2011 Project Abstract
For the Period Ending June 30, 2014

PROJECT TITLE: Northeast Minnesota White Cedar Plant Community Restoration
PROJECT MANAGER: Dale Krystosek
AFFILIATION: Minnesota Board of Water and Soil Resources
MAILING ADDRESS: 403 Fourth Street NW Room 200
CITY/STATE/ZIP: Bemidji, MN 56601
PHONE: 218-755-2603
E-MAIL: dale.krystosek@state.mn.us
WEBSITE: http://www.bwsr.state.mn.us/
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04r
APPROPRIATION AMOUNT: $250,000

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.

Project Goals:

1) Reverse decline of white cedar plant communities in Minnesota.
2) Improve quantity and quality of white cedar plant communities.

Methods: Board of Water and Soil Resources (BWSR) established seven experimental white cedar restorations and reference sites in Beltrami, Koochiching, St. Louis, and Lake Counties. Experimental treatments were designed by Dr. Rod Chimner and evaluated use of cedar seedlings, transplants, seeding and natural regeneration. Protection from browsing by wildlife was by rigid tree protectors and wire mesh enclosures. *(See attached technical Report).*

Results:

Evaluation/Prioritization of White Cedar Restoration Sites:
Goal: Evaluate 100 white cedar sites for restoration/preservation.
Results: 132 sites were evaluated in Aitkin, Koochiching, Itasca, St. Louis, Lake, Cook and Beltrami Counties.

Establishment of Demonstration Sites

Goal: 400 acres restored/preserved.
Results: 7 sites (485 acres) established in Beltrami, Koochiching, St. Louis and Lake County. Groundwater monitoring wells installed.

Training Resource Managers

Goal: Train 30 land managers.
Results: Two training sessions with 66 trained.
June 24, 2014, Meadowlands 38 managers trained.
June 25, 2014, Waskish, 28 managers trained.

Project Findings:

1. Many white cedar swamps are degraded and need restoration.
2. Major disturbances were roads, ditches and herbivory.
3. Most harvested cedar sites have not regenerated back to cedar, but were replaced by tag alder/balsam fir/red maple.
4. Largest single factor affecting cedar survival was hydrological conditions.

5. Site level hydrological conditions altered by roads may end up explaining tree growth and mortality.

Project Significance:

Northern White cedar provides unique wetland functions including:

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

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2011 Work Plan Main Document

Date of Status Update: **8/15/14 FINAL REPORT**
Date of Next Status Update: **---------**
Date of Work Plan Approval: 6/23/2011
Project Completion Date: 6/30/2014 **Is this an amendment request?** __No___

Project Title: Northeast Minnesota White Cedar Plant Community Restoration

Project Manager: Dale Krystosek
Affiliation: Board of Water and Soil Resources
Address: 403 4th Street NW, Ste 200
City: Bemidji **State:** MN **Zipcode:** 56601

Telephone Number: (218) 755-2603
Email Address: dale.krystosek@state.mn.us
Web Address: http://www.bwsr.state.mn.us/

Location:

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

Ecological Section Impacted: Northern Minnesota and Ontario Peatlands (212M), Northern Minnesota Drift and lake Plains (212N), Northern Superior Uplands (212L), Western Superior Uplands (212K)

Total ENRTF Project Budget:		
	ENRTF Appropriation $:	250,000.00
	Amount Spent $:	226,376.58
	Balance $:	23,623.42

Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04r

Appropriation Language:
$125,000 for the first year and $125,000 the second year are from the trust fund to the Board of Water and Soil Resources to assess the decline of northern white cedar plant communities in northeast Minnesota, prioritize cedar sites for restoration, and provide cedar restoration training to local units of government.

I. PROJECT TITLE: Northeast Minnesota White Cedar Plant Community Restoration

II. PROJECT SUMMARY:

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.

Project Goals:

1) Reverse decline of white cedar plant communities in Minnesota.
2) Improve quantity and quality of white cedar plant communities.

Methods: Board of Water and Soil Resources (BWSR) established seven experimental white cedar restorations and reference sites in Beltrami, Koochiching, St. Louis, and Lake Counties. Experimental treatments were designed by Dr. Rod Chimner and evaluated use of cedar seedlings, transplants, seeding and natural regeneration. Protection from browsing by wildlife was by rigid tree protectors and wire mesh enclosures. *(See attached technical Report).*

Results:

Evaluation/Prioritization of White Cedar Restoration Sites:
Goal: Evaluate 100 white cedar sites for restoration/preservation.
Results: 132 sites were evaluated in Aitkin, Koochiching, Itasca, St. Louis, Lake, Cook and Beltrami Counties.

Establishment of Demonstration Sites

Goal: 400 acres restored/preserved.
Results: 7 sites (485 acres) established in Beltrami, Koochiching, St. Louis and Lake County. Groundwater monitoring wells installed.

Training Resource Managers

Goal: Train 30 land managers.
Results: Two training sessions with 66 trained.
June 24, 2014, Meadowlands 38 managers trained.
June 25, 2014, Waskish, 28 managers trained.

Project Findings:

1. Many white cedar swamps are degraded and need restoration.
2. Major disturbances were roads, ditches and herbivory.
3. Most harvested cedar sites have not regenerated back to cedar, but were replaced by tag alder/balsam fir/red maple.
4. Largest single factor affecting cedar survival was hydrological conditions.

III. PROJECT STATUS UPDATES:

Project Status as of January, 2012:

BWSR is working on the following activities to implement the project:

- *Project contract with Koochiching SWCD has been developed, approved by Department of Administration and ready for finalization with BWSR and Koochiching SWCD*
- *Project contract with University of Minnesota Duluth, Natural Resources Research Institute is in development and nearly ready to execute*
- *BWSR has identified an individual to hire for the 50% unclassified wetland specialist position and that person is expected to begin work in February, 2012*
- *NRRI staff and BWSR project manager have had discussions with Dr. Rodney Chimner, Assistant Professor Michigan Tech University School of Forest Resources and Environmental*

Science to bring his expertise into the project through a sub contract with NRRI. Dr. Chimner is an expert in northern white cedar restoration and his research areas focus on wetland ecosystem science, ecohydrology and wetland restoration. Dr. Chimner's goal is to develop ecosystem knowledge of wetlands and use that knowledge to: 1) understand how they will be affected by climate change and other perturbations, 2) improve management and conservation of wetlands and 3) restore disturbed wetlands.

- *White cedar forest inventory data has been assembled and is ready for analysis to begin prioritization process for selection of restoration sites.*

Project Status as of September 2012:
BWSR has made the following progress to date:

- The core project team has been assembled and includes: Dale Krystosek, BWSR Project Manager; Jerry Stensing BWSR Project Technician; Dr. Rodney Chimner (Michigan Tech University) Technical Advisor; Kurt Johnson, University of Minnesota Duluth, Natural Resource Research Institute; Rick Dahlman (retired DNR Forestry Best Management Practice Coordinator), Brian Fredrickson, and Tom Estabrooks, Minnesota Pollution Control Agency. Additional advisors from DNR and local units of government have also participated in the project and an additional advisory committee will be established which will include additional DNR staff, U.S. Army Corps of Engineers, U.S. Forest Service and local units of government.

Project Status as of March 2013:
BWSR has made the following progress to date: The Core project team has finalized plans for establishment of 7 demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake County. The seven sites total 485 acres in area. Restoration and site preparation plans or monitoring plans have been developed for each of the sites (attached). Contracts with the Minnesota Conservation Corps have been executed to complete the restoration work on several of the sites including site preparation, tree planting, white cedar seeding and installation of tree protectors to prevent deer browsing damage.

Project Status as of January, 2014:
In May and June of 2013, the project team established 7 demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake County. The seven sites total 485 acres in area. Restoration and site preparation plans for each of the sites were implemented by the Minnesota Conservation Corps with supervision by BWSR staff. Restoration work on the sites included site preparation, tree planting, white cedar seeding and installation of tree protectors to prevent deer browsing damage and monitoring activity. Monitoring wells were also installed by Dr. Rodney Chimner, project consultant to collect data on groundwater influences on cedar survival.

Final Project Report by August 15, 2014:
In May and June of 2014, Project Graduate Student Rose Schwartz monitored and collected data on the 7 demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake County. The sites were reviewed to evaluate restoration work including site preparation, tree planting, white cedar seeding success and installation of tree protectors to prevent deer browsing damage. Monitoring well information was also downloaded to collect data on groundwater influences on cedar survival.

- ***See attachment one, Technical Report - Northeast Minnesota White Cedar Plant Community Restoration, Phase 1*** *(Chimner, Schwartz, Stensing, Dahlman and Krystosek).*

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.
Project Goals:

3) Reverse decline of white cedar plant communities in Minnesota.

4) Improve quantity and quality of white cedar plant communities.

Methods: Board of Water and Soil Resources (BWSR) established seven experimental white cedar restorations and reference sites in Beltrami, Koochiching, St. Louis, and Lake Counties. Experimental treatments were designed by Dr. Rod Chimner and evaluated use of cedar seedlings, transplants, seeding and natural regeneration. Protection from browsing by wildlife was by rigid tree protectors and wire mesh enclosures. *(See attached technical Report).*

Results: ***Evaluation/Prioritization of White Cedar Restoration Sites:***
Goal: Evaluate 100 white cedar sites for restoration/preservation.
Results: 132 sites were evaluated in Aitkin, Koochiching, Itasca, St. Louis, Lake, Cook and Beltrami Counties.
Establishment of Demonstration Sites **Goal:** 400 acres restored/preserved.
Results: 7 sites (485 acres) established in Beltrami, Koochiching, St. Louis and Lake County. Groundwater monitoring wells installed.
Training Resource Managers **Goal:** Train 30 land managers.
Results: *Two training sessions with 66 trained.*
June 24, 2014, Meadowlands 38 managers trained.
June 25, 2014, Waskish, 28 managers trained.

Project Findings:

a) Many white cedar swamps are degraded and need restoration.
b) Major disturbances were roads, ditches and herbivory.
c) Most harvested cedar sites have not regenerated back to cedar, but were replaced by tag alder/balsam fir/red maple.
d) Largest single factor affecting cedar survival was hydrological conditions.
e) Site level hydrological conditions altered by roads may end up explaining tree growth and mortality.

Project Significance:
Northern White cedar provides unique wetland functions including:

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

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Identify High Priority White Cedar Restoration and Preservation Sites - Three sources of data will be used to review and prioritize sites: *1) Northeast Minnesota Wetland Inventory and Assessment Project (BWSR and Barr Engineering, 2009), 2) Land Type Associations (Minnesota DNR Ecological Classification System), 3) forest inventory data sets (DNR Forestry and county).* BWSR will contract with Soil and Water Conservation Districts in northeast and north central Minnesota to evaluate and prioritize northern white cedar sites for restoration and preservation. An interagency technical team will establish criteria for prioritizing these sites. The data would be used to target potential sites for restoration and high priority ecologically sensitive sites that would benefit from preservation. Projects will be targeted on county or state lands and be protected by a long term vegetation agreement. (Projects on private land would be protected by a permanent easement granted to a public entity with details to be developed later, if necessary). SWCDs would field check and prioritize potential sites within the region. The project will review several seedbed preparation treatments where regeneration has not occurred to determine the most effective white cedar restoration techniques. Design and management of restoration projects would involve DNR, BWSR, county land departments, and the interagency technical team. Budget for this component would be for a ½ time BWSR Wetland Specialist to coordinate the effort for two years and also contracts with SWCDs. Sites identified through review of the three data sets will be field checked, evaluated and prioritized. 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 restoration and preservation. This work will include inspection of a minimum of 100 potential sites.

Activity 1: ***Identify High Priority White Cedar Restoration and Preservation Sites***

Summary Budget Information for Activity 1:

ENRTF Budget: $ 82,125.00
Amount Spent: $ 72,373.01
Balance: $ 9,751.99

Activity Completion Date: 7/12

Outcome for Activity 1:	**Completion Date**	**Budget**
1. ***Identify High Priority White Cedar Restoration and Preservation Sites using NE Wetland Mitigation Inventory, and Land Type Association data and forest inventory data.***	*3/12*	$ 36,625.00
2. ***Up to 12 Soil and Water Conservation Districts within the project area will inspect and prioritize sites*** (Sites identified through review of the three data sets will be field checked, evaluated, and prioritized.)	*5/12*	$ 30,000.00
3. ***Potential white cedar plant community restoration and preservation sites will be prioritized based on results of outcomes 1 and 2 above.***	*7/12*	$ 17,500.00

Activity Status as of January, 2012: BWSR staff has discussed accessing data for Activity 1.1 and will begin prioritization process in March, 2012.

Activity Status as of September 2012:
The following progress has been achieved for activity 1:

- The project team has reviewed potential sites high priority white cedar restoration and preservation sites demonstration using the Northeast Wetland Mitigation Inventory, and Land Type Association data and forest inventory data using geographic information system expertise from the University of Minnesota Duluth, Natural Resources Resource Institute. Potential sites were reviewed in Cook, Lake, St. Louis, Koochiching, Beltrami, Lake of the Woods, Itasca, Aitkin, Cass, Crow Wing, Aitkin, Hubbard, Wadena, Kanabec, Pine, Clearwater and Carlton County.
- The project team spent 4 days on field investigations of potential demonstration sites, coordinating closely with Minnesota DNR Foresters and ecologists and County Land Department foresters.

Activity Status as of March 2013:
BWSR has made the following progress to date: The Core project team has developed and finalized plans for establishment of 7 demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake County. The 7 sites total 485 acres in area. Restoration and site preparation plans or monitoring plans have been developed for each of the sites (attached). A contract with the Minnesota Conservation Corps has been executed to complete the restoration work on several of the sites including site preparation, tree planting, white cedar seeding and installation of tree protectors to prevent deer browsing damage. Dr. Rodney Chimner, project consultant, has developed a protocol for testing various treatments to restoration sites including:

- ***Planting of white cedar seedlings and yellow birch seedlings***
- ***Planting white cedar transplants***
- ***Protection of some seedlings and transplants by wire mesh cages (and others with no protection)***

- ***Test various site preparation techniques,***
- ***Installed monitoring wells with data loggers to determine hydrologic conditions at demonstration sites***
- ***Installed soil temperature probes,***
- ***Performed full vegetation surveys and conducting floristic quality assessments***
- ***Test groundwater PH, conductivity and a suit of anion and cation concentrations***

Restoration of the demonstration sites is planned for May 2013 and all necessary plant materials, deer protection materials have been ordered and the required labor force appears to be ready for installation.

Please note that Activity 1.2 will be completed in summer of 2013.

Project Status as of January, 2014:
BWSR has made the following progress to date:

- White cedar restoration sites were evaluated and prioritized. ***(Activity 1.1 was completed)***
- Contracts were implemented with Koochiching Soil and Water Conservation District (SWCD), Itasca SWCD, Aitkin SWCD and South St. Louis SWCD. ***(Activity 1.2 was completed)***
- Over 100 potential white cedar restoration sites have been evaluated in northeast and north central Minnesota including sites in Koochiching, Beltrami, Aitkin, Itasca, St. Louis, Lake and Cook counties.
- Potential white cedar plant community restoration and preservation sites were evaluated and prioritized and seven sites were selected for project demonstration sites. ***(Activity 1.3 was completed)***

Final Report Summary:

- All project activities previously completed.
- See attachment 1. ***Technical Report, Northeast Minnesota White Cedar Plant Community Restoration: Phase 1****, Chimner, R.A., Schwartz, R., Dahlman, R. and Krystosek, D.*
- *See attachment 2,* ***White Cedar Potential Restoration Sites – County Maps (Natural Resources Research Institute,*** *University of Minnesota, Duluth)*
- See attachment 3, ***Restoration Potential Level One Assessments for Beltrami, Cook, Lake and St. Louis County*****,** *Jerry Stensing, Minnesota Board of Water and Soil Resources***.**

Activity 2: Establish 5 white cedar restoration and preservation projects - A minimum of 5 projects will be established with a goal of 400 acres restored or preserved. The University of Minnesota, Duluth Natural Resource Research Institute will provide technical expertise in designing white cedar restoration projects. This work will include literature reviews, field data collection and project design. The sites selected for restoration or preservation will be based on criteria developed by the interagency technical team for demonstration of white cedar plant community restoration. Up to 5 contracts with county land departments will be implemented for restoration or preservation of high priority sites. These contracts would be to develop a minimum of 5 demonstration white cedar restoration or preservation projects totaling a minimum of 400 acres. This work will include site preparation, tree planting, installation of deer browse protection, and management of demonstration sites during project duration (2 years).

Summary Budget Information for Activity 2:

ENRTF Budget: $ 146,125.00
Amount Spent: $ 132,954.33
Balance: $ 13,170.67

Activity Completion Date: 5/13

Outcome	Completion Date	Budget

1. *BWSR staff will develop agreements with County Land Departments with high priority sites to implement projects*	*912*	$ 9,500.00
2. *Restoration or preservation plans for selected priority sites will be developed and implemented for a minimum of 5 sites.* (A minimum of 5 projects will be established with a goal of 400 acres restored or preserved.)	*5/13*	$ 135,125.00
3. A minimum of 2 Field Tours and a workshop will be held for local and state land managers and interested groups.	*5/13*	$ 1,500.00

Activity Status as of January, 2012: No work has been completed on this work item.

Activity Status as of September 2012:

- Seven demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake were identified (see attachment 9, map)
- Restoration plans and prescribed treatment plans were developed for the seven sites.
- Plant materials including white cedar seedlings, transplants and seed have been ordered and reserved for the restoration work.
- Currently researching suitable seedling protection to prevent white tailed deer damage to white cedar seedlings and transplants.
- Currently working on developing contracts with several land departments to implement demonstration sites.

Activity Status as of March 2013: Final restoration plans and prescribed treatment plans were developed for the seven sites demonstration sites in Beltrami, Koochiching, St. Louis and Lake County. Plant materials including white cedar seedlings, transplants and seed orders have been confirmed and reserved for the restoration work. The seedling protection to prevent white tailed deer damage to white cedar seedlings and transplants has been ordered (wire mesh) and a biodegradable alternative will be also be tested as part of the project.

BWSR has executed contracts with the following organizations to assist in implementation of the project:

- Natural Resources Research Institute $44,998.00
- Koochiching Soil and Water Conservation District $16,750.00
- Conservation Corps of Minnesota $21,060.00
- Lake County Land Department $19,950.00

Two to three additional contracts are anticipated to be developed during summer of 2013.

Project Status as of January, 2014:
BWSR has made the following progress to date: The Core project team has implemented establishment of 7 demonstration sites in Beltrami County, Koochiching County, St. Louis County and Lake County totaling 485 acres in area. Restoration and site preparation plans or monitoring plans have been implemented for each of the sites *(previously provided in March, 2013)*. A contract with the Minnesota Conservation Corps was executed to complete the restoration work on the sites including site preparation, tree planting, white cedar seeding and installation of tree protectors to prevent deer browsing damage. Dr. Rodney Chimner, project consultant, is collecting data to test various treatments to restoration sites including:

- ***Planting of white cedar seedlings and yellow birch seedlings***
- ***Planting white cedar transplants***
- ***Protection of some seedlings and transplants by wire mesh cages (and others with no protection)***
- ***Test various site preparation techniques,***

- ***Installed monitoring wells with data loggers to determine hydrologic conditions at demonstration sites***
- ***Installed soil temperature probes,***
- ***Performed full vegetation surveys and conducting floristic quality assessments***
- ***Test groundwater PH, conductivity and a suit of anion and cation concentrations***

Restoration of the demonstration sites was implemented in May and June of 2013.

BWSR has executed additional contracts *(see also those listed above)* with the following organizations to assist in implementation of the project:

- Aitkin Soil and Water Conservation District $ 6,625.00
- Itasca Soil and Water Conservation District $ 6,625.00
- South St. Louis Soil and Water Conservation District $ 20,000.00
- Koochiching Soil and Water Conservation Dist.(added/amended) $ 17,365.00

Final Report Summary:
All activities were completed including:

- Field Tour with Society of Wetland Scientists where 35 wetland scientists from around the world viewed white cedar restoration sites in St. Louis County on June 2, 2013.
- Field Workshop/Tour on August 19, 2013 to train SWCDs on white cedar restoration site evaluation.
- See also previously reported items.

Activity 3: Develop and deliver training for at least 30 local & state land managers and road authority staff regarding northern white cedar plant community restoration and minimizing wetland impacts by roads and trails. This activity would develop training materials and conduct training for local and state road authorities regarding 1) minimizing impacts to natural hydrology where roads cross forested wetlands and 2) site preparation and revegetation techniques for restoration of northern white cedar plant communities. This training initiative will target road authority staff to improve road project design to reduce hydrologic impacts to adjacent forested wetland plant communities, and land managers regarding site preparation and revegetation techniques for white cedar restoration.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 21,748.00
Amount Spent: $ 21,049.24
Balance: $ 698.76

Activity Completion Date: 6/13

Outcome	Completion Date	Budget
1. ***Develop training materials for northern white cedar plant community restoration and minimizing wetland impacts***	*3/13*	$ 19,000.00
2. ***Develop and deliver training for at least 30 local & state land managers and road authority staff regarding northern white cedar plant community restoration and minimizing wetland impacts by roads and trails.*** (This training initiative will target road authority staff for improved design to reduce hydrologic impacts to forested wetland plant communities adjacent to road projects and land managers regarding site preparation and revegetation techniques for white cedar restoration)	*6/13*	$ 2,750.00

Activity Status as of January, 2012: No work has been completed on this work item.

Activity Status as of September 2012: No work has been completed on this work item.

Activity Status as of March 2013: Initial discussion of training sessions has been discussed by the core project team. The preliminary training materials are being developed and will be finalized beginning in early winter, 2013 and the training will be conducted in spring of 2014.

Dale Krystosek and Rick Dahlman gave a presentation at a workshop of the Society of American Foresters meeting on February 26th, 20013 at Bunker Hills. Approximately 30 professional foresters attended the workshop and the project received general support and a high level of interest.

Project Status as of January, 2014:

- *Plans for developing and conducting a minimum of **2 Field Tours and a workshop for local and state land managers (Activity 2.3)** are being developed and the plan is to hold the training and tours in June, 2014.*
- ***The Society of Wetland Scientists toured one of the project demonstration sites in June, 2013** with about 35 wetland scientists from around the world learning about the Northeast Minnesota White Cedar Plant Community Restoration project.*
- *Project Manager Dale Krystosek gave **a presentation to the Society of American Foresters in January** that discussed the white cedar project.*
- *Project Manager Dale Krystosek and Project Technician Jerry Stensing gave **a presentation on the white cedar project at the Board of Water and Soil Resources "BWSR Academy" in October** which was attended by about 50 local government staff.*

Final Report Summary:
The project set a goal of developing and delivering training for at least 30 local & state land managers and road authority staff regarding northern white cedar plant community restoration and minimizing wetland impacts by roads and trails**.** The training included improved design to reduce hydrologic impacts to forested wetland plant communities adjacent to road projects and land managers regarding site preparation and revegetation techniques for white cedar restoration.

Results:** Two training sessions were held with a total of 66 resource managers trained. **June 24, 2014, Meadowlands, MN - 38 resource managers trained.
June 25, 2014, Waskish, MN - 28 resource managers trained.

- ***See attachment 6, White Cedar Training Flyer, June 24 and 25, 2014.***
- ***See attachment 4** - **An Ecological Case Study of Selected White Cedar Stands on State Lands in Beltrami County, Minnesota,** Harvey Tjader, CF NW Region Staff Forester, Department of Natural Resources, Jesse Lehner, Forestry intern, Michigan Technological University.*
- ***See attachment 5 - A visual comparison of canopies and regeneration of northern white cedar in selected stands in Northern Minnesota, Addendum to Cedar in NW Minnesota, and ECS case study**. Harvey Tjader, CF, NW Region Staff Forester, Department of Natural Resources, 2115 Birchmont Beach Road NE, Bemidji, MN 56601, and Jesse Lehner, Forestry intern Michigan Technological University masters candidate, 14837 161st. Ave, Wadena MN 56482*
- ***See Attachment 7 - White Cedar Training Sessions Photographs**.*

V. DISSEMINATION:

- **Field tours of white cedar restoration sites**
- **Training Session**
- **Final Report**

Description:

Status as of January, 2012: No work has been completed on this work item.

Status as of September 2012:
Several excellent tour sites have already been identified including:

- A site in Beltrami County that starkly demonstrates the impacts of hydrologic manipulation (roads and ditches) to white cedar regeneration and northern white cedar plant community understory composition and diversity. The diversion and drainage of natural hydrology on this site had drastic impacts not only on white cedar regeneration, but also on the understory and diversity of the plant community.
- Sites in St. Louis County that demonstrate impacts of hydrologic manipulation on white cedar plant communities.
- Site in Koochiching County that demonstrates the importance of maintaining seed trees to promote white cedar regeneration.

Status as of March 2013: BWSR hosted a project update meeting in Grand Rapids on February 6, 2013 and invited DNR, the US Forest Service, Soil and Water Conservation Districts, county land Departments and other interested parties. The meeting was well attended with 19 participants. The meeting agenda included:

- ***Project Overview - Dale Krystosek, BWSR Wetland Special Project Lead***
- ***White Cedar Ecology & Restoration - Dr. Rodney Chimner, Professor, Michigan Tech U.***
- ***Project benefits & Interagency Coordination - Rick Dahlman DNR Forestry BMP Coord.***
- ***Demonstration Site Description - Jerry Stensing, BWSR Project Technician (& Chimner)***
- ***Forest Succession in unaltered wet white cedar communities - Harvey Tjader, DNR Region Forest Ecologist***
- ***How can you participate in project - Dale Krystosek***

Meeting participants responded very favorably to the project and most offered to participate in the project including:

- ***Participate on the technical advisory committee***
- ***Develop criteria for targeting white cedar restoration sites***
- ***Participate in training session for foresters and ecologists regarding white cedar plant community restoration techniques***
- ***Conduct field review of potential white cedar restoration sites***
- ***Participate in training for road and trail design to minimize impacts to wetlands***
- ***Participate in project field days and tours***
- ***Development of plans for next phase of project for cedar restoration.***

The meeting participants expressed a strong interest and support for the project and expressed a desire to extend the effort to include monitoring of restoration success.

