Caroline Lake Forest Reserve
Forest Management Plan

Prepared for
State of Wisconsin Managed Forest Law Program by
Compass Land Consultants, Inc.

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Signatures of plan writers *Date*

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Statement of Purpose

This forest management plan has been developed to guide the management activities of the Caroline Lake Forest Reserve in accordance with the State of Wisconsin's Managed Forest Law requirements and the objectives of the landowner, The Nature Conservancy. This plan has been written to guide activities on the property for at least the next 10 years and should be reviewed and revised if needed at least every 10 years. This plan is one component of the comprehensive management plan for this property which will include collaborative research and written policies regarding various aspects of property management.

The Nature Conservancy (the Conservancy) is an international, private, nonprofit organization whose mission is to conserve the lands and waters on which all life depends. To achieve this mission, the Conservancy uses a science-based, non-confrontational and market-based approach.

With the management of the Caroline Lake property, The Nature Conservancy in Wisconsin is making the commitment to 'working forest lands' as a critical conservation strategy and land management philosophy. The Conservancy manages similar forest lands across the country including Michigan, Minnesota, Pennsylvania, Maryland, Virginia, Vermont, and Maine.

The goal in the Conservancy's efforts regarding this property is to reach a balance between enhancing the quality of water resources, improving diversity of forest communities and wildlife resources along with sustaining jobs, timber management, and timber revenue.

Forest Management Goals

The following are overarching goals that will drive the management activities on the property:

1. Maintain, restore, and enhance the biological diversity, water quality, and ecological integrity of Caroline Lake property through long-term, sustainable, forest management practices.

2. Meet the requirements of Wisconsin's Managed Forest Law, as well as The Nature Conservancy's organizational objectives in all aspects of land management.

3. Reinvest revenue generated from sustainable production of forest products into the property, as well as fund additional conservation work in the State of Wisconsin.

4. Foster the sharing of lessons learned and future forest management innovation by partnering with the Northern Institute of Applied Climate Science and establish Caroline Lake as a demonstration forest for climate-adaptive and ecologically based land management.

5. Create and maintain positive, viable collaborations with other landowners to achieve individual and common objectives across the landscape.

6. Contribute to the local economy through forest jobs, forest products, and compatible outdoor recreation opportunities.

Forest Management Principals

An important component of achieving the management goals on this property involves adhering to the following set of management principles when conducting any management activities. The principles are grouped by categories. Specific objectives for the various forest types on the property are presented in the "Forest Cover Type Description and Objectives" section of this plan.

Protecting Soil and Water Resources

- Ensure that all activities meet or exceed Best Management Practices, state (WIDNR), or county soil and sedimentation regulations
- Assess potential impacts of all management activities on soil & water resources before conducting those activities.
- Ensure that roads do not degrade water quality of wetlands and/or streams or modify sheet flows of water.
- Use the existing road network rather than constructing new roads and close or improve roads that are found to have negative impacts on water resources.

Forest Characteristics

- Promote age and structural diversity across the forested landscape that is appropriate for a variety of tree species.
- Promote species composition of forests that are appropriate for the site characteristics.
- Promote levels of standing and down coarse woody debris that are necessary for regeneration for a variety of tree species.
- Promote species composition of forests that are appropriate for the site characteristics and consider the adaptive capacity of species to a changing climate.
- Where economically possible, silviculture should attempt to mimic the natural disturbance patterns of the landscape (such as windthrow, disease, and fire).

Protection of Wildlife and Natural Communities

- Consult with Wisconsin's Natural Heritage Inventory database before conducting any activity in areas identified as Element occurrences (rare species or exemplary natural communities).
- Assess proposed harvest sites for rare species and other wildlife considerations (vernal pools, bear dens, raptor nests, etc.) before conducting harvests.
- Minimize negative impacts of harvests on wildlife, understory vegetation, and soils by limiting all harvest activities to frozen ground conditions or dry summer months when possible.
- Inspect harvest area for invasive species. Apply control treatments prior to harvest or

immediately post-harvest to promote desired herbaceous and tree species. If necessary, require the sanitation of harvest equipment if the equipment has recently operated in an area with known populations of invasive species.

Research

- Partner with academic institutions and other public and private forest land managers to incorporate practical, forest management-related research questions into harvests on the property.

Property Management

- Identify all property boundaries before beginning any management activity, consulting with the adjacent landowner if necessary to ensure accuracy of the boundary line.
- Develop or adopt a system of documentation to track all management activities on the property.
- Support local economy directly by hiring local loggers, selling wood products to local merchants; and indirectly by allowing access for canoeing, fishing, and hunting.
- Be a responsible landowner in the community by developing good working relationships with adjacent landowners, recreational enthusiasts, and community organizations.

General Property Description and History

Location

The property known as Caroline Lake consists of 1,044 acres of land all within Morse Township, Ashland County, Wisconsin. The property is a contiguous ownership and has the following legal description(s):

- SE ¼ section 13 T44N R02W
- South ½ NE ¼ section 23 T44N R02W
- NE ¼ NE ¼ section 23 T44N R02W
- West ½ section 24 T44N R02W
- West ½ NE ¼ section 24 T44N R02W
- NE ¼ NE ¼ section 24 T44N R02W
- West ½ SE ¼ section 24 T44N R02W
- SE ¼ SE ¼ section 24 T44N R02W
- North ½ NW ¼ section 25 T44N R02W
- NE ¼ section 25 T44N R02W
- NW ¼ SE ¼ section 25 T44N R02W

Refer to Exhibit 1 for general location and detailed property maps.

History

The Caroline Lake property was purchased by The Nature Conservancy in 1997 from Georgia Pacific, Inc. Prior to the acquisition by the Conservancy, the property had a long history of industrial ownership. The property was likely first logged in the late nineteenth century along with much of northern Wisconsin. The first logging in the region likely focused on the removal of white pine as it was a prized building material. During, and subsequent to the white pine harvest, other softwood and hardwood species were also harvested for many uses including fuelwood, railroad ties, and flooring.

After the initial harvests in the late nineteenth century, much of the region began a period of regrowth and recovery with cut-over lands naturally regenerating back to forest land. During that time, much of the cut-over land in northern Wisconsin was considered “tax forfeited” and transition to new ownership took place. In the mid-twentieth century, Nekoosa Papers acquired large tracts in the region through the tax forfeiture process. The property now owned by The Nature Conservancy was part of this initial acquisition. Nekoosa Papers acquired the property to produce fiber to support their milling operations in Wisconsin. In 1990, a merger of Nekoosa Paper into the Georgia Pacific Corporation transferred ownership at Caroline Lake to Georgia Pacific.

Physical Setting

The Caroline Lake property occurs within the Chequamegon Bay Watershed conservation area (1.5 million acres). Primary landforms include undulating and hilly lacustrine moraines adjacent to Lake Superior, outwash plains, bedrock controlled moraine, and rolling collapsed moraine. Soils in the undulating lacustrine moraines are typically somewhat poorly drained clays over calcareous clay till while hilly lacustrine moraines are characterized by a well-drained complex of clay, loam, and sand. Soils in the bedrock and rolling collapsed moraines are composed of well-drained fine sandy loams over acid sandy-loam till or bedrock.

The Caroline Lake property occurs within the Valhalla/Marenisco Moraines Land Type Association. The primary landform characteristics are rolling collapsed moraine with well-drained fine sandy loam over acid sandy-loam till or outwash sands.

The Caroline Lake property is a complex of undeveloped, natural area quality lakes (Caroline Lake, Twin Lakes-East and Twin Lakes-West) that include the headwaters (Caroline Lake) of the Bad River. The Caroline Lake complex was named in the Kakagon/Bad River Conservation Plan as the upland area most significant for the protection of the Kakagon/Bad River watershed. The Kakagon/Bad River Sloughs are the largest and healthiest full-functioning estuarine system remaining in the upper Great Lakes basin. The quality and quantity of water draining from the Caroline Lake property is integral to the maintenance and protection of the Wisconsin designated outstanding resource waters of the Bad River and National Natural Landmark found down river in the Kakagon/Bad River Sloughs.

Mellen, Wisconsin is the nearest town to the Caroline Lake property. According to U.S. Climate Data (www.usclimatedata.com) Mellen receives 33.35 inches of annual precipitation. Annual snowfall is 103 inches and is due in large part to lake effect snow from Lake Superior. Average high temperatures range from 70 degrees Fahrenheit in July to average lows of 2 degrees Fahrenheit in January. The average growing season at Caroline Lake is 105 days.

Existing Infrastructure

The Caroline Lake property is comprised of one contiguous parcel located east of State Highway 13 and south of State Highway 77. Mellen, Wisconsin is the nearest town and is located 5 miles to the northwest.

Roads

There are two public roadways that bisect the property. Lake Caroline Road crosses the property to the north in section 13 and re-enters the property in sections 24 and 25 and Minnow Creek Road crosses the property to the south in section 25. Both of these public roads are the origin of a network of "woods" roads that access the property. These "woods" roads were originally constructed to facilitate logging operations by the previous landowners and are in varying condition. Most of these roads are now primarily used for light foot traffic but will be suitable for future harvesting operations. All roads on the property are gated to restrict the use of motorized vehicles. Table 1 summarizes the roads on the property. The road system is also shown on all maps included in Exhibit 1.

Table 1 – Road Network Summary

Road Type	Description	Total Length
Public - maintained	Portions of Lake Caroline Rd, and Minnow Creek Rd.	1.6 miles
Woods Roads	Old haul roads or access roads; many have been used in the past to support harvest operations	6.5 miles
	TOTAL of all roads	8.1 miles

Leases or Easements

There are no legal leases or easements contained within the Caroline Lake property.

Sand and Gravel Pits

The Nature Conservancy is not actively extracting any sand or gravel from the property. There are likely small, abandoned borrow pits adjacent to roadways that were used by the previous owners.

Natural Disturbance

Prior to the large-scale harvesting of the forests in this region in the late 1800s, the primary sources of natural disturbance were windthrow, fire, insect damage, and beaver activity. Fire and insect infestations were probably more common on the drier pine sites while small patches of windthrow were likely common within the hardwood, mixed hardwood conifer, and lowland conifer forests (Price 1994).

These disturbance regimes have a shaping effect on the successional pathways and distribution of successional classes on the landscape. In general, for the ecological systems that experienced frequent natural stand-altering disturbances such as jack pine forests, there would have been a greater proportion of early stage successional classes. Conversely, in ecological systems with relatively rare stand-altering disturbances late successional classes would have been most prevalent. For example, it is estimated that roughly 80% of the pre- settlement northern hardwood/hemlock forests would have been in a late successional class (LANDFIRE 2008).

Past Conditions

Our understanding of the historical forests suggests that the forests in the region today differ significantly from the forests prior to when widespread timber harvesting began in the late 1800s. Based on an analysis of Government Land Office (GLO) line tree data, and based on GLO vegetation maps, there do not appear to be dramatic patterns of forest conversion on the property from one forest type to another over the past 150 years. Rather, the changes appear to be related to the structural and compositional diversity of the forests.

Finley's (1976) map of pre-Euro settlement vegetation shows two main upland classes within Caroline Lake: hemlock, sugar maple, yellow birch, white pine, red pine, and sugar maple as well as yellow birch, white pine, and red pine. An examination of GLO bearing trees within 2.5 miles of the preserve boundary shows that yellow birch, hemlock, and sugar maple comprised almost 70% of the stems with yellow birch the most abundant. Boreal conifers (balsam fir, spruces, and tamarack) made up approximately 16% of stems. Aspen was not recorded as a bearing or line tree within this zone. A broader look at bearing trees using the Valhalla/Marenisco Moraines Land Type Association boundary shows similar results for yellow birch, hemlock and sugar maple, and boreal conifers. Aspen and paper birch made up less than 1% of stems, respectively.

Climate Change Stressors

Northern Great Lakes region forests have been significantly altered since the pre-European settlement era. Extensive logging and large, severe, slash-fueled fires during the settlement era (late 19th-early 20th centuries) led to dramatic changes in forest ecosystems. Both forest composition and landscape structure have become dramatically more homogeneous. Dominance shifted from late-successional or mid-seral conifer and hardwood species to early successional hardwood species.

This regional shift towards homogeneity in composition and spatial pattern likely will make forests more vulnerable to the suite of emerging stressors including climate change, invasive species, pests and pathogens, atmospheric deposition, and continued demand for forest products.

Recent work suggests that many characteristic northern forest species (paper birch, balsam fir, jack pine, red pine, black and white spruce) may decline significantly over the next 50 to 100 years even under moderate greenhouse gas emission scenarios (Scheller and Mladenoff 2005, 2008, Janowiak et al. 2014). Climate change may lead to increased mortality due to fire, insect outbreaks, drought stress, and wind storms. In addition, high deer populations and non-native earthworms may limit tree growth and establishment. Hemlock wooly adelgid (HWA) is an exotic organism that causes high levels of mortality in eastern hemlock. HWA currently occurs in 17 states along the central Appalachian Mountains and southern New England in eastern North America. HWA spreads at a rate of 12-19 miles/year and can survive in extreme cold in its native Japan. However, recent studies indicate HWA mortality increases at higher latitudes in eastern North America. Cold winter temperatures in the northern Lake States could slow or limit the spread of HWA to northern Wisconsin, though the projected climate warming in the coming decades would increase the frequency of conditions favorable for survival and spread of HWA. Emerald ash borer (EAB) poses a significant threat to Northern Wisconsin. Currently there are no viable populations of EAB in Wisconsin but EAB can be found in a number of locations in the Upper Peninsula of Michigan. It is widely believed that it is only a matter of time before an EAB population is established in Wisconsin and projected temperature increases could lead to increased growth, survival and dispersal of EAB populations and corresponding increased damage to preferred host species (white ash, black ash and green ash).

Carbon dioxide levels may allow for increased productivity over the short term and may offset some impacts of a warming climate over longer time spans (Frelich and Reich 2009). Increased carbon dioxide can increase water-use efficiency under warmer temperatures and increase establishment and growth. Nitrogen deposition may also lead to some increased productivity, particularly on sites that are nitrogen limited.

While carbon dioxide (CO2) fertilization and nitrogen deposition may offset some of the negative impacts, the suite of climate change related stressors will challenge and limit the capacity for forests to provide key ecosystem services such as water quality, biological diversity, wood fiber, carbon storage, recreation, and spiritual values.

Soils

Although there are 9 different soil map units represented on the property, 3 of these soils together comprise 84% of the property. All soils are shown in Table 2 along with the percentage of the property that they represent according to the Ashland County Soil Survey. Exhibit 1 contains detailed soils maps for all soil types found at Caroline Lake,

One of the most important factors regarding the soils in relation to forest management is the prevalence of poorly drained soils. To protect both soils and aquatic resources, riparian management zones adjacent to streams and wetlands will be established prior to harvests. Within riparian management zones there will be no activities that result in the exposure of bare mineral soil.

Due to the limitations of the poorly drained soils, any harvesting activity in these wetland soils will be limited to frozen ground conditions. To meet our objective of maintaining the natural hydrology of the wetlands across this property, prior to any harvesting there must be a careful evaluation of the potential impacts of the winter activities on the hydrology of the site.

