M.L. 201 4, Chp. 226, Sec. 2, Subd. 06d Project Abstract
For the Period Ending June 30, 2017

PROJECT TITLE: Northeast Minnesota White Cedar Restoration – Phase 2
PROJECT MANAGER: Dale Krystosek
AFFILIATION: Minnesota Board of Water and Soil Resources
MAILING ADDRESS: 520 Lafayette Road North
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 06d

APPROPRIATION AMOUNT: $335,000
AMOUNT SPENT: $248,216
AMOUNT REMAINING: $86,784

Overall Project Outcomes and Results

Project Background: Northern white cedar (Thuja occidentalis) has been declining in Minnesota for decades. White cedar provides ecologically diverse plant communities and critical wildlife habitat and wetland functions. (Phase 2).

Project Goals:

1) Reverse decline of white cedar plant communities in Minnesota.
2) Complete two hydrologic restorations of white cedar plant communities and develop recommendations for restorations.

Methods: Board of Water and Soil Resources (BWSR) established 2 white cedar hydrologic restorations in Itasca and Lake Counties. Engineering designs were developed to restore natural groundwater flows where forest roads had impacted white cedar stands. A training video was developed for land managers. Dr. Rod Chimner evaluated the effectiveness of the hydrologic restorations plus the phase 1 vegetative restorations of northern white cedar plant communities.

Results:

1) Hydrologic Restoration:
Goal: Restore 2 sites where roads had impacted white cedar plant communities.
Results: Two experimental methods of hydrologic restoration were completed in Itasca and Lake Counties.

2) **Monitor seven phase one white cedar restoration sites:**
Results: 7 sites established in Beltrami, Koochiching, St. Louis and Lake County were monitored.

3) **Develop recommendations for white cedar restoration and evaluate additional sites:**
Results:

- Recommendations for white cedar restoration were developed.
- 75 additional restoration sites were evaluated by SWCDs.
- Northern white cedar has limited ability to replace black ash stands due to high water levels.
- White cedar restoration video developed and disseminated.

Project Findings:

a) Many white cedar swamps are degraded and need restoration.
b) Major disturbances were roads, ditches and herbivory.
c) After two years, the largest single factor affecting northern white cedar survival was hydrology.

d) Light levels (shading) plays a role in cedar regeneration.
e) After one season, the hydrologic restoration of two forest roads were successful, restoring hydrologic flow conditions.

Project Significance:

Northern White cedar provides unique functions including:

- Thermal winter cover for white tailed deer
- Critical habitat for pine marten, bear, fish, songbirds
- Provides thermal buffering for cold water fisheries (brook trout streams)

Project Results Use and Dissemination

Presentations were given at a scientific conference, to other various interested organizations and project stakeholders (Voyageurs National Park, MN DNR, MN DOT, St. Louis County Highway Department, Superior National Forest, U of M, NRRI, Michigan Tech). A 30 minute radio interview was conducted at KTWH, Two Harbors. Scheduled to present project results to the Minnesota Forest Resources Council and Forestry Committee in International Falls.

Collaboration with the Itasca Community Television (ICTV) to capture video and photography of all stages of construction of hydrologic construction sites. Footage has been edited and training videos have been created. The videos have been distributed to multiple stakeholders, including BWSR, DNR, MPCA and County Forestry Offices, U of M and Federal Agencies. Videos will be made available on the BWSR web page (https://spaces.hightail.com/space/wYWZBy450n).

Work with staff from the Superior National Forest to set up field reviews of potential sites that the Forest Service would like to restore hydrology and white cedar plant communities, by utilizing this project's findings. Work is continuing in reaching out to foresters from County Land and Forestry Departments, DNR Foresters, U.S. Forest Service to build avenues for disseminating project findings and generate interest in for white cedar restoration.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Date of Report: August 10, 2017

Date of Next Status Update Report: August 30, 2017

Date of Work Plan Approval: June 4, 2014

Project Completion Date: June 30, 2017

Does this submission include an amendment request? No

PROJECT TITLE: Northeast Minnesota White Cedar Restoration – Phase 2

Project Manager: Dale Krystosek

Organization: Minnesota Board of Water and Soil Resources

Mailing Address: 520 Lafayette Road North

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Web Address: http://www.bwsr.state.mn.us/

Location: Aitkin, Beltrami, St. Louis, Cass , Clearwater, Koochiching, Itasca, Lake, Cook, Carlton, Pine, Kanabec Mille Lacs, Crow Wing, Wadena, Hubbard, Lake of the Woods Counties

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$335,000**
	Amount Spent:	**$248,216**
	Balance:	**$86,784**

~~**92617**~~

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 06d

Appropriation Language:
$335,000 the second year is from the trust fund to the Board of Water and Soil Resources to continue an assessment of the decline of northern white cedar plant communities in northeast Minnesota, demonstrate restoration techniques, and provide cedar restoration training to local units of government. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Northeast Minnesota White Cedar Restoration - Phase 2 *(ENRTF ID: 152-F)*

II. PROJECT STATEMENT: White cedar swamps provide unique wetland functions including high value timber, long-term carbon storage, providing thermal cover for white tailed deer and other wildlife during winter, critical habitat for pine marten, fisher, and songbirds and providing thermal buffering for cold water fisheries (brook trout streams). Northern White *(Thuja occidentalis)* wetlands have been declining in Minnesota for decades. This project is a continuation of the Northeast Minnesota White Cedar Plant Community Restoration Project that received ENRTF funding in 2011. This project has established seven demonstration sites and has already identified significant impacts from modification of hydrology by roads, trails and ditches on the health and regeneration of white cedar plant communities. This initiative has ignited interest in reversing the decline of this important resource, but needs continued funding to ensure that additional progress can be achieved by demonstrating hydrologic restoration.

The goals of the project are:

1. To reverse the decline of northern white cedar wetland plant communities in Minnesota. The project will achieve its goals by evaluating and prioritizing additional white cedar stands for restoration and establishment of demonstration projects.
2. The second goal of the project is implementation of practical application of the research findings to improve the quantity and quality of white cedar plant communities in northeast and north central Minnesota. The project will accomplish this by continued development of a training program for local government resource managers regarding restoration techniques for white cedar plant communities regarding site preparation and revegetation techniques and protecting white cedar from damage by poorly designed wetland crossings for roads and trails.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 30, 2015:
During August through October, 2014, the Project Technical Team, including Dale Krystosek, Board of Water and Soil Resources (BWSR), Wetland Special Project Lead, Rick Dahlman, retired DNR Forestry Best Management Practice Coordinator, Dr. Rodney Chimner, project consultant form Michigan Tech University, and Jerry Stensing, BWSR White Cedar Project Technician completed field tours of potential hydrologic restoration sites. See additional information below.

PROJECT OUTREACH:

- ***On December 15, 2014, gave presentation at BWSR staff meeting on Phase 1 project results and overview of phase 2 activities.***
- ***On January 14, 2015, Dale Krystosek gave presentation on the Northeast White Cedar Plant Community Restoration Project at the Minnesota Wetland Conference at the University of Minnesota Landscape Arboretum. Approximately 170 people attended including wetland consultants, staff from Soil and Water Conservation Districts, Watershed Districts, and state and federal agency staff.***

Project Status as of September 30, 2015:

- ***On February 23, 2015 - Met with Itasca Community Television, Inc. and Project Technical Team to edit project training video that was developed during Phase One of the project. Video will be posted on the Minnesota Board of Water and Soil Resources website for use by local government staff and other interested individuals.***
- ***April 1, 2015 – Met at Voyageurs National Park with Park staff, Minnesota DNR, Minnesota Department of Transportation, St Louis County Highway Department and Superior National Forest staff regarding potential restoration of 400 acres of white cedar impacted by the Ash River Trail, a St. Louis County road on the south edge of Voyageurs National Park. There was some interest in evaluating this potential project. Developed follow up plans.***

- ***April 15, 2015 – Participated in Legacy Amendment and Funding Workshop, sponsored by Northwest Minnesota Foundation in Bemidji, MN. Made presentation on Northeast Minnesota White Cedar Restoration – Phase 2. Workshop was attended by local government and non-profit organization staff.***
- ***April 16, 2015 – Participated in Legacy Amendment and Funding Workshop, sponsored by Northwest Minnesota Foundation in Thief River Falls, MN. Made presentation on Northeast Minnesota White Cedar Restoration – Phase 2. Workshop was attended by local government and non-profit organization staff.***
- ***April 20, 2015 - Held project stakeholders meeting in Duluth, MN. Meeting was attended by staff from BWSR, MnDOT, Aitkin Soil and Water Conservation District, Koochiching Soil and Water Conservation District, Superior National Forest, University of Minnesota, NRRI, Michigan Tech University, and Fond du Lac Reservation. Presented phase one results and discussed phase 2 work plan.***

Overall Project Status as of January 30, 2016:

- ***Significant progress on the project was made since the last report on design of the two hydrologic restoration sites. Two sites have been selected for hydrologic restoration, one in Itasca County, near Wirt and the other north of Two Harbors in Lake County. Engineering and design for the Itasca County hydrologic near Wirt is being completed by North Central Minnesota Joint Powers Board Engineer, Bill Westerberg and Engineering Technician Brad Kennedy. Itasca SWCD Technician Matt Johnson and Natural Resource Conservation Service staff from Duluth completed soil borings and collected field data for engineering and design in September and October. Draft designs for hydrologic restoration to mimic natural groundwater flow through a forest road where white cedar and black ash have been flooded out on the up-gradient side of the road and hydrology has been reduced on the down gradient side of the road were completed in January.***
- ***Design for the Lake County site located north of Two Harbors will be completed by Lake County Soil and Water Conservation District Engineer Derrick Passe and SWCD Manager Dan Schutte with review by North Central Minnesota Joint Powers Board Engineer, Bill Westerberg and Engineer Technician Brad Kennedy. Natural Resource Conservation Service staff from Duluth completed soil borings and collected field data for engineering and design in September and October. Engineering review of the hydrologic restoration will be provided by U.S. Forest Service Engineers Marty Rye (Superior National Forest) and Jon Hodgson (Chippewa National Forest). In January, Derrick Passe completed a preliminary design to restore natural groundwater flow through a forest road where white cedar and black ash have been flooded out on the up-gradient side of the road and hydrology has been reduced on the down gradient side of the road.***
- ***Several project dissemination and trainings were also completed during the last several months (see Project Outreach, page 12 for details).***

Overall Project Status as of September 30, 2016:

- ***Working with MnDOT and other agencies to develop standards for rock vein crossings to equalize hydrology along roads. Some additional progress has been made in discussions with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Meeting was held February 17th in Grand Rapids with all project participants to discuss alternative designs for hydraulic restoration of wetlands adjacent to roads where white cedar or other plant communities have been negatively impacted. Engineers from Lake County Soil and Water Conservation District, North Central Joint Powers Board, Minnesota Department of Transportation and the U.S. Forest Service attended the meeting as well as BWSR and LGU and DNR staff. Preliminary restoration designs were reviewed and recommended for final design.***
- ***Lake County Soil and Water Conservation District Engineer Derrick Passe has developed a preliminary design for the Lake County hydrologic restoration site. Bill Westerberg, engineer for the North Central Joint Powers Board has developed several alternative designs for the Itasca County Design hydrologic restoration site. Preliminary design has commenced for 2 additional hydrologic restoration sites in St.***

Louis County on federal lands (cooperative effort with Superior National Forest and our project which will be funded by U.S. Forest Service).

- ***An RFP was conducted by Bill Westerberg, engineer for the North Central Joint Powers Board during summer, 2016 for the Itasca County site. A contractor was selected in August, 2016 to complete the hydrologic restoration in Itasca County. The Lake County site was completed by the Lake County Highway Department under the supervision of the Lake County Engineer. Both hydrologic restorations were successfully completed in August and September, 2016.***

Overall Project Status as of January 30, 2017:

- ***Post construction (as-built) drawings and specifications have been submitted for both hydrologic restoration sites in Itasca County and Lake County to update documentation to reflect project modifications to the initial design plans.***
- ***Hydrologic data was been collected after restoration for the Itasca County site and Lake County site and hydrologic data has been analyzed to compare pre-restoration hydrologic conditions to post restoration hydrologic conditions. This analysis has shown that the restoration of hydrology at both sites appears to be functioning as designed.***
- ***The remaining project activities are making progress and are expected to be included in the final project report.***

Overall Project Outcomes and Results:

Final field visits to all Phase I and II sites were completed and data was collected. The hydrologic restoration projects are functioning as anticipated. The final project report of results has been incorporated into the *Final Technical Report, Northeast Minnesota White Cedar Plant Community Restoration: Phases I & II (see attachment 2).*

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: ***Implement two hydrologic restorations of white cedar plant communities***

Description:

a) Design and implement two white cedar plant community hydrologic restoration projects where the sites have been degraded by roads, trails and ditches where hydrology needs to be restored to the natural hydrologic regime. A minimum of 40 potential sites will be evaluated. The restoration actions may include improving groundwater flows by installing culverts, trail and road modifications, etc. Project will design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff. The project goal will be to restore 200 acres of white cedar plant communities.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 185,000
Amount Spent: $ 127,134
Balance: $ 57,866

Activity Completion Date: 10/2015

Outcome	Completion Date	Budget
1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated.	9/2014	$20,000
2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff.	3/2014	$15,000
3.Implement 2 white cedar plant community hydrologic restorations	10/2015	$141,000
4. Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads		$9,000

Activity Status as of January 30, 2015:

1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated.

- *The team reviewed several sites in Beltrami County in coordination with DNR Forestry Staff, Ronald Rabe based in Kelleher. These sites had been impacted by roads and ditches and had some potential for hydrologic restoration.*
- *The team reviewed sites in Lake of the Woods County in cooperation with Lake of the Woods Environmental Services Director Josh Stromlund along with DNR Forestry and DNR Wildlife staff based in Baudette, MN. Several sites were reviewed which had been impacted by roads and ditches.*
- *The Team reviewed sites in Itasca County in cooperation with Jim Gustafson, Itasca Soil and Water Conservation District Manager. One site near Wirt, MN was reviewed, a township road which had affected a white cedar stand on both sides of the road. This site was determined to be ideal in terms of scale and well suited as a white cedar hydrologic restoration site.*
- *The Team reviewed sites in Aitkin County in coordination with Aitkin Soil and Water Conservation staff. These white cedar sites were impacted by roads and ditches but had complicating factors that made them less than ideal for hydrologic restoration sites.*
- *In September, BWSR project staff Dale Krystosek and Jerry Stensing toured several sites in northern St. Louis County with DNR Forester Dave Soposi. These sites had major hydrologic impacts from roads, where, in one case, hundreds of acres of white cedar had been killed by flooding due to improper cross drainage under a major road adjacent to Voyageurs National Park. This site was determined to be too costly for our project, but we will be setting up a meeting with St. Louis County Highway Department, Voyageurs National Park staff, MnDOT and DNR to determine whether other funding may be available to restore this site.*
- *In September, BWSR project staff Dale Krystosek and Jerry Stensing toured three sites in Lake County with Lake County Forester Bill Nixon. All 3 of the sites had significant hydrologic impacts due to roads blocking normal hydrologic flows within white cedar plant communities. One site was selected for hydrologic restoration due to its ideal size and scope which should fit within the scope of the phase 2 budget.*

2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff.

- *Met with Peter Leete, MnDOT/DNR Liaison and several MnDOT engineers to explore opportunities for cooperation on the project. MnDOT appears to be interested in working jointly to develop designs that will minimize hydrologic impacts to white cedar plant communities and other plant communities along MnDOT roads.*

PROJECT CONTRACTS:

- ***Completed a contract with Itasca Soil and Water Conservation District to assist in evaluating and selecting white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands.***
- ***Completed a contract with Koochiching Soil and Water Conservation District to assist in evaluating and selecting white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands.***
- ***Completed a contract with the University of Minnesota Natural Resource Research Institute to assist in evaluating and selecting white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands.***

Activity Status as of September 30, 2015:

- ***March 26, 2015 - Met with Itasca County Soil and Water Conservation District, Itasca County Highway Department to discuss white cedar hydrologic restoration site near Wirt, MN. Parties agreed to proceed with plans to use this site as a demonstration site.***
- ***June 16, 2015 – met with Itasca County Board of Commissioners to discuss white cedar hydrologic restoration site near Wirt, MN. The County Board agreed to proceed with plans to use this site as a demonstration site.***
- ***July 30, 2015 – Met with North Central Minnesota Joint Powers Board Engineer, Bill Westerberg and Engineer Technician Brad Kennedy and Itasca SWCD Technician Matt Johnson to discuss engineering and design for Itasca County white cedar hydrologic restoration site near Wirt. Bill and Brad expressed interest in providing engineering assistance for the project.***
- ***August 10, 2015 - Met on site at Itasca County hydrologic site with North Central Minnesota Joint Powers Board Engineer, Bill Westerberg and Engineer Technician Brad Kennedy, Itasca SWCD Technician Matt Johnson and Natural Resource Conservation Service to do soil borings and collect field data for engineering and design for Itasca County white cedar hydrologic restoration site near Wirt. Set goal of completing design during winter, 2015-16 with construction set for summer, 2016.***
- ***September 21, 2015 – Met with Lake County Soil and Water Conservation District Manager Dan Schutte and SWCD Engineer Derrick Passe and North Central Minnesota Joint Powers Board Engineer, Bill Westerberg and Engineer Technician Brad Kennedy along with Lake County Land Department staff to discuss design and engineering for Lake County white cedar hydrologic restoration site. Set goal of completing design during winter, 2015-16 with construction set for summer, 2016.***
- ***Scheduled meeting for October 1, 2015 in Cook, Minnesota with U.S. Forest Service staff from the Superior National Forest along with Minnesota DNR and BWSR to view potential hydrologic restoration site on the Superior National Forest. This project will be funded by the Forest Service, but our project will consult with them to share technical data and recommendations.***

1/30/16 Progress Report – Activity 1 Outcomes:
1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated. ***STATUS, 1/30/16: Completed - A total of 85 sites were evaluated, and over 20 were determined to be good candidates for hydrologic restoration***
2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff. ***STATUS, 1/30/16: Lake County Soil and Water Conservation District Engineer Derrick Passe has developed a preliminary design for the Lake County hydrologic restoration site. Bill Westerberg, engineer for the North Central Joint Powers Board has developed several alternative designs for the Itasca County Design hydrologic restoration site. Preliminary design has commenced for 2 additional hydrologic restoration sites in St. Louis County on federal lands (cooperative effort with Superior National Forest and our project which will be funded by U.S. Forest Service).***
3. Implement 2 white cedar plant community hydrologic restorations.

STATUS, 1/30/16: Hydrologic restorations are scheduled for summer, 2016 and the design efforts are on schedule to allow compliance with that timeline.
4. <u>Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads.</u> ***<u>STATUS, 1/30/16:</u> Some additional progress has been made in discussions with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Meeting is scheduled for February 17th in Grand Rapids with all project participants to discuss alternative designs for hydraulic restoration of roads where white cedar or other plant communities have been negatively impacted.***

Activity Status as of January 30, 2016:

- ***Lake County Soil and Water Conservation District Engineer Derrick Passe has developed a preliminary design for the Lake County hydrologic restoration site.***
- ***Bill Westerberg, engineer for the North Central Joint Powers Board has developed several alternative designs for the Itasca County Design hydrologic restoration site.***
- ***Preliminary design has commenced for 2 additional hydrologic restoration sites in St. Louis County on federal lands*** **(cooperative effort with Northeast Minnesota White Cedar Restoration – Phase 2 and the Superior National Forest and which will be funded by U.S. Forest Service).**
- **Working with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads. Some additional progress has been made in discussions with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Meeting is scheduled for February 17 in Grand Rapids with all project participants to discuss alternative designs for hydraulic restoration where roads have impacted hydrology.**
- **Project technician Jerry Stensing retired from the project due to his wife's medical condition. Rick Dahlman, retired Minnesota Department of Natural Resources Forestry BMP (*Best Management Practice)* Coordinator was selected to fill the position.**
- **Hydrologic restorations are scheduled for summer, 2016 and the project design progress is on schedule to allow implementation within that timeline.**

1/30/16 Progress Report – Activity 1 Outcomes:
1. <u>Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated.</u> ***<u>STATUS, 1/30/16:</u> Completed - A total of 85 sites were evaluated, and over 20 were determined to be good candidates for hydrologic restoration***
2. <u>Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff.</u> ***<u>STATUS, 1/30/16:</u> Lake County Soil and Water Conservation District Engineer Derrick Passe has developed a preliminary design for the Lake County hydrologic restoration site. Bill Westerberg, engineer for the North Central Joint Powers***

Board has developed several alternative designs for the Itasca County Design hydrologic restoration site. Preliminary design has commenced for 2 additional hydrologic restoration sites in St. Louis County on federal lands (cooperative effort with Superior National Forest and our project which will be funded by U.S. Forest Service).
3. <u>Implement 2 white cedar plant community hydrologic restorations.</u> ***STATUS, 1/30/16: Hydrologic restorations are scheduled for summer, 2016 and the design efforts are on schedule to allow compliance with that timeline.***
4. <u>Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads.</u> ***<u>STATUS, 1/30/16:</u> Some additional progress has been made in discussions with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Meeting is scheduled for February 17th in Grand Rapids with all project participants to discuss alternative designs for hydraulic restoration of roads where white cedar or other plant communities have been negatively impacted.***

Activity Status as of September 30, 2016:

- ***Maintained regular contact with cooperators involved with the Itasca County and Lake County project sites to keep everyone informed and identify and resolve issues holding back progress.***
- ***Worked closely with Bill Westerberg and Matt Johnson to produce the RFP and award the bid for construction at the Itasca County site in Wirt. Attended pre-bid meeting with Bill and prospective bidders and reviewed modifications of RFP that resulted from that meeting.***
- ***Bid process:***
    - ***Quote tabulation with Engineers estimate= Received 3 Quotes***
    - ***The process for receiving quotes was the following:***
        - ***Prepare plans and specifications so contractor knows how each bid item is measured and what is included in the unit price for that item such as materials and construction requirements.***
    - ***Posted Solicitation for Quotes on questcdn.com website***
        - ***Website sends out notice to potential bidders and suppliers based on type of construction specified in solicitation.***
        - ***By Pre-quote Meeting had 7 plan holders***
    - ***Pre-quote Meeting on June 22, 2016***
        - ***Explained Project to 4 contractors that attended pre-quote meeting***
        - ***Answered questions***
        - ***Issued Addendum to project summarizing pre-quote meeting and made some changes and clarifications to project based on contractors recommendations to keep cost down***
    - ***Received quotes June 30, 2016***
        - ***Received 3 quotes with Bid Bond of 5% of Contractors Bid. Bid Bond is given to Owner if Contractor decides not to enter into contract with owner.***
        - ***Entered unit prices into quote tabulation spreadsheet to verify quotes and compare. Quotes were very close and lower than Engineers Estimate.***

- *Asked for references from low quote contractor*
  - *Contractor sent me references and list of projects he has worked on similar to this project.*
  - *Check references and recommended award to Contractor- RK Construction Services*
- *Contract Awarded to RK Construction Services on August 1, 2016.*
- *Held preconstruction meeting with contractor, Owner and Utilities to discuss how project would proceed the end of July.*
- *Construction began August 10, 2016 and was completed August 12, 2016.*

- ***Monitored progress on both Itasca and Lake County construction by phone, e-mail, and field visits. Had to make design modifications to Lake County site due to wet conditions the created a safety issue that could have eliminated all work on the site for the project. Found storm damage to the erosion blanket at the Itasca site and arranged with Matt Johnson to get the damage repaired.***
- ***White cedar hydrologic restorations were successfully completed in Itasca County and Lake County in September, 2016.***

9/30/16 Progress Report – Activity 1 Outcomes:
1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated. **<u>STATUS, 9/30/16:</u> A total of 85 sites were evaluated, with over 20 good candidates for hydrologic restoration. Additional field evaluations to be completed by Lake County SWCD and Koochiching County SWCD staff.**
2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff. **<u>STATUS, 9/30/16:</u> Designs were completed for 2 hydrologic restoration sites in Itasca and Lake County. Project is collaborating with U.S. Forest Service in St. Louis County on several sites. (Cooperative effort with Superior National Forest – project costs paid for by Forest Service).** ***Lake County Soil and Water Conservation District Engineer Derrick Passe developed a final design for the Lake County hydrologic restoration site. Bill Westerberg, engineer for the North Central Joint Powers Board has developed a final design for the Itasca County hydrologic restoration site. Preliminary design has commenced for 2 additional hydrologic restoration sites in St. Louis County on federal lands (cooperative effort with Superior National Forest and our project which will be funded by U.S. Forest Service).***
3. Implement 2 white cedar plant community hydrologic restorations. **<u>STATUS, 9/30/16:</u>** ***An RFP was conducted by Bill Westerberg, engineer for the North Central Joint Powers Board during summer, 2016 for the Itasca County site. A contractor was selected in August, 2016 to complete the hydrologic restoration in Itasca County. The Lake County site was completed by the Lake County Highway Department under***

the supervision of the Lake County Engineer. Both hydrologic restorations were successfully completed in August and September, 2016. *See attachments 1 & 2 – Photo documentation of restoration of the sites in Itasca and Lake counties.*
4. Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads. ***STATUS, 9/30/16:*** *Some additional progress has been made in discussions with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Meeting was held February 17th in Grand Rapids with all project participants to discuss alternative designs for hydraulic restoration of roads where white cedar or other plant communities have been negatively impacted. Engineers from Lake County Soil and Water Conservation District, North Central Joint Powers Board, Minnesota Department of Transportation and the U.S. Forest Service attended the meeting as well as BWSR and LGU and DNR staff. Preliminary restoration designs were reviewed and recommended for final design.*

Project Status as of January 30, 2017:

- *Post construction (as-built) drawings and specifications have been submitted for both hydrologic restoration sites in Itasca County and Lake County to update documentation to reflect project modifications to the initial design plans.*
- *Hydrologic data was been collected after restoration for the Itasca County site and Lake County site and hydrologic data has been analyzed to compare pre-restoration hydrologic conditions to post restoration hydrologic conditions. This analysis has shown that the restoration of hydrology at both sites appears to be functioning as designed.*

1/30/17 Progress Report – Activity 1 Outcomes:
1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated. **STATUS, 1/30/17: A total of 85 sites have been evaluated, with over 20 good candidates for hydrologic restoration. Additional field evaluations are being conducted by Lake County SWCD and Koochiching County SWCD staff and results will be included in the final report.**
2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff. **STATUS, 1/30/17: Designs were completed for 2 hydrologic restoration sites in Itasca and Lake County (see above).**
3. Implement 2 white cedar plant community hydrologic restorations.

STATUS, 1/30/17: ***Restorations completed. Monitoring of effectiveness is occurring.***
4. Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads. ***STATUS, 1/30/17: Continue work with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Hydrologic restoration designs will be incorporated into final project report.***

Final Report Summary:

Final field visits to all Phase I and II sites have been completed and data collected. The hydrologic restoration projects are functioning as anticipated. The final project report of results has been completed. See *Final Technical Report, Northeast Minnesota White Cedar Plant Community Restoration: Phases I & II (attachment 2).*

6/30/17 Final Report – Activity 1 Outcomes:
1. Evaluate and select white cedar plant communities where hydrologic modifications such as roads, trails, ditches have degraded white cedar stands. A minimum of 40 sites will be evaluated. **STATUS, 6/30/17: A total of 85 sites have been evaluated, with over 20 good candidates for hydrologic restoration. Additional field evaluations were conducted by Lake County SWCD and Koochiching County SWCD staff and results are included in the final report (see attachment 6).**
2. Design 2 white cedar plant community hydrologic restoration projects and work with MnDOT to develop recommendations for forested treatment wetlands to treat impervious area runoff. **STATUS, 6/30/17: Designs were completed for 2 hydrologic restoration sites in Itasca and Lake County (see above). The final technical report has been shared with MnDOT.**
3. Implement 2 white cedar plant community hydrologic restorations. **STATUS, 6/30/17:** ***Restorations have been completed. Monitoring of effectiveness was completed. The final project costs were considerably lower than anticipated, due in part to in-kind contributions from Lake County, Lake SWCD and Itasca SWCD.***
4. Work with MnDOT to develop standards for rock vein crossings to equalize hydrology along roads. **STATUS, 6/30/17:** ***Continued work with engineers from MnDOT, Lake County, North Central Joint Powers Board, Board of Water and Soil Resources and U.S. Forest Service. Hydrologic restoration designs were incorporated into final project technical report.*** *(See Final Technical Report, Northeast*

Minnesota White Cedar Plant Community Restoration: Phases I & II, attachment 2).

