Forest Service 2001). The Pine Barren plant community is endangered in Wisconsin (WDNR -Endangered Resources Web 2015). Prior to European settlement, the pine barren was characterized by scattered jack pine or less commonly red pine, sometimes mixed with scrubby Hill's and bur oak (Radeloff 2000). The scattered trees or groves are interspersed with openings in which shrubs such as hazelnuts and "grass dominated prairies" are the common cover types. These species benefit from periodic episodes of fire in creating and sustaining this mosaic of forests, openings and prairies. The best example in the BRW of a pine barren community is the Mott's Ravine State Natural Area designated in 2003, which is managed through prescribed fire treatments and tree removal. Examples of this state and globally rare community are also present in at Crex Meadows State Wildlife Area (Burnett County), Namekagon Barrens (Burnett County), Solon Springs Sharptail Barrens State Natural Area (Douglas County), and the Moquah Barrens (Bayfield County) (WDNR -Endangered Resources Web 2015).

SUMMARY

The Bois Brule River flows through some of the most diverse and unique habitats found anywhere in the state. In 2015, our survey teams were able to analyze and collect more than 7,500 data points of tree and sapling data in ten different forest community types to compare with Dr. Davidson's 7,500 data points. We used the point-centered quarter method of sampling which was popularized in the late 1950's by Grant Cottam and John Curtis. Today there are more sophisticated and contemporary forest sampling methods (USFS, 2005; Sanders et.al. 2008; Sanders and Grochowski 2014) but we choose to stay with this older method providing a stronger comparisons between the two surveys.

In the Davidson data, we found low number of stands in certain community types. This factor along with a lack of access to some privately held stands restricted our ability to fully analyze these communities (i.e. black ash swamps, black spruce/tamarack bogs, pine barren, and white cedar swamps). Still, this years' data and its' comparison with the 1968-69 Davidson data, can be used to inform land managers (public and private), community decision makers and others in how this land will be used and conserved for future generations. Though our data is limited, this report illustrates that the forest communities are multi-aged with high biodiversity of tree and sapling species, sustaining the plant and animal species that are dependent on these communities, as well as the human community. In 1968, Dr. Davidson identified five old growth forests (#13, #39, #40, #41, and #44). These stands continue to thrive today. There are also stands like #4 and #35 that have just reached or soon will achieve old growth status **(Appendix G.).**

The 2003 Brule River State Forest Management Plan outlined a 100 year conservation plan to restore the boreal forest by reducing the amount of aspen density and dominance, while increasing white pine, white spruce and paper birch north of the Town of Brule to the mouth of the river (Van Horn et.al 2003). Data from the boreal forest depicts a forest in recovery from the initial harvest in the 1880's, with later successional to mature old growth forests present in some stands. Analyzing our data from the boreal forest stands indicates over the past 13 years, that the boreal forest has higher tree IV values for balsam fir, white spruce and higher sapling IV values white pine, but a declining presence of paper birch.

Paper birch has been declining throughout the northern portion of Wisconsin since the early 1980's. Our data confirms the continuing trend of the paper birch's precipitous decline, to dangerously low numbers today. One can only guess on how this will change the landscape and the ecology of the area.

A second species of concern in the watershed are the black and green ash. These species are seriously threatened by the introduced emerald ash borer from China. Though not present in the stands we surveyed, the emerald ash borer creeps ever so closer to the Brule River watershed, as the pest was discovered 35 miles to the west in Superior, Wisconsin. What will replace these species? From our data, we can postulate that red maple and balsam fir may be the future benefactors. Red maple and balsam fir density continues to be strong across several forest community types and has

increased in IV values in others that are adjacent to black ash swamps. Red maple and balsam fir have a high tolerance of shade, moisture and soils.

In Phase II we will return to the Davidson plots to record baseline quantitative data on the shrub and groundcover layers in the forest to create a more complete ecological analysis of the forests, by using a modified version of forest sampling methods created by the United States Forest Service (USFS) and the National Park Service (NPS). These reports will be added to earlier scientific works on the Brule River and will serve and inspire future foresters and botanist to repeat the study in another 50 years, just as the Davidson, Thomson and original land surveys inspired the authors of this project.

CHAPTER 2 - LITERATURE CITED

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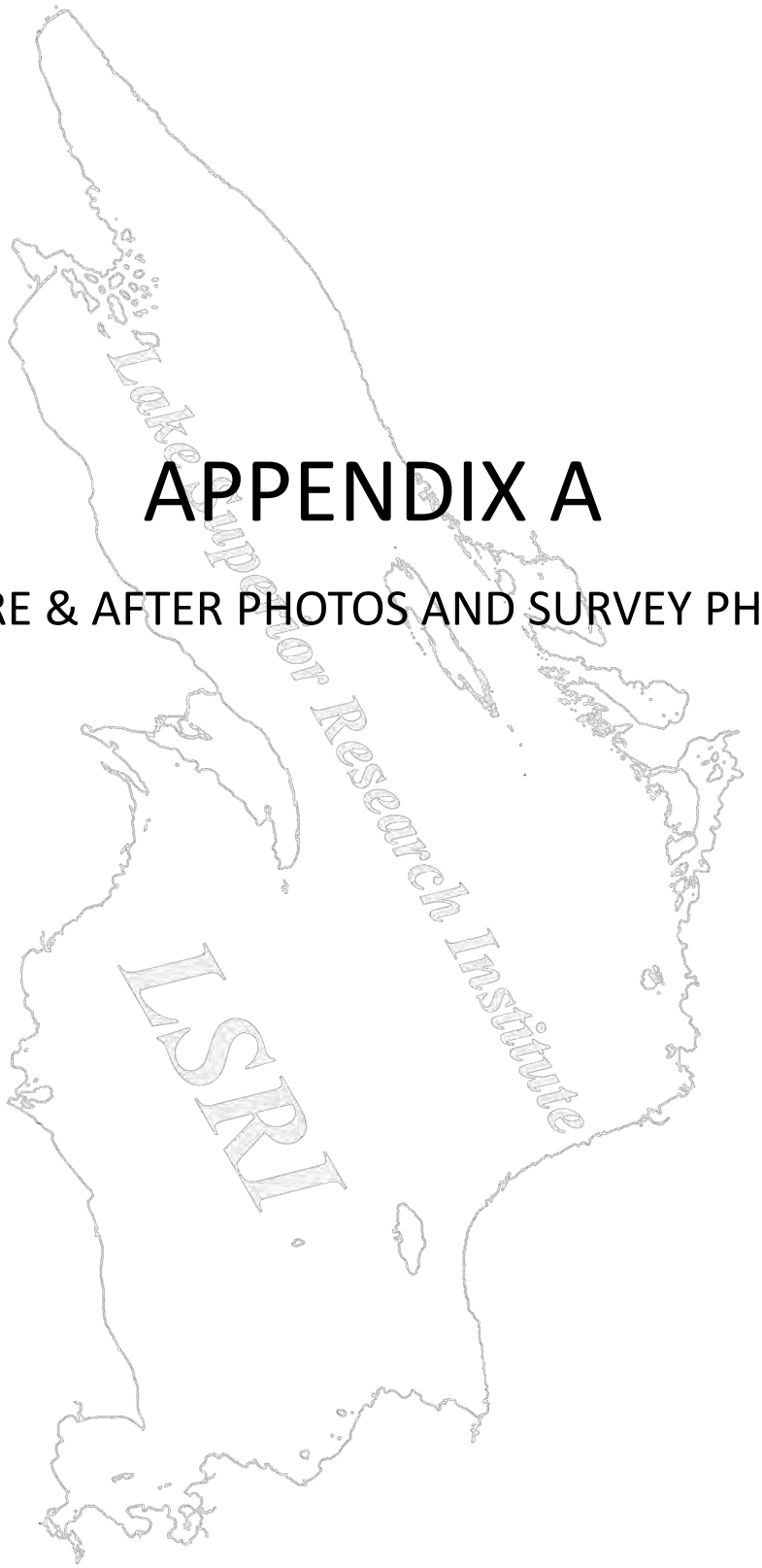


APPENDIX A

BEFORE & AFTER PHOTOS AND SURVEY PHOTOS

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Boreal Forest – (*Erosion From Cut-Over 1880's – 1900)*

1943 NP Johnson Bridge

Eroding bank below N. P. Johnson Bridge. Sec. 15, T.48N., R.10W.

2015 County Road FF,
(formerly the NP Johnson Bridge)

CONIFEROUS FOREST BOG

Winter 1943

The Brule Bog at County P

PLATE 4. The Brule Bog at Highway P. Sec. 8, T.45N., R.11W.

Summer 2015

The Brule Bog at County P

BRULE CONIFEROUS BOG AND SURROUNDING FOREST

1943 Portage Trail – Brule Bog

PLATE 1. Looking eastward across Brule Bog. Sec. 3. T.45N., R.11W. Photograph by Dr. J. W. Thomson.

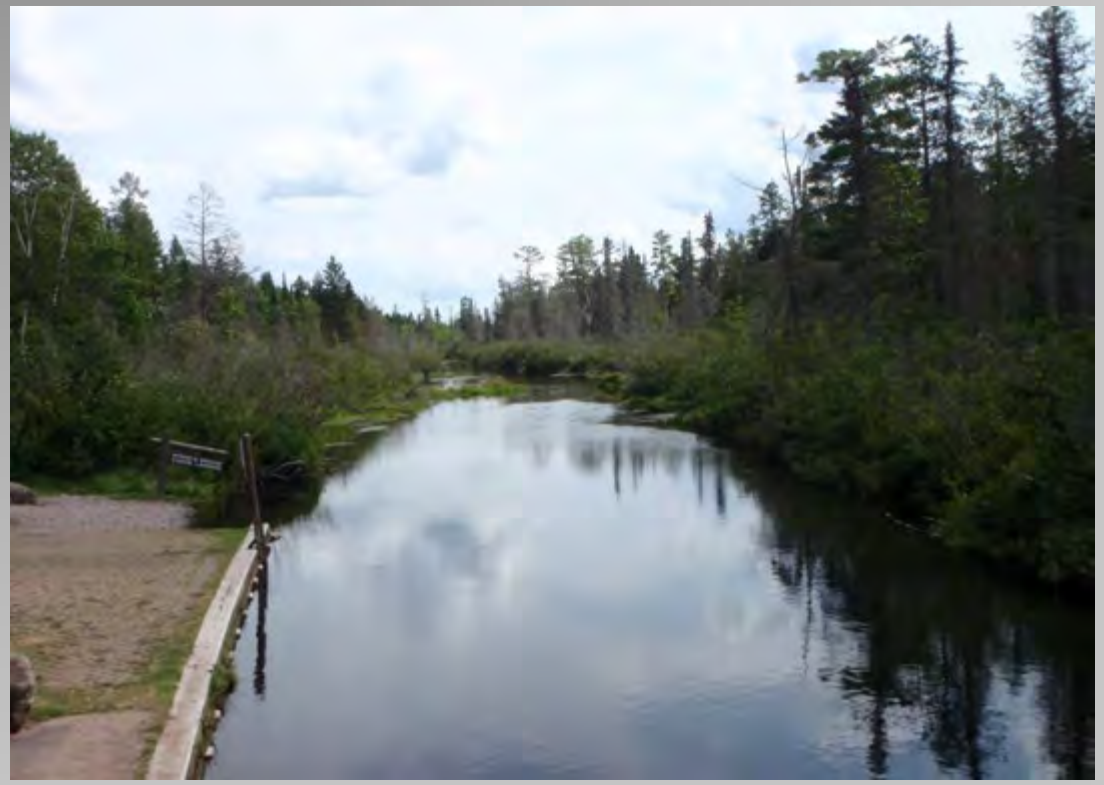
2015 – Portage Trail - Brule Bog

White Cedar Swamps

Winter 1943

PLATE 3. The Brule Bog near Stones Bridge. Sec. 30, T.46N., R.10W.

Summer 2015



PINE BARRENS

Winter 1943 – Lone Pines

PLATE 6. The Barrens. Sec. 32, T.46N., R.10W.

Summer 2015 –

Lone Pines w/oak scrub

NEAR MOTTS RAVINE STATE NATURAL ARAEA

Winter 1943– Sand Barrens

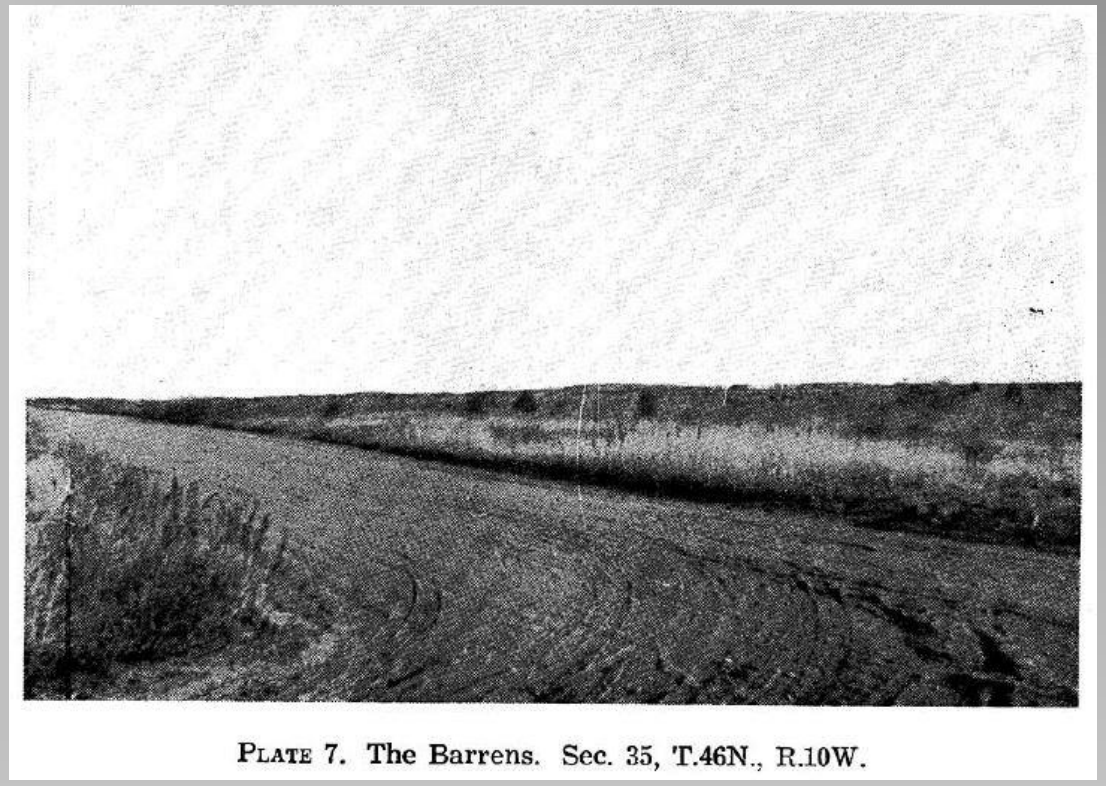


PLATE 7. The Barrens. Sec. 35, T.46N., R.10W.

Summer 2015 – Pine Plantation

PINE BARRENS OPENING

Winter 1943

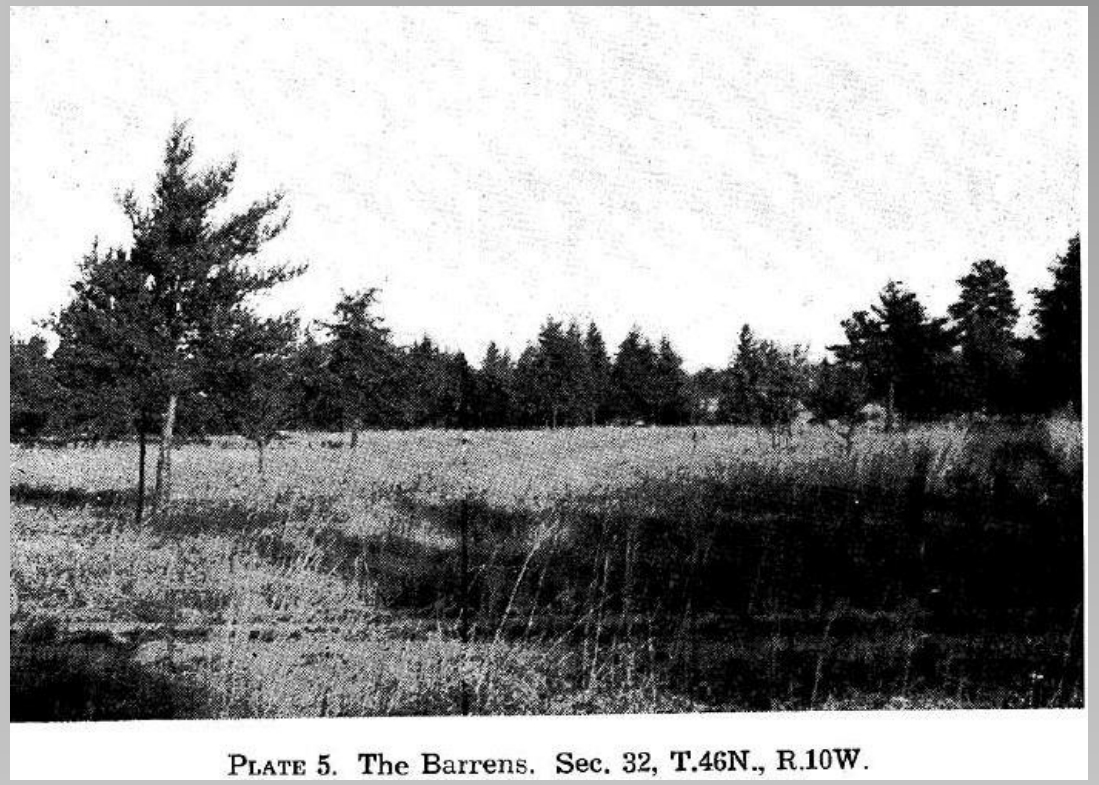


PLATE 5. The Barrens. Sec. 32, T.46N., R.10W.

Summer 2015

DIGITAL COPIES OF JOHN W. THOMSON 1942-1944 COLLECTION

Pine Barrens

White Cedar Swamp

Boreal Forest

Viola labradorica – alpine violet

Boreal Forest

Viburnum lentago, nannyberry

Carex assiniboinensis, Assiniboine sedge

Anemone americana, round-lobed hepatica

Aquilegia canadensis, wild columbine

Triosteum aurantiacum, early horse gentian

Calypso Orchid – *Calypso bulbosa*

White Cedar Swamp

Lapland Buttercup – *Ranunculus lapponicus*

Yellow lady slipper orchid – Cypripedium parviflorum var. makasin

Mountain cranberry - *Vaccinium vitis-idaea*

Dwarf scouring rush - Equisetum scirpoides

Asclepias ovalifolia, oval milkweed

Pine

Chamerion angustifolium, fireweed

Pedicularis canadensis, wood betony

Pinus banksiana, jack pine

Pyrola elliptica, ellipitical shin-leaf

Barrens

Corylus americana, American hazelnut

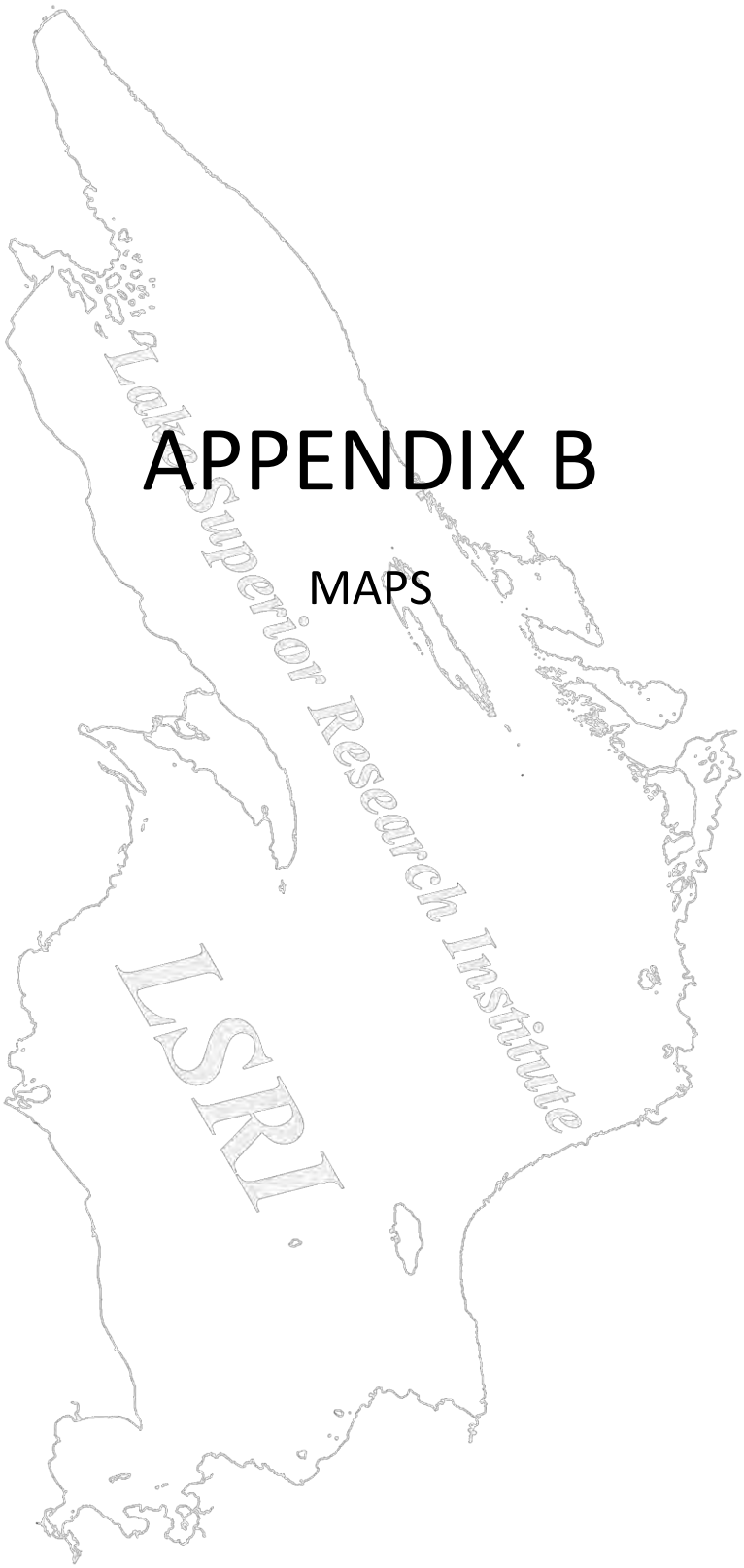
2016 BRULE RIVER WATERSHED BOTANY BLITZ

*Mr Paul Marcum and Mr. Reed Schwarting, surveying a **remote bog** and securing duplicate collections for State herbariums.*

*Dr. Emmet Judziewicz, Ms. Stephanie Glass, Mr. Derek Anderson and Mr. Reed Schwarting re-surveying **a boreal forest ravine** adjacent to the Bois Brule River.*

*Dr. Loy Richard Phillippi, Dr. Brenda Melano-Flores, Dr. Emmet Judziewicz, Mr. Paul Marcum, Mr. Paul Hlina, and Mr. Reed Schwarting gathering associate species growing with Asclepias ovalifolia (a rare species) in the **pine barrens**.*

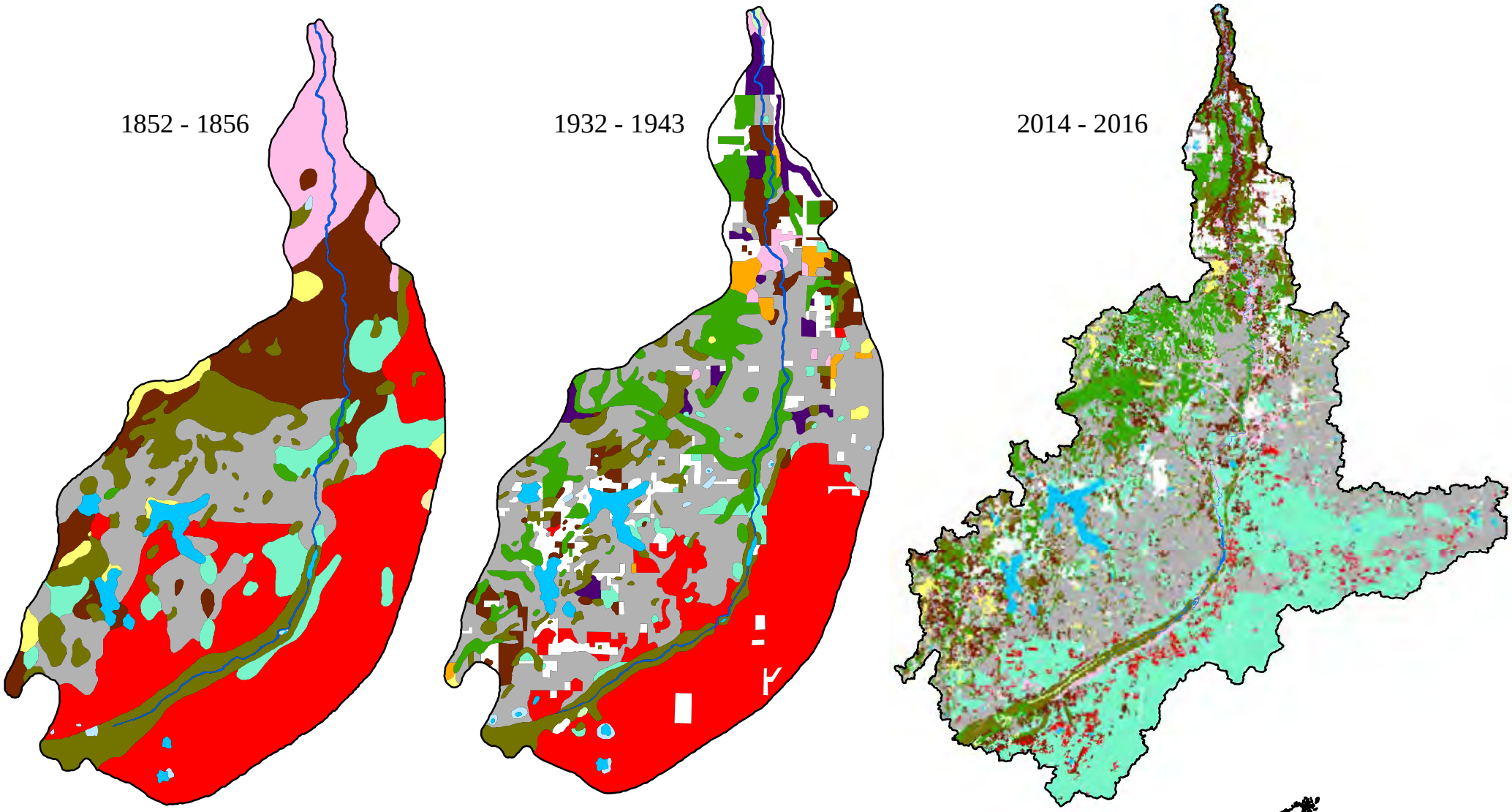
Dr. Loy Richard Phillippi, Dr. Brenda Melano-Flores, Dr. Mary Ann Feist pressing aquatic plants from the Bois Brule River .



APPENDIX B

MAPS

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

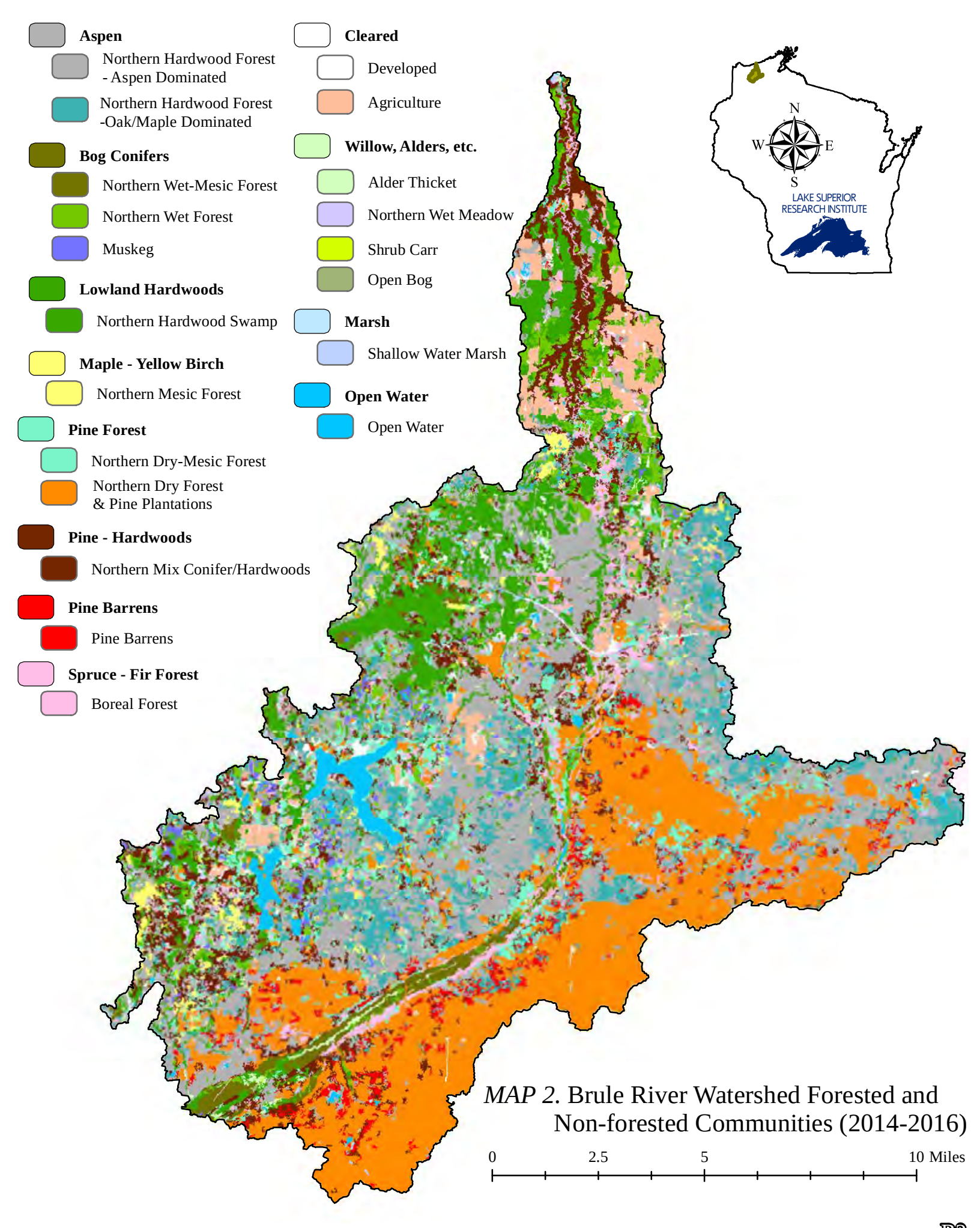


Map 1. Brule River Watershed Forested and Non-Forested Community Transistion (1852-2016)

- Aspen
- Bog Conifers
- Brule River
- Cleared
- Lowland Hardwoods
- Maple - Yellow Birch
- Maple Coppice
- Marsh
- Open Water
- Pine - Hardwoods
- Pine Barrens
- Pine Forest*
- Small Fir and Aspen
- Spruce - Fir Forest
- Willow, Alders, etc.

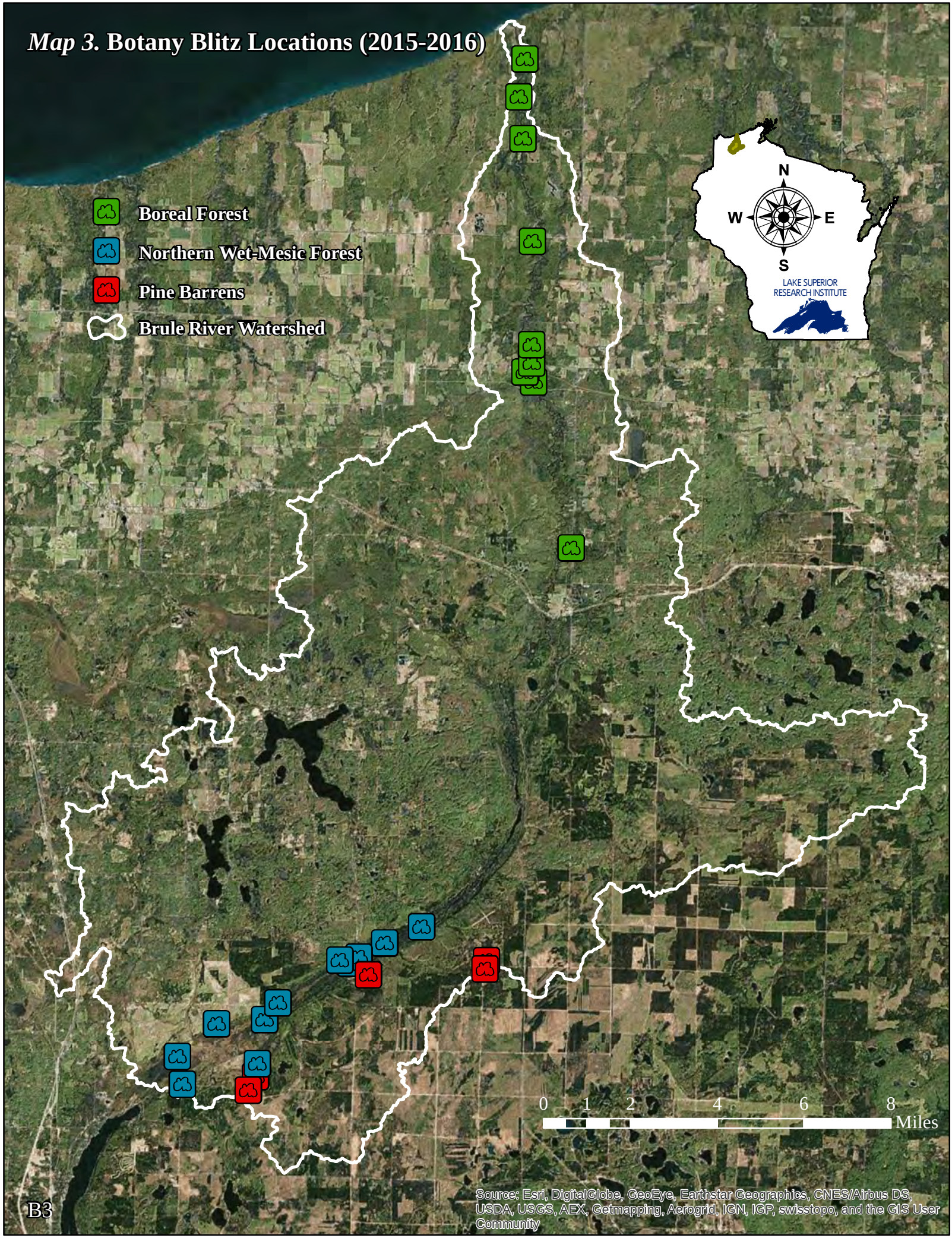
It should be noted that the 2014-2016 map does not accurately reflect the communities that were historically considered Pine Forest. The majority of the community type shown under that category is red and jack pine plantations. Please see Map 3. for more detail.