Project Status as of January, 2014:

- ***2 Field Tours and a workshop for local and state land managers*** *- Plans for developing and conducting a workshop are being developed and the plan is to hold the training and tours in June, 2014.*
- ***Presentation to the Society of American Foresters -*** *project Manager Dale Krystosek gave presentation in January, 2014 that discussed the white cedar project.*
- ***BWSR Academy -*** *Project Manager Dale Krystosek and Project Technician Jerry Stensing gave a presentation on the white cedar project at the Board of Water and Soil Resources BWSR Academy in October, 2013 which was attended by about 50 local government staff.*

Final Report Summary:

- ***Dale Krystosek and Rick Dahlman gave a presentation at a workshop of the Society of American Foresters*** meeting on February 26th, 2013 at Bunker Hills. Approximately 30 professional foresters attended the workshop and the project received general support and a high level of interest.

- ***The Society of Wetland Scientists toured one of the project demonstration sites in June, 2013*** *with about 35 wetland scientists from around the world learning about the Northeast Minnesota White Cedar Plant Community Restoration project.*

- *Project Manager Dale Krystosek gave* ***a presentation to the Society of American Foresters in January*** *that discussed the white cedar project.*

- *Project Manager Dale Krystosek and Project Technician Jerry Stensing gave* ***a presentation on the white cedar project at the Board of Water and Soil Resources "BWSR Academy"*** *in October, 2013 in Brainerd which was attended by about 50 local government staff.*

- **Project Goal: Develop and deliver training for at least 30 local & state land managers and road authority staff regarding northern white cedar plant community restoration and minimizing wetland impacts by roads and trails.** *(This training initiative will target road authority staff for improved design to reduce hydrologic impacts to forested wetland plant communities adjacent to road projects and land managers regarding site preparation and revegetation techniques for white cedar restoration)*.
  Results: *Two training sessions conducted with 66 resource managers trained.*
  - ***June 24, 2014, Meadowlands 38 managers trained.***
  - ***June 25, 2014, Waskish, 28 managers trained.***
  - ***Video of training was obtained which will be used to develop provided training materials on white cedar restoration and protection for foresters, ecologists, Soil and Water Conservation District staff and private consulting foresters.***

- ***See Attachment 7 – White Cedar Training Session, photos***

- ***See Attachment 8A and Attachment 8B – Northeast Minnesota White Cedar Plant Community Restoration - Dr. Chimner's White Cedar Training Presentation***

- **See Attachment 9 – Northeast Minnesota White Cedar Plant Community Restoration, Plant Materials – Restoration Process** *(Stensing presentation at training session)*

- ***See Attachment 10 – White Cedar Training Registry***

- **See Attachment 11 – White Cedar Project Article on "Snap Shot", BWSR Website *http://www.bwsr.state.mn.us/news/webnews/December2013/1.pdf***

- ***See Attachment 12 – Outdoor News article***

- ***Project Manager Dale Krystosek has been asked to present project findings at the Minnesota Wetlands Conference in January, 2015 in St. Paul.***

- ***The final report and attachments for this project will be posted on the Board of Water and Soil Resources website: http://www.bwsr.state.mn.us/ .***

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget: $250,000.00

Budget Category	$ Amount	Explanation
Personnel:	$ 74,250	Unclassified (50% time) Wetland Specialist (Board of Water and Soil Resources for 2 years) Salary - 74% Benefits - 26%
Professional/Technical		**Soil and Water Conservation Districts ($30,000)** Up to

Contracts:	$137,500	12 contracts with SWCDs based on criteria, priorities and targeted areas established by the interagency technical team. This field work would be to to complete field investigations and prioritization of white cedar sites for restoration and preservation. This work will include inspection of a minimum of 100 potential sites. **Natural Resource Research Institute ($45,000)** to provide technical expertise in designing white cedar restoration projects. This work will include evaluation of white cedar restoration field techniques in other states, field data collection and project design. This contract will also include providing assistance in development and delivery of training on white cedar restoration. **County Land Departments ($61,500)** - Up to 5 contracts with county land departments based on selection of highest priority sites by the interagency technical team for demonstration of white cedar plant community restoration. These contracts would be to develop a minimum of 5 demonstration white cedar restoration or preservation projects totaling a minimum of 400 acres. This work will include site preparation of demonstration sites, tree planting, installation of deer browse protection, and management of site during project duration (2 years).
Equipment/Tools/Supplies:	$29,250	Field supplies including costs for field demonstration of restoration techniques (fencing, plant materials, deer repellants, tree protection devices).
Travel Expenses in MN:	$9,000	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 18 county project area, c) Travel for BWSR staff to training sessions (Grand Rapids, Duluth, International Falls, etc.)
TOTAL ENRTF BUDGET:	**$250,000**	

Explanation of Capital Expenditures Greater Than $3,500: N/A

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 1.0 (1/2 time unclassified position for 2 years)

B. Other Funds: No cash match, however there will be in-kind contributions.

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$	$	
State			
15% of BWSR Senior Wetland Specialist (In-kind staff time)	$12,000.00	$ 12,000.00	Project Management
TOTAL OTHER FUNDS:	**$12,000.00**	**$ 12,000.00**	

VII. PROJECT STRATEGY:

A. Project Partners: The overall project will be managed by the Minnesota Board of Water and Soil Resources. Project partners that will be paid from ENRTF funds include: BWSR, NRRI, SWCDs and County land Departments. Project partners that will not receive ENRTF funds include DNR, MPCA, USF&WS, US Army Corps of Engineers and local government units. Design and management of restoration projects would involve Natural Resource Research Institute (NRRI)**,** DNR, BWSR, several county land commissioners and other local, state and federal agencies. Technical oversight will be accomplished by a regional inter-agency Northeast Wetland Restoration Committee made up of technical staff of NRRI, University of Minnesota, DNR, MPCA, BWSR, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and LGUs. Technical review will occur during late winter, 2011.

B. Project Impact and Long-term Strategy: The project will result in substantially improved northern white cedar wetland plant communities in the northeast and north central regions of Minnesota. Project benefits will include improved understanding of white cedar plant community restoration techniques and demonstration sites and training that will improve management of this important resource in the state.

C. Spending History: *N/A*

Funding Source	**M.L. 2005 or FY 2006-07**	**M.L. 2007 or FY 2008**	**M.L. 2008 or FY 2009**	**M.L. 2009 or FY 2010**	**M.L. 2010 or FY 2011**
2007 General Fund Appropriation for the Northeast Wetland Mitigation Inventory	$375,000.00				

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. MAP(S): See Attachment 2.

X. RESEARCH ADDENDUM: N/A

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted not later than January 30 2012, September 30, 2012, and March 30, 2013 and January 31, 2014. A final report and associated products will be submitted between June 30 and August 15, 2014 as requested by the LCCMR.

Attachment A: Budget Detail for M.L. 2011 (FY 2012-13) Environment and Natural Resources Trust Fund Projects

Project Title: Northeast Minnesota White Cedar Plant Community Restoration

Legal Citation: $125,000 for the first year and $125,000 the second year are from the trust fund to the Board of Water and Soil Resources to assess the decline of northern white cedar plant communities in northeast Minnesota, prioritize cedar sites for restoration, and provide cedar restoration training to local units of government

Project Manager: Dale Krystosek, BWSR Senior Wetland Specialist

M.L. 2011 (FY 2012-13) ENRTF Appropriation: $ 250,000

Project Length and Completion Date: 2 years, June30, 2014 Completion date

Date of Update: AUG 6, 2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	Activity 3 Budget	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Activity 1: Identify High Priority White Cedar Restoration and preservation Sites***			***Activity 2: Establish 5 white cedar restoration and preservation projects***			***Activity 3: Develop and deliver training for at least30 local and state land managers and road authority staff regarding northern white cedar plant community restoration and minimizing wetland impacts by roads and trails***				
Personnel (Wages and Benefits) BWSR Wetland Specialist (50% fulltime employment) 74% Salary, 26% for benefits - one person will fill this position through an unclassified position	$ 34,625.00	$ 25,996.09	$ 8,628.91	$ 28,075.00	$ 23,173.89	$ 4,901.11	$ 11,550.00	$ 11,416.31	$ 133.69	$ 74,250.00	$ 13,663.71
Professional/Technical Contracts - 1)Soil and Water Conservation Districts -Up to 12 contracts with SWCDs for additional staff based on criteria, priorities and targeted areas established by the interagency technical team. This field work would be to to complete field investigations and prioritization of white cedar sites for restoration and preservation.This work will include inspection of a minimum of 100 potential sites.	$ 30,000.00	$ 30,000.00	$ -							$ 30,000.00	$ -
Professional/Technical Contracts - 2) Natural Resource Research Insitiute - Contract to provide technical expertise in designing white cedar restoration projects. Work will include review and evaluation of techniques in other states, field data collection and project design. This contract will also development and delivery of training on white cedar restoration.	$ 15,000.00	$ 14,452.74	$ 547.26	$ 21,000.00	$ 21,537.26	$ (537.26)	$ 8,998.00	$ 8,998.00	$ -	$ 45,000.00	$ 12.00
Professional/Technical Contracts - 3) County Land Departments - Up to 5 contracts with county land departments based on selection of highest priority sites by the interagency technical team for demonstration of white cedar plant community restoration. These contracts would be to develop a minimum of 5 demonstration white cedar restoration or preservation projects totaling a minimum of 400 acres. This work will include site preparation of demonstration sites, tree planting, installation of deer brouse protection, and management of site during project duration (2 years).				$ 62,500.00	$ 62,500.00	$ -				$ 62,500.00	$ -
Equipment/Tools/Supplies - Field supplies including costs for field demonstration of restoration techniques (fencing, plant materials, deer repellants, tree protection devices).				$ 29,250.00	$ 22,386.70	$ 6,863.30				$ 29,250.00	$ 6,863.30
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 18 county project area, c) Travel for BWSR staff to training sessions (Grand Rapids, Duluth, International Falls, etc.)	$ 2,500.00	$ 1,924.18	$ 575.82	$ 5,300.00	$ 3,356.48	$ 1,943.52	$ 1,200.00	$ 634.93	$ 565.07	$ 9,000.00	$ 3,084.41
COLUMN TOTAL	**$ 82,125.00**	**$ 72,373.01**	**$ 9,751.99**	**$ 146,125.00**	**$ 132,954.33**	**$ 13,170.67**	**$ 21,748.00**	**$ 21,049.24**	**$ 698.76**	**$ 250,000.00**	**$ 23,623.42**

ATTACHMENT 1a1 – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

Final report prepared for the Legislative and Citizens Commission on Minnesota Resources

Funded by:

Environment and Natural Resources Trust Fund

Chimner, R.A.[1], Schwartz, R.[1], Stensing, J.[2], Dahlman, R.[3] and Krystosek, D.[4]

[1]Michigan Technological University, School of Forest Resources and Environmental Science, Houghton, MI 49931
[2]Minnesota Board of Water and Soil Resources, Waskish, MN 56685.
[3]Minnesota Department of Natural Resources, Div. of Forestry (Retired), Elk River, MN 55330
[4]Minnesota Board of Water and Soil Resources, Bemidji, MN 56601.

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 objectives of this research are: 1) to assess the condition of cedar swamps in N. Minnesota, 2) to characterize the hydrologic conditions of NWC swamps, 3) quantify the success of direct seeding of cedar, 4) quantify the success of planting cedar along a gradient of wetness and water chemistry, and 5) quantify the usefulness of single tree protectors.

Methods

Site Descriptions and Treatments

The Minnesota Board of Water and Soil Resources (BWSR) has established seven unique experimental restoration 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).

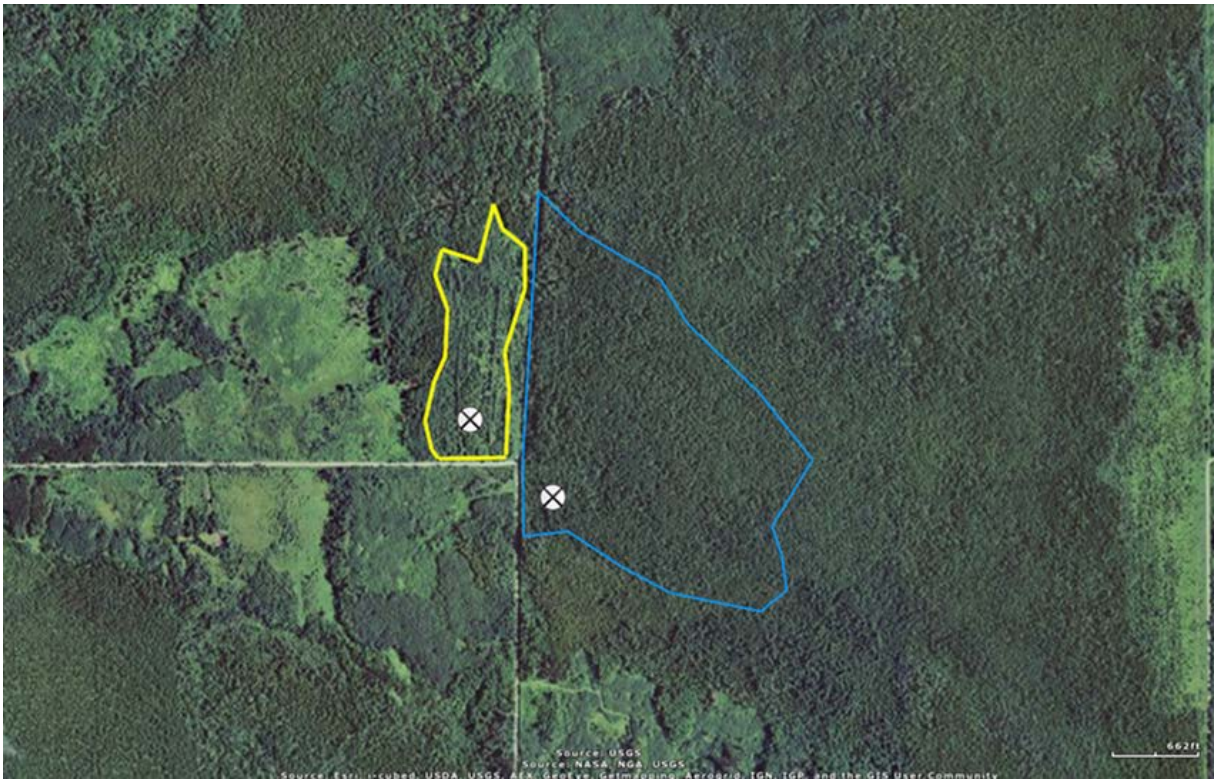

Figure 3. Aerial photo of site #664 in Beltrami County. Yellow outline indicates location of planting and seeding and blue line indicates secondary reference site. White circles indicate location of groundwater wells.

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.

ATTACHMENT 1a2 – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

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).

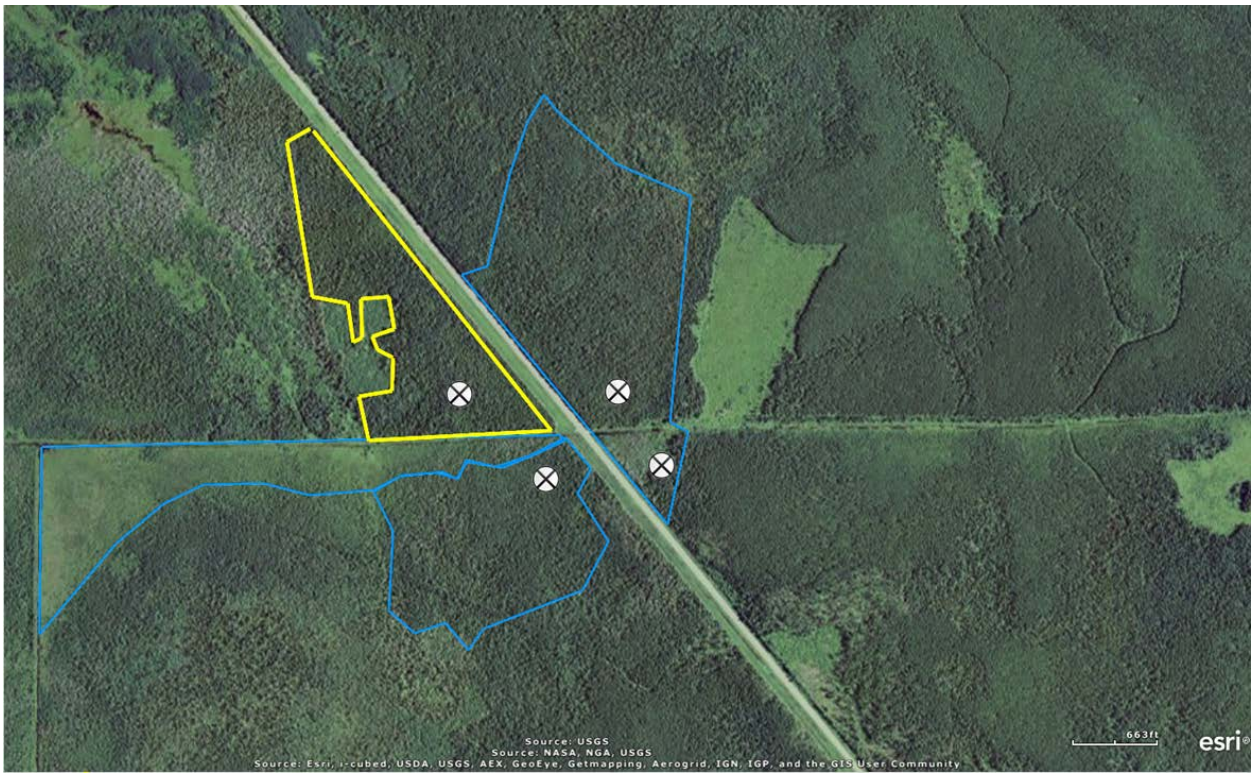

Figure 4. Aerial photo of site #276 (yellow outline) and adjacent sites (blue outline) in Beltrami County. White circles indicate location of groundwater wells.

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.

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Results and Discussion

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).

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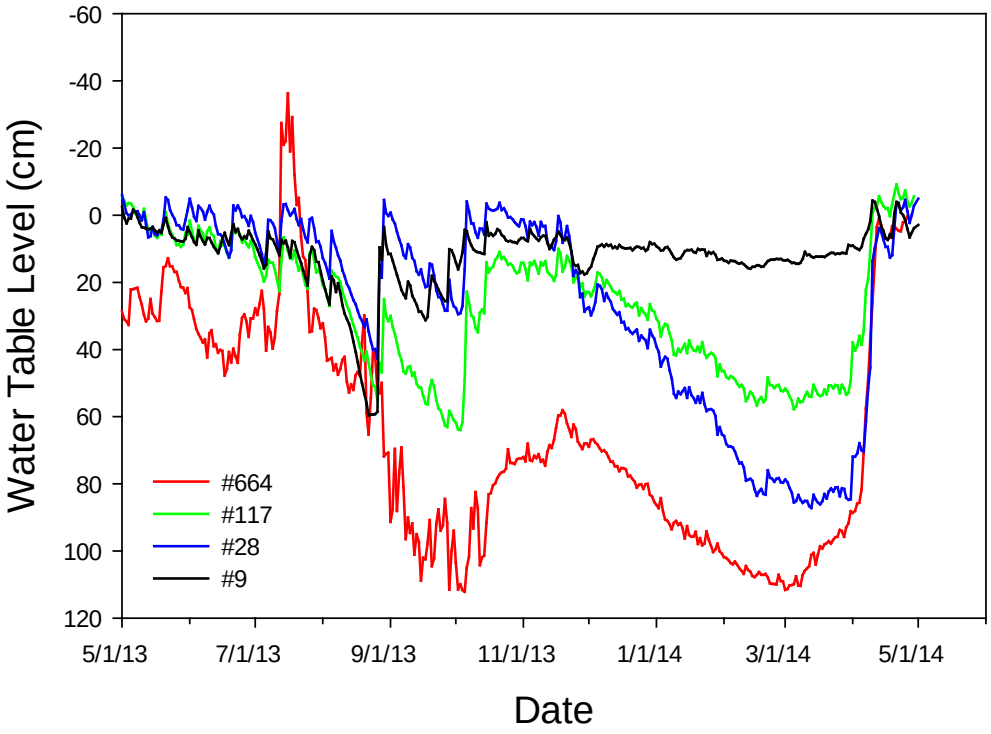

Figure 9. Time series of water table elevations at restoration sites. Negative numbers indicate water table levels the above ground surface.

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.

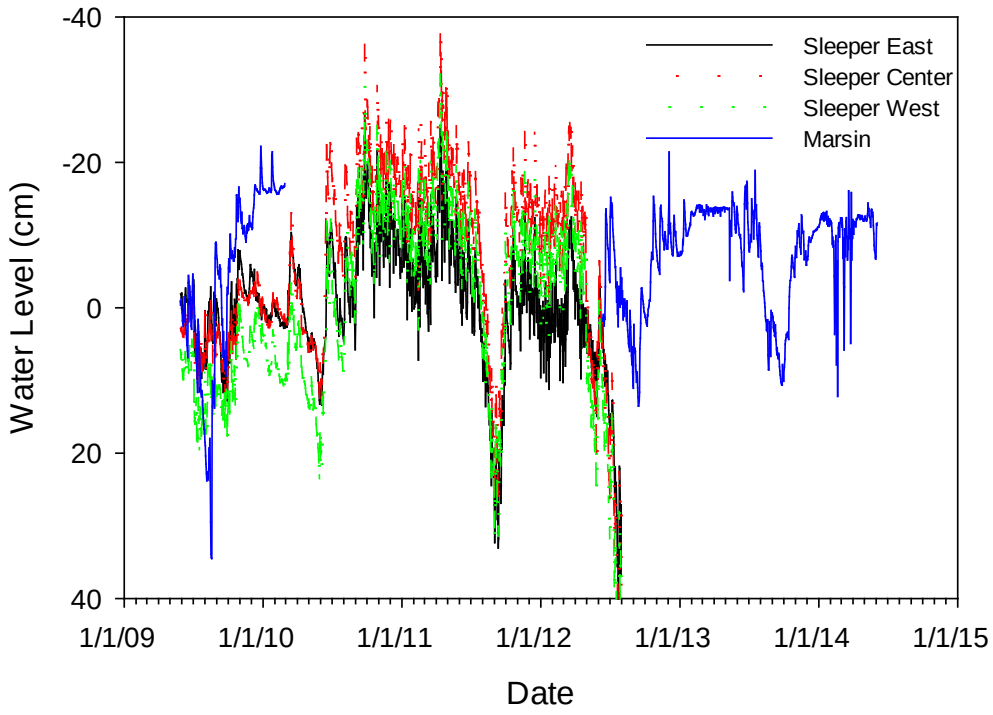

Figure 10. Reference water table levels from two undisturbed cedar swamps (Sleeper and Marsin) in the Upper Peninsula of Michigan (Chimner unpublished data).

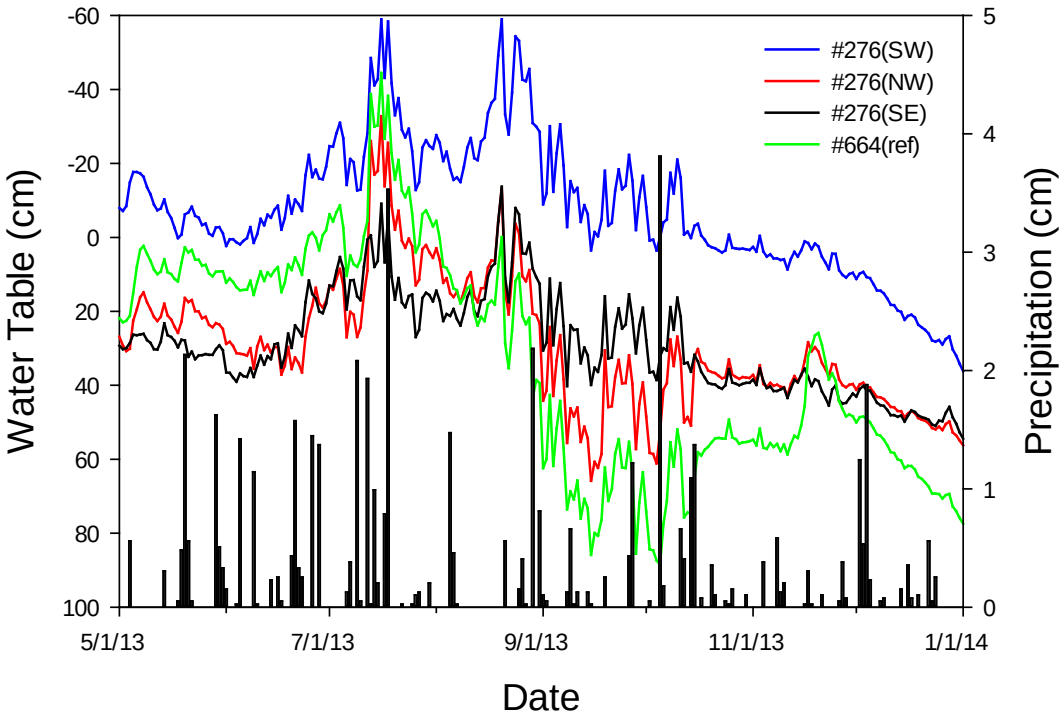

Figure 11. Water table levels of non-restoration sites in Minnesota.

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).

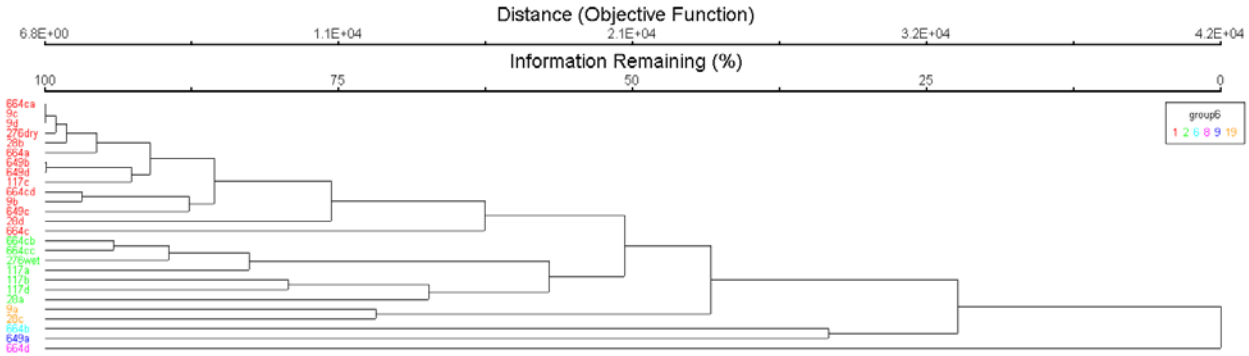

Figure 12. Cluster analysis of understory species at restoration sites.