ACTIVITY 2: Monitor Seven Phase 1 white cedar demonstration projects

Description: Conduct continued monitoring of demonstration sites to a) determine regeneration success, b) evaluate effects of canopy shading on white cedar regeneration and evaluate the need for thinning to improve regeneration, c) identify previous white regeneration efforts and evaluate success, and d) maintain protective cages and evaluate timing of removal to ensure cedar is beyond critical stage for deer browsing damage.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 97,800
Amount Spent: $ 97,800
Balance: $ 0

Activity Completion Date: 10/2015

Outcome	Completion Date	Budget
1. Monitor seven demonstration sites from phase 1 to determine regeneration success	5/2016	$30,000
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration.	5/2016	$15,800
3. Review previous white cedar regeneration efforts and perform site assessments.	5/2016	$20,000
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when white cedar is beyond critical stage for deer browsing damage.	5/2016	$32,000

Activity Status as of January 30, 2015:

- ***The seven white cedar demonstration sites from Phase 1 were monitored in fall of 2014 for hydrology and vegetative condition by Rose Schwartz, graduate assistant. This data is documented and will be incorporated into future scientific publications.***

Activity Status as of September 30, 2015:

- ***The seven white cedar demonstration sites from Phase 1 are being monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant. This data is documented and will be incorporated into future scientific publications.***

9/30/15 Progress Report – Activity 2 Outcomes:
1. Monitor seven demonstration sites from phase 1 to determine regeneration success. **STATUS, 9/30/16: *Phase 1 sites are being monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant.***
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration. **STATUS, 9/30/16: Work Scheduled for summer, 2016.**
3. Review previous white cedar regeneration efforts and perform site assessments. **STATUS, 9/30/16: Work Scheduled for winter, 2015-16.**
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when

white cedar is beyond critical stage for deer browsing damage. **STATUS, 9/30/16: Ongoing.**

Activity Status as of January 30, 2016:

1/30/16 Progress Report – Activity 2 Outcomes:
1. Monitor seven demonstration sites from phase 1 to determine regeneration success. ***STATUS, 1/30/16: Completed - Phase 1 sites were monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant.***
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration. ***STATUS, 1/30/16: Work Scheduled for summer, 2016.***
3. Review previous white cedar regeneration efforts and perform site assessments. ***STATUS, 1/30/16: Work Scheduled for winter, 2016-17.***
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when white cedar is beyond critical stage for deer browsing damage. ***STATUS, 1/30/16: Ongoing.***

Activity Status as of September 30, 2016:

- Ongoing *(see table below)*

9/30/16 Progress Report – Activity 2 Outcomes:
1. Monitor seven demonstration sites from phase 1 to determine regeneration success. **STATUS, 9/30/16: *Phase 1 sites were monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant and incorporated into her Graduate thesis which has been completed.***
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration. **STATUS, 9/30/16: Research to be reviewed, November - December, 2016.**
3. Review previous white cedar regeneration efforts and perform site assessments. **STATUS, 9/30/16: Work Scheduled for winter, 2016-17.**
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when white cedar is beyond critical stage for browsing damage. **STATUS, 9/30/16: Ongoing.**

Project Status as of January 30, 2017:

- Ongoing (see table below)

1/30/17 Progress Report – Activity 2 Outcomes:
1. Monitor seven demonstration sites from phase 1 to determine regeneration success. **STATUS, 1/30/17:** ***Phase 1 sites were monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant and incorporated into her Graduate thesis which has been completed and will be included in final project report.***
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration. **STATUS, 1/30/17: Rick Dahlman, retired DNR Forestry BMP Coordinator and Dr. Rodney Chimner, Michigan Tech University professor, (project consultants) have been reviewing data on shading for incorporation into final report.**
3. Review previous white cedar regeneration efforts and perform site assessments. **STATUS, 1/30/17: Rick Dahlman is currently working on this project component.**
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when white cedar is beyond critical stage for browsing damage. **STATUS, 1/30/17: Analysis is ongoing and will be included in final report.**

Final Report Summary:

Rod Chimner has completed reviewing these sites and incorporated the results in the final technical report. (See Final Technical Report, Northeast Minnesota White Cedar Plant Community Restoration: Phases I & II, attachment 2).

6/30/17 Final Report – Activity 2 Outcomes:
1. Monitor seven demonstration sites from phase 1 to determine regeneration success. **STATUS, 6/30/17:** ***Phase 1 sites were monitored in fall of 2015 for hydrology and vegetative condition by Rose Schwartz, graduate assistant and incorporated into her Graduate thesis which has been completed and is included in final project report.*** *See Attachment 3 - CARBON CYCLING AND RESTORATION IN TEMPERATE FORESTED PEATLANDS by Rose B. Schwartz, a THESIS submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE In Applied Ecology, MICHIGAN TECHNOLOGICAL UNIVERSITY 2016.*
2. Evaluate effects of canopy shading on white cedar regeneration and evaluate need for thinning to improve regeneration. **STATUS, 6/30/17: Light intensity (shading) was evaluated on the Phase 1 sites, each of which had different stand densities, from dense shade, medium shade, small patch cuts, strip thinning, and clear cut. Dr. Chimner determined cedar height**

growth was influenced by the amount of light reaching the trees during the 2 year measurement period.
3. Review previous white cedar regeneration efforts and perform site assessments. **STATUS, 6/30/17: Met with Itasca, St Louis, Lake, and Koochiching Counties, MN DNR Grand Rapids and Bemidji Regional, Superior National Forest, and Fond du Lac Reservation forestry offices, as well as the Bemidji BWSR office provided multiple sites where efforts to regenerate white cedar have been attempted over the past 30 plus years. A list of the sites identified is attached.** See *Attachment 4 - Northern White Cedar Mineral Sites.*
4. Maintenance of protective cages and evaluation of safe timing for removal of browsing protection and determine when white cedar is beyond critical stage for browsing damage. **STATUS, 6/30/17: The report indicates that protected planted seedling and transplant survival is sufficiently better than unprotected to justify utilizing protection. Also, the wire cages stood up better than the tubes, which are easily knocked over by wildlife. How long the protection needs to be maintained is not discussed. Growth rates vary greatly between sites depending on light intensity and hydrologic conditions, and growth rates once the planting are a little older may increase over what has been observed to date.**

ACTIVITY 3: Develop recommendations for white cedar plant community restoration plan for Minnesota and evaluate and prioritize additional white cedar restoration projects.

Description:

Develop recommendations for white cedar plant community restoration recommendations and prioritize additional white cedar restoration projects. This will include:

A) Identify and evaluate degraded black ash (from emerald ash borer) and tamarack sites to determine whether white cedar has potential to fill that niche for restoration

B) Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities,

C) Review historic timber sale and management records and interview current and retired forest managers to identify additional degraded or former white cedar stands to identify additional restoration opportunities,

D) Utilize interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota, MnDOT, LGUs, Michigan Tech and federal agencies to develop white cedar plant community restoration recommendations.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 52,200
Amount Spent: $ 23,282
Balance: $ 28,918

Activity Completion Date: 10/2015

Outcome	Completion Date	Budget
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche	10/2015	$10,000
2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities	10/2015	$12,000

3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations	10/2015	$5,000
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature	7/2016	$25,200

Activity Status as of January 30, 2015:

1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche

- ***Project team reviewed current research on this topic and had discussions with University of Minnesota Researchers and U.S. Forest Service staff to coordinate project activities.***

Activity Status as of September 30, 2015:

- ***Project team continues review of current research on this topic and continues discussions with University of Minnesota Researchers and U.S. Forest Service staff to coordinate project activities.***

9/30/15 Progress Report – Activity 3 Outcomes:
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche **STATUS, 9/30/15: Ongoing, to be included in final report.**
2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities **STATUS, 9/30/15: Work scheduled for 2016-17**
3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations **STATUS, 9/30/15: Work scheduled for 2016-17**
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature **STATUS, 9/30/15: Work scheduled for 2016-17**

Activity Status as of January 30, 2016:

- ***Project team continues review of current research on this topic and continues discussions with University of Minnesota Researchers and U.S. Forest Service staff to coordinate project activities.***

1/30/16 Progress Report – Activity 3 Outcomes:
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche. ***STATUS, 1/30/16: Ongoing, to be included in final report.***
2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities. ***STATUS, 1/30/16: Work scheduled for 2016-17***
3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to

develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations. ***STATUS, 1/30/16: Initiated discussions with DNR, University of Minnesota and local government units regarding this work item. Additional partners (U.S. Forest Service, etc.) will be engaged at February 17th meeting.*** ***Work scheduled for 2016-17***
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature. ***STATUS, 1/30/16: Initiated discussions with DNR, University of Minnesota and local government units regarding this work item. Work scheduled for 2016-17***

Activity Status as of September 30, 2016:

- **Ongoing, work schedule for winter of 2016-2017** ***(see table below)***

9/30/16 Progress Report – Activity 3 Outcomes:
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche. ***STATUS, 9/30/16: Ongoing, to be included in final report.***
2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities. ***STATUS, 9/30/16: Work scheduled for winter, 2016-17***
3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations. ***STATUS, 9/30/16: Continue discussions with DNR, University of Minnesota and local government units regarding this work item. Additional partners (U.S. Forest Service, etc.) were engaged at February 17th meeting.*** ***Work scheduled for winter 2016-17***
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature. ***STATUS, 9/30/16: Initiated discussions with DNR, University of Minnesota and local government units regarding this work item. Work scheduled for winter, 2016-17***

Project Status as of January 30, 2017:

- Ongoing (see table below)

1/30/17 Progress Report – Activity 3 Outcomes:
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche. ***STATUS, 1/30/17: Ongoing, to be included in final report.***

2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities. ***STATUS, 1/30/17: Meetings with county and state foresters are occurring during winter, 2016-17***
3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations. ***STATUS, 1/30/17: Meetings with DNR, University of Minnesota local government units, U.S. Forest Service scheduled for March through May, 2017***
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature. ***STATUS, 1/30/17: Initial discussions about recommendations have been initiated. Recommendations on track to be part of final report.***

- ***Soil and Water Conservation Districts in Lake, St. Louis, Itasca and Koochiching County and state and county forestry offices have been contacted about identifying additional former white cedar stands on mineral soil seeps, as well as black ash and black spruce and tamarack stands with a cedar component that might be potential restoration sites. SWCD staff are reviewing and evaluating these sites.***

Final Report Summary:

Lake, St Louis, Itasca, and Koochiching County SWCDs, county and state forestry offices were contacted about identifying additional former white cedar stands, white cedar sites on mineral soil seeps, as well as black ask and black spruce and tamarack stands with a cedar component that might be good restoration opportunities. Itasca, Lake, Koochiching, and St Louis County SWCD staff have selected 20 to 30 sites each from these lists and have completed on-site evaluations of those sites.

Research review by Rod Chimner, the lead researcher for the project, has determined that black ash stands have limited potential for white cedar due to raised water levels caused by the death of ash due to emerald ash borer that would flood out cedar. The US Forest Service and the U of M are conducting research on numerous species that might be appropriate to replace black ash, including white cedar.

A meeting of multiple stakeholders was held March 17, 2017 to develop recommendations for white cedar restoration. These comments were incorporated into the final report.

6/30/17 Final Report – Activity 3 Outcomes:
1. Evaluate black ash sites to determine whether white cedar has potential to fill that niche. ***STATUS, 6/30/17: The results of Phase I & II indicate that white cedar has limited potential to replace tamarack at lower pH sites. This is less of a problem for black ash, but the increased risk of flooding or inundation from higher water level after the ash dies or is removed significantly limits this opportunity. In addition, the University of Minnesota and USDA Forest Service have an extensive study underway on the Chippewa National Forest***

evaluating multiple species as potential replacements for black ash wetlands.
2. Identify mineral soil wetland sites that historically were white cedar as potential wetland restoration opportunities. ***STATUS, 6/30/17:*** ***MN DNR Forestry and the County forestry departments for Koochiching, Itasca, St Louis, and Lake Counties have provided lists of white cedar stands on mineral soils. The SWCD offices in those counties have completed 75 site evaluations utilizing the same evaluation system used to identify sites during Phase 1. A list of the sites identified is attached*** *(see attachment 4, Northern White Cedar Mineral Sites).*
3. Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations and develop white cedar plant community restoration recommendations. ***STATUS, 6/30/17:*** ***Meetings were held with DNR, University of Minnesota, local government units, U.S. Forest Service March through May, 2017.***
4. Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature. ***STATUS, 6/30/17:*** ***Multiple meetings were held throughout the course of Phase I and II. The input obtained has been considered and incorporated into the recommendations developed by the project. For recommendations, see Final Technical Report, Northeast Minnesota White Cedar Plant Community Restoration: Phases I & II, attachment 2).***

V. DISSEMINATION:

- **Project updates will be posted on BWSR Website**
- **Field tours of white cedar restoration sites**
- **Training Session**
- **Final Report to be posted on BWSR Website**
- **Final Report**

Description:

The project will disseminate information through the following methods:

- Convene interagency team including BWSR, DNR, MPCA, Corps of Engineers, University of Minnesota and federal agencies to develop white cedar plant community restoration recommendations
- Develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature

Status as of January 30, 2015:

PROJECT OUTREACH:

- ***On December 15, 2014, Dale Krystosek and Jerry Stensing gave presentation at BWSR staff meeting on Phase 1 project results and overview of phase 2 activities.***
- ***On January 14, 2015, Dale Krystosek gave presentation on the Northeast White Cedar Plant Community Restoration Project at the Minnesota Wetland Conference at the University of Minnesota***

Landscape Arboretum. Approximately 170 people attended including wetland consultants, Soil and Water Conservation Districts, Water shed Districts, and state and federal agency staff.

Status as of September 30, 2015:

PROJECT OUTREACH:

- ***On February 23, 2015 - Met with Itasca Community Television, Inc. and Project Technical Team to edit project training video that was developed during Phase One of the project. Video will be posted on the Minnesota Board of Water and Soil Resources website for use by local government staff and other interested individuals.***
- ***Dale Krystosek, Project Manager, gave presentation on April 1, 2015 at Voyageurs National Park to National Park staff, Minnesota DNR, Minnesota Department of Transportation, St Louis County Highway Department and Superior National Forest staff on project and potential restoration of 400 acres of white cedar impacted by the Ash River Trail***
- ***Dale Krystosek, Project Manager, gave presentation on April 15, 2015 at Legacy Amendment and Funding Workshop, sponsored by Northwest Minnesota Foundation in Bemidji, MN. Made presentation on Northeast Minnesota White Cedar Restoration – Phase 2. Workshop was attended by local government and non-profit organization staff.***
- ***Dale Krystosek, Project Manager, gave presentation on April 16, 2015 at Legacy Amendment and Funding Workshop, sponsored by Northwest Minnesota Foundation in Thief River Falls, MN. Made presentation on Northeast Minnesota White Cedar Restoration – Phase 2. Workshop was attended by local government and non-profit organization staff.***
- ***Dr. Rodney Chimner, Michigan Tech University, Jerry Stensing, BWSR Technician and Dale Krystosek, Project Manager gave presentation on April 20, 2015 at project stakeholders meeting in Duluth. Meeting was attended by staff from BWSR, MnDOT, Aitkin Soil and Water Conservation District, Koochiching Soil and Water Conservation District, Superior National Forest, University of Minnesota, NRRI, Michigan Tech University, and Fond du Lac Reservation. Presented phase one results and discussed phase 2 work plan.***

Status as of January 30, 2016:

- ***Dale Krystosek and Dr. Rodney Chimner (project consultant) conducted a program at the BWSR Academy on October 29th on the topic of peatland restoration which discussed the Northeast Minnesota White Cedar Restoration – Phase 2 project.***
- ***In January, Dale Krystosek, project manager and Derrick Passe, Lake County Soil and Water Conservation District Engineer participated in a 30 minute radio interview regarding the Northeast Minnesota White Cedar Restoration – Phase 2 project with Emily Nelson.*** **The program will air on KTWH** ***Two Harbors Community Radio. It will also stream on their website www.ktwh.org. The Lake County SWCD will also be hosting it as a podcast on their website.***

Status as of September 30, 2016:

- ***Held meeting on February 17th, 2016 with Itasca SWCD, Lake SWCD, Koochiching SWCD DNR Forestry, University of Minnesota, MnDOT, U.S. Forest Service to discuss hydrologic restoration techniques, and implementation of other phases of the program.***
- ***Maintained regular contact with cooperators involved with the Itasca County and Lake County project sites to keep everyone informed and identify and resolve issues holding back progress.***
- ***Worked closely with Bill Westerberg and Matt Johnson to produce the RFP and award the bid for construction at the Itasca County site in Wirt. Attended pre-bid meeting with Bill and prospective bidders and reviewed modifications of RFP that resulted from that meeting.***
- ***Project staff monitored progress on both Itasca and Lake County construction sites by phone, e-mail, and field visits. Had to make design modifications to Lake County site due to wet conditions the created a safety issue that could have eliminated all work on the site for the project. Found storm***

damage to the erosion blanket at the Itasca site and arranged with Matt Johnson, Itasca SWCD to get the damage repaired.

- ***Working with Itasca Community Television (ICTV)/Two Rivers Video to video record construction at both the Itasca and Lake County sites to document how the projects were installed to help communicate the project outcomes to multiple parties.***
- ***Worked with Erica Hahn from the Superior National Forest and Rod Chimner to set up a field review of one or two sites the Forest would like to restore hydrology and white cedar plant communities, building on what the project is learning.***

Status as of January 30, 2017:

- ***Itasca Community Television (ICTV, Grand Rapids, MN) completed capturing video and still photography of all stages of construction for both hydrologic construction sites. Rick Dahlman is working with ICTV to edit footage and create training videos for both construction techniques which will be used for training of local governments and other agencies on white cedar plant community restoration techniques.***
- ***In October, project staff met with Erica Hahn and other personnel from the Superior National Forest and Dr. Rod Chimner to conduct a field review of sites the Forest Service would like to restore hydrology and white cedar plant communities, utilizing this project's findings.***
- ***Briefed other BWSR staff from Wetland Section regarding project findings and potential for use of restoration techniques in other state and local government wetland restoration initiatives.***
- ***Rick Dahlman continues reaching out to foresters from County Land and Forestry Departments, DNR foresters, U.S. Forest Service personnel, and Voyageurs National Park to build avenues for disseminating project findings and generate interest for white cedar restoration.***

Final Report Summary:

ICTV completed capturing video and still photography of all stages of construction for both hydrologic construction sites. Rick Dahlman has completed work with ICTV to edit the footage and create training videos for both construction options. For video link, see attachment 6.

The video describing the 2 hydrologic restoration projects has been completed. The video has been distributed to multiple stakeholders, including BWSR, DNR, MPCA, County Forestry offices, Corps of Engineers, University of Minnesota and federal agencies as well as other states and Canada. It will be made available on the BWSR web page. Informational meetings will be held with several agencies, including the Minnesota Forest Resource Council. The project reports will also be posted on line and shared with numerous stakeholders in Minnesota and across the US and Canada.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$ 80,900	**Unclassified (50% time) Wetland Specialist** (Board of Water and Soil Resources for 2 years) Salary - 74% Benefits - 26%

Professional/Technical/Service Contracts:	$122,000	**1) Natural Resource Research Institute - University of Minnesota, Duluth -** Contract to provide technical expertise in designing white cedar hydrologic restoration projects. Work will include review and evaluation of techniques in other states, field data collection and project design. This contract will also include development of recommendations for white cedar restoration. *($45,000)* **2) Soil and Water Conservation Districts and County Land Departments -** Up to 7 contracts with SWCDs and/or County Land Departments for additional staff based on criteria, priorities and targeted areas established by the interagency technical team. This field work would be to complete field investigations and prioritization of white cedar sites for hydrologic restoration and inspection and monitoring of phase 1 restoration sites. *($77,000)*
Equipment/Tools/Supplies:	$124,100	**Equipment/Tools/Supplies - Construction costs and restoration costs** and field supplies including costs for field demonstration of hydrologic restoration techniques *(culverts, restoration of natural hydrologic flows). ($124,100)* **1) Earthwork and grading - *Estimated costs = $80,000*** **2) Culverts and/or rock conveyance systems to restore and equalize hydrology on both sides of roads/trails within white cedar stand - *estimated costs = $44,100* -** *These are estimated costs for hydrologic restoration and the selection of restoration sites will be highly influenced by the scope of hydrologic restoration needs, and the earthwork and grading and restoration material costs at each restoration site that is evaluated. The project team has considered several restoration designs including:* *a) **installation of culverts and redistribution channels** at the appropriate density to adequately recharge groundwater downstream from the roads/trail that is impacting the white cedar stand or* *b) **Installation of crushed rock veins within the road/trail** to provide adequate cross groundwater flows to restore natural hydrologic*

		conditions for white cedar plant community restoration. *c) **Other potential designs will be considered, based on input from BWSR engineers, MnDOT staff, University of Minnesota, Michigan Tech University, and DNR Division of Forestry.***
Travel Expenses in MN:	$8,000	This budget item is to cover BWSR staff travel costs including mileage, meals, lodging costs for Interagency coordination meetings, field site visits and training. For example: a) travel from Bemidji BWSR office to Duluth for interagency technical team meetings, b) travel costs for BWSR Wetland Specialists from office (Duluth) to field and demonstration sites within project area, c) Travel for BWSR staff to training sessions (Grand Rapids, Duluth, International Falls, etc.)
TOTAL ENRTF BUDGET:	**$335,000**	

Explanation of Use of Classified Staff: The only use of classified staff will be in-kind support by the BWSR Wetland Special Project Lead.

Explanation of Capital Expenditures Greater Than $5,000: None planned.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 1.5

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 1.0

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$	$	
State			
10% of BWSR Wetland Special Project Lead (In Kind Staff Time)	$16,400	$ 8,250	Project management, field work, site inspections, and meetings with partners.
TOTAL OTHER FUNDS:	**$16,400**	**$8,250**	

VII. PROJECT STRATEGY:

A. Project Partners: Interagency team including BWSR, DNR, MPCA, MnDOT, Corps of Engineers, University of Minnesota, Soil and Water Conservation Districts, County Land Departments and federal agencies will develop white cedar plant community restoration.

Partners receiving funding: University of Minnesota Duluth (NRRI), SWCDs and county land departments

B. Project Impact and Long-term Strategy: The long term strategy of the project is to develop recommendations for white cedar restoration in the state and present recommendations to BWSR, DNR Commissioner and Minnesota Legislature.

C. Spending History:

Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14
ENRTF				$250,000	$335,000

VIII. ACQUISITION/RESTORATION LIST:

- Two hydrologic restoration sites will be restored by the project. These sites will be on public lands (either state or county) and will be selected based on suitability for restoration, costs of restoration, level of interest by land managers and other factors.

IX. VISUAL ELEMENT or MAP(S): (see attached map)

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET:

XI. RESEARCH ADDENDUM:

XII. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than January 30, 2015, September 30, 2015, January 30, 2016, September 30, 2016, January 30, 2017. A final report and associated products will be submitted between June 30 and August 30, 2017.

Final Report Attachments:

Attachment 1- Final Budget Report

Attachment 2 - Northeast Minnesota White Cedar Plant Community Restoration: Phases I & II Final Technical Report prepared for Environment and Natural Resources Trust Fund, *Chimner, R.A., Schwartz, Michigan Technological University, School of Forest Resources and Environmental Science, Houghton, MI 49931 Stensing, J. Minnesota Board of Water and Soil Resources (Retired), Waskish, MN 56685 Dahlman, R. Minnesota Department of Natural Resources, Div. of Forestry (Retired), Elk River, MN 55330 and Krystosek, D. Board of Water and Soil Resources, St. Paul, MN 55155*

Attachment 3 - **CARBON CYCLING AND RESTORATION IN TEMPERATE FORESTED PEATLANDS by Rose B. Schwartz** a THESIS submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE In Applied Ecology, MICHIGAN TECHNOLOGICAL UNIVERSITY 2016.

Attachment 4 - **Northern White Cedar Mineral Sites**

Attachment 5 - Restoration Site Evaluations

Attachment 6 - Restoration Video

Environment and Natural Resources Trust Fund

M.L. 2014 Project Budget

Project Title: Northeast Minnesota White Cedar Restoration, Phase 2

Legal Citation: *M.L. 2014, Chp. 226, Sec. 2, Subd. 06d*

Project Manager: Dale Krystosek

Organization: Minnesota Board of Water and Soil Resources

M.L. 2014 ENRTF Appropriation: $ 335,000

Project Length and Completion Date: 3 Years - June 30, 2017

Date of Report: August 16, 2017

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Revised Activity 2 Budget 04/14/2016	Amount Spent	Activity 2 Balance	Revised Activity 3 Budget 04/14/2016	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***ACTIVITY 1: Implement two hydrologic restorations of white cedar plant communities***										
Personnel (Wages and Benefits) *($80,900)* **BWSR Wetland Specialist (50% fulltime employment)** 74% Salary, 26% for benefits - one person will fill this position through an unclassified position.	$18,500	$18,500	$0	$11,868	$11,868	$0	$0	$0	$0	$30,368	$0
Professional/Technical Contracts - 1) Natural Resource Research Insitiute - University of Minnesota, Duluth - Contract to provide technical expertise in designing white cedar hydrologic restoration projects. Work will include review and evaluation of techniques in other states, field data collection and project design. This contract will also include development of recommendations for white cedar restoration. *($45,000)*	$24,500	$24,500	$0	$10,500	$10,500	$0	$10,000	$9,832	$168	$45,000	$168
Professional/Technical/Service Contracts **2) Soil and Water Conservation Districts and County Land Departments -** Up to 7 contracts with SWCDs and/or County Land Departments for additional staff based on criteria, priorities and targeted areas established by the interagency technical team. This field work would be to complete field investigations and prioritization of white cedar sites for hydrologic restoration and inspection and monitoring of phase 1 restoration sites. *($69,000)*	$15,400	$15,400	$0	$72,032	$72,032	$0	$40,100	$10,857	$29,243	$127,532	$29,243
Equipment/Tools/Supplies - Construction costs and restoration costs and field supplies including costs for field demonstration of hydrologic restoration techniques *(culverts, restoration of natural hydrologic flows). ($124,100)* **1) Earthwork and grading - Estimated costs = $80,000 2) Culverts and/or rock conveyance systems to restore and equalize hydrology on both sides of roads/trails within white cedar stand - estimated costs = $44,100 A.***These are estimated costs for hydrologic restoration and the selection of restoration sites will be highly influenced by the scope of hydrologic restoration needs, and the earthwork and grading and restoration material costs at each restoration site that is evaluated. The project team has considered several restoration designs including a) installation of culverts and redistribution channels at the appropriate density to adequately recharge groundwater downstream from the roads/trail that is impacting the white cedar stand or b) installation of crushed rock veins within the road/trail to provide adequate cross groundwater flows to restore natural hydrologic conditions for white cedar plant community restoration.c) Other potential designs will be considered, based on input from BWSR engineers, MnDOT staff, University of Minnesota, Michigan Tech University, DNR Division of Forestry.*	$124,100	$66,234	$57,866							$124,100	$57,866

Travel expenses in Minnesota - This budget item is to cover BWSR staff costs for Interagency coordination meetings, field site visits and training. For example: a) travel from Bemidji BWSR office to Duluth for interagency technical team meetings, b) travel costs for BWSR Wetland Specialists from office (Duluth) to field and demonstration sites within project area, c) Travel for BWSR staff to training sessions (Grand Rapids, Duluth, International Falls, etc.) *($8,000)*	$2,500	$2,500	$0	$3,400	$3,400	$0	$2,100	$2,593	-$493	$8,000	-$493
TOTALS	$185,000	$127,134	**$57,866**	$97,800	$97,800	**$0**	$52,200	$23,282	**$28,918**	$335,000	**$86,784**

Minnesota Board of Water & Soil Resources

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Northeast Minnesota White Cedar Restoration - Phase II

Restoration Site Evaluations:

Beltrami County (14 stands)

Cook County (12 stands)

Itasca County (7 stands)

Hubbard County (2 stands)

Lake of the Woods County (17 stands)

Lake County (12 stands)

St. Louis County (23 stands)

Located in Beltrami County
S5 T155 R30

Hydrologic Restoration Indicator Stand 1050072

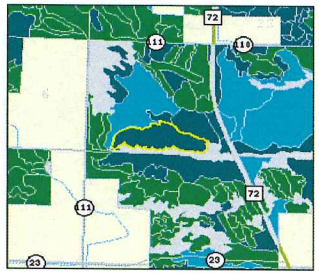
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*											
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15330w1050072

(No NPC)

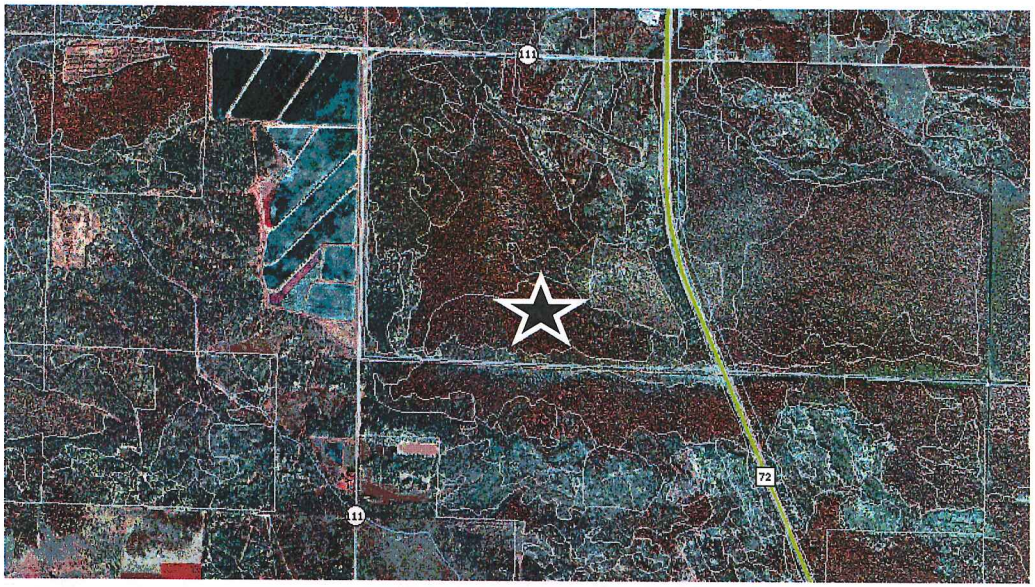
Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	23
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	77.4
Management Status	Normal timber harvest allowed

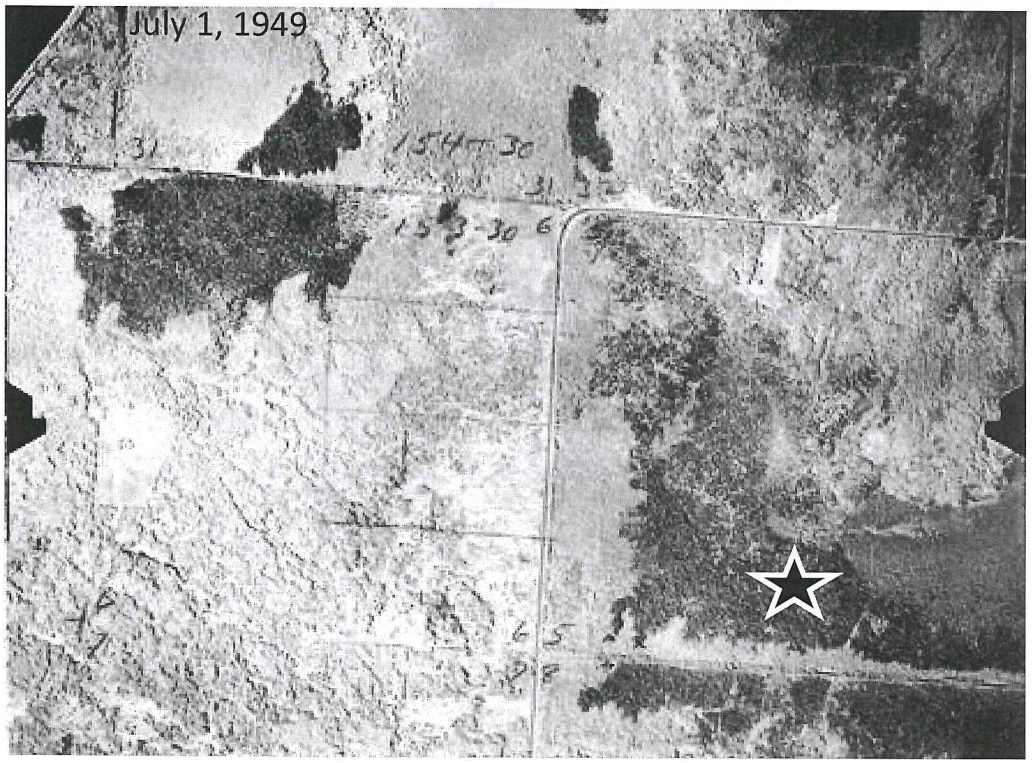


Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1982
Age at Inventory	117 years
Average Diameter Class	5 to 8.9 inches
Density Class	7.5-12.5 cords per acre
Basal Area	85 square feet per acre
Volume	11.0 cords per acre
Condition Class	Mature
Understory Type - White Cedar	
Average Diameter Class	1 to 2.9 inches
Density class	750-1250 stems per acre