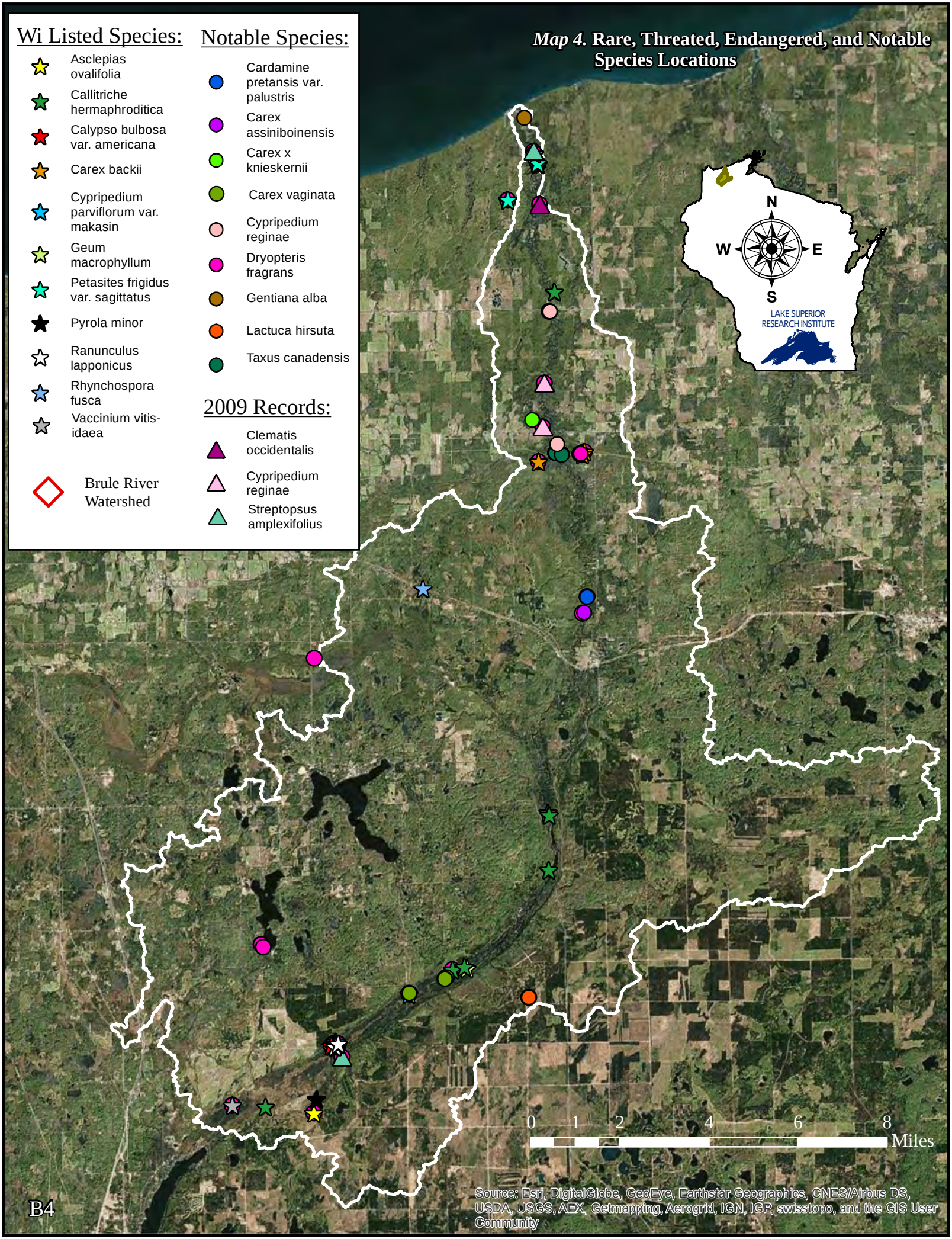
B1

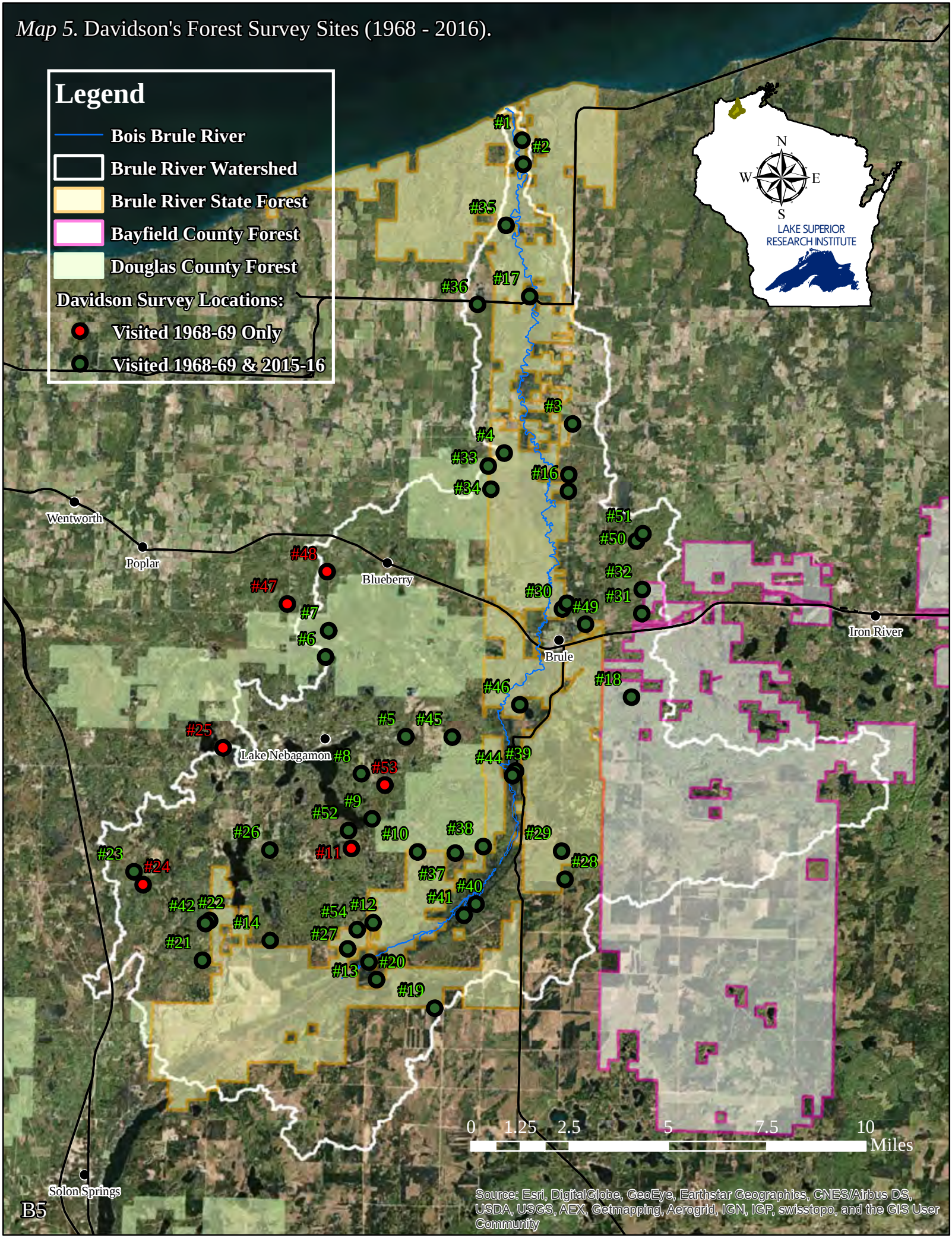


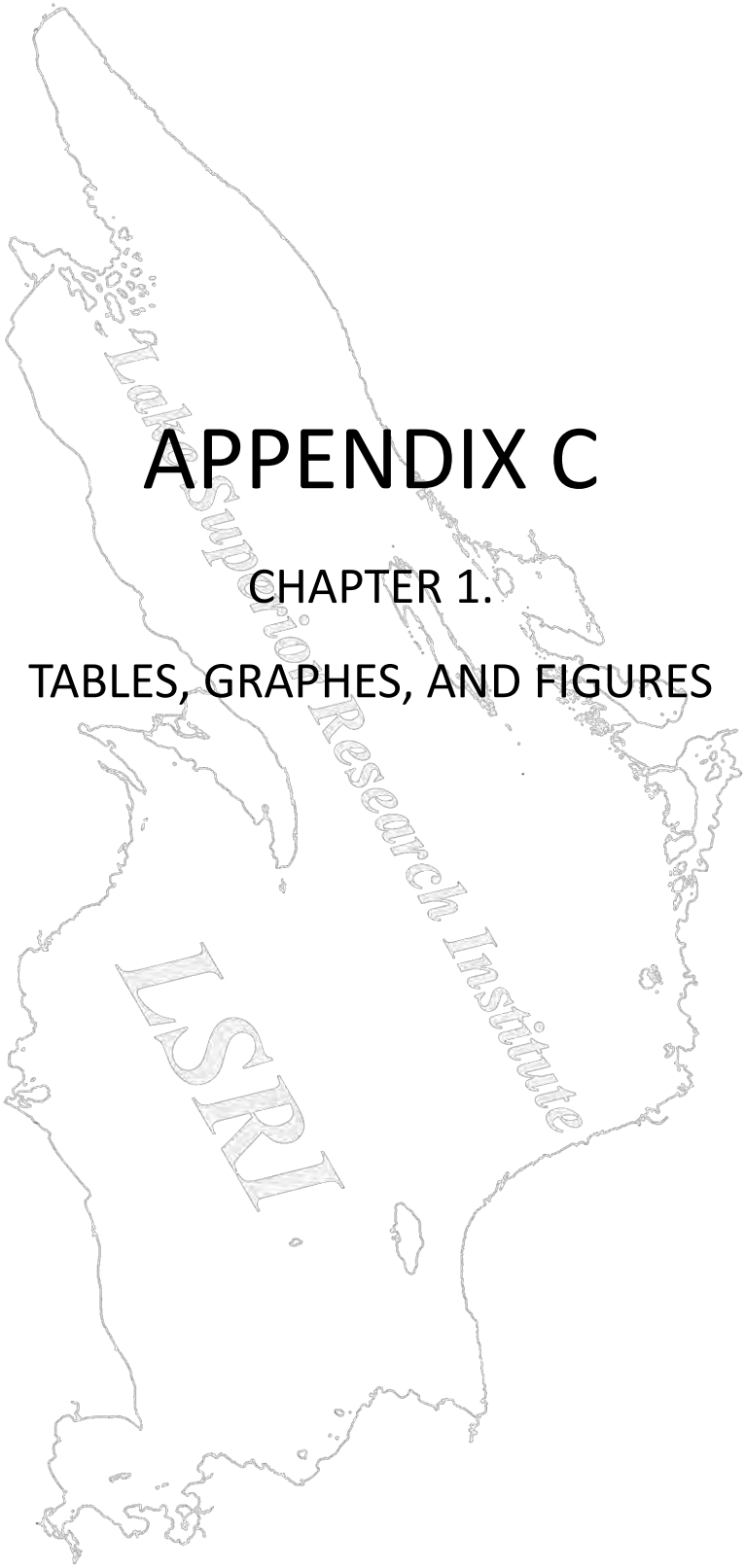
MAP 2. Brule River Watershed Forested and Non-forested Communities (2014-2016)

B2


Map 3. Botany Blitz Locations (2015-2016)
Boreal Forest
Northern Wet-Mesic Forest
Pine Barrens
Brule River Watershed
N
W
E
S
LAKE SUPERIOR
RESEARCH INSTITUTE
0 1 2 4 6 8
Miles
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
B3


Wi Listed Species:
Asclepias ovalifolia
Callitriche hermaphroditica
Calypso bulbosa var. americana
Carex backii
Cypripedium parviflorum var. makasin
Geum macrophyllum
Petasites frigidus var. sagittatus
Pyrola minor
Ranunculus lapponicus
Rhynchospora fusca
Vaccinium vitis-idaea
Brule River Watershed
Notable Species:
Cardamine pretansis var. palustris
Carex assiniboinensis
Carex x knieskernii
Carex vaginata
Cypripedium reginae
Dryopteris fragrans
Gentiana alba
Lactuca hirsuta
Taxus canadensis
2009 Records:
Clematis occidentalis
Cypripedium reginae
Streptopsus amplexifolius
Map 4. Rare, Threated, Endangered, and Notable Species Locations
N
W
E
S
LAKE SUPERIOR RESEARCH INSTITUTE
0 1 2 4 6 8
Miles
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
B4


Map 5. Davidson's Forest Survey Sites (1968 - 2016).
Legend
Bois Brule River
Brule River Watershed
Brule River State Forest
Bayfield County Forest
Douglas County Forest
Davidson Survey Locations:
Visited 1968-69 Only
Visited 1968-69 & 2015-16
N
W
E
S
LAKE SUPERIOR RESEARCH INSTITUTE
#1
#2
#35
#36
#17
#3
#4
#33
#16
#34
#51
#50
#32
#31
#30
#49
#48
#47
#7
#6
Wentworth
Poplar
Blueberry
Brule
Iron River
#46
#18
#25
#5
#45
Lake Nebagamon
#8
#53
#44
#39
#9
#52
#26
#10
#38
#29
#23
#24
#11
#37
#28
#40
#41
#42
#22
#54
#12
#14
#27
#21
#20
#13
#19
0 1.25 2.5 5 7.5 10
Miles
Solon Springs
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
B5



APPENDIX C

CHAPTER 1.

TABLES, GRAPHES, AND FIGURES

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Table 1. Area summary of community types across time periods, maps 1 and 2.

Community Types (1852-1944)	Land cover in acres by digitized maps:				LSRI Community Types (2016)
	1852-1856	1932-1943	2014-2016[1]	2014-2016[2]	
Aspen	18803.4	37480.9	39041.3		
				30286.6	Northern Hardwood Aspen Dominated
				8754.7	Northern Hardwood Oak/Maple Dominated
Bog Conifers	16561.8	8822.5	7574.2		
				2252.2	Northern Wet-Mesic Forest
				4292.2	Northern Wet Forest
				1029.8	Muskeg
Lowland Hardwoods	568.1	12325.5	11789.5		
				11789.5	Northern Hardwood Swamps
Maple - Yellow Birch	2283.2	474.4	1694.2		
				1694.2	Northern Mesic Forest
Pine Forest	9017.2	2176.2	31908.5		
				5885.4	Northern Dry-Mesic Forest
				26023.1	Northern Dry Forest & Pine Plantations
Pine - Hardwoods	16598.6	5179.0	10219.2		
				10219.2	Northern Mix Conifer/Hardwoods
Pine Barrens	41717.2	30355.5	2151.1		
				2151.1	Pine Barrens
Spruce - Fir Forest	8434.1	1066.3	4290.9		
				4290.9	Boreal Forest
Cleared	0.0	9910.0	5003.0		
				1008.9	Developed
				3994.1	Agriculture
Willow, Alders, etc.	0.0	146.3	1288.2		
				621.0	Alder Thicket
				106.1	Northern Wet Meadow
				25.3	Shrub Carr
				535.8	Open Bog
Marsh	209.2	497.9	433.9		
				433.9	Shallow Water Marsh
Open Water	3681.8	3662.8	1979.7		
				1979.7	Open Water
Maple Coppice	112.9	1586.7	0.0		
Small Fir & Aspen	0.0	3084.8	0.0		
Totals:	**117987.5**	**116768.8**	**117373.7**		

[1]*The years of 2014-16 were grouped using Fassett's and Thomson's community designations.*

[2]*The years of 2014-16 were grouped using the Curtis' community designations.*

Table 2. Wiscland 2.0 land use classification

Wiscland 2.0 Class Categories				LSRI Natural Communities Designations	Area (Acres)
Level 1	Level 2	Level 3	Level 4		
Agriculture (2000)	Crop Rotation (2100)	Dairy Rotation (2130)		Agriculture	103.0
Barren (7000)				Developed	71.6
Open Water (5000)				Open Water	1860.2
Urban/Developed (1000)	Developed, High Intensity (1100)			Developed	64.5
	Developed, Low Intensity (1200)			Developed	531.4
Grassland (3000)	Forage Grassland (3100)	Hay (3110)		Agriculture	842.3
		Pasture (3120)		Agriculture	1784.4
	Idle Grassland (3200)	Cool-season Grass (3210)		Agriculture	1062.0
		Warm-season Grass (3220)		Agriculture	202.4
Forest (4000)	Coniferous Forest (4100)	Fir Spruce (4110)		Boreal Forest	4290.9
		Pine (4120)	Jack Pine (4121)	Northern Dry Forest	13729.6
			Red Pine (4122)	Northern Dry Forest	12293.5
			White Pine (4123)	Northern Dry-mesic Forest	5885.4
		Hemlock Hardwoods (4130)		Northern Mesic Forest	34.3
	Broad-leaved Deciduous Forest (4200)	Aspen/Paper Birch (4210)	Aspen Forest (4211)	Northern Hardwood Forest Aspen Dominated	21805.5
			Paper Birch (4212)	Northern Hardwood Forest Aspen Dominated	8481.1
		Red Maple (4220)		Northern Hardwood Forest Oak/Maple Dominated	513.9
		Oak (4230)	N. Pin Oak, Black Oak (4231)	Pine Barrens	2151.1
			Red Oak (4232)	Northern Hardwood Forest Oak/Maple Dominated	8240.8
		Northern Hardwoods (4250)	Sugar Maple (4251)	Northern Mesic Forest	156.8
			Other Northern Hardwoods (4252)	Northern Mesic Forest	1503.1
	Mixed Deciduous/Coniferous Forest (4300)			Northern Mix Conifer/Hardwoods	10219.2
Wetland (6000)	Floating Aquatic Herbaceous Vegetation (6100)			Open Water	119.5
	Emergent/Wet Meadow (6200)	Cattails (6210)		Shallow Water Marsh	433.9
		Reed Canary Grass (6220)		Developed	341.4
		Other Emergent/Wet Meadow (6230)		Northern Wet Meadow	106.1
	Lowland Scrub/ Shrub (6300)	Broad-leaved Deciduous Scrub/Shrub (6310)	Other Broad-leaved Deciduous Scrub/Shrub (6312)	Alder Thicket	621.0
		Broad-leaved Evergreen Scrub/Shrub (6320)		Open Bog	535.8
		Needle-leaved Scrub/Shrub (6330)		Shrub Carr	25.3
	Forested Wetland (6400)	Coniferous Forested Wetland (6410)	White Cedar (6411)	Northern Wet-mesic Forest	2252.2
			Black Spruce (6412)	Northern Wet Forest	871.8
			Tamarack (6413)	Muskeg	1029.8
			Other Coniferous Forested Wetland (6414)	Northern Wet Forest	3420.4
		Aspen Forested Wetland (6420)	Aspen Forested Wetland (6420)	Northern Hardwood Swamp	6925.7
		Swamp Hardwoods (6440)	Black Ash (6441)	Northern Hardwood Swamp	4825.7
			Other Swamp Hardwoods (6442)	Northern Hardwood Swamp	35.2
		Mixed Deciduous/Coniferous Forested Wetland (6550)		Northern Hardwood Swamp	2.9

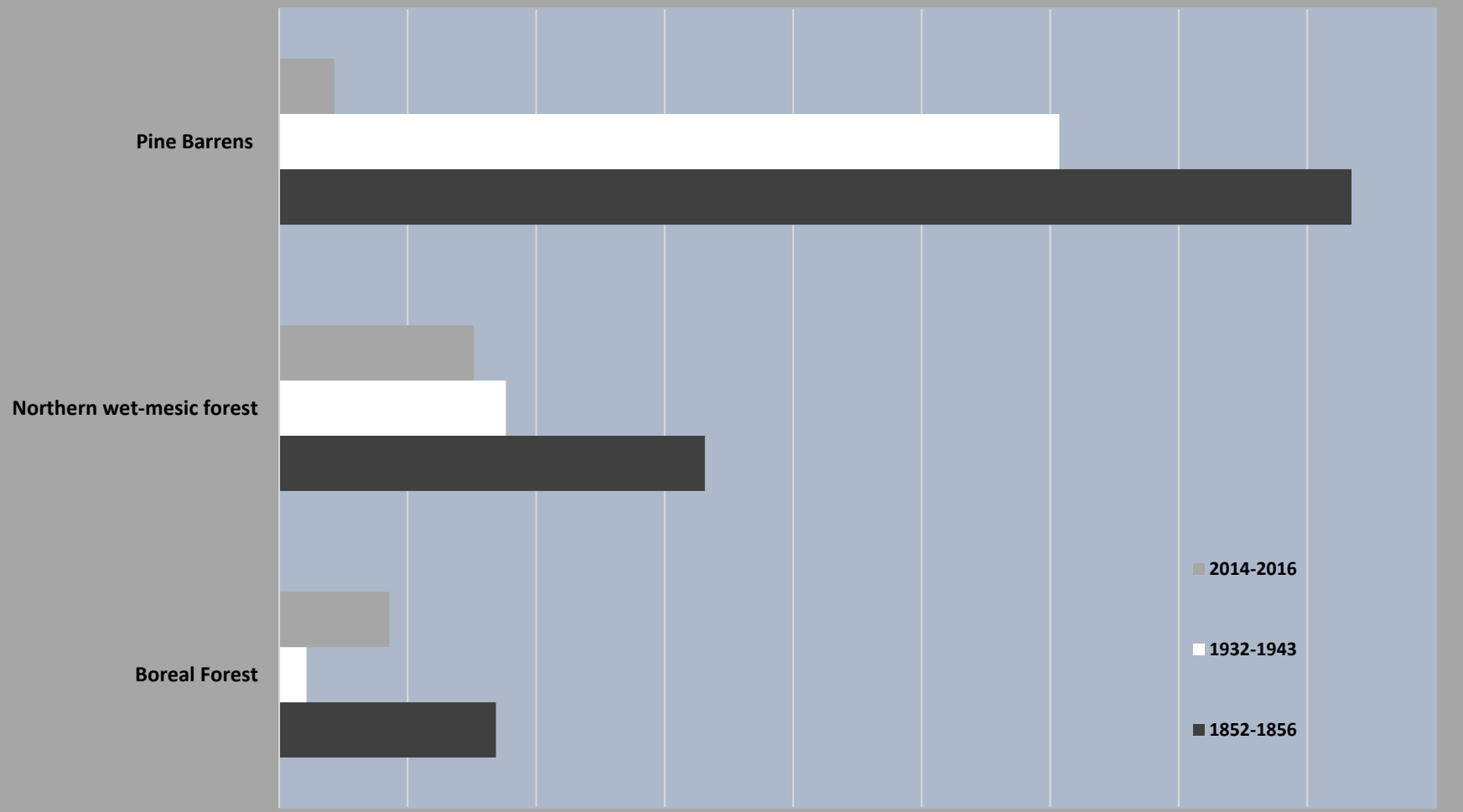


Figure 1. **Vegetaive Cover Change of the Brule River Watershed**

Table 3. Sørenson coefficient comparison between boreal forest sites.

Boreal Forest	Rocky Run	May' Ledges (S)	May's Ledges (east)	Lenroot Ledges (east)	Lenroot Ledges (west)	Weir Riffles	Trask Creek	Harvey Road	Fredericks	BF10
Rocky Run (152)		**0.5422**	**0.5**	**0.5157**	**0.5369**	**0.4806**	**0.5723**	**0.4679**	**0.44**	**0.5524**
Mays Ledges (S) (127)			**0.6124**	**0.5525**	**0.7022**	**0.5526**	**0.6181**	**0.5106**	**0.5364**	**0.6094**
Mays Ledges (east) (131)				**0.54406**	**0.5502**	**0.5862**	**0.6301**	**0.5356**	**0.6161**	**0.5328**
Lenroot Ledges (east) (130)					**0.5833**	**0.5541**	**0.5155**	**0.4874**	**0.5202**	**0.5328**
Lenroot Ledges (west) (182)						**0.5866**	**0.6531**	**0.5724**	**0.5891**	**0.6434**
Weir Riffles (101)							**0.6489**	**0.689**	**0.5155**	**0.6087**
Trask Creek (161)								**0.6766**	**0.4961**	**0.6025**
Harvey Road (108)									**0.4876**	**0.6076**
Fredericks (93)										**0.6344**
BF10 (129)										

Table 4. Sørenson coefficient comparison between Northern Wet-Mesic Forest sites. Highlighted cell indicate rejected communities.

Northern Wet-Mesic Forest	Leppala	Divide Swamp	Stone Chimney	Blue Springs	Cedar NW	Angel Creek	McDougal Springs	Stones Bridge 1	Stones Bridge 2	CS7	CS8	CS11
Leppala (81)		**0.3273**	**0.3378**	**0.4272**	**0.442**	**0.3976**	**0.3825**	**0.3333**	**0.4309**	**0.3841**	**0.4686**	**0.4938**
Divide Swamp (84)			**0.5828**	**0.5072**	**0.4565**	**0.4523**	**0.5699**	**0.6394**	**0.59887**	**0.4675**	**0.5185**	**0.5347**
Stone Chimney (67)*				**0.4375**	**0.4431**	**0.4615**	**0.4615**	**0.5023**	**0.5**	**0.4526**	**0.4535**	**0.4324**
Blue Springs (125)					**0.7111**	**0.675**	**0.6872**	**0.6933**	**0.6697**	**0.544**	**0.6286**	**0.6667**
Cedar NW (100)						**0.6791**	**0.6878**	**0.66**	**0.6321**	**0.5294**	**0.6048**	**0.633**
Angel Creek (115)							**0.636**	**0.6296**	**0.6442**	**0.5081**	**0.6**	**0.6609**
McDougal Springs (102)								**0.6831**	**0.7692**	**0.5**	**0.5314**	**0.7353**
Stones Bridge 1 (100)									**0.7254**	**0.7254**	**0.6364**	**0.6446**
Stones Bridge 2 (93)										**0.47**	**0.6439**	**0.6606**
CS7 (70)											**0.5714**	**0.5934**
CS8 (105)												**0.6278**
CS11 (118)												

**Site remains in calculations even thougn having a low Sørenson coefficient when compared to the other sites.*

Table 5. Sørenson coefficient comparison between Pine Barren sites. Highlighted cell indicate rejected communities.

Pine Barrens	Highland	Moreland	Motts North	Motts South	Pine Barren 1	Pine Barren 2
Highland (102)		**0.4768**	**0.5377**	**0.4725**	**0.5189**	**0.5792**
Moreland (49)			**0.415**	**0.4031**	**0.4091**	**0.4317**
Motts North (90)				**0.6211**	**0.601**	**0.62**
Motts South (83)					**0.638**	**0.58824**
Pine Barren 1 (90)						**0.7871**
Pine Barren 2 (80)						

Boreal Forest

1942-44 THOMSON		
% by Form		
Form	#Species	%
Tree	16	15.2
Shrub	21	20.0
Forb	57	54.3
Graminoids	8	7.6
Vine	3	2.9
Total	105	100%

BF BOTANY BLITZ_2015-2016		
% by Form		
Form	#Species	%
Tree	27	7.7
Shrub	50	14.3
Forb	205	58.7
Graminoids	62	17.8
Vine	5	1.4
Total	349	100%

Table 6. Boreal forest plant growth form changes in the past 72 years.

Northern wet-mesic forest (Cedar Swamps)

Thomson		
% by Form		
Form	#Species	%
Tree	6	7.228916
Shrub	14	16.86747
Forb	55	66.26506
Graminoid	8	9.638554
Vine	0	0
Total	83	100%

WC BOTANY BLITZ 2015		
% by Form		
Form	#Species	%
Tree	18	6.896552
Shrub	48	18.3908
Forb	142	54.40613
Graminoid	51	19.54023
Vine	2	0.766284
Total	261	100%

Table 7. Northern wet-mesic forest plant growth form changes in the past 72 years.

Pine Barrens

1943-44 Thomson		
% by Form		
Form	Species	%
Trees	7	5.511811
Shrubs	19	14.96063
Forbs	81	63.77953
Graminoids	18	14.17323
Vine	1	0.787402
Moss	1	0.787402
Total	127	100

PB BOTANY BLITZ, 2015		
% by Form		
Form	Species	%
Trees	12	6.349206
Shrubs	27	14.28571
Forbs	117	61.90476
Graminoids	31	16.40212
Vine	1	0.529101
Moss	1	0.529101
Total	189	100

Table 8. Pine barrens plant growth form changes in the past 72 years.

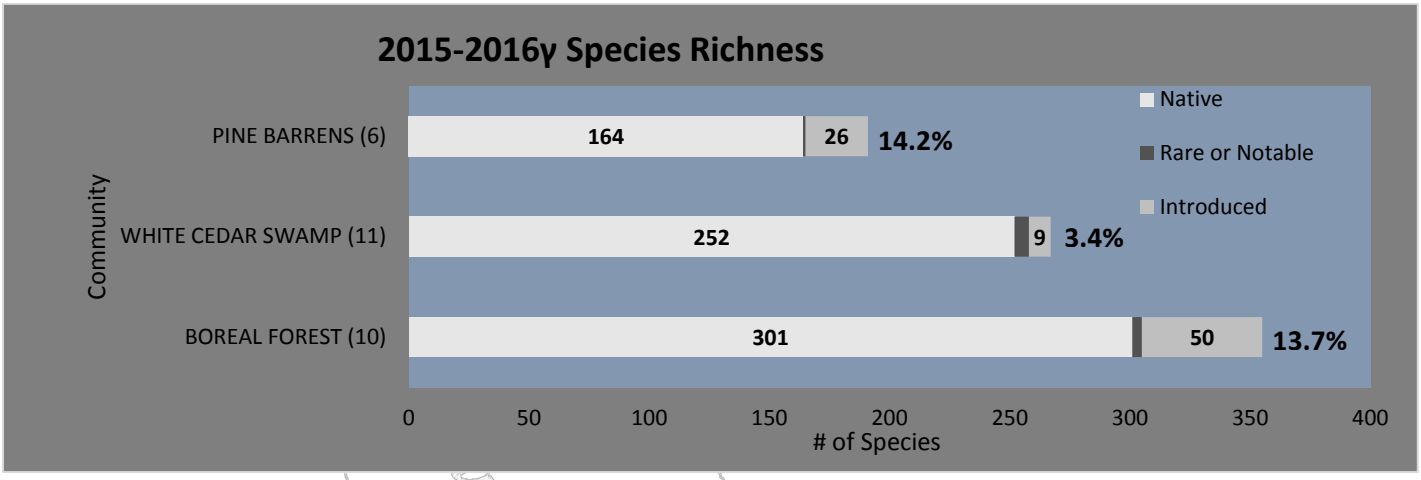


Figure 2. Boreal forest has greatest species richness with 351 species today, while the pine barrens has the lowest number of species at 190 and the largest percentage (14.3%) of introduced species.

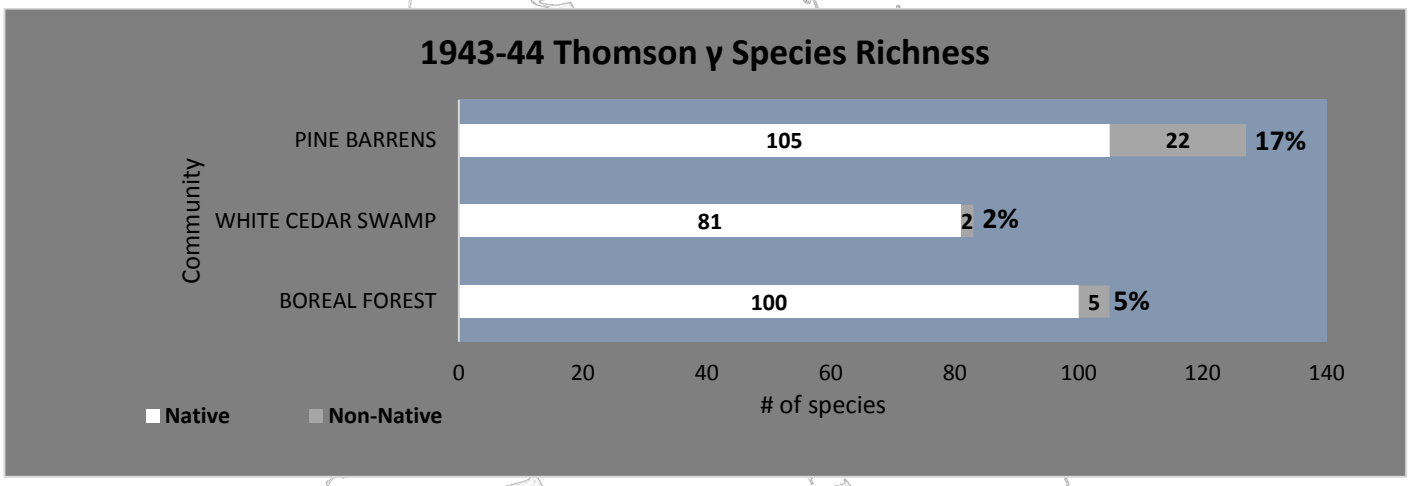


Figure 3. Pine barrens had the greatest species richness with 127 species and the largest percentage (17%) of introduced species. Note that Thomson species richness is lower in all communities. This is a reflection of available human resources for field work than drastic changes in plant communities.