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).

ATTACHMENT 1b – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

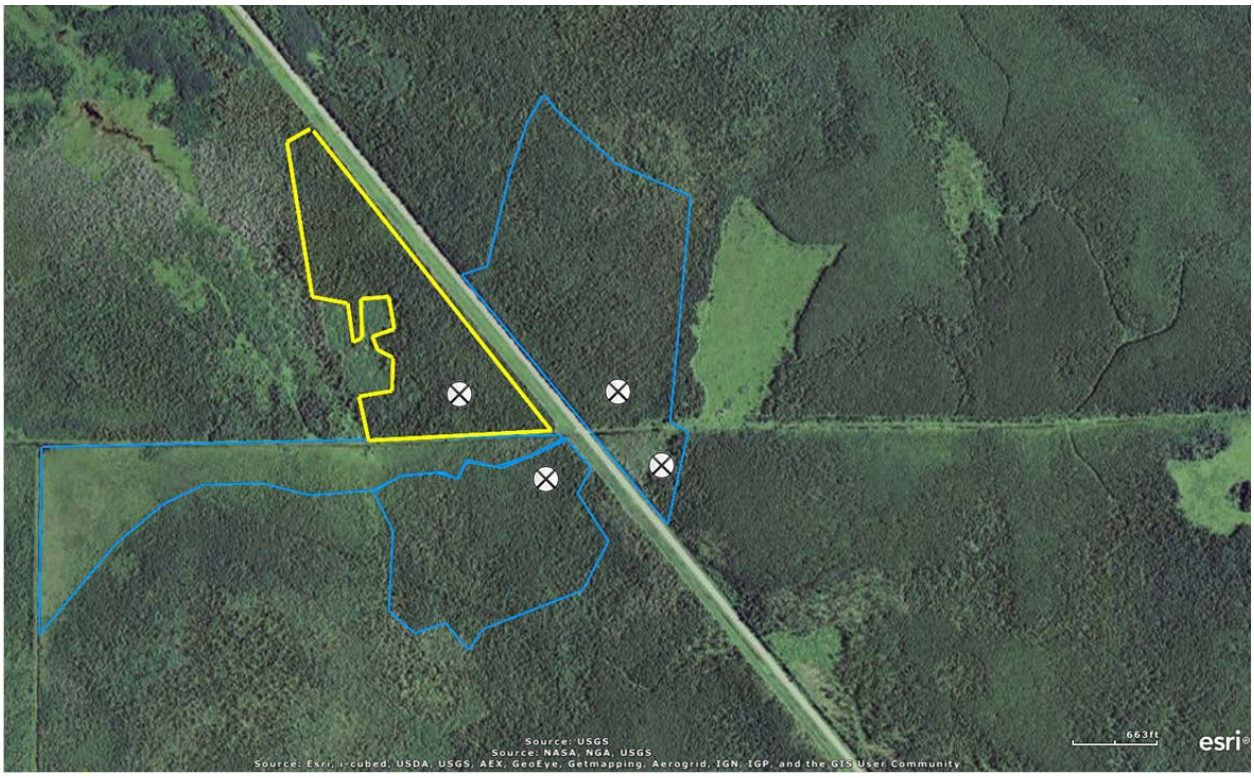

Figure 4. Aerial photo of site #276 (yellow outline) and adjacent sites (blue outline) in Beltrami County. White circles indicate location of groundwater wells.

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.

<u>County Land Department Stand #09-29TA "Boomer Road"</u>

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.

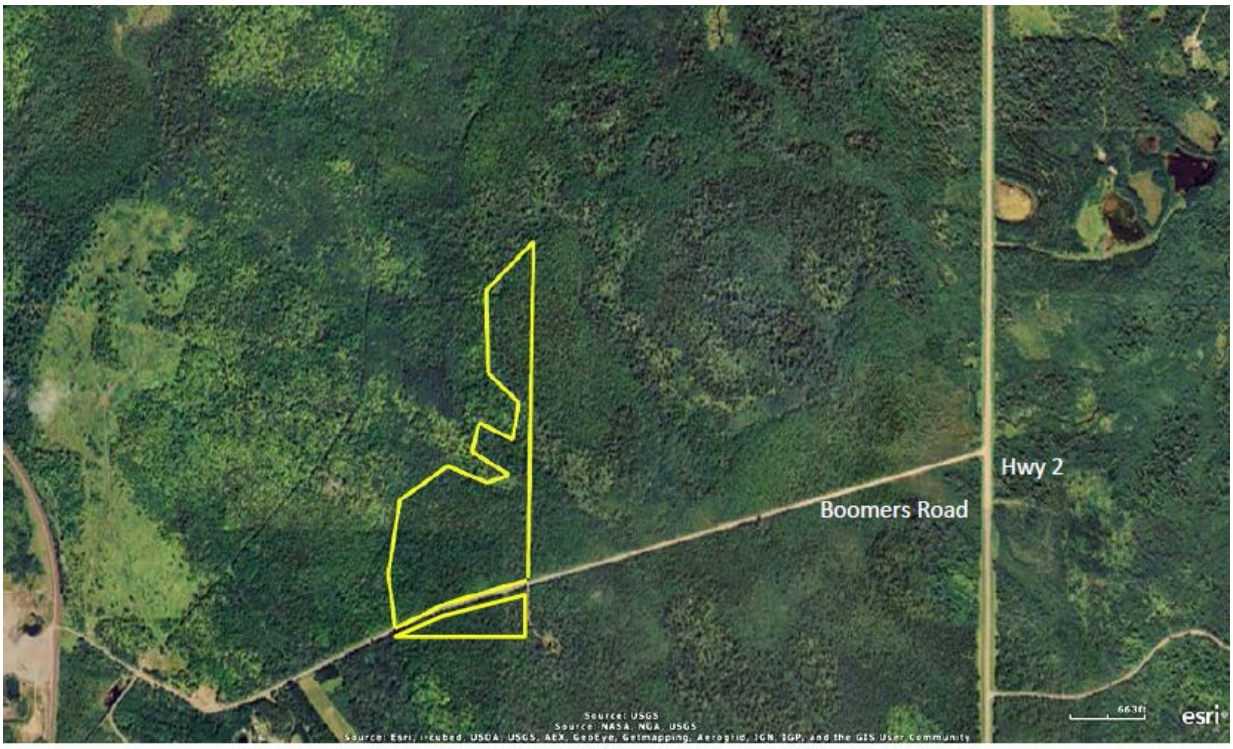

Figure 7. Aerial photo of site #09-29TA (yellow outline) in Lake County.

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.

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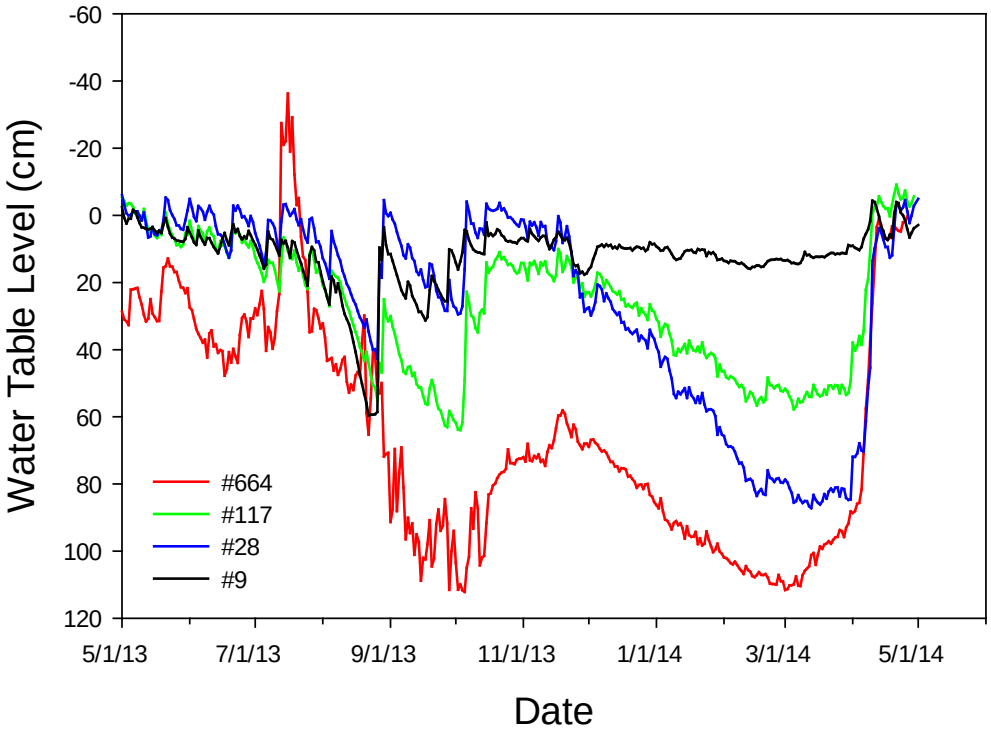

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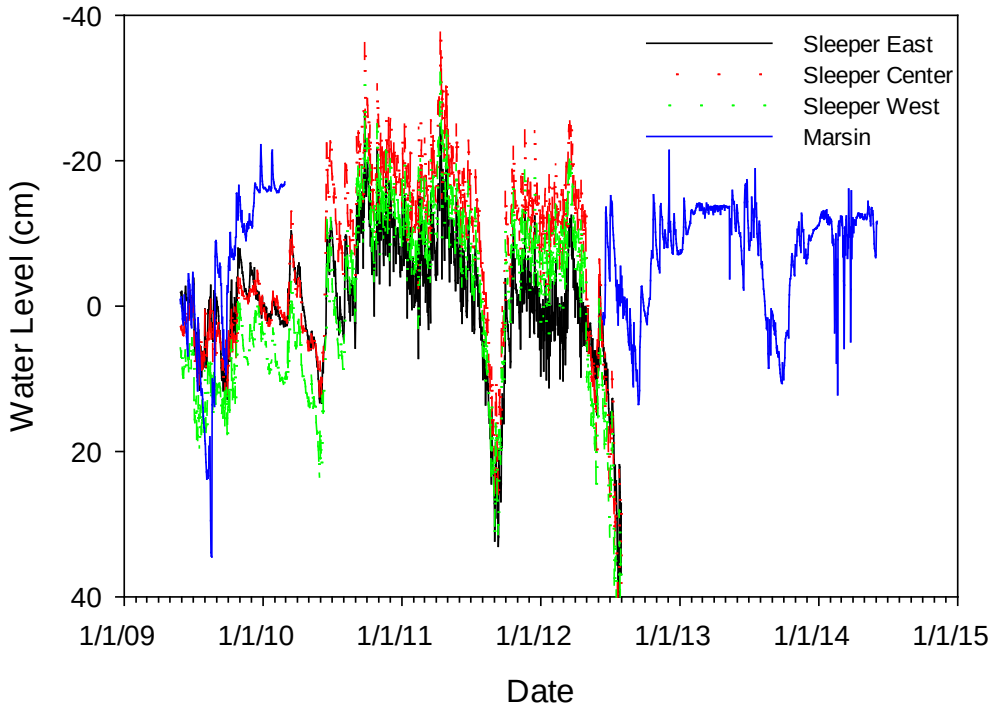

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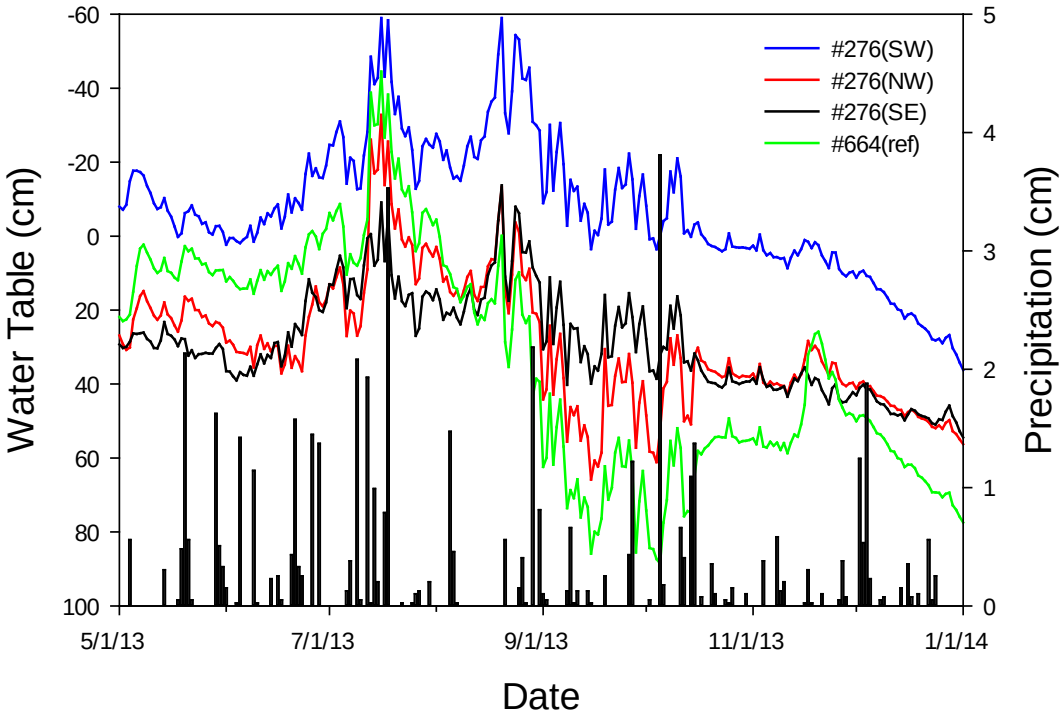

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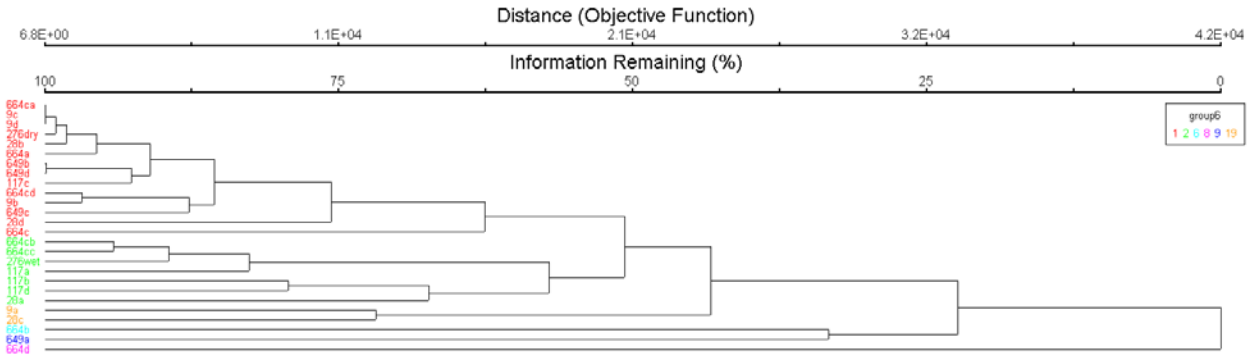

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ATTACHMENT 1c – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

Literature Cited

Boulfroy, E., E. Forget, P. V. Hofmeyer, L. S. Kenefic, C. Larouche, G. Lessard, J.-M. Lussier, F. Pinto, J.-C. Ruel, and A. Weiskittel. 2012. Silvicultural guide for northern white-cedar (eastern white cedar). General Technical Report NRS-98, United States Department of Agriculture, United States Forest Service, Northern Research Station.

Caulkins, H. L. 1967. The ecology and reproduction of northern white-cedar. University of Michigan.

Chimner, R. A., and J. B. Hart. 1996. Hydrology and microtopography effects northern white-cedar regeneration in Michigan's Upper Peninsula. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere 26:389-393.

Chimner R.A., D.J. Cooper and J.M. Lemly. 2010. Mountain fen distribution, types and restoration priorities, San Juan Mountains, Colorado, USA. Wetlands 30:763-771.

Cornett, M. W., P. B. Reich, K. J. Puettmann, and L. E. Frelich. 2000. Seedbed and Moisture Availability Determine Safe Sites for Early Thuja occidentalis (Cupressaceae) Regeneration. American Journal of Botany 87:1807-1814.

Cornett, M. W., K. J. Puettmann, L. E. Frelich, and P. B. Reich. 2001. Comparing the importance of seedbed and canopy type in the restoration of upland Thuja occidentalis forests of northeastern Minnesota. Restoration ecology 9:386-396.

Curtis, J. D. 1946. Preliminary Observations on Northern White Cedar in Maine. Ecology 27:23-36.

Doepker, R., and J. Ozoga. 1991. Wildlife values of northern white-cedar. Research report from the Michigan State University Agricultural Experiment Station, East Lansing.

Forester, J. D., D. P. Anderson, and M. G. Turner. 2008. Landscape and Local Factors Affecting Northern White Cedar (Thuja occidentalis) Recruitment in the Chequamegon-Nicolet National Forest, Wisconsin (USA). American Midland Naturalist 160:438-453.

Gorham, E. 1991. Northern peatlands: role in the carbon cycle and probable responses to climatic warming. Ecological Applications 1: 182-195.

Haworth, B. K. 2011. Response of Thuja occidentalis and Abies balsamea Seedlings to Stand Manipulations in Northern Minnesota Riparian Forests. University of Minnesota.

Heitzman, E., K. S. Pregitzer, and R. O. Miller. 1997. Origin and early development of northern white-cedar stands in northern Michigan. Canadian Journal of Forest Research 27:1953-1961.

Heitzman, E., K. S. Pregitzer, R. O. Miller, M. Lanasa, and M. Zuidema. 1999. Establishment and development of northern white-cedar following strip clearcutting. Forest Ecology and Management 123:97-104.

Hofstra, G., and R. Hall. 1971. Injury on roadside trees: leaf injury on pine and white cedar in relation to foliar levels of sodium and chloride. Canadian Journal of Botany 49:613-622.

Holcombe, J. W. 1976. Bryophyte flora of Thuja seedbed logs in a northern white-cedar swamp. Michigan botanist.

Johnston, W. F. 1977. Northern White cedar in the North Central States. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station.

Johnston, W. F. 1990. Thuja occidentalis (L.) Northern White-Cedar. Silvics of North America 1:580-589.

Kangas, L. C. 2012. Restoration of forested wetlands: Case studies in Michigan and Finland. Master´s thesis, Michigan Technological University, Michigan, USA.

Kost, M., D. Albert, J. Cohen, B. Slaughter, R. Schillo, C. Weber, and K. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Pages 1–10. . Lansing, MI.

Larouche, C., J.-C. Ruel, and J.-M. Lussier. 2011. Factors affecting northern white-cedar (Thuja occidentalis) seedling establishment and early growth in mixedwood stands. Canadian Journal of Forest Research 41:568-582.

Minnesota Department of Natural Resources. 2003. Field guide to the native plant communities of Minnesota: the Laurentian Mixed Forest Province. MNDNR, St. Paul, MN.

Nelson, T. C. 1951. A reproduction study on northern white cedar: including results of investigations under federal aid in Wildlife Restoration Project Michigan 49-R., Research Report for the Game Division of the Michigan Department of Conservation, Lansing, MI.

Ott, C. A. 2013. Carbon in the Peatlands in the Great Lakes Region. Michigan Technological University.

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Roulet, N.T. 2000. Peatlands, carbon storage, greenhouse gases, and the Kyoto Protocol: prospects and significance for Canada. Wetlands 20: 605-615.

Satterlund, D.R. 1960. Some interrelationships between groundwater and swamp forest in the western Upper Peninsula of Michigan. Dissertation. University of Michigan.

Scott, M. L., and P. G. Murphy. 1987. Regeneration Patterns of Northern White Cedar, an Old-Growth Forest Dominant. American Midland Naturalist 117:10-16.

Smith, P.C. and E.L. Borczon. 1981. Cutting plans for deer and timber in cedar swamps. Ont. Min. Nat. Res. 33pp.

Soil Survey Staff. Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at: http://websoilsurvey.nrcs.usda.gov/. Accessed February 26, 2014.

Thornton, P. L. 1957. Effects of cutting methods on advance reproduction in two mature mixed coniferous swamps in Upper Michigan. Journal of Forestry 55:448-451.

Verme, L.J. and W.F. Johnson. 1986. Regeneration of northern white-cedar deeryards in Upper Michigan. J. Wild. Manag. 50:307-313.

Zasada, Z. 1952. Reproduction on cut-over swamplands in the Upper Peninsula of Michigan. Division of Forest Management, Lake States Forest Experiment Station, US Department of Agriculture--Forest Service.

Appendix I: Assessment form and notes used in 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

ATTACHMENT 1d – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

Literature Cited

Boulfroy, E., E. Forget, P. V. Hofmeyer, L. S. Kenefic, C. Larouche, G. Lessard, J.-M. Lussier, F. Pinto, J.-C. Ruel, and A. Weiskittel. 2012. Silvicultural guide for northern white-cedar (eastern white cedar). General Technical Report NRS-98, United States Department of Agriculture, United States Forest Service, Northern Research Station.

Caulkins, H. L. 1967. The ecology and reproduction of northern white-cedar. University of Michigan.

Chimner, R. A., and J. B. Hart. 1996. Hydrology and microtopography effects northern white-cedar regeneration in Michigan's Upper Peninsula. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere 26:389-393.

Chimner R.A., D.J. Cooper and J.M. Lemly. 2010. Mountain fen distribution, types and restoration priorities, San Juan Mountains, Colorado, USA. Wetlands 30:763-771.

Cornett, M. W., P. B. Reich, K. J. Puettmann, and L. E. Frelich. 2000. Seedbed and Moisture Availability Determine Safe Sites for Early Thuja occidentalis (Cupressaceae) Regeneration. American Journal of Botany 87:1807-1814.

Cornett, M. W., K. J. Puettmann, L. E. Frelich, and P. B. Reich. 2001. Comparing the importance of seedbed and canopy type in the restoration of upland Thuja occidentalis forests of northeastern Minnesota. Restoration ecology 9:386-396.

Curtis, J. D. 1946. Preliminary Observations on Northern White Cedar in Maine. Ecology 27:23-36.

Doepker, R., and J. Ozoga. 1991. Wildlife values of northern white-cedar. Research report from the Michigan State University Agricultural Experiment Station, East Lansing.

Forester, J. D., D. P. Anderson, and M. G. Turner. 2008. Landscape and Local Factors Affecting Northern White Cedar (Thuja occidentalis) Recruitment in the Chequamegon-Nicolet National Forest, Wisconsin (USA). American Midland Naturalist 160:438-453.

Gorham, E. 1991. Northern peatlands: role in the carbon cycle and probable responses to climatic warming. Ecological Applications 1: 182-195.

Haworth, B. K. 2011. Response of Thuja occidentalis and Abies balsamea Seedlings to Stand Manipulations in Northern Minnesota Riparian Forests. University of Minnesota.

Heitzman, E., K. S. Pregitzer, and R. O. Miller. 1997. Origin and early development of northern white-cedar stands in northern Michigan. Canadian Journal of Forest Research 27:1953-1961.

Heitzman, E., K. S. Pregitzer, R. O. Miller, M. Lanasa, and M. Zuidema. 1999. Establishment and development of northern white-cedar following strip clearcutting. Forest Ecology and Management 123:97-104.

Hofstra, G., and R. Hall. 1971. Injury on roadside trees: leaf injury on pine and white cedar in relation to foliar levels of sodium and chloride. Canadian Journal of Botany 49:613-622.

Holcombe, J. W. 1976. Bryophyte flora of Thuja seedbed logs in a northern white-cedar swamp. Michigan botanist.

Johnston, W. F. 1977. Northern White cedar in the North Central States. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station.

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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?	
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Is cedar continous, in clumps, or scattered?		
What % of the swamp do you think has altered vegetation?		
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		Condition
Overall condition (pick one)		
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% of swamp assessed that is disturbed		
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List photo names:		

Notes for questions on form: Rapid Swamp Assessment

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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.

ATTACHMENT 1e – TECHNICAL REPORT

Northeast Minnesota White Cedar Plant Community Restoration: Phase I

10. 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?

11.What is you best guess for how much of the swamp has altered forest canopy?
11. What condition do you think this site is in overall given the above answers?
12. What do you see that has disturbed this swamp. Typical disturbances to swamps are from: forestry activities, excessive deer herbivory, or hydrology (ditches, roads).
13. Of the total area of swamp assessed, what proportion is disturbed (best guess)?
14. Does this site require restoration?
15. 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".
16. List all photo names for this site.