Stand Composition By Major Tree Species

Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	7 inches	6.2 cords	35 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Black Spruce	8 inches	4.6 cords	Well distributed





Located in Beltrami County
S21 T153 R30

Hydrologic Restoration Indicator Stand 1210321

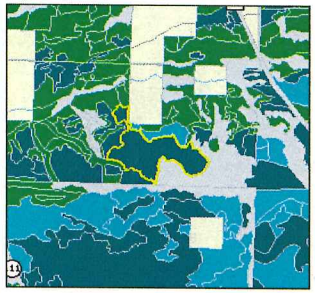
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15330w1210321

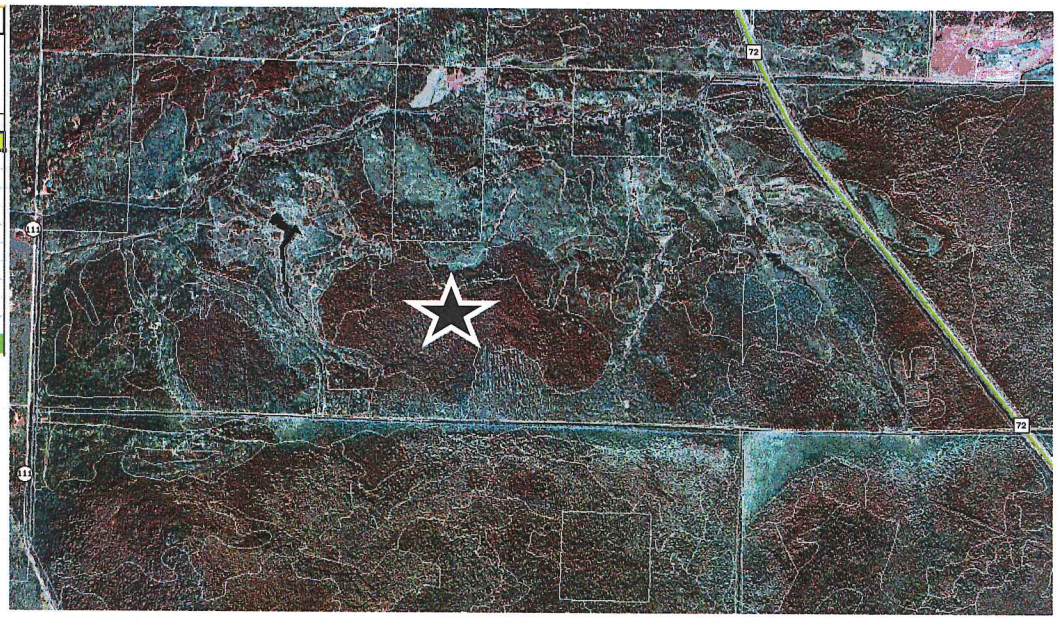
(No NPC)

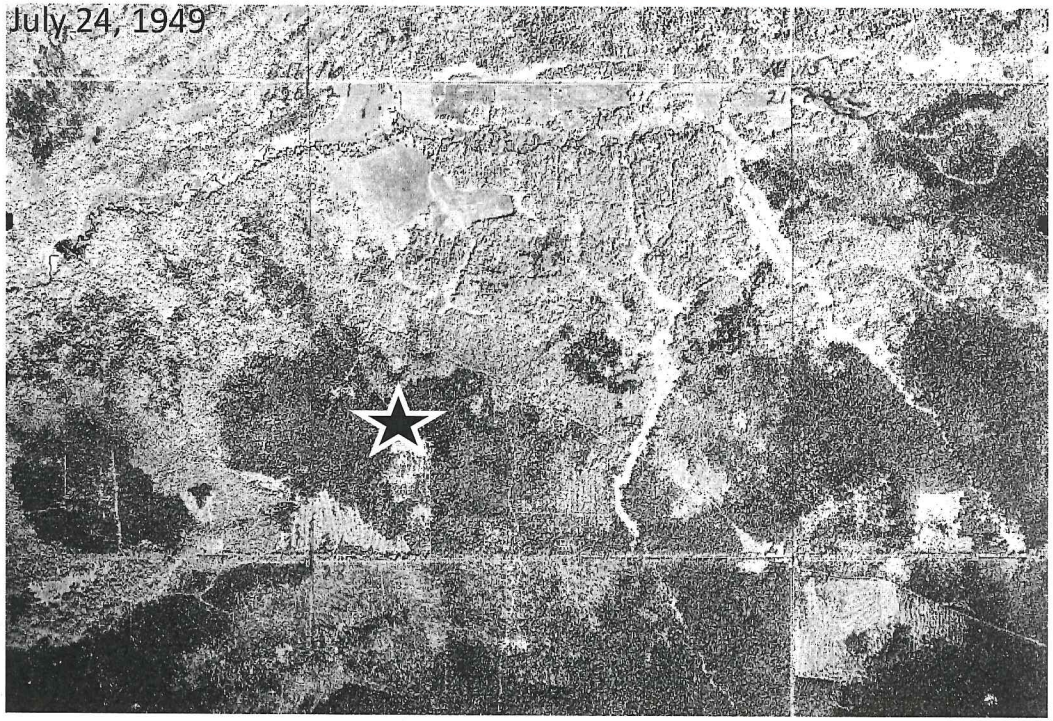
Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	24
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	121.8
Management Status	Restricted timber harvest alloved



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1982
Age at Inventory	111 years
Average Diameter Class	5 to 8.9 inches
Density Class	22.5-27.5 cords per acre
Basal Area	145 square feet per acre
Volume	24.0 cords per acre
Condition Class	Mature
Understory Type - Balsam Fir	
Average Diameter Class	0 to 0.9 inches
Density class	2,250-2,750 stems per acre

Stand Composition By Major Tree Species			
Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	20.6 cords	36 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Balsam Fir	8 inches	2.8 cords	Well distributed
Black Spruce	9 inches	1.1 cords	Well distributed





Located in Beltrami County
S11 T152 R30

Hydrologic Restoration Indicator Stand 1110261

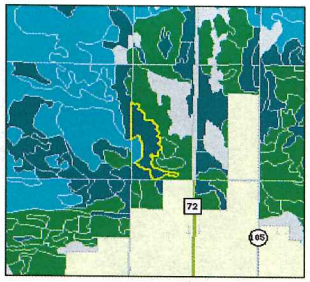
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15230w1110261

(No NPC)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	24
Physiographic Class	Hydric Site
Topography	Level
Stand Acres	54.2
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	2000
Age at Inventory	93 years
Average Diameter Class	5 to 8.9 inches
Density Class	17.5-22.5 cords per acre
Basal Area	153 square feet per acre
Volume	19.0 cords per acre
Condition Class	Immature
Understory Type - White Cedar	
Average Diameter Class	3 to 4.9 inches
Density class	250-750 stems per acre

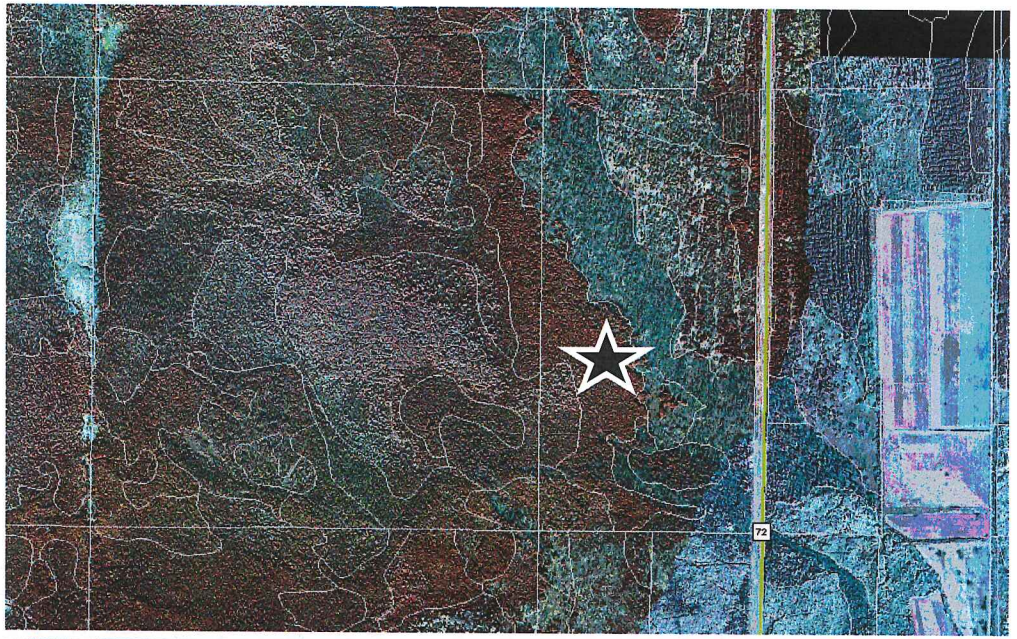
Stand Composition By Major Tree Species

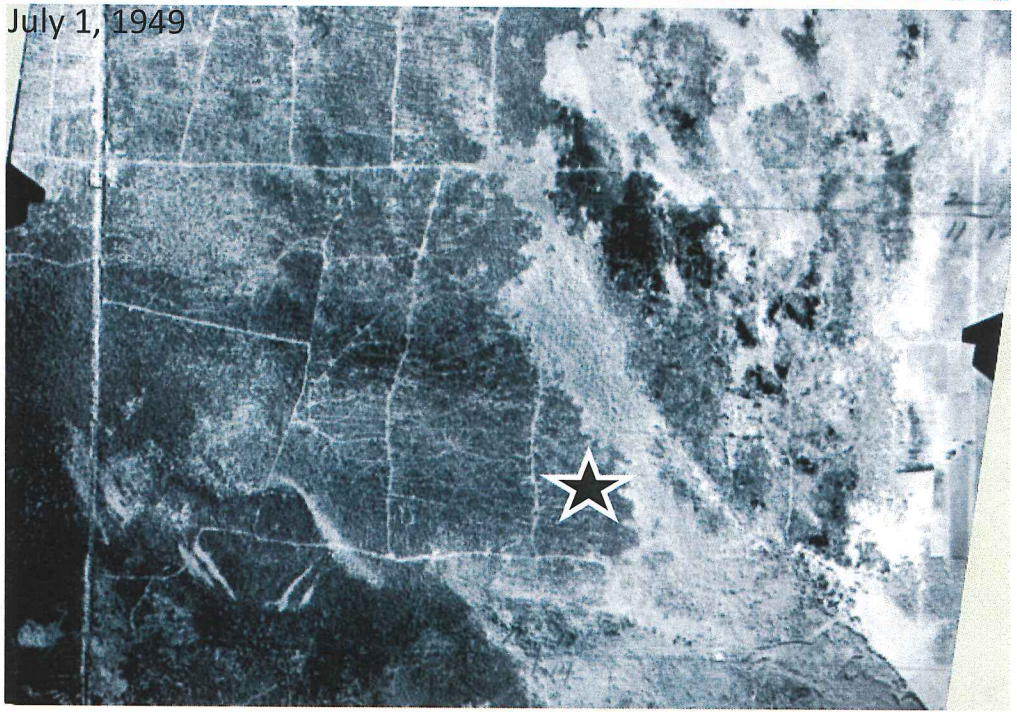
Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	17.7 cords	32 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Black Ash	9 inches	0.3 cords	Mod. well distributed
Paper Birch	6 inches	0.6 cords	Well distributed
Balm of Gilead	9 inches	0.3 cords	Mod. well distributed
Balsam Fir	6 inches	0.3 cords	Well distributed





Located in Beltrami County
S36 T154 R30

Hydrologic Restoration Indicator Stand 1360550

Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*											
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15430w1360550

FPn63 (Anez)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	26
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	58.9
Management Status	Normal timber harvest allowed

Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	2007
Age at Inventory	73 years
Average Diameter Class	5 to 8.9 inches
Density Class	17.5-22.5 cords per acre
Basal Area	133 square feet per acre
Volume	21.0 cords per acre
Condition Class	Mature
Understory Type - White Cedar	
Average Diameter Class	0 to 0.9 inches
Density class	250-750 stems per acre

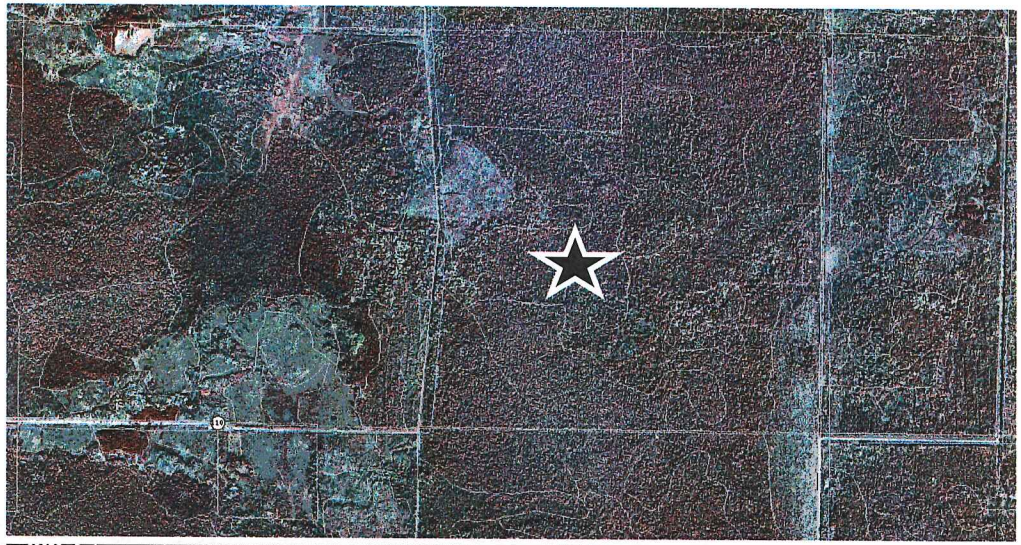
Stand Composition By Major Tree Species

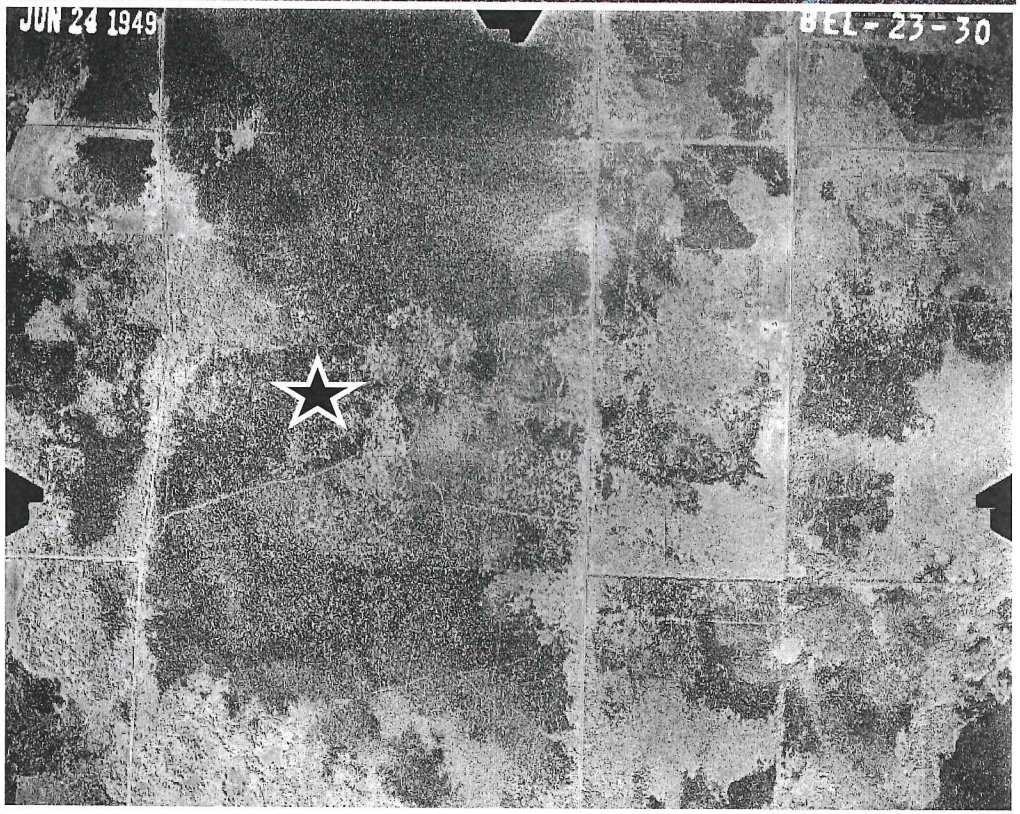
Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	15.6 cords	37 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Paper Birch	7 inches	0.7 cords	Patchy
Balsam Fir	7 inches	0.7 cords	Patchy
Black Spruce	8 inches	1.3 cords	Well distributed
Tamarack	10 inches	2.7 cords	Well distributed



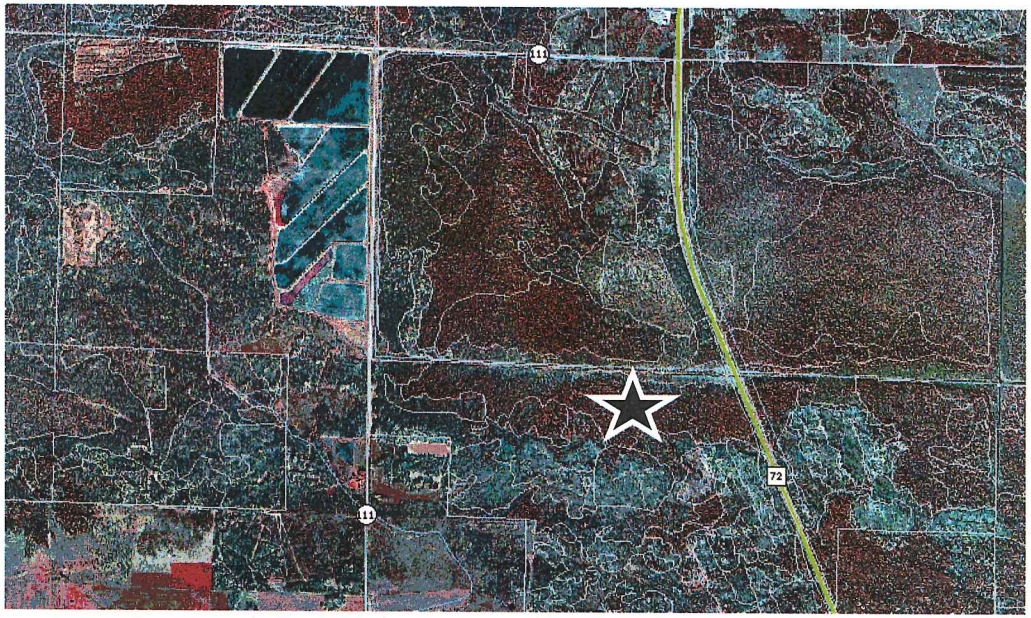


Located in Beltrami County
S8 T153 R30

Hydrologic Restoration Indicator Stand 1080080

Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															



Stand ID t15330w1080080

FPn63 (Tjader)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	24
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	108.4
Management Status	Normal timber harvest allowed

Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1982
Age at Inventory	144 years
Average Diameter Class	5 to 8.9 inches
Density Class	17.5-22.5 cords per acre
Basal Area	126 square feet per acre
Volume	20.0 cords per acre
Condition Class	Mature
Understory Type - White Cedar	
Average Diameter Class	1 to 2.9 inches
Density class	750-1250 stems per acre

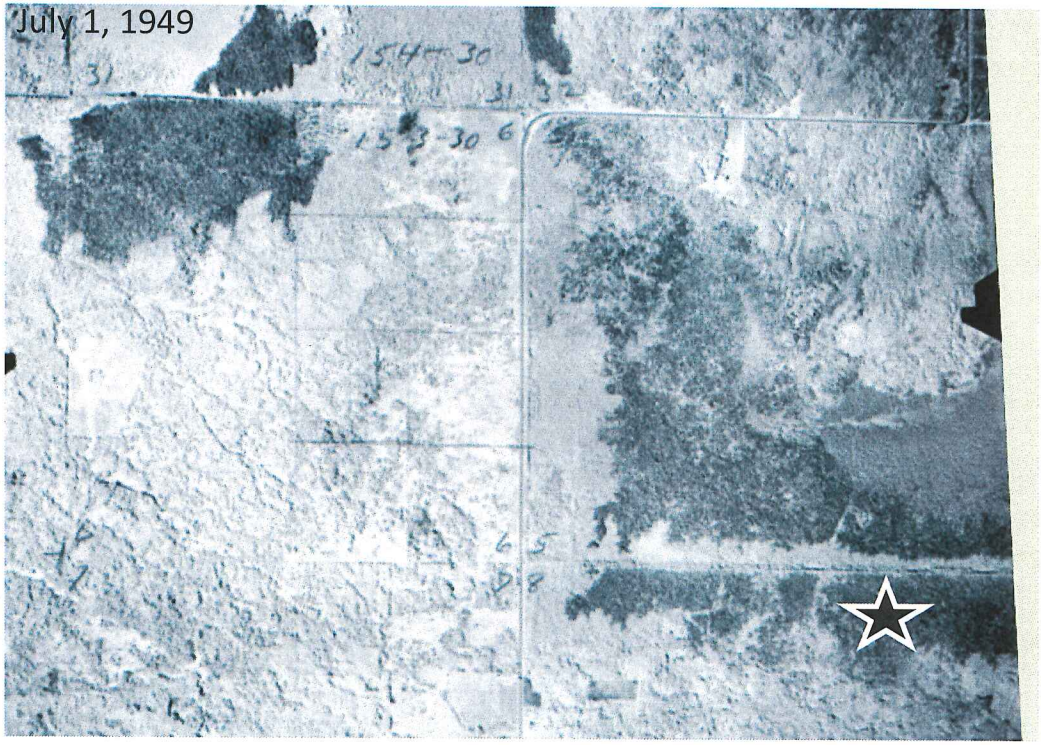
Stand Composition By Major Tree Species

Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	15.0 cords	37 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Paper Birch	8 inches	0.3 cords	Mod. well distributed
Black Spruce	7 inches	4.5 cords	Well distributed
Black Spruce	7 inches	0.4 cords	Patchy
Northern White Cedar	8 inches	0.3 cords	Patchy



Located in Beltrami County
S2 T153 R30

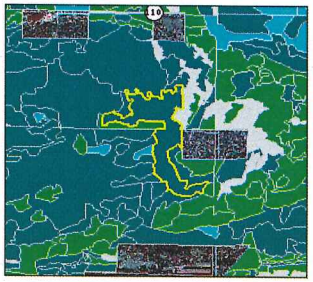
Hydrologic Restoration Indicator Stand 1020071

Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15330w1020071

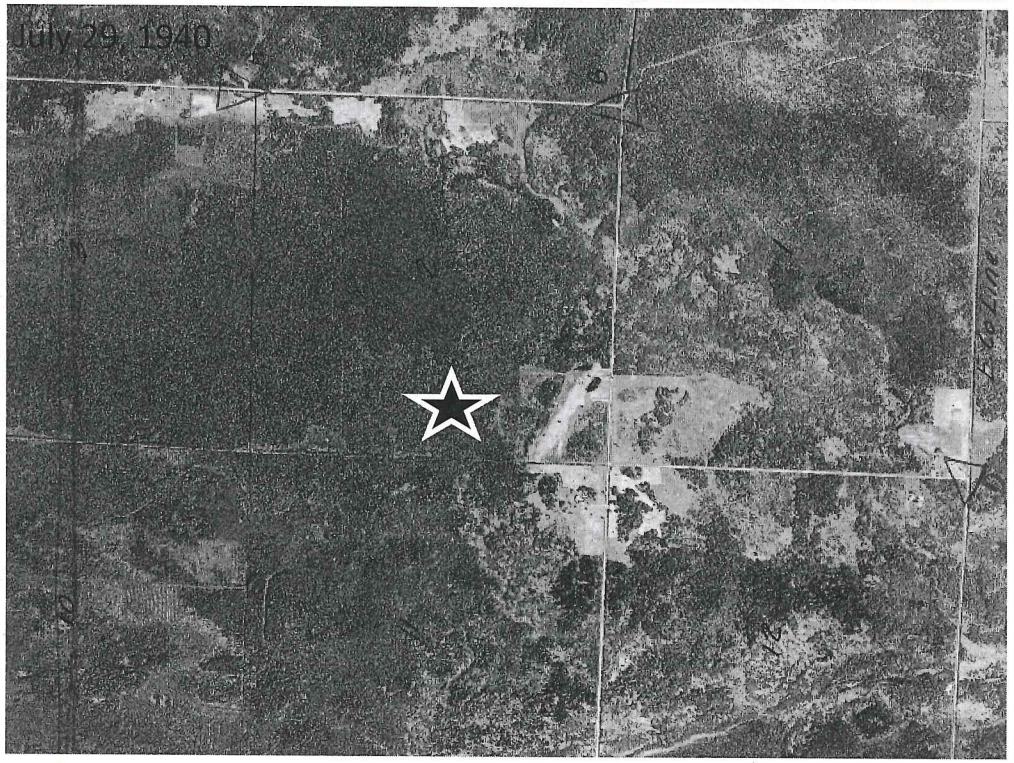
FPn63 (Bates)



Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	23
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	139.9
Management Status	Normal timber harvest allowed

Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1982
Age at Inventory	111 years
Average Diameter Class	5 to 8.9 inches
Density Class	17.5-22.5 cords per acre
Basal Area	161 square feet per acre
Volume	21.0 cords per acre
Condition Class	Mature
Understory Type - White Cedar	
Average Diameter Class	0 to 0.9 inches
Density class	750-1250 stems per acre

Stand Composition By Major Tree Species			
Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	17.9 cords	33 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Paper Birch	8 inches	0.2 cords	Well distributed
Balsam Fir	6 inches	1.4 cords	Well distributed
Black Spruce	8 inches	1.2 cords	Well distributed
Tamarack	6 inches	0.4 cords	Well distributed



Located in Beltrami County
S6 T153 R30

Hydrologic Restoration Indicator Stand 106002

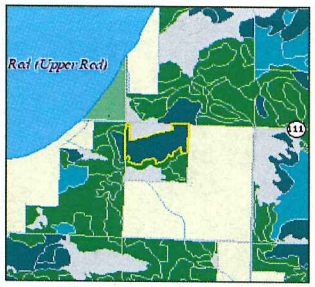
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15330w1060002

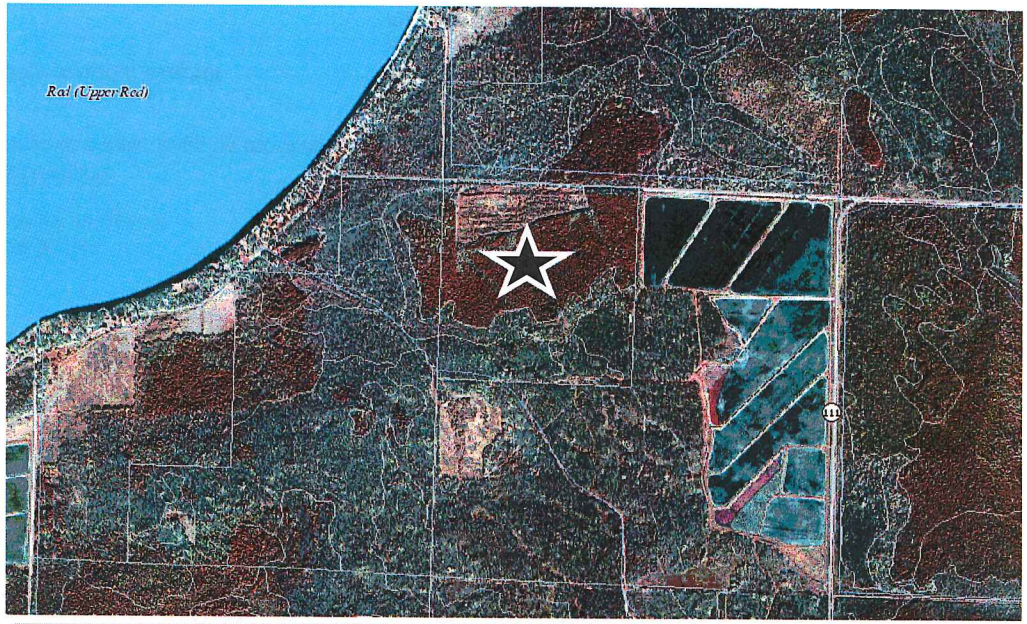
(No NPC)