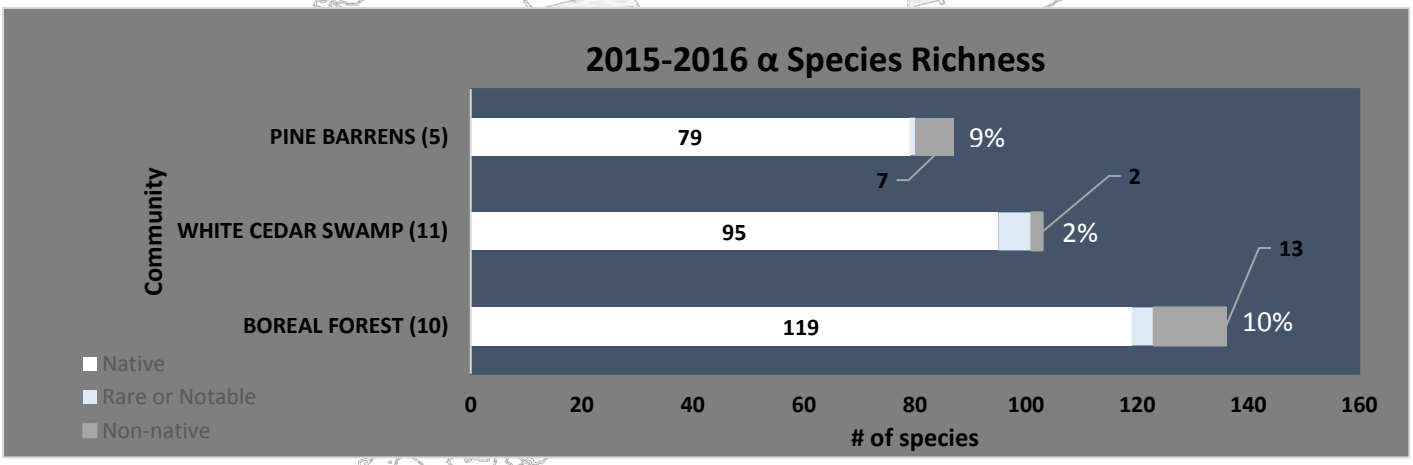


Figure 4. 2015-2016 Alpha species averages for each community type.

2015 Boreal Forest			2015 Northern Wet-Mesic Forest (white cedar)			2015 Pine Barrens		
Species	Freq of occurence	Freq of A or C	Species	Freq of occurence	Freq of A or C	Species	Freq of occurence	Freq of A or C
Eurybia macrophylla	100	100	Rubus pubescens	100	100	Comptonia peregrina	100	100
Maianthemum canadense	100	90	Coptis trifolia	100	100	Corylus americana	100	100
Pteridium aquilinum	100	80	Maianthemum canadense	100	91	Prunus pumila	100	100
Aralia nudicaulis	80	100	Trientalis borealis	100	82	Rubus flagellaris	100	100
Cornus canadensis	100	50	Cornus canadensis	100	82	Carex pensylvanica	100	100
Carex gracillima	100	50	Clintonia borealis	100	64	Vaccinium angustifolium	100	100
Athyrium filix-femina	90	67	Gaultheria hispidula	100	64	Andropogon gerardii	83	100
Rubus parviflorus	90	67	Mitella nuda	100	55	Danthonia spicata	83	100
Cornus sericea	90	56	Alnus incana	100	55	Quercus macrocarpa	100	83
Equisetum arvense	90	56	Osmunda cinnamomea	100	55	Quercus ellipsoidalis	100	83
Anemone quinquefolia	80	63	Aralia nudicaulis	91	50	Monarda fistulosa	83	80
Corylus cornuta	80	63	Orthilla secunda	91	50	Hieracium aurantiacum	100	50
Calamagrostis canadensis	80	50	Ilex verticillata	82	56	Schizachyrium scoparium	100	50
Alnus incana	80	50	Acer spicatum	82	56	Solidago nemoralis	100	50
			Carex disperma	82	56	Acrostaphylos uva-ursi	83	60
						Bromus kalmii	83	60

Table 9. - Boreal Forest, Northern wet-mesic forest and pine barren prevalent species.

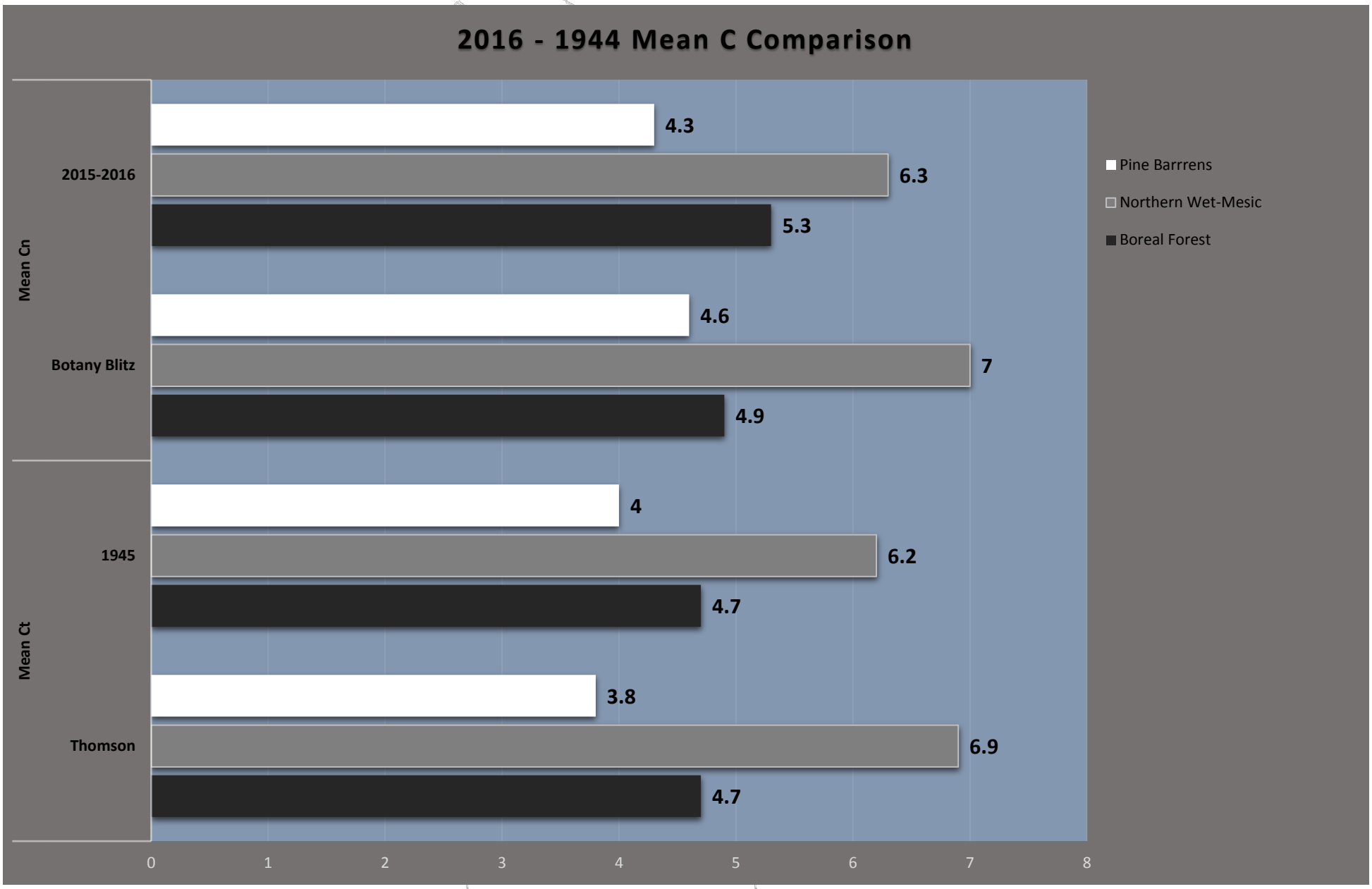
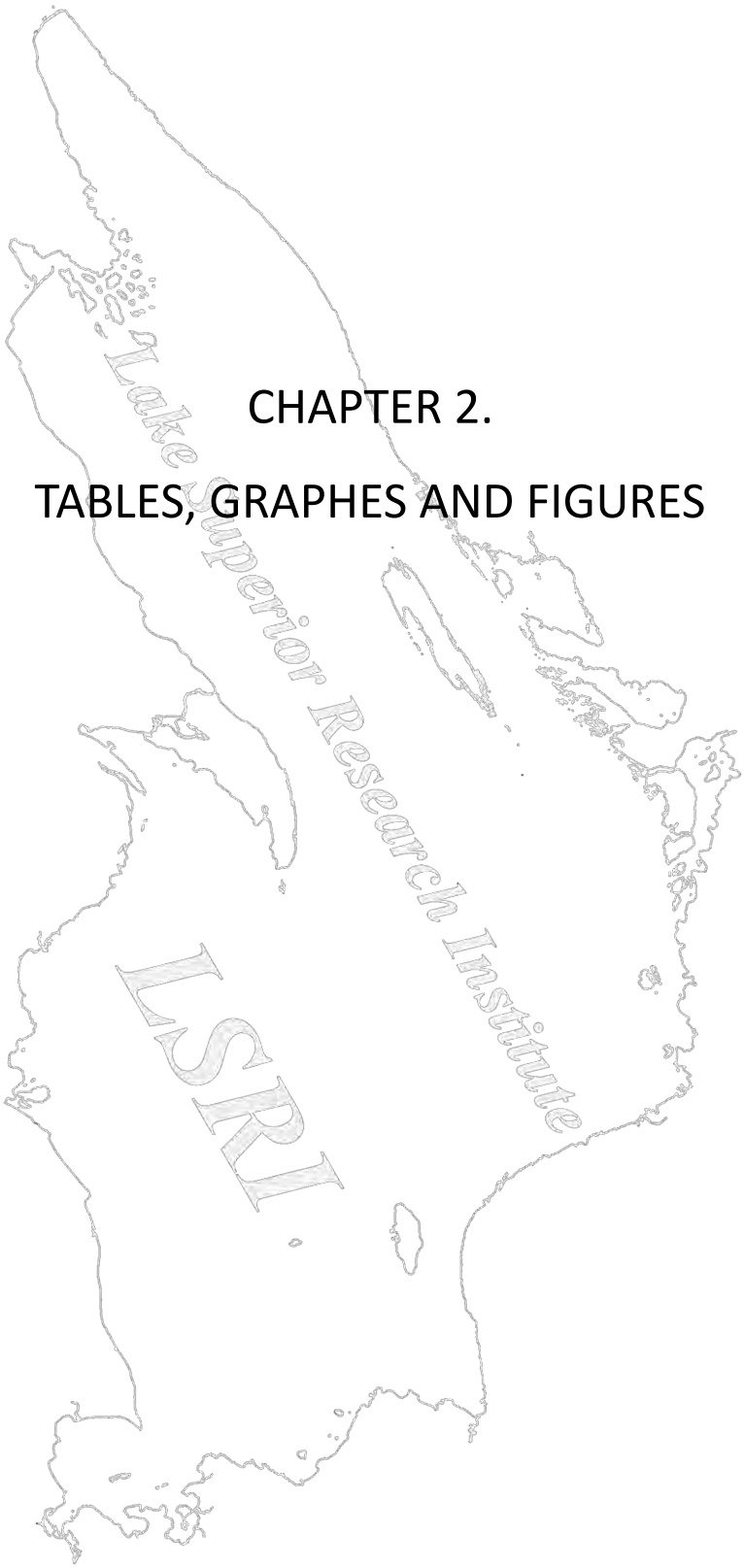


Figure 5. Mean Cn and Mean Ct values temporally and by community type.



CHAPTER 2.

TABLES, GRAPHES AND FIGURES

Table 10. Bray-Curtis Dissimilarity Distances for forest communities in the Brule River watershed.

*Forest Community Type	[1]1968T_2015T	[2]1968S_2015T	[3]2015T_2015S
Boreal Forest	0.26	0.31	0.31
Northern Dry-Mesic Forest (Old Growth)	0.28	0.45**	0.28
Northern Hardwood Forest - Aspen	0.36	0.33	0.37
Northern Hardwood Forest – Oak, Maple	0.37	0.42	0.26
Northern Mixed Conifer/Hardwood Forest	0.29	0.31	0.27
Northern Mesic Forest	0.31	0.37	0.24

T=Tree; S= Shrub

*The Pine Barrens, Northern Hardwood Swamp, Northern Wet-Mesic Forest and Northern Wet Forest community type stands were poorly represented (only 1 or 2) and not analyzed by this metrics.

** The northern dry-mesic forest (old growth) exhibits a higher dissimilarity distance in the past 47 years with red and white pine saplings missing. If low intensity fires are not introduced in combination with some opening in these communities, it is likely the future forest will be dominated by red maple and red oak.

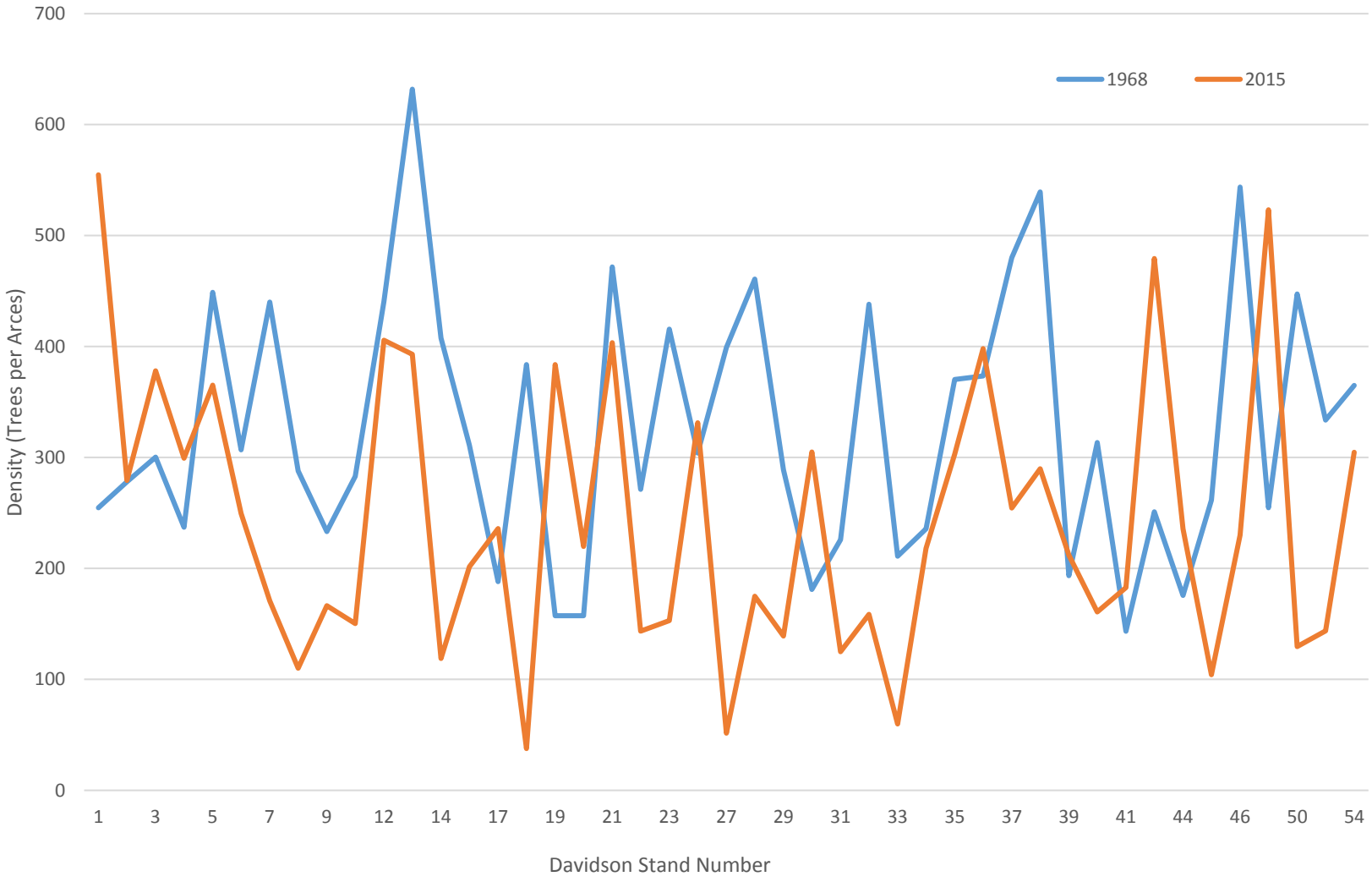


Figure 6. Comparing the Absolute Density of trees for each surveyed site in the Brule River Watershed

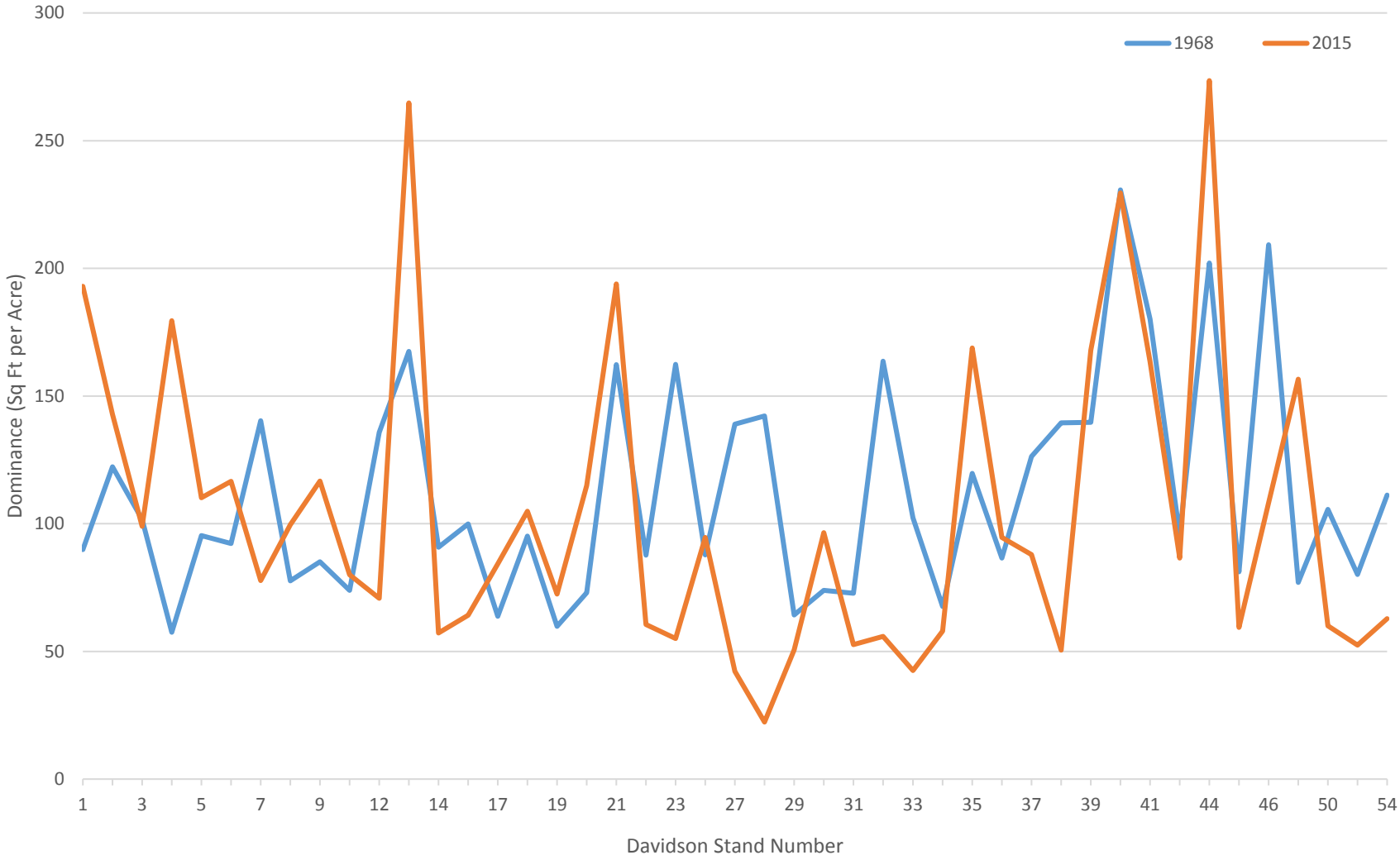
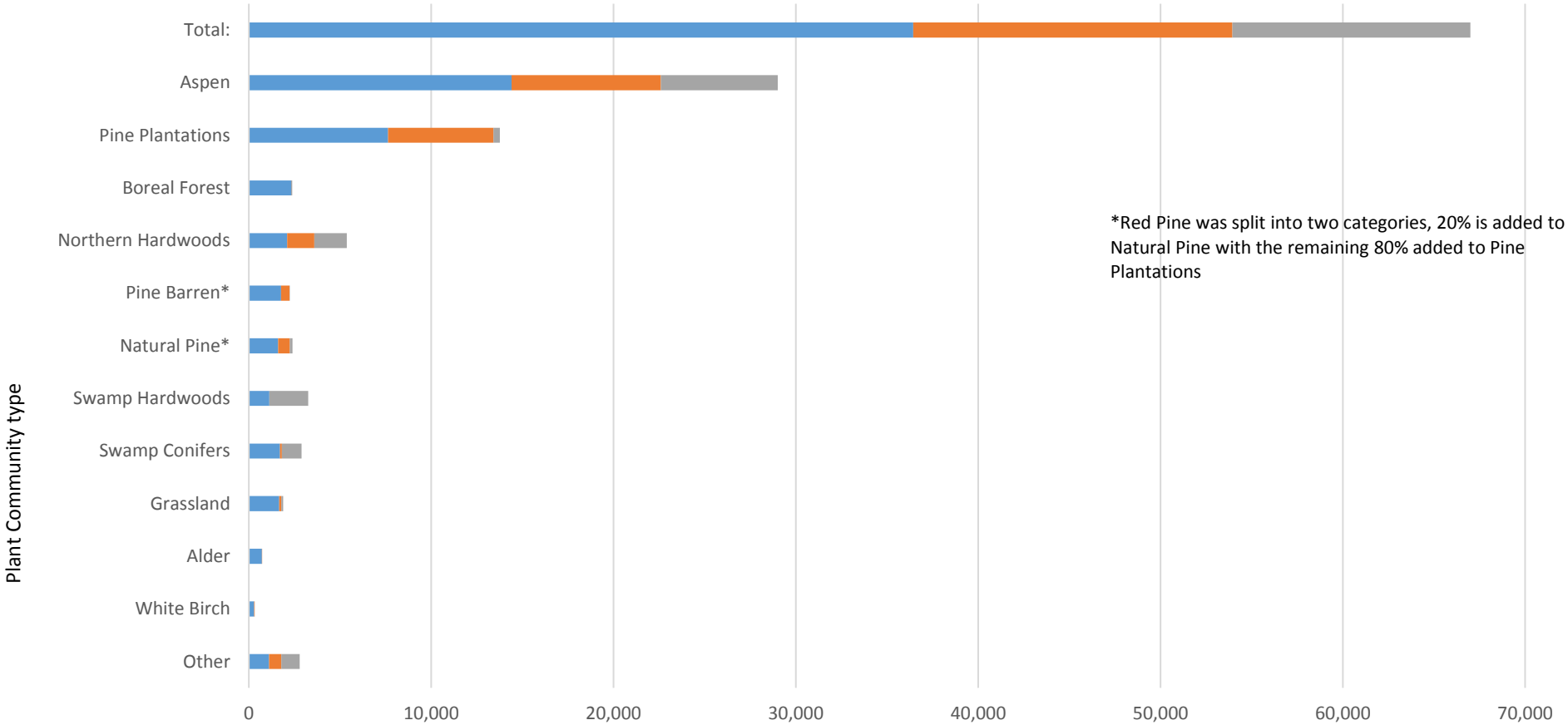


Figure 7. Comparing the absolute dominance of trees for each surveyed stand in the Brule River Watershed

Table 11. Site Number and Forest Community type - Dr. Davidsons Stands 1968-69
BRSF – Brule River State Forest Stands; DCF – Douglas County Forest Stands; BCF – Bayfield County Forest Stands; PV- Private Forest Stands

Forest Stand #	Plant Community Type (1968- 1968)	Forest Stand #	Plant Community Type (1968- 1968)
#01 BRSF	Boreal Forest	#28 PV	Northern hardwood Forest - Oak, Maple
#02 BRSF	Boreal Forest	#29 BRSF	Northern hardwood Forest - Oak, Maple
#03 PV	Northern Mixed Conifer/ Hardwood Forest	#30 BRSF	Northern Hardwood Forest_Aspen
#04 BRSF	Northern Mesic Forest	#31 PV	Northern hardwood Forest - Oak, Maple
#05 PV	Northern Wet Forest	#32 PV	Northern hardwood Forest - Oak, Maple
#06 PV	Northern Mixed Conifer/ Hardwood Forest	#33 DCF	Northern Mesic Forest
#07 DCF	Northern Hardwood Swamp	#34 BRSF	Northern Mesic Forest
#08 PV	Northern Mixed Conifer/ Hardwood Forest	#35 BRSF	Boreal Forest
#09 PV	Northern Mixed Conifer/ Hardwood Forest	#36 PV	Northern Hardwood Forest_Aspen
#10 BRSF	Northern Mixed Conifer/ Hardwood Forest	#37 PV	Northern Hardwood Forest_Aspen
#11 PV	Northern Mesic Forest	#38 DCF	Northern Hardwood Forest_Aspen
#12 BRSF	Northern Hardwood Forest_Aspen	#39 PV	Northern Dry-Mesic Forest
#13 BRSF	Northern Wet-Mesic Forest	#40 PV	Northern Dry-Mesic Forest
#14 PV	Northern Hardwood Forest_Aspen	#41 PV	Northern Dry-Mesic Forest
#15 PV	Northern hardwood Forest - Oak, Maple	#42 PV	Northern Mesic Forest
#16 PV	Northern Mixed Conifer/ Hardwood Forest	#43 PV	Northern Hardwood Forest_Aspen
#17 BRSF	Boreal Forest	#44 PV	Northern Dry-Mesic Forest
#18 BCF	Northern hardwood Forest - Oak, Maple	#45 PV & DCF	Northern hardwood Forest - Oak, Maple
#19 PV	Pine Barrens	#46 BRSF	Northern Hardwood Forest_Aspen
#20 BRSF	Pine Barrens	#47	Northern Mesic Forest – Outside of Watershed
#21 PV	Northern Hardwood Forest_Aspen	#48 PV	Northern hardwood Forest - Oak, Maple
#22 PV	Northern Mixed Conifer/ Hardwood Forest	#49 BRSF	Northern Hardwood Forest_Aspen
#23 PV	Northern Mesic Forest	#50 PV	Northern hardwood Forest - Oak, Maple
#24 PV	Northern hardwood Forest - Oak, Maple	#51 PV	Northern Hardwood Forest_Aspen
#25 PV	Northern Mesic Forest - No locality information	#52 PV	Northern hardwood Forest - Oak, Maple
#26 PV	Northern hardwood Forest - Oak, Maple	#53 PV	Northern hardwood Forest - Oak, Maple
#27 BRSF	Northern hardwood Forest - Oak, Maple	#54 BRSF	Northern hardwood Forest - Oak, Maple
Private - Not surveyed - Permission to access denied			

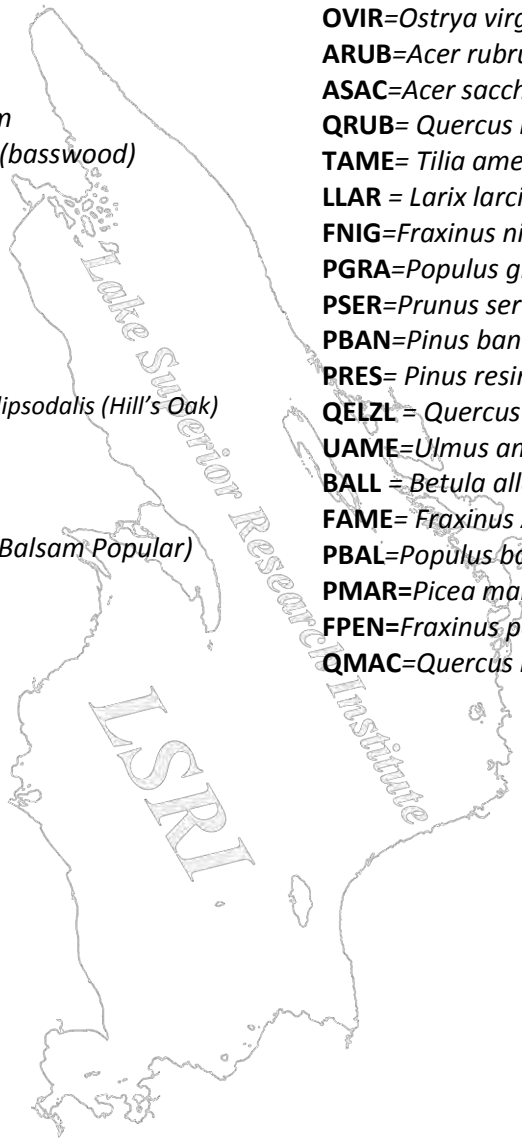


Acres	Other	White Birch	Alder	Grassland	Swamp Conifers	Swamp Hardwoods	Natural Pine*	Pine Barren*	Northern Hardwoods	Boreal Forest	Pine Plantations	Aspen	Total:
Brule River State Forest	1105	288	708	1658	1705	1129	1609	1768	2103	2321	7636	14412	36442
Bayfield County Forest	676	28	2	127	102	0	644	463	1494	5	5780	8181	17503
Douglas County Forest	1004	0	0	100	1081	2122	135	6	1782	49	352	6419	13050

Figure 8. Brule River Watershed WDNR, WisFir Database Landcover Analysis, 2016

1968-1969 KEY TO TREE SPECIES

TOC or THU *= Thuja occidentalis*
ABAL *=Abies balsamea*
PST*= Pinus strobes*
PTR or PT*=Populus tremuloides*
BPAP*= Betula papyrifera*
PGLA*= Picea glauca*
OVIR*=Ostrya virginiana*
AR*=Acer rubrum*
ASAC*=Acer saccharam*
QR or QRUB*= Quercus rubrum*
BAS or Tilia*= Tilia americana (basswood)*
LLAR *= Larix larcina*
FNIG*=Fraxinus nigra*
PGR*=Populus grandentata*
PSER*=Prunus serotina*
PBAN*=Pinus banksiana*
PR or PRES*= Pinus resinosa*
QE or HIL or HILO*= Quercus ellipsodalis (Hill's Oak)*
UAME*=Ulmus americana*
BLUT *= Betula alleghaniensis*
FAM*= Fraxinus americana*
PBAM*=Populus balsamifera (Balsam Popular)*
QMAC*=Quercus macrocarpa*



2015-2018 KEY TO TREE SPECIES

TOCC *= Thuja occidentalis*
ABAL *=Abies balsamea*
PSTR*= Pinus strobus*
PTRE *=Populus tremuloides*
BPAP*= Betula papyrifera*
PGLA*= Picea glauca*
OVIR*=Ostrya virginiana*
ARUB*=Acer rubrum*
ASAC*=Acer saccharam*
QRUB*= Quercus rubrum*
TAME*= Tilia americana*
LLAR *= Larix larcina*
FNIG*=Fraxinus nigra*
PGRA*=Populus grandentata*
PSER*=Prunus serotina*
PBAN*=Pinus banksiana*
PRES*= Pinus resinosa*
QELZL *= Quercus ellipsodalis*
UAME*=Ulmus americana*
BALL *= Betula alleghaniensis*
FAME*= Fraxinus Americana*
PBAL*=Populus balsamifera*
PMAR=*Picea mariana*
FPEN=*Fraxinus pennsylvanica*
QMAC*=Quercus macrocarpa*

1968-69 KEY TO SAPLINGS

PT or PTR = *Populus tremuloides*
BPAP = *Betula papyrifera*
ABAL = *Abies balsamifera*
AMEL=*Amenlanchier sp.*
PVIR = *Prunus virginiana*
THU = *Thuja occidentalis*
PR = *Pinus resinosa*
OVIR = *Ostrya virginiana*
PST = *Pinus strobes*
AR or ARUB = *Acer rubrum*
ne
PGLA = *Picea glauca*
ASAC or AS = *Acer saccharum*
TILIA or BASS or BAS = *Tilia americana*
PMAR = *Picea mariana*
LLAR = *Larix larcina*
FNIG = *Fraxinus nigra*
PGRA or PGR = *Populus grandentata*
ELM or UAMER or ULAM = *Ulmus americana*
PPEN = *Prunus pensylvanica*
PSER = *Prunus serotina*
CARP = *Carpinus carolianiana*
QE or HILO = *Quercus ellipsoids*
PBAN = *Pinus banksiana*
FAM or FRAX= *Fraxinus americana*
PBAM or PBAL = *Populus balsamifera*
BLUT = *Betula alleghenensis*
QMAC =*Quercus macrocarpus*
TCAN = *Tsuga canadensis*
ULRU = *Ulmus rubra*

2015-18 KEY TO SAPLINGS

PTRE = *Populus tremuloides*
BPAP = *Betula papyrifera*
ABAL = *Abies balsamifera*
AMEL=*Amenlanchier sp.*
PVIR = *Prunus virginiana*
TOCC = *Thuja occidentalis*
PRES = *Pinus resinosa*
OVIR = *Ostrya virginiana*
PSTR = *Pinus strobus*
ARUB = *Acer rubrum*
QRUB = *Quercus rubra*
PGLA = *Picea glauca*
ASAC = *Acer saccharum*
TAME = *Tilia americana*
PMAR = *Picea mariana*
LLAR = *Larix larcina*
FNIG = *Fraxinus nigra*
PGRA = *Populus grandentata*
UAME = *Ulmus americana*
PPEN = *Prunus pensylvanica*
PSER = *Prunus serotina*
CCAR= *Carpinus carolianiana*
QELL =*Quercus ellipsoids*
PBAN = *Pinus banksiana*
FAME = *Fraxinus americana*
PBAL = *Populus balsamifera*
BALL = *Betula alleghenensis*
QMAC =*Quercus macrocarpus*
TCAN = *Tsuga canadensis*
AINC= *Alnus incana*
ANEG = *Acer negunda*
CCOR = *Corylus cornuta*
IMUC= *Ilex mucronata*
IVER = *Ilex verticillata*
PNIG= *Prunus nigra*
SDIS=*Salix discolor*
RCAT=Rhamnus cathartica
URUB = *Ulmus rubra*

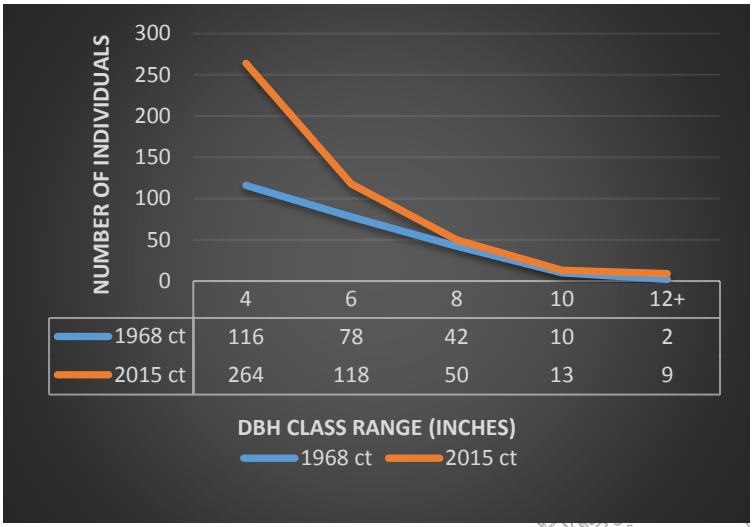


Figure 9. Balsam Fir grouped by dBh class ranges in variables of 2".