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			*			*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
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*	*	*				*Carex lacustris*	common lakeshore sedge
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		*	*	*	*	*Cornus cancanadensis*	bunchberry
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*						*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

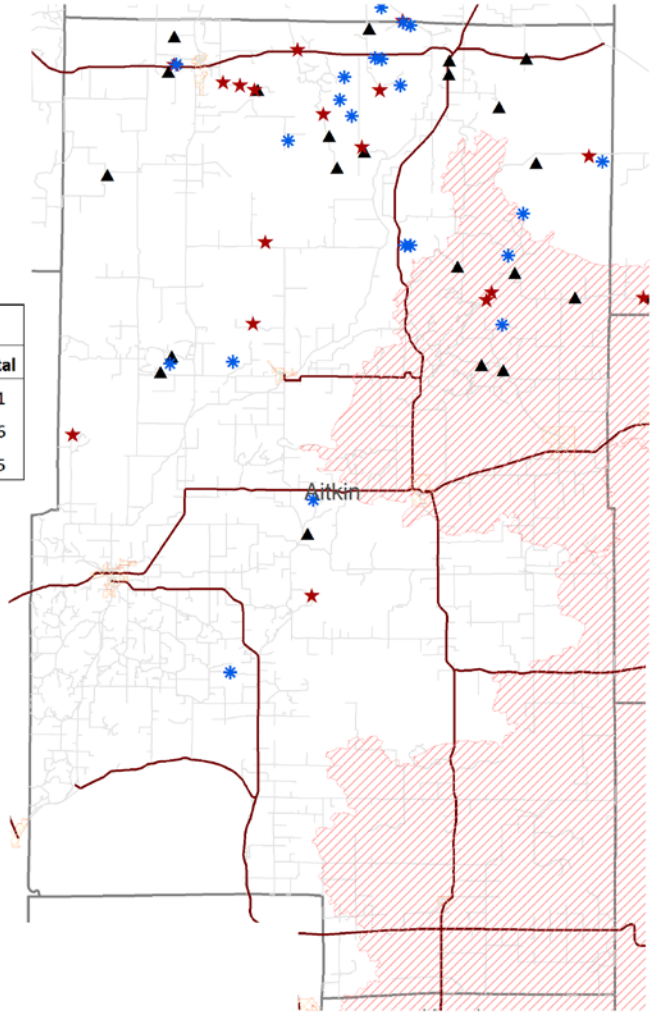
	*		*	*Rhytidiadelphus triquetrus*	rough goose neck moss
		*		*Sphagnum angustifolium*	
		*		*Sphagnum fuscum*	
		*		*Sphagnum girgensohnii*	
		*	*	*Sphagnum magellanicum*	
	*	*		*Sphagnum russowii*	
*		*	*	*Sphagnum sp.*	
	*			*Sphagnum warnstorfii*	
*				*Thuidium delicatulum*	delicate thuidium moss

ATTACHMENT 2

WHITE CEDAR POTENTIAL RESTORATION SITES – COUNTY MAPS *(Natural Resources Research Institute, University of Minnesota, Duluth)*

AitkinCounty

Aitkin County					
species	County	State	Federal	Tribal	Total
cedar	1	10	0	0	11
ash	0	16	0	0	16
tamarack	0	15	0	0	15



White Cedar Restoration

Potential High Quality Sites

- Cedar
- Ash / Cedar
- Tamarack / Cedar
- TMDL* Impaired Watersheds
- City Boundaries
- Major Roads
- Minor Roads

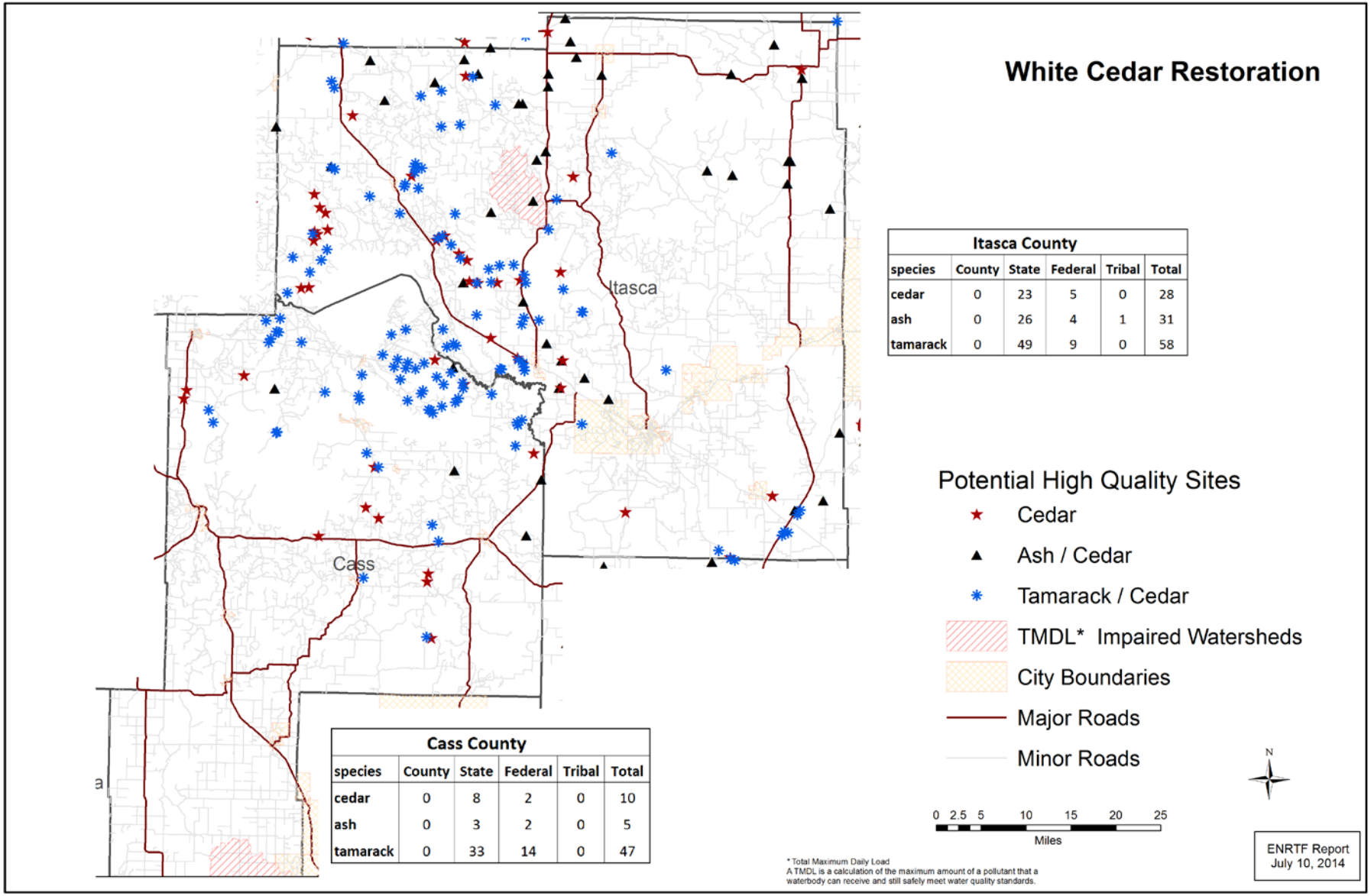
0 2 4 8 12 16 20
Miles

N

* Total Maximum Daily Load
A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.

ENRTF Report
July 10, 2014

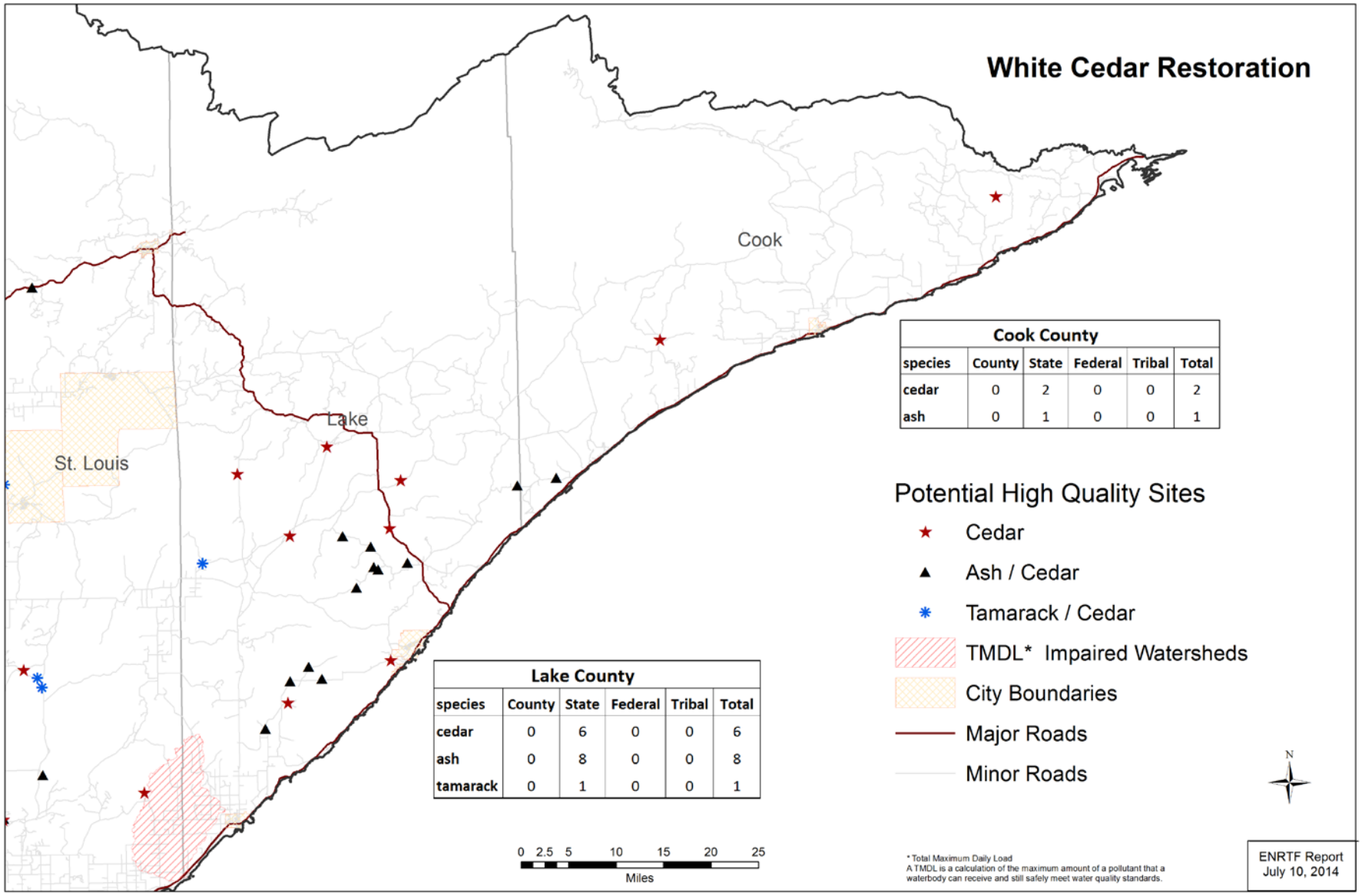
Itasca County



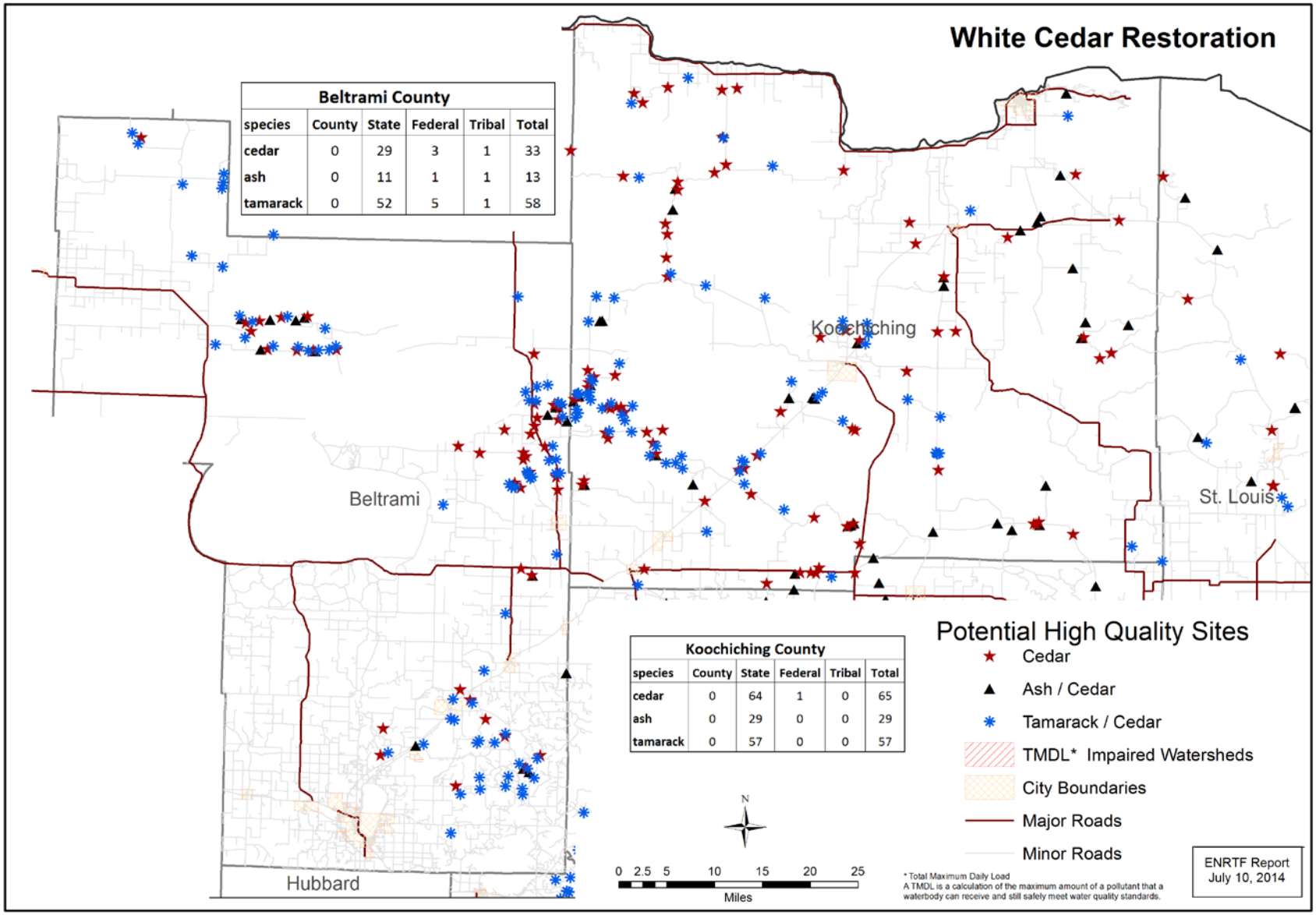
Itasca County					
species	County	State	Federal	Tribal	Total
cedar	0	23	5	0	28
ash	0	26	4	1	31
tamarack	0	49	9	0	58

Cass County					
species	County	State	Federal	Tribal	Total
cedar	0	8	2	0	10
ash	0	3	2	0	5
tamarack	0	33	14	0	47

Cook and Lake County

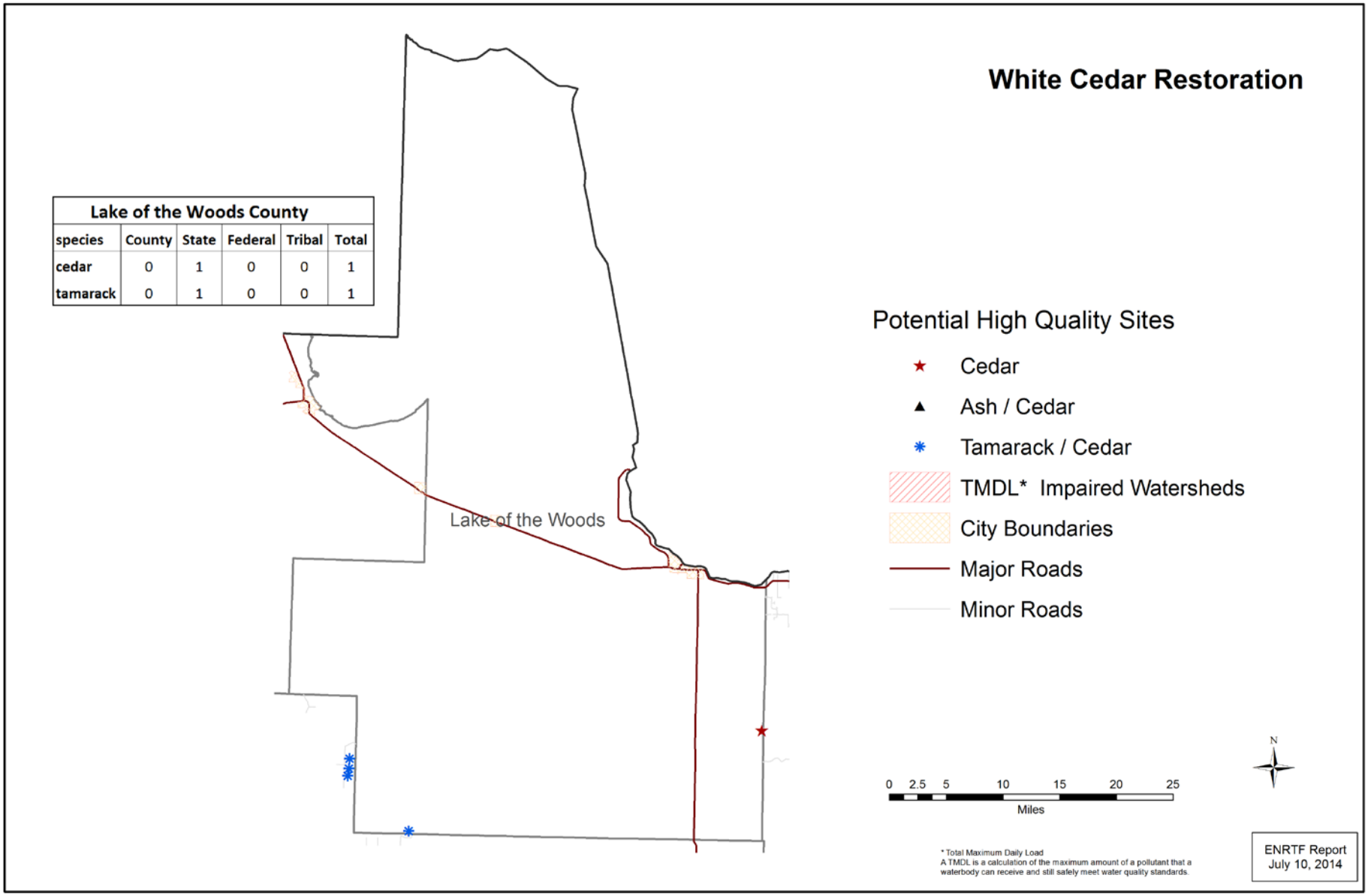


Beltrami and Koochiching County

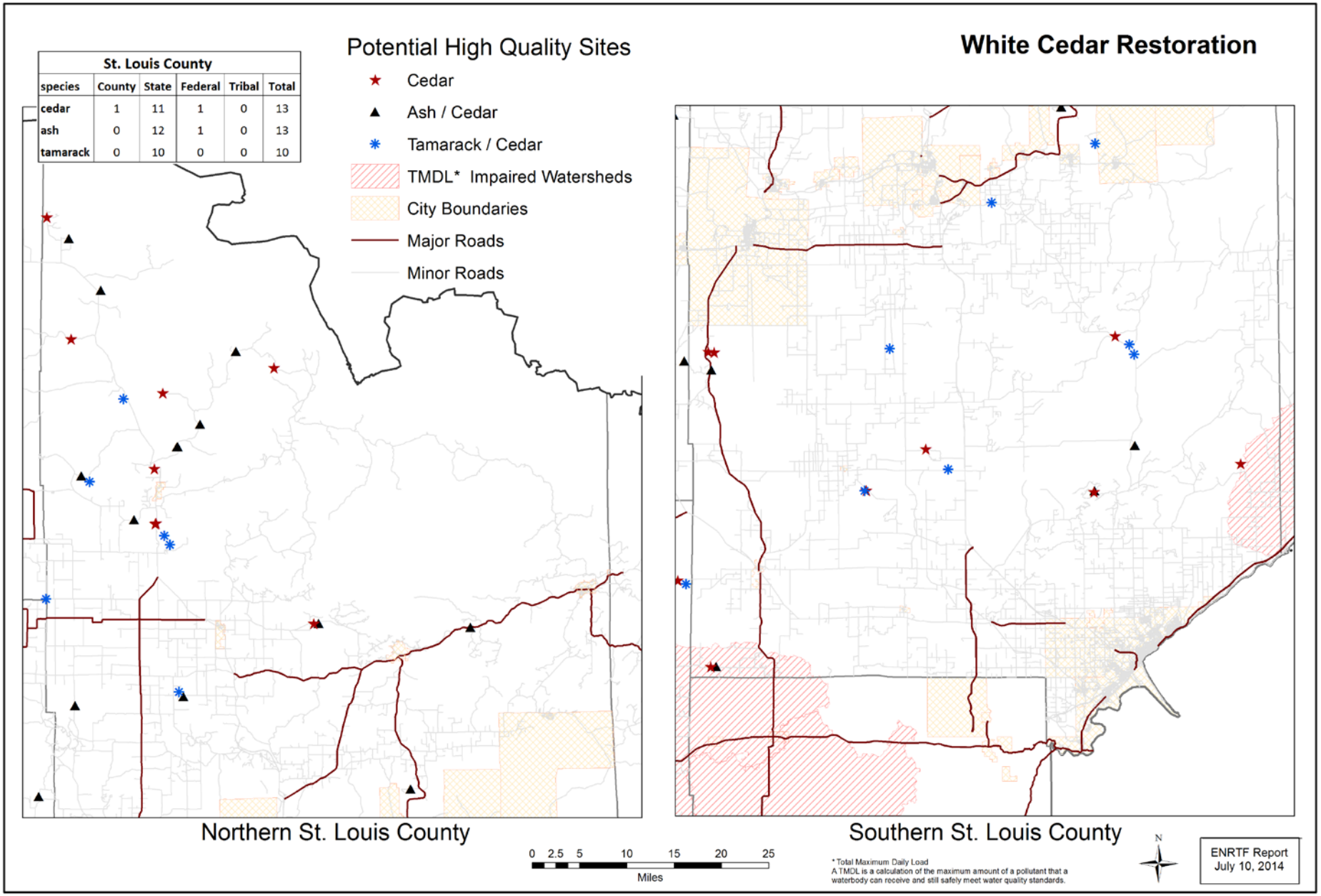


Lake of the Woods County

Lake of the Woods County					
species	County	State	Federal	Tribal	Total
cedar	0	1	0	0	1
tamarack	0	1	0	0	1



St. Louis County



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															
Resevour	LV=2	2	1+0+1	t06304e1280555	555 C 54	87.5	62	1	2	165	5	5	103	25	73
Road	LV=3	3	1+0+2	t06304e1110173	173 C 55	63.5	62	1	4	133	4	5	129	26	73
Road	LV=2	3	0+0+3	t06103w1360257	257 C 53	75.0	62	1	0	57	3	5	89	51	13
		5	2+0+3	t06002w1010003	3 C54	87.2	13	1	1	115	3	2	94	33	73
Road	LV=3	3	0+0+3	t06304e1180229	229 C 54	35.9	62	1	4	59	3	5	89	42	13
Road	LV=3	3	1+0+2	t06304e1110928	928 C 56	138.5	62	1	4	91	4	5	135	28	73
		4	1+0+3	t06403e1350331	331 C 51	106.1	62	1	2	122	3	2	34	26	73
		4	2+0+2	t06304e1100202	202 C55	70.6	62	1	3	145	2	2	141	30	73
Road	LV=3	3	0+0+3	t06304e1100182	182 C 56	84.5	62	2	3	19	3	5	131	66	12
Road	LV=1	3	0+0+3	t06302e1160038	38 C 41	87.2	12	1	4	21	3	5	57	55	12
		4	2+0+2	t06304e1140240	240 C53	134.3	62	1	1	130	4	2	97	35	73
		5	2+0+3	t06002w1090087	87 C54	140.3	62	1	3	120	3	2	118	30	73
Cook County															

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
Pipeline	LV=1	3	1+0+2	t05411w1360051	51 C 54	61.0	1	2	2	112	4	5	106	28	73
		4	1+0+3	t05508w1100010	10 C56	78.3	62	1	9	150	3	2	105	32	73
		4	1+1+2	t05809w1040028	28 C43	57.3	73	3	1	90	4	3	178	27	73
Road	LV=1	3	1+0+2	t05808w1150332	332 C53	82.0	62	1	4	120	4	2	87	23	73
Road	LV=1	3	1+0+2	t05510w1360201	201 C55	57.6	1	1	6	110	4	3	185	26	73
		5	1+1+2	t05808w1160327	327 C53	55.3	73	1	1	85	4	3	100	26	73
Road	LV=2	2	1+0+1	t05808w1010003	3 C53	74.3	62	1	6	93	5	3	114	24	73
Road	LV=2	3	1+0+2	t05909w1150154	154 C53	49.4	62	1	4	180	4	2	103	26	73
Railroad	LV=3	2	1+0+1	t05909w1330328	328 C 53	112.6	0	0	0	135	5	2	100	25	73
		6	1+3+2	t05807w1120082	82 C53	125.7	73	1	3	120	4	2	168	25	73
		4	1+1+2	t05808w1130322	322 C54	69.8	73	1	1	125	4	2	138	24	73
Lake County															
Road	LV=1	3	1+0+2	t06619w1150127	127 C 45	135.0	62	1	7	119	4	2	217	26	73
Road	LV=1	3	1+0+2	t06619w1360388	388 C 54	61.6	62	1	2	172	4	2	113	28	73
Road	LV=1	3	1+0+2	t06719w1360085	85 C 55	65.2	62	1	6	212	4	2	160	26	73
		4	1+1+2	t05318w1160028	28 C45	57.0	73	3	1	124	4	2	173	24	73
		5	2+0+3	t06619w1090098	98 C55	57.2	62	1	2	105	3	3	170	30	73
		5	2+0+3	t06619w1160195	195 C56	54.3	62	1	1	112	3	2	185	33	73
Road	LV=2	2	1+0+1	t06117w1040029	29 C45	98.4	85	0	0	160	5	1	190	25	73
		6	1+3+2	t06820w1100069	69 C45	56.9	73	1	5	95	4	2	205	27	73
Road	LV=2	3	1+0+2	t05318w1160096	96 C52	102.7	1	1	2	102	4	3	120	23	73
		4	2+0+2	t06619w1220213	213 C57	102.2	62	1	2	85	4	3	204	32	73
		5	1+2+2	t06820w1100089	89 C 43	104.3	73	2	2	119	4	2	120	23	73
Road	LV=2	3	1+0+2	t05913w1360078	78 C43	88.6	62	1	2	70	4	3	125	26	73
Road	LV=1	2	1+0+1	t06820w1140251	251 C 59	126.8	62	1	9	115	5	5	236	26	73
Road	LV=1	3	1+0+2	t06621w1110057	57 C43	55.5	62	1	3	106	4	3	120	24	73
Road	LV=1	3	1+0+2	t06519w1150097	97 C 56	59.8	1	1	3	151	4	2	165	28	73
Road	LV=1	3	1+0+2	t06019w1050018	18 C11	59.7	0	0	0	1	4	4	0	23	73
St. Louis County															

Level 1 Assessment Process

Potential restoration sites were selected from a pool of 6945 cedar stands.