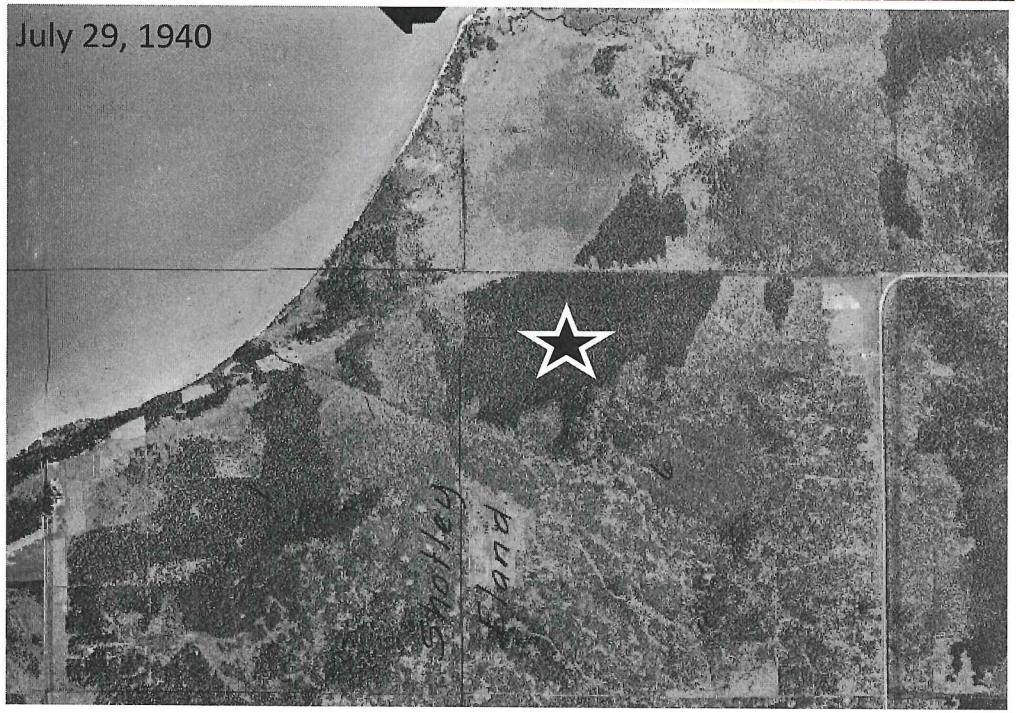
Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	28
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	73.0
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1982
Age at Inventory	121 years
Average Diameter Class	9 to 14.9 inches
Density Class	22.5-27.5 cords per acre
Basal Area	163 square feet per acre
Volume	25.0 cords per acre
Condition Class	Mature
Understory Type - Balsam Fir	
Average Diameter Class	0 to 0.9 inches
Density class	1,250-1,750 stems per acre

Stand Composition By Major Tree Species			
Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	9 inches	23.0 cords	41 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Balm of Gilead	6 inches	0.2 cords	Patchy
Balm of Gilead	7 inches	0.4 cords	Patchy
Balsam Fir	7 inches	1.0 cords	Well distributed





Located in Beltrami County
S22 T153 R30

Hydrologic Restoration Indicator Stand 1220534

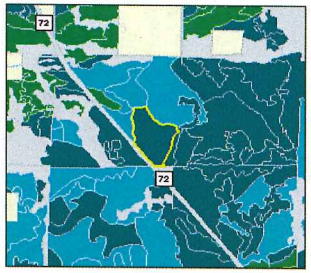
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data (consolidated)										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15330w1220534

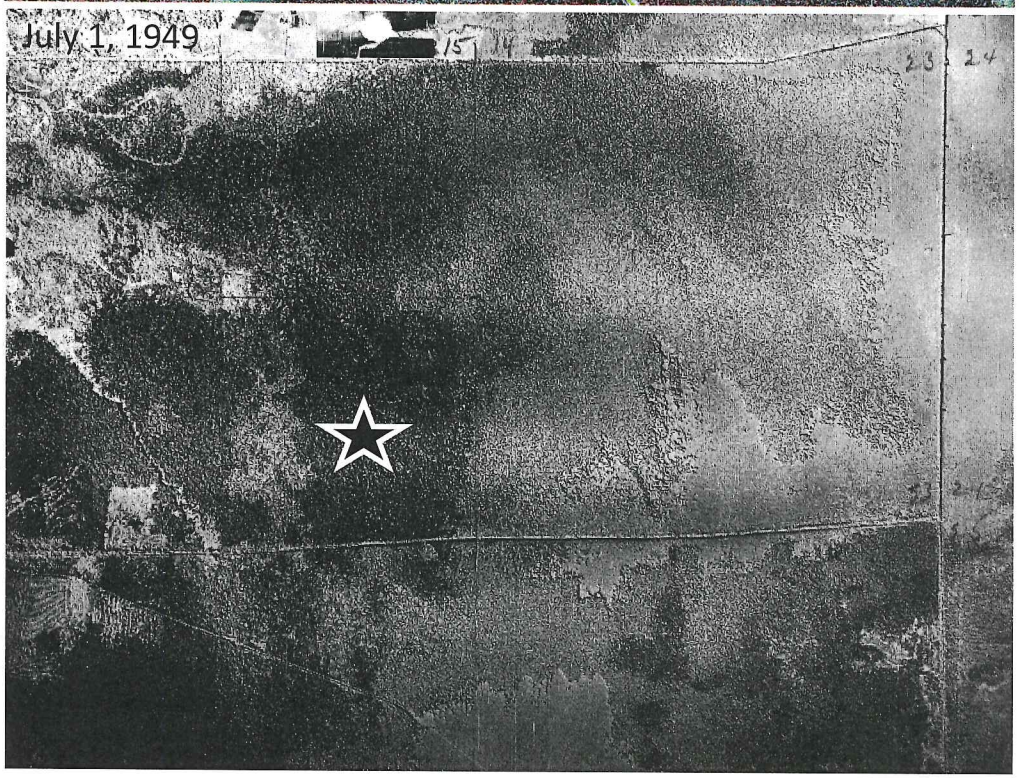
FPn63 (Tjader)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	24
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	73.1
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1998
Age at Inventory	91 years
Average Diameter Class	5 to 8.9 inches
Density Class	7.5-12.5 cords per acre
Basal Area	138 square feet per acre
Volume	11.0 cords per acre
Condition Class	Mature
Understory Type - Tamarack	
Average Diameter Class	0 to 0.9 inches
Density class	4,250+ stems per acre

Stand Composition By Major Tree Species			
Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	6 inches	5.9 cords	35 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Black Spruce	6 inches	3.2 cords	Well distributed
Tamarack	9 inches	1.7 cords	Well distributed

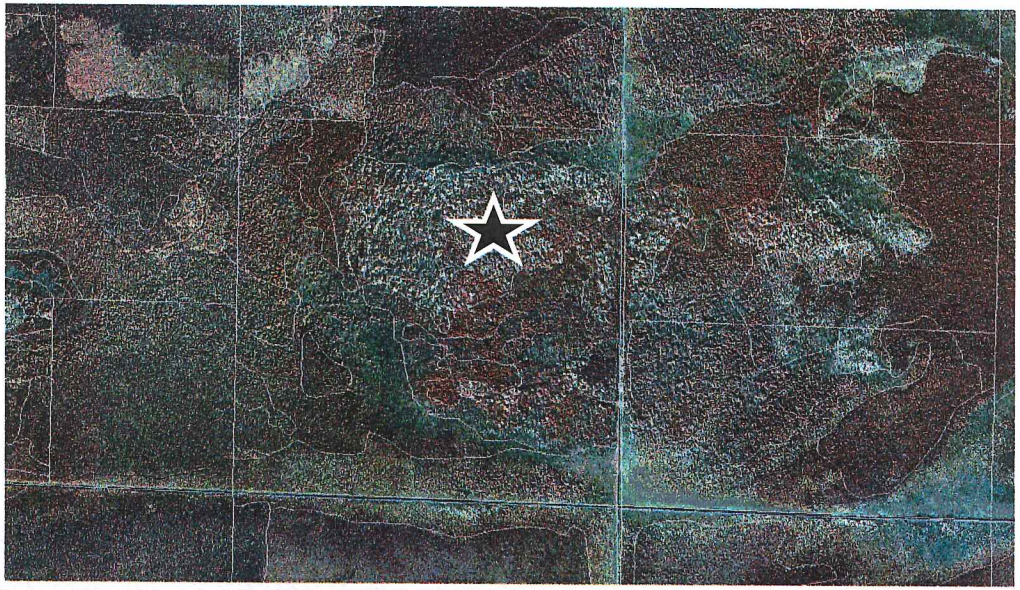


Located in Beltrami County
S32 T156 R30

Hydrologic Restoration Indicator Stand 1320045

Vegetation

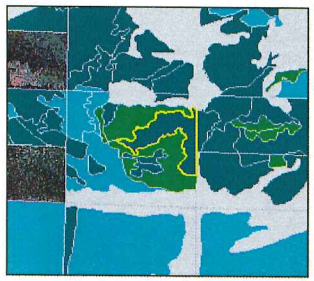
Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND IDN	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															



Stand ID t15630w1320045

(No NPC)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	30
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	89.6
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	2007
Age at Inventory	41 years
Average Diameter Class	5 to 8.9 inches
Density Class	12.5-17.5 cords per acre
Basal Area	80 square feet per acre
Volume	17.0 cords per acre
Condition Class	Immature
Understory Type - Balsam Fir	
Average Diameter Class	0 to 0.9 inches
Density class	250-750 stems per acre

Stand Composition By Major Tree Species

Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	7 inches	6.2 cords	41 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Black Ash	8 inches	3.7 cords	Mod. well distributed
Trembling Aspen	6 inches	3.0 cords	Well distributed
Paper Birch	8 inches	1.1 cords	N/A
Balm of Gilead	6 inches	0.6 cords	Well distributed
Balsam Fir	6 inches	1.9 cords	Mod. well distributed
Black Spruce	6 inches	0.5 cords	Patchy

Located in Beltrami County
S11 T153 R31

Hydrologic Restoration Indicator Stand 1110322

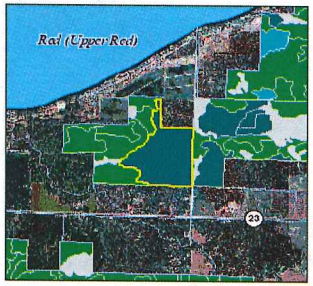
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data (consolidated)											
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15331w1110322

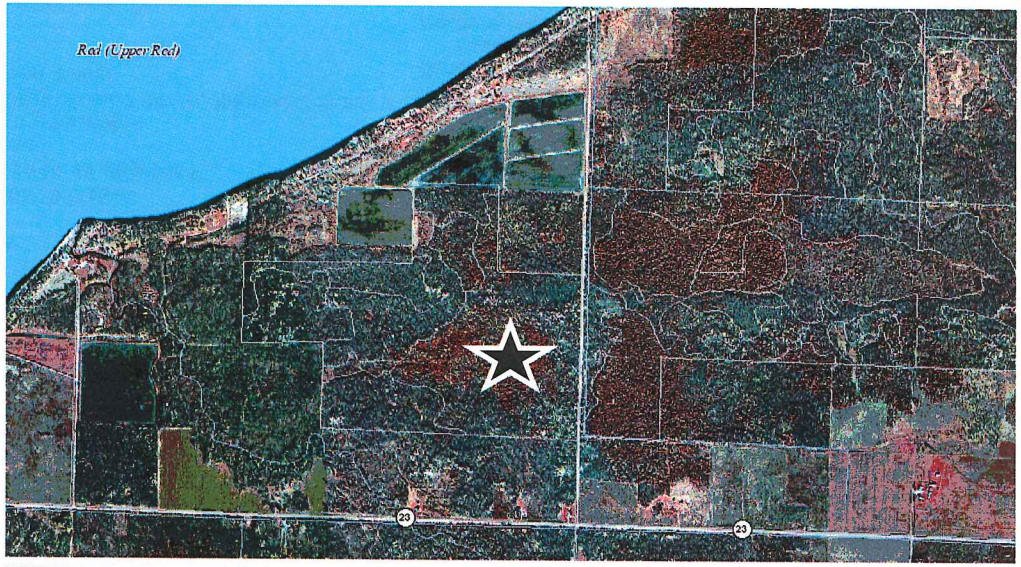
(No NPC)

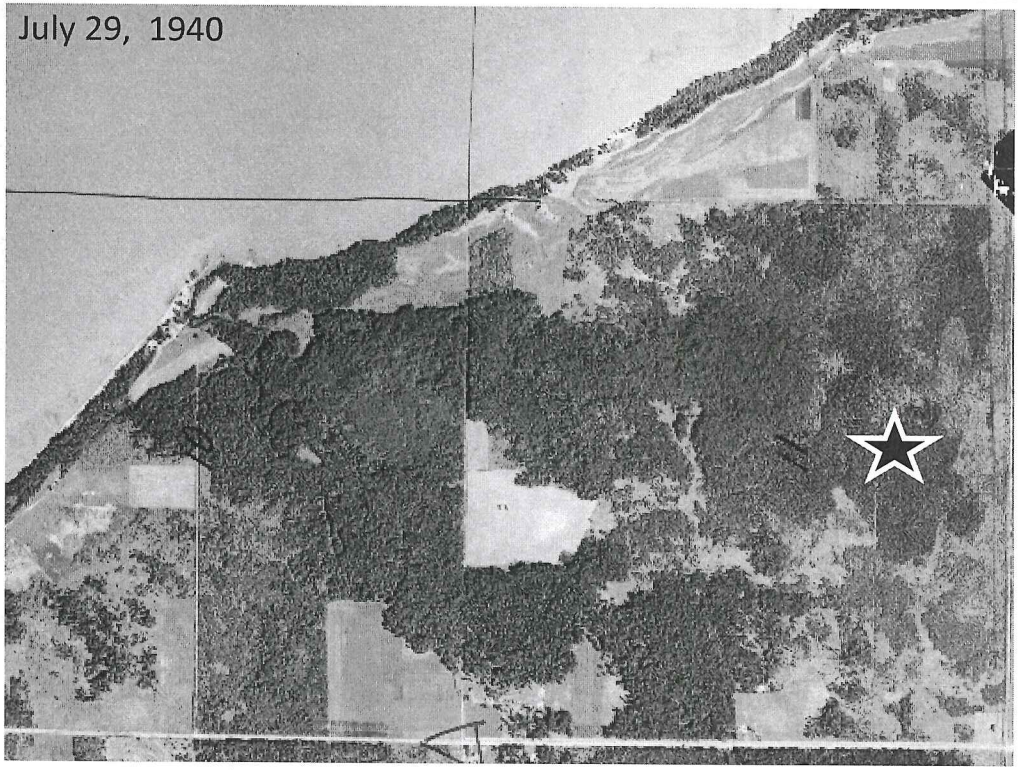
Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	37
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	141.7
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1999
Age at Inventory	84 years
Average Diameter Class	5 to 8.9 inches
Density Class	27.5-32.5 cords per acre
Basal Area	140 square feet per acre
Volume	32.0 cords per acre
Condition Class	Immature
Understory Type - Black Ash	
Average Diameter Class	0 to 0.9 inches
Density class	2,750-3,250 stems per acre

Stand Composition By Major Tree Species			
Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	18.8 cords	51 feet
Other Species			
Species	Average DBH	Volume per acre	Distribution
Black Ash	9 inches	1.3 cords	Mod. well distributed
Trembling Aspen	10 inches	2.5 cords	Mod. well distributed
Paper Birch	8 inches	5.3 cords	Well distributed
Green Ash	6 inches	1.4 cords	Well distributed





Located in Beltrami County
S19 T153 R31

Hydrologic Restoration Indicator Stand 1190171

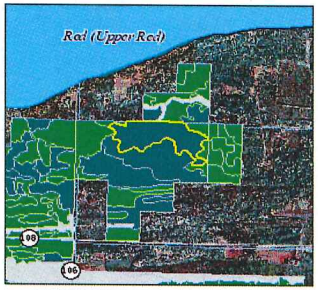
Vegetation

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t15331w1190171

(No NPC)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	30
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	93.0
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1999
Age at Inventory	67 years
Average Diameter Class	9 to 14.9 inches
Density Class	17.5-22.5 cords per acre
Basal Area	148 square feet per acre
Volume	22.0 cords per acre
Condition Class	High Risk
Understory Type - Balsam Fir	
Average Diameter Class	0 to 0.9 inches
Density class	2,250-2,750 stems per acre

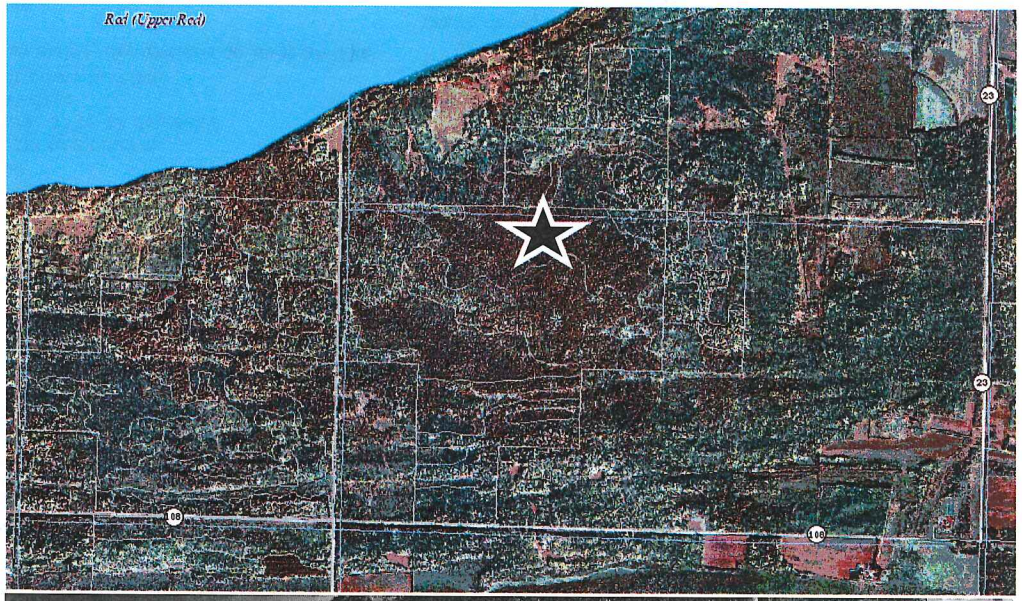
Stand Composition By Major Tree Species

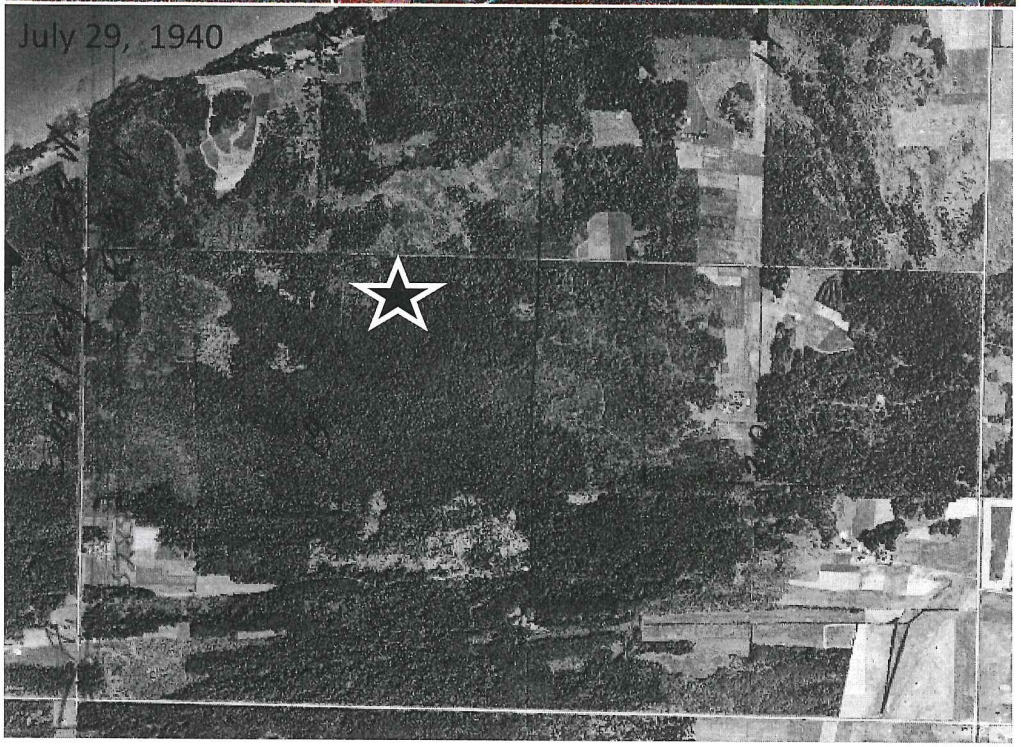
Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	9 inches	16.0 cords	37 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Trembling Aspen	8 inches	1.5 cords	Mod. well distributed
Balm of Gilead	7 inches	0.5 cords	Mod. well distributed
Balsam Fir	7 inches	1.9 cords	Well distributed
Black Spruce	10 inches	1.1 cords	Mod. well distributed

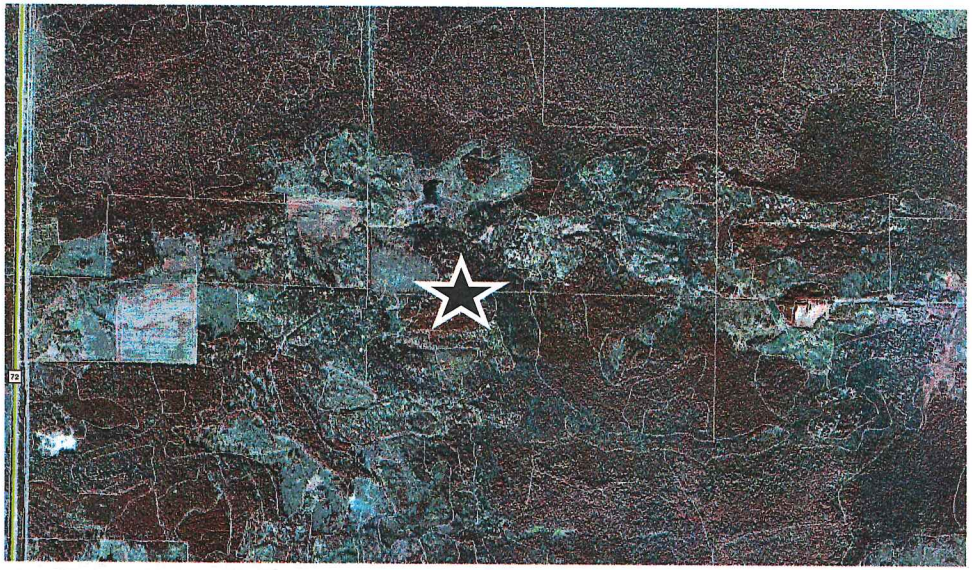




Located in Beltrami County
S34 T154 R30

Hydrologic Restoration Indicator Stand 1340530
"Nyberg Trail" Site

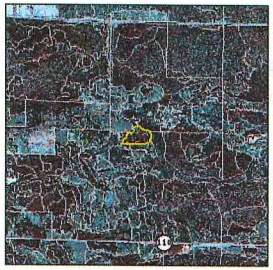
Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*											
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
Trail				t15430w1340530	530 C47	17.8	73	3	3	74	4	2	218	33	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															



Stand ID t15430w1340530

MHn44 (Tjader)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	33
Physiographic Class	Mesic Site
Topography	Level
Stand Acres	17.8
Management Status	Normal timber harvest allowed

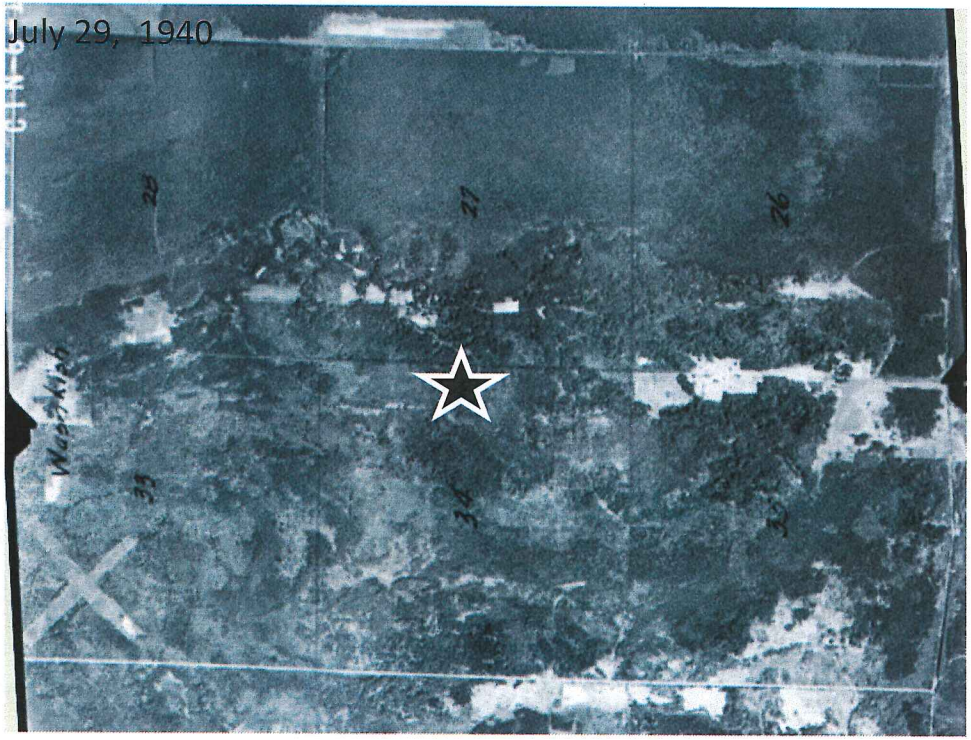


Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	2004
Age at Inventory	74 years
Average Diameter Class	5 to 8.9 inches
Density Class	32.5-37.5 cords per acre
Basal Area	218 square feet per acre
Volume	32.7 cords per acre
Condition Class	Immature
Understory Type - White Cedar	
Average Diameter Class	3 to 4.9 inches
Density class	1,250-1,750 stems per acre

Stand Composition By Major Tree Species

Main Species			
Species	Average DBH	Volume per acre	Height
Northern White Cedar	7 inches	21.0 cords	44 feet

Other Species			
Species	Average DBH	Volume per acre	Distribution
Trembling Aspen	12 inches	0.8 cords	Patchy
Paper Birch	8 inches	2.2 cords	Well distributed
Balm of Gilead	12 inches	7.5 cords	Well distributed
Balsam Fir	7 inches	1.2 cords	Mod. well distributed



Located in Beltrami County
S24 T153 R32

Hydrologic Restoration Indicator Stand 1240108
"Nyberg Trail" Comparison Site

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data (consolidated)												
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
				t15332w1240108	108C59	11.6	12	1	2	97	4	3	238	41	73
Trail				t15430w1340530	530 C47	17.8	73	3	3	74	4	2	218	33	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County																

Stand ID t15332w1240108

MHn44 (Bates)

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	41
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	11.6
Management Status	Normal timber harvest allowed

Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	2008
Age at Inventory	97 years
Average Diameter Class	9 to 14.9 inches
Density Class	42.5+ cords per acre
Basal Area	238 square feet per acre
Volume	2800 board feet plus 39.8 cords per acre
Condition Class	Immature
Understory Type - Aspen	
Average Diameter Class	0 to 0.9 inches
Density class	750-1250 stems per acre

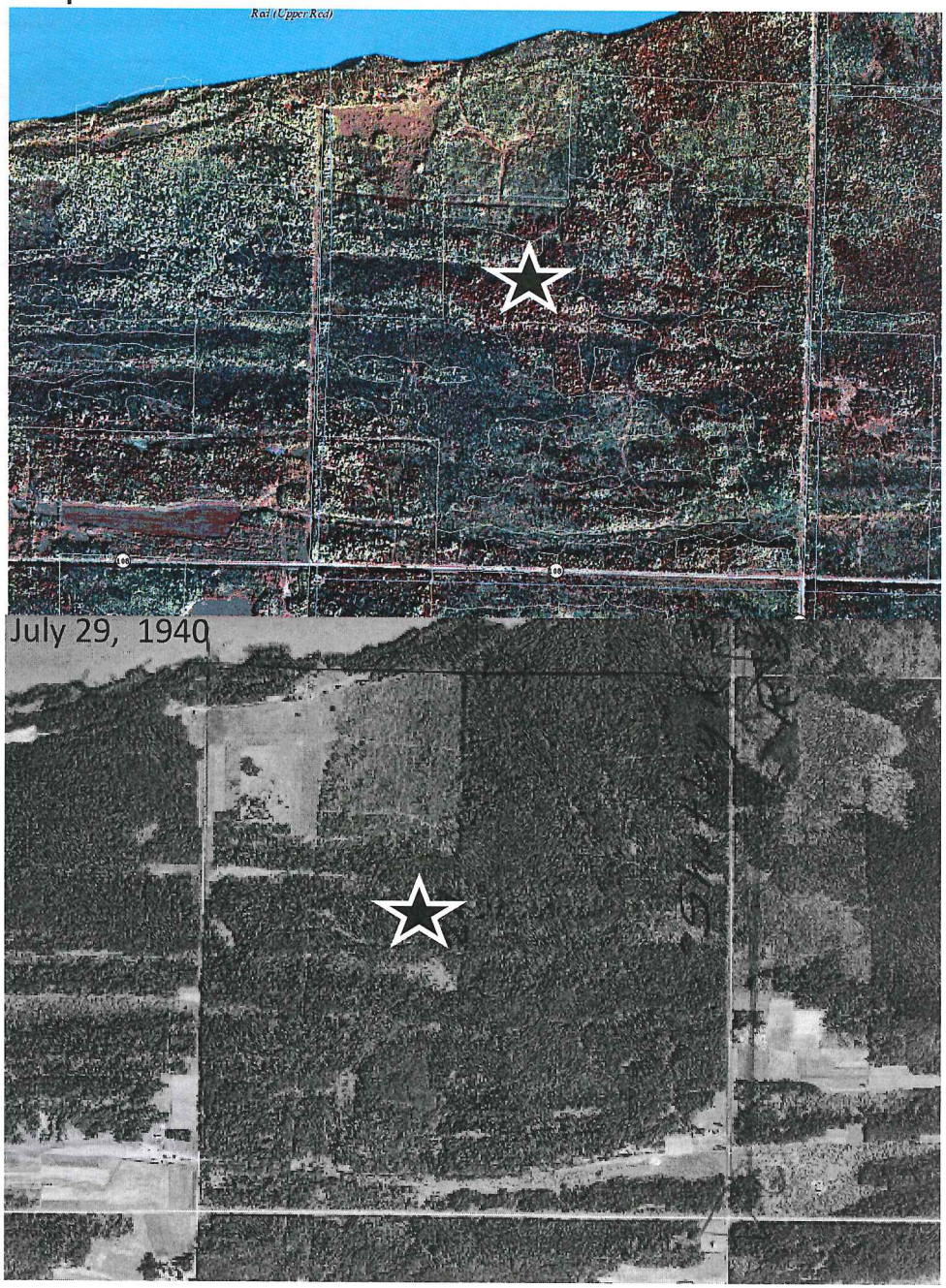
Stand Composition By Major Tree Species

Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	10 inches	34.5 cords	63 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Black Ash	10 inches	0.5 cords	Patchy
Trembling Aspen	19 inches	2400 board feet	Well distributed
Paper Birch	8 inches	4.3 cords	Well distributed
Balm of Gilead	18 inches	200 board feet	N/A
White Spruce	17 inches	300 board feet	N/A
Black Spruce	7 inches	0.5 cords	Patchy