Table 2 – Caroline Lake Soils

Symbol	Description	GIS Acres	Percent
5172C	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 18 percent slopes	360.96	34%
5141A	Lupton-Pleine-Cathro complex, 0 to 1 percent slopes	287.18	27%
5171B	Tula-Wormet-Gogebic complex, 0 to 6 percent slopes, very stony	241.64	23%
5170A	Minocqua-Pleine-Cathro complex, 0 to 2 percent slopes	61.59	6%
5172B	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 6 percent slopes	36.08	3%
5374A	Bowstring-Arnheim complex, 0 to 1 percent slopes, frequently flooded	23.34	2%
5172D	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 35 percent slopes	21.44	2%
5173D	Gogebic-Pence complex, 18 to 35 percent slopes, very stony	11.57	1%
5140A	Dawson, Greenwood, and Loxley soils, 0 to 1 percent slopes	4.05	0%
W	Water	2.08	0%
	Totals	**1,049.93**	**100%**

Public Use of Property

The property is open to non-motorized public access for hunting, fishing, hiking, birdwatching, and nature study. As stipulated by the Managed Forest Law, public access on foot for hunting and fishing is allowed. In addition, the Conservancy desires that the general public be able to access and enjoy this property for any low-impact activity. The following list of activities is prohibited:

- Picking or collecting of flowers, nuts, berries, seeds, shells, rocks, or other parts of the natural landscape
- Horseback riding
- Bicycles or other off-road vehicles, including motorized vehicles
- Camping
- Camping or picnic fires
- Trapping
- Free running dogs for bear or coyote hunting, including training thereof
- Baiting for hunting of any game species

Inventory Data

In the summer of 2012 The Nature Conservancy, in partnership with The Northern Institute of Applied Climate Science (NIACS), contracted Compass Land Consultants, Inc. (Compass) to conduct a comprehensive inventory of the Caroline Lake property. Compass began this process by generating an initial cover type map for the entire property based on aerial photo interpretation. This initial cover type delineation showed that there were six general cover types on the property. The total acreage in each cover class is shown in Table 3.

Table 3 – Initial cover types

Cover type	GIS Acreage	Percentage
Northern Hardwood	635.30	60%
Swamp Conifer	259.48	25%
Swamp Hardwood	110.38	11%
Lowland Brush	28.33	3%
Marsh, Muskeg, Water	16.43	1%
TOTAL	**1,049.92**	**100%**

During the fall of 2012 foresters from Compass conducted a comprehensive property-wide inventory on the Caroline Lake property. A random sample consisting of 200 permanent inventory points was placed in all strata represented on the property. Based on work conducted for The Nature Conservancy in Michigan, it was determined that an inventory protocol for determining Key Ecological Attributes (KEA) would be employed at Caroline Lake. The goal in collecting robust forest inventory data was that by measuring numerous ecological metrics, the data could be further evaluated and developed to help guide management activities in response to climate change. Furthermore, it was the hope of Compass, TNC, and NIACS that new metrics for climate-informed forest inventory would be developed. In addition to "traditional" forest inventory metrics, a summary of climate-informed metrics and descriptions can be found in Table 4 below. A sample of both "traditional" stand data and KEA data collected for the property can be found in Exhibit 2.

Table 4 – Key Ecological Attribute (KEA) data

Key Ecological Attribute	Metric	Description
KEA 1	Total Stocking	Function of basal area and trees per acre, expressed in percentage of "available" stocking
KEA 2	Acceptable Growing Stock	Similar to KEA 1 with "acceptable" stems per USFS guidelines
KEA 3	Tree Species Diversity (Richness)	Total number of overstory tree species in a given stand
KEA 4	Tree Species Evenness (Richness Distribution)	The relative abundance of tree species
KEA 5	Large Live Trees	Measure of trees greater than 19" DBH per acre
KEA 6	Large Snags	Measure of standing snags greater than 10" DBH per acre
KEA 7	Large Coarse Woody Debris	Measure of a downed woody debris greater than 13" diameter expressed in ft^3 per acre
KEA 8	Established Regeneration	Total number of seedlings/saplings greater than 1" DBH per acre
KEA 9	Desirable Seedlings	Total percentage of KEA 8 determined "desirable" *

* "Desirability" determined on a case-by-case basis per landowner's goals

Based on the analysis of inventory data and forester observations, initial forest cover types were further refined. 42 individual stands were delineated in 11 cover types on the Caroline Lake property. Refer to Table 5 for a complete cover type summary.

Table 5 – Caroline Lake cover type summary

Cover Type Code	Cover Type	GIS Acres	Percentage
NH	Northern Hardwoods	327.49	31%
MR	Red Maple	307.81	29%
T	Tamarack	123.67	12%
C	White Cedar	107.91	10%
SH	Swamp Hardwoods	78.32	7%
LBA	Lowland Brush	28.33	3%
SB	Black Spruce	27.91	3%
A	Aspen	24.08	2%
KG	Marsh	13.96	1%
H	Hemlock	7.98	1%
LM	Minor - Lake	2.47	0%
	TOTAL	**1,049.93**	**100%**

A map of the property with unique stand I.D. and cover type codes can be found in Exhibit 3. Exhibit 3 also contains the Managed Forest Law compliant section maps that can be uploaded to the Wisconsin DNR's mapping site for private lands open to public recreation (http://dnrmaps.wi.gov/opfl/). The maps in Exhibit 3 are coded using cover type codes and stocking densities designated by the Wisconsin Department of Natural Resources. Table 6 below

summarizes the cover type descriptions found on the Caroline Lake property and Tables 7 and 8 summarize the size class and stocking density codes. These three tables can be used together as a key with the maps in Exhibit 3 to determine the species composition and relative size/density for all stands on the property.

Table 6 – Detailed cover type descriptions

Code	Cover Type	Description
NH	Northern Hardwoods	Any combination of sugar maple, beech, basswood, white ash, and yellow birch that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands.
MR	Red Maple	Red Maple that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands. If soil is poorly drained, then swamp hardwood
T	Tamarack	Tamarack that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands. If mixed swamp conifer stands, tamarack is predominant.
C	White Cedar	White cedar that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands. If mixed swamp conifer stands, white cedar is predominant.
SH	Swamp Hardwoods	Any combination black ash, green ash, red maple, silver maple, swamp white oak, and American elm that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands. This type occurs on wetlands characterized by periodic inundation and nearly permanent subsurface water flow.
LBA	Alder	Lowland stands with more than 50% red alder.
SB	Black Spruce	Black spruce that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands. If mixed swamp conifer stands, black spruce is predominant.
A	Aspen	Aspen that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands.
KG	Lowland Grass	Groundcover consisting of more than 50% of true grasses such as canary grass, bluejoint, redtop, cordgrass, big bluestem, etc.
H	Hemlock	Hemlock that comprises 50% or more of stand basal area in saw-timber/pole stands and 50% or more of stems in seedling/sapling stands.
LM	Minor - Lake	Open water – less than 40 acres in area.

Table 7 – Size class codes

Symbol	Class	DBH
0 – 5	Seedling or sapling	0 – 5”
5 – 9 or 11	Pole-timber	5” – 9” or 11”
9 or 11 – 15	Small saw-timber	9” or 11” – 15”
15+	Large saw-timber	15” +

Table 8 – Stand density class

Size Class	Units per Acre	Density Classes		
		1	2	3
Seedlings	Trees	1,501+	601 – 1,500	200 - 600
Seedlings	Trees	901+	301 - 900	100 - 300

Size Class	Units per Acre	Density Classes				
		5	4	3	2	1
Pole-timber and Saw-timber	Basal area (sq. ft./acre)	150+	111 - 150	71 - 110	31 -70	10 – 30

Discussion of Climate Risk

As discussed above, it was the hope of Compass, TNC, and NIACS to develop a new set of climate-informed metrics for forest inventory once we had collected and compiled the inventory data for the property. In an effort to accomplish that task, there were a series of meetings with partners and peers from Compass, TNC, NIACS, USFS, Wolf River Forestry, and the Wisconsin DNR aimed at using forest inventory to evaluate climate change risk. Through that process, it became clear that a risk metric would be the most useful tool managers could use when evaluating climate change impacts. As a result of the meetings, 9 climate-informed metrics were developed and summarized in Table 9 below. An example of climate-informed inventory report can be found in Exhibit 4.

Table 9 - Climate-Informed Metric (CIM) data

Climate Informed Metric	Metric	Description
CIM1	Total Stocking	Function of basal area and trees per acre, expressed in percentage of "available" stocking
CIM 2	Tree Species Diversity (Richness)	Total number of overstory tree species in a given stand
CIM 3	Tree Species Evenness (Richness Distribution)	The relative abundance of tree species
CIM 4	Large Coarse Woody Debris	Measure of a downed woody debris greater than 13" diameter expressed in ft^3 per acre
CIM 5	Established Regeneration	Total number of established sapling per acre 1" to 4.5" DBH
CIM 6	Seedlings per Acre	Total number of seedlings per acre 0" to 0.9" DBH
CIM 7	Climate Risk - Overstory	Expressed as percentage of species likely to decline in a changing climate. Represented in a PCM B1 (low) and GFDL A1FI (high) climate change scenario
CIM 8	Climate Risk – Established Regeneration	Expressed as percentage of species likely to decline in a changing climate. Represented in a PCM B1 (low) and GFDL A1FI (high) climate change scenario
CIM 9	Climate Risk - Seedlings	Expressed as percentage of species likely to decline in a changing climate. Represented in a PCM B1 (low) and GFDL A1FI (high) climate change scenario

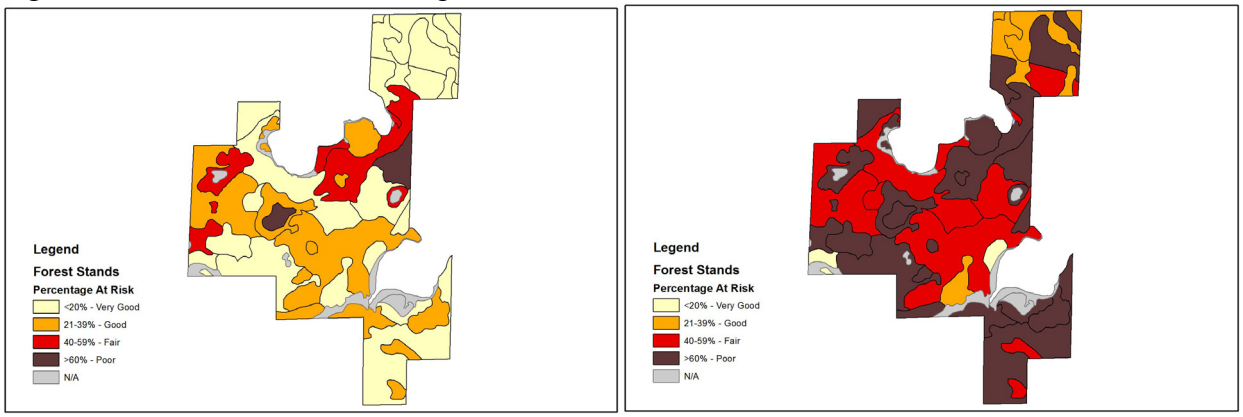
The first five climate-informed metrics are also found in the traditional KEA data. There was also an addition of a sixth climate-informed metric related to seedling abundance. It was determined by the peer group that these six KEAs, which are related to stocking, species diversity, structural diversity, and regeneration, have relevance to assessing climate risk. It was generally accepted that a well-stocked, diverse stand with adequate regeneration will be best suited to deal with increased climate pressures. What those six metrics didn't tell managers is if the individual species in a given stand were at risk of decline. As a result, new metrics were developed to specifically quantify climate change risk.

To assess risk at the stand level, individual tree data was evaluated for the "risk of decline" of a tree species through the end of the century. The determination of "risk of decline" was compiled by evaluating the Climate Change Tree Atlas climate model results developed as part of a climate change vulnerability assessment for northern Wisconsin and western Upper Michigan (Janowiak et al. 2014). Once this data was evaluated, a list of tree species was compiled for northern Wisconsin and was grouped into three categories. Those categories included what species were expected to decrease in a changing climate, species expected to have little change, and species expected to increase in abundance. This analysis was repeated twice for a low climate change scenario (PCM B1) and a high climate change scenario (GFDL A1F1).

The new climate risk metrics (climate metrics 7-9) use species data at the stand level to arrive at an overall risk of decline for a forested stand. For each stand, the number is expressed as a percentage based upon the relative abundance of species that are considered to be at risk of decline. For example, a risk value of 40% indicates that 40% of the stand (based upon importance value) is made up of species that are projected to decline by 2100. The process was repeated for overstory species (CIM7), established regeneration (CIM8), and seedlings (CIM9) in both the low change (PCM B1) and high change (GFDL A1FI) scenario. The combination of the three new metrics gives managers an overall assessment of the risk that a stand will decline in coming decades (overstory) and farther into the future (established regeneration and seedlings).

The analysis of climate-informed inventory data for Caroline Lake resulted in pronounced differences between the low and high climate change scenarios. The figures below illustrate the difference between the two scenarios with respect to overstory risk. The colors in the illustrations relate to risk by stand with brown representing high risk (60%+ at risk), red representing moderate risk (40% to 59% risk), orange representing low risk (21% - 39% risk), and yellow representing very low risk (less than 20% at risk). Map summaries of overstory, established regeneration, and seedling risk can be found in Exhibit 5.

Figure 1 – Caroline Lake Risk Maps



PCMB1 (low change) GFDL A1FI (high change)

Northern Hardwoods (includes NH cover type)

Nearly 31% of the Caroline Lake property falls into the northern hardwoods classification (approximately 327 acres). Historically, this cover type has been managed frequently by previous landowners and common silvicultural prescriptions appear to have been employed. The northern hardwood stands on the property have been previously managed using single tree selection techniques and current stocking suggests that residual basal area targets of 80 ft^2 were employed. When compared the northern hardwood resource in the region, the northern hardwood stands on Caroline Lake have an exceptional amount of species diversity. This suggests that previous managers did not favor any single species and largely employed good timber stand improvement techniques in managing the resource.

The northern hardwood resource on the Caroline Lake property is dominated by sugar maple (41%) with secondary components of red maple (22%), yellow birch (9%) and red oak (5%). There are 13 other associated species found in the northern hardwood type but none represent more than 4% of the total stocking. Currently the northern hardwood type averages 101ft^2 of basal area per acre. Stand volumes average 2,094 board feet of saw-timber and 21 cords of pulpwood per acre in all species.

Overall, the management objective for the northern hardwood resource is to promote and maintain an all-aged mixed hardwood forest. Species diversity is a primary goal of management activities, particularly given the threats posed by a changing climate. Enhancement and maintenance of structural diversity is also a management objective in this forest type given the historical context and past management of this resource regionally. Activities designed to encourage structural diversity include growth of a larger diameter saw-timber resource, retention of coarse woody debris, maintenance of age class distribution, and creation / maintenance of canopy gaps.

Mixed Hardwood / Hemlock (includes MR, SH and H cover type)

The mixed hardwood resource includes three cover types that account for 394 acres (37%) of the Caroline Lake property. Red maple (MR) is by far the most dominant cover type in this group with 307 acres (29%), while swamp hardwood (SH) and hemlock (H) represent 78 acres (7%) and 8 acres (1%) respectively.

The red maple (MR) cover type on the property is dominated by red maple (32%) with secondary components of yellow birch (14%), balsam fir (10%), white cedar (8%), and hemlock (8%). There are 13 other associated species found in the northern red maple type but none represent more than 5% of the total stocking. Currently the red maple type averages 104ft^2 of basal area per acre. Stand volumes average 958 board feet of saw-timber and 22 cords of pulpwood per acre in all species.

All cover types in this group are situated on transitional sites between northern hardwood dominated uplands and conifer dominated lowlands or wetlands. These stands generally have a

higher seasonal water table and in the case of the SH stands, standing or pooled water may be present during the growing season.

Similar to the northern hardwood resource on Caroline Lake, the mixed hardwood resource represents a tremendous amount of species diversity. Evidence suggests that where previous management occurred, managers treated the mixed hardwood resource in a similar manner to the northern hardwood stands on the property. In general, residual basal areas appear to have been $70ft^2 – 90ft^2$ and management did not focus on any single species or product.

The management objective for the mixed hardwood timber type is very similar to the objectives of the northern hardwood resource. The overall goal is to promote and maintain an all-aged mixed hardwood / softwood forest. Species diversity remains a goal of management activities and the maintenance of long-lived conifers (e.g. hemlock and white pine) is a primary focus. Enhancement and maintenance of structural diversity is also a management objective in this forest type. Activities designed to encourage structural diversity include growth of a larger diameter saw-timber resource, retention of coarse woody debris, maintenance of age class distribution, and creation / maintenance of canopy gaps.

Lowland Mixed Conifer (includes T, C, and SB cover types)

The lowland conifer resource includes three cover types that account for 259 acres (25%) of the Caroline Lake property. Tamarack (T) is the most dominant cover type in this group with 124 acres (12%), while white cedar (C) and black spruce (SB) represent 108 acres (10%) and 28 acres (3%) respectively.