Selections were based upon the following factors:

1) Stand size larger than 50 acres.
2) Hydrologic impediments obvious through aerial photo interpretation.

Fifty one stands were identified as potential restoration sites.

Stand condition was ranked to identify the highest potential restoration sites.

Ranking was based upon the following factors:

Ranking Values 3=good 2=medium 1=low

1) Site index (40=good 30=medium 20=low)
2) Cedar regeneration present (>1251stems/ac=3, 751-1250=2, 251-750=1, 0-250=0)
3) Physiographic class (Mesic=3, Xeromesic and Hydromesic=2, Xeric and Hydric=1)

Scores ranged from 8=Stand in Good Condition to 2=Stand in Low Condition

Twenty two stands were identified as low condition.

Landscape-based value of the twenty two was ranked by the following factors:

1) Total acres of adjacent cedar stands within the broader-community.
2) Position and setting within broader landscape.

Eight high landscape value potential restoration sites were identified.

Feasibility of restoration was ranked by type of hydrologic impediment.

Ditch=3 high, road=2 medium, railroad, pipeline or resevour=1 low

An Ecological Case Study

of

Selected White Cedar Stands

on State Lands in Beltrami County, Minnesota

Harvey Tjader, CF

NW Region Staff Forester

Department of Natural Resources

2115 Birchmont Beach Road NE

Bemidji, MN 56601

Jesse Lehner

Forestry intern

Michigan Technological University

14837 161st. Ave, Wadena MN 56482

August 20, 2013

MNDNR Ecological Land Classification: "Improving the scientific foundations of silviculture"

The Northeast Minnesota White Cedar Plant Community Restoration Project is a study being conducted by Minnesota Bureau of Water and Soil Resources (BWSR) to examine the regeneration capabilities of northern white cedar (*Thuja occidentalis*) in northern Minnesota ecosystems as they exist today. This study includes analysis of hand planting and broadcast seeding to determine survivability and success of artificial regeneration of northern white cedar in areas with possible hydrologic changes caused by spoil banks, road development, and with pressures due to high herbivore populations. Some sites within this study aim to restore drainage in areas changed hydrologically by past human activities; this will be achieved through the placement of culverts designed to not restrict current travel opportunities.

This paper addresses those project sites within the DNR's Northwest Region. Most of our plots fell within the Beltrami Pine Island Peatlands Land Type Association. A portion of our work in Site 3 fell in the Beltrami Pine Island Beach Ridges Land Type Association. It was all within the Minnesota Ontario Peatlands Ecological Section.

Our initial goal in relation to the BWSR study was to identify the Native Plant Communities of the study sites within Beltrami County so that any successful results can be applied to other areas with similar Native Plant Communities. A secondary goal was to examine the possibility that impeded drainage had caused a change in Native Plant Community, either upstream or downstream from the impediment. A third goal evolved during our field work: quantify stand densities that allowed or discouraged regeneration of white cedar.

In all of these Beltrami County sites, underground water flow moves in a northwesterly direction.

Discussion

In the course of looking at these sites and the stands surrounding them, it seems there are two factors that can affect regeneration and survival of white cedar: intermittent flooding and shade.

Intermittent Flooding

We found no consistent evidence in our ecological classifications that the areas to the NW of a road intersection (the downstream quadrant in terms of groundwater and runoff) tend to have drier Native Plant Communities than in any other quadrant. The effects of impeded drainage appear to be on the upstream side of the impediment, intermittent and temporary, related to insufficient drainage under roads during periods of high precipitation and runoff or during times of beaver activity. They also appear to be limited to areas ranging from 250-500' of the road, although there are some affected areas that that extend as much as a quarter mile from the road. These areas often contain dead cedars, indicating that they were once forested, but now are dominated by shrubs and are likely to key out to FPn73, Northern Alder Swamp. The total acreage of such areas over the landscape is significant, as is the economic impact of lost timber production. Downstream changes cannot be verified from sites in this small sample.

Shading

USDA Forest Service silvicultural guidelines for northern white cedar state that partial shading in white cedar stands can promote the establishment of white cedar in the understory. They recommend gaps of 1 - 1.5 tree lengths in width or reducing stand basal area to as low as 55 square feet per acre. If stand canopy densities are not maintained to sustain sunlight penetration after treatment, a dense overstory can become re-established after seeding, eliminating almost all established seedlings. Additional impediments to recruitment of white cedar can be due to desiccation from full sunlight, understory competition, and browse. It is estimated that it takes an individual cedar 20 to 40 years to grow out of the browse range of whitetail deer and that white cedar cannot survive if more than 25% of the foliage is browsed. Due to cedar's relatively slow growth compared to competing vegetation, release treatments may be necessary to improve survivability of white cedar (Boulfroy, 2012).

The main wetland cedar communities are WFn53 (Northern Wet Cedar Forest) and FPn63 (Northern Cedar Swamp).

We learned in the “natural regeneration strategies” included in the DNR Ecological Classification System silviculture interpretations that in WFn53 (Northern Wet Cedar Forest), primary regeneration and recruitment historically occurred in canopy gaps, formed by wind storms that were strong enough to affect the larger trees, but not the smaller ones. A shelterwood approach is suggested where the overstory is thinned with a careful logging approach, after advanced reproduction is present.

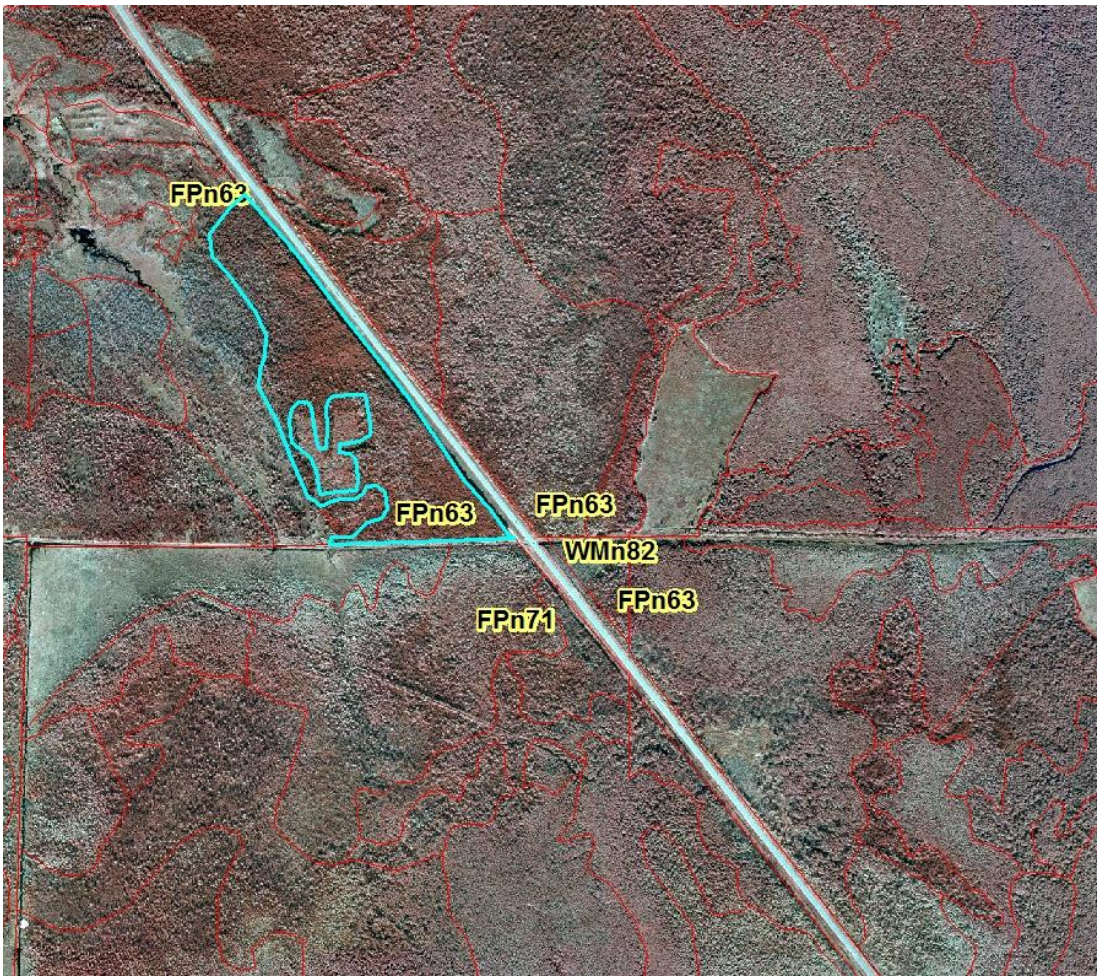
White cedar is a mid-successional species in FPn63 (Northern Cedar Swamp), recruiting during the decline of the initial cohort of balsam fir and paper birch. Due to cedar’s ability to reproduce vegetatively, white cedar can persist into the older growth stages (Almendinger, 2010).

Looking to verify the relationship between shade and regeneration, we thought that we could perhaps discover a correlation between basal area and natural cedar seedling establishment, so some sites described below have basal area and seedling plot data. However, it seems that basal area, alone, isn’t a reliable predictor of seedling numbers. The influence of age and species composition of the canopy is probably equal to the influence of basal area. Shade from a canopy of young cedars seems to be a less serious deterrent to seedling establishment than from a canopy of mature cedars, possibly due to the deeper shade afforded by the deep mature crowns. A canopy of deciduous hardwoods (like in the WFn64 stand) or a canopy of black spruce/tamarack (like in the tamarack dominated FPn63 stand) also seems to admit more sunlight than a canopy of mature white cedar. Perhaps a light meter would be an effective tool for measuring the probability of regeneration success.

We considered trying to quantify canopy cover from photographs taken of the canopy while lying on the ground, and then assess the cedar regeneration in the same location with a 1/250 acre plot. A review of literature on the internet suggests that such photographic canopy cover quantification is subject to great variability. However, we have included the photos and corresponding regeneration plots for an ocular comparison in an addendum to this report.

While considering regeneration data, it’s important to consider that recruitment (movement from the seedling to sapling stage) takes time. A recent canopy gap may have abundant seedlings and few, if any, saplings. We need to exercise patience before concluding the seedlings are failing to recruit.

Site 1. DNR Stand #276 Hydrologic Restoration Project



Located at S ½ Section 22, Township 153N, Range 30W in Beltrami County Mn
Scale 1:10,000

BWSR's strategy on this site is to improve/restore the natural hydrologic conditions by installing culverts in the ditch bank road which is perceived to be causing a water flow impediment. After the completion of this project, monitoring of vegetative effects such as possible increases in white cedar regeneration will be studied. The ditch bank road is used as a winter snowmobile trail and as a winter logging access road so current use must not be disturbed with culvert installation.

Intermittent flooding appears to have transformed 144 acres in Section 27-T153-R30, from FPn63 (Northern cedar swamp) and FPn71 (Northern rich spruce swamp) to FPn73 (Northern alder swamp). Impeded drainage does not appear to have caused significant changes in Native Plant Communities "downstream" from the impediment, in other words, stands that may be drier now than they would be without the impediment. The NW quadrant, which should be driest, is FPn63, as are the stands in the NE and SE quadrants.

Site 1. Stand #276, FPn63, Northern Cedar Swamp, NW quadrant of the intersection

Stand #276 is a very dense 137-year-old stand of northern white cedar. We noticed the occurrence of dead standing white cedar saplings between the heights of 7-15 feet. Ground flora covers <5% of plot area and primarily resides in small wind or single tree death gap openings. We saw several downy rattlesnake plantains (Goodyera pubescens) and a one-flowered wintergreen (Moneses uniflora) in bloom in early August. Though tiny plants, they stood out against the leaf litter because there is so little ground vegetation. We classified the native plant community as FPn63 (Northern cedar swamp). The growth stage is mature.

Basal area (ft^2/ac)	Canopy cover (%)	Cedar 0-1" dbh (trees/ac)	Cedar 1-5"	Other species
210	90	0	0	0
290	90	0	0	1250 b.fir 0-1"

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 20 / 2013**

Site Code[1]: C4 **Stand: 276** **Acres: 55** **T153 R30S22**

GPS Coordinates: Easting: 390068 Northing: 5322935
Lat: _____ Long: _____

Comments: target stand in BWSR cedar project. This is a very dense stand with few under-story plants except under canopy gaps. Master Releve key favors FP (214) over WF (58). MOP dichotomous key favors FPn63. Appendix B favors WF (327) over FP (276). We favor FPn63 due to the depth of peat and the agreement of two keys.

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black ash, balsam fir, black spruce
Growth stage[1]: mature

Soil Map Unit[3] 561 Bullwinkle
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 64" Depth to: gray mottles ____ **gray matrix 42" standing water: 11"**
Semipermeable layer Depth: 42" Type: hardpan, clayey texture, both (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
Woody	
sapric	
Peat 41	
Sand 42	
sandy	
clay	
Loam 50	
clay	
Loam 55	
Clay 64	

Comments & Notes: pH_____

42-50" very dark grey with carbonate nodules

55-64" gley 1 7/5G, some rocks

Native Plant Community Worksheet

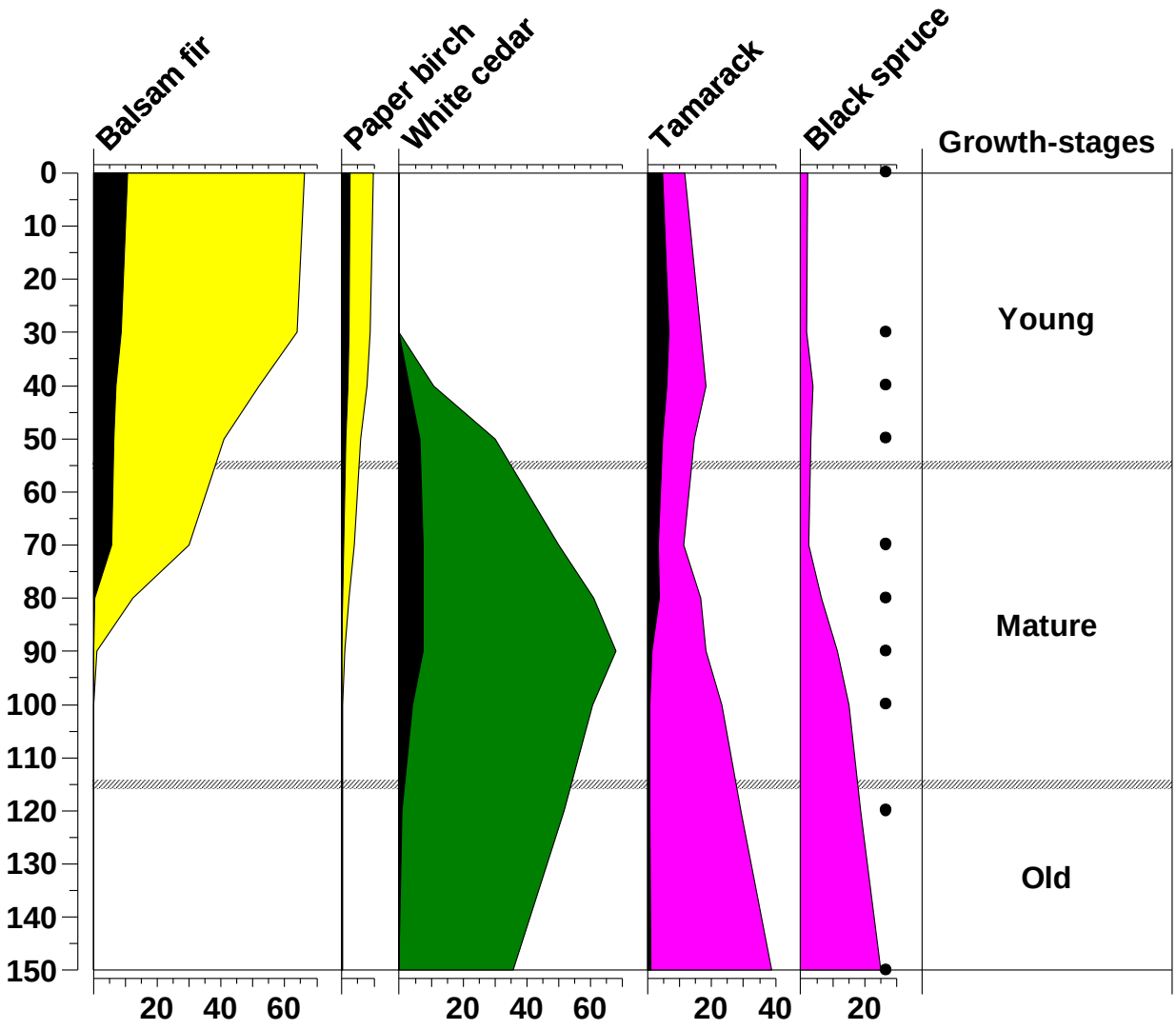
Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 1**	**Grasses, sedges & rushes collective cover[1]: 1**
Thuja occidentalis	**D/5**	**Coptis trifolia**	**Carex sp**
Larix laricina	**C/2**	**Mitella nuda**	**Unknown grass**
Abies balsamea	**F/1**	**Galium triflora**	
Betula papyrifera (dead)	**R/1**	**Trientalis borealis**	
Picea mariana	**F/1**	**Maianthemum canadense**	
		Osmorhiza claytonii	
		Trillium sp	
		Linnaea borealis	
		Cornus Canadensis	
		Dryopteris carthusiana	
		Lycopodium clavatum	
		Thalictrum dioicum	
Understory trees & Shrubs collective cover[1]: 3	**A[2]/C[1] ⬇**	**Fragaria virginiana**	**Mosses & Lichens collective cover[1]: 1**
		Thelypteris palustris	
e.g. Red maple	***C/2***	**Viola renifolia**	**Climacium dendroides**
Abies balsamea	**A/2**	**Lycopodium annotinum**	**Pleurozium sp**
Thuja occidentalis	**A/2**	**Geum macrophyllum**	**Plagiomnium sp**
Lonicera canadensis	**C/1**	**Impatiens sp**	
Ribes hirtellum	**F/1**	**Dryopteris cristata**	
Lonicera hirsuta	**R/1**	**Mentha sp**	
Sorbus decora	**F/1**	**Aster puniceus**	**Additional plants or Plants collected/photographed**
Rubus idaeus	**R/1**	**Lysimachia thyrsiflora**	
Fraxinus nigra	**F/1**	**Saxifraga pensylvanica**	
		Gymnocarpium dryopteris	
		Rubus acaulis	
		Circaea alpina	
		Goodyera pubescens	
		Moneses uniflora	

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***



FPn63, J.C. Almendinger, November 2008

As shown in the table, above, the composition of young FPn63 is often dominated by balsam fir and paper birch, with some residual tamarack and black spruce. White cedar begins to recruit into the stand around age 30 and becomes dominant in the mature growth stage. Old stands have a balance of cedar, tamarack and spruce

Site 1. FPn63, Northern Cedar Swamp, SE quadrant of the intersection

This site is 'upstream' from the BWSR site, lying SE of the intersection of highway 72 and the ditch bank road. A culvert lies under the highway along the south edge of the ditch bank road, directing water flow from the east to the west side the highway 72. The canopy cover consists primarily of tamarack and black spruce aged at 116 years, with a minor white cedar component. Current understory cover averages >75%, but is variable with greater density in the numerous wind-created canopy gaps which have allowed regeneration of white cedar and recruitment into higher canopy levels due to increased sunlight. We found a ram's head ladyslipper (*Cypripedium arietinum*) in this stand. The ecological classification of this site is FPn63 (Northern cedar swamp). The growth stage is mature. This is probably the most interesting site we visited on this project, due to the active stand maintenance disturbance and the understory response.

Basal area (ft^2/ac)	Canopy cover (%)	Cedar 0-1" dbh (trees/ac)	Cedar 1-5"	Other species
60	30	3250		500 p.birch 0-1" 250 b.fir 0-1"
220	70	2000	750	
120	60	3500	250	250 b.spruce 1-5"
80	60	2000		750 p.birch 0-1" 250 b.fir 0-1"

ECS Site Classification Worksheet

Version 1.4, Apr 2012

Surveyor Names: _Harvey Tjader, Jesse Lehner_____ **Date:** mm _06_ / dd _14_ / yyyy _2013_

Site Code[1]: __C1_____ **Stand:** _401___ **Acres:** _140____ **T_153 R30S26**

GPS Coordinates: Easting: 390591_____ **Northing:** 5322568_____
Lat: _____ **Long:** _____

Comments: BWSR Cedar project. Mixed swamp conifer stand lying upstream from drainage Impediment and east of Highway 72 (SE quadrant). Some windthrown trees in patches. One ramshead orchid found at the above GPS coordinates. Master Releve key strongly favors a classification of FP; dichotomous key determined FPn63.

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black spruce, balsam fir, tamarack, p birch
Growth stage[1]: _____

Soil Map Unit[3]:_541 Rifle mucky peat
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: moss peat
Drainage class: very poor
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

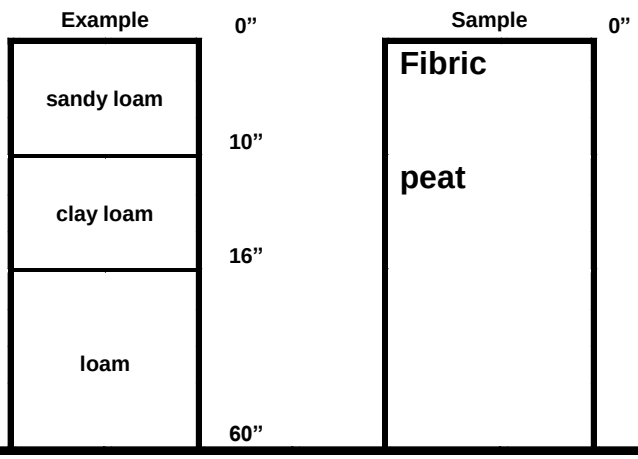
Landscape position: top/crest – side slope – toe – (level) – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 60 Depth to: gray mottles ____ **gray matrix** ____ **standing water: 5"**

Semipermeable layer Depth: _____ **Type: hardpan, clayey texture, both** (circle one)

Humus type: mor – moder – mull – muck – (moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____



Comments & Notes: pH_____
Occasional woody chunks
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 3**	**Grasses, sedges & rushes collective cover[1]: 2**
Larix laricina	**A/3**	**Trientalis borealis**	**Calamagrostis Canadensis**
Picea mariana	**A/3**	**Maianthemum canadense**	**Carex lacustris**
Thuja occidentalis	**F/1**	**Mitella nuda**	**Carex sp**
Betula papyrifera	**R/1**	**Rubus pubescens**	
		Cornus Canadensis	
		Cypripedium acaule	
		Galium triflorum	
		Clintonia borealis	
		Viola renifolia	
		Thalypteris palustris	
		Dryopteris carthusiana	
		Gymnocarpium dryopteris	
Understory trees & Shrubs collective cover[1]: 5	**A[2]/C[1]**	**Coptis trifolia**	**Mosses & Lichens collective cover[1]: 5**
		Linnaea borealis	
e.g. Red maple	***C/2***	**Impatiens sp**	**Sphagnum spp**
Thuja occidentalis	**C/1**	**Pyrola secunda**	**Pleurozium spp**
Picea mariana	**C/1**	**Fragaria virginiana**	**Plagionium spp**
Ledum groenlandica	**C/1**	**Caltha palustris**	
Abies balsamea	**F/1**	**Pyrola acerifolia**	
Salix sp	**F/1**	**Stellaria longifolia**	
Ribes hirtellum	**C/1**	**Smilacina trifolia**	**Additional plants or Plants collected/photographed**
Cornus sericea	**C/1**	**Equisetum laevigatum**	
Betula pumila	**F/1**	**Taraxicum sp**	
Rhamnus alnifolia	**F/1**	**Dryopteris cristata**	
Andromeda glaucophylla	**F/1**	**Galium labradoricum**	
Gaultheria hispidula	**F/1**	**Aralia nudicaulis**	
Vaccinium oxicoccus	**C/1**	**Athyrium felix-femina**	
Potentilla (Comarum) palustre	**F/1**	**Thalictrum dasycarpum**	
Rubus idaeus	**C/1**	**Aster puniceum**	
Ribes cynosbati	**R/1**	**Lysimachia thyrsiflora**	**Ribes americanum R/1**
Lonicera oblongifolia	**C/1**	**Circaea alpina**	**Vaccinium myrtilloides F/1**
Unknown flowering shrub	**R/1**	**Cypripedium arietinum**	**Betula papyrifera F/1**
Lonicera Canadensis	F/1	**Corallorhiza trifida**	**Acer rubrum F/1**
Juniperus communis	F/1	**Rubus acaulis**	**Rosa acicularis R/1**
Larix laricina	R/1	**Saxifraga pensylvanica**	**Alnus incana R/1**
Chamaedaphne calyculata	R/1		**Prunus pensylvanica R/1**
Lonicera hirsuta	R/1		Amelanchier sp R/1

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 1. FPn63, Northern Cedar Swamp, NE quadrant of the intersection

This stand lies north of the ditch bank road and east of Highway 72. White cedar is more dominant in the canopy of this stand than in the SE quadrant, with a minor tamarack component. The occurrence of dead white cedar trees between the heights of 7 to 15 feet were noted in this stand (failure to recruit into the canopy?). The FIM-reported age of this stand is 113 years. We identified the Native Plant Community as an FPn63 (Northern cedar swamp).

Basal area (ft^2/ac)	Canopy cover (%)	Cedar 0-1" dbh (trees/ac)	Cedar 1-5"	Other species
210	80	0	1000	250 b. fir 0-1"
240	80	0	1500	250 p.birch 0-1" 500 b.fir 0-1"

ECS Site Classification Worksheet

Version 1.4, Apr 2012

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 14 / 2013** (mm dd yyyy)

Site Code[1]: c2 **Stand: 534** **Acres: 73** **T153 R30S22**

GPS Coordinates: Easting: 390427 Northing: 5322811
Lat: _____ Long: _____

Comments: species richness lower than in C1. Cedar regen present but not as frequent. Downstream of impediment and east of Hwy 72. A culvert runs on the south side of the ditchbank, leading to the west side of Hwy 72. Less light penetrating the canopy here than in C1. Worms found in the soil sample. Master Releve favors FP (467) over WF (62) and indicates FPn63 as the Native Plant Community.