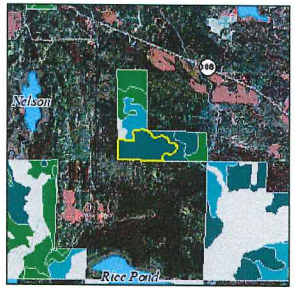
Located in Beltrami County
S10 T148 R31

Hydrologic Restoration Indicator Stand 1100036

Restoration Potentials Level 1 Assessments				MnDNR/Forestry Cooperative Stand Assessment Data *(consolidated)*										
Drainage Impediment	Feasibility and Landscape Value 1=low 3=good	Stand Condition 1=low 8=good	Assessment Ranking 1=low 3=good	STAND LOCATION and STAND ID#	SLABEL	AC	UTYPE	USIZE	UDEN	AGE	PHYS	COND	BA	SI	SPECIES
		5	1+2+2	t15330w1050072	72 C42	77.4	73	2	2	117	4	2	85	23	73
Ditch	LV=3	3	1+0+2	t15330w1210321	321 C45	121.8	62	1	5	111	4	2	145	24	73
Road	LV=3	3	1+1+1	t15230w1110261	261 C44	54.3	73	3	1	93	5	3	153	24	73
		4	1+1+2	t15430w1360550	550 C 44	58.9	73	1	1	73	4	2	133	26	73
		5	1+2+2	t15330w1080080	80 C44	108.4	73	2	2	144	4	2	126	24	73
		5	1+2+2	t15330w1020071	71 C44	139.7	73	1	2	111	4	2	161	23	73
Road	LV=2	3	1+0+2	t15330w1060002	2 C55	72.9	62	1	3	121	4	2	163	28	73
Road	LV=3	3	1+0+2	t15330w1220534	534 C42	73.1	72	1	9	91	4	2	138	24	73
		4	2+0+2	t15630w1320045	45 C 43	179.2	62	1	1	41	4	3	80	30	73
		4	2+0+2	t15331w1110322	322 C46	140.4	1	1	6	84	4	3	140	37	73
		4	2+0+2	t15331w1190171	171 C54	92.9	62	1	5	67	4	1	148	30	73
		8	3+3+2	t14831w1100036	36 C41	57.2	73	1	4	71	4	3	80	47	73
Beltrami County															

Stand ID t14831w1100036

Site Attributes	
County	Beltrami
DNR Forestry Area	Blackduck Area
Site Index	47
Physiographic Class	Hydromesic Site
Topography	Level
Stand Acres	57.5
Management Status	Normal timber harvest allowed



Stand Attributes	
Cover Type - White Cedar	
Year of Inventory	1999
Age at Inventory	71 years
Average Diameter Class	5 to 8.9 inches
Density Class	3-7.5 cords per acre
Basal Area	80 square feet per acre
Volume	7.0 cords per acre
Condition Class	Immature
Understory Type - White Cedar	
Average Diameter Class	0 to 0.9 inches
Density class	1,750-2,250 stems per acre

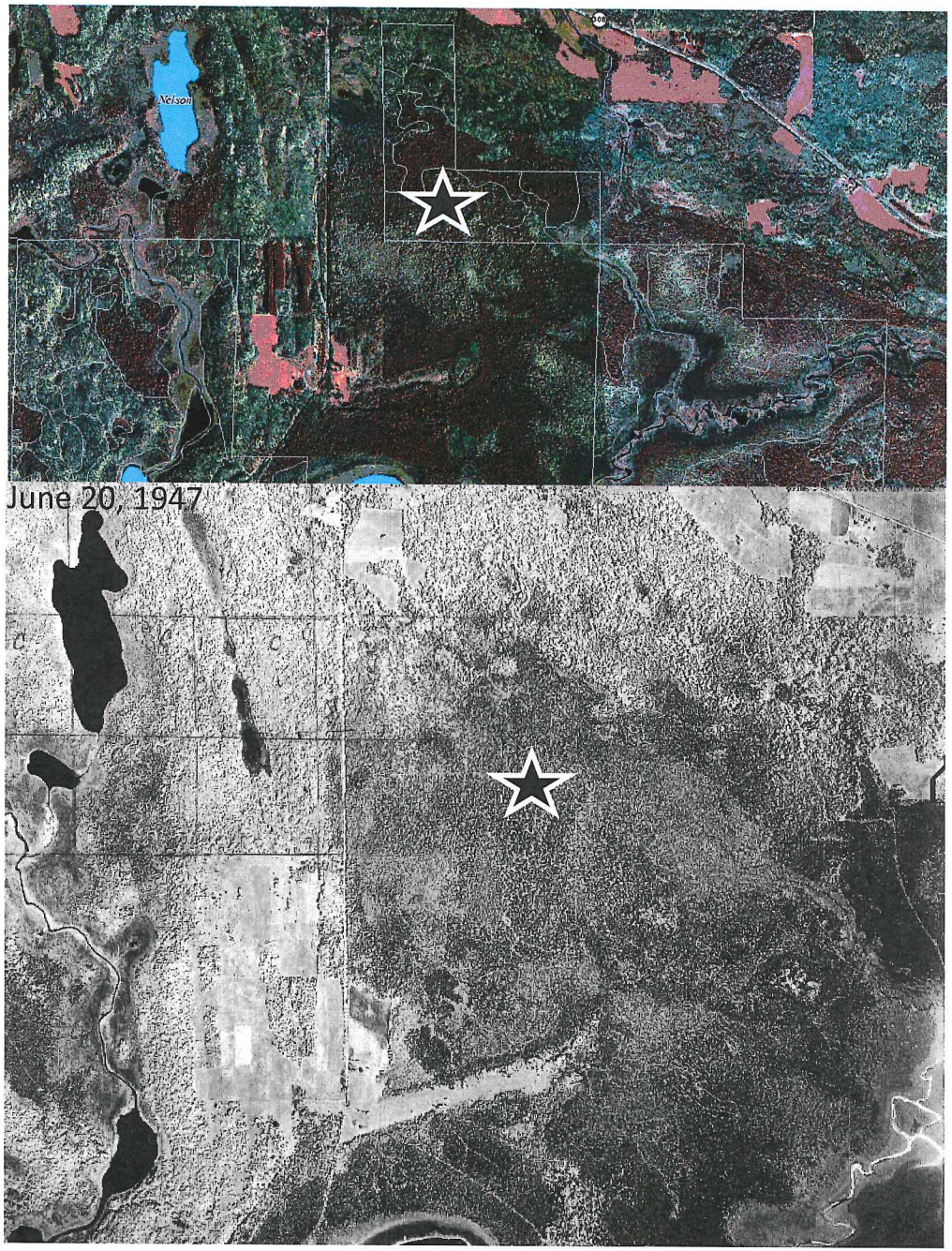
Stand Composition By Major Tree Species

Main Species

Species	Average DBH	Volume per acre	Height
Northern White Cedar	8 inches	4.5 cords	40 feet

Other Species

Species	Average DBH	Volume per acre	Distribution
Black Spruce	7 inches	0.7 cords	Mod. well distributed
Tamarack	8 inches	1.7 cords	Mod. well distributed



Northeast Minnesota White Cedar Plant Community Restoration: Phases I&II

Final Technical Report prepared for Environment and Natural Resources Trust Fund

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Introduction

Northern white-cedar (NWC) (*Thuja occidentalis*) grows in a variety of habitats including mesic forests, limestone cliffs, sand dunes, riparian systems, abandoned farm fields, and swamps (Johnston 1977, Kost et al. 2007). Most NWC swamps are typically found in areas with calcium rich groundwater (Johnston, 1977). Northern white cedar swamps are valuable ecosystems in the Great Lakes region for several reasons: 1) NWC swamps are peatlands, which are an important component of the global carbon cycle because they both sequester carbon and emit the greenhouse gas methane (Gorham 1991, Roulet 2000). NWC swamps might be one of the major stores of carbon in the Great Lakes region (Ott 2013), 2) Cedar swamps are valuable wildlife habitat, particularly as thermal cover and browse during winters for deer, 3) Ojibwe tribes use cedar for medicine and ceremony (Rooney et al. 2002, Boulfroy et al. 2012), 4) NWC swamps are one of the most biodiverse ecosystems and are home to many rare species of plants and animals, and 5) NWC occupies more than 2 million hectares of commercial forest land in the northern Lake states (Johnston, 1977) and is an important forestry tree because the rot- and termite-resistant wood is used for products in contact with water and soil (e.g., houses, fence posts, decks, saunas, furniture and shingles). However, despite the importance of cedar swamps, they are an endangered ecosystem because there has been a problem regenerating cedar for over 70 years (Heitzman et al. 1997).

Over-browsing by white-tailed deer is possibly the most well-known factor contributing to regeneration failure in cedar (Curtis 1946, Rooney et al. 2002, Haworth 2011, Boulfroy et al. 2012). Deer find NWC to be particularly tasty, and they rely on cedar as a food source in the winter, when many other nutritious food sources are absent or scarce (Johnston 1977). The dense canopies that are typical of a healthy cedar stand also provide a thermal cover for deer and other wildlife (Johnston 1977, Johnston 1990, Pregitzer 1990, Doepker and Ozoga 1991, Heitzman et al. 1999, Rooney et al. 2002, Boulfroy et al. 2012). Heavily browsed cedar stands are likely to experience inadequate recruitment of young cedar into the overstory, which creates a negative feedback loop that jeopardizes the health and survival of the deer population. Managers believe that deer browse on cedar may be reduced by deep snow packs, small stands, distance from traditional yarding areas, cutting during years of low deer abundance, distance from forest harvesting, protection by tops left by harvesting, or distance from roads (Heitzman et al 1999;

Forester et al 2008); however, most of these concepts are derived from observations with little scientific testing conducted.

Explanations for the lack of cedar regeneration have been concerned mainly with either silvicultural practices (i.e. cutting intensity, seedbed preparation, slash piles, incident light) or with overbrowsing by wildlife (Nelson 1951, Smith and Borczon 1981, Verme and Johnson 1986, Pregitzer 1990, Haworth 2011, Larouche et al. 2011). Both of these factors are important for cedar regeneration, but it is also imperative to understand the problem from an ecosystem level. Managing a species requires understanding not only of the species, but also the ecosystem in which the species inhabits. In this case, northern white cedar is a wetland tree that grows in forested peatlands. However, there have only been a few studies that have tried to understand cedar swamps from an ecosystem or hydrological viewpoint (Satterlund 1960, Chimner and Hart 1996), and there has never been an in-depth study treating cedar as a wetland tree. Forested wetlands are controlled by different processes than other forest types, and require different measurements and methods to quantify what controls tree distribution, production and regeneration. We also need to understand cedar as part of a wetland ecosystem to be able to predict changes to cedar due to changes in climate or other human disturbances (e.g., road building, development, forestry practices and climate change).

Water-plant relations appear to play an important role in cedar success. Microtopography has been found to be a key feature contributing to successful cedar regeneration across different habitat types (Nelson 1951, Caulkins 1967, Holcombe 1976, Scott and Murphy 1987, Chimner and Hart 1996, Cornett et al. 2000, Cornett et al. 2001, Forester et al. 2008). In both dune forests and lowland areas, decaying logs create favorable microsites for cedar germination and growth by retaining an intermediate level of moisture (Holcombe 1976, Scott and Murphy 1987, Forester et al. 2008). In wetland sites, cedars also do well on hummocks which protrude from the water, probably because their roots have been relieved from the stressful anaerobic conditions of water-logged soils (Chimner and Hart 1996). Understanding the importance of these different microsite types in cedar growth may become especially important to implementing successful cedar restoration as climates change.

Roads and other hydrological disturbances can also influence NWC regeneration. Forester et al. (2008) found that cedar density had a negative relationship with proximity to roads. Abiotic and/or biotic factors may explain this relationship. The road-side edge of cedar swamps may

serve as both a corridor and refugia for deer, which could potentially cause these to be areas of high browse (Forester et al. 2008). Alternately, or possibly additionally, roads are known to alter the hydrology and water quality in adjacent wetland areas (Forester et al. 2008), and roadside sodium and chloride levels are specifically known to be injurious to northern white cedar (Hofstra and Hall 1971). Understanding the role of edge effects on cedar swamps should be important in deciding restoration priorities.

The importance of forested wetlands and lack of restoration knowledge is currently at the forefront in the Great Lakes region. To exemplify this point, a conference was held in Traverse City MI, by The Association of State Wetland Managers, Inc., Michigan Department of Environmental Quality, Grand Traverse Band of Ottawa and Chippewa Indians, and U.S. Environmental Protection Agency, highlighting the complexities of restoration of northern forested wetlands. The special symposium was titled: ***"Restoration of Northern Forested Wetlands.*** *The science of restoring forested wetlands in the north has lagged behind bottomland hardwoods and other forested wetland types. A series of presentations will be devoted to identifying gaps and improving the science.*" It is clear from the lack of published papers and from symposiums such as this, that NWC swamp restoration is not common, and is mostly guided by poorly tested silvicultural guidelines (Johnston 1990, Boulfroy et al 2012). Because northern white-cedar swamps are in a state of decline and restoration techniques for them are lacking, **the overall objectives of this research were: 1) to assess and prioritize the condition and restoration potential of cedar swamps in N. Minnesota, 2) quantify the feasibility of restoring NW cedar plants by using enrichment plantings, and 3) Design and implement experimental hydrologic restoration of two NW cedar wetlands where they have been hydrologically modified by roads, and 4) Develop recommendations for NW cedar swamps restoration for Minnesota.**

Methods for Cedar Enrichment

Site Descriptions and Treatments

We established seven unique experimental enrichment restoration sites in NWC swamps in Beltrami, Koochiching, St. Louis, and Lake Counties. These sites have primarily organic soil and are less than 80 acres in size. Five of these sites currently have experimental treatments and

the other two sites are currently only being monitored as reference sites. Treatments vary across sites and are detailed by site in the sections below.

Northern white cedar seedlings (3-0), as well as northern white cedar transplants (2-2) were purchased from Badoura State Forest nursery (Akeley, MN). Trees were lifted from their growing medium on May 21, 2013, and shipped May 30, 2013. Upon reception, boxes were covered in cold tarp and placed in cold storage. Tree health was vigorous, and the substantial roots (typically about 24" long) required nominal pruning (to 16"-18" long) prior to installation. After pruning, roots were dipped in Terra-Sorb solution (Plant Health Care, Inc., Pittsburgh, PA). Trees were then placed in a tub with a moss-lined bottom and tops were rinsed to remove dirt. During transport to sites, trees were covered by a thermal cold-tarp to prevent wind damage. Upon arrival at the restoration sites, trees were brought to a central location within the planting site that was protected from shade and sun. Here, the planters placed trees in bags for ease of transport within the site. Planting was done by the Conservation Corps of Minnesota and Iowa, trained by and working under direct supervision of BWSR staff.

Installation of trees involved opening a deep hole (about 40 cm) with a sharpshooter-planting spade. Roots were gently pushed to the bottom of this hole, and then the plant was pulled up to the appropriate depth. The spade was then inserted into the ground adjacent to the hole, and was used to close the hole by pushing soil toward first the bottom and then the top of the hole, with a final packing from the surface of the soil to remove any air bubbles. All trees were planted by June 5, 2013.

Cedar protection from herbivory was accomplished through the use of rigid tree protectors (for 3-0 cedar seedlings) and wire mesh enclosures (for 2-2 cedar transplants) (Figure 1). The rigid tree protectors are 5" in diameter and 4' tall and are secured with three zip ties to a bamboo rod (16-20 mm in diameter by 6' tall), driven 2' into the ground. The wire mesh enclosures were 32" diameter and 4' tall and made of 16-gauge wire mesh (2"x4"). They were secured using eight 6" sod staples, although loose top soil conditions at the sites mandated the additional use of four 4'bamboo stakes.

Figure 1. Photo showing the wire cages and plastic rigid tree protectors.

Northern white cedar seeds were gathered at the Badoura State Forest nursery with 70% germination rate. Seeding was performed by hand broadcast and spot application. Seeds were broadcast preferentially over areas that would favor germination, such as mossy patches or decaying logs; however, locations of seed dispersal were not precisely recorded. All seeding was completed by June 16, 2013.

DNR Stand #649

This Beltrami County site (13 acres) was a mixed tamarack (site index = 37) stand that was cutover in 2011, removing dead tamarack and leaving behind northern white cedar (Figure 2). There is currently a low volume residual cedar overstory with scattered paper birch. Low-density regeneration is dominated by balsam fir with paper birch and alder, with little cedar regeneration. It is likely that hydrology is being influenced by the nearby road. The Web Soil Survey lists this site as having Bullwinkle (60%) and Tawas (40%) mucks (Soil Survey Staff).

Along the perimeter of the site, 250 cedar transplants were planted every 20 feet. Fifty wire mesh enclosures were installed on every fourth tree on the west boundary, and every fifth tree on the highway side. From a total of 250 cedar seedlings, approximately 80 were planted every 20

feet in each of three north-south transects, with a rigid tree protector installed on every fourth tree (50 total protectors). Every planted, unprotected cedar tree was marked with a blue ribbon. Between transects, 500 tamarack seedlings (2-0) were installed at 20 foot by 20 foot spacing. Forty ounces of northern white cedar seed was broadcast along the perimeter and down the center transect.

Figure 2. Aerial photo of site #649 (yellow outline) in Beltrami County.

DNR Stand #664

This Beltrami County site is a 21.6-acre, former cedar swamp that was cutover about 26 to 30 years ago and converted to a tamarack (site index = 47) plantation (Figure 3). The Native Plant community is Northern Very Wet Ash Swamp (WFn64) in the south and Northern Wet Cedar Forest (WFn53) in the north (Minnesota Department of Natural Resources 2003). Just prior to implementation of treatments, it was a young, understocked tamarack stand with very little cedar regeneration restricted to nurse logs in the northwest corner and nominal understory that is not representative of a cedar swamp. There is possible hydrological alteration. The Web Soil Survey

lists this site as having Northwood-Berner complex (49%), Grygla loamy fine sand (49%), and Bullwinkle muck (2%) soil types (Soil Survey Staff).

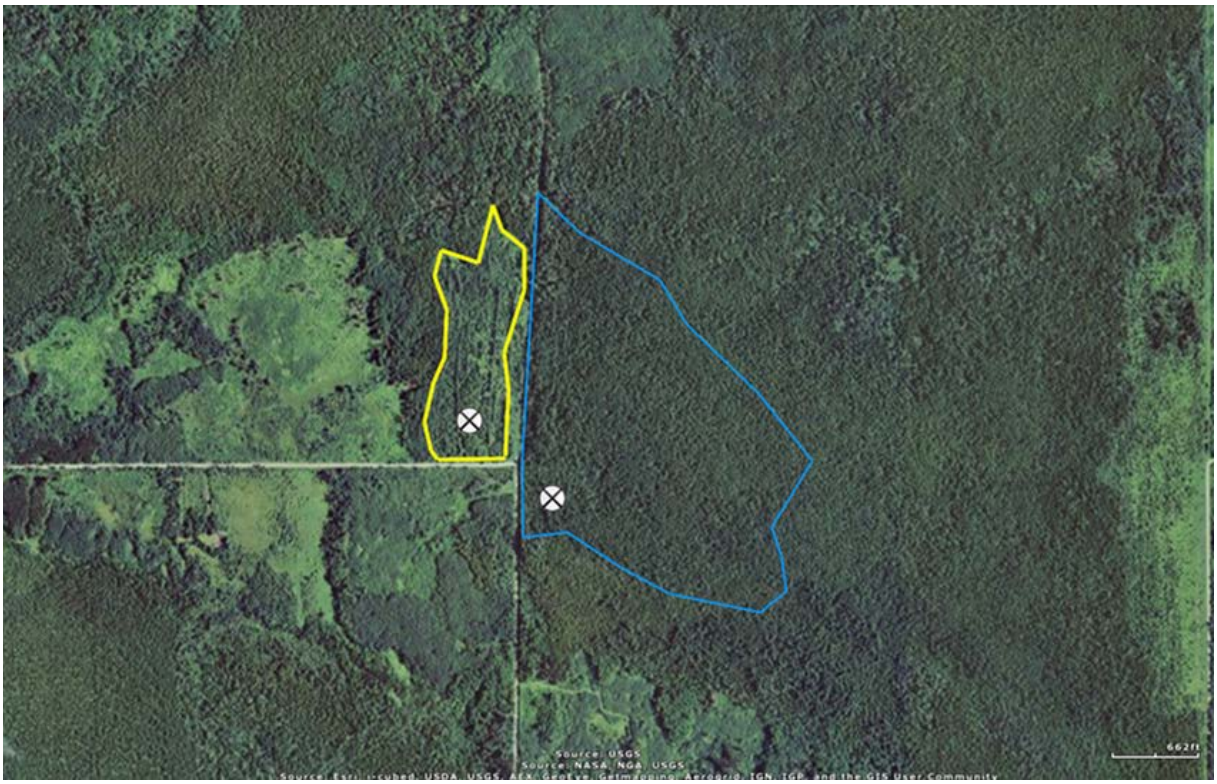

Figure 3. Aerial photo of site #664 in Beltrami County. Yellow outline indicates location of planting and seeding and blue line indicates secondary reference site. White circles indicate location of groundwater wells.

Protection from herbivory at this site was organized into five north-south transects with alternating propagule and protection type. Each transect contained trees installed at 20' spacing with every tree marked by blue ribbon within 3 feet of the tree. Every fourth transplant was protected by wire mesh enclosures, and rigid tree protectors protected every fourth seedling. This created two transects with 240 cedar transplants (60 protected by wire mesh enclosures and 180 left unprotected), and three transects with 240 cedar seedlings (60 protected by rigid tree protectors and 180 unprotected). The west perimeter was planted with 92 cedar transplants, with 23 of those protected by wire mesh enclosures. None of the unprotected, planted cedars on the west perimeter were marked with flagging. The remaining 268 transplants were planted adjacent to wire mesh enclosure transects, and the remaining 360 seedlings were planted adjacent to the

rigid tree protector transects. Twelve hundred black spruce seedlings (3-0) were installed at 20 foot by 20-foot spacing in the area located between the two eastern-most transects.

DNR Stand #276

This Beltrami County site contains 55 acres of a mature (137 years old), Northern Wet Cedar Forest stand (WFn53; cedar site index = 26; Minnesota Department of Natural Resources 2003) with cedar, balsam fir, and tamarack in the subcanopy (Figure 4). The Web Soil Survey lists this site as having Bullwinkle (71%) and Tawas (28%) mucks (Soil Survey Staff).

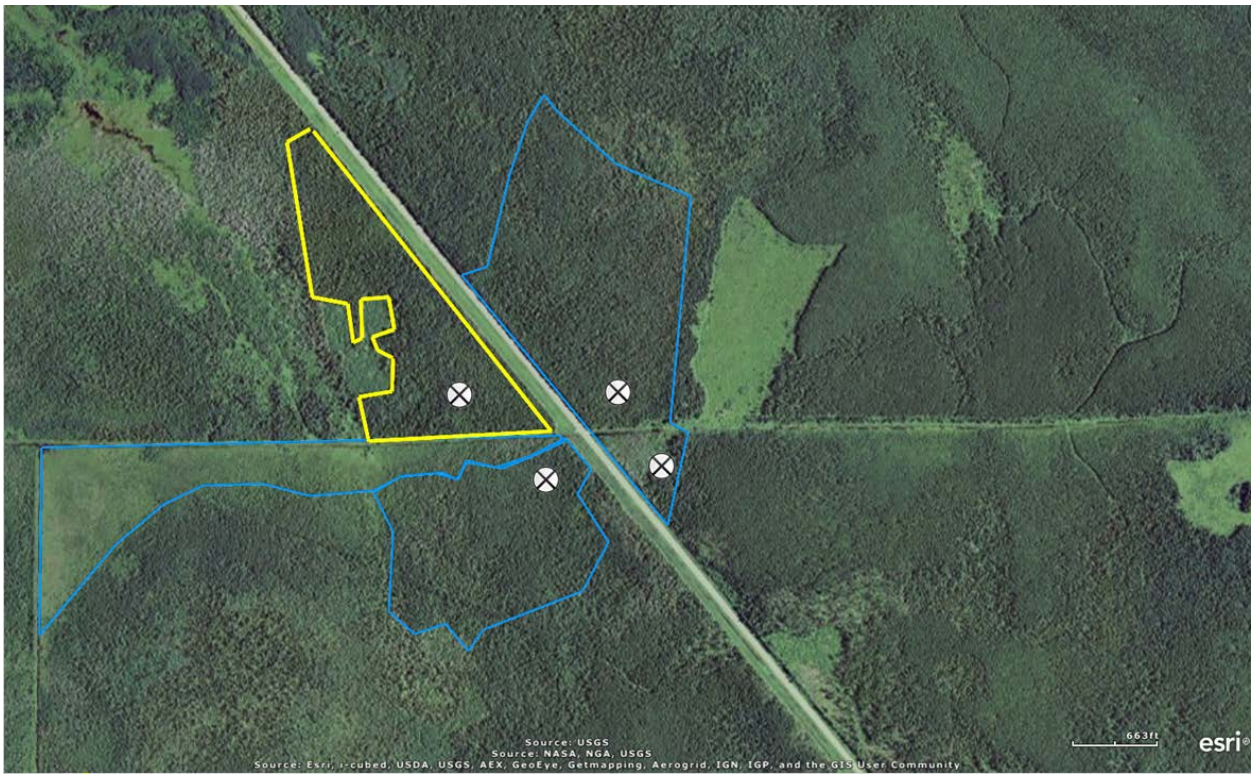

Figure 4. Aerial photo of site #276 (yellow outline) and adjacent sites (blue outline) in Beltrami County. White circles indicate location of groundwater wells.

This site is located in the northwest corner of the intersection of Minnesota State Highway 72 and a ditch that runs from east to west. The construction of these structures occurred about 95 years ago and divided a cedar swamp into four sections and altered the hydrology in the area.

The road and ditch have caused groundwater flowing through this area from the southeast to build up in the southeast corner, while severely restricting flow to the northwest corner.

Excessively wet conditions in the southeast corner have caused massive loss of woody vegetation, including northern white cedar. Excessively dry conditions in the northwest corner have caused subsidence of peat and die-off of wetland shrubs and groundcover. Regeneration of northern white cedar has also reduced in this area. Just upstream of the ditch, and adjacent to this site, there is ample advance regeneration of northern white cedar occurring in the northeast corner of the intersection.

This site provides ideal conditions to observe the effects of roads and ditches, and associated altered hydrology, on cedar swamps. BWSR staff initially installed wells in each corner of the road-ditch intersection to monitor hydrology. Three pressure transducers were placed in the wells with the exception of the northeast corner that was monitored by hand.

No treatments have been implemented at this site; it will continue to be monitored as a reference site.

DNR Stand #117

This St. Louis County site is a 25-acre, mature (128-year-old) Northern Cedar Swamp (FPn63; cedar site index = 23; Minnesota Department of Natural Resources 2003) in which four small patch cuts (0.25 acres each) were made over 20 years ago in a failed attempt to stimulate cedar regeneration (Figure 5). Just prior to application of treatments, the patch cuts were dominated by dense willow and alder with nominal tree regeneration present, and the understories were not representative of a Northern Cedar Swamp. The Web Soil Survey lists this site as being entirely Mooselake mucky peat (Soil Survey Staff).

During the 2012-2013 winter, the shrub component was removed manually from each block, with stumps cut to within two inches of the ground. Cut materials were piled compactly in windrows at the outer edges of the treatment area. Black spruce, tamarack, and other saplings and pole timber were left undisturbed, resulting in variable densities – ranging from 1-5% to 51-75% coverage – of residuals across blocks.

Installation of 300 cedar transplants (75 trees/block) occurred at 12 foot by 12-foot spacing in the west half of all four 0.25 ac blocks (0.5 ac total planting area). Three hundred cedar seedlings (75 trees/block) were interplanted with 6 foot by 6-foot spacing. Mesh enclosures were constructed and installed on 25 evenly distributed cedar transplants in each block (100 total). Tree protectors were installed on 50 evenly distributed cedar seedlings in each block (200 total).

Northern white cedar seed was broadcast over the east half of each block (0.125 acres each, 0.5 acres total) at a rate of 1 ounce per acre by May 28th, 2013.

Figure 5. Aerial photo of site #117 in St. Louis County. Yellow outline indicates location of patch cuts where cutting, planting, and seeding occurred. The blue line indicates the site boundary.

DNR Stand #28

This St. Louis County site is a 57-acre, mature (153-year-old) Northern Wet Cedar Forest (WFn53; cedar site index = 24; Minnesota Department of Natural Resources 2003) with low to moderate density sapling understory and little to no cedar regeneration (Figure 6). Open areas that were created by past timber harvest contain patchy alder. The site is hydrologically isolated by two ditches and a road, Highway 133, which surround it. Areas adjacent to the ditches have experienced peat subsidence and have no cedar regeneration. The Web Soil Survey lists this site as being entirely Mooselake mucky peat (Soil Survey Staff).

Evenly mixed plantings of 500 cedar transplants and 500 cedar seedlings were installed at 20 foot by 20-foot spacing across the planting area (9 acres). Mesh enclosures were constructed and installed on 100 evenly distributed cedar transplants. Tree protectors were installed on 360 evenly distributed cedar seedlings. Northern white cedar seed was broadcast along the border and the center line at a rate of four ounces per acre.

Figure 6. Aerial photo of site #28 (blue outline) in St. Louis County. Yellow outline indicates location of planting and seeding. White circles indicate location of groundwater wells.

County Land Department Stand #09-29TA "Boomer Road"

This Lake County site is a 40-acre Northern Wet Cedar Forest (WFn53; Minnesota Department of Natural Resources 2003; Figure 7). Carbon dating in the soils has indicated the presence of cedar for past 7000 years (Ott 2013). Additionally, old stumps, indicating two previous stand rotations, suggest that this stand regenerated to alder, fir, and ash following harvest.

Figure 7. Aerial photo of site #09-29TA (yellow outline) in Lake County.