All of the cover types in this group are situated on forested wetlands and water may be at or near the surface throughout the growing season. All of the cover types in this group are very similar with the only distinction being the relative percentages of the dominant tree species. All of the mixed conifer stands on the property are even-aged and stand ages vary between 60 to 100 years.

The management objective for the lowland mixed conifer resource is to maintain the existing cover types and promote long-term health of these important stands. All of the lowland conifer stands on the property are critical in the protection of water quality. These stands support important natural processes surrounding water filtration, retention, and regulation. They are also critical to the maintenance of the high quality associated with Caroline Lake, Twin Lakes, and the Bad River.

Aspen (includes A cover type)

The aspen cover type is a minor component of the Caroline Lake property. Currently there is only one stand that represents 24 acres (1%) of the ownership. The current aspen resource is approximately 35 years of age with aspen being the dominant species (42%) and red maple (20%), balsam fir (20%), and yellow birch (7%) being minor associated species.

There will be no active management in this timber type for the next 15+ years. The long term goal for this type is to convert to and all-aged mixed hardwood / conifer stand. This process may take a number of entries and multiple silvicultural methods may be employed.

Non-Productive Lowland (includes LBA, KG and LM cover types)

The non-productive types on the Caroline Lake property total 45 acres and account for 4% or the total property. These types are a combination of alder thicket, open marsh/grassland and open water.

The long term goal for these types is to maintain their cover and composition. Similar to the lowland conifer timber type, these cover types are critical to the function and protection of the water resource. An area of special concern associated with these cover types is the monitoring and control of potential invasive species. It is recommended that mangers conduct routine monitoring and surveillance of these areas to look for invasive species occurrence.

Silviculture by Forest Type

The following discussion of silviculture by cover group is designed to clarify TNC's long term goals are for the cover types found on Caroline Lake and to discuss what impacts a changing climate may have on achieving those goals. Each cover group will include a discussion on what the overall management goals are for the group, what challenges and opportunities exist with climate change, and what silvicultural techniques may be employed to help achieve management goals given climate change. These summaries are based upon a more detailed analysis that was done using the adaptation workbook to integrate climate change considerations into management on the property.

Northern Hardwoods (includes NH cover type)

Management Goals

The general management objective for this cover type is to maintain and/or enhance both species and structural diversity. This cover type currently has excellent species diversity and every effort will be taken to protect and enhance that native diversity. An analysis of the climate-informed data for the cover type reveals that the northern hardwood resource is lacking desired structural diversity in the number of large trees, standing snags, and coarse woody debris. This is not uncommon in the managed landscape and is most likely due to a number of decades where managers focused on pulpwood production.

Challenges to Meeting Objectives due to Climate Change

Many of the species in this cover type are expected to decline in the high (GFDL A1F1) climate change scenario. These include species that currently define the northern hardwoods timber type including sugar maple and yellow birch. Other species expected to decline under this scenario are hemlock, balsam fir, and white spruce. In addition to species decline, reduced winter precipitation and reduced snow depths could result in increased deer herbivory and less successful regeneration. Forest pests and invasive species also pose a threat to the northern hardwood resource in a changing climate. Of particular concern are emerald ash borer and hemlock wooly adelgid. Both species represent a real and current risk and would further jeopardize species diversity.

Opportunities for Meeting Objectives due to Climate Change

There are currently 17 tree species represented in the northern hardwoods type at Caroline Lake. Although some species are forecast to decline, there are a number of species that are expected to adapt quite well to a changing climate. In particular, red maple, red oak, and basswood are all expected to increase in the future and all are present on the property. Although many species are predicted to decline it should not be a justification for managers to reduce species diversity or eliminate species secondary to management. Furthermore, the Great Lakes may help to moderate changes, and Caroline Lake could act as refugia due to its proximity to Lake Superior. In addition to climate

impacts on species distribution, increases in wind and storm events that may actually help create more blowdowns and increase structural diversity in the canopy.

Silvicultural Guidelines

It is recommended that the northern hardwood resource at Caroline Lake continue to be largely managed on an individual tree selection system while considering opportunities to employ small group selection and shelterwood systems. Silvicultural treatments should be prescribed when target stands reach 120 square feet of basal area and overall residual basal areas should be 80 – 90 square feet. As mentioned above, maintenance of species diversity is a primary goal. Given that goal, opportunities to help regenerate climate adapted species should be considered. Mid-tolerant and potentially future-adapted species such as red oak and white pine should be encouraged through the thoughtful creation of canopy gaps and subsequent use of seed trees. The benefits of creating these gaps will be twofold in that they will encourage regeneration as well as help create needed canopy structure. In areas of abundant balsam fir regeneration, it may be necessary to leave a slightly higher residual basal area (90 – 100 square feet) to deter growth and future seeding of balsam fir. Currently there are balsam thickets in the northern hardwood understory that prevent establishment of longer lived, climate-adapted species.

In an effort to increase structural diversity it is recommended that the northern hardwood stands on Caroline Lake be managed for long term saw-log production. Currently there is a lack of large diameter trees on the property and managing for saw-log production will maximize both ecological and economic benefits. In addition to increasing average diameters it is also recommended that all large snags and coarse woody debris be protected from damage in harvesting operations. It may also be necessary in some stands to artificially create a number of large snags and subsequent coarse woody debris by girdling a number of trees. His should be evaluated on a stand by stand basis to achieve desired goals.

Mixed Hardwood / Hemlock (includes MR, SH and H cover type)

Management Goals

As stated above, the management goals for the mixed hardwood / hemlock types found at Caroline lake are very similar to the northern hardwood resource. As with the upland hardwoods, the general management objective for this cover type is to maintain and/or enhance both species and structural diversity. This cover type currently has excellent species diversity and every effort will be taken to protect and enhance that native diversity. An analysis of climate-informed data for the cover type reveals that the mixed hardwood / hemlock resource is lacking desired structural diversity in the number of large trees, standing snags, and coarse woody debris.

Challenges to Meeting Objectives due to Climate Change

A changing climate will likely affect the mixed hardwood / hemlock resource differently than the northern hardwood resource found at Caroline Lake. While the northern hardwoods are at a low risk of decline in the low change PCM B1 (11.4%) scenario, the mixed hardwood / hemlock resource is at greater risk (25.4%) in the low change scenario. This higher percentage is due to the greater percentage of white birch, balsam fir, and aspen in the overstory. Given this higher percentage of vulnerable species, these stand types will likely see earlier signs and stressors associated with climate change. In addition to these climate stressors, forest pests and invasive species pose an eminent threat to this forest type primarily with emerald ash borer and possibly hemlock wooly adelgid. The swamp hardwood type in northern Wisconsin is defined by the presence of black ash, and with the anticipated invasion of emerald ash borer, this forest type will likely see dramatic changes in overstory composition. One concern with a loss of black ash in the swamp hardwood type is that we may see a proliferation of already established red alder and significant increases in non-commercial tree and shrub species. That possibility, combined with challenges to implementing winter operations posed by reduced winter precipitation and reduced snow depths pose a significant management challenge for these forest types.

Opportunities for Meeting Objectives due to Climate Change

There are currently 18 tree species represented in this forest type. Although a number of species are forecasted to decline, this type is defined by the presence of red maple with smaller percentages of red oak, white pine, and basswood. Red maple is well adapted to a changing climate and its abundance in the mixed hardwood / hemlock cover types will help maintain an intact forest canopy. It is also predicted that an increase in wind and storm events that may actually help create significantly more blowdowns in these cover type and that should aid in the establishment of mid-tolerant long-lived species such as red oak and white pine.

Silvicultural Guidelines

It is recommended that the red maple, swamp hardwood, and hemlock resource at Caroline Lake continue to be managed on an individual tree selection system while also considering the use of small to mid-size group selections and shelterwood systems. Similar to the northern hardwood resource, silvicultural treatments should be prescribed when target stands approach 120 square feet of basal area and overall residual basal areas between group selections should be 80 – 90 square feet. Continued maintenance of species diversity is a primary goal and regeneration of climate adapted species should be a priority. Mid-tolerant and potentially future-adapted species such as red oak and white pine should be encouraged through the thoughtful creation of canopy gaps and subsequent use of seed trees. The use of this group selection / shelterwood technique will be critical to maintaining mid-tolerant climate adapted species. Similar to other stands found at Caroline Lake, there is a lack of large diameter trees, standing snags and coarse woody debris found in these forest types. It is recommended that all large snags and

coarse woody debris be protected from damage during harvesting operations. Furthermore, it may also be necessary in some stands to artificially create a number of large snags and subsequent coarse woody debris by girdling a number of trees. This should be evaluated on a stand by stand basis to achieve desired goals.

The management of the swamp hardwood stands found at Caroline Lake is a primary concern. Given the likelihood of a future emerald ash borer infestation, assisted reforestation of climate-adapted species should be considered, possibly in advance of overstory mortality. In particular, both swamp white oak and bur oak are well suited for these sites and establishment could help maintain a health forest canopy after the loss of black ash. The issue of assisted migration of tree species is controversial in some forest management circles and a comprehensive risk assessment and evaluation of benefit should be completed prior to any reforestation effort.

Lowland Mixed Conifer (includes T, C, and SB cover types)

Management Goals

As discussed in the 'Forest Cover Type Description' portion of this report, the management objective for the lowland mixed conifer resource is to maintain the existing cover types and promote long-term health of these important stands. All of the lowland conifer stands on the property are critical in the protection of water quality. These stands support important natural processes surrounding water filtration, retention and regulation and are critical to the maintenance of the high qualities associated with Caroline Lake, Twin Lakes, and the Bad River.

Challenges to Meeting Objectives due to Climate Change

The cover types associated with the lowland swamp conifer type represent the greatest management challenge with respect to meeting objectives in light of climate change. Nearly all of the species that define this type (white cedar, black spruce, and tamarack) are expected to be some of the first species to decline in a changing climate. The combination of altered precipitation (potential drying during the growing season) and warmer temperatures will significantly challenge the hallmark species of this forest type. In addition to these direct climate stressors, the lowland conifer stands found at Caroline Lake have less species diversity and tend to be more homogenous, making it more likely that any changes will affect large portions of these stands. To that point, the KEA "Risk of Decline" metric shows that in a high change (GFDL A1F1) scenario, stands in the black spruce and tamarack types have a 95% risk of decline while the cedar type stands have an 82% risk of decline.

Opportunities for Meeting Objectives due to Climate Change

The most optimistic opportunity for these stands to adapt in a changing climate is that there is a minor component of climate-adapted species represented in these stand types. In all types, slight changes in micro topography tend to encourage the establishment of red maple and white pine. All of these species are expected to fare better in a changing climate and, in particular, red maple and white pine are expected to increase in the PCM B1 scenario, and red maple is expected to increase in the GFDL A1FI scenarios.

Silvicultural Guidelines

Currently, none of the swamp conifer stands at Caroline Lake will be considered for harvest in the 10-year planning horizon of this plan due to stand ages. Generally, when these stands are managed, the primary goals will be the protection of the hydrological function of the associated wetlands and regeneration of climate-adapted species. When considering harvest, a primary consideration should be potential to release of red maple and white pine regeneration. Beyond that provision, maintenance and regeneration of viable populations of swamp conifer species will be considered. Regeneration of these species will be accomplished by creating irregular patch harvests designed to mimic natural disturbance patterns. Patch size will range from 0.5 to 5 acres in size and landform and micro topography will dictate where and how large patch opens should be. It is also important to remember that sites such as Caroline Lake may act as refugia due to its proximity to Lake Superior and the overall health of the swamp conifer type should be closely monitored and silvicultural prescriptions should be adjusted accordingly.

Aspen (includes A cover type)

Management Goals

A very small percentage of the Caroline Lake property occurs in the aspen cover type. Due to current stand ages, there will be no planned management activities in this type during the life of this plan. However, it is important to note that the overall management goal for this type is to maintain aspen as a cohort, but over time transition this type to longer lived and more climate-adapted mixed hardwoods.

Challenges to Meeting Objectives due to Climate Change

Maintaining aspen forest type on the landscape will become challenging in a changing climate. Both aspen and white birch are expected to be some the first species to decline secondary to climate change. In fact, on TNC managed projects on Minnesota's north shore, a moderate 2-3 drought resulted in significant dieback and mortality in young white birch and aspen. As these types of climate stresses increase it is expected this type impact will be seen at the landscape level.

Opportunities for Meeting Objectives due to Climate Change

The overall management objective is to transition aspen stands to a longer lived and more diverse mixed hardwood stand. Currently, the aspen stand found at Caroline Lake contains a number of climate-adapted hardwood species. Most significant is the occurrence of red maple as well as minor occurrences black cherry and red oak. As the aspen stand transitions either due to natural processes or active management, there should be adequate native species to populate the future stand.

Silvicultural Guidelines

Currently, the aspen stand at Caroline Lake will not be considered for harvest in the 10-year planning horizon of this plan. When this stand is managed in the future opportunities to remove aspen and maintain a hardwood overstory should be considered. Generally, if there will be greater than 50-60 square feet of residual hardwood, aspen should be removed similar to a natural successional process. In areas where aspen basal area greatly exceeds hardwood, small patch openings shall be created to encourage regeneration of early successional species and promote landscape-level diversity. As with the swamp hardwood type, the overall health of this stand should be closely monitored and silvicultural prescriptions should be adjusted accordingly.

Water Quality

Protection of water quality is a priority for all management activities on the Caroline Lakes property. The Caroline Lake property is a complex of undeveloped, natural area quality lakes (Caroline Lake, Twin Lakes-East and Twin Lakes-West) that include the headwaters (Caroline Lake) of the Bad River. The Caroline Lakes complex was named in the Kakagon/Bad River Conservation Plan as the upland area most significant for the protection of the Kakagon/Bad River watershed. While important primarily for its position at the headwaters of the Bad River, the lake is surrounded by numerous high quality plant communities as well. Due to these factors Caroline Lake has been designated by the State of Wisconsin as State Natural Area having Outstanding/Exceptional Resource Waters due to its high quality. All management activities on the property will be conducted in a manner to protect the water quality, scenic beauty, and ecological health of this unique system.

In addition to being designated as a State Natural Area, both Caroline Lake and the Twin Lakes have been designated as Areas of Special Natural Resource Interest (ASNRI) / Endangered, Threatened or Special Concern Area. This ASNRI designation is a result of having found waters inhabited by any endangered, threatened, special concern species or unique ecological communities identified in the Natural Heritage Inventory. More information on Wisconsin's Natural Heritage Inventory can be found at http://dnr.wi.gov/topic/NHI/.

There is evidence that selective harvesting in northern hardwoods may impact aquatic habitats and their invertebrate populations (Huckins and Burgess 2004). As a result, special attention will be given to aquatic impacts when designing harvest plans and silvicultural prescriptions for all stands on the property. At a minimum, Wisconsin BMP's will be strictly adhered to throughout all management activities. In addition, existing stream crossings and roads that were constructed by previous owners will be assessed and upgraded to prevent deterioration of water quality.

Conservation of Biological Diversity, Rare Species, and Natural Communities

The conservation of biological diversity at Caroline Lake is central to the organizational mission of The Nature Conservancy and a management goal of this property. All management activities on the property will be carefully evaluated to determine the potential impacts on biodiversity, rare species, and natural communities.

Shortly after acquiring the property, scientists and staff from the Nature Conservancy conducted a property wide assessment to establish baseline data for the occurrence and presence of rare, threatened and endangered species. Table 9 and 10 below summarize the results of that assessment a detail the species and natural communities of concern associated with the property.