Balsam Fir trees are more numerous in all sizes and becoming a greater presence in the forests. By the time they reach 8"dbh, they are often harvested. The size distribution curve depicts that fir may be replacing aspen in the boreal forest areas of the watershed.

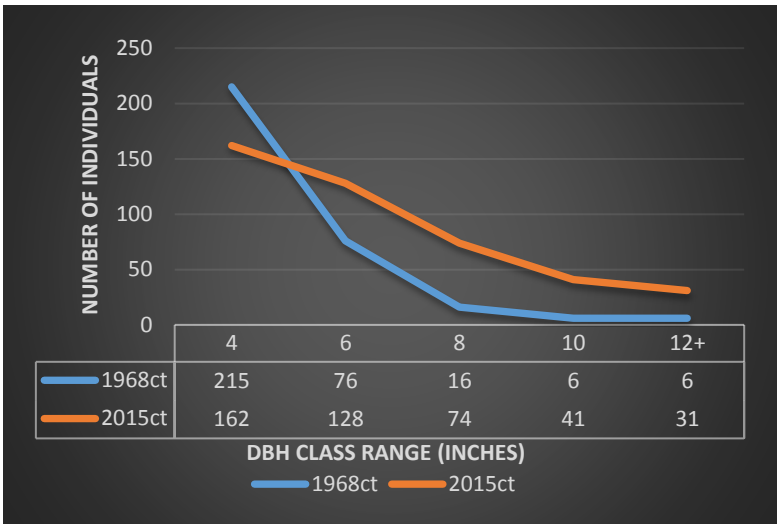


Figure 10. Red Maple grouped by dBh class ranges in variables of 2".

Red Maple is increasing in presence and size and replacing habitat niches in both upland and lowland forests and is likely to replace black ash in northern hardwood swamps.

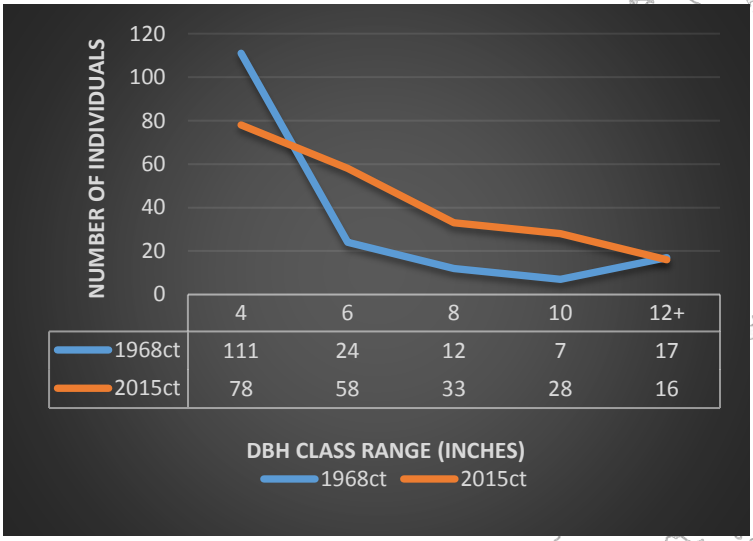


Figure 11. Sugar Maple grouped by dBh class ranges in variables of 2".

In 1968, Sugar Maple were even aged stands with an element of older growth maple. In 2015, a multi-aged forests is better represented indicating a succession towards a later successional complex forest ecosystem creating more niche habitats, than in the earlier even-aged stands.

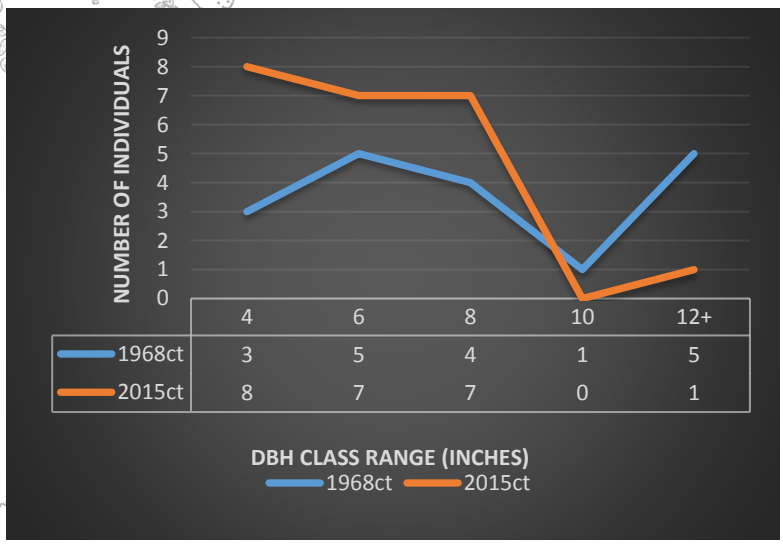


Figure 12. Yellow Birch grouped by dBh class ranges in variables of 2".

Yellow Birch has never been a common tree species in the BRW. Yellow Birch is near the edge of its natural range in NW WI.

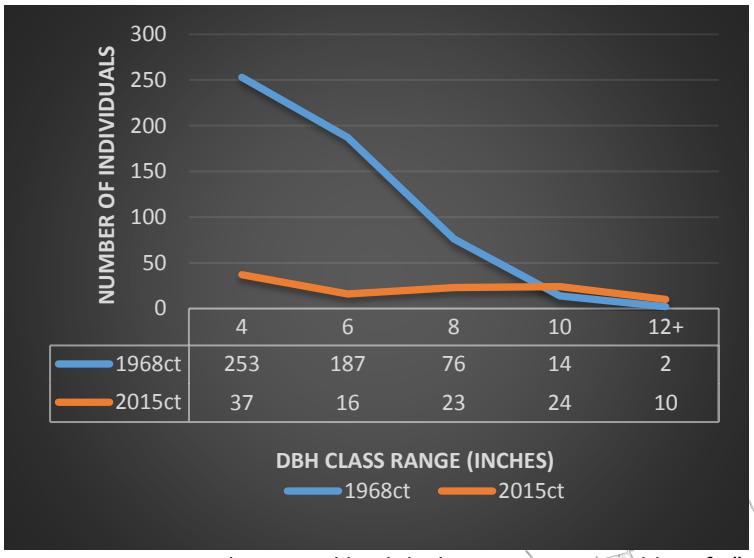


Figure 13. Paper Birch grouped by dBh class ranges in variables of 2".

With Paper Birch we are experiencing a tree species that is trending towards extinction. Causes have been insect and fungal diseases, a warming climate and droughts There are no small trees surviving and only the larger trees in old growth forests are surviving.

Figure 14. Black Ash grouped by dBh class ranges in variables of 2".

Like Cedar, we only had one Black Ash site. These stand has remained constant with a small increase in size over the years. We did not observe emerald ash borer on this site. Deer herbivory is at extreme levels on ash, with most seedlings damaged, but not killed.

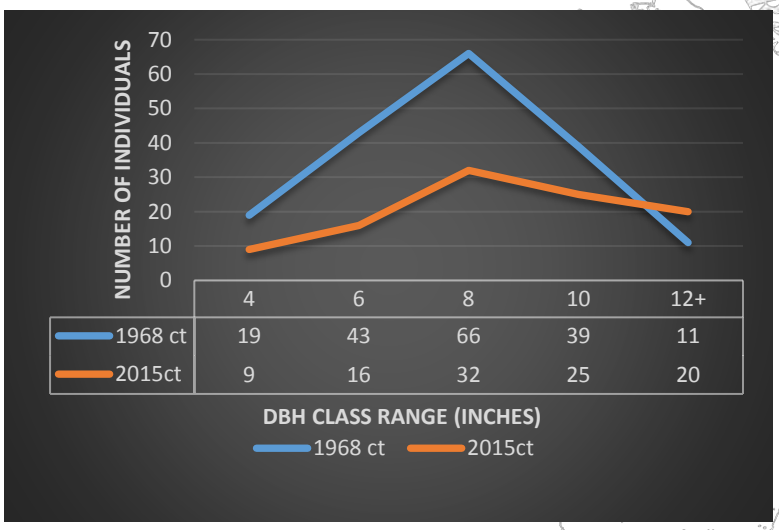


Figure 15. Jack Pine grouped by dBh class ranges in variables of 2".

Most of the jack pine forest stands surveyed in 1968 pine plantations, while in 2015, these same stands have scattered mixed aged pines and grassy meadow areas.

Figure 16. Red Pine grouped by dBh class ranges in variables of 2".

The red pine forests were old growth pine forests in 1968 and remain so today. The average dBh in 1968 was 17.7 while today, the average has increased to 20.1. Red pine is surviving well in these old growth forests, even surviving earlier fires as evidence by scars on their trucnks. We estimate that some of these trees are 250-300 years old

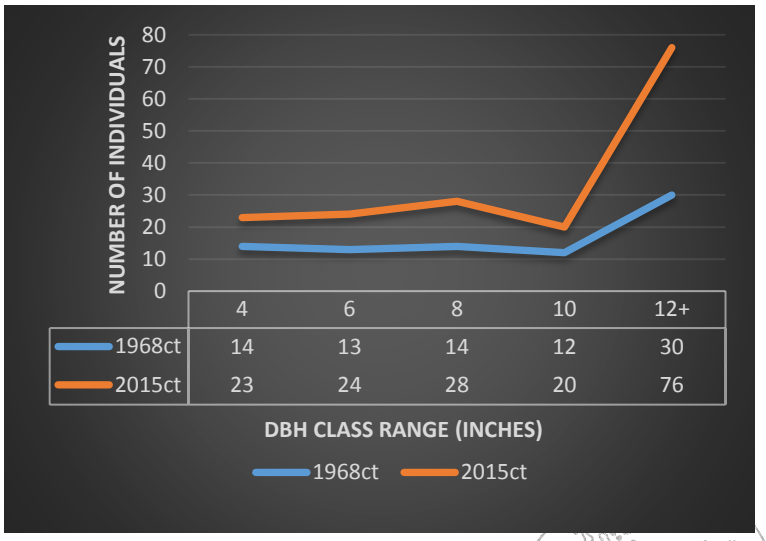


Figure 17. White Pine grouped by dBh class ranges in variables of 2".

Figure 18. White Spruce grouped by dBh class ranges in variables of 2".

The average dBh of old growth white pine in 1968 was 14.8 and today it is 18.8. White Pine was less numerous than red pine in the old growth pine forests. However all of the white pine that was >35" dBh was observed to be a snag. These trees were alive during Davidson's time.

White Spruce had a reduced presence in 1968 than today. Trends indicate that white spruce may be rebounding to a greater presence, as younger size trees are prevalent today.

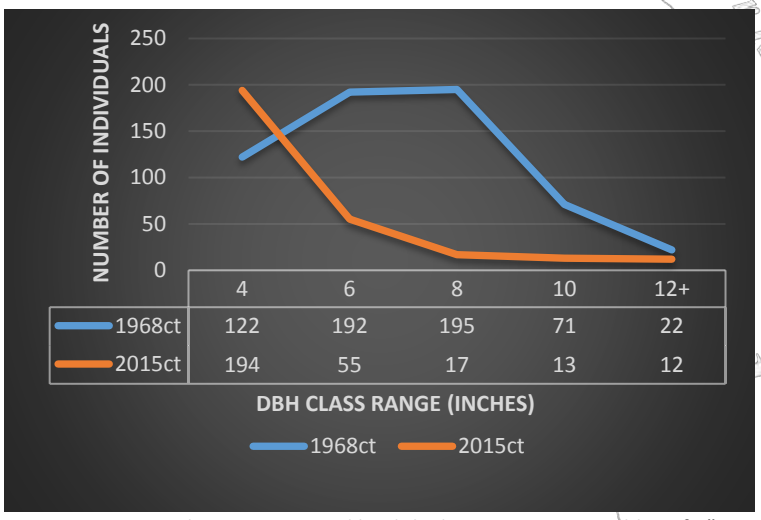


Figure 19. Big Tooth Aspen grouped by dBh class ranges in variables of 2".

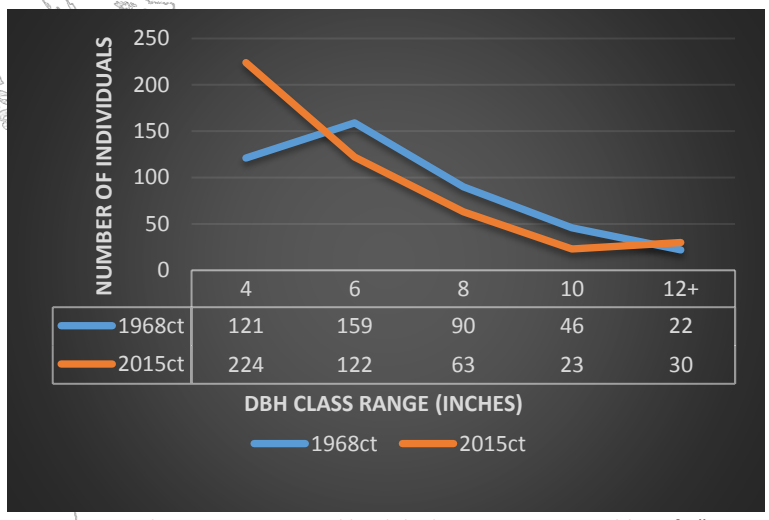


Figure 20. Quaking Aspen grouped by dBh class ranges in variables of 2".

Big Tooth Aspen is an early successional tree in the Northern Hardwoods Forest. The steep decline of Big Tooth Aspen is probably due to harvesting at a younger age, as well as the forest moving into a later successional tree with oaks, maples, fir and spruce becoming more prevalent

Quaking Aspen is an early successional tree in the Northern Hardwood and Boreal Forest. It remains a dominant tree on the landscape. In the boreal forest areas, we see a general decline in aspen temporally, while fir and white pine are slowly increasing.

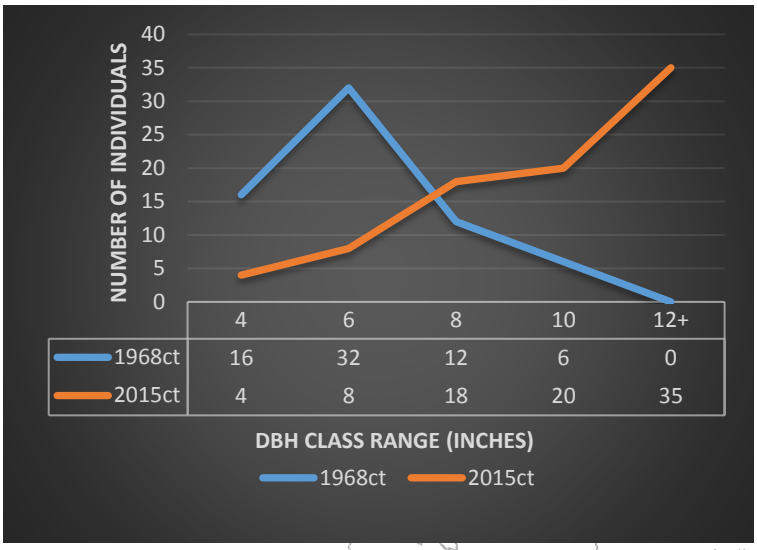


*Figure 21.*White Cedar grouped by dBh class ranges in variables of 2".

White Cedar is getting older and larger. We only had one stand of white cedar with its origins dating back to 1838. Thomson (1945) recommended that harvesting of the white cedar cease immediately, as these swamps maintain a year-round constant flow to the Bois Brule River sustaining the waters as a cold water trout stream.

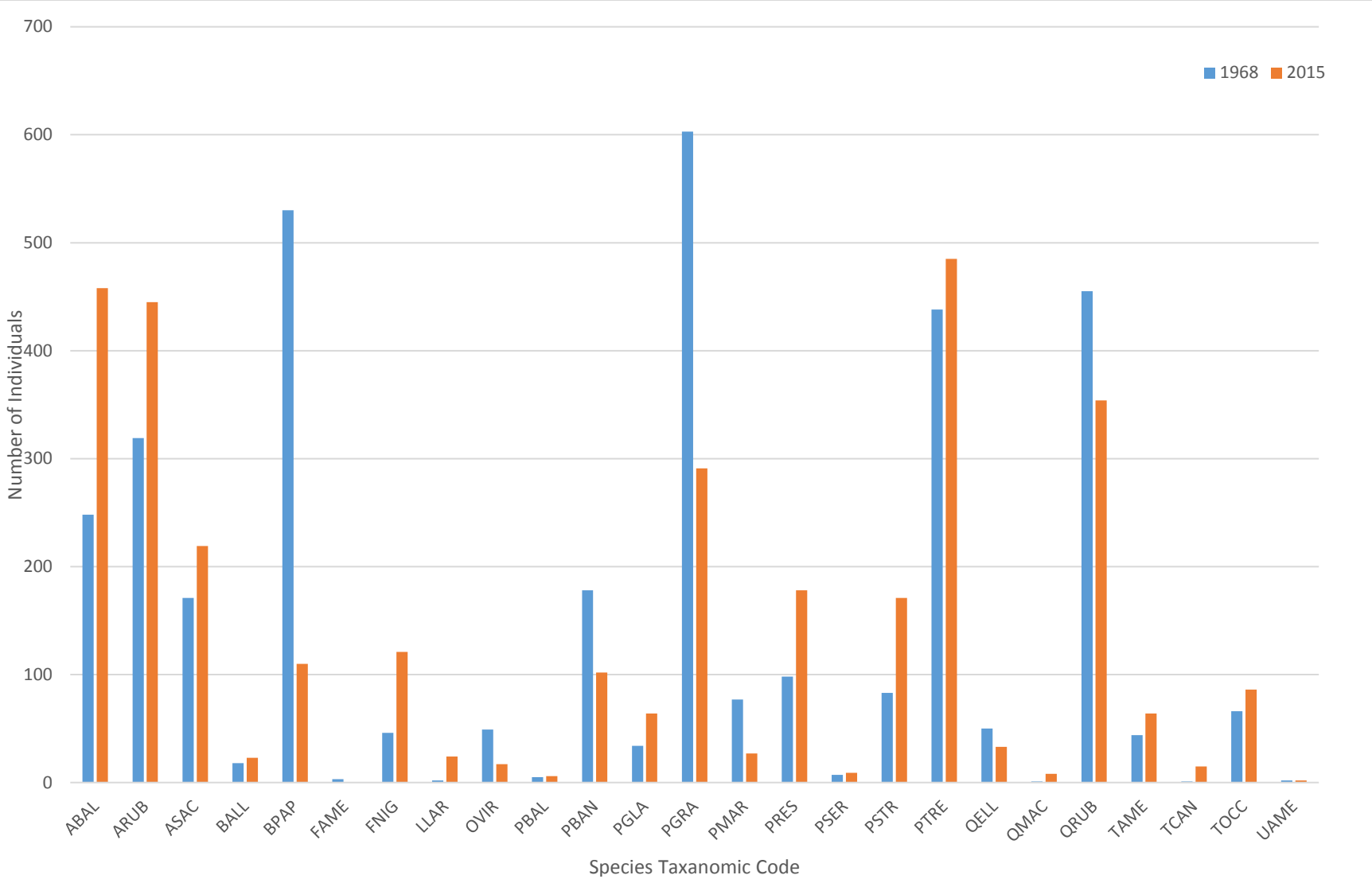
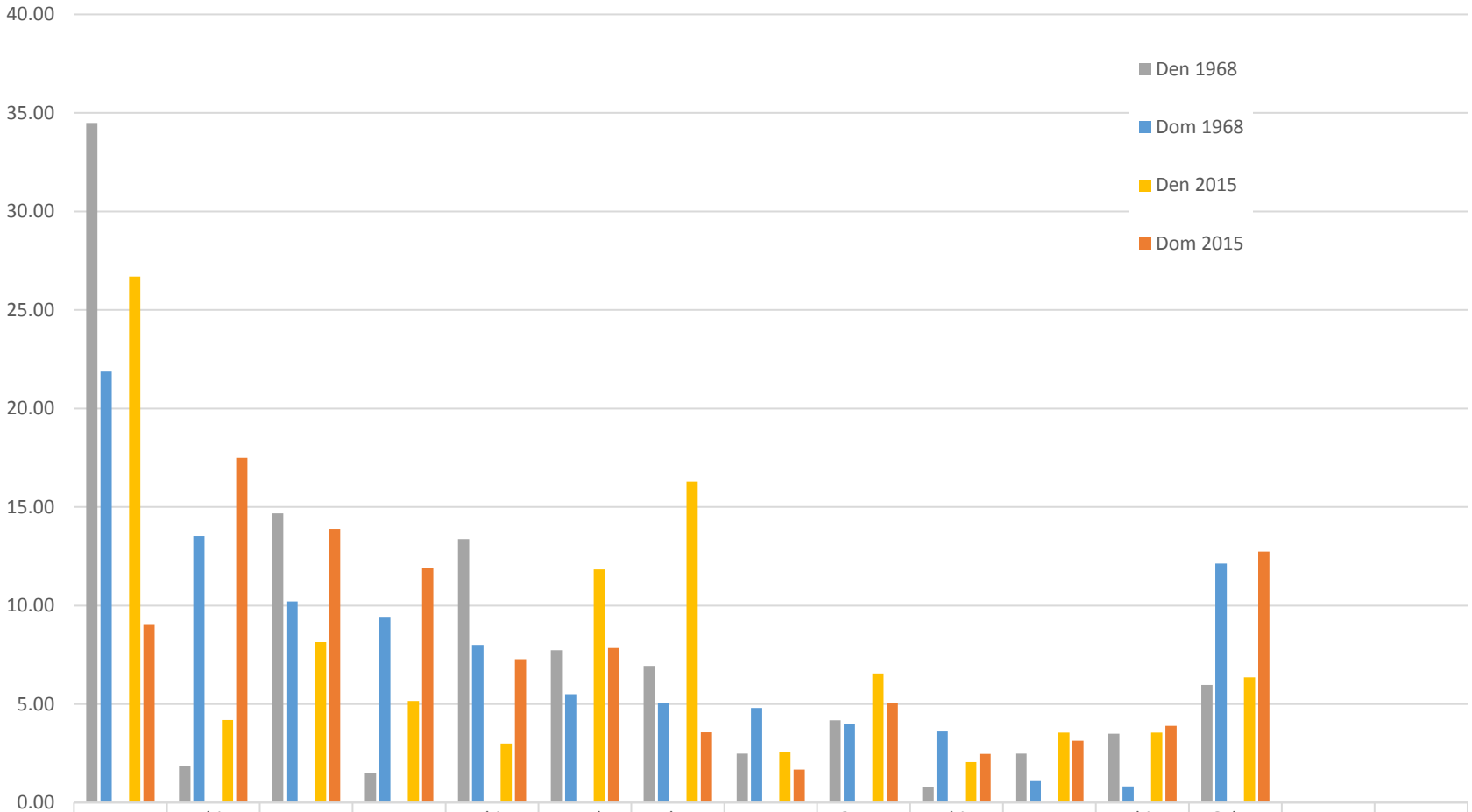


Figure 22. Summary of Forest Trees by Total Count.



	Aspen	White Pine	Red Oak	Red Pine	White Birch	Red Maple	Balsam fir	Jack Pine	Sugar Maple	White Spruce	Black Ash	White Cedar	Other Species		
Den 1968	34.50	1.86	14.68	1.50	13.38	7.73	6.94	2.49	4.18	0.81	2.48	3.49	5.97		
Dom 1968	21.87	13.52	10.20	9.42	8.00	5.50	5.04	4.80	3.98	3.61	1.09	0.82	12.13		
Den 2015	26.70	4.20	8.14	5.16	2.99	11.84	16.29	2.59	6.56	2.06	3.56	3.55	6.36		
Dom 2015	9.05	17.50	13.87	11.91	7.27	7.85	3.56	1.68	5.08	2.46	3.14	3.89	12.74		

Figure 23. Brule River Watershed Relative Density and Relative Dominance by tree species

Table 12. Brule River Watershed Forest by Relative Importance values.

TREE SPECIES			SAPLING SPECIES		
Species	Relative (IV)		SPECIES	Relative IV	
	1968	2015		1968-69	2015
Balsam Fir (ABAL)	5.496	10.57	Balsam Fir (ABAL)	11.361	21.589
Red Maple (ARUB)	8.852	13.591	Red Maple (ARUB)	26.399	16.544
Sugar Maple (ASAC)	6.001	6.946	Sugar Maple (ASAC)	16.175	6.283
Yellow Birch (BALL)	0.732	0.713	Yellow Birch (BALL)	0.104	0.547
Paper Birch (BPAP)	13.577	3.438	White Birch (BPAP)	10.117	3.676
Black Ash (FNIG)	1.645	3.344	Black Ash (FNIG)	1.633	3.975
Jack Pine (PBAN)	4.272	2.977	Ironwood (OVIR)	2.581	7.658
White Spruce (PGLA)	1.064	1.905	White Spruce (PGLA)	0.595	2.207
Big Tooth Aspen (PGRA)	15.127	8.297	Aspen (PGRA/PTRE)	9.128	16.156
Red Pine (PRES)	2.983	7.54	Red Pine (PRES)	0.208	1.607
White Pine (PSTR)	2.764	6.431	Black Cherry (PSER)	0.443	1.838
Quaking Aspen (PTRE)	15.068	12.777	White Pine (PSTR)	0.661	1.132
Red Oak (QRUB)	14.015	14.307	Red Oak (QRUB)	3.229	5.971
Basswood (TAME)	1.828	2.586	Buckthorn (RCAT)	0	0.061
White Cedar (TOCC)	1.62	0.676	White Cedar (TOCC)	0.5	0.067
Other	4.956	3.902	Other	16.868	10.69

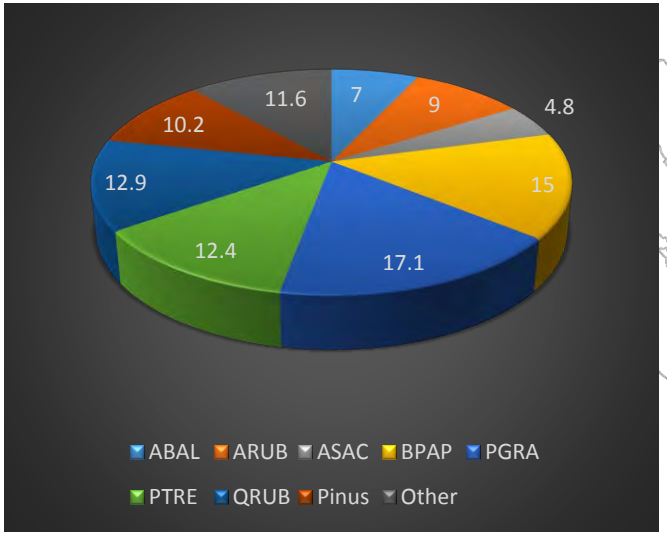


Figure 24. 1968 Forest Tree Composition

Species	1968	2015
ABAL	14.5	24.9
ARUB	34	16.3
ASAC	14.9	5.4
BPAP	10.6	3.8
PGRA	3.5	7.7
PTRE	7.2	9.6
QRUB	3.1	6
Pinus	0.9	3.1
Other	11.3	23.2

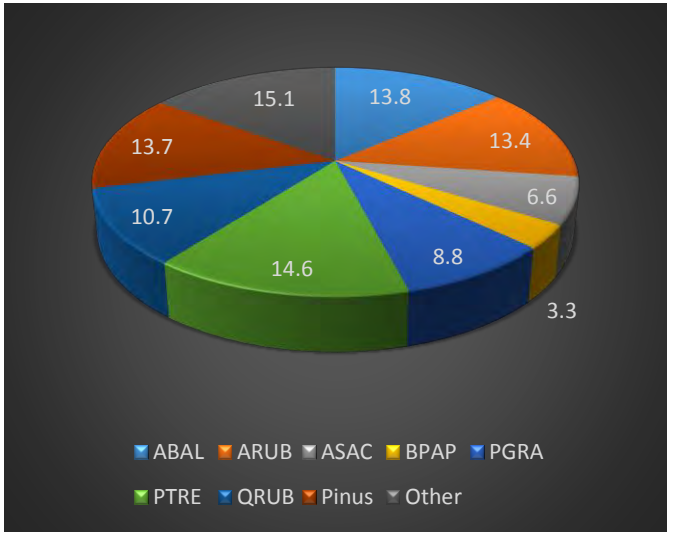


Figure 25. 2015 Forest Tree Composition

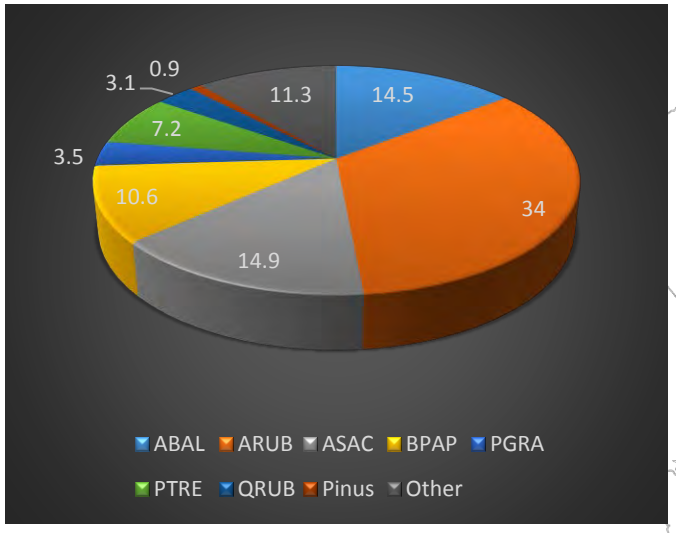


Figure 26. 1968 Forest Sapling Species Composition

Species	1968	2015
ABAL	7	13.8
ARUB	9	13.4
ASAC	4.8	6.6
BPAP	15	3.3
PGRA	17.1	8.8
PTRE	12.4	14.6
QRUB	12.9	10.7
Pinus	10.2	13.7
Other	11.6	15.1

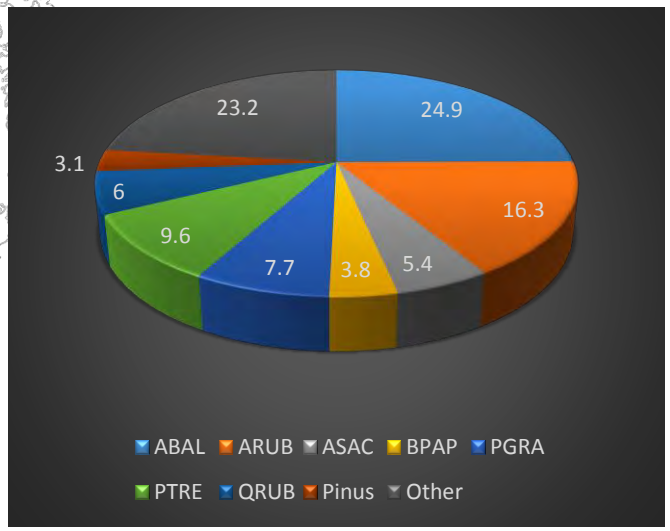
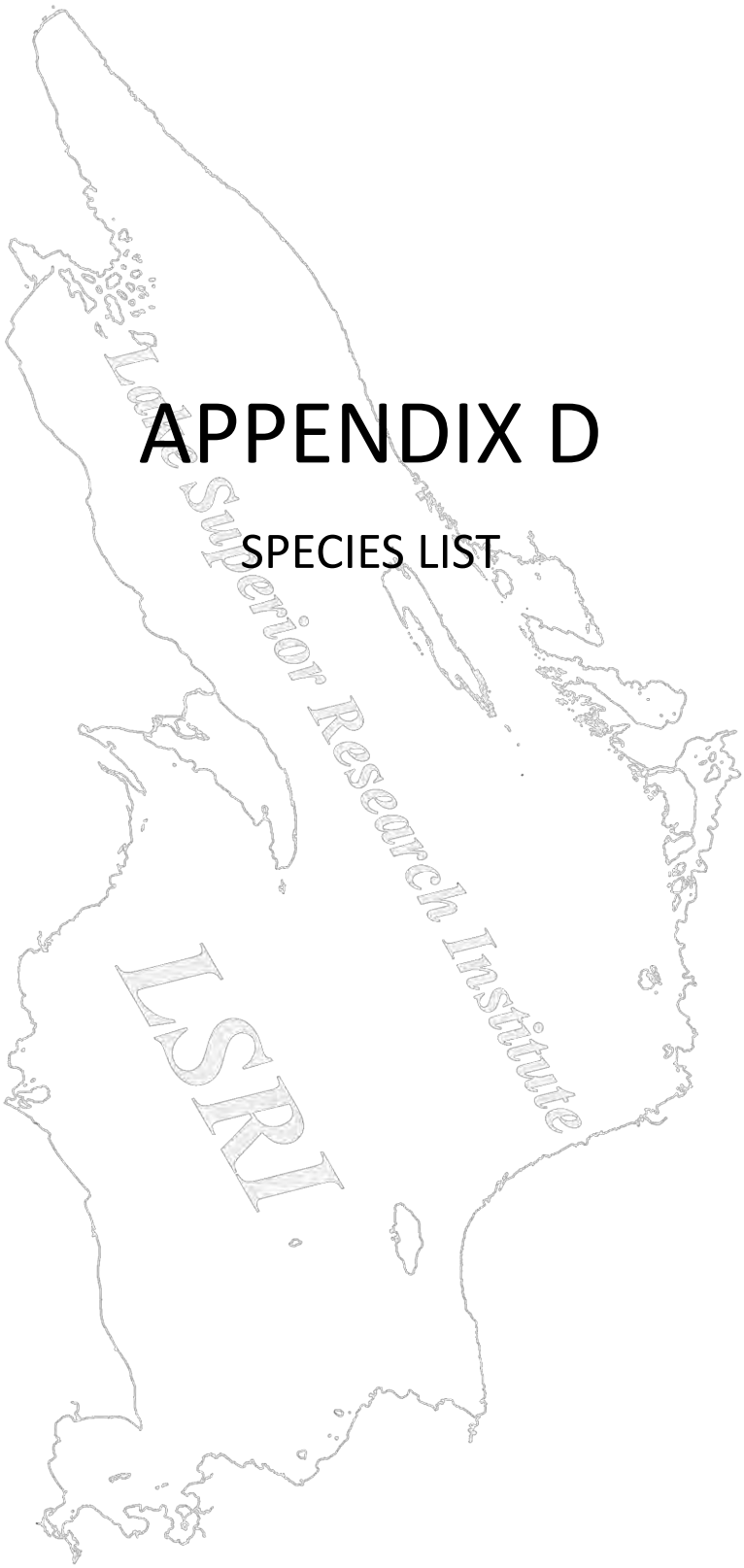