The soils are patchy mineral soils with woody peat. The Web Soil Survey lists this site as having Mooselake muck (51%), Normanna-Hermantown complex (23%), Dora mucky peat (15%), Normanna-Canosia-Hermantown complex (6%), Ahmeek-Normanna-Canosia complex (3%), Augustana-Hegberg complex (3%), and Giese muck (0.4%) soil types (Soil Survey Staff).

During the 2012-2013 winter, all woody vegetation less than two inches in diameter was removed mechanically (Figure 8) in 20 strips, approximately 30 feet wide and separated by untreated 30 to 60-foot wide strips. A 30-foot buffer was left along the road. Some slash was mulched with a masticator machine, and chips were distributed evenly across the site. Much slash was left as debris across the cut areas. This is the only site for which measurements of initial peat depths exist.

Installation of 1750 cedar transplants (2-2) occurred at 20 foot by 20-foot spacing across the entire planting area (about 16 acres). Evenly mixed planting of 1250 cedar seedlings and 50 yellow birch whips were interplanted with 10 foot by 10-foot spacing. Mesh enclosures were

constructed and installed on 325 evenly distributed cedar transplants. Tree protectors were installed on 600 evenly distributed cedar seedlings and on the yellow birch whips.

Figure 8. Photo of equipment used to create strips in dense vegetation at site #9.

Soil and Hydrology

Soil series contained in each site were obtained from the Natural Resources Conservation Service's Web Soil Survey (Soil Survey Staff 2014). At least one groundwater monitoring well with a pressure transducer (for monitoring water table levels; Solinst Canada, Ltd., Georgetown, ON) were installed at each site prior to implementation of treatments. Water table data from the pressure transducers were downloaded once per season. Groundwater pH and conductivity were recorded at each well.

Initial Vegetation Survey

Prior to implementation of treatments, a full vegetation survey was conducted of trees, vascular plants, and mosses. In a 400m^2 (0.1 acre) circular plot, overstory trees and saplings taller than breast height were identified to species as either alive or dead and measured for diameter at breast height (DBH). Trees below breast height (i.e. regeneration) and shrubs were tallied as alive or dead and by three height classes: 0-40cm, 40-80cm, and 80-137cm. For herbaceous vegetation, a 50 m transect was established, with 25m to the east and 25m to the west of the plot center. Herbaceous vegetation was identified in a 50m by 10m belt transect, centered over the 50m transect line. Four 1m^2 (0.5m by 2m) subplots were established at 14m intervals along the belt transect. Herbaceous cover was measured in each subplot.

Seedling Survival Survey

Tree monitoring

Survival of planted northern white cedar seedlings and transplants at the five sites was monitored from late April to mid-June of 2014. Monitoring techniques for tree survival varied across sites because unprotected cedar seedlings and transplants were difficult to find. Only two sites – DNR stands #664 and #649 – had unprotected trees that were marked with blue ribbon. DNR stand #117 had high density planting that was done in small (4 x 0.125 ac) areas, making trees far easier to find. At these three sites, site-level monitoring was performed to assess tree survivorship.

At the other two sites – DNR stand #28 and CLD stand #09-29TA – subplots were created within the site in order to devote time spent searching for unprotected trees to a smaller spatial area. Protected and unprotected seedlings were sampled in six haphazardly placed 400m^2 (20m x 20m) subplots across the planting area of DNR stand #28, with three on either side of the old logging road that bisects the site. In CLD stand 09-29TA, 400m^2 (6m x 67m) subplots were placed in every other transect, at a rotating distance of 0, 25, and 50 m from the beginning of the transect.

Regardless of sampling technique, each tree sampled was noted as unprotected, protected by wire mesh enclosures, or protected by rigid tree protectors, and was assessed on four variables: condition of the tree, soil moisture, microtopography, and presence and/or level of browse. Condition of the tree was marked as one of the following:

Alive (“A”)	Indicates that tree is alive, even if it is in poor health
Nearly Dead (“ND”)	Indicates that tree looks like it will soon die
Dead (“D”)	Indicates absence of any green foliage

Soil moisture was ranked on a scale of 1-4:

1. There is standing water at the base of the tree
2. The soil at the base of the tree releases water when pressure is applied
3. The soil at the base of the tree is moist to the touch, but does not release water under pressure
4. The soil at the base of the tree is without any moisture

Microtopography was noted visually as one of the following:

	The level of the ground at the base of the tree is:
Lawn (“L”)	similar to most of the site
Pool (“P”)	lower than most of the site
Hummock (“H”)	higher than most of the site

If a tree was browsed, it was noted as such by one of the following:

Heavily Browsed (“+B”)	Browsing which appears to significantly impact the tree's health
Lightly Browsed (“-B”)	Browsing which does not appear to have a significant impact on the tree's health

Results and Discussion for Cedar Enrichment

Hydrological and Environmental Conditions

The pH of the water ranged from about 5 to 7 units across all the sites (Table 1). The lowest pH values were found in Site #28 and the greatest occurred at #9 and #664 (Table 1). Specific conductivity ranged between 75 and 350 µS cm^{-2}. Most of the pH and conductivity values are within the normal range for NWC swamps (5.5 – 7.2: Johnston 1990). However, two of the

restoration sites, #28 and #117 are at the very low end or just below the recommended pH gradient (Table 1).

Continuously recorded water table levels indicate that these cedar swamps have a very wide amplitude (Figure 9). Natural undisturbed water table levels from two sites in the Upper Peninsula show a much smaller annual fluctuation, with water table levels typically fluctuating between 20 cm above and below the ground surface as measured from a pool (Figure 10: Chimner unpublished data). This pattern of water table levels was also seen in another study of cedar in the Upper Peninsula of Michigan (Chimner and Hart 1996).

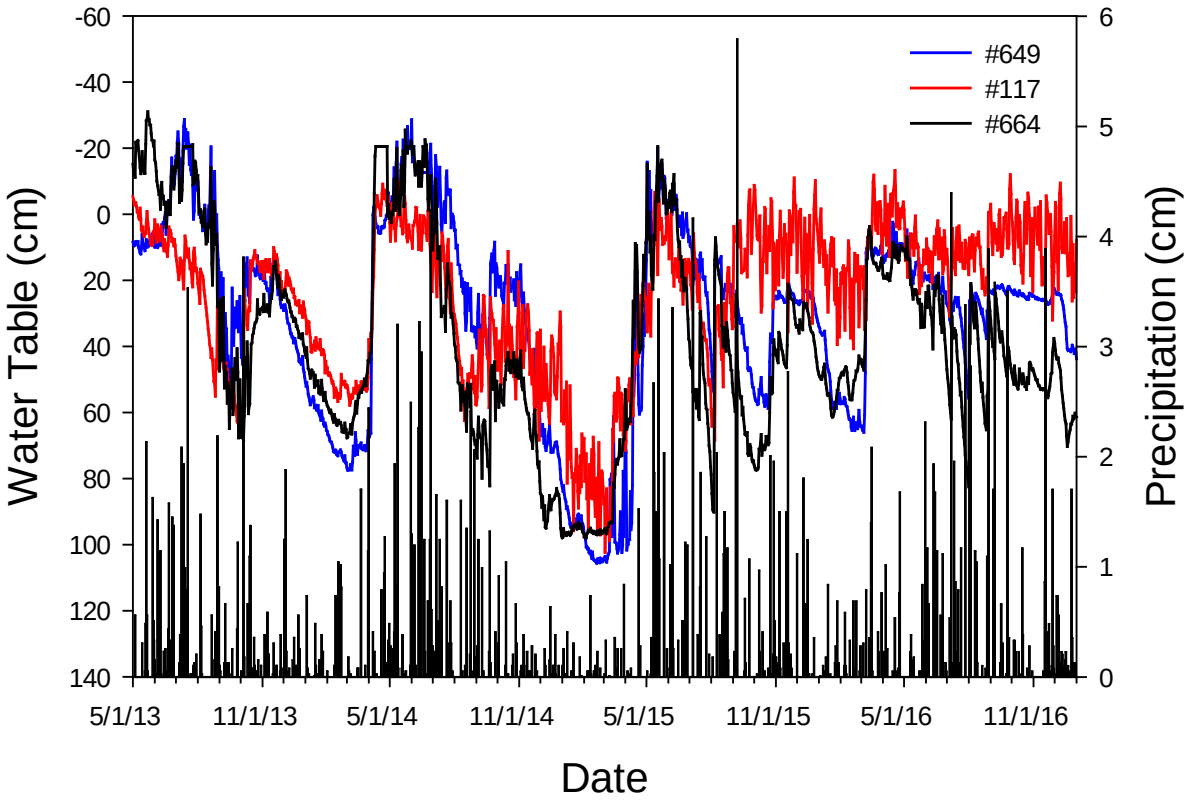

Figure 9. Time series of water table elevations at two of the restoration sites. Precipitation data is from USFS Marcel Experimental Forest (S2). Negative water table values indicate water table levels are above the ground surface.

Contrastingly, all the restoration sites had water table levels that dropped below 20 cm below the surface during 2013 (Figure 9). In the early half of the summer, all the sites were wet from snow melt and spring rains, with the exception of #664, which was 20-40 cm below the soil

surface. In the northern Beltrami County sites (#664 and reference site), the water levels spiked after a large precipitation event(s). By later summer, most of the restoration sites had rapidly dropping water table levels that reached a low of 40 to 110 cm below the soil surface, then rose again in the spring of 2014.

In addition to monitoring the restoration sites, we also monitored a few reference sites (Figure 11). The impeded drainage site (#649SE) was the wettest site with a water table that rarely dropped below the soil surface. The other sites showed a similar pattern to the restoration sites, they were wet in the spring and very dry in the late summer/fall.

In summary, most of the restoration sites had acceptable hydrology and water chemistry values to support cedar restoration. However, site #664 has low water tables that could be problematic, and site #117 and #28 have low pH values that could also be problematic.

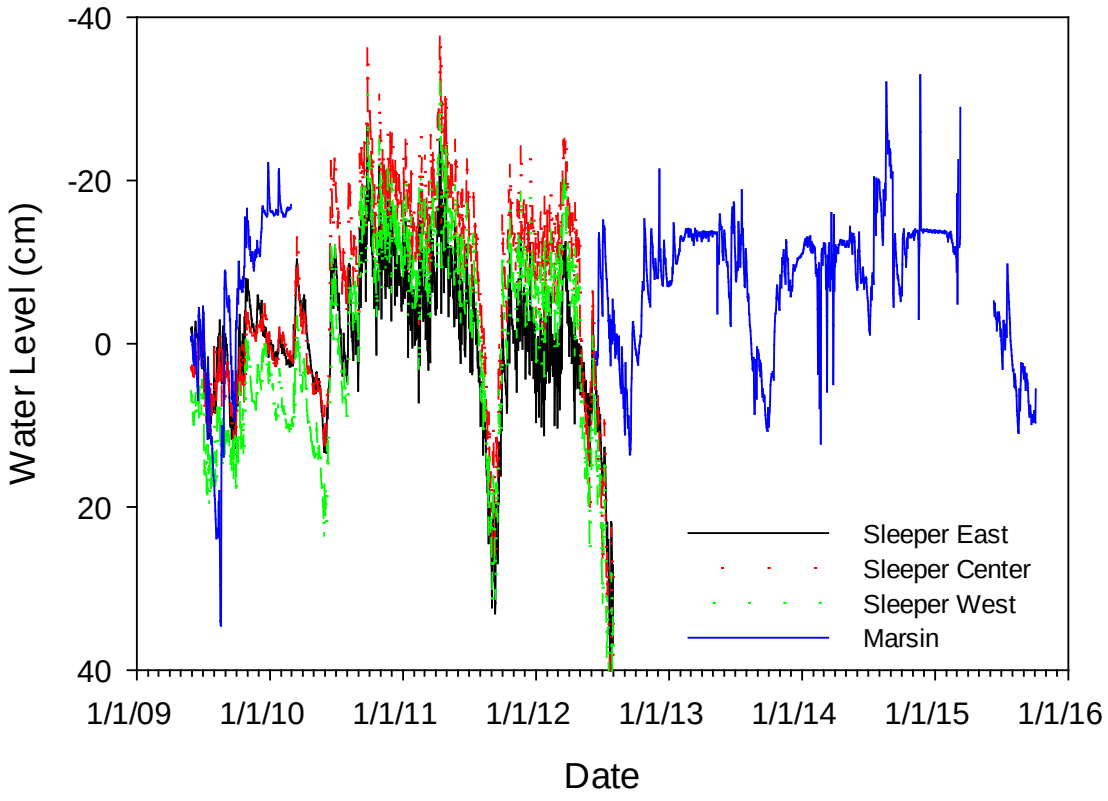

Figure 10. Reference water table levels from two undisturbed cedar swamps (Sleeper and Marsin) in the Upper Peninsula of Michigan (Chimner unpublished data).

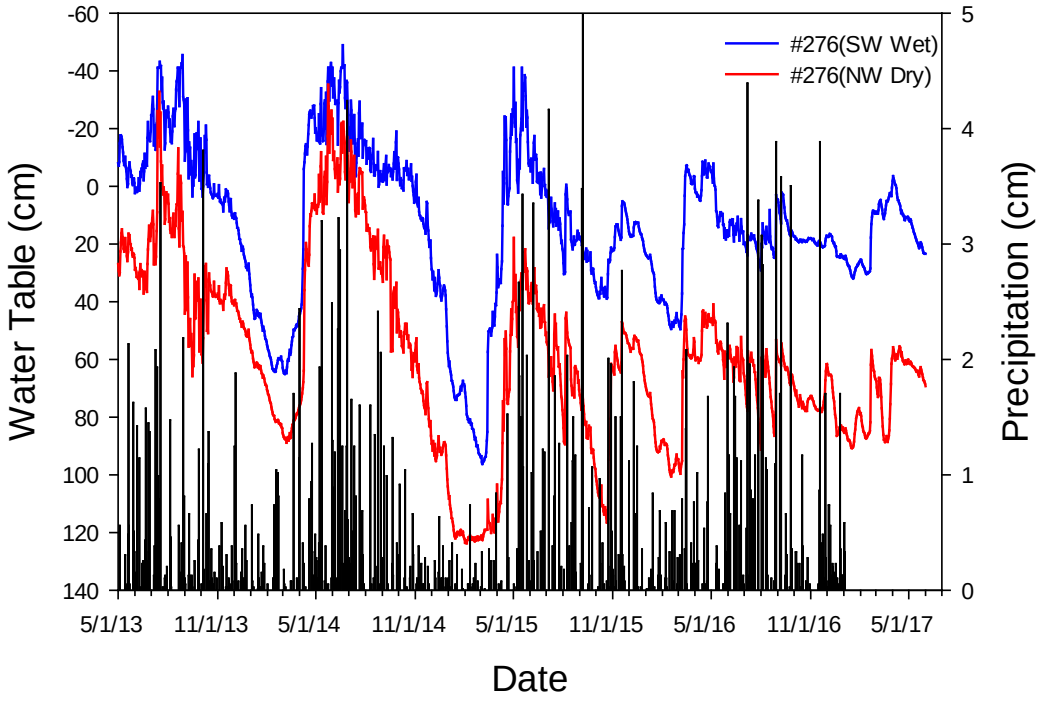

Figure 11. Water table levels of non-restoration sites in Minnesota.

Table 1. Descriptions of water chemistry and summary water table data.

Site	pH	Specific Conductivity (µS cm)	Average Water Table (cm)	Minimum Water Table (cm)
#649	6.38	99	30	80
#664	6.82	354	43	112
#664-ref	6.69	257	18	85
#276 (SE)	6.74	132	-17	3.5
#276 (NE)	5.80	228	22	66
#117	5.05	75	21	64
#28	4.95	107	9	42
#9	6.90	166	15	60

Initial Vegetation Surveys

Our sampling found 75 species of vascular plants and bryophytes in the understory (Appendix 2). The most common species found were various species of sedges, grasses, *Sphagnum* mosses, bunchberry (*Cornus canadensis)*, bog Labrador tea (*Ledum groenlandicum*), *Thuidium delicatulum*, and raspberry (*Rubus ideaus* & *R. pubescens).* Cluster analysis found that understory plants at our sites separated into two main types of communities, with a few outliers

that did not fit into these two groups (Figure 12). These two groups were also evident in the NMS analysis (green and red polygons in Figures 13 & 14).

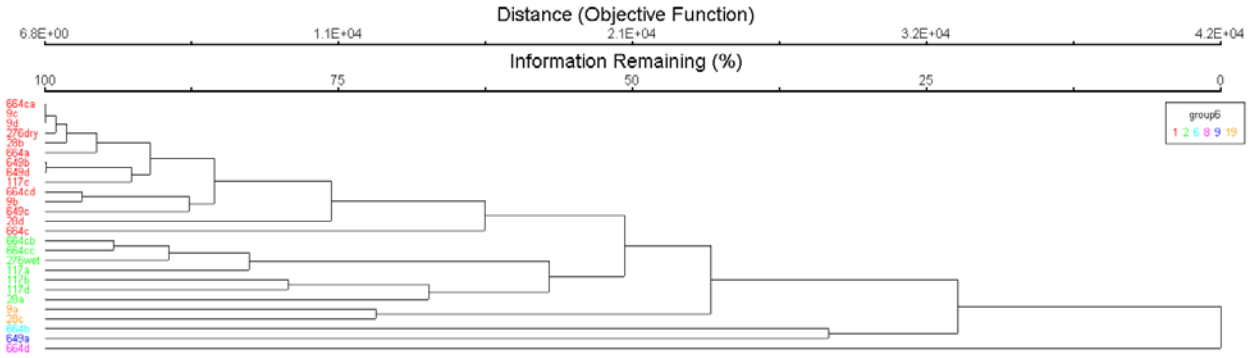

Figure 12. Cluster analysis of understory species at restoration sites.

The NMS analysis found that these two groups were correlated with hydrology and, to a lesser extent, water chemistry. NMS and indicator analysis found that community 2 (green lines in Figures 13 & 14) was a transitional black spruce swamp with slightly lower pH levels and indicator species that include: *Cornus canadensis*, *Ledum groenlandicum*, *Sphagnum* mosses, and *Thuidium delicatulum*. This community was found mostly at the site #117 and some locations in #664-ref, both of which had black spruce in the overstory (Table 2).

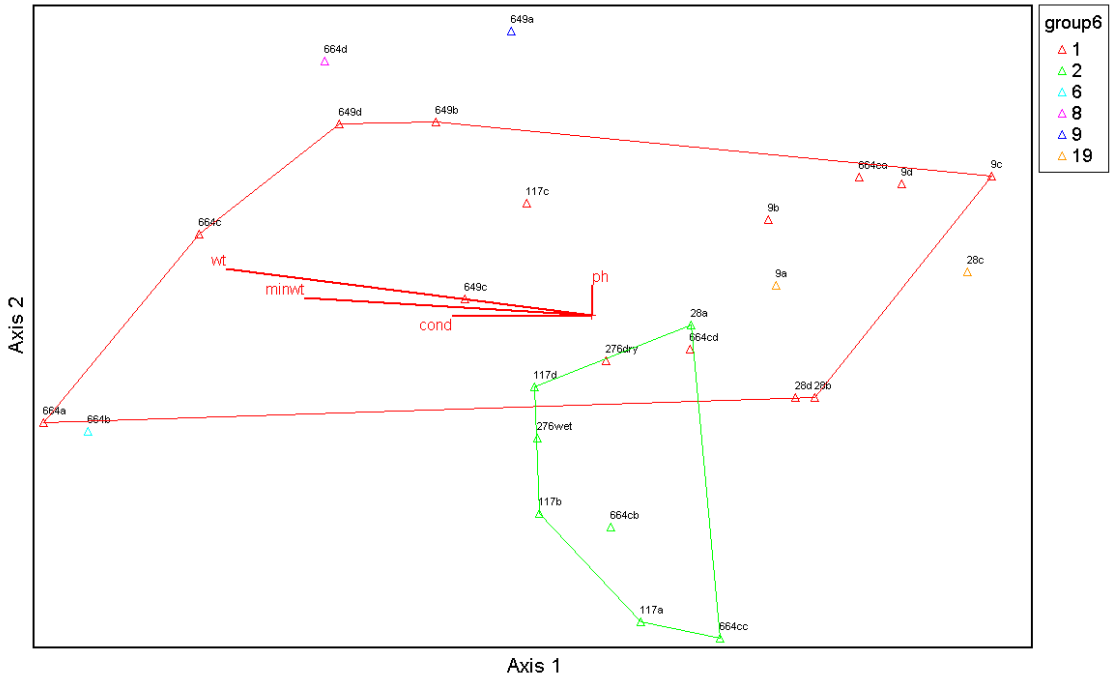

Figure 13. NMS showing sites.

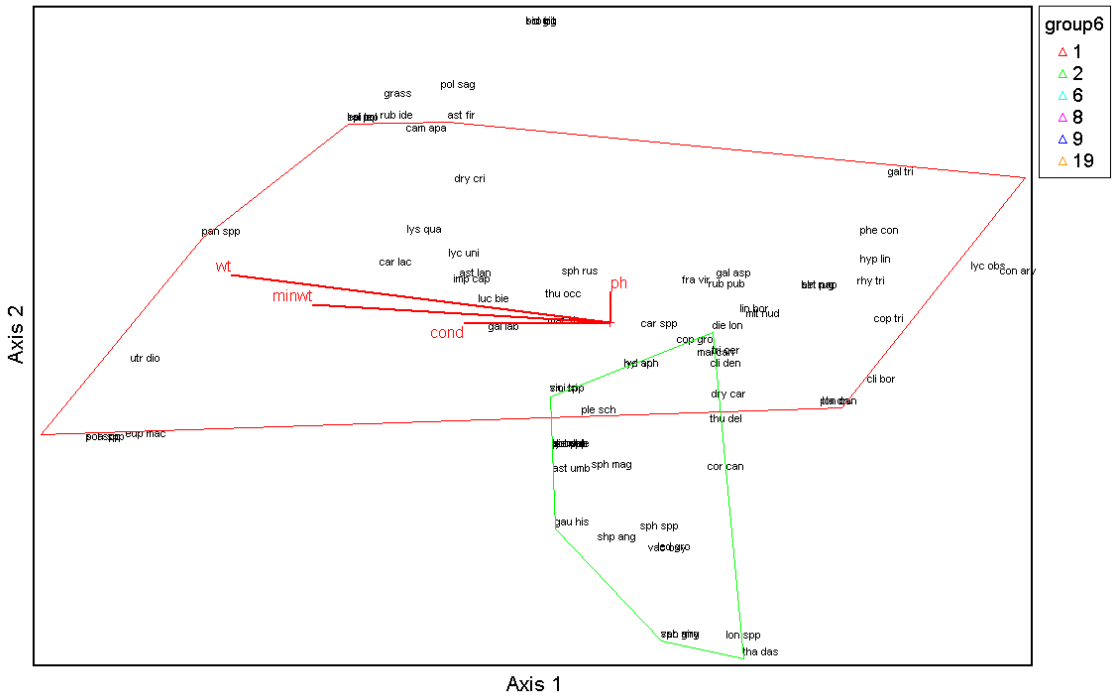

Figure 14. NMS showing species.

Table 2. Basal area (m2/ha) of overstory trees at sites before restoration treatments.

Species	#9	#28	#117	#649	#664	#664-Ref
Abies balsamea	7.55		1.30	0.47		6.88
Acer saccharum	0.08					
Acer spicatum	0.19					
Alnus incana	2.04		0.37			0.10
Amelanchier sp.	0.07					
Betula papyrifera	6.03			0.32		0.87
Cornus spp.			1.28			
Fraxinus nigra	6.80					
Larix laricina			1.98		12.62	0.28
Picea mariana			3.67			1.01
Populus balsamea						0.69
Salix sp.			0.20		2.94	3.41
Thuja occidentalis	1.02	70.53	0.28			17.15
Grand Total	**23.78**	**70.54**	**9.09**	**0.79**	**15.56**	**30.39**

Table 3. Tree density (trees/ha) of overstory trees at sites before restoration treatments.

Species	#9	#28	#117	#649	#664	#664-Ref
Abies balsamea	3800		150	150		1825
Acer saccharum	100					
Acer spicatum	275					
Alnus incana	1550		450			100
Amelanchier sp.	75					
Betula papyrifera	125			100		125
Cornus spp			125			
Fraxinus nigra	1000					
Larix laricina			350		400	75
Picea mariana			450			75
Populus balsamea						125
Salix sp.			250		1225	675
Thuja occidentalis	50	2225	25			3750
Grand Total	**6975**	**2225**	**1825**	**250**	**1625**	**6750**

Basal area and density of trees at restoration site varied greatly. Basal area of overstory trees at the restoration sites ranged from 0.9 m2/ha at #117 to 70.54 m2/ha at #28 (Table 2). Basal area of cedar also varied from zero at #649 and #664, to 70.53 m2/ha at #28. Tree density was very high at sites #9 and #28, and very low to absent at the rest of the sites (Table 3). There was almost no cedar regeneration at any of the sites, with most regeneration consisting of balsam fir, tag alder, willow and dogwood (Table 4).

Table 4. Regeneration density (trees/ha) of understory trees and shrubs at sites before restoration treatments.

Species/	**#9**	**#28**	**#117**	**#649**	**#664**	**#664-Ref**
Size class (cm)	**stems/ha**	**stems/ha**	**stems/ha**	**stems/ha**	**stems/ha**	**stems/ha**
Abies balsamea						
0-40	1900				100	800
41-80	800				200	300
81-137	1100				200	100
Acer spicatum						
0-40	400					
41-80	300					
81-137						
Alnus incana						
0-40	400		200			
41-80	400		200			
81-137	200					
Amelanchier sp.						
0-40	300					
41-80	400					
81-137						
Aronia melanocarpa						
0-40						
41-80			100			
81-137			100			
Betula pumila						
0-40						
41-80			300			
81-137					200	
Cornus spp						
0-40				15900	1600	
41-80				5200	2900	
81-137				2300	400	
Corylus cornuta						
0-40						
41-80			100			
81-137						
Fraxinus nigra						
0-40	200					
41-80						
81-137						
Salix sp.						
0-40			700			
41-80			900			
81-137			1800			
Thuja occidentalis						
0-40	100					1400
41-80						1500
81-137						600
TOTAL	**6500**	**0**	**4400**	**23400**	**5600**	**4700**

Seeding Success

We found no seeds germinated at any site during the initial visits in the spring of 2014 (Figure 15). However, some seeds were seen germinating by the next sampling trip in the late spring. It appears that the seeds over summered and wintered before germinating.

Figure 15. Photo showing ungerminated cedar seed.

Survival of Planted Stock

General survival of planted cedar

We found no significant differences in any parameter between seedlings and transplants, so all further analysis is done with pooled seedlings and transplants. Average cedar survival across sites was 69% after the first year (2014) (Figure 16), and dropped to 45% after 2 years.

Roughly 20% of cedar found were dead, 10% were missing, and 20% were classified as nearly dead. Most of the missing cedar was assumed to be dead by herbivory, but some

were likely alive and not able to be located. The cedar classified as nearly dead were very sickly looking and were thought to be dying (Figure 16). Most of the cedar found dead appeared to die from obvious causes (e.g., to wet or high herbivory), however, many had no clear cause of death. Many of those had fungus on them.

Overall survival of found cedar varied by site, with Site #649 having the lowest survival of found cedar, averaging ~70%. Site #664 had survival rates near 80%, while site #28 had just over 40% survival (Figure 17).

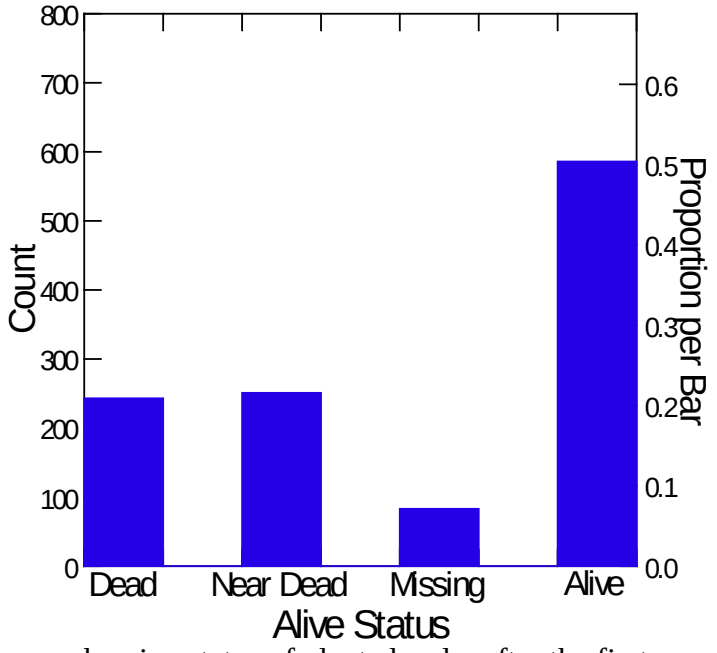

Figure 16. Histogram showing status of planted cedar after the first year across all sites.

Hydrology effects on planted cedar

Wetness of the microsite was the most important variable explaining short-term cedar survival (Figure 18). Both the soil moisture index and microtopography feature were highly significant factors ($p<0.0001$) explaining survival of planted cedar (Figures 19 & 20). Cedar survival was lowest (~20%) after two years when they were planted in a depression or pool (Figure 19). Survival of cedar was greater when planted on flat lawns

(~45%) or mounded hummocks (60%). The microtopographic position was strongly correlated with the soil moisture index that we used ($p<0.0001$; Figure 21). Therefore, a similar pattern emerged when looking at cedar survival compared to soil moisture index. The cedar survival was lowest in the wettest index (standing water) compared to the other categories (Figure 19). This indicates that cedar survived poorly in very wet pools, and survived better in slightly drier lawns and hummocks.

Height growth also varied by where the cedar was planted. Cedar grew slowest when planted in pools (Figure 22). In 2015, cedar appeared to grow faster in the pools, but the data is skewed by the fact that only a couple of cedar survived in the pools after the first year. In summary, cedar had much lower survival and grew slower when planted in pools compared to lawns or hummocks.

Certain hummocks, however, can be too dry to encourage cedar survival. For instance, at site #649, the many of the hummocks planted were actually perched root mats with lots of air space under them. The effect of this was that cedar roots were dried out, and the trees often died when planted on these hollow root mats (Figure 23).