Table 9 - Species of Concern

Scientific Name	Common Name	State Status	Federal Status	Global Rank/ State Rank
Empidonax flaviventris	Yellow-bellied Flycatcher	SC/M	None	G5/S2B
Contopus borealis	Olive-sided Flycatcher	None	None	G5/S3B, S
Periosteum Canadensis	Gray Jay	SC/M	None	G5/S3B
Haliaeetues leucocephalus	Bald Eagle	SC/FL	LTN	G4/S2N, S3S4B
Pandion haliaetus	Osprey	THR	None	G5/S3S4B
Gavia immer	Common Loon	SC/M	None	G5/S3S4
Mniotilta varia	Black-and-white Warbler	None	None	
Dendroica fusca	Blackburnian Warbler	None	None	
Vermivora chrysoptera	Golden-winged Warbler	SC/M	None	G4/S4
Dendroica caerulescens	Black-throated blue Warbler	SC/M	None	G5/S3B
Lycaena dorcas	Dorcas copper butterfly	SC/N	None	G4/S2
Boloria freija	Freija fritillary butterfly	SC/N	None	G5/S2
Oeneis jutta	Jutta arctic butterfly	SC/N	None	G5/S3

Table 10 - Natural Communities of Concern

Natural Community Type	Global Rank/ State Rank
Alder Thicket	G4/S4
Lake, soft, shallow, drainage	GU/S3
Stream – fast, soft, cold	GU/SU
Northern Sedge Meadow	G4/S3
Shrub Carr	S4
Open Bog	G5/S4
Northern Dry Mesic Forest	G4/S3
Northern Mesic Forest	G4/S4
Northern Wet Forest	G4/S4
Black Spruce Swamp	G5/S3
Tamarack Swamp	G4/S3
Poor Fen	G3G4/S3
Submergent Aquatic	S4
Emergent Aquatic	G4/S4
Muskeg	S4

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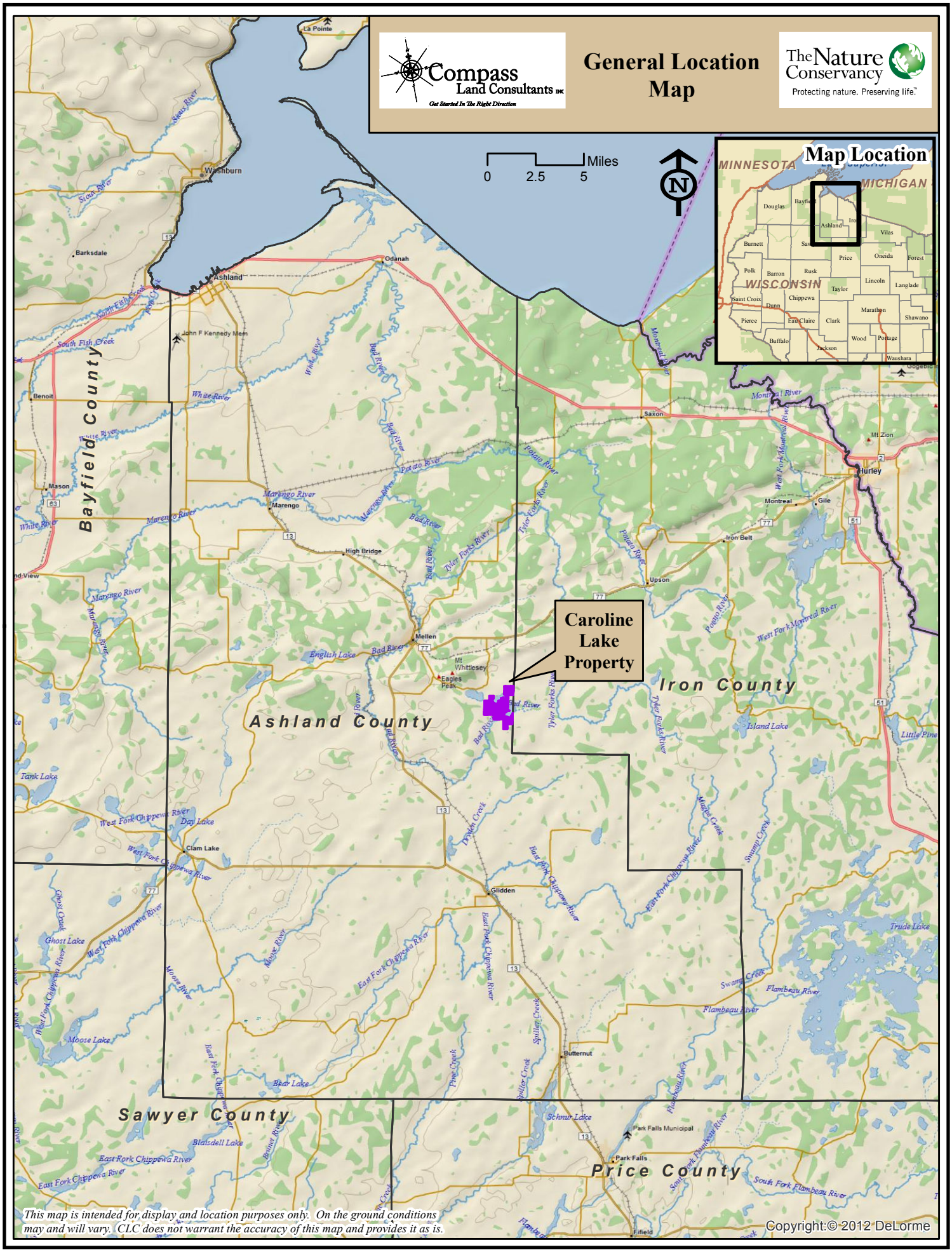
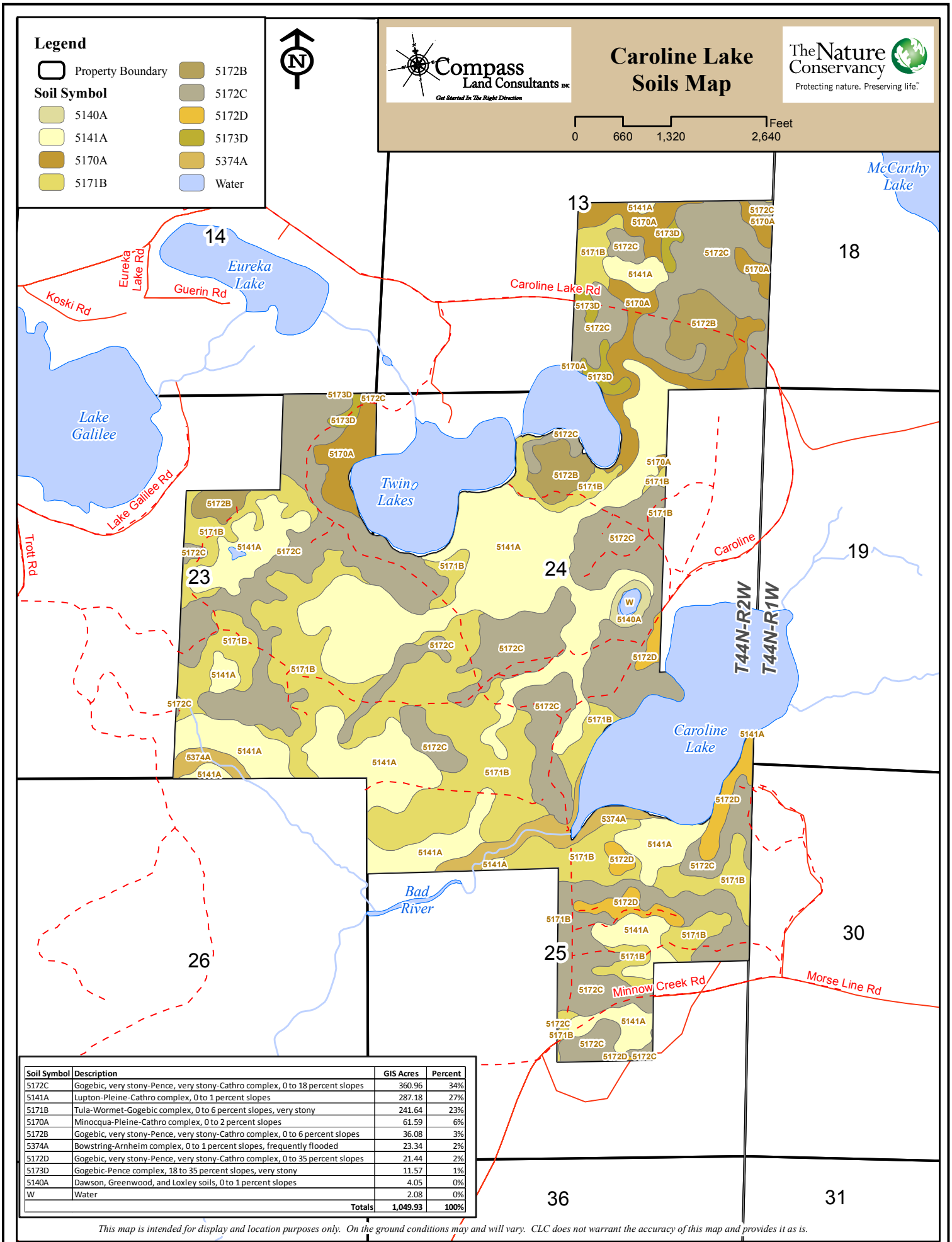
Scheller, R.M. and D.J. Mladenoff, 2005. *A spatially interactive simulation of climate change, harvesting, wind, and tree species migration and projected changes to forest composition and biomass in northern Wisconsin, USA*. Global Change Biology 11: 307-321.

Exhibit 1

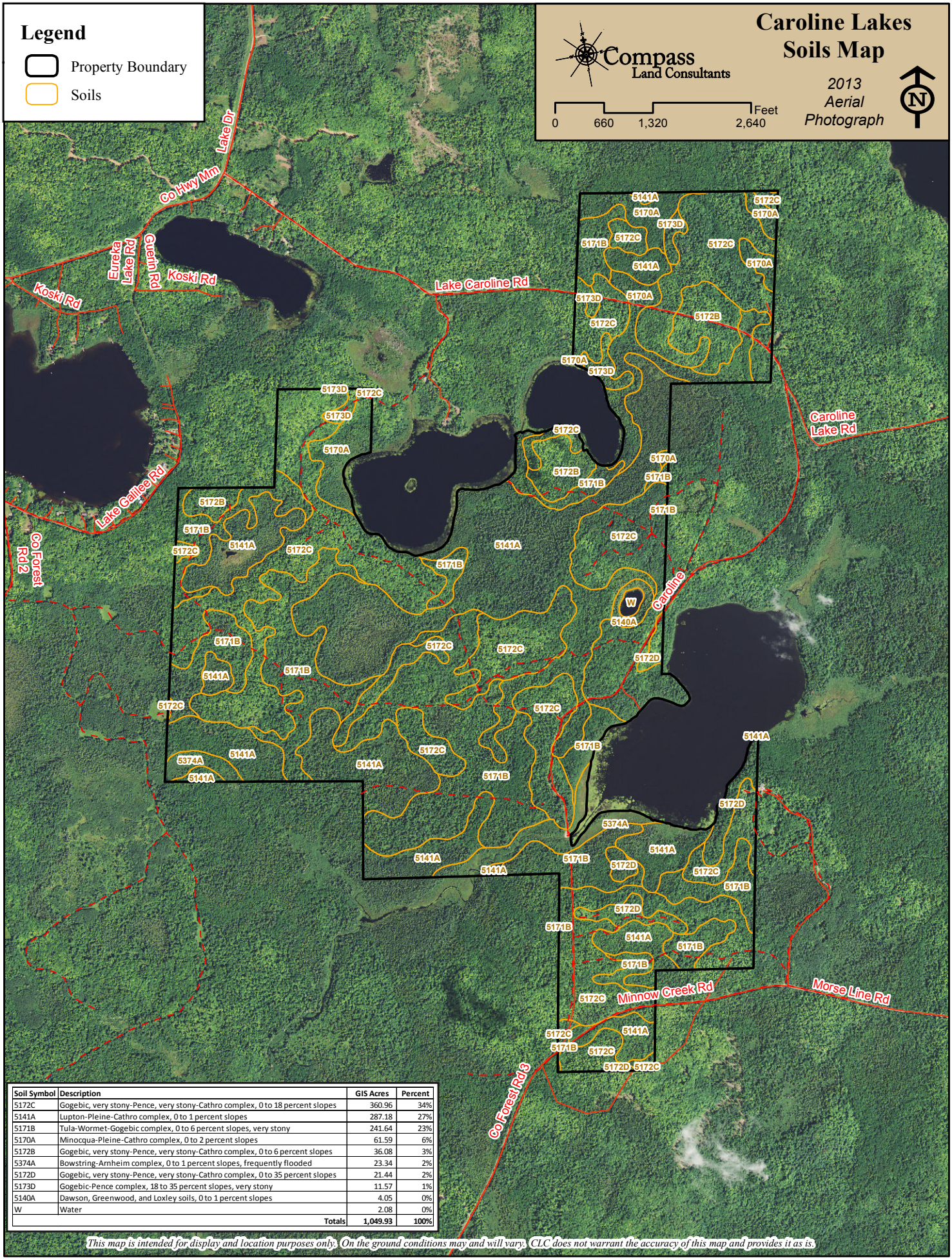


This map is intended for display and location purposes only. On the ground conditions may and will vary. CLC does not warrant the accuracy of this map and provides it as is.



Soil Symbol	Description	GIS Acres	Percent
5172C	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 18 percent slopes	360.96	34%
5141A	Lupton-Pleine-Cathro complex, 0 to 1 percent slopes	287.18	27%
5171B	Tula-Wormet-Gogebic complex, 0 to 6 percent slopes, very stony	241.64	23%
5170A	Minocqua-Pleine-Cathro complex, 0 to 2 percent slopes	61.59	6%
5172B	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 6 percent slopes	36.08	3%
5374A	Bowstring-Arnheim complex, 0 to 1 percent slopes, frequently flooded	23.34	2%
5172D	Gogebic, very stony-Pence, very stony-Cathro complex, 0 to 35 percent slopes	21.44	2%
5173D	Gogebic-Pence complex, 18 to 35 percent slopes, very stony	11.57	1%
5140A	Dawson, Greenwood, and Loxley soils, 0 to 1 percent slopes	4.05	0%
W	Water	2.08	0%
	Totals	1,049.93	100%

This map is intended for display and location purposes only. On the ground conditions may and will vary. CLC does not warrant the accuracy of this map and provides it as is.