Figure 27. 2015 Forest Sapling Species Composition



APPENDIX D

SPECIES LIST

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Red = County Record
Blue = New Brule River Watershed Record

Fern and Fern Allies

BF: Boreal Forest; WC:Whtie Cedar and PB: Pine Barrens

DENNSTAEDTIACEAE	**Bracken Fern Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected (Pre 2015)**
Pteridium aquilinum (L.) Kuhn	bracken fern		X	X	X			X
DRYOPTERIDACEAE	**Wood Fern Family**							
Athyrium filix-femina (L.) Roth	common lady fern	F6037, F6074, M6844, M6882	X	X				X
Cystopteris fragilis (L.) Bernh.	brittle bladder fern	F5654	X					
Cystopteris tenuis (Michx.) Desv.	MacKay's brittle fern							X
Dryopteris carthusiana (Vill.) H. P. Fuchs	spinulose wood fern	F6002, F6005, F6092, M6845, M6862	X	X				X
Dryopteris cristata (L.) A. Gray	crested shield fern	M6838, M6860	X	X				X
Dryopteris fragrans (L.) Schott	fragrant fern	F5658				X		X
Dryopteris intermedia (Willd.) A. Gray	evergreen wood fern	F5624, P43857	X	X				X
Gymnocarpium dryopteris (L.) Newm.	common oak fern	F6008, F6093, M6863	X	X				X
Matteuccia struthiopteris (L.) Todaro	ostritch fern	P43774	X					X
Onoclea sensibilis L.	sensitive fern	F6118, P43775.1	X	X				X
Woodsia ilvensis (L.) R. Br.	rusty cliff fern	F5646, F5650.1				X		X
EQUISETACEAE	**Horsetail Family**							
Equisetum arvense L.	common horsetail		X	X				X
Equisetum hyemale L.	scouring rush		X					X
Equisetum scirpoides Michx.	dwarf scouring rush	F5618, F5644, F6139, M6721	X	X				X
Equisetum sylvaticum L.	woodland horsetail	F5634, M6720, P43787	X	X				X
Equisetum x ferrissii Clute	Ferris' horsetail							X
LYCOPODIACEAE	**Club-Moss Family**							
Dendrolycopodium dendroideum (Michx.) A. Haines	tree club moss	F6101, M6649, P43848	X	X				X
Dendrolycopodium hickeyi (W.H. Wagner, Beitel & R.C. Moran) A. Haines	Hickey's tree club moss	M6849		X				
Dendrolycopodium obscurum (L.) A. Haines	ground pine			X				X
Diphasiastrum complanatum (L.) Holub	norhtern ground-cedar	M6766				X		
Huperzia lucidula (Michx.) R.Trevis.	shining club moss	F5610	X	X				X
Huperzia selago (L.) Bernhardi	fir club moss							X
Lycopodiella inundata (L.) Holub	bog club moss							X
Lycopodium clavatum L.	running ground pine	M6650, P43866		X				X
Spinulum annotinum (L.) A. Haines	stiff clubmoss	F5615, F6100, M6651, M6866	X	X				X
OPHIOGLOSSACEAE	**Adder's-Tounge Family**							
Botrychium lanceolatum (Gmel.) Angstrom	lance leaf moonwort							X
Botrypus virginianus (L.) Michx.	rattlensake fern			X				X
Sceptridium multifidum (S. G. Gmel.) M. Nishida	leathery grape fern				X			X
Sceptridium rugulosum (W. H. Wagner) Skoda	St. Lawrence grape fern							X

Red = County Record
Blue = New Brule River Watershed Record

		Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
OSMUNDACEAE	**Royal Fern Family**							
Osmunda cinnamomea L.	cinnamon fern			X				X
Osmunda claytoniana L.	interrupted fern		X	X				X
Osmunda regalis L.	royal fern			X				X
POLYPODIACEAE	**Polypody Fern Family**							
Polypodium virginianum L.	common polypody fern	F5645.1				X		X
PTERIDACEAE	**Maidenhair Fern Family**							
Adiantum pedatum L.	maidenhair fern							X
SELAGINELLACEAE	**Spikemoss Family**							
Selaginella rupestris (L.) Spring	rock spikemoss	F5651			X			X
THELYPTERIDACEAE	**Marsh Fern Family**							
Phegopteris connectilis (L.) Slosson	northern beech fern	F6011, F6073, M6874	X	X				X
Thelypteris palustris Schott	marsh fern		X	X				X
Gymnosperms								
CUPRESSACEAE	**Cyperss Family**							
Thuja occidentalis L.	white cedar		X	X				X
PINACEAE	**Pine Family**							
Abies balsamea (L.) Mill.	balsam fir		X	X	X			X
Larix laricina (Du Roi) K. Koch	tamarack			X				X
Picea abies (L.) H. Karst	Norway spruce		X				X	
Picea glauca (Moench) Voss	white spruce		X	X	X			X
Picea mariana (Mill.) Britton, Sterns & Poggenb.	black spruce		X	X				X
Pinus banksiana Lamb.	jack pine	M6691, M6810			X			X
Pinus resinosa Aiton	red pine	F5652	X		X			X
Pinus strobus L.	white pine	P43779	X	X	X			
Tsuga canadensis (L.) Carrière	eastern hemlock	F6098	X					X
TAXACEAE	**Yew Family**							
Taxus canadensis Marshall	American yew	P43784	X	X				X
Flowering Dicots								
ADOXACEAE	**Moschatel Family**							
Sambucus racemosa L.	red elderberry	F5625, F6060	X	X				
Viburnum acerifolium L.	maple-leaved viburnum							X
Viburnum lentago L.	nanny berry	P43884	X	X				X
Viburnum rafinesquianum Schult.	arrow-wood	P43783	X		X			
Viburnum trilobum Marshall	American high-bush cranberry		X	X				X

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		Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
AMARANTHACEAE	**Amaranth Family**							
Chenopodium album L.	lamb's quarters				X			X
Chenopodium simplex (Torr.) Raf.	maple leaf goosefoot	F6125	X					
Cycloloma atriplicifolium (Spreng.) J. M. Coult.	winged pig weed							X
Froelichia gracilis (Hook.) Moq.	cottonweed						X	X
ANACARDIACEAE	**Cashew Family**							
Rhus typhina L.	staghorn sumac							X
Rhus x pulvinata Greene	hybrid sumac							X
Toxicodendron rydbergii (Small ex Rydb.) Greene	western poison-ivy		X	X				
APIACEAE	**Parsley Family**							
Carum carvi L.	caraway						X	X
Cicuta bulbifera L.	bulblet water hemlock		X	X				X
Cicuta maculata L.	water hemlock	F6089, M6864	X	X				X
Cryptotaenia canadensis (L.) DC.	honewort							X
Heracleum maximum Bartram	cow parsnip	M6730	X	X				X
Osmorhiza claytonii (Michx.) C. B. Clarke	hairy sweet cicely							X
Pastinaca sativa L.	wild parsnip						X	X
Sanicula canadensis L.	Canadian black snakeroot		X					
Sanicula marilandica L.	black snakeroot	F6079, M6765, M6808	X	X	X			X
Sanicula odorata (Raf.) Pryer & Phillippe	clustered black snakeroot							X
Sium suave Walter	water parsnip							X
Zizia aurea (L.) W. D. J. Koch	common golden alexanders	P43867	X					
APOCYNACEAE	**Dogbane & Milkweed Family**							
Apocynum androsaemifolium L.	spreading dogbane		X		X			
Apocynum cannabinum var. *hypericifolium* L.	clasping dogbane		X					
Asclepias exaltata L.	poke milkweed	H3511			X			
Asclepias incarnata L.	swamp milkweed							X
Asclepias ovalifolia Decne	dwarf milkweed				X			
Asclepias syriaca L.	common milkweed		X					X
Vinca minor L.	greater periwinkle		X				X	
AQUIFOLIACEAE	**Holly Family**							
Ilex mucronata (L.) M. Powell, V. Savolainen & S. Andrews	mountain holly	A2441, M6662, M6827		X				X
Ilex verticillata (L.) A. Gray	winterberry	F6061, F6146, M6823, P43868	X	X				X
ARALIACEAE	**Ginseng Family**							
Aralia hispida Vent.	bristly sarsaparilla							X
Aralia nudicaulis L.	wild sarsaparilla	P43746	X	X				X
Aralia racemosa L.	American spikenard	P43860	X	X				X
Hydrocotyle americana L.	marsh pennywort	H3556,M6842		X				
Panax trifolius L.	dwarf ginseng		X					X

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ARISTOLOCHIACEAE	**Birthwort Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Asarum canadense L.	Canadian wild-ginger			X				X
ASTERACEAE	**Sunflower Family**							
Achillea millefolium L.	common yarrow		X		X			X
Achillea ptarmica L.	sneezewort						X	X
Ambrosia artemisiifolia L.	ragweed				X			
Ambrosia psilostachya DC.	western ragweed							X
Anaphalis margaritacea (L.) Benth.	pearly everlasting		X	X	X			X
Antennaria howellii Greene	small pussy's toes	F5657, M6696			X			X
Antennaria neglecta Greene	cat's foot		X					X
Antennaria parlinii Fernald	smooth pussy's toes	M6693, P43760	X		X			X
Antennaria plantaginifolia (L.) Hook.	plantain-leaved pussy's toes		X		X			X
Arctium minus Bernh.	common burdock		X				X	X
Artemisia pontica L.	Roman wormwood						X	X
Artemisia vulgaris L.	mugwort						X	X
Bidens beckii Torr. ex Spreng.	watter beggar-ticks							X
Bidens cernua L.	nodding beggar's tick							X
Bidens connata Muhl.	purple-stemmed tickseed							X
Bidens frondosa L.	common beggar's tick	F6138, M6848	X	X				X
Bidens tripartita L.	straw-stem beggar-ticks							X
Centaurea jacea L.	brown knapweed						X	X
Centaurea nigra L.	black knapweed						X	X
Centaurea stoebe L.	spotted knapweed				X		X	X
Cirsium arvense (L.) Scop.	Canada thistle	H3834	X	X	X		X	X
*Cirsium discolor (*Muhl. ex. Willd) Spreng.	field thistle				X			
Cirsium muticum Michx.	swamp thistle		X	X				X
Cirsium vulgare (Savi) Ten.	bull thistle				X			
Conyza canadensis (L.) Cronq.	horseweed	M6778, P43898			X			X
Coreopsis palmata Nutt.	prairie coreopsis							X
Crepis tectorum L.	hawk's beard				X		X	X
Doellingeria umbellata (Mill.) Nees	flat-topped aster	F6080, M6832, M6885, P43869	X	X				X
Erechtites hieraciifolius (L.) Raf.	burnweed							X
Erigeron annus (L.) Pers.	annual fleabane		X					
Erigeron glabellus Nutt.	streamside fleabane							X
Erigeron philadelphicus L.	common fleabane		X					
Erigeron strigosus Willd.	daisy fleabane	M6746, M6790			X			X
Eupatorium perfoliatum L.	boneset							X
Eurybia macrophylla (L.) Cass.	big-leaved aster	F6072	X	X				X
Euthamia graminifolia (L.) Nutt.	grass-leaved goldenrod	P43906			X			X
Eutrochium maculatum (L.) E. E. Lamont	spotted Joe-pye-weed	M6858	X	X				X
Gnaphalium uliginosum L.	cud weed						X	X
Grindelia squarrosa (Pursh) Dunal	gumweed						X	X
Helianthus giganteus L.	giant sunflower	P43881	X					X
Helianthus hirsutus Raf.	hairy sunflower	H3486				X		
Helianthus occidentalis Riddell	western sunflower	M6745, M6785			X			X

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ASTERACEAE	Sunflower Family	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Helianthus strumosus L.	pale-leaved sunflower	M6792						
Hieracium aurantiacum L.	devil's paintbrush	M6788, P43897	X		X		X	
Hieracium caespitosum Dumort.	yellow hawkweed	M6743			X		X	X
Hieracium lachenalii C. C. Gmel.	common hawkweed	F6029, F6097, P43865	X	X			X	
Hieracium piloselloides Vill.	glaucous king-devil			X			X	
Hieracium scabrum Michx.	rough hawkweed	P43891, P43907	X		X			X
Hieracium umbellatum L.	Canada hawkweed	F6076, M6793	X	X	X			
Hudsonia tomentosa	false heather				X			
Krigia biflora (Walter) S. F. Blake	false-dandelion	H3842			X			
Lactuca biennis (Moench) Fernald	tall blue lettuce			X	X			
Lactuca canadensis L.	Canada lettuce	P43854		X	X			X
Lactuca hirsuta Nutt.	hairy tall lettuce	M6749			X			
Lactuca serriola L.	prickly lettuce		X				X	
Leucanthemella serotina (L.) Tzvelev	giant daisy						X	X
Leucanthemum vulgare Lam.	ox-eye daisy		X		X		X	X
Liatris aspera Michx.	rough blazing star	M6781, P43904		X	X			X
Liatris ligulistylis (A.Nelson) K.Schum.	meadow blazing star							X
Packera aurea (L.) Á. Löve & D. Löve	golden ragwort			X				X
Packera paupercula (Michx.) Á. Löve & D. Löve	northern ragwort				X			X
Petasites frigidus (Aiton) A. Gray	sweet colt's-foot		X	X				X
Petasites frigidus v. sagittatus (L.) Fr.	arrowhead sweet colt's foot					X		
Prenanthes alba L.	white lettuce	F6086	X	X	X			X
Pseudognaphalium obtusifolium (L.) Hilliard & B. L. Burtt	cat's-foot; fragrant cudweed	F6087, M6794, P43919	X		X			
Ratibida pinnata (Vent.) Barnhart	yellow coneflower							X
Rudbeckia hirta L.	black-eyed Susan							X
Rudbeckia laciniata L.	cut-leaved coneflower							X
Senecio viscosus L.	sticky ragwort						X	X
Solidago canadensis L.	Canada goldenrod		X		X			X
Solidago flexicaulis L.	zig-zag goldenrod	F6123	X					X
Solidago gigantea Aiton	giant goldenrod	F6077, F6112, P43871	X	X	X			X
Solidago hispida Willd.	hairy goldenrod	P43910			X			X
Solidago juncea Aiton	early goldenrod	P43895			X			X
Solidago nemoralis Aiton	gray goldenrod	M6776, P43894			X			X
Solidago ptarmicoides (Torr. & A. Gray) B. Boivin	upland white goldenrod				X			X
Solidago speciosa Nutt.	showy goldenrod	M6796			X			X
Solidago uliginosa Nutt.	bog goldenrod	M6877		X				X
Sonchus arvensis L.	field sow-thistle	F6126	X				X	
Symphyotrichum boreale (Torr. & A. Gray) Á. Löve & D. Löve	northern bog aster							X
Symphyotrichum ciliolatum (Lindl.) Á. Löve & D. Löve	northern heart-leaved aster	P43863	X	X	X			X
Symphyotrichum laeve (L.) Á. Löve & D. Löve	smooth aster	M6740, P43912			X			X
Symphyotrichum lanceolatum (Willd.) G. L. Nesom var. *lanceolatum*	panicled aster	F6111, M6789	X					X

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ASTERACEAE	**Sunflower Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve	calico aster	F6075, P43870	X					X
Symphyotrichum oolentangiense (Riddell) G. L. Nesom	sky blue aster	M6777, P43889	X		X			X
Symphyotrichum pilosum (Willd.) G. L. Nesom	frost aster							X
Symphyotrichum puniceum (L.) Á. Löve & D. Löve	swamp aster	M6822, M6868	X					X
Symphyotrichum urophyllum (DC.) G. L. Nesom	arrow-leaved aster			X	X			
Tanacetum vulgare L.	common tansy		X	X			X	X
Taraxacum officinale F. H. Wigg	common dandelion	F5636	X	X	X		X	
Tephroseris palustris (L.) Rchb.	marsh groundsel							X
Tragopogon dubius Scop.	lesser goat's beard				X		X	X
BALSAMINACEAE	**Touch-Me-Not Family**							
Impatiens capensis Meerb.	orange jewel-weed		X	X				X
BERBERIDACEAE	**Barberry Family**							
Caulophyllum thalictroides (L.) Michx.	blue cohosh		X					X
BETULACEAE	**Birch Family**							
Alnus incana (L.) Moench	speckled alder	F5642, F6071, M6836	X	X				X
Alnus viridis (Chaix) DC.	green alder							X
Betula alleghaniensis Britton	yellow birch			X				X
Betula papyrifera Marshall	paper birch	M6677	X	X				X
Betula pumila L.	bog birch							X
Corylus americana Walter	American hazelnut	P43918	X	X	X			X
Corylus cornuta Marshall	beaked hazelnut			X				X
Ostrya virginiana (Mill.) K. Koch	ironwood		X	X				X
BORAGINACEAE	**Borage Family**							
Cynoglossum boreale Fernald	northern wild comfrey	F6049	X					X
Lithospermum canescens (Michx.) Lehm.	hoary puccoon	M6687, M6798			X			X
Lithospermum caroliniense (J. F. Gmel.) MacMill.	hairy puccoon							X
Lithospermum officinale L.	gromwell						X	X
Myosotis arvensis (L.) Hill	field forget-me-not	P43762	X				X	
Myosotis laxa Lehm.	small forget-me-not							X
Myosotis scorpioides L.	forget-me-not	F6142	X	X			X	X
Myosotis sylvatica Hoffm.	garden forget-me-not		X				X	X
BRASSICACEAE	**Mustard Family**							
Arabis pycnocarpa M. Hopkins	hairy rock cress							X
Barbarea vulgaris W. T. Aiton	yellow rocket		X				X	X
Berteroa incana (L.) DC.	hoary alyssum						X	X
Boechera grahamii (Lehmann) Windham & Al-Shehbaz	rock cress							X
Boechera laevigata (Willd.) Al-Shehbaz	smooth bank-cress					X		
Boechera missouriensis (Greene) Al-Shehbaz	Missouri rock cress							X
Cardamine concatenata (Michx.) O.Schwarz	toothwort	H3895	X					

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BRASSICACEAE	**Mustard Family**	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Cardamine diphylla (Michx.) A. W. Wood	broad-leaved toothwort		X					
Cardamine pensylvanica Muhl. Ex. Willd	Pensylvania bitter-cress		X					
Cardamine pratensis v. palustris Wimm. & Grab	cuckoo flower	H3896	X					
Erysimum cheiranthoides L.	wormseed mustard						X	X
Hesperis matronalis L.	dame's rocket						X	X
Lepidium densiflorum Schrad.	small pepper grass						X	X
Nasturtium microphyllum Rchb.	water cress						X	X
Nasturtium officinale W. T. Aiton	water cress						X	X
Rorippa palustris (L.) Besser	yellow cress							X
Sisymbrium altissimum L.	tumble mustard						X	X
Thlaspi arvense L.	penny-cress						X	X
Turritis glabra L.	tower mustard	M6820			X			X
CALLITRICHACEAE	**Water-Starwort Family**							
Callitriche hermaphroditica L.	autumal water-starwort	H4016				X		
CAMPANULACEAE	**Bell Flower Family**							
Campanula aparinoides Pursh	marsh bellflower			X				X
Campanula rotundifolia L.	harebell	M6738			X			X
Lobelia inflata L.	Indian tobacco							X
CANNABACEAE	**Hemp Family**							
Humulus lupulus L.	common hops							X
CAPRIFOLIACEAE	**Honeysuckle Family**							
Diervilla lonicera Mill.	bush honeysuckle	F6134, F6143, P43908	X	X	X			X
Linnaea borealis L.	twinflower	M6760	X	X				X
Lonicera canadensis W. Bartram ex Marshall	American fly honeysuckle	F5616, P43759, P43773,M6663	X	X				X
Lonicera hirsuta Eaton	hairy honeysuckle	F6144, M6888	X	X	X			
Lonicera morrowii A. Gray	Asian fly honeysuckle		X				X	
Lonicera oblongifolia (Goldie) Hook.	swamp fly honeysuckle		X	X				X
Lonicera tatarica L.	Tartarian honeysuckle	F6059	X				X	
Lonicera villosa (Michx.) Schultes	mountain fly honeysuckle	F6025, M6668		X				X
Lonicera x bella Zabel	hybrid honeysuckle						X	
Symphoricarpos albus (L.) S. F. Blake	snowberry	M6819			X			X
Symphoricarpos occidentalis Hook.	wolfberry							X
Triosteum aurantiacum E. P. Bicknell	early horse-gentian	P43873	X					
Valeriana officinalis L.	common valerian	F6109, P43877	X	X			X	X
CARYOPHYLLACEAE	**Pink Family**							
Arenaria serpyllifolia L.	thyme-leaved sandwort		X					
Cerastium arvense L.	field chickweed							X
Cerastium fontanum Baumg.	mouse-ear chickweed		X				X	X
Gypsophila muralis L.	cushioin baby's breath	M6855				X	X	
Moehringia lateriflora (L.) Fenzl	wood sandwort	P43772	X					
Scleranthus annuus L.	knawel	M6756			X		X	X

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CARYOPHYLLACEAE	Pink Family	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Silene antirrhina L.	sleepy catchfly	M6758				X		
Silene dichotoma Ehrh.	forked catchfly						X	X
Silene latifolia Poir.	white campion				X		X	X
Silene vulgaris (Moench) Garcke	bladder campion						X	X
Stellaria borealis Bigelow	northern stitchwort							X
Stellaria graminea L.	starwort						X	X
Stellaria longifolia Willd.	long-leaved chickweed	M6709		X				X
CELASTRACEAE	**Bittersweet Family**							
Celastrus scandens L.	American bittersweet							X
CERATOPHYLLACEAE	**Hornwort Family**							
Ceratophyllum demersum L.	coon's tail							X
CISTACEAE	**Rock-Rose Family**							
Crocanthemum bicknellii (Fernald) Janch.	Bicknell's rock-rose	M6732			X			
Crocanthemum canadense (L.) Britton	common frostweed	P43902			X			X
Lechea intermedia Britton	intermediate pinweed	M6803, M6816, P43921			X			
CONVOLVULACEAE	**Morning Glory Family**							
Calystegia spithamaea (L.) Pursh	low bindweed	M6751			X			X
CORNACEAE	**Dogwood Family**							
Cornus alternifolia L. f.	pagoda dogwood		X	X				X
Cornus canadensis L.	bunchberry	F6137, M6869, P43761	X	X				X
Cornus foemina subsp. *racemosa* Mill.	gray dogwood		X					X
Cornus rugosa Lam.	round-leaved dogwood	F6078	X					X
Cornus sericea L.	red-oiser dogwood	F6048, F6116	X	X	X			X
CUCURBITACEAE	**Gourd Family**							
Echinocystis lobata (Michx.) Torr. & A. Gray	wild cucumber		X					X
DROSERACEAE	**Sundew Family**							
Drosera rotundifolia L.	round-leaved sundew	M6901		X				X
ELAEAGNACEAE	**Oleaster Family**							
Shepherdia canadensis (L.) Nutt.	soapberry	F6044	X					X
ERICACEAE	**Heath Family**							
Andromeda polifolia L. var. *latifolia* L.	bog rosemary	A2609				X		X
Arctostaphylos uva-ursi (L.) Spreng.	bearberry				X			X
Chamaedaphne calyculata (L.) Moench	leatherleaf							X
Chimaphila umbellata (L.) W. P. C. Barton	pipsissewa	M6764	X					X
Epigaea repens L.	trailing arbutus			X				X
Gaultheria hispidula (L.) Bigelow	creeping snowberry	F5633, F6013	X	X				X
Gaultheria procumbens L.	wintergreen	F6102, M6679	X	X	X			X
Hypopitys monotropa Crantz.	pinesap	A2612		X				
Kalmia polifolia Wangenh.	bog-laurel			X				X
Moneses uniflora (L.) A. Gray	one-flowered pyrola	F5609, F6006, F6018, P43864	X	X				X
Monotropa uniflora L.	Indian-pipe	F6007	X	X				X

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ERICACEAE	**Heath Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Orthilia secunda (L.) House	one-sided pyrola	F5617, F6004, M6667, M6676, M6763, M6829.1, M6870		X				X
Pyrola americana Sweet	American wintergreen; round-leaved shin-leaf	M6762, P43874	X				X	
Pyrola asarifolia Michx.	pink shinleaf	F6131	X	X				X
Pyrola chlorantha Sw.	green shinleaf		X					X
Pyrola elliptica Nutt.	large-leaved shinleaf	F6032, F6090, F6127, M6834	X	X				X
Pyrola minor L.	snowline wintergreen	M6829.2		X				
Rhododendron groenlandicum (Oeder) Kron & Judd	labrador tea	M6894		X				X
Vaccinium angustifolium Aiton	early low blueberry	M6660, M6680, P43767	X	X	X			X
Vaccinium macrocarpon Aiton	large cranberry			X				
Vaccinium myrtilloides Michx.	velvet-leaf blueberry	M6661, P43788	X	X	X			
Vaccinium oxycoccos L.	small cranberry			X				X
Vaccinium vitis-idaea L.	lingonberry					X		X
FABACEAE	**Pea and Bean Family**							
Amphicarpaea bracteata (L.) Fernald	American hog peanut	F6085	X					X
Astragalus canadensis L.	Canadian milkvetch	F6051	X					
Dalea candida Michx. ex Willd.	white prairie clover							X
Dalea purpurea Vent.	purple prairie clover							X
Lathyrus ochroleucus Hook.	cream pea	F5666	X					X
Lathyrus venosus Willd.	veiny pea		X					X
Lespedeza capitata Michx.	round headed bushclover							X
Lotus corniculatus L.	bird's foot trefoil		X	X	X		X	
Lupinus polyphyllus Lindl.	garden lupine						X	X
Medicago lupulina L.	black medic		X				X	
Melilotus albus Medik.	white sweet-clover		X				X	
Robinia pseudoacacia L.	black locust						X	X
Securigera varia (L.) Lassen	crown-vetch		X				X	
Trifolium aureum Pollich	hop clover		X				X	X
Trifolium campestre Schreb.	low hop clover						X	X
Trifolium hybridum L.	alsike clover		X				X	X
Trifolium pratense L.	red clover		X				X	X
Trifolium repens L.	white clover		X				X	X
Vicia americana Willd.	American vetch		X					X
Vicia villosa Roth	hairy vetch						X	X
FAGACEAE	**Beech Family**							
Quercus ellipsoidalis E. J. Hill	northern pin oak	P43855	X		X			X
Quercus macrocarpa Michx.	bur oak		X	X	X			X
Quercus rubra L.	red oak		X	X	X			X
GENTIANACEAE	**Gentian Family**							
Gentiana alba Muhl. ex. Nutt.	pale gentian					X		
Gentiana rubricaulis Schwein.	red-stemmed gentian							X
Halenia deflexa (Sm.) Griseb.	spurred gentian	M6711, M6853, M6887	X	X				X

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GERANIACEAE	**Geranium Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Geranium bicknellii Britton	Bicknell's geranium				X			X
Geranium carolinianum L.	Carolina crane's bill							X
GROSSULARIACEAE	**Gooseberry Family**							
Ribes americanum Mill.	wild black current	F5635	X	X				X
Ribes cynosbati L.	prickly wild gooseberry	F5648	X					X
Ribes glandulosum Grauer	skunk current	A2443, A2445, M6646, M6654.2	X	X				X
Ribes hirtellum Michx.	swamp gooseberry	F5665, M6655	X	X				X
Ribes hudsonianum Richardson	northern black current	F5606, F6024, F6039, M6645	X	X				X
Ribes lacustre (Pers.) Poir.	bristly black current	M6729, P43782	X	X				
Ribes triste Pall.	swamp red current	F5619, F6054, M6647, M6654.1	X	X				X
HALORAGACEAE	**Water-milfoil Family**							
Myriophyllum sibiricum Komarov	spiked water-milfoil							X
Myriophyllum tenellum Bigelow	slender water-milfoil							X
Myriophyllum verticillatum L.	water-milfoil							X
HYPERICACEAE	**St. John's Wort Family**							
Hypericum ascyron L.	giant St. John's Wort							X
Hypericum perforatum L.	common St. John's Wort				X		X	
Triadenum fraseri (Spach) Gleason	marsh St. John's Wort			X				X
LAMIACEAE	**Mint Family**							
Agastache foeniculum (Pursh) Kuntze	blue giant hyssop	M6757				X		X
Ajuga genevensis L.	bugle						X	X
Clinopodium vulgare L.	wild basil							X
Dracocephalum parviflorum Nutt.	American dragonhead	M6818			X			
Galeopsis tetrahit L.	hemp-nettle						X	X
Lycopus americanus W. P. C. Barton	common water horehound			X				X
Lycopus uniflorus Michx.	northern bugleweed	M6847, M6893	X	X				X
Mentha canadensis L.	wild mint			X				X
Monarda fistulosa L.	wild bergamot				X			X
Nepeta cataria L.	catnip				X		X	
Prunella vulgaris L.	self-heal		X	X	X			X
Scutellaria galericulata L.	marsh skullcap		X	X				X
Scutellaria lateriflora L.	mad-dog skullcap	M6861		X				X
Stachys arenicola Britton	marsh hedge nettle							X
Stachys palustris L.	marsh hedge nettle		X		X			X
Stachys tenuifolia Willd.	smooth hedge nettle	M6783	X	X				X
LENTIBULARIACEAE	**Bladderwort Family**							
Utricularia vulgaris L.	common bladderwort							X
LINDERNIACEAE	**False Pimpernel Family**							
Lindernia dubia (L.) Pennell	false pimpernel							X
LYTHRACEAE	**Loosestrife Family**							
Lythrum salicaria L.	purple loosestrife						X	X

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MALVACEAE	**Mallow Family**							
Tilia americana L.	basswood		X					X
MENYANTHACEAE	**Buckbean Family**							
Menyanthes trifoliata L.	buckbean							X
MOLLUGINACEAE	**Carpetweed Family**							
Mollugo verticillata L.	carpetweed						X	X
MYRICACEAE	**Bayberry Family**							
Comptonia peregrina (L.) J. M. Coult.	sweet fern	M6686, M6734, P43905			X			X
Myrica gale L.	sweet gale			X				X
NYCTAGINACEAE	**Four-O'clock Family**							
Mirabilis nyctaginea (Michx.) MacMill.	wild four o'clock							X
NYMPHAEACEAE	**Water Lily Family**							
Nuphar variegata Durand	yellow pond lily							X
OLEACEAE	**Olive Family**							
Fraxinus americana L.	white ash							X
Fraxinus nigra Marshall	black ash		X	X				X
Fraxinus pennsylvanica Marshall	green ash		X					X
ONAGRACEAE	**Evening-Primrose Family**							
Chamerion angustifolium L.	fireweed	A2606, M6791	X	X	X			
Circaea alpina L.	small enchanter's nightshade	M6843, M6889	X	X				X
Epilobium ciliatum Raf.	willow herb	F6135	X	X				X
Epilobium coloratum Biehler	cinnamon willow herb	M6878						X
Epilobium leptophyllum Raf.	American marsh willow-herb	M6833, M6857		X				X
Epilobium palustre L.	marsh willow-herb	M6896		X				X
Oenothera biennis L.	common evening primrose	P43899			X			X
Oenothera clelandii W. Dietr., Raven & W.L. Wagner	evening primrose	M6744			X			
Oenothera perennis L.	small evening primrose				X			
Oenothera villosa Thunb.	evening primrose	M6780			X			
OROBANCHACEAE	**Broom-rape Family**							
Conopholis americana (L.) Wallr.	American cancer-root	A2604				X		
Euphrasia stricta D. Wolff ex J. F. Lehm.	drug eye-bright	M6856				X	X	
Melampyrum lineare Desr.	cow-wheat	A2488, M6733, M6761			X			X
Pedicularis canadensis L.	wood-betony	M6695			X			X
OXALIDACEAE	**Wood-sorrel Family**							
Oxalis acetosella L. subsp. *montana* (Raf.) D. Löve	mountain wood-sorrel	M6890		X				
Oxalis dillenii Jacq.	southern yellow wood-sorrel	M6805	X					
Oxalis stricta L.	wood-sorrel				X			

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PAPAVERACEAE	**Poppy Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Capnoides sempervirens (L.) Borkh.	pink corydalis	F5650				X		X
Sanguinaria canadensis L.	bloodroot		X					
PENTHORACEAE	**Stonecrop Family**							
Penthorum sedoides L.	ditch stonecrop							X
PHRYMACEAE	**Lopseed Family**							
Mimulus glabratus Kunth	James' monkey-flower							X
Mimulus ringens L.	monkey-flower			X				X
PLANTAGINACEAE	**Plantain Family**							
Callitriche hermaphroditica L.	autumnal water starwort							X
Callitriche palustris L.	water starwort	F6015, M6903		X				X
Chelone glabra L.	turtle head	F6113, M6831, M6872	X	X				X
Linaria vulgaris Mill	butter and eggs						X	X
Nuttallanthus canadensis (L.) D. A. Sutton	blue toad-flax							X
Plantago major L.	broad-leaved plantain	P43858	X		X		X	
Plantago patagonica Jacq.	woolly plantain	M6804			X		X	
Plantago rugelii Decne.	American plantain	H3903	X					
Veronica anagallis-aquatica	water speedwell					X		
Veronica beccabunga var. *americana* Raf.	American brooklime	F6003, M6900		X				X
Veronica longifolia L.	garden veronica	F6034	X				X	
Veronica officinalis L.	common speedwell	F6150	X				X	X
Veronica peregrina L.	purslane speedwell							X
Veronica serpyllifolia L.	thyme-leaved speedwell		X					X
POLYGALACEAE	**Milkwort Family**							
Polygala paucifolia Willd.	fringed polygala	F5620, P43850		X	X			X
Polygala polygama Walter	racemed milkwort	M6737, M6797, M6813			X			X
Polygala sanguinea L.	field milkwort							X
POLYGONACEAE	**Buckwheat Family**							
Fallopia cilinodis (Michx.) Holub	fringed black bindweed	P43861		X				
Fallopia convolvulus (L.) Á. Löve	black bindwweed	M6814, P43911	X		X		X	X
Fallopia scandens (L.) Holub	false buckwheat		X					X
Fallopia x bohemica (Chrtek & Chrtkova) J.P.Bailey	bohemian knotweed						X	X
Persicaria amphibia (L.) Delabare	water smartweed							X
Persicaria lapathifolia (L.) Delabare	nodding smartweed							X
Persicaria maculosa Gray	curly-top knotweed	H3969			X		X	
Persicaria punctata (Elliott) Small	dotted smartweed							X
Persicaria sagittata (L.) H. Gross	arrow-leaved tear-thumb	M6865		X				X
Polygonella articulata (L.) Meisn.	coastal jointweed	M6801, P43887			X			
Polygonum achoreum S. F. Blake	leathery knotweed							X
Polygonum aviculare L.	prostrate knotweed							X
Polygonum erectum L.	erect knotweed							X
Rumex acetosella L.	sheep sorrel				X		X	X
Rumex britannica L.	great water dock		X	X				X