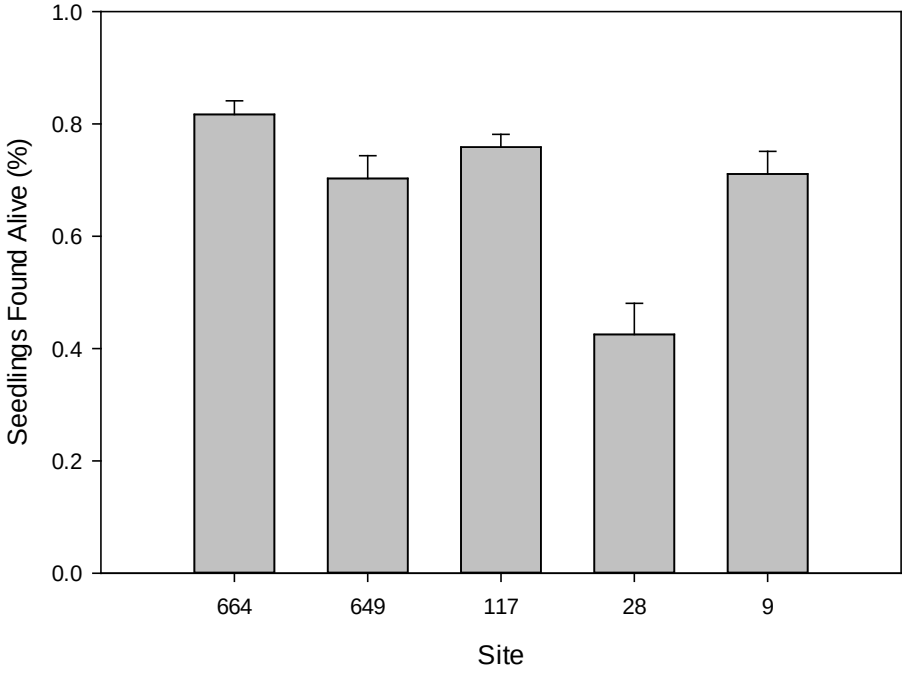

Figure 17. NW cedar survival varied by site after the first year ($p<0.001$).

Figure 18. Photo showing a dead cedar planted in wet conditions.

Our results are in line with other studies that have found that microtopography is important for cedar survival (Chimner and Hart 1996, Kangas 2012). Microtopography is small-scale variation in topography creates microhabitats with different water levels, ranging from drier, raised hummocks to flooded pools. In a study of a northern white-cedar stand 30 years following clearcutting (Chimner and Hart 1996), the land area

composed of hummock microtopography was correlated with white-cedar density. Areas with greater than 70% hummock microtopography had the greatest densities of white-cedar. As hummock microtopography decreased in extent, white-cedar density decreased proportionally, with less topographically diverse areas becoming dominated by shrubs and hardwoods (Chimner and Hart 1996).

White-cedar cannot withstand prolonged inundation (Johnston 1990), thus, hummock microtopography benefits cedar by elevating seedlings above high water levels. Our results suggest that the effectiveness of hummocks vary depending on site hydrology. Hummocks were associated with improved seedling survival in sites with long periods of standing water, but as the number of days of inundation decreases, hummock microtopography may become less necessary.

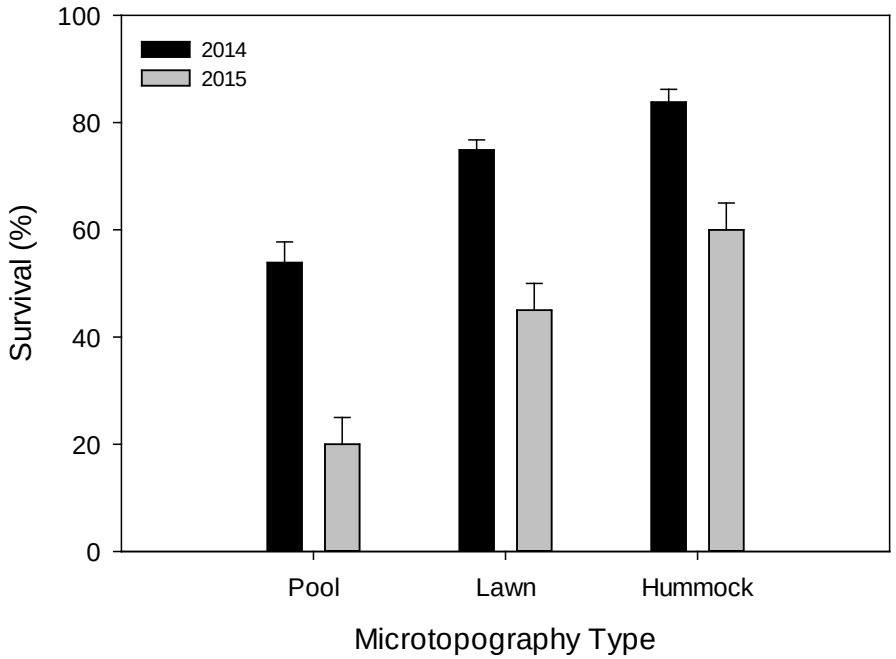

Figure 19. Cedar survival by microtopographic feature ($p<0.0001$). All differences between years and microtopography are significant at $p<0.05$.

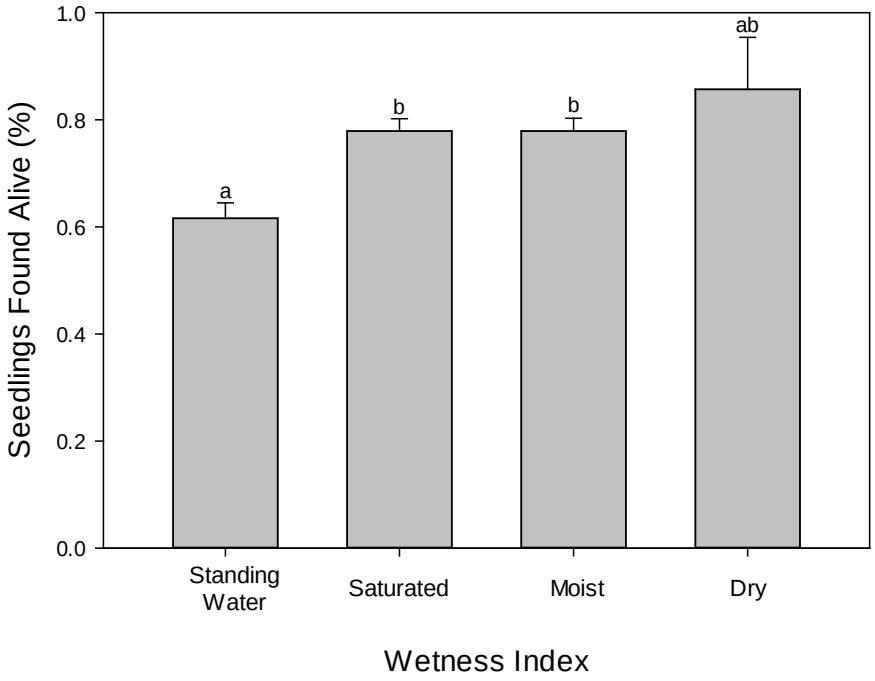

Figure 20. Cedar survival by moisture status (P<0.0001). Letters denote significant differences at p<0.05.

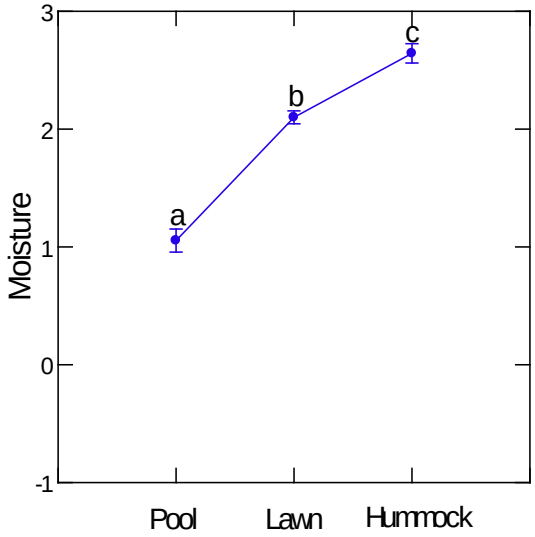

Figure 21. Correlation between microtopography and moisture status (1=standing water, 2=saturated, 3=moist, 4=dry). Letters denote significant differences at p<0.05.

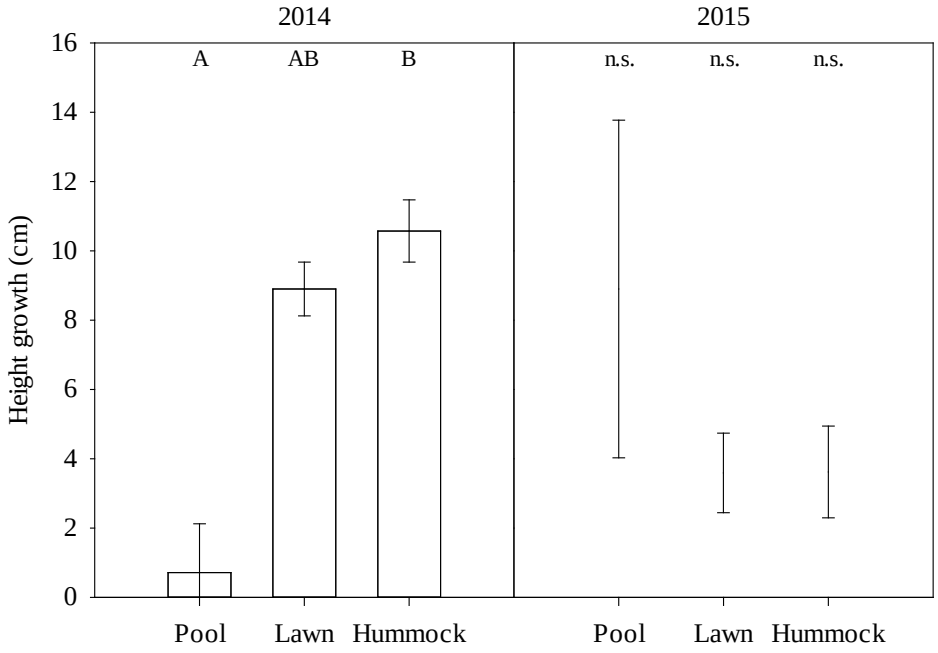

Figure 22. 2014 and 2015 mean height growth by microtopography on which the tree was planted. Error bars are ±1 standard error. Mean and standard error of height growth were calculated across all sites.

Figure 23. Planted cedar dead on top of hummock root mat. Notice the large air space between water table and peat in left photo.

Herbivory effects on planted cedar

There was no effect after two years of single tree protectors on planted cedar survival (Figure 24). Single tree protection devices did, however, reduce the amount and severity of browsing on planted cedar ($p<0.001$) (Figure 25 & 26). Roughly 80% of protected cedar had no evidence of browsing with the other 20% being split equally among light and heavy browse (Figure 27). Roughly 50% of all unprotected cedar showed no signs of browse on them, with 20% having light browse and 30% having heavy browse (Figure 28). There was little difference between rigid and wire protectors ($p> 0.05$), but rigid protectors appeared to be slightly more effective at preventing browse (Figure 26). Heavy browsing occurred most often in unprotected cedar, but also occurred in protected seedlings (Figure 29). Browsing was observed to have occurred from deer, rodents, porcupine, and grouse. The larger herbivores ate the unprotected cedar, while the smaller herbivores routinely browsed trees in both types of single tree protectors.

There was no significant difference in cedar survival between cages and plastic ($p=0.29$) (Figure 30). However, there was a significant difference ($p<0.001$) between seedling and transplant survival when unprotected. Cedar seedlings had greater survival (89% (0.03 SE)) than transplants (70% (0.04 SE)). There were however, no significant differences in browsing between seedlings and transplants when left unprotected. This

indicates that seedlings planted into the swamps had generally better survival than transplants, however, both had sufficient survival to justify their use.

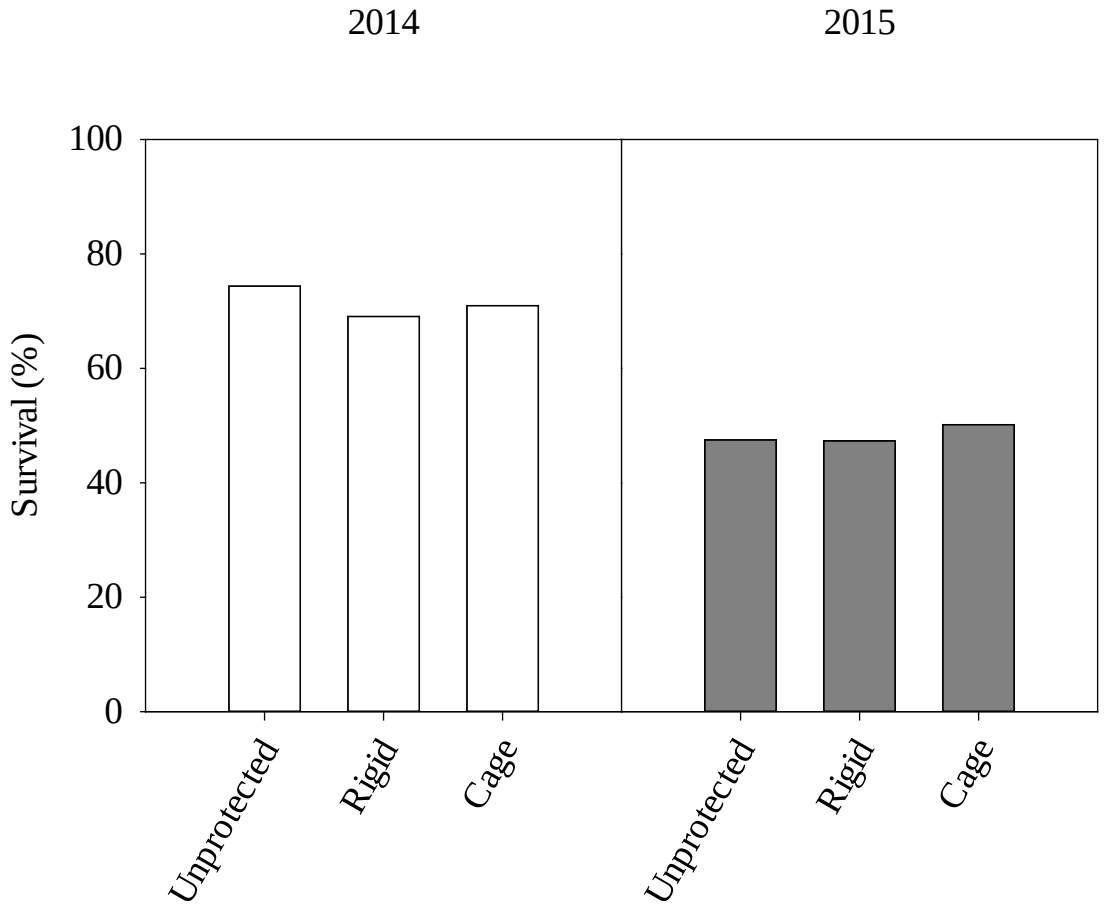

Figure 24. Survival of unprotected trees, trees with rigid plastic protectors, and trees with wire cage protectors one year after planting (2014) and two years after planting (2015). Percent survival for each year was calculated by taking the number of alive trees in each protection form divided by the total number of trees in that protection form.

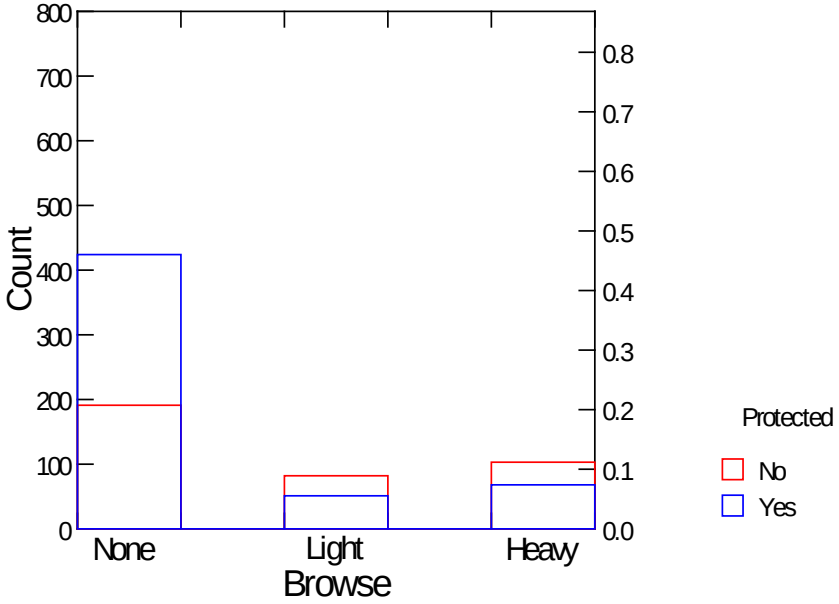

Figure 25. Pattern of browsing observed by protected (blue) and unprotected (red) cedar.

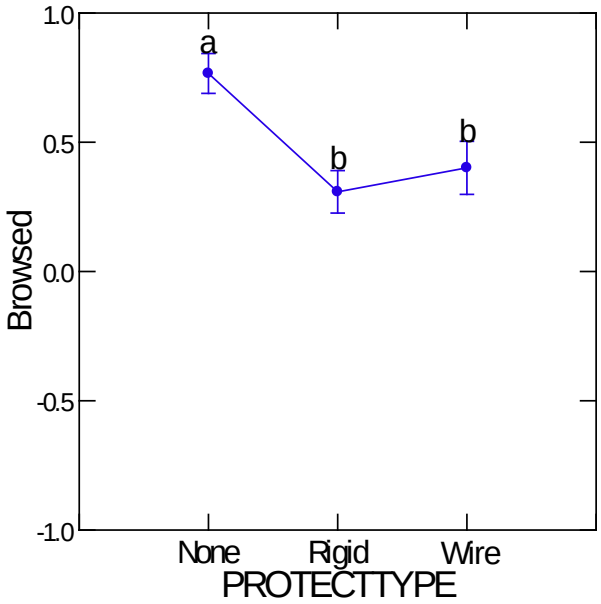

Figure 26. Browsing was significantly lower in protection units (0=no browsing, 1=some browsing, 2=heavy browsing). P>0.001.

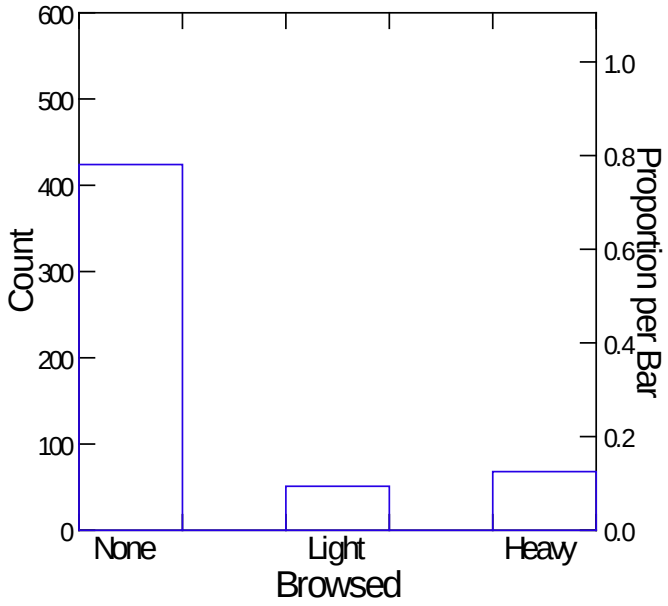

Figure 27. Pattern of herbivory on protected planted cedar.

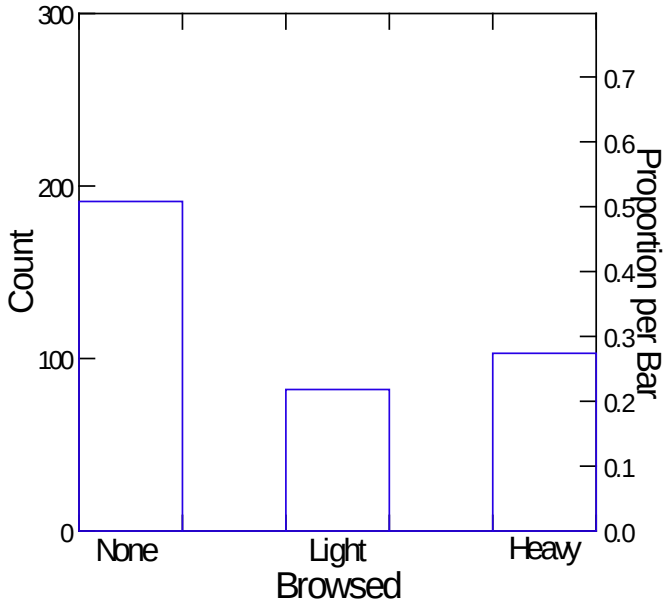

Figure 28. Pattern of herbivory on unprotected planted cedar.

Figure 29. Photo showing a heavily browsed cedar.

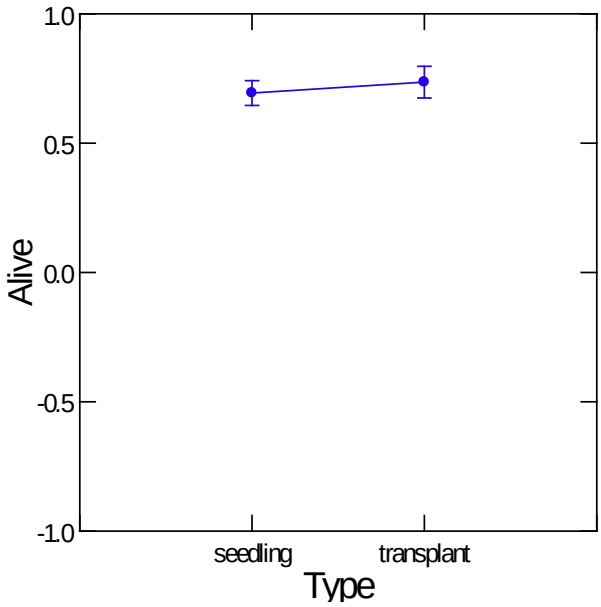

Figure 30. Survival of protected cedar seedlings and transplants (p=0.29).

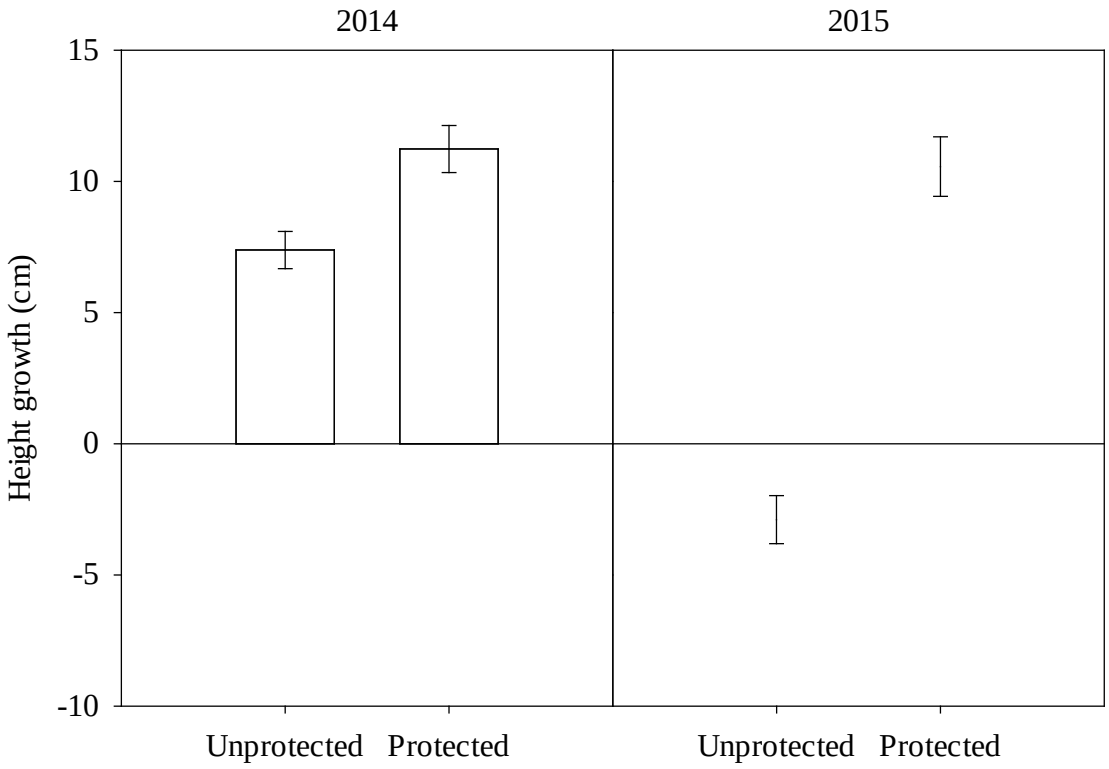

Figure 31. Mean height growth of unprotected trees and trees protected by wire cages by season of measurement. Error bars are ±1 standard error. Mean and standard error of height growth were calculated across all sites. A t-test found a significant difference ($p<0.05$) in height growth between unprotected and protected trees in both 2014 ($p = 0.0009$) and 2015 ($p < 0.0001$).

Figure 32. Photos of cedar in wire and plastic protectors.

Although short-term survival was not altered by protection, the decreased herbivory allowed for significantly faster tree growth compared to unprotected cedar trees. Trees that were protected had significantly greater growth than those that were unprotected in 2014 ($p = 0.0009$) and 2015 ($p < 0.0001$) across all sites (Figure 31). Although there was no significant difference in survival between cages and plastic, we did notice that wire cages seemed to be working better. Most of the trees in the wire cages were much taller and had more biomass than in the smaller plastic cages (Figure 32). Also, the plastic protectors tended to be knocked over frequently, have trees stick out of them, or have foliage browsed when sticking out of the plastic (Figure 33). The plastic also did not fare well in areas in heavy snow.

Figure 33. Some examples of issues with plastic protectors.

Light effects on planted cedar

Cedar height growth over the entire 2-year measurement period was influenced by the amount of light reaching the trees (Figure 34). Trees with less than 20% PPFD grow very slowly, and increased in growth linearly increasing growth. The light affect was also influenced by browsing levels. When the trees were browsed, light had little to no influence on growth, mainly because growth was removed by grazing.

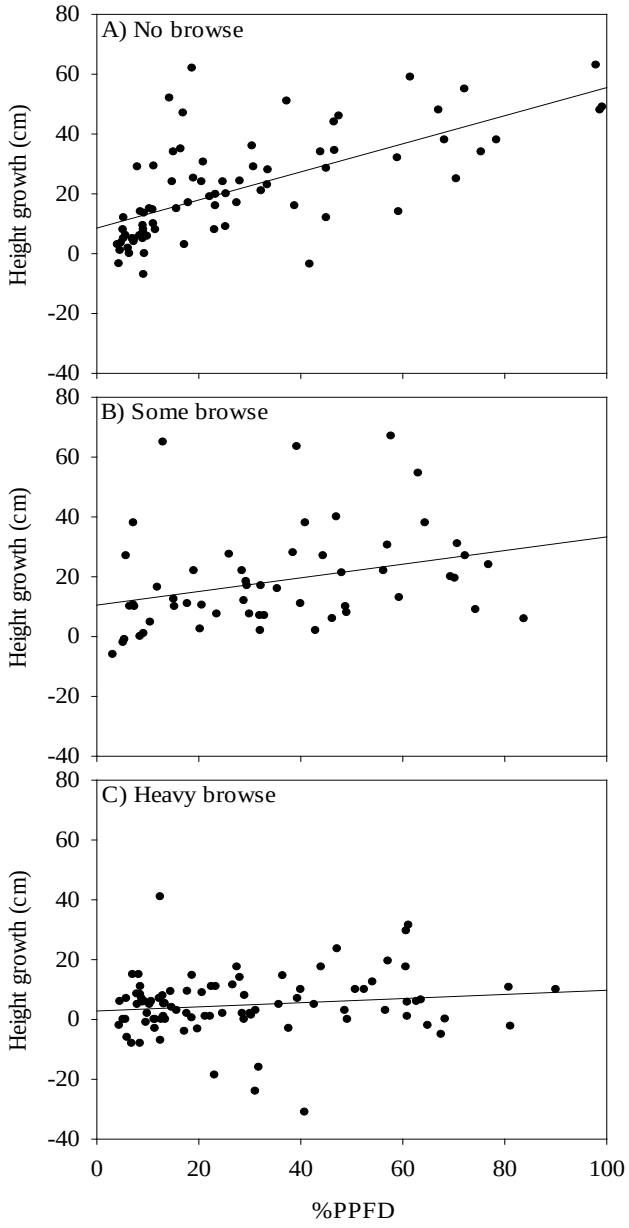

Figure 34. Height growth of each sample tree over the two-year measurement period (spring 2014 to fall 2015) by average %PPFD (canopy transmittance of photosynthetically active light) measured over that tree in July 2014, October 2014, and July 2015, for trees with A) no browse, B) some browse, and C) heavy browse. Each tree is separated into one of these three graphs, based on the highest level of browsed observed for that tree over the measurement period.

Methods for Cedar Assessments

To gauge the condition of NWC swamps in the study region, a rapid field assessment form (Appendix 1) was created for dissemination. The form was designed to rapidly evaluate the condition of cedar swamps and what if anything was impacting the swamps. The form was modified from a long-term peatland assessment formed used in Colorado (Chimner et al. 2010).

Disturbances were identified using aerial imagery, topographic maps and during site visits. The level of severity of each disturbance was assessed by the proportion of swamp it impacted. Hydrologic disturbances – including ditches, diversions and road cuts to swamps – were assessed by estimating the proportion of area that was altered, based largely on the vegetational characteristics of the swamp. Vegetation disturbance was assessed by determining the adequacy of regeneration and cedar density, and by identifying the degree of browsing. Each site's restoration priority was assessed as very high, high, low or very low based on the likely ease or difficulty of restoration and the condition of the swamp. Sites considered high or very high restoration priorities could easily be restored or were poor-condition swamps. Sites rated as low or moderate restoration priority were slightly impacted or so severely impacted that restoration would be cost prohibitive.

Results and Discussion of Cedar Assessments

A total of 93 sites were field assessed by managers in Aitken, Itasca, and Koochiching counties. An additional 51 cedar swamps were assessed using MNDNR inventory and are not presented, but listed in Appendix III. Half of all the sites assessed were county lands, and the other half were split between state and private lands (Table 5). Most of the assessed cedar sites were less than 20 acres, but some sites were greater than 50 ac (Table 6).