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5374A	Bowstring-Arnheim complex, 0 to 1 percent slopes, frequently flooded	23.34	2%
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5173D	Gogebic-Pence complex, 18 to 35 percent slopes, very stony	11.57	1%
5140A	Dawson, Greenwood, and Loxley soils, 0 to 1 percent slopes	4.05	0%
W	Water	2.08	0%
	Totals	1,049.93	100%

Exhibit 2

Date	10/22/12
Cruiser	DLJ/JJC
AV Acres	76

Covertype Code	NH	Size Density	5
Pulp Sample Err.	16%	Saw Sample	55%
Full Plots	13	Plot Acres	78
Regen Revisit			

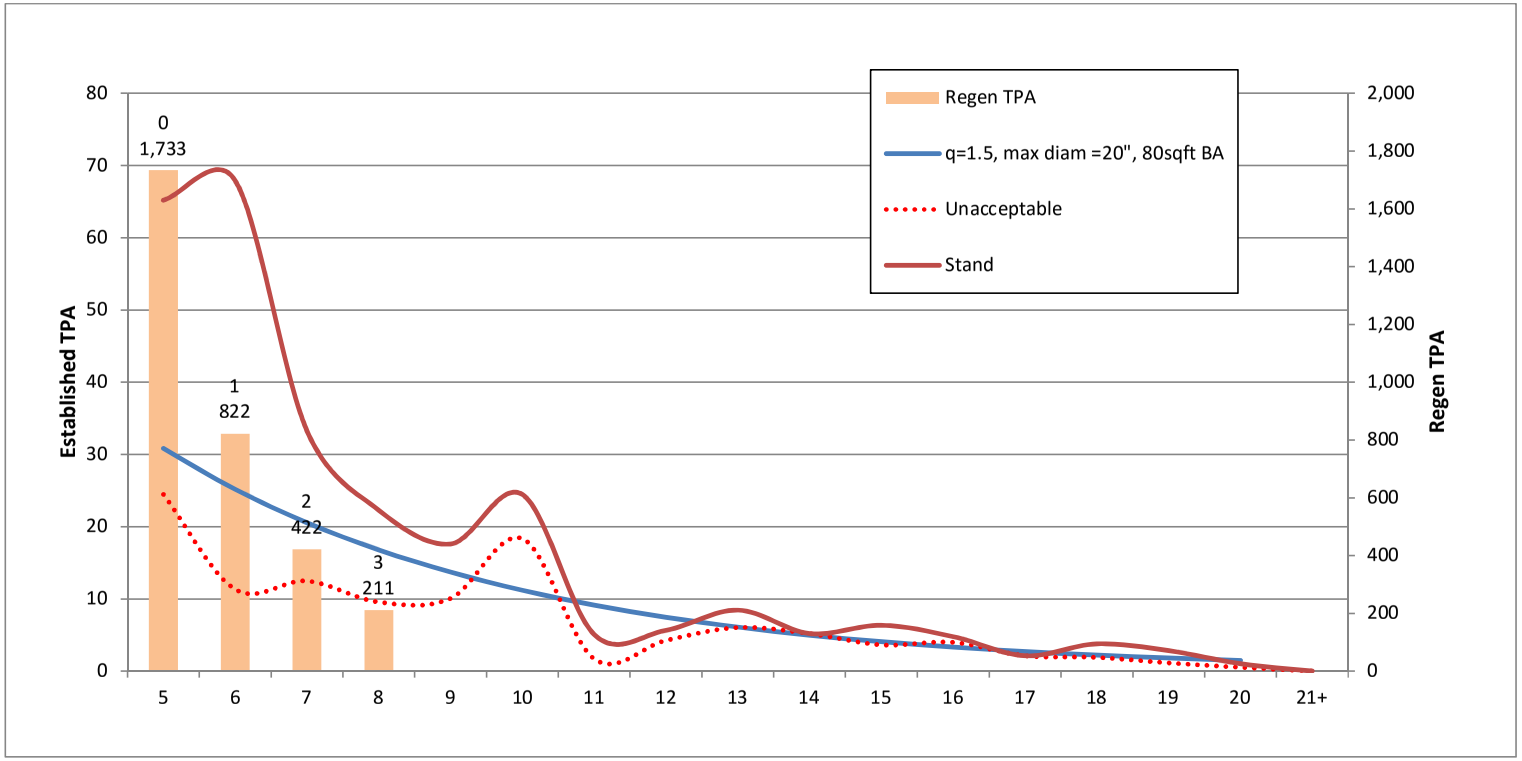
Stand By Covergroup

Stand	**28**

	Values								
Species Group	**BA/Ac**	**BA Poles**	**BA Saw**	**BF/Acre**	**Cds./ Acre**	**Non Grow Cords**	**Stems/ Acre**	**Species Group**	**Regen TPA**
Conifer	17	16	1	31	4	3	43	Aspen	11
Hardwood	99	68	31	1,961	23	14	186	Conifer	756
Aspen	2	2	0	0	1	0	1	Hardwood	2,422
Grand Total	**118**	**86**	**32**	**1,992**	**27**	**17**	**229**	**Grand Total**	**3,189**

	Values							
Species	**BA/Ac**	**BA Poles**	**BA Saw**	**BF/Acre**	**Cds./ Acre**	**Unaccpt Cords**	**Stems/ Acre**	**Avg DBH**
Red Maple	30	29	1	46	7	6	70	12
Balsam Fir	21	21	0	0	4	1	92	7
White Cedar	20	13	7	283	3	2	33	12
Yellow Birch	20	19	1	45	5	4	26	16
Hemlock	8	6	2	91	2	1	6	16
Quaking Aspen	7	7	0	0	2	0	15	10
Black Ash	7	2	4	294	1	0	17	13
Sugar Maple	4	4	0	0	1	1	10	12
Black Spruce	1	1	0	0	0	0	3	9
White Spruce	1	1	0	0	0	0	6	6
Grand Total	**119**	**103**	**16**	**759**	**24**	**15**	**278**	**12**

Stand TP	**Size Class**				
Species Group	**0**	**1**	**2**	**3**	**Grand Total**
Aspen				11	11
Conifer	344	178	156	78	756
Hardwood	1,389	644	267	122	2,422
Grand To	**1,733**	**822**	**422**	**211**	**3,189**


Regen TPA
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Unacceptable
Stand
Established TPA
Regen TPA
0
1,733
1
822
2
422
3
211
80
70
60
50
40
30
20
10
0
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
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5
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11
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14
15
16
17
18
19
20
21+

Date	10/22/12
Cruiser	DLJ/JJC

Pulp Sample Err.	19%
Saw Sample Err.	89%
Plot Acres	78
Full Plots	13

Covertype Code	NH
Size Density	8
Op Season	All
Access	1

Stand By Covergroup

Select Stand	28

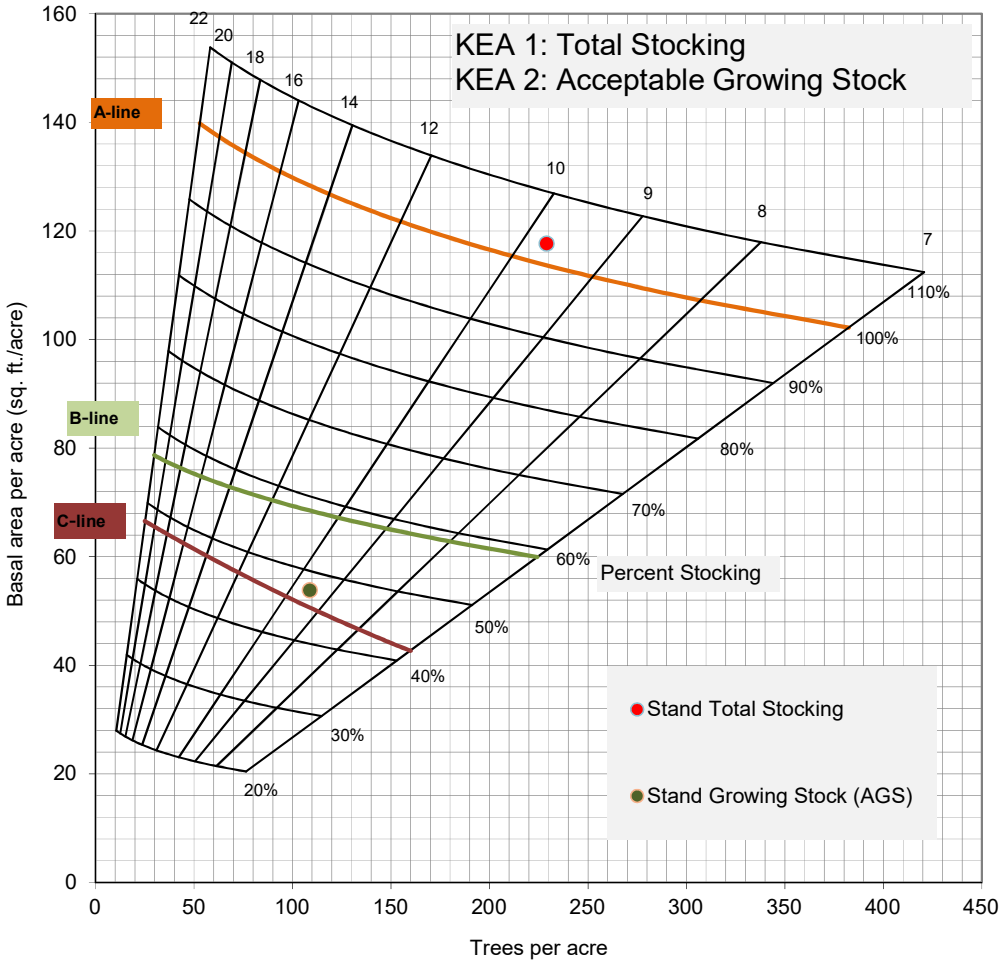
Row Labels	Values Stand BA	Stand TPA	TPA Acceptable	TPA unacceptable
Conifer	17	43	26	17
Hardwood	99	186	82	103
Aspen	2	1	1	0
Grand Total	**118**	**229**	**109**	**120**

KEA 1: Total Stocking

- Poor 0-41%
- Fair 41-60%
- Good 61-79%
- Very Good 80-100%

KEA 2: Acceptable Growing Stock

- Poor 0-41%
- Fair 41-53%
- Good 54-69%
- Very Good > 70%



KEA 3: Tree Species Diversity (Richness)

Indicator: Average number of tree species per stand (stems > 5" dbh)

- Poor <3
- Fair 3-6
- Good 7-9
- Very Good >10

Stand Richness	11.00

KEA 4: Tree Species Evenness (Richness Distribution)

Indicator: Distribution of tree species diversity across forest stand (stems > 5" dbh)

- Poor 0-0.6 — 0-0.6
- Fair 0.61-0.7 — 0.61-0.7
- Good 0.71-0.8 — 0.71-0.8
- Very Good > 0.81 — >0.81

$$J' = \frac{H'}{H'_{\max}}$$

Stand Evenness	0.72

KEA 5: Large Live Trees

Indicator: Average number of live trees per acre (by stand)

>16" dbh

- Poor <= 3
- Fair 4-8
- Good 9-16
- Very Good >17

>19" dbh

- Poor <=3
- Fair 3-5
- Good 6-12
- Very Good >13

TPA >= 16" DBH	20.1

TPA >= 19" DBH	7.7

KEA 6: Large Snags

Indicator: Average number of snags per acre (by stand) >10" dbh

- Poor 0-2
- Fair 3-5
- Good 6-8
- Very Good >9

TPA Large Snags	3.5

KEA 7: Large Coarse Woody Debris

Indicator: Cu.ft. volume per acre; all pieces >13" diameter (large end) and 5' min. length

- Poor <100
- Fair 101-500
- Good 501-999
- Very Good >1000

CWD Ft^3	69.1

Regeneration

KEA 8: Established Regeneration

Indicator: total number all established seedlings per acre 1"-4.5"

- Poor 0-100
- Fair 101-250
- Good 251-400
- Very Good >400

Seedlings/Acre	1,030.8

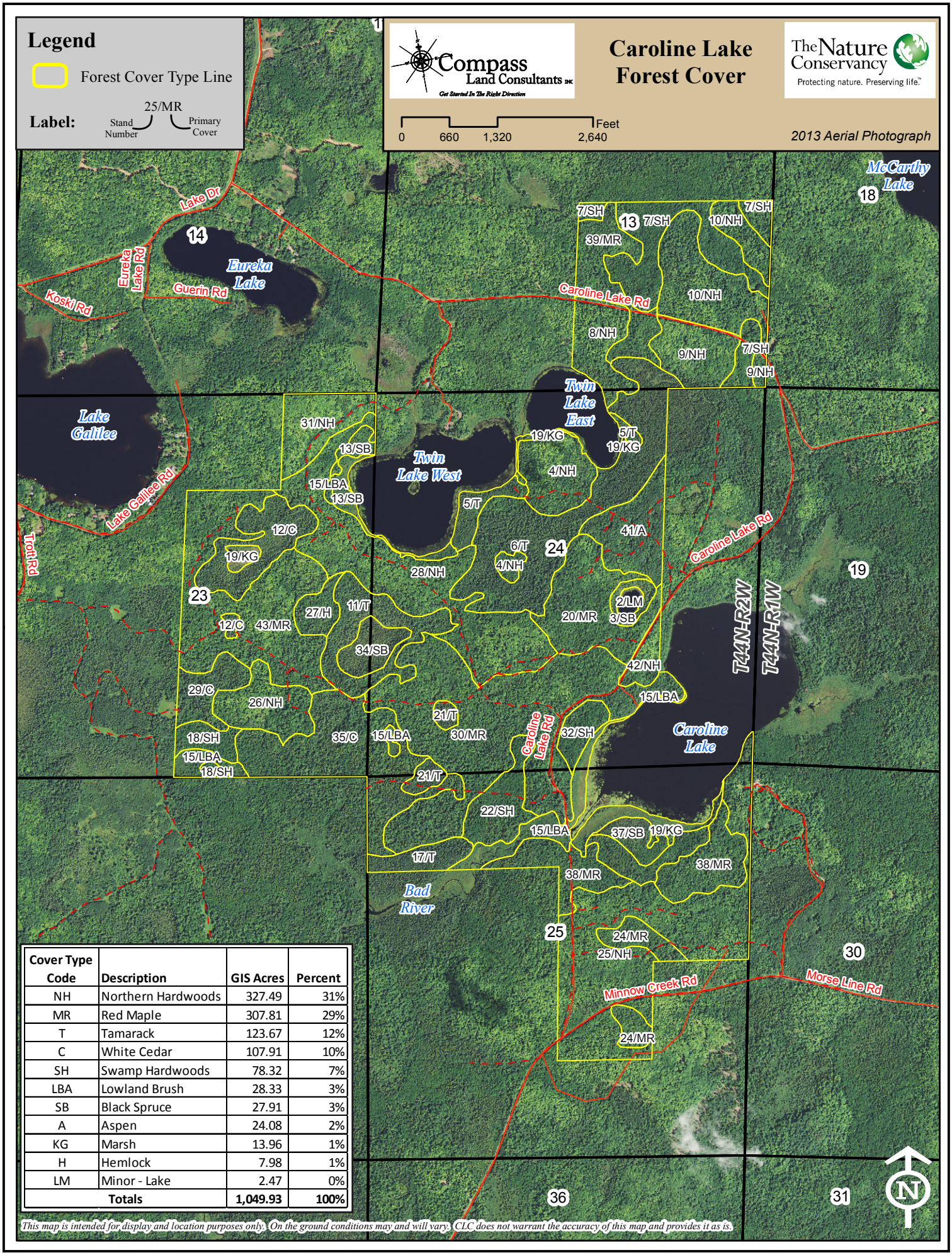
KEA 9: Desirable Established Regeneration

Indicator: Ratio of total established seedlings to total desired established seedlings per acre.