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar
Black spruce, balsam fir, tamarack
Growth stage[1]: _____

Soil Map Unit[3]561 Bullwinkle
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: mossy peat
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

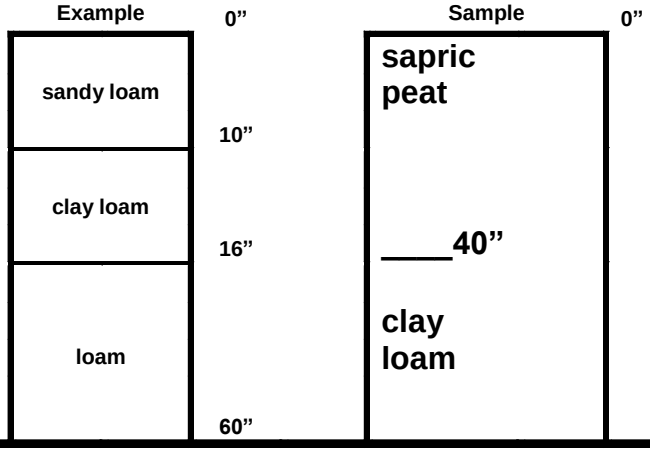
Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 48" Depth to: gray mottles ____ **gray matrix** ____ **standing water:** ____

Semipermeable layer Depth: _____ **Type: hardpan, clayey texture, both** (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____



Comments & Notes: pH_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 2**	**Grasses, sedges & rushes collective cover[1]: _____**
Larix laricina	**A/2**	**Trientalis borealis**	
Picea mariana	**F/1**	**Linnaea borealis**	
Thuja occidentalis	**A/3**	**Mitella nuda**	
Abies balsamea	**F/1**	**Rubus pubescens**	
		Maianthemum canadense	
		Lysimachia thyrsiflora	
		Galium triflorum	
		Thelypteris palustris	
		Cornus Canadensis	
		Coptis triflorum	
		Viola renifolia	
		Smilacina trifolia	
Understory trees & Shrubs collective cover[1]: 3	**A[2]/C[1] ⬇**	**Galium boreale**	**Mosses & Lichens collective cover[1]: 4**
		Taraxicum sp	
e.g. Red maple	***C/2***	**Caltha palustris**	**Pleurozium spp**
Thuja occidentalis	**C/3**	**Senecio aureus**	**Sphagnum spp**
Larix laricina	**F/1**	**Cypripedium calceolus**	
Picea mariana	**R/1**	**Cypripedium acaule**	
Rhamnus alnifolia	**F/1**	**Iris versicolor**	
Ledum groenlandica	**F/1**	**Aster puniceus**	
Lonicera canadensis	**C/1**	**Cirsium muticum**	**Additional plants or Plants collected/photographed**
Abies balsamea	**C/1**	**Impatiens sp**	
Andromeda glaucophylla	**R/1**	**Clintonia borealis**	
Vaccinium oxicoccus	**R/1**	**Rubus acaulis**	
Gaultheria hispidula	**R/1**	**Equisetum laevigatum**	
Cornus sericea	**R/1**	**Lycopodium annotinum**	
Betula pumila	**F/1**		
Amelanchier sp	**R/1**		
Ribes sp	**R/1**		

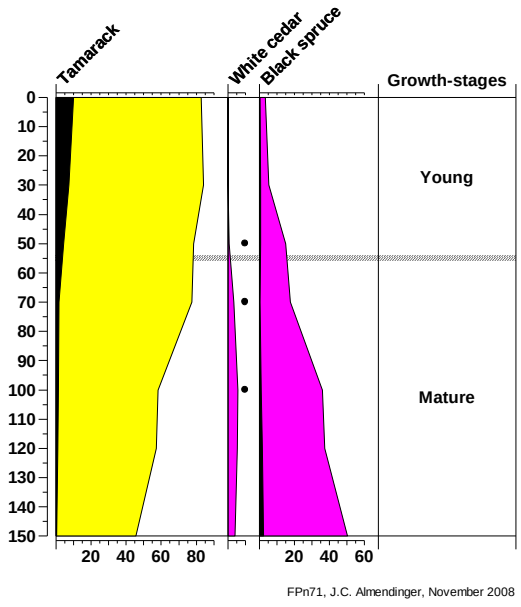
1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 1. FPn71, Northern Rich Spruce Swamp, SW quadrant of the intersection

This stand lies south of the BWSR targeted stand, south of the ditch bank road and west of Highway 72. The stand contains 139-year-old tamarack with a few black spruces scattered within the canopy. Crown closure is 25-50% allowing for a well-developed understory (>75%) and ground flora layer (25-50%) to be present. The basal area of this stand is 120 square feet per acre. We found natural regeneration of white cedar from both seed and layering. We classified the native plant community as FPn71 (Northern rich spruce swamp). The growth stage is mature.



The FPn71 community typically begins with tamarack dominance, as depicted in the graph to the left. In the mature growth stage, some tamarack is replaced by black spruce and white cedar. Cedar tends to remain a secondary species in this community.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 20 / 2013** (mm dd yyyy)

Site Code[1]: C-3 **Stand: 375** **Acres: 60** **T 153 R30 S 27**

GPS Coordinates: Easting: 390327 **Northing: 5322592**
Lat: _____ **Long: _____**

Comments: Master Releve key strongly favors FP, but NPC determination was inconclusive. FPn71 was determined by MOP FP dichotomous key.
Young thicket of mixed swamp conifers with supercanopy of tamarack and b spruce. Transect runs south. This site is associated with the BWSR cedar study, lying south of BWSR's target stand and upstream of a ditchbank road. Cedar regen from seed and layering

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn71 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: black spruce
_____
Growth stage[1]: _____

Soil Map Unit[3] 561 Bullwinkle
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 62" Depth to: gray mottles ____ **gray matrix 59" standing water: 0"**
Semipermeable layer Depth: _____ **Type: hardpan, clayey texture, both** (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
Sapric Peat 59"	
Loamy Sand	
62"	

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

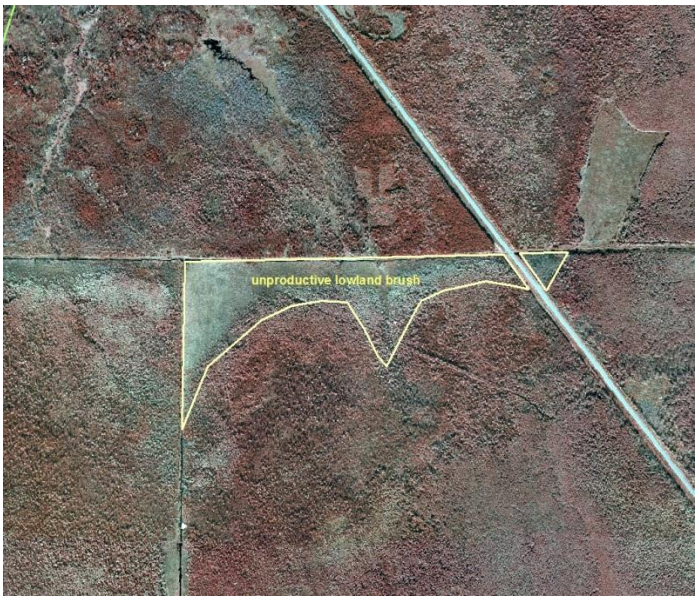
Overstory trees (> 33 feet) collective cover[1]: 3	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 3**	**Grasses, sedges & rushes collective cover[1]: 1**
Larix laricina	**A/2**	**Cornus Canadensis**	**Carex spp**
Picea mariana	**F/1**	**Linnaea borealis**	
		Trientalis borealis	
		Maianthemum canadensis	
		Cypripedium calceolus v. parv	
		Rubus pubescens	
		Thelypteris palustris	
		Pyrola sp	
		Menyanthes trifolia	
		Lysimachia thyrsiflora	
		Equisetum fluviatile	
		Viola renifolia	
Understory trees & Shrubs collective cover[1]: 5	**A[2]/C[1] ⬇**	**Viola macloskeyi**	**Mosses & Lichens collective cover[1]: 5**
		Mitella nuda	
e.g. Red maple	***C/2***	**Coptis trifolia**	**Sphagnum spp**
Thuja occidentalis	**A/4**	**Smilacina trifolia**	**Pleurozium spp**
Ledum groenlandica	**C/4**	**Caltha palustris**	**Plagiomnium spp**
Picea mariana	**F/1**	**Sarracenia purpurea**	
Cornus sericea	**C/1**	**Galium triflorum**	
Lonicera canadensis	**F/1**	**Rubus acaulis**	
Lonicera villosa	**C/1**	**Impatiens sp**	**Additional plants or**
Rhamnus alnifolia	**C/1**	**Taraxicum sp**	**Plants collected/photographed**
Betula pumila	**F/1**	**Aster puniceus**	**Arctic raspberry**
Abies balsamea	**F/1**	**Solidago sp**	**sedge**
Gaultheria hispidula	**F/1**	**Fragaria virginiana**	**Pyrola sp**
Vaccinium oxycoccos	**R/1**	**Cicuta bulbifera**	
Larix laricina	**C/2**		
Chamaedaphne calyculata	**F/1**		
Amelanchier sp	**R/1**		
Andromeda glaucophylla	**R/1**		

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

An area of intermittent temporary flooding lies between this SW quadrant stand and the ditch bank road



to the north. About 144 acres appears to have been affected by such impeded drainage on the south side of the ditch road, lying between Highway 72 on the east and another ditch 1.16 miles to the west. The widest area is in the SE quadrant of the intersection formed by the east-west ditch road and the north-south ditch lying 1.16 miles west of Highway 72. This area is not producing commercial timber. We sampled the ten-acre patch of similar habitat on the east side of Highway 72, south of the ditchbank road, and found the NPC to be FPn73, Northern Alder Swamp.

←Photo: flooded area south of the ditch road in Sec 27-153-30

Site 1. FPn73 Northern Alder Swamp, SE quadrant of the intersection

This is the 10-acre lowland brush community located along the southeast corner of the road intersection. This area shows remnants of a northern white cedar stand indicated by standing dead trees. There is no tree canopy layer in this area but, a well-developed understory (50-75% cover) exists primarily composed of willow species. Additionally, a high cover of grasses and sedges are found on this site. The conversion seen in this stand from a forest to a brush community may be the result of the roadways impeding drainage during temporary flooding events caused by beaver activity or heavy precipitation. We identified a native plant community of FPn73 (Northern alder swamp). The intermittently flooded area west of this site may well be similar in composition.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 20 / 2013**

Site Code[1]: C6 **Stand: 544** **Acres: 10** **T153 R30S27**

GPS Coordinates: Easting: 390490 Northing: 5322627
Lat: _____ Long: _____
Comments: lowland brush stand SE of BWSR project target stand
Lots of dead cedars

_____

_____

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WMn82 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: _____
_____
Growth stage[1]: _____

Soil Map Unit[3] 561 Bullwinkle
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

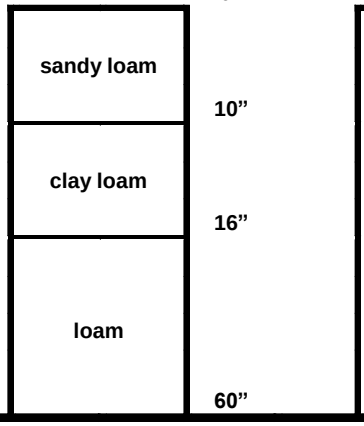
Landscape position: top/crest – side slope – toe – level – depression (circle one)

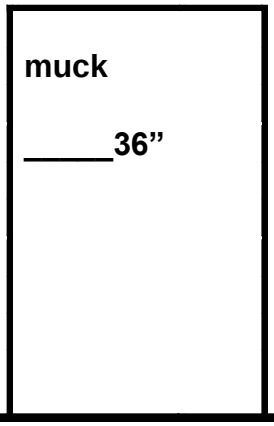
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 36" Depth to: gray mottles ____ **gray matrix** ____ **standing water: 4"**

Semipermeable layer Depth: _____ **Type: hardpan, clayey texture, both** (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____





Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

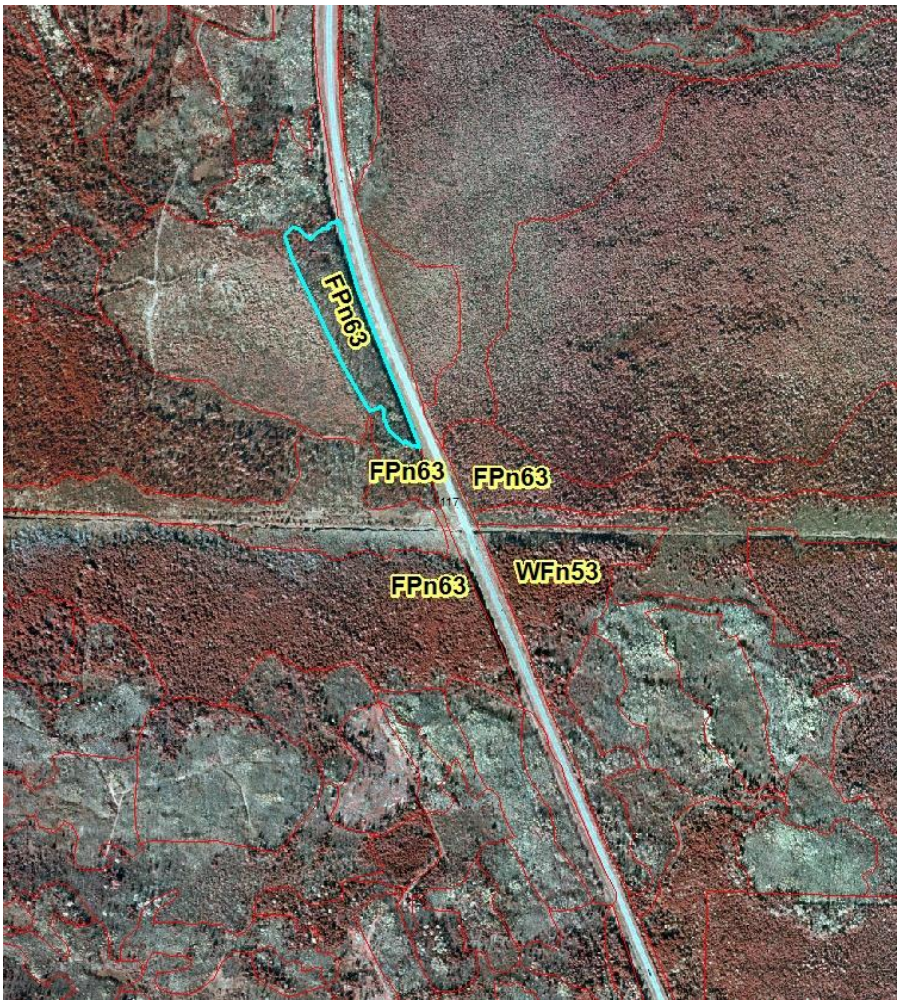
Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: _____	**A[2]/C[1]** ⬇	**Forbs, Ferns, & Fern Allies collective cover[1]: 1**	**Grasses, sedges & rushes collective cover[1]: 5**
		Thelypteris palustris	**Calamagrostis Canadensis**
		Potentilla palustris	**Carex lacustris**
		Viola renifolia	
		Linnaea borealis	
		Impatiens sp	
		Galium labradoricum	
		Taraxicum sp	
		Rumex sp	
		Cicuta maculata	
		Epilobium strictum	
		Potentilla norvegica	
Understory trees & Shrubs collective cover[1]: 4	**A[2]/C[1]** ⬇		**Mosses & Lichens collective cover[1]:** _____
e.g. Red maple	***C/2***		
Betula pumila	**C/1**		
Salix petiolaris	**C/1**		
Andromeda glaucophylla	**C/1**		
Larix laricina	**F/1**		
Cornus sericea	**F/1**		
Populus balsamifera	**F/1**		**Additional plants or Plants collected/photographed**
Rubus idaeus	**F/1**		
Thuja occidentalis	**R/1**		
Rhamnus alnifolia	**F/1**		
Rosa acicularis	**F/1**		
Lonicera canadensis	**F/1**		
Vaccinium oxycoccos	**F/1**		
Vaccinium angustifolium	**R/1**		
Betula papyrifera	**F/1**		
Salix planifolia	**C/1**		
Salix bebbiana	**C/1**		
Salix humilis	**C/1**		
Salix candida	C/1		
Salix (cf) pseudomonticola	C/1		

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

Site 2. DNR Stand #649 Tree Planting and Tree Protection Project



Located at SE ¼ Section 5 and SW ¼ Section 4, Township 153N, Range 30W in Beltrami County Mn
Scale 1:10,000

Stand #649 was a tamarack stand that had become infested with larch beetles. Thirty percent of the trees had been killed when a timber sale was made to salvage the wood. A delay in logging, caused by a warm winter without ground-freezing conditions, allowed mortality to reach 90% before salvage could occur. In the spring of 2013, Conservation Corps of Minnesota workers planted 250 white cedar transplants along with 250 white cedar seedlings and 500 tamarack seedlings. Four ounces of northern white cedar seed per acre were broadcast after planting. Fifty mesh enclosures were constructed around evenly distributed cedar transplants and 75 tree protectors on cedar seedlings to reduce herbivore impacts.

There are about 74 acres typed in the DNR Forest Inventory Module (FIM) as lowland brush in Section 5 T153 R30w (DNR Stand 668) and about 161 acres in Section 3 T153 R30w (DNR Stand 43). These stands have a linear shape, following ditchbank roads, implying that intermittent drainage impediments may be rendering these areas incapable of timber production. The distance from the ditchbank road to the stand boundaries varies from 250' to a quarter mile. Contrary to what we saw in Section 22, the **upstream** stand in Section 9-T153-R30 (SE quadrant of the intersection) is classified as WFn53, **slightly drier** than the downstream stands, which are classified as FPn63. Both WFn53 and FPn63 communities are good for cedar production.

Site 2. FPn63, Northern Cedar Swamp

This is DNR stand #649. Willows and grass currently dominate the site. We classified a native plant community of FPn63 (Northern cedar swamp). A typical composition for FPn63 in this growth stage would be dominated by balsam fir with secondary populations of paper birch, tamarack and black spruce. Cedar would ingress as balsam fir and paper birch diminish, around age 30.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 26 / 2013**

Site Code[1]: B-4 **Stand: 649** **Acres: 11** **T 153 R 30 S 05**

GPS Coordinates: Easting: 387652 Northing: 5327921
Lat: _____ Long: _____

Comments: Conor Reynolds was also in the party. This site is in the BWSR cedar project. Beetle infested tamarack was harvested. BWSR planted cedar.
We had few hits on the dichotomous key. The probability key was tied btwn FPn81 & 82. Master releve key indicates FPn63.

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black spruce, balsam fir
Growth stage[1]: young

Soil Map Unit[3] 561 Bullwinkle/627 Tawas
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 43" Depth to: gray mottles ____ **gray matrix 40" standing water: 1"**

Semipermeable layer Depth: 40" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
sapric Peat 40" silty Clay	
43"	

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 1	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 3**	**Grasses, sedges & rushes collective cover[1]: 5**
Thuja occidentalis	**F/1**	**Potentilla palustris**	**Carex lacustris**
Larix laricina	**F/1**	**Aster puniceus**	**Poa pratense**
Abies balsamea	**F/1**	**Impatiens sp**	**Milium effusum**
Betula papyrifera	**F/1**	**Saxifraga pensylvanica**	**Calamagrostis Canadensis**
		Fragaria virginiana	**Bromus ciliatus**
		Maianthemum canadense	**Muhlenbergia racemosa**
		Dryopteris carthusiana	**Phalaris arundinacea**
		Aralia nudicaulis	
		Taraxicum sp	
		Iris versicolor	
		Dryopteris cristata	
		Caltha palustris	
Understory trees & Shrubs collective cover[1]: 3	**A[2]/C[1]**	**Urtica dioica**	**Mosses & Lichens collective cover[1]: 1**
		Osmunda cinnamomea	
e.g. Red maple	***C/2***	**Stellaria longifolia**	**Sphagnum spp**
Betula pumila	**F/1**	**Equisetum fluviatile**	**Pleurozium spp**
Ribes americanum	**F/1**	**Rumex orbiculata**	
Ledum groenlandicum	**F/1**	**Potentilla norvegica**	
Rubus ideaus	**F/1**	**Campanula aparinoides**	
Betula papyrifera	**F/1**	**Smilacina trifolia**	
Picea mariana	**F/1**	**Thelypteris palustris**	**Additional plants or Plants collected/photographed**
Thuja occidentalis	**F/1**	**Lycopus uniflorus**	
Cornus sericea	**F/1**	**Athyrium felix-femina**	
Abies balsamea	**F/1**	**Scutellaria lateriflora**	**Mitella nuda**
Amelanchier sp	**F/1**	**Linnaea borealis**	**Onoclea sensibilis**
Salix bebbiana	**F/1**	**Galium triflorum**	**Polyganum sagitattum**
Ribes hirtellum	**F/1**	**Solidago ugilinosa**	**Rumex crispus**
Larix laricina	**F/1**	**Galium labradoricum**	**Solidago gigatea**
Quercus macrocarpa	**F/1**	**Aster lanceolatus**	**Trientalis borealis**
Rhamnus alnifolia	**F/1**	**Bidens frondosa**	
Andromeda glaucophylla	**R/1**	**Rubus pubescens**	
Vaccinium oxycoccos	**R/1**	**Chelone glabra**	
Salix candida	F/1	Cicuta bulbifera	
Vaccinium angustifolium	F/1	Epilobium palustris	
Lonicera oblongifolia	R/1	Eupatorium maculatum	Corylus americana R/1
Ulmus americana	R/1	Lactuca sp	Corylus cornuta R/1
Kalmia polifolia	R/1	Lysimachia sp	Chamaedaphne calyculata R/1

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 2. WFn53, Northern Wet Cedar Forest, SE quadrant of the intersection

This stand lies south of the treatment area and east of Highway 72. The Forest Inventory Module-(FIM)-designates it as stagnant cedar. Its age is approximately 171 years. Site canopy density is >75%. Northern white cedar dominates the canopy layer although paper birch (*Betula papyrifera*) and black ash (*Fraxinus nigra*) are present. Understory density is 5-25% cover with naturally regenerated cedar being a common component. We classified this as WFn53 (Northern Wet Cedar Forest). We found common polypody (*Polypodium virginianum*) growing on upturned cedar root wads, a species that is fairly rare in this part of the state.


common polypody, Polypodium virginianum

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 21 / 2013**

Site Code[1]: B-1 **Stand: 91** **Acres: 19** **T153 R30S09**

GPS Coordinates: Easting: 388034 Northing: 5327442
Lat: _____ Long: _____

Comments: This site lies in the SE quadrant of the intersection of Hwy 72 and a ditchbank road. We visited it as part of the BWSR cedar project. It has the appearance of a nice old Growth stand. We found common polypody growing on upturned root wads near GPS coord 388028E 5327405N. Transect runs south from the above coordinates.
Master Releve key favors FP (203) over WF (198). Appendix B favors WF (442) over FP (265)

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WFn53 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black ash, paper birch, balsam fir
Growth stage[1]: mature

Soil Map Unit[3] 627 Tawas
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 42" Depth to: gray mottles ____ **gray matrix** ____ **standing water: 9"**
Semipermeable layer Depth: 32" Type: hardpan, clayey texture, both (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
sapric	
Peat 32	
clay	
loam	

Comments & Notes: pH_____
_____
_____
_____
Clay loam color 5yr 5/2
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]** ⬇	**Forbs, Ferns, & Fern Allies collective cover[1]: 1**	**Grasses, sedges & rushes collective cover[1]: 1**
Thuja occidentalis	**D/4**	**Mitella nuda**	**Unknown grass sp**
Betula papyrifera	**F/1**	**Rubus pubescens**	**Carex lacustris**
Fraxinus nigra	**R/1**	**Maianthemum canadense**	
		Thelypteris palustris	
		Trillium sp	
		Circaea alpina	
		Dryopteris carthusiana	
		Impatiens sp	
		Aralia nudicaulis	
		Lysimachia thyrsiflora	
		Urtica dioica	
		Matteusia struthiopteris	
Understory trees & Shrubs collective cover[1]: 2	**A[2]/C[1]** ⬇	**Gymnocarpium dryopteris**	**Mosses & Lichens collective cover[1]: 1**
		Trientalis borealis	
e.g. Red maple	***C/2***	**Cornus Canadensis**	**Plagiomnium sp**
Prunus virginiana	**F/1**	**Clintonia borealis**	**Pleurozium sp**
Fraxinus nigra	**F/1**	**Linnaea borealis**	**Sphagnum sp**
Thuja occidentalis	**C/1**	**Viola renifolia**	**Leucobryum sp**
Lonicera canadensis	**F/1**	**Rubus acaulis**	
Abies balsamea	**F/1**	**Coptis trifolia**	
Ribes americanum	**F/1**	**Asarum canadense**	**Additional plants or Plants collected/photographed**
Cornus sericea	**F/1**	**Smilacina trifolia**	
Ribes cynosbati	**F/1**	**Polypodium virginianum**	
Rubus idaeus	**F/1**	**Dryopteris cristata**	
Amelanchier sp	**F/1**	**Botrichium virginianum**	
Lonicera hirsuta	**R/1**	**Caltha palutris**	
Fraxinus pensylvanica	**F/1**	**Lycopus uniflorus**	
Corylus cornuta	**F/1**	**Cicuta bulbifera**	
Vaccinium angustifolium	**R/1**	**Galium triflorum**	
Ulmus Americana	**R/1**	**Fragaria virginiana**	
Alnus incana	**F/1**	**Geum macrophyllum**	
Acer rubrum	**F/1**	**Taraxicum sp**	
Betula papyrifera	**F/1**	**Cypripedium calceolus**	
Viburnum trilobum	**R/1**	**Galium boreale**	
Ledum groenlandicum	**F/1**		

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 2. FPn63, Northern Cedar Swamp, NE quadrant of the intersection

This stand lies north of the previously described stand. A ditch bank road separates them. It has a canopy density of >75% and is dominated by 86 year old tamarack, with white cedar being a secondary component of the over story. The FIM data shows this site as lowland black spruce but tamarack is currently the main timber species present. In the understory, white cedar is a common species which includes germinants, seedlings, and saplings in the stand. However, the understory layer only consisted of 5-25% coverage caused by the dense canopy that reduces sunlight from hitting the ground. Scattered canopy gaps are allowing some understory development. We classified this site as FPn63 (Northern cedar swamp). A gradual release effected through shelterwood, group selection or femelschlag would likely encourage recruitment of cedar into the canopy.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner **Date: 06 / 26 / 2013**

Site Code[1]: B-2 **Stand: 70** **Acres: 35** **T 153 R 30 S 04**

GPS Coordinates: Easting: 387943 Northing: 5327672
Lat: _____ Long: _____

Comments: This site was examined in association with a BWSR cedar study. It lies in the NE quadrant of the intersection of Hwy 72 and a ditchbank road. We found white cedar germinants, seedlings and saplings. Master Releve key favors FPn73 (350) over FPn63 (323). Dichotomous key favors FPn63. Probability key favors FPn82.