Table 5. Ownership categories of cedar assessment sites.

Ownership	# of Stands	Total Area (ac)	% of Total Area
Federal	0	0	0
State	35	515	34
Private	13	291	19
Industry	1*	4	2.5
Tribal	0	0	0
County	46	696	46
Other	1	7	0.5

Table 6. Count of cedar swamp area of assessed sites.

Area (ac)	Count	%
0-10 ac	12	14
10-20 ac	35	41
20-30 ac	14	16
30-40 ac	7	8
40-50 ac	15	17.5
50-100 ac	3	3.5

Thirty-nine percent of all assessed cedar sites were ranked as being in fair or poor condition (Table 7). Only 8.5% of assessed sites were listed as being in excellent condition. Greater than half of the sites were ranked as being in good condition. Roughly 50% of all sites were listed as needing restoration, with 25% of those ranked as having high or very high restoration priority (Table 7).

Table 7. Overall condition category.

Overall Condition	Count	%	Restoration Priority	Count	%
Excellent	8	8.5	Very High	13	14
Good	51	53	High	10	11
Fair	25	26	Moderate	25	27
Poor	12	12.5	Low	45	48

Two major disturbances, roads and animals (deer), were identified as the most common disturbances found to be impacting the cedar swamps (Table 8). Combined, they accounted for almost half of the identified disturbances. Other common disturbances noted were from forestry, drainage ditches, recreation vehicles, and utilities.

Overall, around 38% of all sites assessed were listed as being hydrologically altered. Roughly half of all the assessments indicated that there was a road, ditch or other barrier to groundwater flow near their sites. The proportion of the cedar swamps impacted was evenly distributed across the categories, with impact area varying from less than 10% to greater than 50% of the swamps being hydrologically modified (Table 9). Two-thirds of the sites identified as being hydrologically modified were identified as being drier than normal, with the other third listed as being too wet with dead trees killed by flooding.

Table 8. Types and percentages of disturbances encountered during assessments.

category	**count**	**%**
Roads	32	23.0
Forestry	13	9.4
Drainage ditch	5	3.6
Grazing	1	0.7
Animal	28	20.1
4x4	7	5.0
Recreation	9	6.5
Utilities	7	5.0
Other	4	2.9
None/Unknown	33	23.7

Overall, 55% of the sites were identified as not having acceptable cedar density compared to what it should have been. However, only 10% of sites were listed as being harvested in the last 50 years. In addition, 85% of sites were listed as not having enough cedar regeneration. At least 25% of sites had browse lines, with many additional sites listed as not having trees within browse height.

Table 9. Count of cedar swamps hydrologically or vegetatively altered.

	Hydrologically Modified	Vegetation Modified
0%	44	29
1-10%	7	9
11-20%	7	7
21-50%	7	15
≥51%	6	5

Figure 35. Very shady conditions hampered cedar seedling growth, but moderate light was fine.

Methods for Road Restoration

Two roads were identified in N. Minnesota that were impeding water flow, which had caused inundation and cedar mortality on the upgradient side and drying on the downgradient side (Figure 36). We conducted experimental restoration in two segments of the roads to allow for better hydrologic connection between both sides of the road. One road was in Itasca Country and the other was in Lake County.

Figure 36. Dead cedar killed by inundation from poorly design road in N. Minnesota.

Site Descriptions and Methods

Itasca County Site

The first site is on a minimum maintenance forest road (Ranch Road) near Wirt in northern Itasca County (Figure 37). The road provides access for forest management on county land and seasonal access for one privately owned parcel. The road crosses about 200’ of NW cedar

wetland that flows toward the Big Fork River, which is about 300’ South of the road. The road crosses over about 3’ of mucky peat and was originally constructed on a corduroy base, which is now rotted. The main culvert was partially blocked, causing inundation on the upstream side of the road (Figure 38. The private landowner installed a smaller plastic pipe in an attempt to allow some of the surface water to drain past the road. A porous roadbed was designed to restore the normal surface and subsurface water flow through the wetland to the river.

A transect of groundwater monitoring wells were installed perpendicular to the road in October of 2014 (Figure 39). Wells were monitored periodically by hand and three pressure transducers were installed for daily automatic readings.

Construction consisted of removing the existing roadbed down to the corduroy with useable material stored for reuse and the remainder hauled away. Then a rock bed wrapped in non-woven geotextile was installed to permit subsurface flow to move through the road bed (Figure 40A). A new culvert was added to allow water to flow through during periods of high volume surface flow. Geotextile was laid out and 12” of 4 to 6-inch rock was spread out over the fabric, then another layer of geotextile fabric was laid over the top of the rock (Figure 40B). Additional 4 to 6”-rock was placed at the toe of the slope over the geotextile fabric exposed below the gravel roadbed. Erosion blankets were placed to cover the disturbed surfaces alongside the road (Figure 40C). Construction began on August 8, 2016 and was completed on August 12, 2016. The total cost of the project was $55,174.90.

Figure 37. Ranch Road in Wirt, MN before restoration.

Figure 38. Ponded water upgradient that caused NW cedar tree mortality.

Figure 39. Wirt site with well placements.

Figure 40. Sequence of Wirt road restoration: A) Roadbed was removed, then geotextile was laid out and 12" of 4 to 6-inch rock was spread out over the fabric, B) then another layer of geotextile fabric and more dirt was laid over the top of the rock, C) additional rock was placed at the toe of the slope over the geotextile fabric exposed below the gravel roadbed and erosion blankets were placed to cover the disturbed surfaces alongside the road, D) finished road as of June 2017.

Lake County Site

The second experimental location is the Dufrene Road in Lake County, which is an old railroad grade that was converted into a road. Dufrene is a now a county forest road used for management, access for several private properties, by hunters, and the general public. Originally. there was a culvert in place, but was completely blocked, causing ponding on the upgradient side, killing all the trees (Figure 41A). The wetland surrounding the road is a mineral soil forested wetland.

Figure 41. Sequence of Defrense road restoration: A) Upgradient road before restoration showing deep ponding, B) Upgradient road after restoration show large drop in ponding and new vegetation growing, C) Downgradient of road after restoration, and D) Close up of water seeping out under the road on the downgradient side of the road after restoration.

The goal of this road retrofitting was to use a modified H-culvert design to allow the water to flow under the road (Figure 42). The first step was to replace the blocked culvert on June 27-29, 2016, with a new culvert (Figure 43). The second step was to dig trenches about 4-feet deep alongside the toe of the roadbed on both sides of the road to intercept subsurface water flow above the road and redistribute it below the road (Figure 42). Each trench was filled with clean 1.5-inch rock. The original design was to wrap the rock in geo-textiles and put drain tiles in the middle of the trench. However, when work to dig the roadside trenches began, conditions were too wet so that it was not safe to have people get in the trench to lay the geotextile and drain tile. Time and funding constraints forced a decision to install the rock in the roadside trenches without the geotextile wrap or the drain tile. Additional trenches were installed under the road

connecting to the two lateral trenches to move water under the road. It was possible to utilize the geotextile wrap and drain tile in the cross road trenches. One additional leadoff trench with drain tile was installed perpendicular to the down flow roadside trench. The trenches were constructed over two days in September 20-23, 2016 at a total cost of $33,057.55.

Figure 42. Modified H-culvert design used for Defense site. Blue arrows indicate water flow. Blue boxes represent buried rock trenches.

Two transects of groundwater monitoring wells were installed parallel to the road in 2015 (Figure 44). Wells were monitored periodically by hand and three pressure transducers were installed for daily automatic readings.

Figure 43. Replacing old culvert at Defrense Road.

Figure 44. Defrense site with well placements.

Results and Discussion for Road Restoration

At Defrense Road, manual well reading indicated that major changes in water table levels occurred after road restoration. Water table levels were 18-45 cm (average 28 cm) greater in June 2017, compared to July 2015 in wells downgradient of the road. Whereas, wells upgradient of the road were 20-24 cm (average 21 cm) lower in June 2017, compared to July 2015. This indicates that the water is not backing up as high behind the road, and that water is flowing under the road and rewetting the wetland behind the road (Figure 41). The largest change in water tables levels occurred when the culvert was replaced, which lowered the water table upgradient by ~30 cm in a couple of days (Figure 45). The large change us water table levels upgradient has already started to change vegetation composition, with horsetails now growing in an area that was previously too deep for emergent vegetation (Figure 41B).

Less obvious changes occurred when the trenches were built. The wetlands away from the culvert is wetter due to water flowing under the road and discharging into the wetland (Figure 41 C&D). Manual water table reading in June of 2017 indicated that water table levels were much wetter below the road than it was before restoration. Monitoring will continue to quantify longer-term changes.

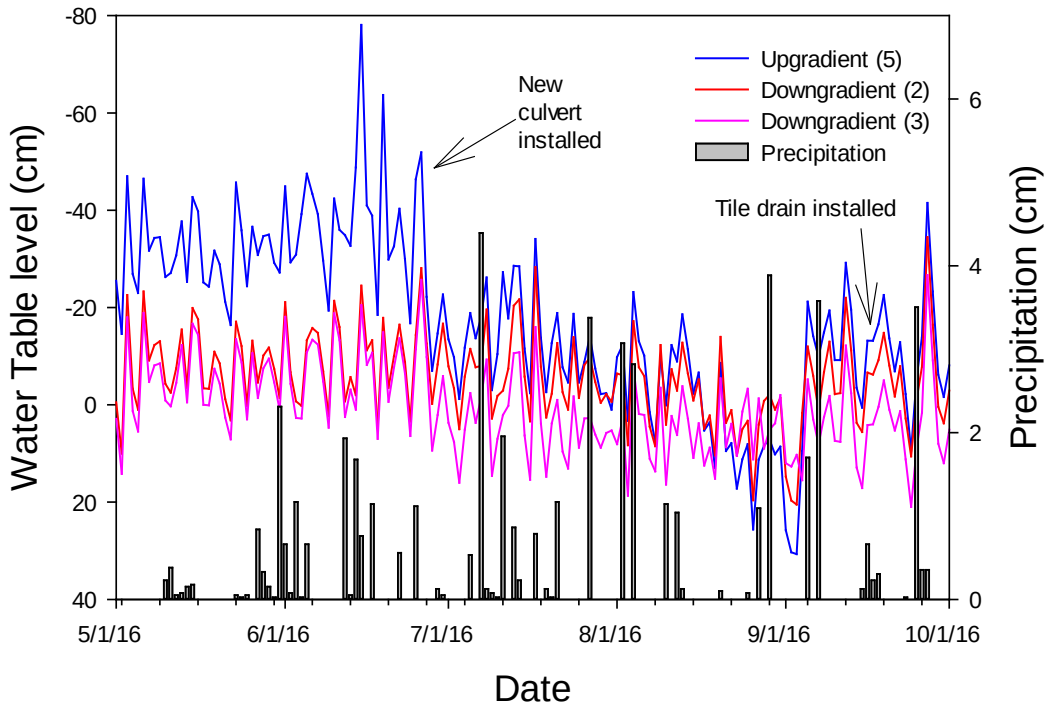

Figure 45. Daily values of water table levels at Defense Road before and after restoration. Daily precipitation values are from Marcel Experimental Forest.

Water table levels in Wirt Road did not show as large of a response of Defrense Road (Figure 46), but restoration did appear to be successful. After the restoration, ponding was decreased upgradient of the road (Figure 47), which made the road bed drier and drivable throughout the spring. Water was also discharging along the entire length of the porous roadbed on the downgradient side (Figure 48). During site visits, now water was seen flowing out of the culvert, which indicates that enough water was flowing under the road to not raise the water table high enough to enter the culvert.

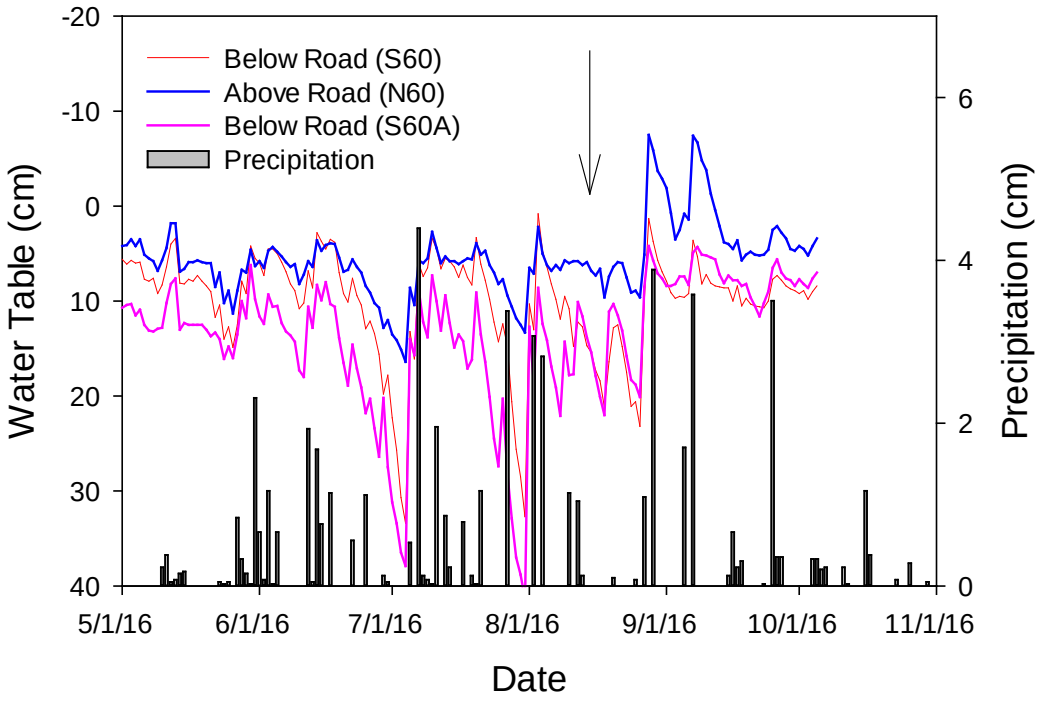

Figure 46. Daily values of water table levels at Wirt Road before and after restoration. Daily precipitation values are from Marcel Experimental Forest.

Figure 47. Upgradient of Wirt road after restoration showing lower ponding of water.

Figure 48. Downgradient of Wirt Road showing water flowing out of the porous roadbed.

Summary and Recommendations

Our assessments confirmed that many NWC swamps are degraded and need restoration. The major disturbances identified were from roads, ditches and high herbivory. Our initial results from NWC tree planting confirm that NWC are sensitive to hydrology and to herbivory. High herbivory has long been known to be detrimental to NWC regeneration. In summary, most harvested cedar sites have not regenerated back to cedar, but instead have been replaced by species such as tag alder (*Alnus rugosa* DuRoi), balsam fir (*Abies balsamea* M.) and red maple (*Acer rubrum* L.) (Nelson 1951, Zasada 1952, Thornton 1957, Chimner and Hart 1996, Heitzman et al. 1997). A study by the Michigan Department of Natural Resources showed that even 50 years after an experimental cutting in a cedar swamp near Marquette, Michigan, cedar was still absent with tag alder and balsam fir dominating in the cut areas (Chimner et al. unpublished data). This indicates that active restoration will be needed in many areas were herbivory levels are high.

The main method used for protecting cedar from herbivory are physical protection. Two main physical methods for protecting NWC are constructing high fences around many cedar (Kangus et al. 2016) or using single tree protectors. Fencing is very expensive, but can be successful for protecting trees from large herbivores. However, fencing still requires constant monitoring because falling trees can damage the fence allowing herbivores to enter the fence.

The option we tested was using single tree protectors to protect seedlings of NWC. We tested both plastic ridged and larger wire protectors. We found that both protectors worked equally well after two years on survival and reducing browsing. The plastic protectors provided extra protection from smaller herbivores (rodents, etc.) compared to the large wire protectors. However, we did find several instances of small rodents burrowing under the rigid protectors. We also found that some larger herbivores were able to push aside the plastic protectors to eat the trees. We also found that many of the plastic protectors where broken and on the ground, or bent over and inhibiting the trees. In our opinion, we feel that the wire protectors are a much better option compared to the plastic protectors. However, the wire protectors are much more expensive compared to the plastic protectors.

Interestingly, we did not find any differences between NWC survival when protected compared to unprotected plantings. However, the tree protectors greatly decreased the herbivory levels compared to unprotected levels. However, results must be taken with caution as these

results are only for the first two years. Previous research indicates that seedlings that have been heavily browsed will eventually die after a few years (Kangas et al. 2016). So we hypothesize that there will be large differences in NWC survival between protected and unprotected after several years. Informal monitoring in 2017 found that it was difficult to find unprotected cedar trees.

After two years, the largest single factor affecting NWC survival was due to hydrological conditions. NWC survival was low if they were planted in wet depressions (pools, hollows) and high if planted in higher and drier flat lawns or higher hummocks. This has direct application to planting cedar in restoration projects. Often the surrounding plant species were a guide to the wetness of the area. If the area was dominated by more obligate wetland species (sedges, dogwoods, etc.) then it is probably too wet for NWC. One factor that came to light in this research is that the seedlings and transplants were planted with roots straight down. This might have accentuated the high mortality in wetter areas. Future research should focus on planting NWC roots more horizontal in wet areas or perhaps grow the seedlings in wetter conditions in the greenhouse.

Some areas were also found to be too dry for NWC. The best example of this is when NWC where planted in root mats with an air pocket below the roots. This resulted in high mortality of planted NWC. Site level hydrological conditions also appear to have been altered by roads and may end up explaining tree growth and mortality across sites. However, it is too early to assess this yet.

Light levels also appear to play a role is successful cedar enrichment plantings. At very low light levels, like seen at site #28 (Figure 35), cedar growth was very low. This indicates that planting cedar under dense canopies are likely to not be successful, planting at moderate light levels are fine as cedar is shade tolerant.

Success of planted cedar also appeared to be correlated with pH. Sites at the low pH end of the gradient had much lower survival compared to the sites with greater pH. This result is in line with the notion that NW cedar is a calciphile and is most abundant when the pH is greater than 6. Our results indicate that NW cedar has a limited ability to be a replacement for tamarack at lower pH sites. NW cedar has a greater ability to be a replacement for Black Ash following emerald ash borer infestations, as Black Ash tend to grow and greater pH levels than tamarack. However, Black Ash tend to grow in more flooded conditions, which become more flooded after Black Ash

die back, which is not ideal for NW cedar as our results show that NW cedar mortality is very high in inundated conditions. NW cedar might be able to be established in Black Ash sites if the seedlings are only planted on the highest hummocks.

Another indication that NW cedar are very susceptible to flooding is the high mortality seen along the upgradient side of many roads that have poor cross drainage (Figure 36). Many roads, especially in the Great Lakes region, dissect groundwater wetlands. The groundwater ponds up against the roads, causing flooding, which kills the wetland trees. Wetland drying also normally occurs on the downgradient side of the road. The normal way to deal with this situation is to use culverts to pass the water through the road. Although culverts can help move water and eliminate flooded conditions, the water is channelized through the culverts and stays channelized on the other side of the road as it discharges from the culvert. The groundwater is thus changed to channelized surface water, which can erode wetland and not allow for rewetting the wetlands on the downgradient side. This phenomenon is large scale in the region and requires new technology to solve it. To this end, we tested two porous road designs that moved the water under the road to allow for better hydrologic connection between both sides of the road.

After one season, the two roads appear to be functioning as designed. The water is not ponding as much behind the roads, and water is discharging under the road and rewetting the wetlands. The roads are also more drivable during the wet periods. The water is flowing under the road and discharging on the other side. No problems have been observed after 1 year. However, the main process that needs to be monitored is the permeability of the porous road bed. If the permeability decreased from excess buildup of sediment, or by blocking by beaver, the design would fail and all the water would flow through the culverts. This will have to be monitored through time to assess this concern.

At a cost of 132-275$/foot to redo the roads, these techniques are cost effective means of improving wetland habitat and in some instances, the drivability of the road. Although these costs may seem high for a long road, usually only small sections of the road need to be redone to improve cross drainage.

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Appendix I: Assessment form and notes used for this study.

MN Swamp Assessment Form 2013		
Site Description		
Swamp name or ID		
Date		
GPS Location		
Ownership	(1=federal, 2=state, 3=private, 4=industry, 5=tribal, 6=other)	
Area of swamp being assessed (acres)		
pH (if you have meter)		
Swamp type (cedar (FPs63 or Wfn53), tamarck, or ash)		
Disturbances		
Hydrology (applies to cedar, tamarack and ash sites)		**Yes/No**
Is the surface of the peat dry?		
Are tree roots visible?		
Are mosses common in the understory?		
Are there lots of dead trees and emergents (~cattails)?		
Are there drainage ditches in the wetland?		
Is there a road/ditch/railroad just upgradient from the wetland?		
Do you think the hydrology of the site altered?		
What % of the swamp is hydrologically altered?		
Vegetation (cedar only)		**Yes/No**
Was site harvested?		
Cedar density acceptable?	Or is there a high density of balsam fir, alder?	
Cedar recruitment acceptable?	Are there cedar trees between 3-15' in height?	
Browse lines visable?		
Is cedar continous, in clumps, or scattered?		
What % of the swamp do you think has altered vegetation?		
Overall Site Condition		
		Condition
Overall condition (pick one)		
Excellent=	All catagories rated as excellent	
Good=	All catagories rated as good or better	
Fair=	All catagories rated as fair or better	
Poor=	All catagories rates as poor or better	
Disturbances that are impacting swamps (list all that apply)		
(1=roads,2=forestry, 3=drainage ditch, 4=irrigation canal, 5=agric,6=grazing,7=mining)		
(8=animal, 9=4x4,10=rec,11=utilities,12=fire,13=development,14=other)		
% of swamp assessed that is disturbed		
Does this swamp need restoration?		
Restoration Priority		
1. very high	disturbances are easily fixed or site has a high value	
2. high	disturbances are fairly easily fixed and site is in fair to poor condition	
3. moderate	disturbances are hard to fix or expensive, or site is in good condition	
4. low	site is in good to excellent condition, or site is very difficult to fix	
List photo names:		

Notes for questions on form: Rapid Swamp Assessment

1. Give a name or location for site. Also add location for each site (GPS or google earth)
2. Date of assessment
3. GPS coordinates, list what coordinate system you are using
4. Who owns the property?
5. Size of NW cedar stand being assessed.
6. If you have a pH meter, take reading of groundwater. If not, do not worry about it
7. Are you assessing a cedar, ash or tamarack swamp? Give MN NPC class if known.
8. Is the surface of the soil dry in mid-summer (discount this if it is in the spring or after a heavy rain)
9. Can you see the large cedar roots easily? This is an indication of drying and peat subsidence. See below photo for example.

10. Mosses are a good indicator of drainage. Put yes if there is less than 50% cover of mosses on the ground. This could be a sign that the site has undergone drainage and is drier than should be. The two photos below show sites with no mosses (drained from road), and one with lots on mosses in undisturbed site.

11. Are there lots of dead cedar trees? Usually from blocked drainage. See photo below for "road kill" cedar from blocked drainage.

12. Are there drainage ditches in the swamp?
13. Look at maps or walk site to see if there is impeded groundwater drainage from roads, train tracks, power lines right of ways, large ditches, or anything that alters ground water flow.
14. Given from what you have seen, and answers to above questions, do you think this swamp's hydrology (movement of water) has been altered?
15. What percentage of the swamp is hydrologically altered? Give a guess, does not have to be precise.
16. Was the site harvested recently (< 50 yrs ago)? Look for stumps or paper trail.
17. Are there as many cedar trees here as would expect given the ecotype? Is the basal area greater than 100 ft2/acre for cedar? If not, put no. Is most of the basal area in balsam fir, tamarack or alder? They typically replace cedar if cedar is removed. See photo below for balsam fir replacing cedar for an example.

18. Are there cedar regenerating in the understory? If there are numerous cedar trees between 3'-15', than say yes. Below show what this size tree looks like.

19. Are the cedar trees showing a "browse line". See photo below for an example of a cedar tree browsed, except for the bottom which was under the snow.

20. If you are in a tamarack or ash stand, is the NW cedar found in a few clumps, scattered about, or continuous found in the under or over-story?
21. What is you best guess for how much of the swamp has altered forest canopy?
22. What condition do you think this site is in overall given the above answers?
23. What do you see that has disturbed this swamp. Typical disturbances to swamps are from: forestry activities, excessive deer herbivory, or hydrology (ditches, roads).
24. Of the total area of swamp assessed, what proportion is disturbed (best guess)?
25. Does this site require restoration?
26. And if so, what priority would you give it? Low priority sites are those that would be expensive, overly difficult, or for sites that are in good shape. High priorities are for sites that are easily restored, high value, or modest effort can restored large areas. Basically, does this site have a " big bang for the buck".
27. List all photo names for this site.

Appendix II: Checklist of plant species identified by site.

649	646	276	9	117	28	*Species list*	Common Name
*			*	*		*Abies balsamea*	balsam fir
			*			*Acer saccharum*	sugar maple
			*			*Acer spicatum*	mountain maple
			*	*		*Alnus incana ssp. Rugosa*	tag alder
			*			*Amelanchier sp.*	service berry
			*		*	*Aralia nudicaulis*	wild sarsaparilla
				*		*Aronia melanocarpa*	black chokeberry
*						*Aster firmus*	Purple stem aster
				*		*Aster nemoralis*	bog aster
*						*Aster lanceolatus*	white panicle aster
			*			*Aster sp.*	aster
			*	*		*Aster umbellata*	parasol whitetop
*			*			*Betula papyrifera*	paper birch
*						*Bidens frondosa*	beggartick
*						*Bromus ciliatus*	fringed brome
*						*Campanula aparinoides*	marsh bellflower
			*			*Carex intumescens*	shining bur sedge
*	*	*				*Carex lacustris*	common lakeshore sedge
*		*	*	*	*	*Carex sp.*	sedge
				*		*Chamaedaphne calyculata*	leatherleaf
			*			*Clintonia borealis*	blue-bead lily
					*	*Convolvulus arvensis*	field Bindweed*
			*	*	*	*Coptis trifolia*	Three-leaf goldthread
		*	*	*	*	*Cornus cancanadensis*	bunchberry
			*			*Cystopteris bulbifera*	bulblet bladderfern
					*	*Diervilla lonicera*	northern bush honeysuckle
*						*Epilobium leptophyllum*	bog willowherb
			*			*Equisetum arvense*	field horsetail
	*			*		*Eupatorium maculatum*	spotted joe-pye-weed
*			*			*Fragaria virginiana*	wild strawberry
			*			*Fraxinus nigra*	black ash
	*	*	*		*	*Galium asprellum*	rough bedstraw
*		*				*Galium labradoricum*	northern bog bedstraw
				*		*Galium triflorum*	fragrant bedstraw
				*	*	*Gaultheria hispidula*	creeping snowberry
*			*	*	*	*Grass sp.*	
*		*			*	*Impatiens capensis*	common jewelweed
*						*Kalmia polifolia*	bog laurel
				*		*Iris versicolor*	blueflag
*						*Lactuca biennis*	tall blue lettuce
	*			*		*Larix laricina*	tamarack
*		*		*	*	*Ledum groenlandicum*	bog Labrador tea
		*	*			*Linnaea borealis*	twinflower
			*		*	*Lonicera candensis*	american fly honeysuckle
		*				*Lonicera oblongifolia*	swamp fly honeysuckle
		*			*	*Lycopus americanus*	american water horehound

*				*		*Lycopus uniflorus*	northern bugleweed
*	*	*				*Lysimachia quadrifolia*	whorled yellow loosestrife
			*		*	*Maianthemum canadense*	false lily-of- the-valley
		*				*Menyanthes trifoliata*	buckbean
*		*	*		*	*Mitella nuda*	naked miterwort
	*					*Panicum sp.*	grass
				*		*Picea mariana*	black spruce
	*					*Poa sp.*	Blue grass
*						*Polygonum sagittatum*	arrowleaf tearthumb
		*		*		*Potentilla palustris*	purple marshlocks
*	*			*	*	*Rubus ideaus*	wild red raspberry
*				*	*	*Rubus pubescens*	dwarf red raspberry
			*			*Ribes sp.*	gooseberry
	*			*		*Salix sp.*	willow
		*				*Scuttelaria lateriflora*	blue skullcap
		*		*		*Smilacina trifolia*	three-leaved solomon's-seal
*						*Solidago gigantea*	giant goldenrod
	*					*Solidago sp.*	goldenrod
				*		*Symplocarpus foetidus*	skunk cabbage
						Thalictrum dasycarpum	purple meadow-rue
		*	*	*	*	*Thuja occidentalis*	nw cedar
			*	*		*Trientalis borealis*	starflower
	*					*Trifolium sp.*	clover
						Trillium cernuum	nodding trillium
*	*					*Utrica dioica*	stinging nettle
				*		*Vaccinium angustifolium*	lowbush blueberry
				*		*Vaccinium myrtilloides*	velvetleaf huckleberry
		*		*		*Vaccinium oxycoccus*	dwarf bog cranberry
		*		*		*Viola sp.*	violet
		Ferns					
*			*	*	*	*Dryopteris carthusiana*	spinulose woodfern
*				*		*Dryopteris cristata*	crested woodfern
			*			*Gymnocarpium robertianum*	scented oakfern
		*		*		*Matteuccia struthiopteris*	ostrich fern
			*			*Phegopteris connectilis*	long beechfern
		Mosses and Clubmosses					
		*	*		*	*Climacium dendroides*	tree climacium moss
		*				*Dicranum sp*	
			*			*Hypnum lindbergii*	lindberg's hypnum moss
				*	*	*Huperzia lucidula*	shining clubmoss
				*		*Lycopodium annotinum*	stiff clubmoss
				*	*	*Lycopodium obscurum*	rare clubmoss
			*			*Leucobryum glaucum*	leucobryum moss
			*			*Mnium hornum*	horn calcareous moss
					*	*Plagiomnium drummondii*	drummond's plagiomnium moss
*		*		*	*	*Pleurozium schreberi*	schreber's big red stem moss
				*		*Polytricum sp.*	haircap moss

	*		*	*Rhytidiadelphus triquetrus*	rough goose neck moss
		*		*Sphagnum angustifolium*	
		*		*Sphagnum fuscum*	
		*		*Sphagnum girgensohnii*	
		*	*	*Sphagnum magellanicum*	
	*	*		*Sphagnum russowii*	
*		*	*	*Sphagnum sp.*	
	*			*Sphagnum warnstorfii*	
*				*Thuidium delicatulum*	delicate thuidium moss