- Poor <25%
- Fair 26-54%
- Good 55-74%
- Very Good >75%

Desireable Seedl./Acre	50.0%

Exhibit 3



Cover Type Code	Description	GIS Acres	Percent
NH	Northern Hardwoods	327.49	31%
MR	Red Maple	307.81	29%
T	Tamarack	123.67	12%
C	White Cedar	107.91	10%
SH	Swamp Hardwoods	78.32	7%
LBA	Lowland Brush	28.33	3%
SB	Black Spruce	27.91	3%
A	Aspen	24.08	2%
KG	Marsh	13.96	1%
H	Hemlock	7.98	1%
LM	Minor - Lake	2.47	0%
Totals		**1,049.93**	**100%**

ORDER NUMBER
Co. Code/Seq. No/Yr. of Entry 02-234-2001

State of Wisconsin Dept. of Natural Resources
MANAGED FOREST LAW MAP
Form 2450-133 R (7/07)

MADISON OFFICE USE ONLY
Acreage Entered

Owner's Name ☐ Multiple Owners	Municipality Name	County
The Nature Conservancy of Wisconsin, Inc.	Town of Morse	Ashland

Township #	Range #	Section	Open Acres	Closed Acres
44	02 ☐ East ■ West	13	156.80	0

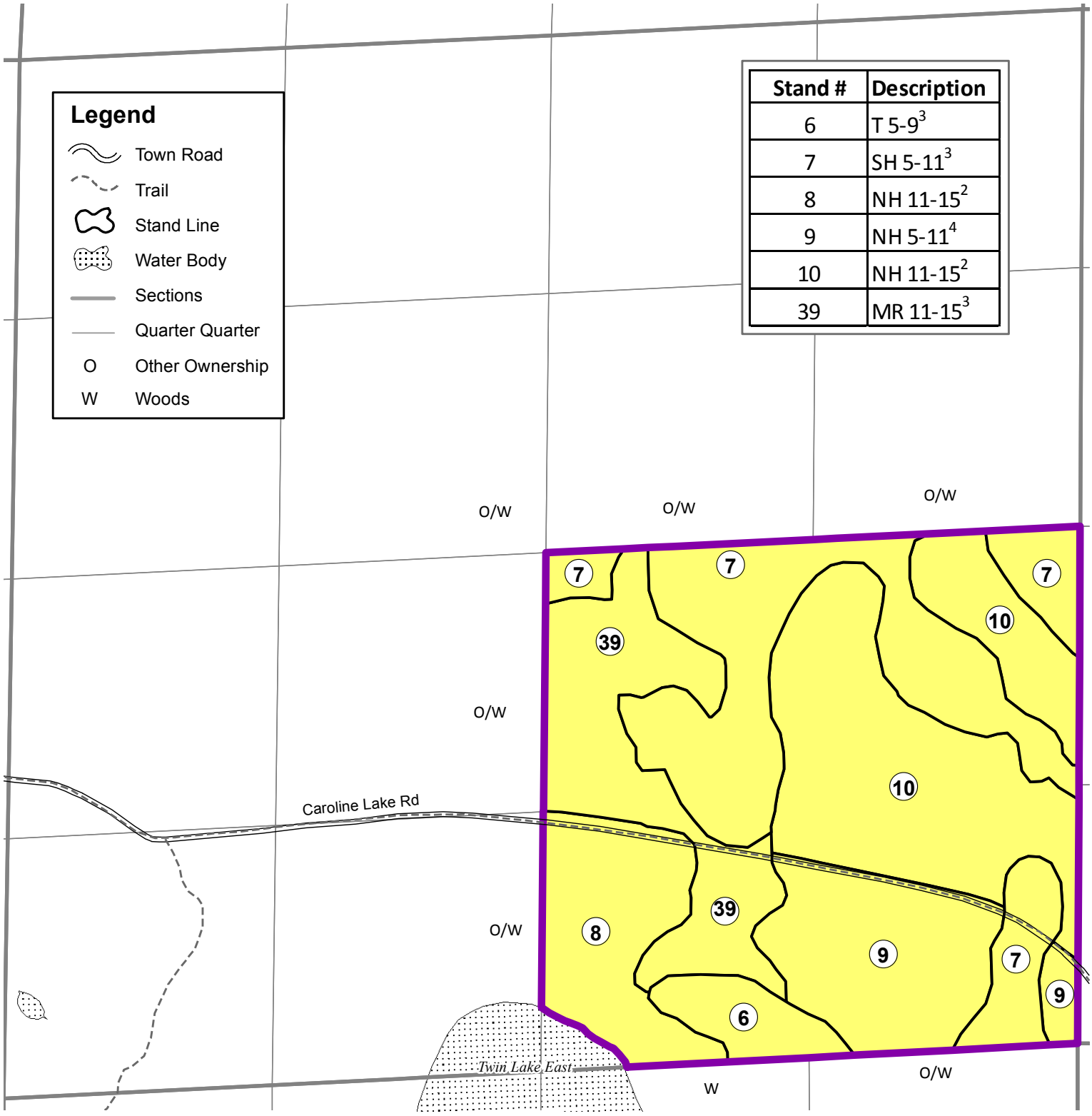
Closed Area Open Area

Section Diagram 8" = 1 Mile

N

Prepared By: Jeremy Chiamulera

Date: 12-28-2014



ORDER NUMBER
Co. Code/Seq. No/Yr. of Entry 02-234-2001

State of Wisconsin Dept. of Natural Resources
MANAGED FOREST LAW MAP
Form 2450-133 R (7/07)

MADISON OFFICE USE ONLY
Acreage Entered

Owner's Name ☐ Multiple Owners	Municipality Name	County
The Nature Conservancy of Wisconsin, Inc.	Town of Morse	Ashland

Township #	Range #	Section	Open Acres	Closed Acres
44	02 ☐ East ■ West	23	273.15	0

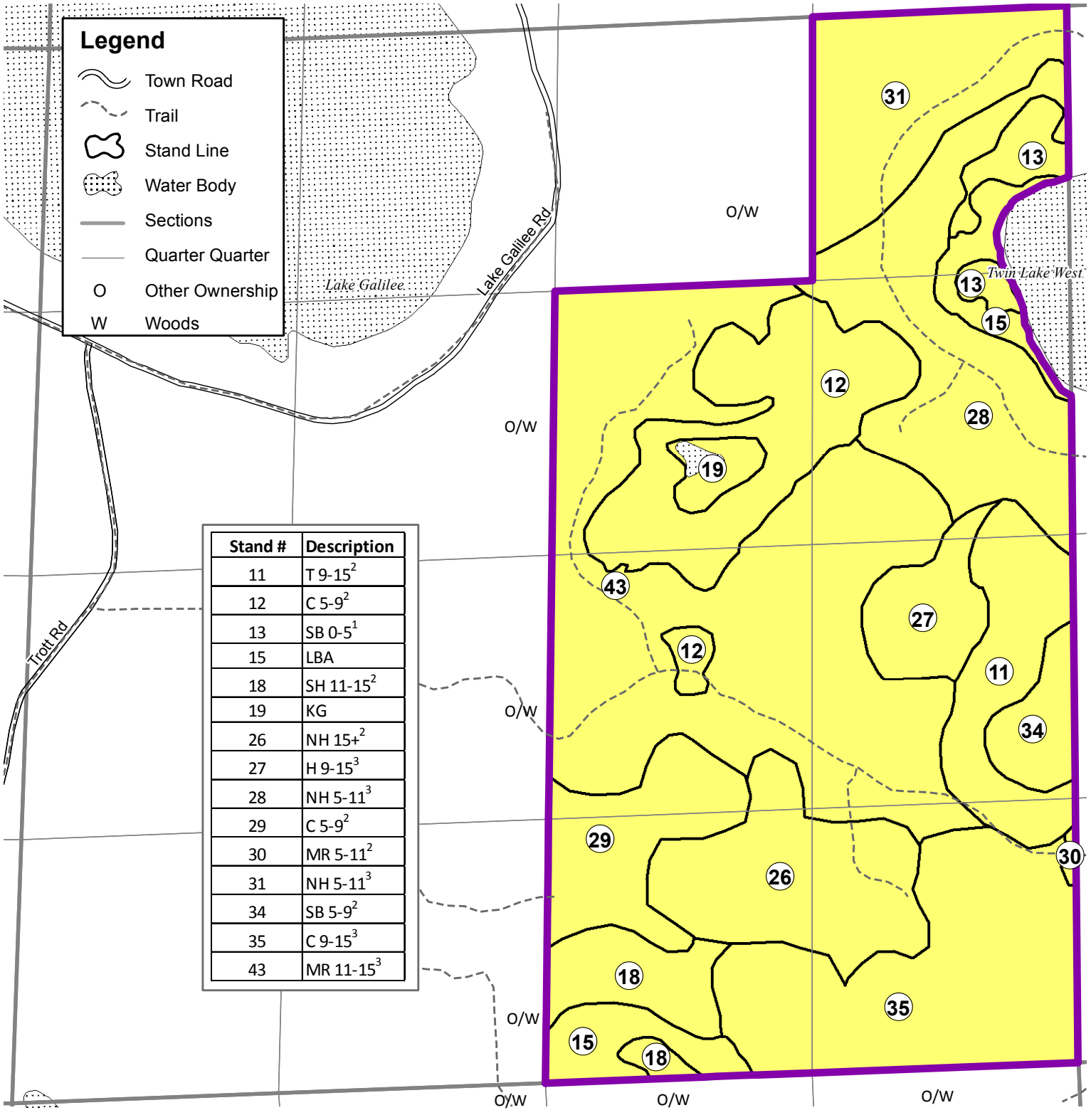
Closed Area Open Area

Section Diagram 8" = 1 Mile

N

Prepared By: Jeremy Chiamulera

Date: 12-28-2014



Stand #	Description
11	T 9-15[2]
12	C 5-9[2]
13	SB 0-5[1]
15	LBA
18	SH 11-15[2]
19	KG
26	NH 15+[2]
27	H 9-15[3]
28	NH 5-11[3]
29	C 5-9[2]
30	MR 5-11[2]
31	NH 5-11[3]
34	SB 5-9[2]
35	C 9-15[3]
43	MR 11-15[3]

ORDER NUMBER
Co. Code/Seq. No/Yr. of Entry 02-234-2001

State of Wisconsin Dept. of Natural Resources
MANAGED FOREST LAW MAP
Form 2450-133 R (7/07)

MADISON OFFICE USE ONLY
Acreage Entered

Owner's Name ☐ Multiple Owners	Municipality Name	County
The Nature Conservancy of Wisconsin, Inc.	Town of Morse	Ashland

Township #	Range #	Section	Open Acres	Closed Acres
44	02 ☐ East ■ West	24	366.19	0

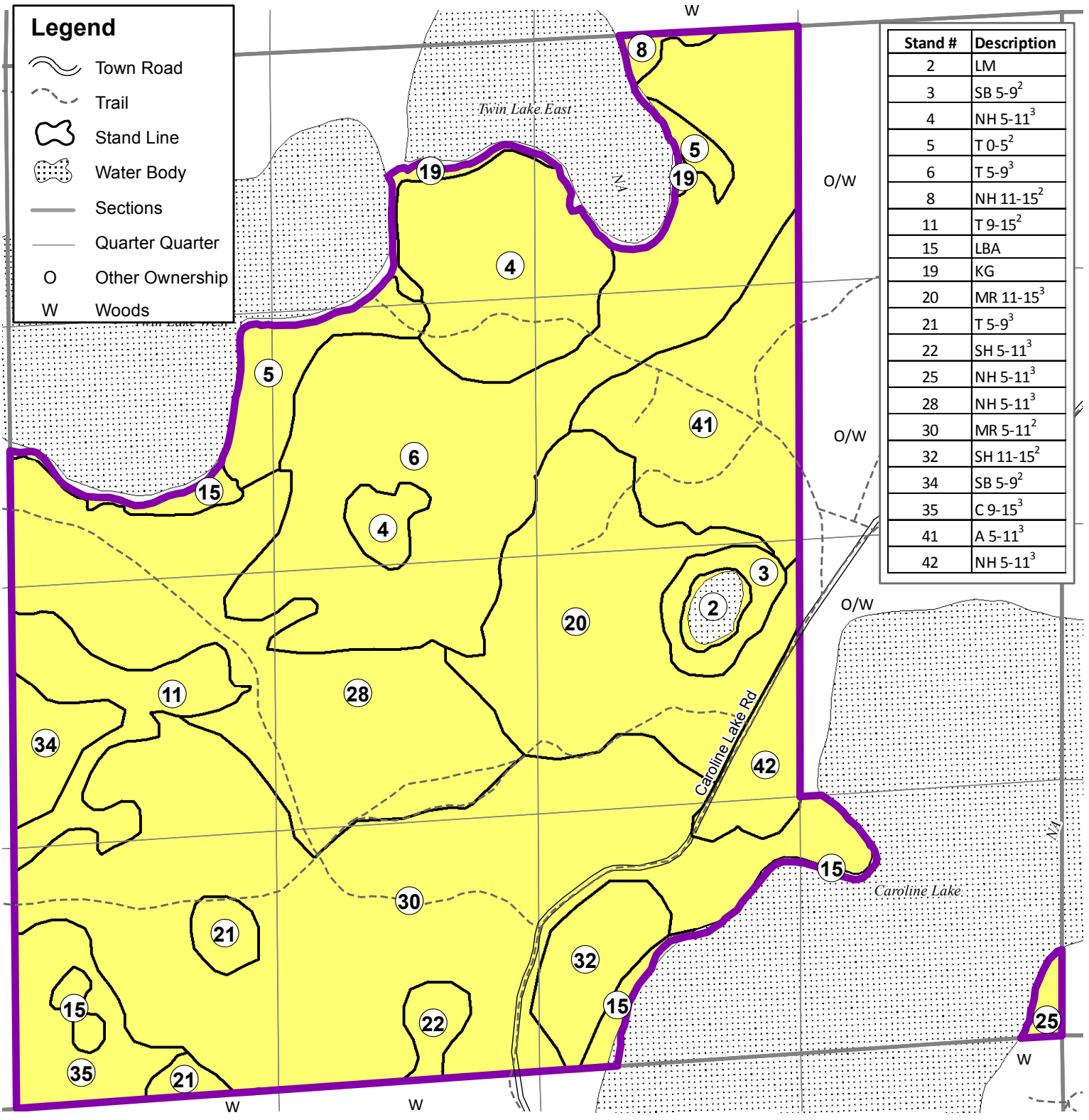
Closed Area Open Area

Section Diagram 8" = 1 Mile

N

Prepared By: Jeremy Chiamulera

Date: 12-28-2014



Stand #	Description
2	LM
3	SB 5-9[2]
4	NH 5-11[3]
5	T 0-5[2]
6	T 5-9[3]
8	NH 11-15[2]
11	T 9-15[2]
15	LBA
19	KG
20	MR 11-15[3]
21	T 5-9[3]
22	SH 5-11[3]
25	NH 5-11[3]
28	NH 5-11[3]
30	MR 5-11[2]
32	SH 11-15[2]
34	SB 5-9[2]
35	C 9-15[3]
41	A 5-11[3]
42	NH 5-11[3]

ORDER NUMBER
Co. Code/Seq. No/Yr. of Entry 02-234-2001

State of Wisconsin Dept. of Natural Resources
MANAGED FOREST LAW MAP
Form 2450-133 R (7/07)

MADISON OFFICE USE ONLY
Acreage Entered

Owner's Name ☐ Multiple Owners	Municipality Name	County
The Nature Conservancy of Wisconsin, Inc.	Town of Morse	Ashland

Township #	Range #	Section	Open Acres	Closed Acres
44	02 ☐ East ■ West	25	247.44	0

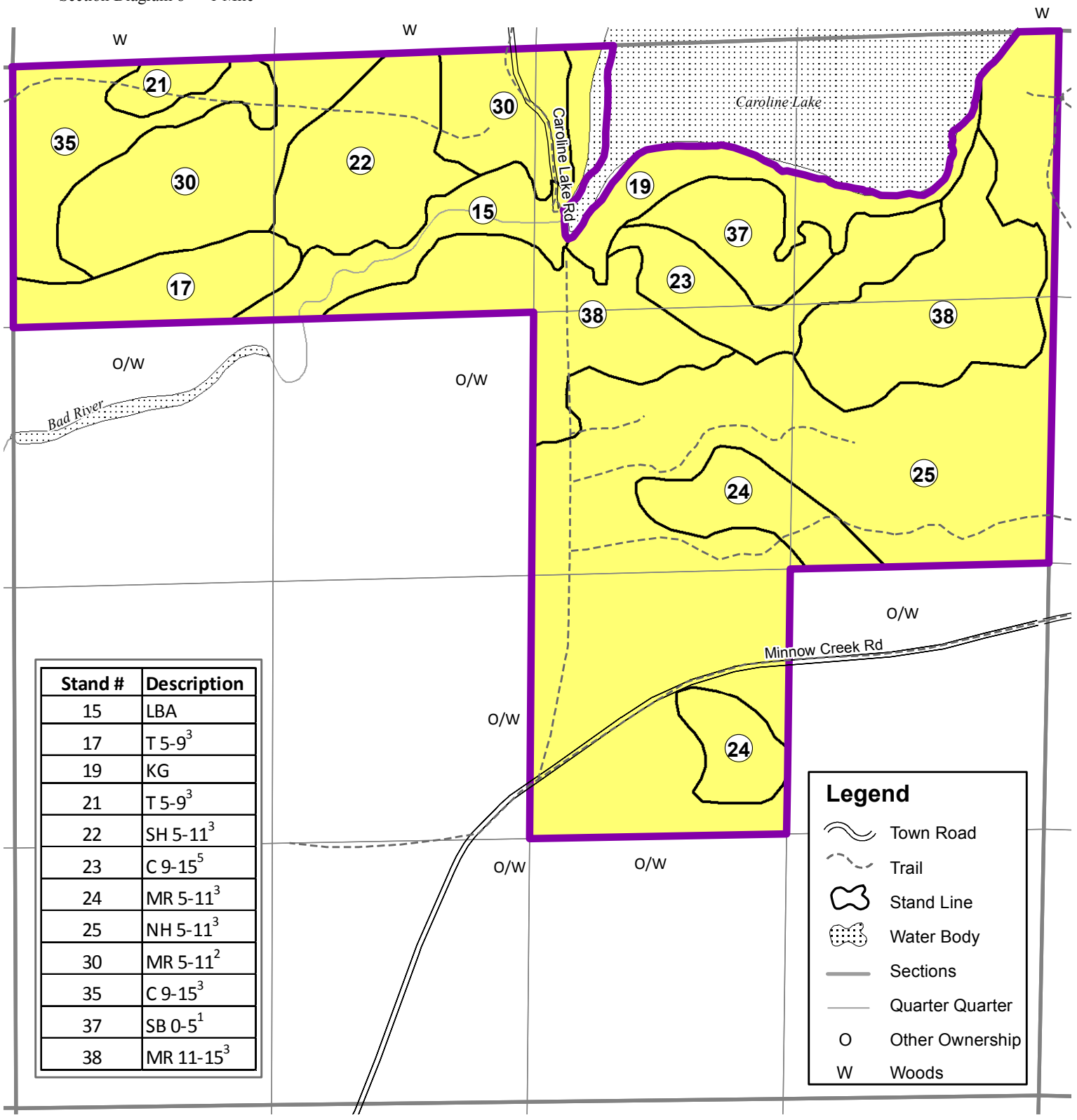
Closed Area Open Area

Section Diagram 8" = 1 Mile

N

Prepared By: Jeremy Chiamulera

Date: 12-28-2014



Stand #	Description
15	LBA
17	T 5-9[3]
19	KG
21	T 5-9[3]
22	SH 5-11[3]
23	C 9-15[5]
24	MR 5-11[3]
25	NH 5-11[3]
30	MR 5-11[2]
35	C 9-15[3]
37	SB 0-5[1]
38	MR 11-15[3]