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black spruce, balsam fir
Growth stage[1]: _____

Soil Map Unit[3] 627 Tawas
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 64" Depth to: gray mottles ____ **gray matrix 57" standing water: 18"**

Semipermeable layer Depth: 57" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
sapric peat	
	57"
silty clay	
	64"

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 2**	**Grasses, sedges & rushes collective cover[1]: 1**
Larix laricina	**D/3**	**Cornus Canadensis**	**Carex spp**
Thuja occidentalis	**C/2**	**Maianthemum canadensis**	**Calamagrostis Canadensis**
Picea mariana	**F/1**	**Rubus pubescens**	**Carex trisperma**
Betula papyrifera	**R/1**	**Dryopteris carthusiana**	**Carex intumescens**
		Galium triflorum	
		Trientalis borealis	
		Thelypteris palustris	
		Iris versicolor	
		Saxifraga pensylvanica	
		Smilacina trifolia	
		Dryopteris cristata	
		Pyrola secunda	
Understory trees & Shrubs collective cover[1]: 2	**A[2]/C[1]**	**Caltha palustris**	**Mosses & Lichens collective cover[1]: 2**
		Lysimachia thyrsiflora	
e.g. Red maple	***C/2***	**Osmunda claytoniana**	**Sphagnum spp**
Thuja occidentalis	**C/1**	**Solidago sp**	**Pleurozium spp**
Alnus incana	**C/1**	**Rubus acaulis**	
Larix laricina	**F/1**	**Impatiens sp**	
Picea mariana	**F/1**	**Mitella nuda**	
Lonicera oblongifolia	**C/1**	**Pyrola asarifolia**	
Cornus sericea	**C/1**	**Linnaea borealis**	**Additional plants or Plants collected/photographed**
Viburnum trilobum	**R/1**	**Fragaria virginiana**	
Ledum groenlandicum	**F/1**	**Aster puniceus**	
Quercus macrocarpa	**R/1**	**Galium labradoricum**	
Gaultheria hispidula	**R/1**	**Galium asprellum**	
Vaccinium oxycoccos	**R/1**	**Rumex orbiculatus**	
Rhamnus alnifolia	**F/1**	**Taraxicum sp**	
Fraxinus nigra	**R/1**	**Osmunda cinnamomea**	
Lonicera hirsuta	**R/1**	**Scutellaria lateriflora**	
Abies balsamea	**R/1**	**Stellaria longifolium**	
Acer rubrum	**R/1**		
Betula papyrifera	**R/1**		
Ribes cynosbati	**F/1**		
Ulmus americana	**R/1**		
Amelanchier sp	**R/1**		**Corylus cornuta R/1**
Ribes americanum	**R/1**		**Prunus virginiana R/1**
Vaccinium myrtilloides	**R/1**		**Lonicera canadensis R/1**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 2. FPn63, Northern Cedar Swamp, SW quadrant of the intersection

This plot lies south of both the BWSR treatment area and a ditch bank road, and west of Highway 72. Current canopy is dominated by 175 year old Northern white cedar and has a closure of >75%. White cedar and Balsam fir are common in the understory which consists of 5-25% cover. Basal area for this plot is 240 square feet per acre causing less understory cover and regeneration. As the canopy thins, moving towards the west, the understory becomes more developed and we saw a greater amount of cedar regeneration. We identified a native plant community of FPn63 (Northern cedar swamp).

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 26 / 2013**

Site Code[1]: B3 **Stand: 80** **Acres: 107** **T 153 R 30 S 08**

GPS Coordinates: Easting: 387804 Northing: 5327386
Lat: _____ Long: _____

Comments: This site is associated with the BWSR cedar study, located in the SW quadrant of the intersection of Hwy 72 and a ditchbank road. We found more cedar regeneration as we moved to the west along the transect and encountered a lighter canopy. Conor Reynolds was also in the party. Master Releve key strongly identifies this as FPn63

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Balsam fir
Growth stage[1]: _____

Soil Map Unit[3] 627 Tawas
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 54" Depth to: gray mottles ____ **gray matrix 12" standing water: 7"**

Semipermeable layer Depth: 29" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"	Sample	0"
sandy loam	10"	sapric Peat 12" loamy	
clay loam	16"	fine Sand 29" Clay 43"	
loam	60"	sandy clay loam 54"	

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 2**	**Grasses, sedges & rushes collective cover[1]: _____**
Thuja occidentalis	**D/5**	**Circaea alpina**	
Abies balsamea	**F/1**	**Galium labradoricum**	
		Maianthemum canadense	
		Mitella nuda	
		Galium triflorum	
		Impatiens sp	
		Dryopteris carthusiana	
		Rubus pubescens	
		Linnaea borealis	
		Trientalis borealis	
		Fragaria virginiana	
		Coptis trifolium	
Understory trees & Shrubs collective cover[1]: 2	**A[2]/C[1]**	**Cornus canadensis**	**Mosses & Lichens collective cover[1]: _____**
		Botrichium virginianum	
e.g. Red maple	***C/2***	**Aralia nudicaulis**	
Lonicera canadensis	**F/1**	**Trillium cernuum**	
Thuja occidentalis	**C/1**	**Smilacina trifolia**	
Fraxinus pensylvanica	**F/1**	**Aster puniceus**	
Ulmus americana	**F/1**	**Saxifraga pensylvanica**	
Abies balsamea	**C/1**	**Thelypteris palustris**	
Rubus ideaus	**R/1**	**Viola renifolia**	**Additional plants or**
Rhamnus alnifolia	**F/1**	**Lysimachia thyrsiflora**	**Plants collected/photographed**
Viburnum trilobum	**R/1**	**Equisetum fluviatile**	
Lonicera oblongifolia	**F/1**	**Caltha palustris**	
Acer rubrum	**R/1**	**Dryopteris cristata**	
Corylus cornuta	**F/1**	**Geum macrophyllum**	
Vaccinium myrtilloides	**F/1**	**Scutellaria lateriflora**	
Ledum groenlandicum	**F/1**	**Gymnocarpium dryopteris**	**Ranunculus abortivus**
Betula papyrifera	**F/1**	**Cypripedium reginae**	**Lycopodium annotinum**
Gaultheria hispidula	**F/1**	**Cicuta bulbifera**	
Ribes cynosbati	**F/1**	**Equisetum pratense**	
Alnus incana	**R/1**	**Pyrola secunda**	
Cornus sericea	**F/1**	**Solidago gigantea**	
Quercus macrocarpa	**R/1**	**Iris versicolor**	
Vaccinium oxycoccos	**F/1**	**Fragaria vesca**	**Lonicera hirsuta R/1**
Salix pseudomonticola	**R/1**	**Polyganum cilinode**	**Amelanchier sp R/1**
Prunus virginiana	**R/1**	**Actaea rubra**	**Ribes hirtellum R/1**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 2. FPn63, Northern Wet Cedar Forest, NW quadrant of the intersection

We took a plot to the south of the BWSR treatment site in what appears to be a remnant of the original stand, but probably containing less tamarack. This stand is west of Highway 72 and north of the ditchbank road. Canopy and understory closure is 50-75% with the canopy being dominated by 175 year old Northern white cedar. The primary understory species are black spruce (*Picea* mariana), speckled alder (*Alnus incana*), red-osier dogwood (*Cornus sericea*), and paper birch. With a basal area of 210 square feet per acre, regeneration sampling showed few white cedars. We classified this as a FPn63 (Northern cedar swamp).

ECS Site Classification Worksheet

Version 1.4, Apr 2012

Surveyor Names: Harvey Tjader, Jesse Lehner, Conor Reynolds **Date:** mm 06 / dd 26 / yyyy 2013

Site Code[1]: B-6 **Stand: 80** **Acres: _____** **T 153 R 30 S 08**

GPS Coordinates: Easting: 387751 Northing: 5327637
Lat: _____ Long: _____

Comments: Jesse Cox was also in the party. This is a remnant of the stand that BWSR planted with cedar, to the north. Master Releve key strongly identifies this as FPn63.

_____

_____

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black ash, balsam fir, paper birch
Growth stage[1]: mature

Soil Map Unit[3] 627 Tawas
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 60" Depth to: gray mottles ____ **gray matrix 34" standing water: 2"**

Semipermeable layer Depth: 48" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	10"
clay loam	16"
loam	60"

Sample	0"
Sapric Peat 34"	
Loamy Sand 48"	
clay	
	60"

Comments & Notes: pH_____

_____

_____

_____

_____

_____

_____

_____

_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

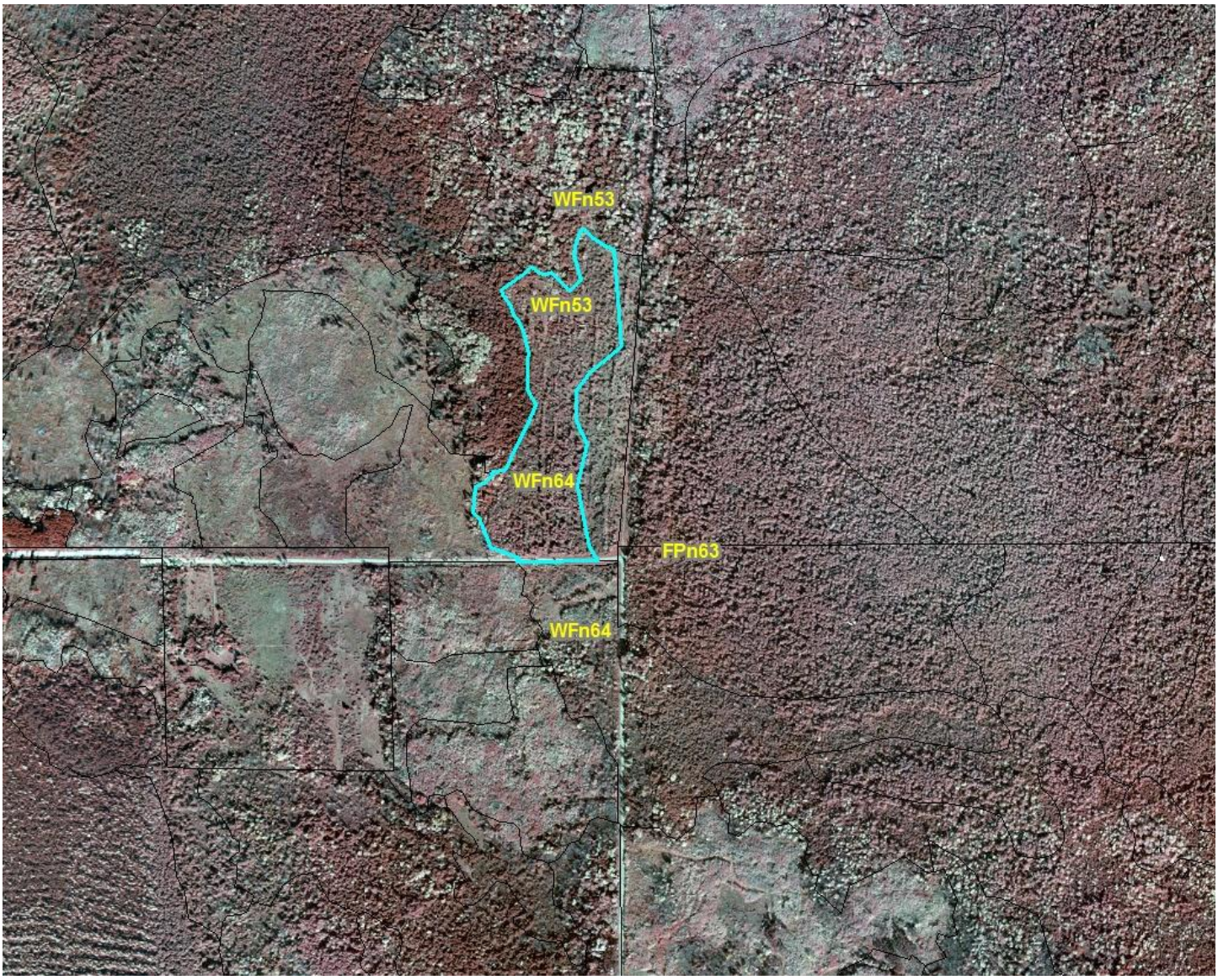
Overstory trees (> 33 feet) collective cover[1]: 4	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 4**	**Grasses, sedges & rushes collective cover[1]: 2**
Thuja occidentalis	**D/4**	**Coptis trifolia**	**Carex lacustris**
Betula papyrifera	**F/1**	**Impatiens sp**	**Poa sp**
Abies balsamea	**F/1**	**Streptopus roseus**	**Milium effusum**
Alnus incana (really!)	**R/1**	**Thelypteris palustris**	
		Maianthemum canadense	
		Osmunda cinnamomea	
		Circaea alpina	
		Trientalis borealis	
		Urtica dioica	
		Galium triflorum	
		Cornus Canadensis	
		Rubus pubescens	
Understory trees & Shrubs collective cover[1]: 4	**A[2]/C[1] ⬇**	**Lycopus uniflorus**	**Mosses & Lichens collective cover[1]: 2**
		Polygonum cilinode	
e.g. Red maple	***C/2***	**Lysimachia thyrsiflora**	**Pleurozium spp**
Alnus incana	**C/2**	**Mitella nuda**	
Cornus sericea	**C/1**	**Fragaria virginiana**	
Betula papyrifera	**C/1**	**Linnaea borealis**	
Ribes americanum	**F/1**	**Caltha palustris**	
Ledum groenlandicum	**F/1**	**Equisetum fluviatile**	
Vaccinium myrtilloides	**F/1**	**Solidago sp**	**Additional plants or Plants collected/photographed**
Rubus ideaus	**F/1**	**Dryopteris carthusiana**	
Ulmus Americana	**F/1**	**Lycopodium annotinum**	
Ribes hirtellum	**F/1**	**Clintonia borealis**	
Corylus cornuta	**F/1**	**Aster puniceus**	
Amelanchier sp	**F/1**	**Circium muticum**	
Abies balsamea	**F/1**	**Solidago gigantea**	
Acer rubrum	**R/1**	**Gymnocarpium dryopteris**	
Lonicera hirsuta	**F/1**	**Taraxacum sp**	
Lonicera oblongifolia	**F/1**	**Galium labradoricum**	
Fraxinus nigra	**R/1**	**Campanula aparinoides**	
Picea mariana	**R/1**	**Saxifraga pensylvanica**	
Rhamnus alnifolia	**F/1**	**Trillium cernuum**	
Gaultheria hispidula	**F/1**	**Iris versicolor**	
		Athyrium felix-femina	
		Arenaria laterifolia	

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 3. DNR stand #664: Tree Planting and Tree Protection Project



Located at SE ¼ Section 35, Township 154N, Range 30W in Beltrami County Mn.
Scale 1:10,000

WFn64 (Northern Very Wet Ash Swamp), found on the SW and NW quadrants of this intersection, rank slightly wetter than does FPn63 (Northern Cedar Swamp) in the ordination chart on page 8 of the Field Guide to the Native Plant Communities of Minnesota. An expected effect of impeded drainage would be a drying of the downstream NW quadrant, which has not happened to an extent that would result in a change of Native Plant Community. There is a wet shrub area along the south edge of the road in the SW quadrant, a likely result of temporary, intermittent flooding.

Site 3. WFn64, Northern Very Wet Ash Forest, DNR Stand #664, Sec 35-T154-R30

Photo: The southern portion of the treatment area.

In Spring 2013, this 21.6 acre treatment area was planted with 600 northern white cedar transplants, 600 white cedar seedlings, and 1200 black spruce seedlings. Mesh enclosures were placed around 60 white cedar transplants. Tree protectors were installed over 60 white cedar seedlings. Ten acres were broadcast seeded with 4 oz/acre of white cedar seed. During our sample, a few natural cedar and black spruce seedlings were noted to exist in the stand in addition to the BWSR project plantings. According to Jon Coil, DNR Forestry, Kelliher, this site is dominated by European larch (*Larix decidua*), planted 27 years ago. Prior to that planting, Ron Rabe, DNR Forestry, Blackduck, said the site was classified as Lowland Brush. In the southern portion of the stand, a low basal area of trees has allowed shrubs and ground vegetation to persist. Understory woody cover is estimated >75%, consisting of planted tree seedlings and willow shrubs. We classified this site as a WFn64 (Northern Very Wet Ash Swamp).

This site should be considered to be a novel ecosystem, as it is dominated by a non-native species (Larix decidua) and includes planted white cedar and black spruce. The latter two species are not uncommon in WFn64, but tend to be secondary species. Black ash, which tends to be strongly dominant in WFn64, is all but non-existent. We noted a few, scattered black ash individuals in the understory. As we struggle to deal with the threat of losing black ash to emerald ash borers, which effectively means having to redesign our WFn64 community, this site may bear watching as an alternative model for species composition.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 27 / 2013**

Site Code[1]: A-5 **Stand: 664** **Acres: 10** **T 154 R 30 S 35**

GPS Coordinates: Easting: 392265 Northing: 5329175
Lat: _____ Long: _____

Comments: Conor Reynolds, also. This site was planted with European larch about 20 yrs ago, and planted this spring with white cedar and black spruce, as part of a BWSR cedar study. The master releve key strongly indicated WFn, but identification of an NPC was indefinite. The dichotomous key weakly indicated WFn64.
We found one naturally occurring cedar seedling and one black spruce on our plot.

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WFn64 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: black ash, Quaking aspen
Growth stage[1]: young

Soil Map Unit[3] 482 Grygla
Land Type Associaton[4]: 212Mb16 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 62" Depth to: gray mottles ____ **gray matrix 26" standing water: 23"**
Semipermeable layer Depth: 41" Type: hardpan, clayey texture, both (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
sapric Peat 26"	
Loam 41"	
Clay 47"	
sandy Loam 54"	
gravelly Sandy loam	
	62"

Comments & Notes: pH_____
No pools or hummocks

Native Plant Community Worksheet

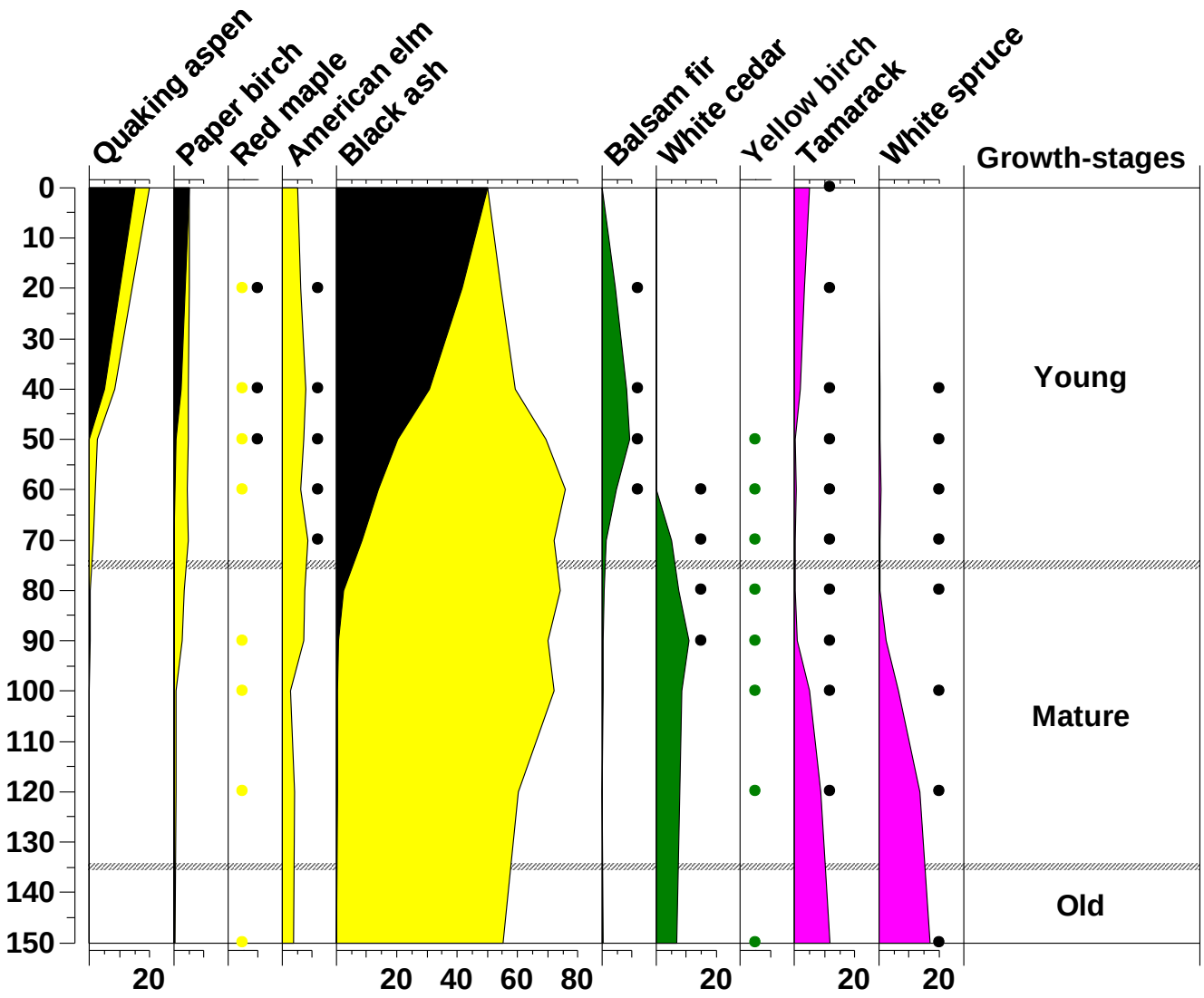
Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 3	**A^2/C^1 ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 5**	**Grasses, sedges & rushes collective cover[1]: 4**
Larix decidua	**D/3**	**Aralia nudicaulis**	**Carex lacustris**
Betula papyrifera	**F/1**	**Equisetum silvicaticum**	**Poa sp**
Salix spp	**R/1**	**Urtica dioica**	**Unknown grass species**
Populus balsamifera	**F/1**	**Rubus pubescens**	
Populus tremuloides	**F/1**	**Solidago gigantea**	
Abies balsamea	**F/1**	**Maianthemum canadense**	
Picea mariana	**R/1**	**Dryopteris carthusiana**	
Thuja occidentalis	**R/1**	**Impatiens sp**	
		Galium asprellum	
		Dryopteris cristata	
		Iris versicolor	
		Lactuca sp	
Understory trees & Shrubs collective cover[1]: 5	**A^2/C^1 ⬇**	**Thelypteris palustris**	**Mosses & Lichens collective cover[1]: 2**
		Mitella nuda	
e.g. Red maple	***C/2***	**Geum macrophyllum**	**Pleurozium spp**
Salix spp	**A/3**	**Caltha palustris**	**Sphagnum spp**
Betula papyrifera	**C/1**	**Petasites sagitattus**	**Climacium dendroides**
Larix decidua	**C/1**	**Potentilla norvegica**	
Ribes hirtellum	**C/1**	**Trillium cernuum**	
Cornus sericea	**C/2**	**Cirsium muticum**	
Rubus idaeus	**C/2**	**Ranunculus abortivus**	**Additional plants or Plants collected/photographed**
Ribes americanum	**C/1**	**Viola renifolia**	
Abies balsamea	**F/1**	**Lamiacaea sp**	
Ulmus Americana	**F/1**	**Heuchera richardsonii**	
Prunus virginiana	**F/1**	**Galium triflorum**	
Thuja occidentalis	**F/1**	**Arisaema triphyllum**	
Picea mariana	**F/1**	**Lysimachia thyrsiflora**	
Populus balsamifera	**F/1**	**Aster puniceus**	
Chamaedaphne calyculata	**R/1**	**Fragaria vesca**	
Vaccinium oxycoccos	**R/1**	**Eupatorium maculatum**	
Ledum groenlandica	**R/1**	**Trientalis borealis**	
Lonicera spp	**R/1**	**Athyrium felix-femina**	
Alnus incana	**R/1**	**Gymnocarpium dryopteris**	
		Matteucia struthiopteris	
		Fragaria virginiana	
		Galium labradoricum	
		Cornus canadensis	**Thalictrum dasycarpum**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***



WFn64, J.C. Almendinger, November 2008

The above table shows a typical composition for a young WFn64 community containing quaking aspen, paper birch, red maple, American elm and being dominated by black ash. Balsam fir becomes established and peaks around age 50. As balsam fir diminishes, white cedar becomes established, but typically remains a secondary species. Tamarack and white spruce ingress during the mature growth stage. Nothing rivals black ash for being well suited to this community.