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POLYGONACEAE	**Buckwheat Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Rumex crispus L.	curly dock		X				X	X
Rumex obtusifolius L.	bitter dock	H3745	X					
Rumex triangulivalvis (Danser) Rech. f.	white dock							X
PORTULACACEAE	**Purslande Family**							
Portulaca oleracea L.	purslane						X	X
PRIMULACEAE	**Primrose Family**							
Lysimachia ciliata L.	fringed loosestrife	F6151	X	X				X
Lysimachia quadriflora Sims	prairie loosestrife				X			X
Lysimachia quadrifolia L.	whorled loosestrife	A2483, P43851, P43900				X		X
Lysimachia terrestris (L.) Britton, Sterns & Poggenb.	swamp candles	A2608		X				X
Lysimachia thyrsiflora L.	tufted loosestrife							X
Trientalis borealis Raf.	star flower	P43752	X	X	X			X
RANUNCULACEAE	**Buttercup Family**							
Actaea pachypoda Elliott	doll's-eyes	H3715				X		
Actaea rubra (Aiton) Willd.	red baneberry	F6132, M6876	X					X
Anemone acutiloba (DC.) G.Lawson	sharp-lobed hepatica		X	X				
Anemone americana (DC.) H.Hara	round-leaved hepatica	F5612	X					X
Anemone canadensis L.	Canada anemone		X					X
Anemone cylindrica A. Gray	thimbleweed	F6047	X		X			
Anemone quinquefolia L.	wood anemone	F5622, M6653, M6682, P43753	X	X	X			X
Anemone virginiana L.	thimbleweed	F6128	X					X
Aquilegia canadensis L.	wild columbine	F5653	X		X			X
Caltha palustris L.	marsh marigold	F5638, M6652	X	X				X
Clematis occidentalis (Hornem.) DC.	purple clematis							X
Clematis virginiana L.	virgin's bower		X					X
Coptis trifolia (L.) Salisb.	goldthread	F5607, M6644	X	X				X
Ranunculus abortivus L.	kidney-leaved buttercup		X	X				X
Ranunculus acris L.	tall buttercup	F6082	X	X			X	X
Ranunculus aquatilis var. *diffusus* With.	aquatic buttercup							X
Ranunculus hispidus Michx.	bristly buttercup	H3820	X					
Ranunculus lapponicus L.	lapland buttercup			X				X
Ranunculus pensylvanicus L. f.	bristly buttercup		X					X
Ranunculus recurvatus Poir.	hooked buttercup	M6719	X	X				X
Thalictrum dasycarpum Fisch. & Avé-Lall.	purple meadow-rue	F6120, M6715, M6867	X	X				X
Thalictrum dioicum L.	early meadow-rue	F5629, M6653, M6682, P43753	X	X				
RHAMNACEAE	**Buckthorn Family**							
Ceanothus americanus L.	New Jersey tea							X
Ceanothus herbaceus Raf.	Jersey tea	P43911			X			X
Rhamnus alnifolia L'Her.	alder-leaved buckthorn	A2444, M6657		X				X
Rhamnus cathartica L.	common buckthorn		X				X	X

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ROSACEAE	Rose Family	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Agrimonia gryposepala Wallr.	tall agrimony	F6045, F6081, P43872	X	X				X
Agrimonia striata Michx.	roadside agrimony							X
Amelanchier arborea (F. Michx.) Fernald	common serviceberry		X	X	X			
Amelanchier bartramiana (Tausch) M. Roem.	mountain Juneberry							X
Amelanchier interior Nielsen	inland serviceberry	M6669		X				X
Amelanchier laevis Wiegand	smooth serviceberry		X	X				X
Amelanchier sanguinea (Pursh) DC.	round-leaved serviceberry	F6043,F5655, M6671	X	X	X			X
Amelanchier spicata (Lam.) K. Koch	shadbush serviceberry	M6697			X			X
Aronia melanocarpa (Michx.) Elliott	chokeberry							X
Aronia x prunifolia (Marshall) Rehder (pro sp.)	chokeberry							X
Comarum palustre L.	marsh cinquefoil	2607		X				X
Crataegus chrysocarpa Ashe	hawthorn	A2545, P43748	X					X
Crataegus macracantha Lodd. ex Loudon var. *occidentalis* (Britton) Eggl.	long-thorned hawthorn							X
Crataegus submollis Sarg.	northern red haw	A2546	X					
Crataegus succulenta Link	hawthorn							X
Drymocallis arguta (Pursh) Rydb.	prairie cinquefoil	M6752, P43920			X			
Filipendula rubra (Hill) B. L. Rob.	queen-of-the-prairie						X	X
Fragaria vesca L.	woodland strawberry		X	X				X
Fragaria virginiana Mill.	wild strawberry	F5643, M6685, P43749	X	X	X			X
Geum aleppicum Jacq.	yellow avens	F6055, F6083	X					X
Geum canadense Jacq.	white avens		X					
Geum fragarioides (Michx.) Smedmark	barren strawberry	P43790	X	X	X			X
Geum macrophyllum Willd.	large-leaved avens	F6010		X				
Geum rivale L.	purple avens	M6726, M6859, M6898	X	X				X
Geum triflorum Pursh	prairie smoke							X
Potentilla argentea L.	silvery cinquefoil				X		X	X
Potentilla norvegica L.	rough cinquefoil			X	X			X
Potentilla recta L.	rough-fruited cinquefoil		X		X		X	
Potentilla simplex Michx.	common cinquefoil		X		X			
Prunus americana Marshall	American plum			X				
Prunus nigra Aiton	Canada plum							X
Prunus pensylvanica L. f.	pin cherry	M6664		X				X
Prunus pumila L.	sand cherry	M6678			X			X
Prunus serotina Ehrh.	black cherry		X	X	X			X
Prunus virginiana L.	chokecherry	F5637, M6659, M6698, P43785	X	X	X			X
Pyrus communis L.	common pear		X				X	
Rosa acicularis Lindl.	bristly rose	F5656, F6019	X	X	X			
Rosa blanda Aiton	smooth rose	A2484, A2487, F6122	X		X			X
Rosa carolina L.	pasture rose	M6747, M6795			X			
Rubus allegheniensis Porter	common blackberry		X		X			X
Rubus flagellaris Willd.	short-stalk dewberry	M6767, P43903			X			
Rubus idaeus subsp. *strigosus* L.	red raspberry		X	X	X			X

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ROSACEAE	**Rose Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Rubus parviflorus Nutt.	thimbleberry		X					X
Rubus pensilvanicus Poir.	Pennsylvania blackberry							X
Rubus pubescens Raf.	dwarf raspberry	F5640, M6656, M6723	X	X				X
Rubus setosus Bigelow	bristly blackberry				X			X
Sibbaldiopsis tridentata (Aiton) Rydb.	three-toothed cinquefoil	A2489, M6736, M6806			X			X
Sorbus americana Marshall	American mountain ash	M6884	X	X				
Spiraea alba Du Roi	white meadowsweet		X	X				
RUBIACEAE	**Madder Family**							
Galium aparine L.	cleavers		X					X
Galium asprellum Michx.	rough bedstraw	F6107	X	X				X
Galium boreale L.	northern bedstraw		X		X			X
Galium tinctorium L.	stiff bedstraw							X
Galium trifidum L.	small bedstraw					X		
Galium triflorum Michx.	fragrant bedstraw	F6022, F6038	X	X				X
Houstonia longifolia Gaertn.	long-leaved bluets	P43915			X			X
Mitchella repens L.	partridgeberry	F6136, P43757	X					X
SALICACEAE	**Willow Family**							
Populus alba L.	silver poplar		X				X	
Populus balsamifera L.	balsam poplar		X	X				X
Populus grandidentata Michx.	big-tooth aspen		X	X	X			X
Populus tremuloides Michx.	quaking aspen		X	X	X			X
Salix alba L.	white willow						X	X
Salix bebbiana Sarg.	Bebb's willow		X	X				X
Salix discolor Muhl.	pussy willow	F6020, M6665	X	X				X
Salix eriocephala Michx.	heart-leaved willow							X
Salix humilis Marshall	prairie willow	M6699, P43747	X		X			X
Salix lucida Muhl.	shining willow							X
Salix nigra Marshall	black willow		X					
Salix pedicellaris Pursh	bog willow							X
Salix petiolaris Sm.	slender willow		X		X			X
Salix pyrifolia Andersson	balsam willow	M6670		X				
Salix x rubens Schrank	hybrid crack willow		X				X	X
SANTALACEAE	**Sandalwood Family**							
Comandra umbellata (L.) Nutt.	bastard toadflax				X			X
SAPINDACEAE	**Soapberry Family**							
Acer negunda L.	box elder		X					
Acer rubrum L.	red maple	P43750	X	X	X			
Acer saccharum Marshall	sugar maple		X					
Acer spicatum Lam.	mountain maple	F5628, F5660, F6001, F6119, M6892, P43862	X	X				X
SARRACENIACEAE	**Pitcher-Plant Family**							
Sarracenia purpurea L.	pitcher plant							X

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		Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
SAXIFRAGACEAE	**Saxifrage Family**							
Chrysosplenium americanum Hook.	golden saxifrage	M6846	X	X				X
Heuchera richardsonii R. Br.	alum root	P43917			X			X
Micranthes pensylvanica (L.) Haw.	swamp saxifrage	F5654	X	X				X
Mitella diphylla L.	bishop's cap	F5621, F5641	X	X				
Mitella nuda L.	naked miterwort	F5613, M6673	X	X				X
SCROPHULARIACEAE	**Figwort Family**							
Scrophularia lanceolata Small	early figwort							X
Verbascum thapsus L.	mullein				X		X	X
SOLANACEAE	**Nightshade Family**							
Physalis virginiana Mill.	Virginia ground cherry	M6750			X			X
Solanum dulcamara L.	bittersweet night-shade	F6130	X	X			X	X
THYMELAECEAE	**Mezereum Family**							
Dirca palustris L.	leatherwood	A2601	X					X
ULMACEAE	**Elm Family**							
Ulmus americana L.	American elm		X					X
URTICACEAE	**Nettle Family**							
Laportea canadensis (L.) Wedd.	wood nettle		X					X
Urtica dioica L.	stinging nettle		X					X
VALERIANACEAE	**Valerian Family**							
Valeriana officinalis L.	garden valerian			X			X	
VERBENACEAE	**Vervain Family**							
Verbena hastata L.	blue vervain							X
VIOLACEAE	**Violet Family**							
Viola adunca Sm.	hook-spur violet	M6681			X			
Viola blanda Willd.	sweet white violet	H3899	X					
Viola cucullata Aiton	blue marsh violet		X	X				
Viola labradorica Schrank	dog violet	F5626, P43754	X		X			X
Viola macloskeyi F. E. Lloyd	smooth white violet	F5627, M6666	X	X				X
Viola pedata L.	bird's-foot violet	M6689			X			X
Viola pubescens Aiton	yellow wood violet	F5630, P43776	X					X
Viola renifolia A. Gray	kidney-leaved violet	H3900		X				
Viola sororia Willd.	common blue violet	H4034	X					
VITACEAE	**Grape Family**							
Parthenocissus inserta (A. Kern.) Fritsch	grape woodbine	P43885	X					
Parthenocissus quinquefolia (L.) Planch.	Virginia creeper		X	X				

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Flowering Monocots

ACORACEAE	**Sweet Flag Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Acorus americanus (Raf.) Raf.	sweet-flag							X
ALISMATACEAE	**Water-Plantain Family**							
Alisma triviale Pursh	northern water plantain							X
Sagittaria cuneata E. Sheld.	arum-leaved arrow-head							X
Sagittaria latifolia Willd.	arrow-head							X
Sagittaria rigida Pursh	stiff arrow-head							X
AMARYLLIDACEAE	**Amaryllis family**							
Allium tricoccum Aiton	wild leeks		X					X
ARACEAE	**Arum Family**							
Arisaema triphyllum (L.) Schott	jack-in-the-pulpit	M6852	X	X				X
Calla palustris L.	wild calla	F5663, M6839		X				X
Lemna minor L.	common duckweed							X
Lemna trisulca L.	star duckweed							X
Lemna turionifera Landolt	red duckweed							X
Spirodela polyrhiza (L.) Schleid.	greater duckweed							X
Symplocarpus foetidus (L.) Nutt.	skunk cabbage		X					X
ASPARAGACEAE	**Asparagus Family**							
Convallaria majalis L.	European lily-of-the-valley		X				X	X
Maianthemum canadense Desf.	wild lily-of-the-valley	F6094, P43768	X	X	X			X
Maianthemum racemosum (L.) Link	false Solomon's-seal	H3545	X	X				
Maianthemum stellatum (L.) Link	starry false Solomon's-seal							X
ASPARAGACEAE	**Asparagus Family**							
Maianthemum trifolium (L.) Sloboda	false may flower			X				X
Polygonatum pubescens (Willd.) Pursh	downy Solomon's-seal	F5659, P43858	X	X				
COLCHICACEAE	**Colchicum family**							
Uvularia grandiflora Sm.	bellwort	F5645, F6056, F6113	X					X
Uvularia sessilifolia L.	sessile bellwort	F6117, M6799, P43786	X		X			X
CYPERACEAE	**Sedge Family**							
Bulbostylis capillaris (L.) C. B. Clarke	dense tuft hair sedge	A2486			X			
Carex adusta Boott	lesser brown sedge	M6759						X
Carex aquatilis Wahlenb.	water sedge	H3999	X	X				
Carex arcta Boott	northern cluster sedge							X
Carex arctata Boott	drooping woodland sedge	F5661, F6027, F6095, F6153		X				X
Carex assiniboinensis W.Boott	Assiniboine sedge	H3628, H3750,A2547	X					
Carex aurea Nutt.	golden sedge	F6046	X					X
Carex backii W. Boott	Rocky Mountain sedge	H3419,A2603, F5649				X		
Carex bebbii (L. H. Bailey) Fernald	Bebb's sedge	M6704		X				X
Carex bicknellii Britton	Bicknell's oval sedge					X		
Carex blanda Dewey	common wood sedge		X					

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CYPERACEAE	Sedge Family	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Carex bromoides Schkuhr ex Willd. subsp. *bromoides*	brome-like sedge	H4007	X					
Carex brunnescens (Pers.) Poir.	brownishh sedge	F6041, M6705	X	X				X
Carex canescens L.	silvery sedge							X
Carex castanea Wahlenb.	chestnut sedge	F6152, M6707, P43764, P43751	X	X				X
Carex chordorrhiza L. f.	cord-root sedge	H3783		X				
Carex communis L. H. Bailey	fiberousroot sedge	F5662, P43766	X					X
Carex crawfordii Fernald	Crawford's sedge	M6800			X			X
Carex crinita Lam.	fringed sedge		X	X				X
Carex cryptolepis Mack.	northeastern sedge							X
Carex deflexa Hornem.	northern sedge	M6658		X				X
Carex deweyana Schwein.	Dewey's sedge	F6033, M6716, P43758	X	X				X
Carex disperma Dewey	soft leaf sedge	F5632, F6012, M6643, M6712	X	X				X
Carex eburnea Boott	bristle-leaf sedge	H3966		X				
Carex echinata Murray subsp. *echinata*	star sedge	H3400	X	X				
Carex echinodes (Fernald) P.Rothr., Reznicek & Hipp.	marsh straw sedge	F6062	X					
Carex foenea Willd.	bronze-headed oval sedge	H3491	X		X			X
Carex gracillima Schwein.	graceful sedge	F6040, F6063, M6713, P43763	X	X	X			X
Carex granularis Willd.	limestone meadow sedge	F6050	X					
Carex gynandra Schwein.	nodding sedge	F6053, F6070, M6717, M6727, M6880, M6899	X	X				X
Carex hirtifolia Mack.	hairy sedge	H3802	X					
Carex houghtoniana Dewey	Houghton's sedge							X
Carex hystericina Willd.	bottlebrush sedge	F6023, M6722, M6897		X				X
Carex interior L. H. Bailey	inland sedge	F6000, M6728		X				X
Carex intumescens Rudge	greater bladder sedge	A2602, F6148, M6706	X	X				X
Carex lacustris Willd.	lake sedge		X	X				X
Carex laxiflora Lam.	beach wood sedge	P43777	X	X				
Carex leptalea Wahlenb.	bristlystalked sedge	F6009, M6873		X				X
Carex leptonervia (Fernald) Fernald	nerveless woodland sedge	F6026	X	X				X
Carex lurida Wahlenb.	shallow sedge							X
Carex magellanica Lam.	boreal bog sedge	F6028, M6826, M6904		X				X
Carex muhlenbergii Schkuhr ex Willd.	Muhlenberg's sedge	M6753			X			
Carex normalis Mack.	greater straw sedge	F6147	X					
Carex oligosperma Michx.	few seed sedge							X
Carex pauciflora Lightf.	few flowered sedge							X
Carex peckii Howe	Peck's sedge	F5614	X	X				
Carex pedunculata Willd.	long-stalk sedge	F5608, M6648, P43756	X	X				
Carex pellita Willd.	broad-leaved wooly sedge							X
Carex pensylvanica Lam.	Pennsylvannia sedge	M6684, P43780	X	X	X			X
Carex projecta Mack.	necklace sedge	M6710, M6714	X	X				X
Carex radiata (Wahlenb.) Small	eastern star sedge		X					
Carex retrorsa Schwein.	deflexed bottlebrush sedge	F6140	X					X

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CYPERACEAE	Sedge Family	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Carex richardsonii	praire hummock sedge				X			
Carex scabrata Schwein.	eastern rough sedge	F6084	X					X
Carex scoparia Willd.	broom sedge		X					X
Carex siccata Dewey	dry-spiked sedge				X			
Carex sprengelii Spreng.	long-beaked sedge; Sprengel's sedge	P43791	X					
Carex stipata Willd.	common fox sedge	M6725	X	X				X
Carex stricta Lam.	tussock sedge		X					X
Carex tenera Dewey	quill sedge	F6145	X					
Carex tenuiflora Wahlenb.	sparseflower sedge			X				X
Carex tonsa (Fernald) E. P. Bicknell var. *rugosperma*	shaved sedge	M6683	X		X			
Carex trisperma Dewey	three seeded sedge			X				X
Carex tuckermanii Dewey	Tuckerman's sedge							X
Carex umbellata Willd.	early oak sedge	F5647				X		
Carex utriculata Boott	yellow lake sedge							X
Carex vaginata Tausch	sheathed sedge	F6017		X				X
Carex vesicaria L.	blister sedge							X
Carex viridula Michx.	little green sedge							X
Carex vulpinoidea Michx.	fox sedge							X
Carex x knieskesnii Dewey (pro sp.)	hybrid sedge	H3714				X		
Cladium mariscoides (Muhl.) Torr.	twig-rush							X
Cyperus houghtonii Torr.	Houghton's nut sedge	M6817, P43893			X			
Cyperus lupulinus (Spreng.) Marcks	slender sand sedge							X
Cyperus schweinitzii Torr.	Great Plains sand sedge				X			
Dulichium arundinaceum (L.) Britton	three-way sedge							X
Eleocharis erythropoda Steud.	bald spike rush							X
Eleocharis intermedia Schult.	intermediate spike rush							X
Eleocharis obtusa (Willd.) Schult.	blunt spike rush							X
Eleocharis palustris (L.) Roem. & Schult.	spike rush							X
Eriophorum angustifolium Honck.	narrow leaf cotton grass							X
Eriophorum gracile W. D. J. Koch	slender leaf cotton grass							X
Eriophorum tenellum Nutt.	conifer cotton grass	A2610				X		
Eriophorum vaginatum L.	cotton grass					X		X
Eriophorum virginicum L.	tawny cotton grass	A2611				X		X
Eriophorum viridi-carinatum (Engelm.) Fernald	green-keeled cotton grass					X		X
Rhynchospora alba (L.) Vahl	white beak sedge					X		
Rhynchospora fusca (L.) W. T. Aiton	brown beak sedge	A2614				X		X
Schoenoplectus tabernaemontani (C. C. Gmel.) Palla	soft stem bulrush					X		X
Scirpus atrovirens Willd.	black bulrush	F6121	X					
Scirpus cyperinus (L.) Kunth	wool-grass		X					X
Scirpus microcarpus C. Presl	panicled bulrush					X		X
Trichophorum alpinum (L.) Pers.	alpine bulrush	A2613				X		X

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ERIOCAULACEAE	**Pipewort Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Eriocaulon aquaticum (Hill) Druce	pipewort							X
HYDROCHARITACEAE	**Frog's-bit Family**							
Elodea canadensis Michx.	common waterweed							X
Elodea nuttallii (Planch.) H. St. John	slender waterweed							X
Najas flexilis (Willd.) Rostk. & Schmidt	slender naiad							X
Vallisneria americana Michx.	eel-grass							X
IRIDACEAE	**Iris Family**							
Iris pseudacorus L.	yellow-flag		X				X	X
Iris versicolor L.	wild blue-flag	M6840	X	X				X
Sisyrinchium campestre E. P. Bicknell	prairie blue-eyed grass				X			
Sisyrinchium montanum Greene	mountain blue-eyed grass				X			X
JUNCACEAE	**Rush Family**							
Juncus balticus Willd.	arctic rush							X
Juncus brevicaudatus (Englem.) Fernald	narrow-panicle rush	H3700		X				
Juncus effusus L.	soft-stem rush	H3974		X				
Juncus interior Wiegand	inland rush							X
Juncus nodosus L.	joint rush							X
Juncus tenuis Willd.	path rush		X		X			X
Juncus vaseyi Engelm.	Vasey's rush							X
Luzula acuminata Raf.	hairy wood rush	F5611, M6642, P43755	X	X				X
multiflora	common wood rush	P43789	X					
LILIACEAE	**Lily Family**							
Clintonia borealis (Aiton) Raf.	blue-bead lily	M6824, M6854, M6895, P43765	X	X				X
Erythronium americanum Ker Gawl.	yellow trout lily	P43781	X					
Lilium michiganense Farw.	Michigan Lily	F6035	X					X
Lilium philadelphicum L.	wood lily	M6735			X			X
Streptopus amplexifolius (L.) DC.	clasp-leaf twisted stalk			X				
Streptopus lanceolatus (Aiton) Reveal	rose twisted stalk	M6850, P43778	X	X				X
MELANTHIACEAE	**Bunchflower Family**							
Trillium cernuum L.	nodding trillium	F5639, F6096, M6718, M6875, P43770	X	X				X
Trillium grandiflorum (Michx.) Salisb.	big white trillium		X	X				
ORCHIDACEAE	**Orchid Family**							
Arethusa bulbosa L.	dragon's mouth							X
Calopogon tuberosus (L.) Britton, Sterns & Poggenb.	grass pink							X
Calypso bulbosa (L.) Oakes	fairy slipper			X				X
Corallorhiza maculata Raf.	spotted coral-root		X					X
Corallorhiza trifida Chatel	early coral-root	M6675	X	X				
Cypripedium acaule Aiton	moccasin flower	M6825		X	X			X
Cypripedium parviflorum Salisb. var. *makasin* (Farw.) Sheviak	small yellow lady's slipper			X				X
Cypripedium parviflorum Salisb. var. *pubescens* (Willd.) O. W. Knight	yellow lady's slipper		X	X				X

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ORCHIDACEAE	**Orchid Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Cypripedium reginae Walter	showy lady's slipper	P43876	X					X
Goodyera pubescens (Willd.) R. Br.	downy rattlesnake plantain							X
Goodyera repens (L.) R. Br.	creeping rattlesnake plantain	M6851		X				X
Goodyera tesselata Lodd.	tesselated rattlesnake plantain							X
Malaxis unifolia Michx.	green adder's mouth			X				X
Neottia cordata (L.) Rich.	heart-leaved twayblade	A2442, F5623, M6674		X				X
Platanthera aquilonis Sheviak	northern green orchid	M6828, M6902		X				
Platanthera clavellata (Michx.) Luer	club-spur orchid							X
Platanthera huronensis (Nutt.) Lindl.	green bog orchid							X
Platanthera obtusata (Pursh) Lindl.	blunt-leaved orchid	M6830		X				X
Platanthera psycodes (L.) Lindl.	purple fringed orchid		X					X
Spiranthes cernua (L.) Rich.	nodding lady tresses							X
POACEAE	**Grass Family**							
Agrostis gigantea Roth	red top		X	X	X		X	X
Agrostis hyemalis (Walter) Britton, Sterns & Poggenb.	tickle grass	A2485			X			X
Agrostis perennans (Walter) Tuck.	autumn bent grass	F6141, M6837, M6881	X	X				X
Agrostis scabra Willd.	tickle grass	M6754, M6784			X			
Alopecurus aequalis Sobol.	short-awned foxtail							X
Ammophila breviligulata Fernald	beach grass							X
Andropogon gerardii Vitman	big bluestem	M6782, P43888			X			X
Anthoxanthum hirtum (Schrank) Y.Schouten & Veldkamp	sweet grass							X
Aristida basiramea Vasey	fork-tipped three-awn grass	M6802, P43890			X			X
Brachyelytrum aristosum (Michx.) P. Beauv. ex Branner & Coville	long-awned wood grass	M6703, M6883	X	X				
Bromus ciliatus L.	fringed brome	F6042, F6088, M6708, M6886	X	X	X			X
Bromus inermis Leyss.	smooth brome						X	X
Bromus kalmii A. Gray	prairie brome	A2490, M6739, M6787			X			X
Calamagrostis canadensis (Michx.) P. Beauv.	blue-joint grass	F6091, F6149, M6841, M6879	X	X				X
Cinna latifolia (Goepp.) Griseb.	wood reed grass	F6103, M6821, M6871	X	X				X
Dactylis glomerata L.	orchard grass						X	X
Danthonia spicata (L.) Roem. & Schult.	poverty oat grass	M6731, M6741, M6742, M6815	X	X	X			X
Dichanthelium acuminatum (Sw.) Gould & C. A. Clark	hairy panic grass	H4005			X			
Dichanthelium columbianum (Scribn.) Freckmann	hemlock panic grass							X
Dichanthelium depauperatum (Muhl.) Gould	starved panic grass	M6755			X			X
Dichanthelium linearfolium (Scrib.) Gould	linear-leaved panic grass					X		
Dichanthelium meridionale Ashe	mat panic grass	M6748			X			
Dichanthelium xanthophysum (A. Gray) Freckmann	slender rosette grass	A2605, M6807, P43852			X			X
Digitaria ischaemum (Schreb.) Muhl.	smooth crabgrass	P43892			X		X	
Echinochloa crusgalli (L.) P. Beauv.	barnyard grass						X	X

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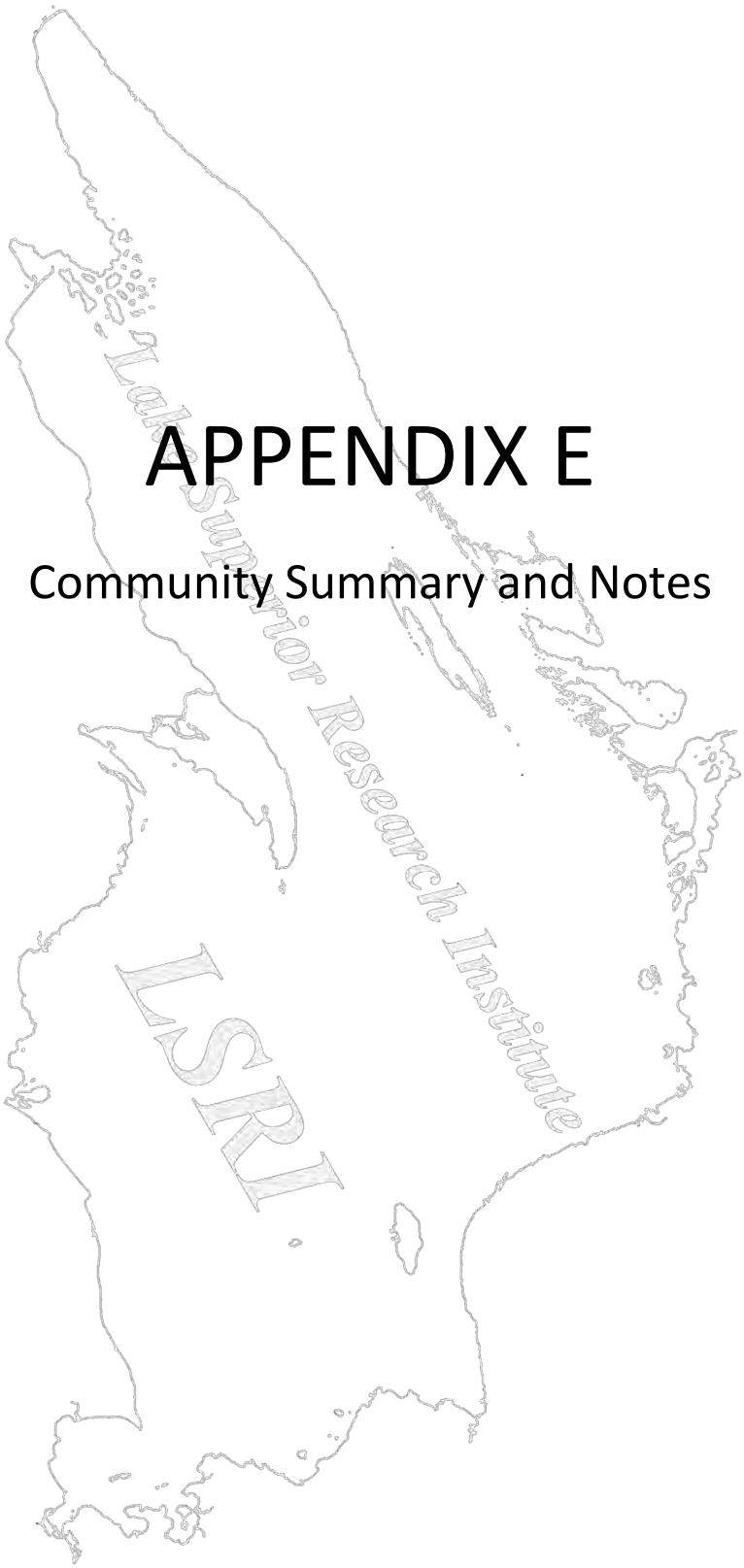
POACEAE	**Grass Family**	**Col. No.**	**BF**	**WC**	**PB**	**OTHER**	**Introd.**	**Previously Collected**
Echinochloa muricata (P. Beauv.) Fernald	barnyard grass							X
Elymus canadensis L.	Canada wild rye							X
Elymus hystrix L.	bottlebrush grass	F6014, F6057, F6114, P43880	X	X				X
Elymus repens (L.) Gould	quack grass				X		X	X
Elymus trachycaulus (Link) Gould	slender wheat grass	H3735,F6058, M6811	X		X			
Elymus villosus Willd.	hairy wild rye		X					
Elymus virginicus L.	Virginia wild rye	H3970,F6106, P43879	X					
Elymus wiegandii Fernald	Wiegand's wild rye	P43878	X					
Eragrostis hypnoides (Lam.) Britton, Sterns & Poggenb.	creeping love grass							X
Festuca saximontana Rydb.	Rocky Mountain fescue	M6692			X			
Festuca trachyphylla (Hack.) Krajina	hard fescue	H3680			X			
Glyceria borealis (Nash) Batch.	northern manna grass							X
Glyceria canadensis (Michx.) Trin.	rattlesnake grass							X
Glyceria grandis S. Watson	reed manna grass		X					X
Glyceria striata (Lam.) Hitchc.	fowl manna grass	F6021		X				X
Koeleria macrantha (Ledeb.) Schult.	June grass				X			X
Leersia oryzoides (L.) Sw.	rice cut grass			X				X
Milium effusum L.	wood millet	F6031, F6099	X					X
Muhlenbergia glomerata (Willd.) Trin.	marsh muhly	P43853, P43913			X			
Muhlenbergia mexicana (L.) Trin.	leafy satin-grass	M6779, P43882	X		X			
Oryzopsis asperifolia Michx.	rough-leaved rice grass	M6688, P43771	X		X			X
Phalaris arundinacea L.	reed canary grass		X				X	
Phleum pratense L.	Timothy		X		X		X	X
Piptatheropsis pungens (Torr. ex Spreng.) Romasch., P. M. Peterson & R. J. Soreng	moutain rice grass	M6694			X			
Poa annua L.	annual bluegrass		X				X	
Poa compressa L.	Canada bluegrass	H3681	X		X		X	
Poa nemoralis L.	wood bluegrass	F6036, F6052, P43849	X				X	
Poa palustris L.	marsh bluegrass	F6030	X	X				X
Poa pratensis L.	Kentucky bluegrass	M6690	X		X		X	
Poa saltuensis Fernald & Wiegand	old pasture bluegrass	H4013	X	X				X
Schizachne purpurascens (Torr.) Swallen	false melic grass	H3405	X	X	X	X		X
Schizachyrium scoparium (Michx.) Nash	little bluestem	M6786, P43896			X			X
Sorghastrum nutans (L.) Nash	Indian grass	P43922			X			X
Spartina pectinata Link	prairie cord grass	P43886				X		
Sphenopholis intermedia (Rydb.) Rydb.	slender wedge grass	A2600, M6724	X	X				
POTAMOGETONACEAE	**Pondweed Family**							
Potamogeton alpinus Balb.	alpine pondweed							X
Potamogeton amplifolius Tuck.	large-leaved pondweed							X
Potamogeton epihydrus Raf.	ribbon leaf pondweed							X
Potamogeton foliosus Raf.	leafy pondweed							X
Potamogeton friesii Rupr.	Fries's pondweed							X
Potamogeton gramineus L.	variable leaf pondweed							X
Potamogeton natans L.	floating-leaf pondweed							X