Exhibit 4

Select Stand

Date	10/22/12
Cruiser	DLJ/JJC

Pulp Sample Err.	19%
Saw Sample Err.	89%
Plot Acres	78
Full Plots	13

Covertype Code	NH
Size Density	8
Op Season	All
Access	1

Stand By Covergroup

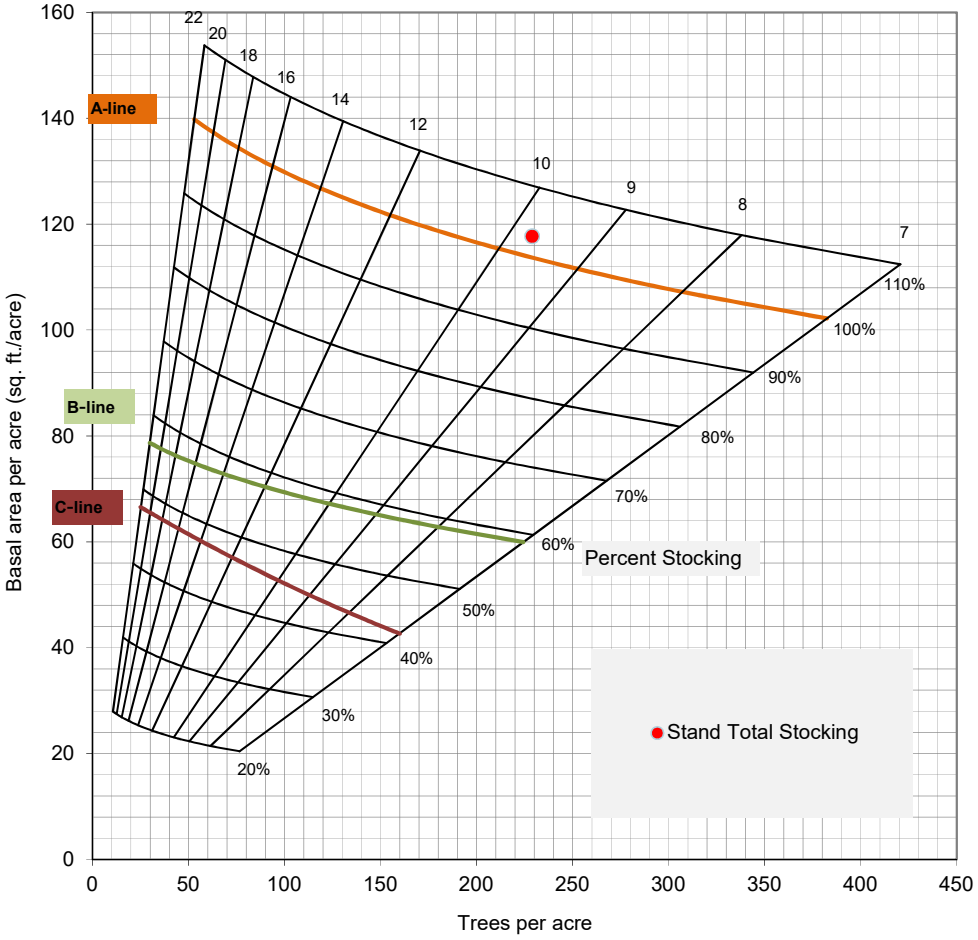
Rpt_Stand	28

Row Labels	Values Stand BA	Stand TPA	TPA Acceptable	TPA unacceptable
Conifer	17	43	26	17
Hardwood	99	186	82	103
Aspen	2	1	1	0
Grand Total	**118**	**229**	**109**	**120**

CIM 1 : Total Stand Stocking

Indicator: Percentage of total stand stocking

- Poor 0-41%
- Fair 41-60%
- Good 61-79%
- Very Good 80-100%



CIM 2: Tree Species Diversity (Richness)

Indicator: Total number of overstory tree species

- Poor <3
- Fair 3-6
- Good 7-9
- Very Good >10

Stand Richness	**11.00**

CIM 3: Tree Species Evenness (Richness Distribution)

Indicator: Relative abundance of all tree species

- Poor 0-0.6 — 0-0.6
- Fair 0.61-0.7 — 0.61-0.7
- Good 0.71-0.8 — 0.71-0.8
- Very Good > 0.81 — >0.81

$$J' = \frac{H'}{H'_{\max}}$$

Stand Evenness	0.72

CIM 4: Large Coarse Woody Debris

Indicator: Measure of downed woody debris greater than 13 inches in diameter

- Poor <100
- Fair 101-500
- Good 501-999
- Very Good >1000

CWD Ft^3	69.1

Regeneration

CIM 5: Established Regeneration

Indicator: total number all established saplings per acre 1"-4.5"

- Poor 0-100
- Fair 101-250
- Good 251-400
- Very Good >400

Seedlings/Acre	1,030.8

CIM 6: Seedlings Per Acre

Indicator: Total number of seedlings per acre

- Poor <1,000
- Fair 1,000-2,500
- Good 2,500-5,000
- Very Good >5,000

Total Seedl./Acre	4,169

CIM 7: Climate Risk - Overstory

Indicator: Percentage of species likely to decline in a PCM scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

Stand Overstory PCM %	12.5%

Indicator: Percentage of species likely to decline in a GFDL scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

Stand Overstory GFDL %	87.8%

CIM 8: Climate Risk - Established Regeneration (1" - 4.5" DBH)

Indicator: Percentage of species likely to decline in a PCM scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

Stand Regeneration PCM %	36.6%

Indicator: Percentage of species likely to decline in a GFDL scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

Stand Regneneration GFDL %	85.8%

CIM 9: Climate Risk -Seedlings

Indicator: Percentage of species likely to decline in a PCM scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

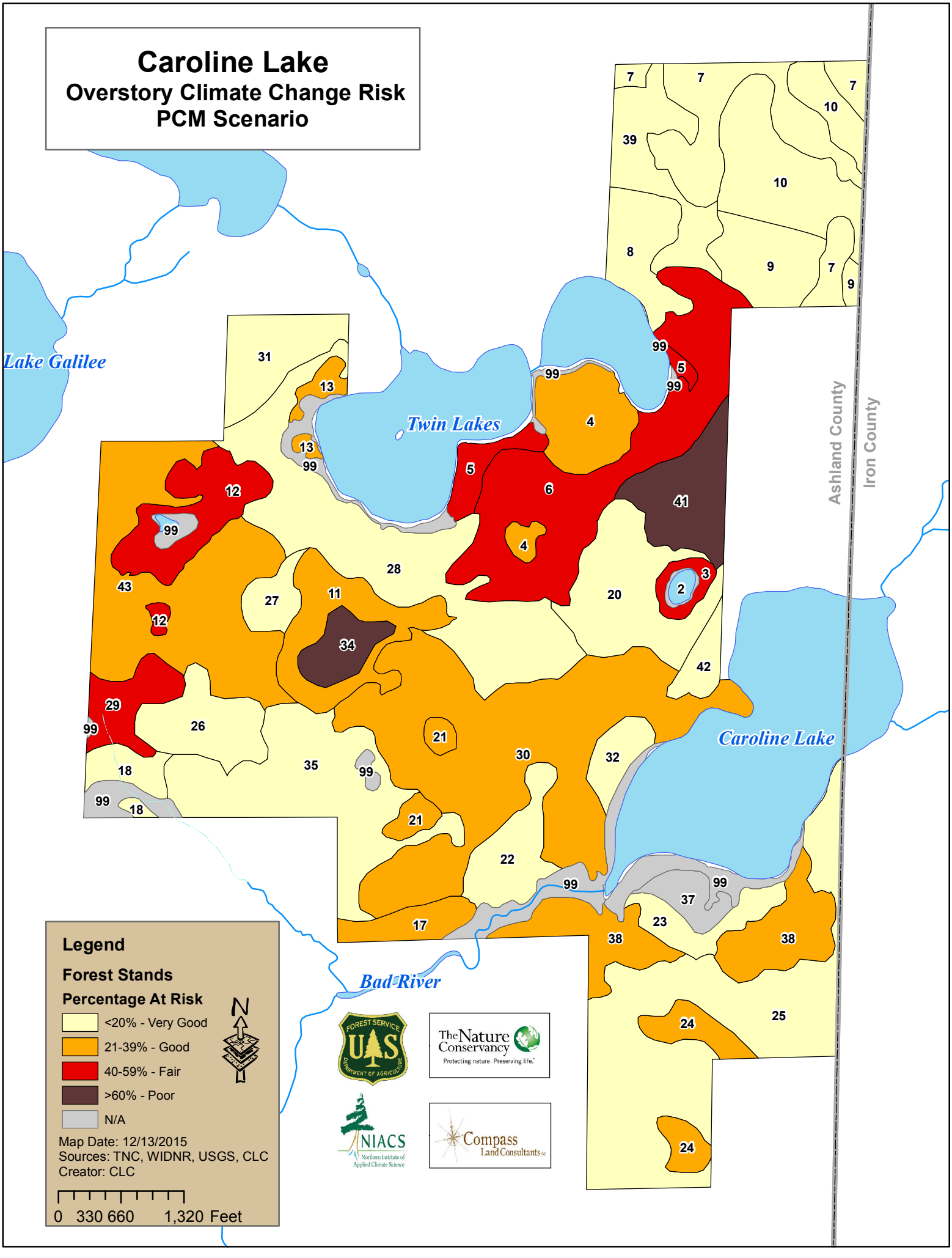
Stand Seedlings PCM %	19.7%

Indicator: Percentage of species likely to decline in a GFDL scenario

- Poor >=60%
- Fair 40-59%
- Good 21-39%
- Very Good <20%

Stand Seedlings GFDL %	86.7%

Exhibit 5


Caroline Lake
Overstory Climate Change Risk
PCM Scenario
Lake Galilee
Twin Lakes
Caroline Lake
Bad River
Ashland County
Iron County
Legend
Forest Stands
Percentage At Risk
<20% - Very Good
21-39% - Good
40-59% - Fair
>60% - Poor
N/A
Map Date: 12/13/2015
Sources: TNC, WIDNR, USGS, CLC
Creator: CLC
0 330 660 1,320 Feet
N
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U.S. DEPARTMENT OF AGRICULTURE
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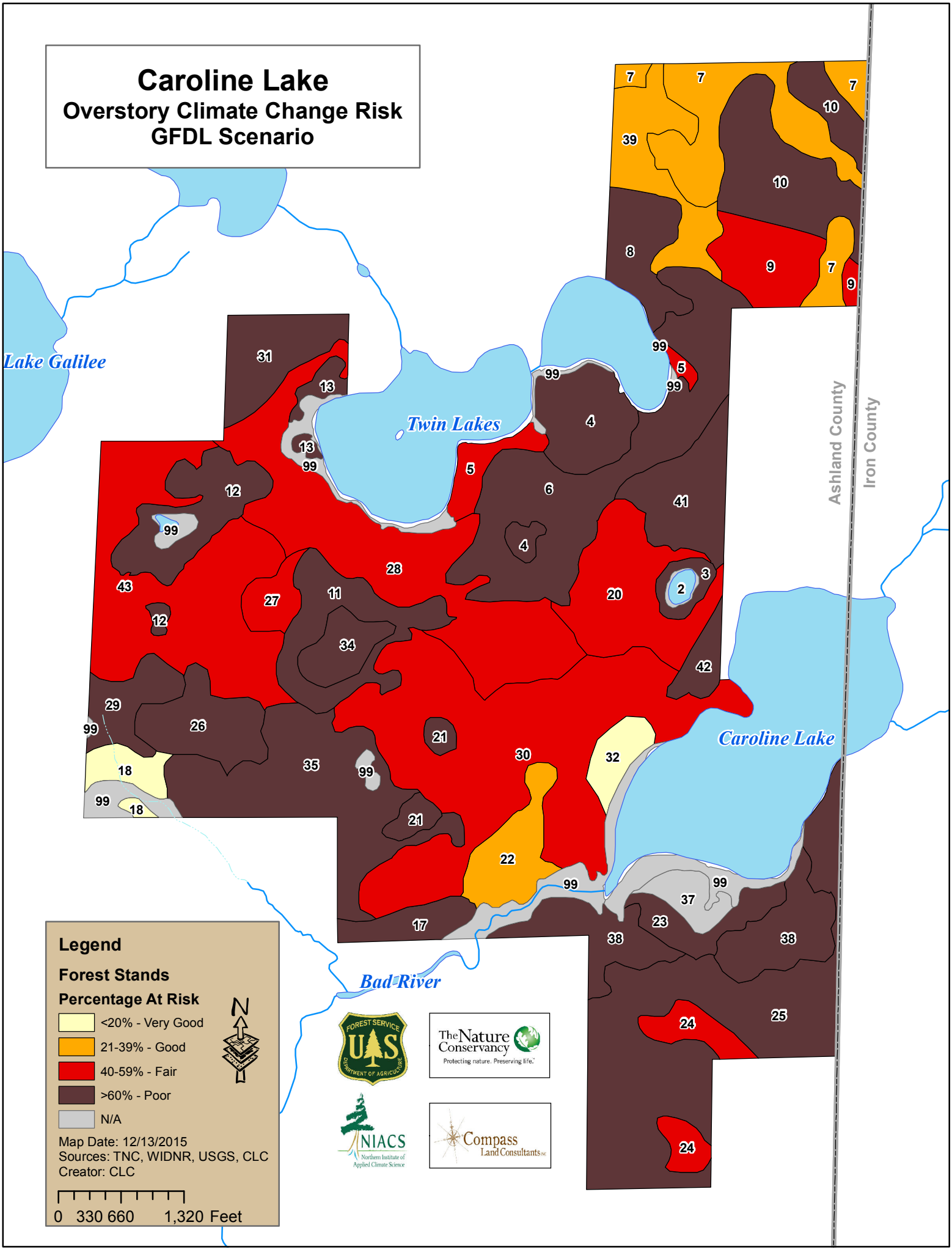
NIACS
Northern Institute of Applied Climate Science
Compass Land Consultants INC


Caroline Lake
Overstory Climate Change Risk
GFDL Scenario
Lake Galilee
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Ashland County
Iron County
Legend
Forest Stands
Percentage At Risk
<20% - Very Good
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>60% - Poor
N/A
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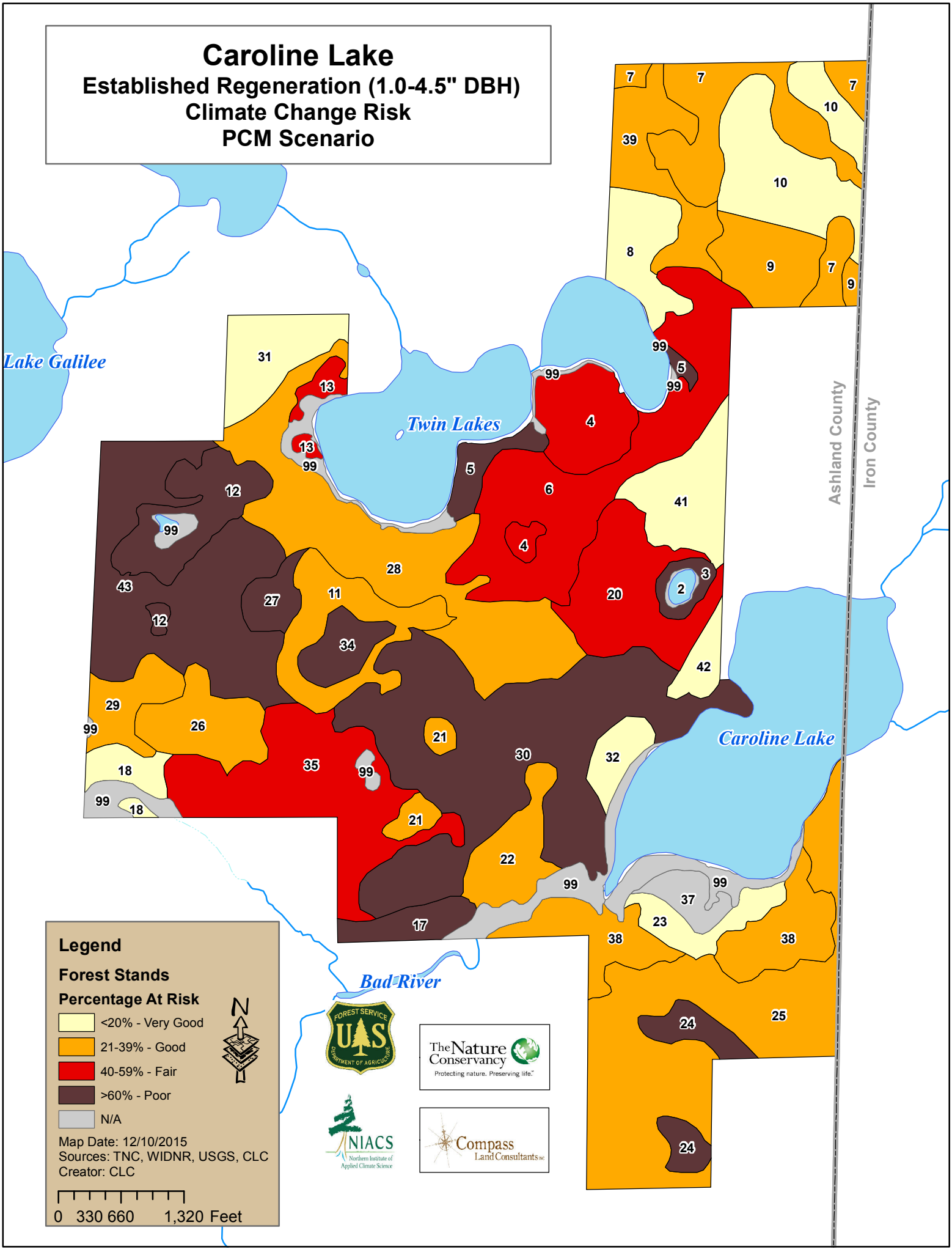
Caroline Lake
Established Regeneration (1.0-4.5" DBH)
Climate Change Risk
PCM Scenario
Lake Galilee
Twin Lakes
Caroline Lake
Bad River
Ashland County
Iron County
Legend
Forest Stands
Percentage At Risk
<20% - Very Good
21-39% - Good
40-59% - Fair
>60% - Poor
N/A
Map Date: 12/10/2015
Sources: TNC, WIDNR, USGS, CLC
Creator: CLC
0 330 660 1,320 Feet
N
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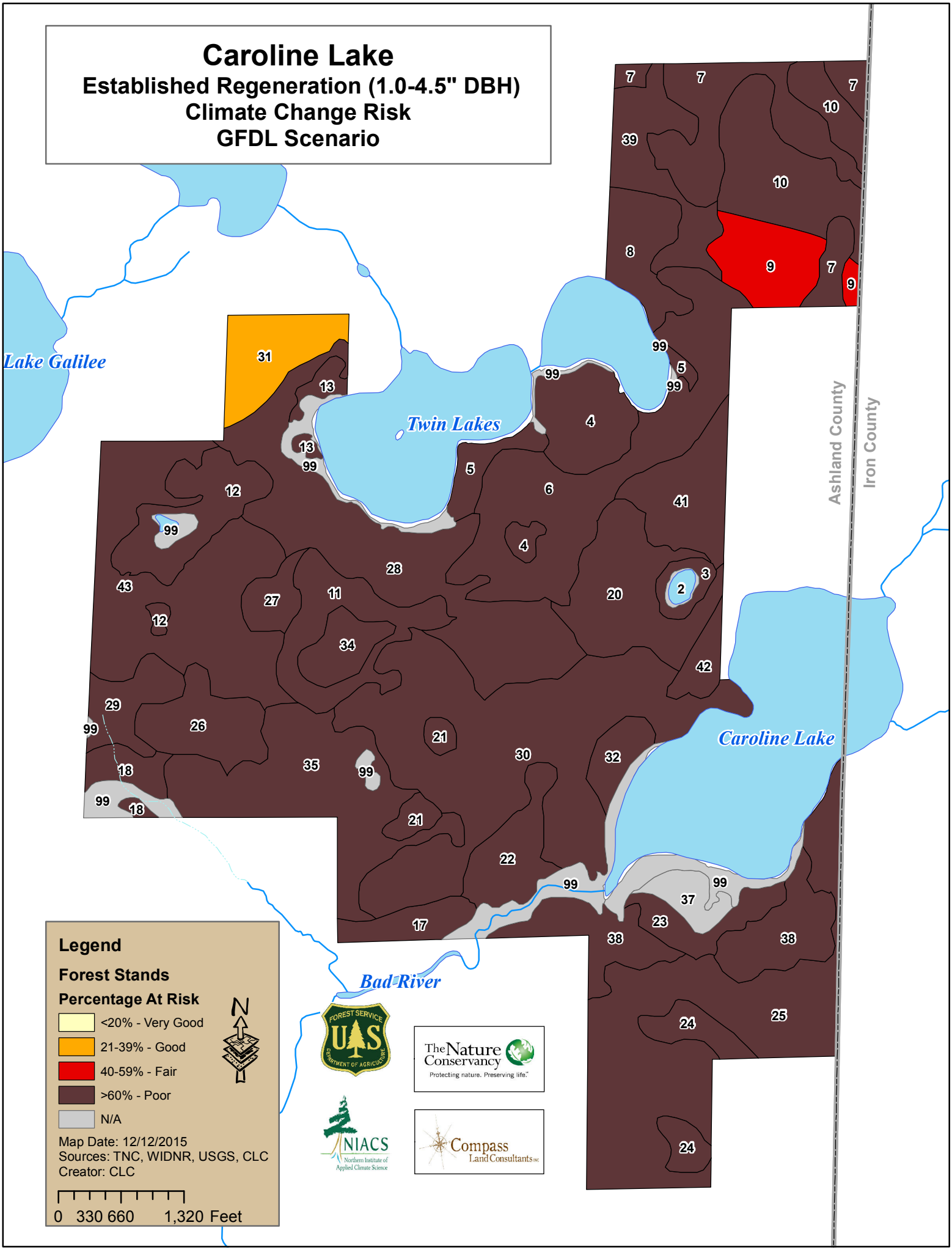
Caroline Lake
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Climate Change Risk
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>60% - Poor
N/A
Map Date: 12/12/2015
Sources: TNC, WIDNR, USGS, CLC
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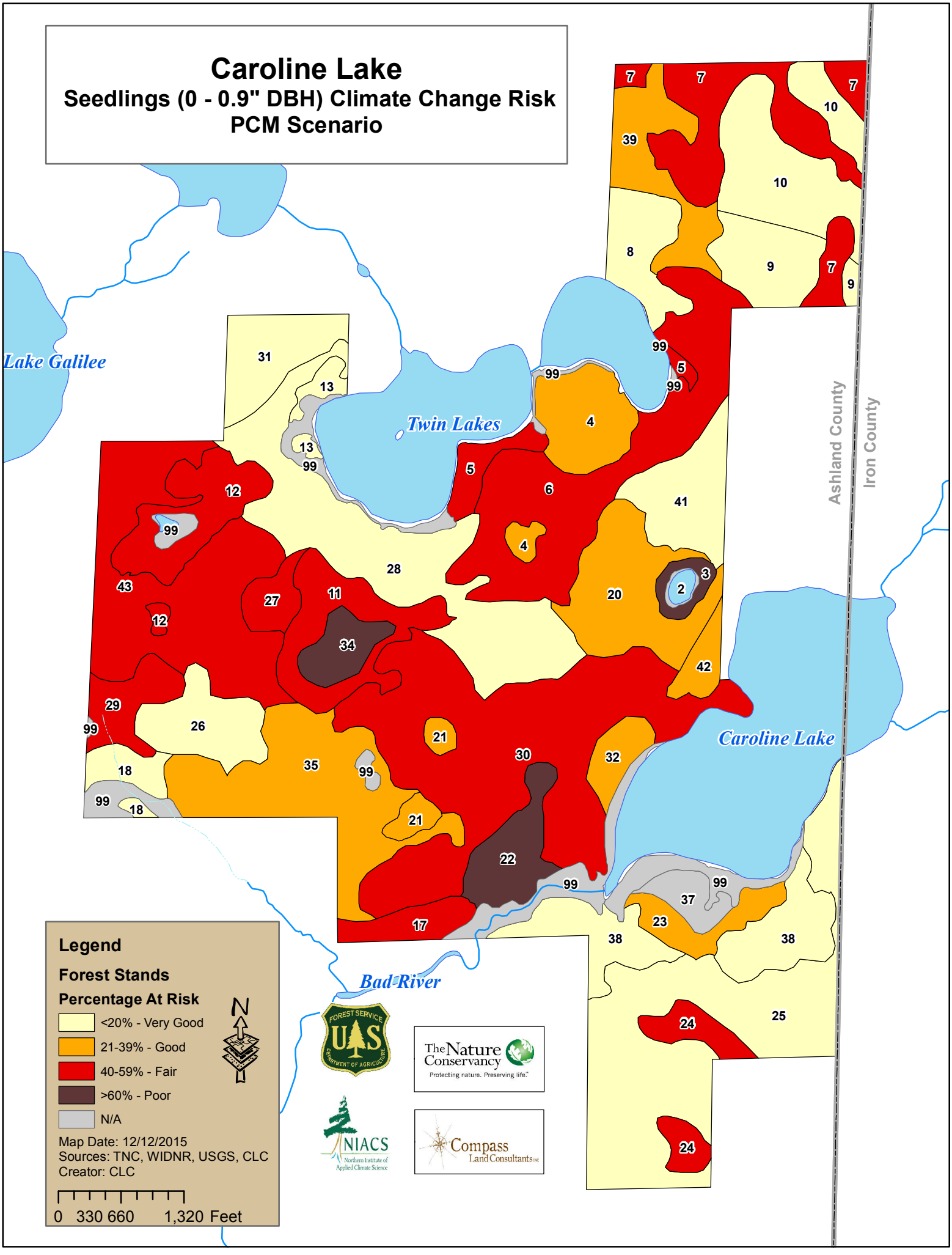
Caroline Lake
Seedlings (0 - 0.9" DBH) Climate Change Risk
PCM Scenario
Lake Galilee
Twin Lakes
Caroline Lake
Bad River
Ashland County
Iron County
Legend
Forest Stands
Percentage At Risk
<20% - Very Good
21-39% - Good
40-59% - Fair
>60% - Poor
N/A
Map Date: 12/12/2015
Sources: TNC, WIDNR, USGS, CLC
Creator: CLC
0 330 660 1,320 Feet
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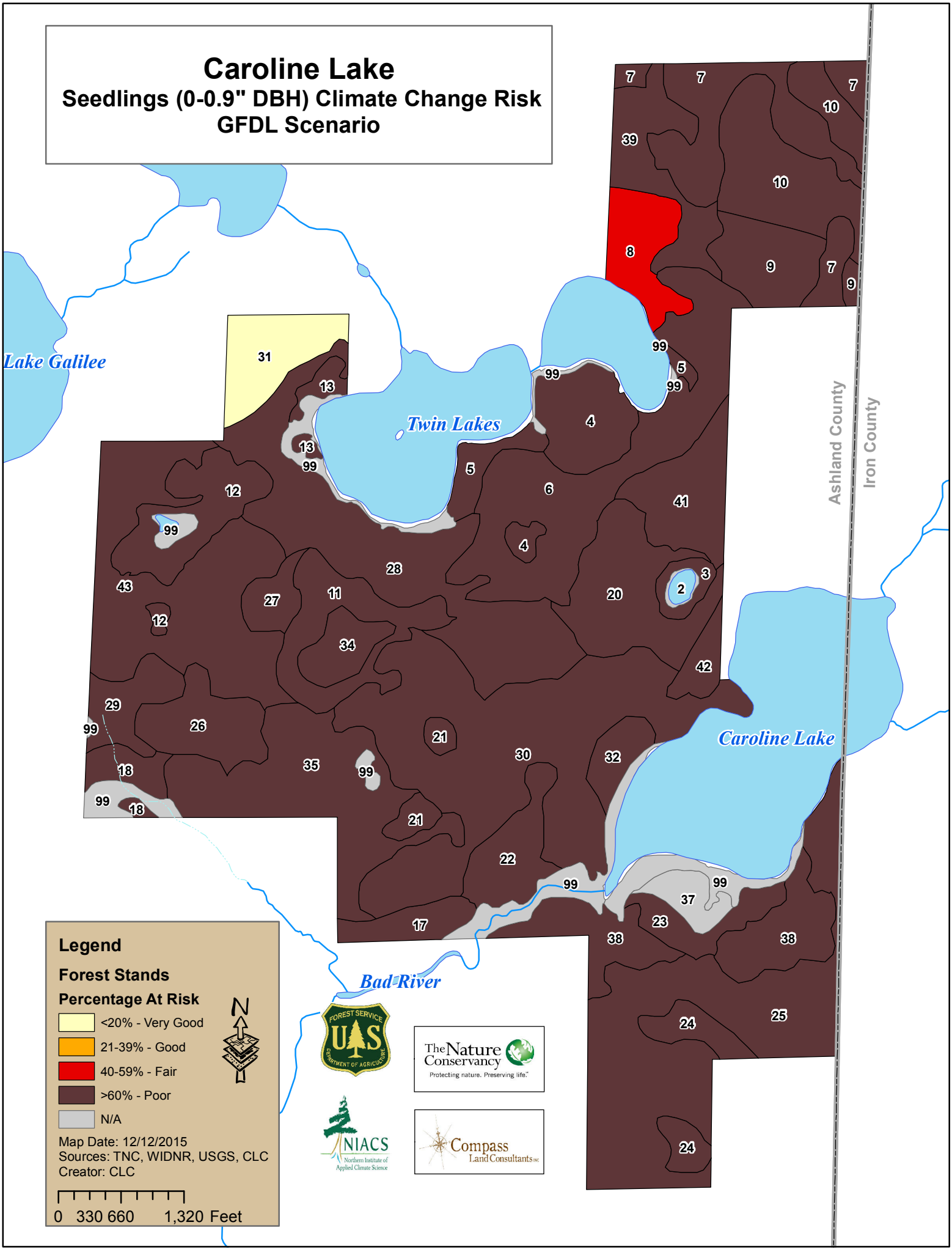
Caroline Lake
Seedlings (0-0.9" DBH) Climate Change Risk
GFDL Scenario
Lake Galilee
Twin Lakes
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Iron County
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40-59% - Fair
>60% - Poor
N/A
Map Date: 12/12/2015
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