Red = County Record
Blue = New Brule River Watershed Record

POTAMOGETONACEAE	**Pondweed Family**	Col. No.	BF	WC	PB	OTHER	Introd.	Previously Collected
Potamogeton obtusifolius Mert. & W.D.J.Koch	blunt-leaf pondweed							X
Potamogeton praelongus Wulfen	white-stemmed pondweed							X
Potamogeton pusillus L.	small pondweed							X
Potamogeton richardsonii (A. Benn.) Rydb.	Richardson's pondweed	F6016		X				X
Potamogeton spirillus Tuck.	spiral pondweed							X
Potamogeton strictifolius A. Benn.	narrow-leaved pondweed							X
Potamogeton zosteriformis Fernald	flat-stemmed pondweed							X
Stuckenia filiformis (Pers.) Börner	narrow-leaved pondweed							X
Stuckenia pectinata (L.) Börner	sago pondweed							X
SCHEUCHZERIACEAE	**Pod-grass Family**							
Scheuchzeria palustris L.	pod-grass			X				
SMILACACEAE	**Carrion Flower Family**							
Smilax ecirrhata (Kunth) S. Watson	upright carrion-flower		X					
Smilax herbacea L.	common carrion-flower		X					
Smilax illinoensis Mangaly	Illinois carrion-flower	P43775.2	X					
Smilax lasionera L.	bristly greenbrier	H3840	X					
TYPHACEAE	**Cat-Tail Family**							
Sparganium americanum Nutt.	American bur-reed							X
Sparganium angustifolium Michx.	narrow-leaved bur-reed							X
Sparganium emersum Rehm.	green-fruited bur-reed							X
Sparganium eurycarpum Engelm.	common bur-reed							X
Sparganium fluctuans (Morong) B. L. Rob.	floating bur-reed							X
Typha latifolia L.	common cat-tail							X
		Totals:	351	261	190		108	



APPENDIX E

Community Summary and Notes

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Community Summaries

	Boreal Forest
Major Tree (IV) Dominants	*Populus tremuloides (.31), Abies balsamea (.25), Picea glauca (.15), Pinus strobus (.13).*
Prevalent Species	*Eurybia macrophylla, Maianthemum canadense, Pteridium aquilinu, Aralia nudicaulis.*
Leading Families	Cyperaceae (10.1%), Asteraceae (9.6%), Rosaceae (8.0%), Poaceae (7.4%) Ranunculaceae (5.3%).
α species richness	132
γ species richness	351
Mean Ct	4.7
MeanCn	5.3
% introduced species	14.20%
growth form	TREES 26, SHRUBS 50, FORBS 207, GRAMINOIDS 64, VINES 6 TOTAL 351.
no. of sites studied	10

	Northern Wet-Mesic Forests
Major Tree (IV) Dominants	*Thuja occidentalis (.79), Abies balsamea (.19).*
Prevalent Species	*Rubus pubescens, Coptis trifolia, Maianthemum canadense, Trientalis borealis,Cornus canadensis.*
Leading Families	Cyperaceae (10.8%), Asteraceae (9.9%), Rosaceae (7.9%), Poaceae (5.8%) and Ericaceae (5.3%).
α species richness	98
γ species richness	261
Mean Ct	6.2
MeanCn	6.3
% introduced species	3.40%
growth form	TREES 18, SHRUBS 48, FORBS 142, GRAMINOIDS 51, VINES 1 TOTAL 261.
no. of sites studied	11

	Pine Barrens
Major Tree (IV) Dominants	*Pinus banksiana (.46) Pinus resinosa (.40).*
Prevalent Species	*Comptonia peregrina, Corylus americana, Prunus pumila, Rubus flagellaris, Carex pensylvanica, Vaccinium angustifolium, Andropogon gerardii, Danthonia spicata, Quercus macrocarpa, Quercus ellipsoidalis, Monarda fistulosa.*
Leading Families	Asteraceae (17.8%), Poaceae (12.0%) and Rosaceae (11.6%).
α species richness	84
γ species richness	190
Mean Ct	4
MeanCn	4.3
% introduced species	13.70%
growth form	TREES 12, SHRUBS 27, FORBS 118, GRAMINOIDS 32, VINES 1TOTAL 190
no. of sites studied	5

DOUGLAS COUNTY NEW RECORDS

Genus	Species	Status
Anemone	acutiloba	
Boechera	laevigata	
Cardamine	pratensis var. palustris	
Carex	backii	SC
Carex	blanda	
Carex	bromoides var. bromoides	
Carex	echinodes	
Carex	hirtifolia	
Carex	normalis	
Carex	richardsonii	
Carex	laxiflora	
Carex	sprengellii	
Carex	x knieskernii	
Conopholis	americana	
Crataegus	submollis	
Dichanthelium	linearifolium	
Elymus	villosa	I
Elymus	wiegandii	
Gentiana	alba	
Helianthus	hirsutus	
Hieracium	lachenallii	I
Kriga	biflora	
Lactuca	hirsuta	I
Lactuca	serriola	I
Moehringia	lateriflora	I
Myosotis	arvensis	
Neptea	cataria	I
Oenothera	clelandii	
Picea	abies	I
Plantago	rugellii	
Pseudognaphlium	obtusifolium	
Pyrola	americana	
Pyrus	communis	
Ribes	lacustre	
Smilax	illinoensis	
Symphyotrichium	urophyllum	
Triosteum	aurantiacum	
Veronica	anagalis-aquatica	
Veronica	longifolia	I
	Total	**40**
	Introduced	**25%**

NOTABLE (RARE) IN BRW

Genus	Species	Status
Asclepias	exaltata	
Cardamine	concatenata	
Cardamine	pratensis v. palustris	
Carex	assiniboinensis	
Carex	bicknellii	
Carex	chordorrihiza	
Carex	eburnea	
Carex	granularis	
Carex	peckii	
Carex	tonsa	
Carex	umbellata	
Carex	tenera	
Carex	vaginata	
Carex	x knieskernii	
Crocanthemum	bicknellii	
Cyperus	houghtonii	
Cypripedium	reginae	
Dendrolycopodium	hickeyii	
Diphasiastrum	complanatum	
Dracocephalum	parviflorum	
Dryopteris	fragrans	
Elymus	trachycaulus	
Eriophorum	tenellum	
Gentiana	alba	
Heliopsis	helianthoides	
Hieracium	piloselloides	I
Hypopithys	monotropa	
Lactuca	hirsuta	
Lechea	intermedia	
Piptatheropsis	pungens	
Populus	alba	I
Silene	antirrhina	
Sphenopholis	intermedia	
Taxus	canadensis	
Viola	renifolia	
	Total	**36**
	Introduced	**6%**

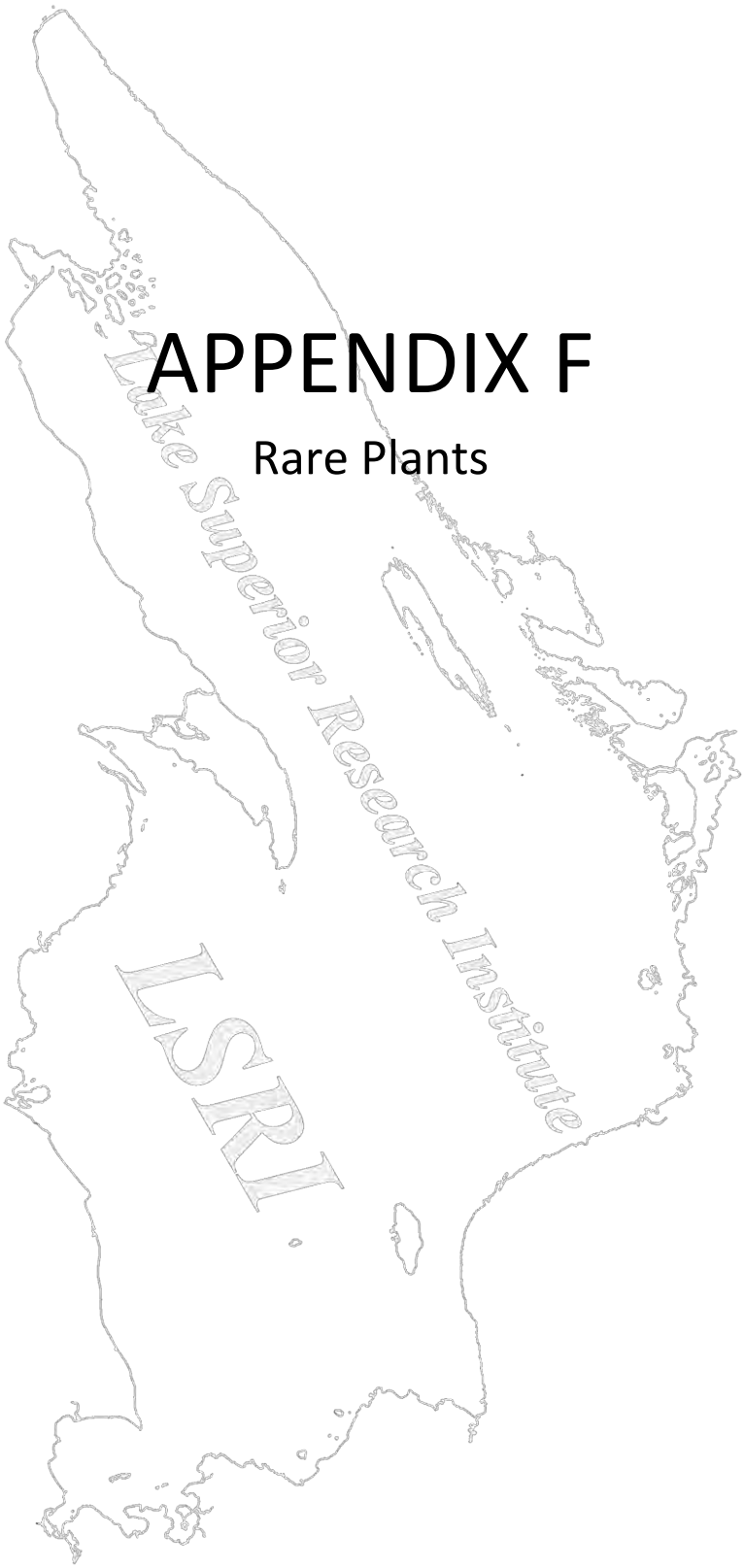
UNDER REPORTED RECORDS IN THE BRW

Genus	Species	Status	Genus	Species	Status
Acer	rubrum		Oxalis	dillenii	
Acer	saccharum		Oxalis	stricta	
Ambrosia	artemisifolia		Parthenocissus	inserta	
Amenlanchier	arborea		Parthenocissus	quinquefolia	
Apocynum	androsaemifolium		Pericaria	maculata	I
Apocynum	cannabium		Pinus	strobus	
Astragalus	canadensis		Plantago	major	I
Brachylectrum	ariostosum		Poa	compressa	
Carex	aquatilis		Poa	pratensis	
Carex	peduculata		Polygonatum	pubescens	
Chamerion	angustifolium		Polygonella	articulata	
Chenopodium	simplex		Potentilla	recta	I
Cirsium	arvense	I	Potentilla	simplex	
Collarahiza	trifida		Ranunculus	hispidus	
Cyperus	schweintzii		Rhynchospora	alba	
Dichanthemlium	acuminatum		Rosa	acicularis	
Digitaria	ischaenum		Rosa	carolina	
Drymocallis	arguta		Rosa	flagellaris	
Elymus	trachycaulus		Rubus	parviflorus	
Erigeron	annus		Salix	nigra	
Erigeron	philadephicus		Salix	pyrifolia	
Erythronium	americana		Sambucus	racemosa	
Fallopia	cilinodis		Sanicula	canadensis	
Festuca	saximontana		Scirpus	atrovirens	
Geum	canadense		Securigera	varia	I
Gypsophila	muralis	I	Sorbus	americana	
Hieracium	aurantiacum	I	Spartina	pectinata	
Hieracium	umbellatum		Spiraea	alba	
Hydrocotyle	americana		Spiraea	tomentosa	
Hypericum	perforatum	I	Taraxacum	officinale	I
Juncus	effusus		Thalictrum	diocum	
Lonicera	hirsuta		Toxicodendron	rydbergii	
Lonicera	morrowii	I	Trillium	grandiflorum	
Lonicera	tatarica	I	Vaccinium	macrocarpa	
Lonicera	x bella	I	Vaccinium	myrtilloides	
Lotus	corniculatus	I	Veronica	longifolia	I
Luzula	multiflora		Viburnum	rafinesquianum	
Maianthemum	racemosum		Vinca	minor	I
Medicago	lupulina	I	Viola	adunca	
Meliotus	alba	I	Viola	cucullata	
Monarda	punctata		Viola	renifoli	
Muhlenbergia	glomerata		Viola	sororia	
Muhlenbergia	mexicana		Zizia	aurea	
Nepeta	cataria	I		**Total**	**90**
Oenothera	villosa			**Introduced**	**12%**
Osmorhiza	longistylis				
Oxalis	acetosella				

Communities_Families	Thomson 1944	Curtis 1959	UW_LSRI 2015
Boreal Forest			
Rosaceae	9.5%	4.1%	8.0%
Asteraceae	8.6%	9.8%	9.6%
Ranunculaceae	7.6%	5.7%	5.3%
Salicaceae	7.6%		2.7%
Poaceae	4.8%	4.7%	7.4%
Liliaceae	3.6%	5.7%	1.1%
Cyperaceae	1.9%	5.7%	10.1%
Northern White Cedar Swamp			
Cyperaceae	8.4%	5.7%	10.8%
Orchidaceae	6.0%		2.9%
Caprifoliaceae	6.0%		2.0%
Rosaceae	6.0%		7.9%
Ericaceae	4.8%		5.3%
Asteraceae	3.6%	9.2%	9.9%
Lilaceae	3.6%	6.1%	1.0%
Poacaeae	2.4%	5.3%	5.8%
Ranunculaceae	2.4%	5.7%	3.8%
Pine Barrens			
Asteraceae	27.6%	23.9%	17.8%
Poaceae	12.6%	10.4%	12.0%
Rosaceae	7.9%	8.2%	11.6%
Cyperaceae	0.1%		4.1%
Ericaceae	3.1%	6.0%	2.1%
Liliaceae	1.6%	6.7%	

SPECIES FOUND IN 1944 BY COMMUNITY TYPE, NOT IN 2015

Genus Species - Boreal Forest	Genus Species - Northern wet-mesic forest (white cedar)	Genus species - Pine Barrens
Agrostis hyemalis	Equisetum fluviatile	Alnus viridis
Antennaria howellii	Geum canadense	Artemisia pontica
Botrypus virginianus	Glyceria canadensis	Bromus inermis
Celastrus scandens	Platanthera dilatata	Calamagrostis canadensis
Dendrolycopodium obscurum		Centaurea jacea
Dichanthelium xanthophysum		Cerastium fontanum
Epigaea repens		Dactylis glomerata
Erigeron strigosus		Echinochloa muricata
Grindelia squarrosa		Erigeron glabellus
Humulus lupulus		Helianthus pauciflorus
Lactuca canadensis		Heliopsis helianthoides
Lycopodium clavatum		Lathyrus venosus
Melampyrum lineare		Lespedeza capitata
Packera paupercula		Linaria vulgaris
Pedicularis canadensis		Lithospermum caroliniense
Polygonum aviculare subsp. buxiforme		Malaxis unifolia
Polypodium virginianum		Mollugo verticillata
Rorippa palustris		Packera aurea
Salix alba		Persicaria lapathifolia
Salix eriocephala		Polygonum achoreum
Salix lucida		Polygonum aviculare subsp. buxiforme
Sceptridium multifidum		Portulaca oleracea
Silene latifolia		Silene vulgaris
Vicia villosa		Symphoricarpos occidentalis



APPENDIX F

Rare Plants

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

RARE AND NOTABLE PLANTS
FOUND IN THE BRULE RIVER WATERSHED
2015-2016

Ranunculus lapponicus (lapland buttercup): State Endangered

26 May 2015 – three populations
Found at the following location in the Brule River State Forest at Stone Chimney
Growing in Cedar Swamp with *Abies balsamea, Thuja occidentalis, Ribes triste, Coptis trifoliata, Clintonia borealis, Cornus canadensis, Sphagnum spp., etc.*

2 July 2015 – same populations as 26 May 2015

Pop 1:
Growing in Sphagnum moss near open water pools
Number of leaf clusters: 15
Number of stems: 56
Associate species include: *Rubus pubescens, *Abies balsamea, *Coptis trifolia, Aralia nudicaluis, Carex intumescens, Rhododendron groenlandicum, Thuja occidentalis, Carex trisperma, Mitella nuda, Neottia cordata, Cornus canadensis, Stachys palustris, Galium triflorum, Gaultheria hispidula, Alnus incana.* *Most abundant.

Pop 2:
Cedar opening, growing in sphagnum moss, not near open pools of water.
Number of leaf clusters: 30
Number of stems: 100+

Pop 3:
Another population of 100+ found 270 degrees from GPS points
Associate species include; *Cornus canadensis, Abies balsamea, Thuja occidentalis, Rubus pubescens, Trientalis borealis, Carex trisperma, Coptis trifolia, Quercus rubra, Linnaea borealis, Corylus americana, Galium triflorum, Lonicera canadensis, Caltha palustris, Calla palustris, Gaultheria hispidula, Pyrola americana.*



Petasites sagittatus (arrow-leaved sweet-coltsfoot): State Threatened

29 May 2015 – four populations
Found at the following locations in the Brule River State Forest:

Pop 1
Roadside ditch within 3km of the mouth of the Brule River. *Growing with Alnus incana ssp. rugosa, Populus tremuloides, Calamagrostis canadensis, Equisetum arvense, Equisetum sylvaticum, Eurybia macrophylla, and Petasites frigidus. 20 individuals, 1 flowering.*

Pop 2
Roadside ditch within 3km of the mouth of the Brule River.

Pop 3
Roadside ditch within 3km of the mouth of the Brule River.

Pop 4
Roadside ditch within 5km of the mouth of the Brule River. 7 individuals, X flowering. *Growing with Alnus incana ssp. rugosa, Fraxinus nigra, Populus tremuloides, Cornus sericea, Ribes hirtellum, Rubus pubescens, Calamagrostis canadensis, Caltha palustris, Equisetum arvense, Equisetum sylvaticum, Eurybia macrophylla, Iris versicolor, Micranthes pensylvanica, Onoclea sensibilis, Petasites frigidus and Thalictrum dasycarpum.*

Carex backii (rocky mountain sedge): State Special Concern

29 May 2015 – three populations
Found at the following locations in the Brule River State Forest at Copper Range Vista Rock:

Pop 1
On rock outcrop growing with *Quercus rubra, Ostrya virginiana, Abies balsamea, Amelanchier arborea, Lonicera tatarica, Prunus virginiana, Aquilegia canadensis, Aralia nudicaulis, and Eurybia macrophylla*

Pop 2
On rock outcrop growing with *Abies balsamea, Acer rubrum, Ostrya virginiana, Quercus rubra, Lonicera tatarica, Prunus virginiana, Vaccinium angustifolium, Pteridium aquilinum, and Capnoides sempervirens*

22 May 2016
Found at the Fire Tower – Sugar Camp Hill – northern mesic forest

Pop 3
On rock outcrop across from the Copper Range Vista Rock on the east facing slope growing with: *Capnoides sempervirens, Pteridium aquilinum, Sorbus americana, Gaultheria procumbens and Antennaria howellii.*

Dryopteris fragrans (fragrant fern): Notable Species

29 May 2015
Found at the following locations in the Brule River State Forest at Copper Range Vista Rock:

Pop 1

34 clumps found growing in moist crevices on rock cliff. Growing with *Acer spicatum, Ostrya virginiana, Actaea rubra, Aquilegia canadensis, Carex arctata, Carex backii, Carex communis, Woodsia ilevensis, and Polypodium virginianum.*

Other species nearby include *Abies balsamea, Pinus resinosa, Quercus rubra, Rubus parviflora, Polygonatum pubescens, Trientalis borealis, Trillium cernuum.*

Taxus canadensis (Canadian Yew): Notable Species

28 May 2015
Found at the following location in the Brule River State Forest at Stone Chimney:

Pop 1
A few plants scattered in the Cedar Swamp just 20-30 ft from boardwalk. Associate Species: *Coptis trifolia, Asarum canadense, Gaultheria procumbens, Maianthemum trifolia and Vaccinium myrtilloides.*

Pop 2

Found on a sliver of boreal forest on a Brule River curve adjacent to a gas pipeline crossing. Just upstream on the west side of lenroot ledges class III rapids. Just south of County FF. Population in the tens of individuals approaching at least 100 or 200 individuals. Associate Species: *Thuja occidentalis, Lonicera canadensis, Carex arctata, Corylus cornuta and Eurybia macrophylla.*

18 July 2015

Pop 3
Southeast of boardwalk at Stone Chimney canoe landing.

Vaccinium vitis-idaea (lingonberry): State Endangered

5 June 2015
Brule Bog SNA

Pop 1

Individuals growing in a 2m circle growing amongst seeps and spaghnum hummocks, Often growing on the wall edges of the seeps. Predominantly in shaded area with spotty sunlight reaching the ground through canopy. Old growth cedar DBH ~12-14″. *Vaccinium vitis-idaea* leaves no longer than 2 cm. The majority of the population growing around dead tree trunks and on edges of the seeps. Total population 70-100. Most 3-5″ tall with some reaching 8″. (25 cm tall) Associate species include *Trientalis borealis, Rhododendron groenlandicum, Osmunda regalis, Cornus canadensis, Coptis trifolia, Maianthemum canadensis, Aralia nudicaulis, Calamagrostis canadensis, Thuja occidentalis, Abies balsamea, and Galium trifidum, Cornus canadensis, Pyrola americana and Rubus pubescens.*

Cypripedium parviflorum v. makasin (Small-flowered Yellow Ladyslipper): State Special Concern

12 June 2015

Pop 1
2 plants – one sterile, one in bloom. Photo taken. Found behind the bathrooms at Stones Bridge Landing on a poorly developed trail 52ft west of the trail. This site was previously identified in 2006 as a *Cypripedium arietinum*. Associate species include: *Ranunculus recurvatus, Rhamnus alnifolia, Frageria virginiana, Rubus pubescens, Carex leptalea, Carex gracillima, Athyrium filix-femina, Mitella nuda, Thuja occidentalis, Fraxinus nigra, Aralia nudicaulis, Maianthemum candense, Trientalis borealis, Acer rubrum and Alnus incana.*

Pop 2
Off deer trail adjacent to Brule River northeast of the end of the Stone Chimney trail. No GPS taken, as unit was left behind accidentally. A random trail was taken back to the boardwalk in which 7 flowering specimens and 6 sterile ones were located. Associate species include: *Abies balsamea, Thuja occidentalis, Picea mariana, Fraxinus nigra, Linnea borealis, Rhododendron groelandicum, Maianthemum canadense, Coptis trifolia, Iris virginiana, Ilex verticellata, Cornus candensis, Acer rubrum, Carex trisperma, Moneses uniflora, Vaccinium angustifolia, Vaccinium myrtilloides and Geum rivale.*

19 June 2016

Same populations as found in 2015 at both locations described above.

Asclepias ovalifolia (dwarf milkweed): State Threatened

19 July 2015

Pop 1
Patch was located in a circular area approximately 10m radius of 200-250 plants, of which 40% where in bloom. Found north of Jersett Road on a recently cut-over Red Pine plantation. Red Pine had been planted about 4 years ago and new trees were from 3-5′ tall, allowing area to be populated with many sand barren species.
Associate species include: *Monarda fistulosa, Bromus kalmia, Comptonia peregrina, Campanula rotundifolia and Stachys palustris.*

Photo by Derek Anderson

Cypripedium reginae (showy ladyslipper): Notable Species

3 Sept 2015
Pop 1
One large clump of 22 plants on top of a clay bank ridge.
Near Boreal Forest #10 Botany Blitz site. Associate species:
Uvularia sessilifolia, Maianthemum canadense, Viburnum trilobum, Rosa acicularis and Prunus virginiana.

20 June 2016
Pop 2
CYPREG - 46.628426″N -91.592846″W elev. 876 ft. WGS 84
Ridgetop above Lenroot Ledges on the Bois Brule River. Three to four plants on ridge top trail above the river. Associates species not recorded.

Pyrola minor (lesser wintergreen) : State Endangered

31 Aug 2015

Pop 1 – 1 plant
Habitat: White Cedar Swamp with *Thuja occidentalis, Picea mariana, Cornus canadensis, Rhododendron groenlandicum, Rubus pubescens, Coptis trifoliata, Platanthera obtusata, P. aquiloni, Corallorhiza trifida*, *Cinna latifolia, Osmunda regalis, Gymnocarpium dryopteris, Carex magellanica,* and *Orthilia secunda*. Sphagnum moss abundant, as was *Orthilla secunda*.

Callitriche hermaphroditica (northern water-starwort) : State Special Concern

08 Aug 2016

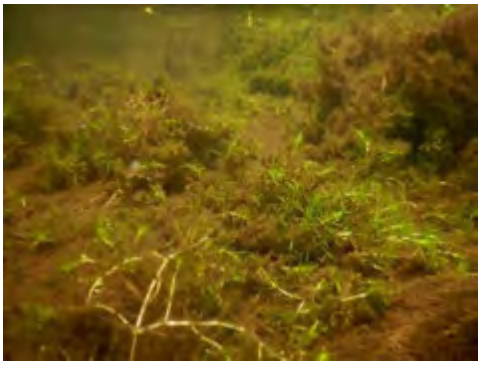
Pop 1
Population: Thousands of plants in very cold water near springs in Big Lake.
Habitat: Aquatic submerged plants growing in association with *Lemna turionfera, Ranunculus aquatilis, Elodea canadensis, Sagittaria rigida, Potamogeton alpinus and Myosotis scorpiodes.*

15 Aug 2016

Pop 2 and Pop 3
Population: Thousands of plants in very cold water near springs.
Found in shallow water, growing in 2″ of soft sediment muck overlying a sandy bottom.
Aquatic submerged plants growing in association with: *Lemna triscula, Elodea Canadensis, Myosotis scorpiodes, Ranunculus aquatilis, and Iris versicolor*.

25 Aug 2016

Pop 4
Population: Thousands of plants in very cold spring waters in 2″-4″cm soft mucky sediments overlying a sandy bottom. Aquatic submerged plants growing in association with: *Lemna triscula, Juncus effusus, Equisetum fluviatile, and Elodea canadensis.*

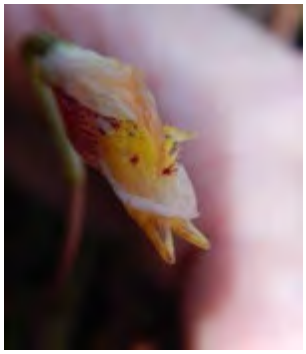


Calypso bulbosa (fairy slipper orchid): State Threatened Plant

22 May 2016

Pop 1 Four plants − two in bloom, two sterile. White Cedar Swamp near headwaters of the Bois Brule river.
Associate species: *Mainathemum trifolia, Ribes hudsonianum, Gaultheria hispidula, Linnaea borealis and Rhododendron groenlandicum*.





Carex vaginata (sheathed sedge): Notable Species

28 May 2015 and 22 May 2016

Pop 1– Hundreds of plants, white cedar swamp near headwaters of the Bois Brule river.
Associate species: *Ranunculus lapponicus, Cypripedium parviflorum v. makasin, Gaultheria hispidula, Equisetum scirpoides and Coptis trifolia.*

Pop 2 – Hundreds of plants, white cedar swamp near headwaters of the Bois Brule River.
Associate species: *Mainathemum trifolia, Coptis trifolia, Linnaea borealis, Calypso bulbosa and Vaccinium myrtilloides.*

Cardamine pratensis v. palustris (cuckoo-flower) Notable species

23 May 2016

Pop 1
One clump of plants with 16 flowering stems in the sandy bottom of rocky run creek ravine, a tributary of the Bois Brule River. Surrounding forest type is boreal. Associate species: *Cardamine concatenata, Cardamine pensylvanica, Cornus sericea, Epilobium ciliatum, and Galium aparine.*

Lactuca hirsuta (hairy lettuce) - Second Collection in Wisconsin

16 July 2015

Pop 1
One plant documented in a pine barren habitat with the following associates: *Prunus pumila, Comptonia peregrina, Danthonia spicata, Campanula rotundifolia, and Polygala polygama.*

Location: Motts Ravine north of Mott's Ravine Road

Gentiana alba (cream gentian) Notable Species

24 Aug 2016

Pop 1
Up to 20 plants on a steep mowed bench on the east side of the Bois Brule River .75km from the mouth.

Geum macrophyllum (large leaf avens) State Special Concern

13 July 2015

Pop 1
Plant growing in spaghnum moss of white cedar swamp near McDougal Springs.
Location: 2.66km from the Stones' Bridge landing on the Bois Brule River.
Associate species: *Thuja occidentalis, Lonicera canadensis, Rubus pubescens Carex leptalea and Clintonia borealis.*

5 Sept 2015

Pop 2
One plant growing at the base of a *Thuja occidentalis* tree at a northern dry mesic forest.
Location: 200m west of the Fisherman's Parking area on Lenroot Road.
Associate species: *Cornus canadensis, Fragaria virginiana, Agrimonia gryposepala, Chamerion angustifolium and Petasites frigidus.*

Carex assiniboinensis (assiniboine sedge) Notable Species

5 Aug 2016
Pop 1
100-200 plants on a floodplain ravine on an unnamed tributary creek in the boreal forest habitat type. Location: Unnamed creek between rocky run creek and fisherman's parking area on the east side of the Bois Brule River in a boreal forest. Associate species: *Carex gracillima, Carex sprengelii, Allium tricoccum, Scutellaria lateriflora and Parthenocissus quinquefolia.*



Photos by Reed Schwarting

Carex x knieskernii - Notable Species

18 July 2016

Pop 1
This is a species only known from Bayfield and Ashland County in Wisconsin previously identified by Dr. Emmet Judziewicz. This species is a hybrid cross between *Carex castanea* and *Carex arctata* and was first identified by Dr. Emmet Judziewicz in May, 2016 during a training session at the Leppala White Cedar survey.

Pop 2
A second specimen is noted here from the northern mesic forest on Sugar Camp Hill with *Acer saccaharum, Clintonia borealis, Carex gracillima, Carex arctata and Fragaria virginiana* as associates collected by Paul B. Marcum.

Rychnospora fusca (brown beaked-rush) State Special Concern

19 July 2016

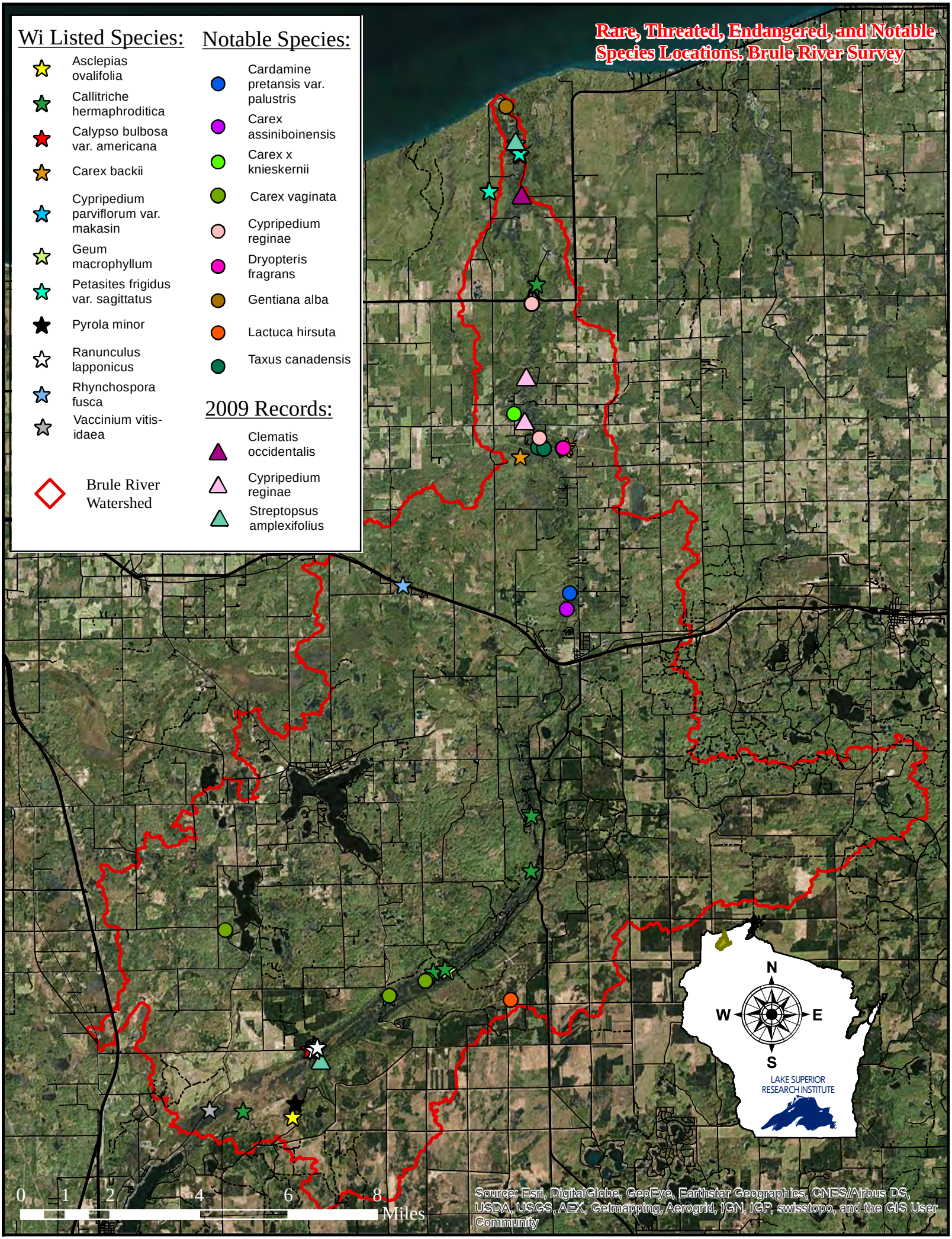
Pop 1
Hundreds of plants in a roadside ditch adjacent to a black spruce swamp. Associate species include *Pogonia ophioglossoides, Trichophorum alpinum, Vaccinum angustifolium, Platanthera obtusata and Juncus brevicaudatus.*

Many of the rare plants of the Brule River watershed (BRW) were first recorded during the late 1990's through a WDNR Biotic Inventory Report (Epstein et. al., 1999). This report was prepared for the Brule River State Forest (BRSF), prior to the first master plan being created (Van Horn and et. al, 2003). Note, that the BRSF and the BRW do not represent the same geographic area. A second biotic inventory was recently published in 2016 (O'conner et. al. 2016) in which this project collaborated to create the following table.

Species	Historical Observations (1930 –2009)	1999 Biotic Inventory	2016 Biotic Inventory (BI) and 2015-2016 Analysis BRW	WI Status*
Asclepias ovalifolia			2016, 1 pop. (200-250 plants)	THR
Callitriche hermaphroditica		4 pops.	2016, 2 pops confirmed 2 pops. New 1 pop. not found 1 pop. not surveyed (springs, thousands)	SC
Calypso bulbosa	1932 – 1 specimen 2005 – 1 pop. (125 plants)	2 pops. Pop. #1 – 2 plants Pop. #2 – 43 plants	1932 pop. not found 1996,2005 – Pop #1, 2016 (4 plants) 1996 – Pop. #2 – Not Found	THR
Carex backii			2015 1 pop. 2016 2 pops.	SC
Carex x knieskernii			2016 (2 plants in two habitats)	???*
Cypripedium parviflorum v. makasin			2015, 2016, 3 pops. (20 plants)	SC
Geum macrophyllum v. macrophyllum			2016, 1 plant	SC
Huperzia selago		1 pop. (50-100 stems)	None Found	SC
Lactuca hirsuta			2015, 1 plant	???**
Parnassia palustris	1949		Not found	THR
Petasites sagittatus	2009, 1 pop.	3 pops.	2015,2016, 2 pops.	THR

		Pop. #1 −220 Pop. #2 −500 Pop. #3 − 6 plnts	1996 - Pop. #1 − 20 plants 1996 - Pop. #2 − 7 plants 2009 Pop. − Not Found	
Pyrola minor			2015, 1 plant	END
Ranunculus lapponicus		250+ plants in five patches	2015,2016 3 pops. (>250+ plants)	END
Rhychnospora fusca		1 Pop. 1000 plants	2016, 1 pop. (hundreds)	SC
Sceptridium rugulosum	1931		Not Found	SC
Species	Historical Observations (1930 −2009)	1999 Biotic Inventory	2016 Biotic Inventory (BI) and 2015-2016 Analysis BRW	WI Status*
Streptopus ampliexifolius	2009, 2 pops. Pop #1 (1 plant) Pop #2 (5 plants)		Not Found	SC
Tephroseris palustris	1897		Not Found	SC
Vaccinium vitis-idaea	1930 (1 specimen) 2011, 1 plant 50 plants		2015, 1 pop. ≈70-100 individuals	END

*END=endangered; THR=Threatened; SC=Special Concern
???* hybrid species described by Dr. Emmet Judziewicz, 2016.
???** Only second time recorded in WI, first in 2013.


Rare, Threated, Endangered, and Notable Species Locations. Brule River Survey
Wi Listed Species:
Asclepias ovalifolia
Callitriche hermaphroditica
Calypso bulbosa var. americana
Carex backii
Cypripedium parviflorum var. makasin
Geum macrophyllum
Petasites frigidus var. sagittatus
Pyrola minor
Ranunculus lapponicus
Rhynchospora fusca
Vaccinium vitis-idaea
Brule River Watershed
Notable Species:
Cardamine pretansis var. palustris
Carex assiniboinensis
Carex x knieskernii
Carex vaginata
Cypripedium reginae
Dryopteris fragrans
Gentiana alba
Lactuca hirsuta
Taxus canadensis
2009 Records:
Clematis occidentalis
Cypripedium reginae
Streptopsus amplexifolius
N
W
E
S
LAKE SUPERIOR RESEARCH INSTITUTE
0 1 2 4 6 8
Miles
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

APPENDIX G

Old Growth

Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Old growth forests are natural stands that have developed over a period of time, generally at least 120 years old, without experiencing a stand-replacing disturbance. Some features of these stands include, advanced stand age, presence of very old and large trees, presence of large, standing trees, increased amount of dead stumps and coarse woody debris, pit and mound topography and presence of canopy gaps. Surveys conclude that only about one percent of Wisconsin's old-growth forests remain intact.

"Old-growth forest represents a unique ecosystem that was once abundant across the forested regions of Wisconsin but is now very rare," says Signe Holtz, bureau director for DNR's endangered resources program. "As stewards of the land it is important for us and our generation to try to maintain and restore this habitat type on Wisconsin's landscape for future generations." (WDNR, Forestry Division, 2015).

Brule River Watershed Old Growth Forests

There were six original 1968-69 Davidson stands that meet the definition of Old Growth Forests (#13, #35, #39, #40, #41 and #44) in the BRW. Four of the sites are considered old growth northern dry-mesic forests with *Pinus resinosa* (red pine) having the largest importance value. Two of these sites were estimated to be 250-300 years old, while the other two sites were 125-200 years old. One Old Growth boreal forest stand was harvesting in 1903 and thinned in 1927 and is managed by the Brule River State Forest (BRSF, WisFir data, 2015).

The last old growth site is a white cedar swamp, near Stone's Bridge canoe landing that originated in 1838. In 1944, these cedar swamps were being threatened by early logging activity and through the "Brule River Survey" of the early 1940's, UWS (formerly Superior State College) plant science professor, John T. Thomson recommended that this land be protected. As early as 1945, the state moved on these recommendations and began to give these white cedar swamps further protection status. Today, the area is a State Natural Area designated in 2003. For further information on cedar swamps see the text and charts under the northern wet-mesic community described earlier in this report.

The Changing Old Growth Forest

The graphs above depict changes in five of six these stands in the past 47 years. Interestingly, these stands may be serving as "refuges" for old growth *Betula papyrifera* (paper birch) which was recorded in the sub-canopy layer of these forests. Where paper birch was present, IV values increased at all old growth sites, except one.

Old Growth Stand #40 is on a steep hill leading up to the glacial ridge above the Bois Brule River. In this stand and others we see a substantial increase of *Pinus resinosa* IV (red pine) far exceeding *Pinus strobus* IV (white pine). Old Growth Stand #41 we see the reverse. Two possible explanations are: 1) Our geo-referencing of the old Davidson stand was not as accurate as we had hoped; and/or 2) the site was at the base of the steep hill and soil moisture was greater creating mesic conditions that favor *Pinus strobus* vs. *Pinus resinosa*.

On the one boreal forest Old Growth site, we see that *Pinus strobus* had the highest IV, indicating a status it once had in the early Public Land Surveys of the 1852-1856 in this community type and has been rarely observed then. Notable is also the decline in the IV of *Abies balsamea* (balsam fir) during this time period, another indication of a later successional forests. In the 2003 Master Plan for the Brule River State Forest, one of the goals is to restore early successional aspen/birch forests to old successional boreal forests. (BRSF, 2003). This stands represent one of those stand.

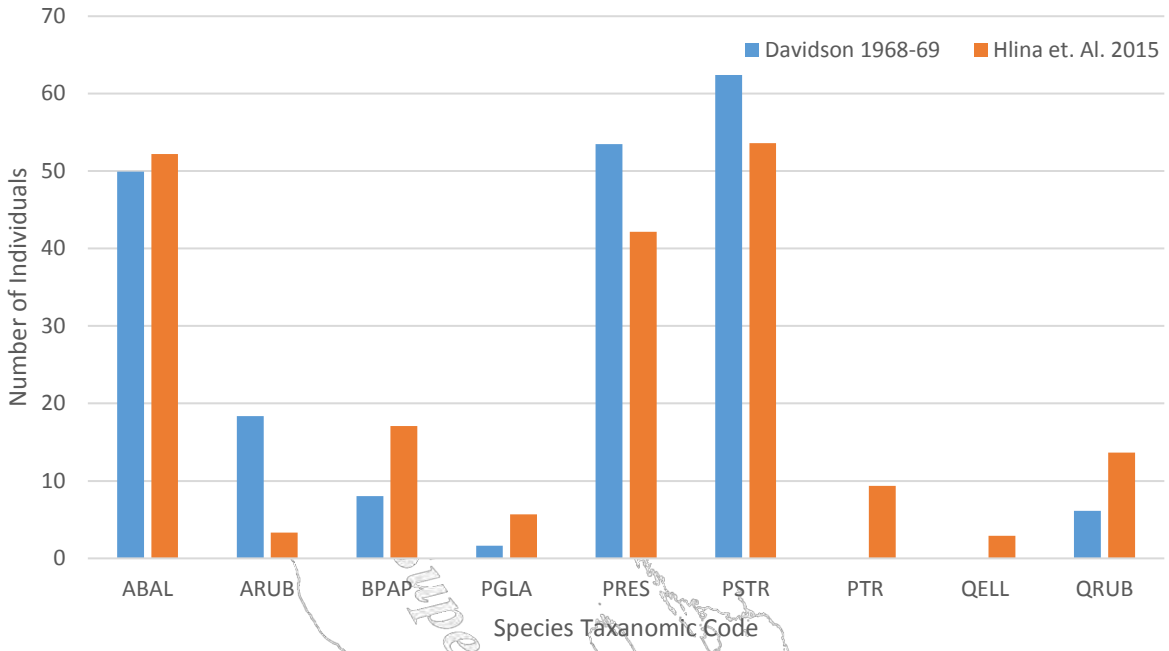


Figure 28. Comparison of tree species with a dBh greater than 12 inches at site #39 (Northern Dry-Mesic Forest).

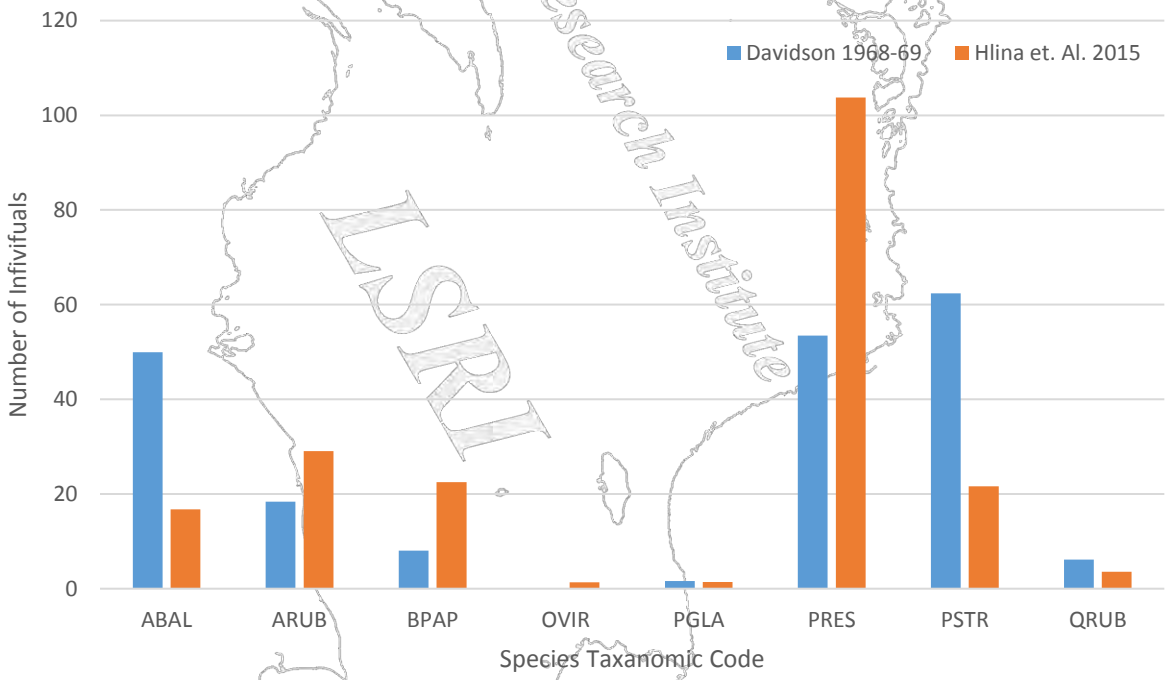


Figure 29. Comparison of tree species with a dBh greater than 12 inches at site #40 (Northern Dry-Mesic Forest).

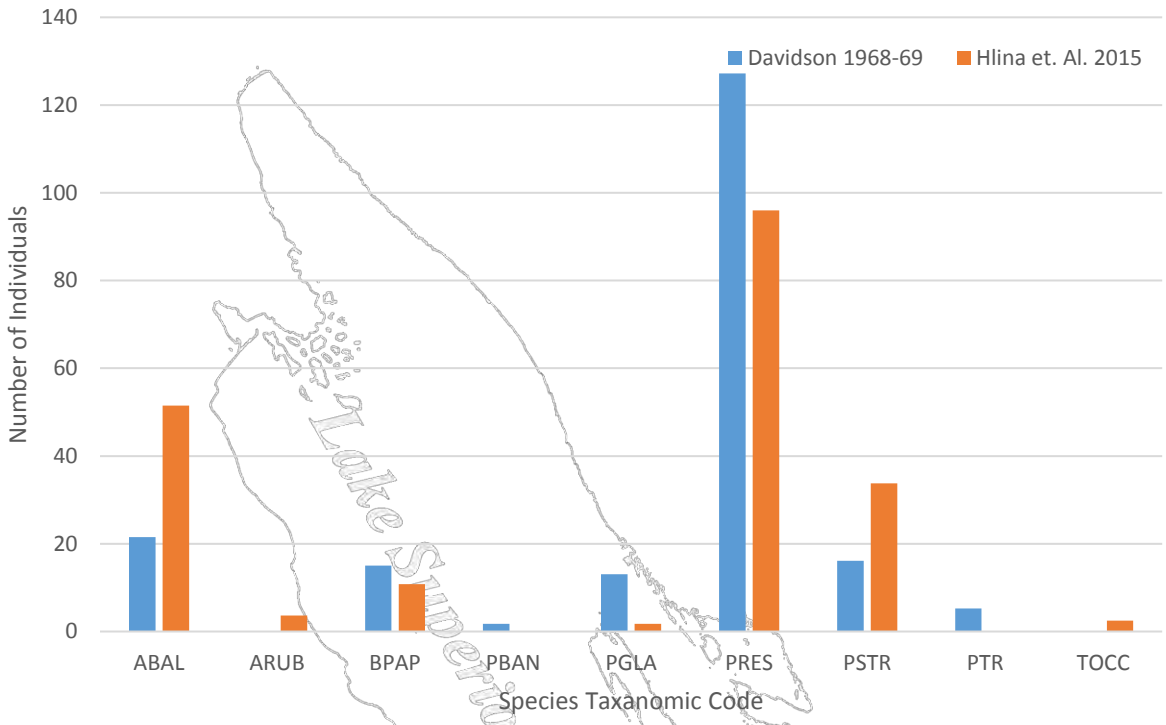


Figure 30. Comparison of tree species with a dBh greater than 12 inches at site #44 (Northern Dry-Mesic Forest).

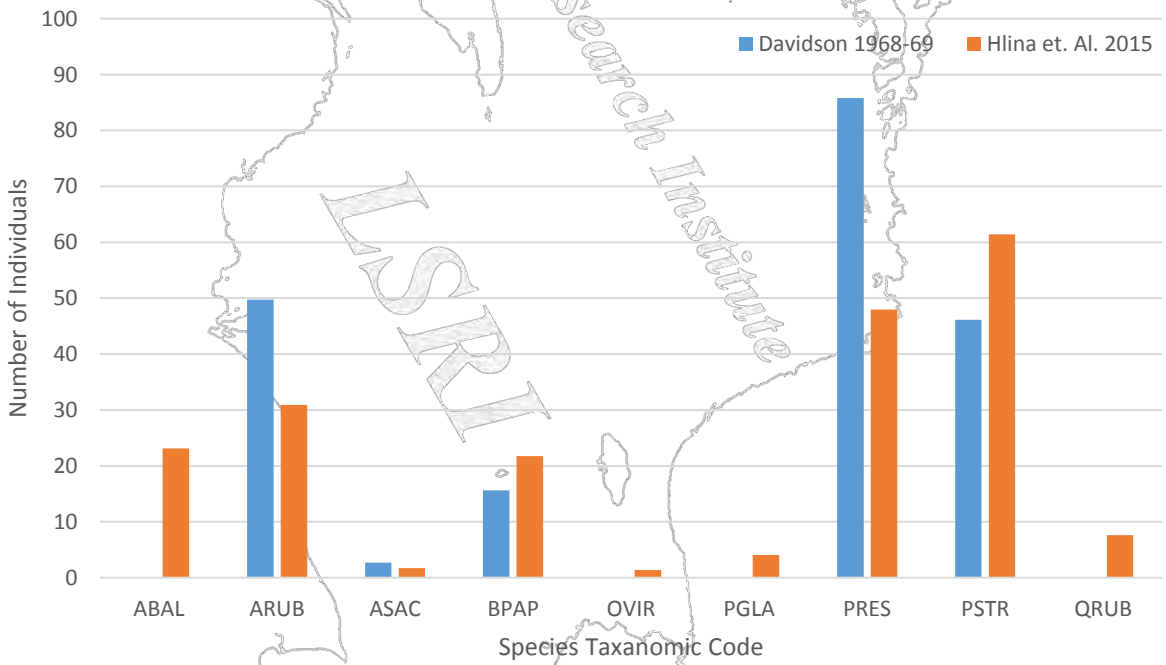


Figure 31. Comparison of tree species with a dBh greater than 12 inches at site #41 (Northern Dry-Mesic Forest).

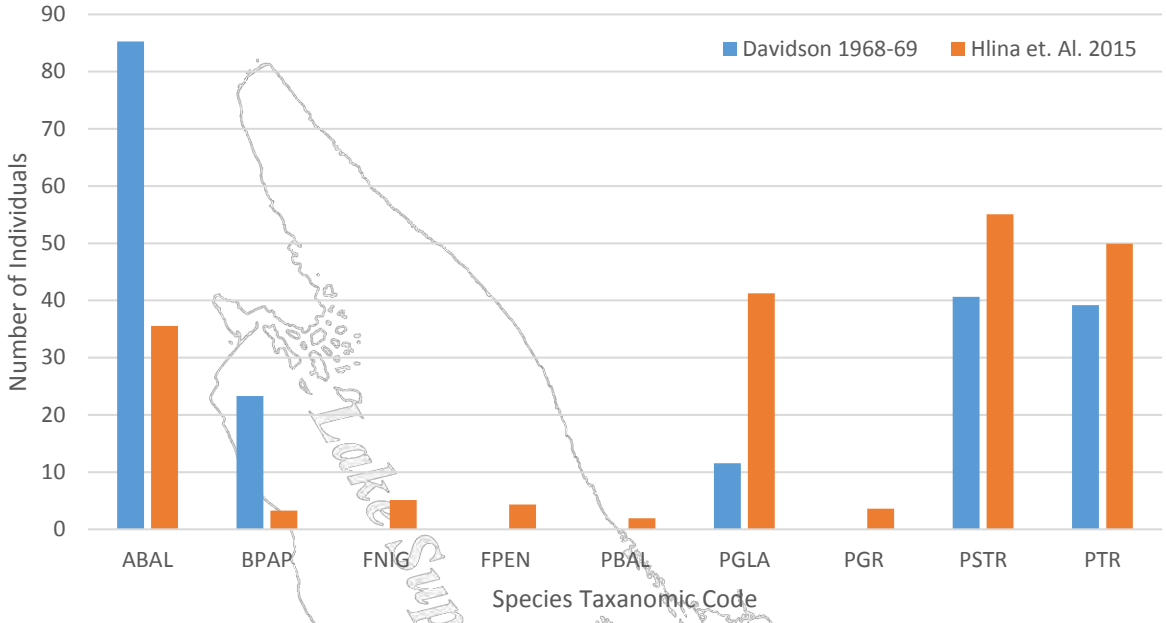
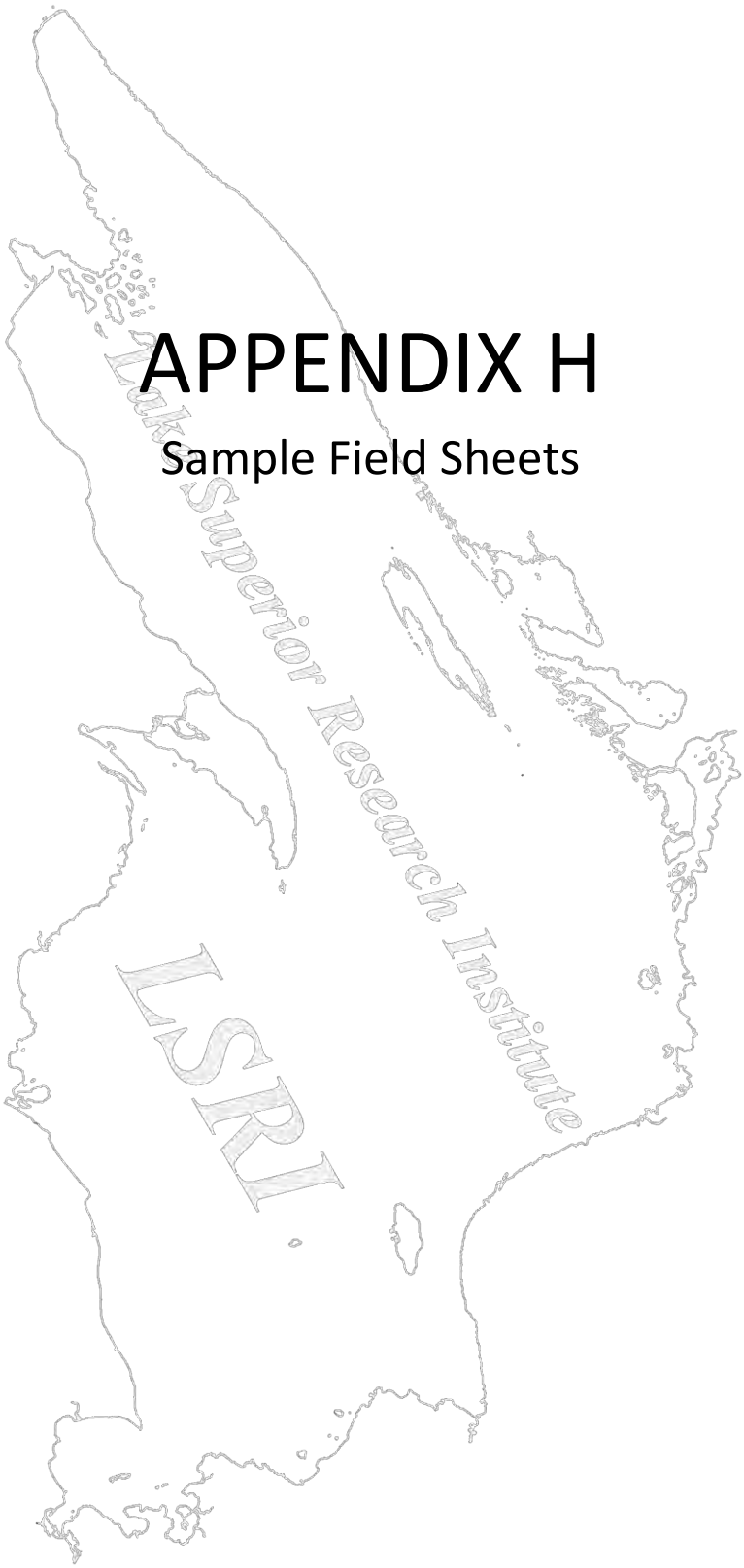


Figure 32. Comparison of tree species with a dBh greater than 12 inches at site #35 (Boreal Forest).

APPENDIX H

Sample Field Sheets



Lake Superior Research Institute
University of Wisconsin – Superior
Wisconsin State Herbarium (UW-Madison)

Paul Marcum, Paul Hlina, Mary Ann Feist, Loy R. Phillippe
Clevedon Road Swamp

BRULE RIVER WATERSHED - RE_SURVEY PROJECT	2016 BOTANY BLITZ								
Abundance Code:	A=abundant, C = Common, O= Occasional,R=Rare								
Date 7/21/16	CLEVEDON ROAD SWAMP						1943-44		
Northern Hardwood Swamp							Thomson		Status
	PRESENT	Abu Code	PRESENT	Abu Code	PRESENT	Abu Code	PRESENT	Abu Code	
Abies balsamea	X	O					X		
Acer rubrum	X	O					X		
Acer spicatum							X		
Actaea pachypoda							X		
Actaea rubra	X	O					X		
Alnus incana	X	C					X		
Apocynum androsaemifolium							X		
Aralia nudicaulis							X		
Asarum canadense							X		
Asclepias incarnata							X		
Athyrium filix-femina	X	C					X		
Betula papyrifera							X		
Botrychium virginianum							X		
Campanula aparinoides							X		
Carex retrorsa							X		
Carex tuckermanii							X		
Corylus americana							X		
Echinocystis lobata							X		
Equisetum arvense	X	O					X		
Eupatorium purpureum							X		
Eurybia macrophylla							X		
Fraxinus nigra	X	A					X		
Geum canadense	X	C					X		
Geum fragarioides							X		
Humulus lupulus							X		
Impatiens capensis	X	C					X		
Laportea canadensis							X		
Lilium michiganense							X		
Lysimachia ciliata							X		
Maianthemum canadense	X	R					X		
Matteuccia struthiopteris							X		
Onoclea sensibilis	X	O					X		
Osmunda claytoniana	X	O					X		
Packera paupercula							X		
Populus balsamifera	X	O					X		
Pteridium aquilinum							X		
Ribes cynosbati							X		
Rubus idaeus	X	C					X		
Rudbeckia laciniata							X		
Sanicula marilandica							X		
Scutellaria lateriflora	X	O					X		
Stachys palustris							X		
Streptopus lanceolatus							X		
Thalictrum dioicum							X		
Thuja occidentalis							X		
Trillium cernuum	X	R					X		

Saxifraga pennsylvanica X C
Thalictrum dasycarpum X C
Ribes triste X O
Ribes hirtellum X C

Lactuca biennis X O
Rubus pubescens X C
Fragaria virginiana X O
Carex projecta X C

Cornus rugosa X O
Prunus virginiana X C
Caltha palustris X O
Equisetum sylvaticum X C

Ulmus americana	X	O					X		
Urtica dioica							X		
Viburnum opulus							X		

Corylus cornuta X O
Cinna latifolia X O
Rhamnus cathartica X O
Populus tremuloides X O
Solidago gigantea X C
Cornus sericea X C
~~Ulmus americana~~ Carex arctata X R
Ranunculus recurvatus X O
Viola labradorica X R
Epilobium coloratum X O
Amelanchier arborea X R
Ranunculus pensylvanicus O
Galium asprellum X C
Symphyotrichum puniceum X C
Ranunculus hispidus var. nitidus X O
Carex crinita X C
Doellingeria umbellata X O
Carex stipata X C
Mentha arvensis X O
Chelone glabra X O
Calamagrostis canadensis X O
Tilia americana X R
Carex gracillima X C
Bromus ciliatus X O
Glyceria striata X C
Geum laciniata X O
Prunus serotina X C
Cicuta maculata X O
Dryopteris cristata X O
~~Phalaris~~ Iris versicolor X O
Cinna arundinacea X O

Elymus hystrix X O
Symphyotrichum lateriflorum X O
Agrimonia gryposepala X O
Geum allepicum X O
Scirpus atrovirens X R
Eupatorium maculatum X R
Cirsium muticum X R
Carex intumescens X C
Brachyelytrum aristosum X O
Carex pedunculata X O
Triantalis borealis X R
Acer saccharum X R
Dryopteris carthusiana X R
Polygonum sagittatum X R
Poa nemoralis X O
Fallopia cilionodis X O
Arisaema triphyllum X O
Carex leptonervia X O
Milium effusum X R
Ranunculus abortivus X O
Salix bebbiana X R
Ribes americana X R
Lycopus uniflorus X R

Stand No. 01 Location(GPS): 01 Start Sampling Team: SAG RJS Date: 17/4/y 2015

T	Sp.	Dist	DBH	Pt. No. GPS	Extra Sap Data
1	ABAL	4.0	6.8	01A1	
2	PTR	2.8	8.5		
3	ABAL	3.4	~~3~~ 4.8		
4	PTR	8.8	9.5		
1	ABAL	9.4	3.2		
2	ABAL	5.2	2.3		-SNAG
3	ABAL	~~4.3~~	~~Wasp~~ 2.3		-Dist. 11.7 | DBH 2.3
4	PTR	13.6	1.4		-SNAG
1	ABAL	7.9	5.0	01A2	
2	ABAL	2.8	4.2		
3	ABAL	10.6	7.4		
4	PTR	9.7	7.9		
1	ABAL	7.6	3.3		
2	ABAL	4.3	1.9		SNAG
3	ABAL	4.6	1.7		
4	ABAL	9.4	2.3		
1	ABAL	3.1	4.6	01A3	
2	ABAL	5.9	5.3		
3	ABAL	4.4	4.3		
4	ABAL	4.5	5.1		
1	ABAL	6.6	2.3		~~SNAG~~ SNAG
2	ABAL	5.0	2.9		
3	BPAP	2.6	1.8		-SNAG
4	ABAL	5.8	1.0		Sp. ABAL
1	ABAL	6.9	4.4	01A4	
2	ABAL	7.9	4.6		
3	ABAL	8.5	4.1		
4	ABAL	1.5	5.9		SNAG TREE→ ABAL, 11.0, 4.3
1	ABAL	2.7	2.2		
2	ABAL	3.4	3.6		SNAG
3	ABAL	8.4	3.5		SNAG
4	ABAL	1.2	1.5		SNAG
1	BPAP	30.3	6.2	01A5	2 (1 rac) PGLA | 15.0 | 6.5
2	PTR	5.7	9.3		-SNAG
3	PTR	6.6	14.7		
4	TOCX	16.7	17.5		
1	ATNC	16.4	2.0		
2	PGLA	34.6	1.7		
3	PGLA	31.4	1.4		
4	ATNC	32.6	1.0		

PSTR — 26.9 01PSTR

T	Sp.	Dist	DBH	Pt. No. GPS	Extra Sap Data
1	ABAL	9.9	4.6	01B1	
2	ABAL	4.7	5.5		
3	ABAL	11.2	5.9		
4	ABAL	6.0	4.6		
1	ABAL	11.4	2.0		
2	ABAL	9.2	3.5		
3	ABAL	5.0	1.1		
4	ABAL	4.3	1.0		
1	~~ABAL~~	~~11.4~~	~~2.0~~	01B2	BPAP | ~~PTR~~ 12.6 | 5.6
2	~~ABAL~~	~~9.2~~	~~3.5~~		ABAL ~~5.0~~ 4.5
3	PTR	5.2	8.1		
4	ABAL	14.4	5.2		
1	ABAL	3.5	2.3		
2	ABAL	~~3.4~~ 3.7	3.2		alnus rugosa
3	~~PTR~~	4.3	1.0		-SNAG
4	ABAL	5.2	2.5		
1	PTR	4.5	6.9	01B3	
2	ABAL	10.7	4.4		
3	PTR	14.2	6.8		
4	PTR	1.3	4.7		SNAG TREE→ PGLA, 7.8, 2.5
1	ABAL	2.8	1.6		
2	ABAL	9.4	1.4		
3	ABAL	5.6	2.9		
4	ABAL	3.2	2.0		
1	ABAL	2.0	4.1	01B4	
2	PGLA	6.7	8.1		
3	ABAL	5.1	4.0		
4	PTR	7.9	5.1		
1	ABAL	1.9	1.6		-SNAG
2	ABAL	4.4	1.8		
3	ABAL	6.6	2.0		-SNAG
4	ABAL	1.5	1.1		-SNAG
1	~~ABAL~~	~~5.1~~	~~4.6~~	01B5 →	PTR | 5.7 | 7.9
2	ABAL	6.5	7.7		
3	PTR	5.0	6.5		
4	PTR	7.1	8.1		
1	~~AB~~	~~5.6~~	~~2.8~~	→	ABAL | 2.7 | 2.8
2	ABAL	5.4	2.9		
3	ABAL	3.5	1.9		
4	ABAL	4.3	3.9		

Entered 7/26 DFB

Stand No. D1 Location(GPS): 01D start Sampling Team: SAG RJS Date: 7-16-15

T	Sp.	Dist	DBH	Pt. No. GPS	Extra Sap Data
1	ABAL	8.9	7.3	01D1	
2	ABAL	11.8	6.7		
3	PGLA	7.6	13.4		
4	PGLA	13.6	8.1		
1	[illegible]	7.3	1.3	SNAG	alnus rugosa
2	ABAL	11.8	2.3		
3	[illegible]	11.3	1.1		
4	ABAL	25.0	1.3		
1	ABAL	7.4	4.2	01D2	
2	ABAL	8.6	7.9		
3	PTR	8.5	11.0		
4	ABAL	2.0	4.4		
1	[illegible]	14.2	1.3		Populus balsamifera balsam pop.
2	ABAL	6.5	2.3		
3	ABAL	7.6	1.8		
4	ABAL	20.6	1.5		
1	ABAL	13.3	6.1	01D3	-01DEND-
2	PTR	24.0	15.4		
3	PTR	4.0	12.6		
4	ABAL	5.8	4.5		
1	ABAL	29.7	3.1	SNAG	
2	ABAL	22.1	2.3		
3	ABAL	13.3	1.6		
4	ABAL	10.3	1.7		
1	ABAL	7.4	6.4	01E1	
2	ABAL	16.9	6.8		
3	PTR	15.6	6.3		
4	PGLA	2.2	4.0		
1	ABAL	16.8	2.9		alnus rugosa
2	[illegible]	8.1	3.4		
3	PGLA	10.2	1.4	SNAG	
4	ABAL	16.1	1.3		
1	ABAL	3.6	4.8	01E2	
2	ABAL	7.6	6.0		
3	PTR	9.1	10.9		
4	ABAL	6.9	5.6		
1	ABAL	7.9	2.0		
2	PGL	25.2	1.8		
3	ABAL	9.7	1.5	SNAG	
4	ABAL	8.2	3.5		

PSTR - 28.4 01PSTR2

T	Sp.	Dist	DBH	Pt. No. GPS	Extra Sap Data
1	PSTR	4.8	16.4	white pine	01E3
2	PGLA	29.8	14.2	white spruce	-01Eend-
3	ASAC	28.4	12.6		
4	SPAP	20.2	8.0		
1	[illegible]			-none-	Large white pine PSTR - 28.4 01PSTR2
2				-none-	
3				-none-	
4				-none-	
1	ABAL	5.9	4.8	01C1	
2	ABAL	5.1	5.6		
3	ABAL	4.0	5.3		
4	PGLA	5.7	5.8	SNAG	TREE → ARUB, 17.8, 3.2
1	ABAL	11.8	1.4		
2	ABAL	6.0	1.5		
3	ABAL	12.7	1.6		
4	ABAL	6.6	1.1	SNAG	
1	ABAL	5.7	5.1	01C2	
2	PTR	3.4	7.9		
3	PTR	15.4	11.2		
4	PTR	5.5	10.9		
1	ABAL	2.8	1.4		
2		16.5	1.3	SNAG	alnus rugosa
3	ABAL	14.7	2.0	SNAG	
4	ABAL	6.4	1.4		
1	ABAL	7.9	5.9	01C3	
2	PTR	12.9	9.6		
3	PTR	8.4	9.9		
4	PTR	10.5	6.6		
1	SPAP	7.6	1.0		
2	ABAL	24.9	1.8		alnus incana
3		8.9	1.0		
4	ABAL	8.6	1.0		
1	PGLA	9.9	6.5	01C4	white spruce
2	ABAL	14.2	9.7		
3	ABAL	4.4	10.4		
4	ABAL	4.1	4.4		
1	ABAL	1.7	1.1	SNAG	
2	ABAL	3.0	1.2		
3	ABAL	1.7	2.4		
4	ABAL	2.6	2.5	SNAG	