Site 3. WFn53, Northern Wet Cedar Forest, NW quadrant of the intersection

Photo: Northern portion of the treatment area in Stand #664

Possibly due to its proximity to the adjacent cedar stand, northern white cedar volunteers were common along our transect, along with planted cedars. Canopy closure of 50-75% is present in this area dominated by paper birch (*Betula papyrifera)*, quaking aspen (*Populus tremuloides*), and balsam fir (*Abies balsamea*) with occasional white cedars present. Our basal area plot was 70 square feet per acre. In addition to natural and planted cedars, the understory has an abundance of red raspberry (*Rubus idaeus*) and willow species. Density of understory woody plant species is between 50-75%. We classified this part of the treatment area as WFn53 (Northern Wet Cedar Forest). The growth stage is young.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 27 / 2013**

Site Code[1]: A-6 **Stand: 664** **Acres: 10** **T 154 R 30 S 35**

GPS Coordinates: Easting: 392280 Northing: 5329480
Lat: _____ Long: _____

Comments: Conor Reynolds, also. This is in the same stand as A-5, to the north and near eastern edge, close to a cedar stand. Numerous cedar volunteers. A few ant hills. Planted 20 years ago with European larch and this spring with cedar and black spruce, as part of a BWSR cedar project. Master releve key: WFn53

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WFn53 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black ash, paper birch, balsam fir
Growth stage[1]: young

Soil Map Unit[3] 563 Northwood
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 60" Depth to: gray mottles ____ **gray matrix 9" standing water: 25"**

Semipermeable layer Depth: 35" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
Muck 9"	
loamy	
Sand 29"	
stony coarse	
Sand 35"	
sandy clay	
60"	

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 4	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 4**	**Grasses, sedges & rushes collective cover[1]: 2**
Betula papyrifera	**C/2**	**Athyrium felix-femina**	**Unidentified grasses**
Populus tremuloides	**C/1**	**Trillium cernuum**	**Carex lacustris**
Abies balsamea	**C/2**	**Impatiens sp**	**Carex spp**
Salix spp	**R/1**	**Galium asprellum**	
Thuja occidentalis	**R/1**	**Cirsium muticum**	
Populus balsamifera	**F/1**	**Mitella nuda**	
Larix decidua	**R/1**	**Galium triflorum**	
Picea mariana	**R/1**	**Circaea alpina**	
		Solidago gigantea	
		Rubus pubescens	
		Cornus canadensis	
		Equisetum silvaticum	
Understory trees & Shrubs collective cover[1]: 4	**A[2]/C[1] ⬇**	**Lactuca sp**	**Mosses & Lichens collective cover[1]: 2**
		Aster puniceus	
e.g. Red maple	***C/2***	**Gymnocarpium dryopteris**	**Pleurozium spp**
Abies balsamea	**C/2**	**Botrychium virginianum**	
Rubus idaeus	**A/3**	**Actaea rubra**	
Salix spp	**A/3**	**Maianthemum canadensis**	
Betula papyrifera	**C/2**	**Iris versicolor**	
Ribes hirtellum	**F/1**	**Solidago altissima**	
Ribes cynosbati	**F/1**	**Thelypteris palustris**	**Additional plants or Plants collected/photographed**
Ulmus americana	**F/1**	**Aralia nudicaulis**	
Viburnum rafinesquianum	**R/1**	**Fragaria virginiana**	**Lysimachia quadrifolia**
Ribes americanum	**C/1**	**Dryopteris cristata**	**Caltha palustris**
Prunus virginiana	**F/1**	**Ranunculus abortivus**	**Onoclea sensibilis**
Thuja occidentalis	**C/1**	**Trientalis borealis**	**Sanicula marilandica**
Cornus sericea	**C/1**	**Geum macrophyllum**	**Lysimachia thyrsiflora**
Rosa acicularis	**F/1**	**Equisetum arvense**	**Dryopteris carthusiana**
Lonicera canadensis	**F/1**	**Epilobium angustifolium**	**Heuchera richardsonii**
Populus balsamifera	**F/1**	**Cirsium (cf) discolor**	**Arisaema triphyllum**
Rhamnus alnifolia	**F/1**	**Equisetum pratense**	
Amelanchier sp	**F/1**	**Coptis trifolia**	
Fraxinus nigra	**F/1**	**Eupatorium maculatum**	
Salix bebbiana	**F/1**	**Aster macrophyllum**	
Populus tremuloides	**R/1**	**Galium labradoricum**	
Ribes triste	**F/1**	**Urtica dioica**	
Acer rubrum	**R/1**	**Trifolium sp**	**Gaultheria hispidula F/1**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 3. FPn63, Northern Cedar Swamp, east side of the intersection

This site lies to the east, across the road from the treated site. Its canopy is dominated by tamarack (*Larix laricina*), aged 62 years, according to FIM. Typical canopy cover was determined to be 50-75% and understory vegetation (predominantly cedar and balsam fir) was found at >75%. Together, the overstory canopy and understory canopy is sufficiently dense in much of the stand to nearly eliminate most ground vegetation, including tree seedlings. Where present, understory tree species include balsam fir, tamarack and northern white cedar. The native plant community for this stand is FPn63 (northern cedar swamp). Tamarack dominance in FPn63 is not documented in the Field Guide to Native Plant Communities of Minnesota, but is not uncommon in Beltrami County. This stand does have a few scattered individual cedars present within the canopy.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehman, Jesse Cox **Date: 06 / 27 / 2013**

Site Code[1]: A-1 **Stand: 28** **Acres: 38** **T 153 R 30S 28**

GPS Coordinates: Easting: 392580 Northing: 5328995
Lat: _____ Long: _____

Comments: this site lies east of a BWSR cedar project site and was visited to examine effects of hydrologic changes. Master releve key strongly identifies this as FPn63.

_____

_____

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: FPn63 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Balsam fir
Growth stage[1]: _____

Soil Map Unit[3] 563 Northwood
Land Type Associaton[4]: 212Mb 04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)

Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___

Tot. Sample Depth 58" Depth to: gray mottles _____ **gray matrix 36" standing water: 5"**

Semipermeable layer Depth: 48" Type: hardpan, clayey texture, both (circle one)

Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	10"
clay loam	16"
loam	60"

Sample	0"
woody sapric Peat 36"	
loamy Sand 48"	
clay	58"

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 4	**A[2]/C[1] ⬇**	**Forbs, Ferns, & Fern Allies collective cover[1]: 2**	**Grasses, sedges & rushes collective cover[1]: 1**
Larix laricina	**D/3**	**Scutellaria lateriflora**	**Carex lacustris**
Abies balsamea	**A/2**	**Cornus canadensis**	**Carex spp**
Betula papyrifera	**F/1**	**Mitella nuda**	**Unknown grasses**
Thuja occidentalis	**F/1**	**Dryopteris cristata**	
		Rubus pubescens	
		Galium triflorum	
		Eupatorium maculatum	
		Smilacina trifolia	
		Linnaea borealis	
		Urtica dioica	
		Petasites sagitattus	
		Equisetum fluviatile	
Understory trees & Shrubs collective cover[1]: 5	**A[2]/C[1] ⬇**	**Rubus acaulis**	**Mosses & Lichens collective cover[1]: 4**
		Galium labradoricum	
e.g. Red maple	***C/2***	**Lysimachia thyrsiflora**	**Sphagnum spp**
Ledum groenlandica	**C/1**	**Thelypteris palustris**	**Pleurozium spp**
Cornus sericea	**C/1**	**Aster puniceus**	**Plagiomnium spp**
Picea mariana	**F/1**	**Coptis trifolia**	
Betula pumila	**F/1**	**Trientalis borealis**	
Thuja occidentalis	**C/2**	**Taraxacum sp**	
Larix laricina	**C/1**	**Geum macrophyllum**	**Additional plants or Plants collected/photographed**
Abies balsamea	**C/2**	**Aralia nudicaulis**	
Rhamnus alnifolia	**C/1**	**Solidago gigantea**	
Fraxinus nigra	**R/1**	**Pyrola asarifolia**	
Ribes hirtellum	**F/1**	**Galium asprellum**	
Rubus ideaus	**F/1**	**Lactuca sp**	
Gaultheria hispidula	**C/1**	**Fragaria virginiana**	
Vaccinium oxycoccos	**F/1**	**Botrichium virginiana**	
Lonicera canadensis	**C/1**	**Maianthemum canadense**	
Ribes cynosbati	**F/1**	**Viola renifolia**	
Populus balsamifera	**R/1**	**Pyrola secunda**	
Ribes triste	**F/1**	**Campanula aparinoides**	**Vaccinium myrtiloides R/1**
Lonicera oblongifolia	**F/1**	**Caltha palustris**	**Ribes sp F/1**
Rosa acicularis	**R/1**	**Iris versicolor**	**Amelanchier sp R/1**
Salix sp	**C/2**	**Stellaria longifolia**	**Betula papyrifera F/1**
Prunus virginiana	**F/1**		**Acer rubrum R/1**
Ulmus americana	**R/1**		**Alnus incana R/1**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 3. WFn64, Northern Very Wet Ash Swamp, SW quadrant of the intersection

This site lies south of the treatment area, across the road. It was "lumped into" a stand designated as stagnant cedar in FIM data, but our recent sample indicates balsam poplar (*Populus balsamifera*) dominance with a northern white cedar component. The deciduous canopy has a density of >75%. The fact that more sunlight penetrates a balsam poplar canopy than a northern white cedar canopy has allowed a dense understory to develop. Basal area on our plot was 140 square feet per acre and scattered white cedar individuals are regenerating in the understory. We determined the native plant community to be WFn64 (Northern Very Wet Ash Swamp).

When our Ecological Land Classification System was developed, northern white cedar occurred in 15% of the relevé plots that were used to define the WFn64 community. When present on a plot, the mean cover was 12%. It is ranked fourth among tree species for suitability in this community, behind black ash, tamarack and quaking aspen. Of the Wet Forest communities, WFn64 ranks poorest for white cedar. White cedar is considered mid-successional in this community. Its presence may increase through natural seeding in large gaps that form during the decline (or removal) of overstory hardwood species. If the black ash component of this stand is diminished due to emerald ash borer infestation and the balsam poplar is not harvested and regenerated, the cedars may play an important role in keeping this site forested.

ECS Site Classification Worksheet

Version 1.4, Apr 2012

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 27 / 2013**
(mm dd yyyy)

Site Code[1]: A-2 **Stand: 26** **Acres: 4** **T 153 R 30 S 01**

GPS Coordinates: Easting: 392386 Northing: 5328946
Lat: _____ Long: _____

Comments: Conor Reynolds, too.
This site is south of a BWSR cedar study planting site, across the road.
Master releve key strongly favored WFn, but was inconclusive regarding NPC. Dichotomous and probability keys favor WFn64.

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WFn64 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: black ash
Quaking aspen
Growth stage[1]: young

Soil Map Unit[3] 482 Grygla
Land Type Associaton[4]: 212Mb16 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 42" Depth to: gray mottles ____ **gray matrix 10" standing water: 14"**
Semipermeable layer Depth: 26" Type: hardpan, clayey texture, both (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	10"
clay loam	16"
loam	60"

Sample	0"
Muck 10"	
Loamy	
Sand 26"	
clay	

Comments & Notes: pH_____
Hit something hard and big at 46"
_____
_____
_____
_____
_____
_____
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 5**	**Grasses, sedges & rushes collective cover[1]: 2**
Populus balsamifera	**D/4**	**Actaea rubra**	**(cf) schizachne purpurascens**
Betula papyrifera	**C/2**	**Caltha palustris**	**Carex spp**
Fraxinus nigra	**C/2**	**Urtica dioica**	**Carex intumescens**
Ulmus americana	**R/1**	**Impatiens sp**	**Calamagrostis Canadensis**
Thuja occidentalis	**R/1**	**Rubus pubescens**	
		Aralia nudicaulis	
		Equisetum silvaticum	
		Circaea alpina	
		Dryopteris carthusiana	
		Lycopus uniflorus	
		Dryopteris cristata	
		Trientalis borealis	
Understory trees & Shrubs collective cover[1]: 4	**A[2]/C[1]**	**Solidago gigantea**	**Mosses & Lichens collective cover[1]: 1**
		Ranunculus recurvatus	
e.g. Red maple	***C/2***	**Gymnocarpium dryopteris**	**Pleurozium spp**
Abies balsamea	**C/2**	**Maianthemum canadense**	**Plagiomnium spp**
Betula papyrifera	**C/1**	**Geum macrophyllum**	
Fraxinus nigra	**C/2**	**Lysimachia thyrsiflora**	
Ulmus americana	**R/1**	**Fragaria virginiana**	
Ribes hirtellum	**C/1**	**Equisetum pratense**	
Ribes americanum	**F/1**	**Lactuca sp**	**Additional plants or Plants collected/photographed**
Corylus cornuta	**F/1**	**Petasites frigidus / palmatus**	
Rubus idaeus	**C/1**	**Cirsium muticum**	
Ribes sp	**F/1**	**Athyrium felix-femina**	
Thuja occidentalis	**F/1**	**Cicaea lutetiana**	
Cornus sericea	**F/1**	**Galium triflorum**	
Parthenocissus vitacea	**F/1**	**Galium asprellum**	
Rhamnus alnifolia	**F/1**	**Aster puniceus**	
Acer rubrum	**R/1**	**Cornus canadensis**	
Acer spicatum	**F/1**	**Aralia racemosa**	
Populus tremuloides	**R/1**	**Lycopus americanus**	
Lonicera hirsuta	**R/1**	**Iris versicolor**	**Viola renifolia**
Rosa acicularis	**R/1**	**Thelypteris palustris**	**Streptopus roseus**
Salix bebbiana	**F/1**	**Osmunda cinnamomea**	**Arisaema triphyllum**
		Botrichium virginianum	**Epilobium angustifolium**
		Stellaria longifolia	**Anemone canadensis**
		Clintonia borealis	**Trillium cernuum**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Site 3. WFn53, Northern Wet Cedar Forest, north of the treatment area

This stand, lying north of the treatment area, has some old growth characteristics and is aged at 131 years. (It also contains some stumps.) Northern white cedar dominates this site creating a dense canopy of >75% cover. Gaps within the stand have allowed an understory between 25-50% cover to develop. Within the understory we noted a few scattered individual white cedars that have become established. Current basal area is 290 square feet per acre creating a heavily shaded forest floor. The native plant community is WFn53 (Northern Wet Cedar Forest).

ECS Site Classification Worksheet

Version 1.4, Apr 2012

mm dd yyyy

Surveyor Names: Harvey Tjader, Jesse Lehner, Jesse Cox **Date: 06 / 27 / 2013**

Site Code[1]: A-4 **Stand: 552** **Acres: 26** **T 154 R 30S 35**

GPS Coordinates: Easting: 392387 Northing: 5329717
Lat: _____ Long: _____
Comments: Also Conor Reynolds. This site lies north of a BWSR cedar project stand. It looks like old growth, except for stumps.

_____

_____

_____

1. your own reference code for the transect

Native Plant Community & Soil Summary

Main NPC[1]: WFn53 (8 char code)
NPC Inclusions:_____
Potential Crop Trees[2] Present: white cedar, Black ash, balsam fir, paper birch
Growth stage[1]: mature

Soil Map Unit[3] 563 Northwood
Land Type Associaton[4]: 212Mb04 (7 char)
Surface texture[5]: muck
Drainage class: vp
Operability rating[6]: Wf

1. See NPC Field Guide. **2. S**ee ECS tree suitability tables. **3**. See SSURGO GIS cover. **4**. See LTA GIS cover. **5**. e.g. sandy loam not medium
6. See ECS season of operability table

Soil Worksheet

Instructions: Dig/auger a soil pit 60" deep and draw soil profile in the sample box below. Indicate changes in soil texture and the depths at which they occur. **Top of the box (0") is the mineral soil surface for MH, FD & FF NPCs and the peat surface for WF, FP, & AP NPCs.** All depths measured in inches.

Landscape position: top/crest – side slope – toe – level – depression (circle one)
Slope(%) _____ **Aspect** _____ **Length of slope above in chains:**___
Tot. Sample Depth 55" Depth to: gray mottles ____ **gray matrix 6" standing water: 7"**
Semipermeable layer Depth: 22" **Type: hardpan, clayey texture, both** (circle one)
Humus type: mor – moder – mull – muck – moss peat (circle one) **Humus Thickness** (MH,FD,FF) ____

Example	0"
sandy loam	
	10"
clay loam	
	16"
loam	
	60"

Sample	0"
muck _____6"	
loamy sand _____22"	
clay	
	55"

Comments & Notes: pH_____
_____
_____
_____
_____
_____
_____
Some stones
_____
_____

Native Plant Community Worksheet

Instructions: Locate a homogeneous portion of the stand. ***Along a 4-chain transect, record all of the plants that you can identify without moving more than a few steps off of the transect***. Record the species of overstory trees, understory trees & shrubs, and other plants in their appropriate life-form columns. ***At the end of the transect, stop to summarize for the whole community/stand*** the ***collective cover[1]*** of all plants in the life-form categories and the ***Abundance/Cover (A/C[2]) codes*** for the individual species of overstory trees, understory trees, and shrubs. Use this list to key out the site in the Field Guide.

Overstory trees (> 33 feet) collective cover[1]: 5	**A[2]/C[1]**	**Forbs, Ferns, & Fern Allies collective cover[1]: 3**	**Grasses, sedges & rushes collective cover[1]: 2**
Thuja occidentalis	**D/4**	**Athyrium felix-femina**	**Carex intumescens**
Betula papyrifera	**C/2**	**Rubus pubescens**	**Carex spp**
Abies balsamea	**C/2**	**Circaea alpina**	
Fraxinus nigra	**C/1**	**Aralia nudicaulis**	
Picea mariana	**F/1**	**Actaea rubra**	
		Impatiens sp	
		Ranunculus abortivus	
		Trientalis borealis	
		Cornus canadensis	
		Galium triflorum	
		Botrichium virginianum	
		Arisaema triphyllum	
Understory trees & Shrubs collective cover[1]: 3	**A[2]/C[1]**	**Galium labradoricum**	**Mosses & Lichens collective cover[1]: 2**
		Mitella nuda	
e.g. Red maple	***C/2***	**Gymnocarpium dryopteris**	**Pleurozium spp**
Cornus sericea	**C/1**	**Equisetum silvaticum**	**Plagiomnium spp**
Fraxinus nigra	**C/1**	**Coptis trifolia**	
Ribes americanum	**F/1**	**Maianthemum canadensis**	
Prunus virginiana	**F/1**	**Clintonia borealis**	
Rubus idaeus	**C/2**	**Fragaria virginiana**	
Corylus cornuta	**F/1**	**Ranunculus (cf) hispidus**	**Additional plants or Plants collected/photographed**
Ribes triste	**F/1**	**Dryopteris carthusiana**	
Lonicera americana	**C/1**	**Matteucia struthiopteris**	
Ulmus americana	**F/1**	**Geum macrophyllum**	
Abies balsamea	**C/1**	**Ranunculus recurvatus**	
Parthenocissus vitacea	**R/1**	**Urtica dioica**	
Thuja occidentalis	**F/1**	**Dryopteris cristata**	
Rhamnus alnifolia	**F/1**	**Thelypteris palustris**	
Lonicera hirsuta	**F/1**	**Smilacina trifolia**	
Betula papyrifera	**C/1**	**Heuchera richardsonii**	
Lonicera sp	**R/1**	**Trillium cernuum**	
Ribes cynosbati	**F/1**	**Viola renifolia**	
Amelanchier sp	**R/1**	**Saxifraga pensylvanica**	
		Solidago gigantea	**Cirsium muticum**
		Linnaea borealis	**Iris versicolor**
		Scutillaria lateriflora	**Caltha palustris**
		Lactuca sp	**Lysimachia thyrsiflora**

1. Cover (C) Codes: 1 = <5% cover, plants occurring as scattered individuals; **2** = 5-25% cover, plants in small patches or spreading individuals; **3** = 25-50% cover, plants in large patches/colonies or co-dominant trees; **4** = 50-75% cover, plants in extensive colonies/mats/interrupted canopy or co-dominant trees; **5** = >75% cover, plants forming continuous canopy/carpet or occurring as dominant trees.

2. Abundance (A) Codes: R = rare, nearly absent; **F** = few, scattered individuals, **C** = common; **A** = abundant, co-dominant; **D** = dominant.

Estimate the abundance and cover of individual species using the combination of the abundance and cover codes above: ***e.g. enter "C/2" for a plant that is common in small patches that cover about 5-25% of the extent of the community in the stand.***

Bibliography:

1) Almendinger J., “Minnesota Department of Natural Resources, Ecological Classification System Silviculture Interpretations”, Minnesota Department of Natural Resources, 2010. http://www.dnr.state.mn.us/forestry/ecs_silv/interpretations.html
2) Boulfroy E., Forget E., Hofmeyer P., Kenefic L., Larouche C., Lessard G., Lussier JM., Pinto F., Ruel JC., Weiskittel A., “Silvicultural Guide for Northern White-Cedar (Eastern White Cedar)”, United State Department of Agriculture, Forest Service, 2012. http://www.nrs.fs.fed.us/pubs/41699
3) Coil, Jon. Personal communication, 2013.
4) Krystosek D., Stensing J., “Northeast Minnesota White Cedar Plant Community Restoration Project” Minnesota Board of Water and Soil Resources, 2012
5) Minnesota Department of Natural Resources (2003). Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province. Ecological Land Classification Program, Minnesota Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.
6) Rabe, Ron. Personal communication, 2013.

A visual comparison of canopies and regeneration of northern white cedar in selected stands in Northern Minnesota

Addendum to Cedar in NW Minnesota, an ECS case study

Harvey Tjader, CF, NW Region Staff Forester, Department of Natural Resources, 2115 Birchmont Beach Road NE, Bemidji, MN 56601, and Jesse Lehner, Forestry intern Michigan Technological University masters candidate, 14837 161st. Ave, Wadena MN 56482

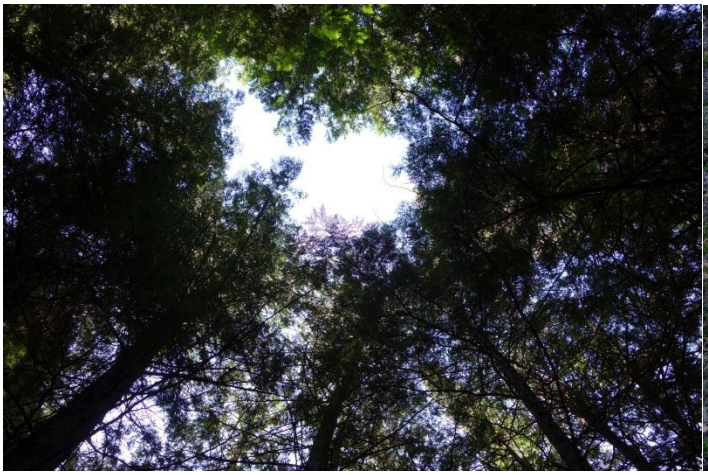
9/17/2013

MNDNR Ecological Land Classification: "Improving the scientific foundations of silviculture"

Photographs of the canopy, taken while lying on the forest floor, are compared with 7.4' radius (1/250 acre) vegetation plots taken in the same location. The sites are related to The Minnesota Board of Water and Soil Resources' Northeast Minnesota White Cedar Plant Community Restoration Project. They are located in Beltrami County. The photos are arranged in order of increasing sunlight at the level of the forest floor. Factors affecting vegetation on the forest floor include tree density, canopy species, depth of canopy, and time elapsed since canopy gap development.

Site 1. WFn53 canopy, Stand #276, mature cedar

WFn53 ground cover included cedar 1-3”dbh @250/ac, balsam fir 0-1”dbh @1000/ac, sparse naked miterworts, starflower, and bristly clubmoss



Site 1. WFn53 canopy, Stand #276, mature cedar

WFn53 ground cover included balsam fir 0-1”dbh @500/ac and similar forbs to the previous photo

Site 1. WFn53 canopy, Stand #276, mature cedar

WFn53 ground cover included balsam fir 0-1”dbh @500/ac and similar forbs to the previous two photos

Site 1. FPn63 canopy, east of Stand #276 (NE quadrant) cedar/tamarack

FPn63 ground cover included cedar 1-3”dbh @750/ac and jewelweed

Site 1. FPn63 canopy, east of Stand #276 (NE quadrant) cedar/tamarack

FPn63 ground cover included cedar 0-1”dbh @250/ac, cedar 1-3”dbh @500/ac, balsam fir 0-1”dbh @250/ac, sedges, and ferns

Site 1. FPn63 canopy, east of Stand #276 (NE quadrant) cedar tamarack

FPn63 ground cover included cedar 0-1”dbh @250/ac, cedar 1-3”dbh @250/ac, black spruce 0-1”dbh @250/ac, black spruce 1-3”dbh @500/ac, balsam fir 0-1”dbh @250/ac

Site 2. WFn53 canopy, SE of DNR Stand #649 mature cedar

WFn53 ground cover included black ash 0-1”dbh @500/ac, dwarf raspberry, ferns, red baneberry and naked miterwort (SE quadrant of the intersection)

Site 2. WFn53 canopy, SE of DNR Stand #649 mature cedar

WFn53 ground cover included cedar 1-3” dbh @500/ac, ferns, alpine enchanters nightshade, wild sarsaparilla, and naked miterwort

WFn53 canopy, SE of DNR stand #649 – a very small gap in mature cedar

WFn53 ground cover included ferns, red osier dogwood, sphagnum, and naked miterwort, but no trees

Site 2.FPn63 canopy, south of DNR Stand #649 (SW quadrant) mature cedar

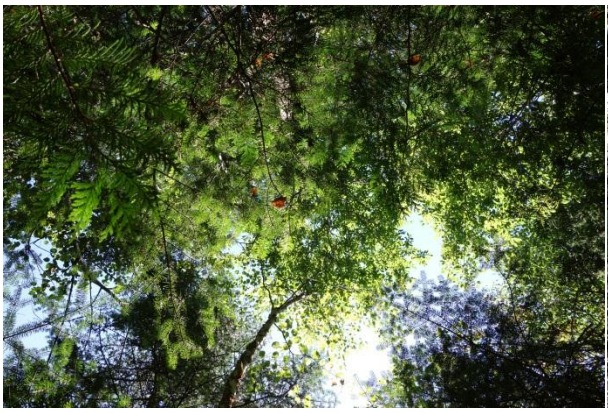
FPn63 ground cover included ferns, wild sarsaparilla, red raspberry and feather mosses

Site 2. FPn63 canopy, south of DNR Stand #649 (SW quadrant) mature cedar

FPn63 ground cover included cedar 0-1”dbh @250/ac, fly honeysuckle, naked miterwort and ferns

Site 3. FPn63 canopy, east of Stand #664 tamarack/black spruce/cedar

FPn63 ground cover included cedar 0-1”dbh @500/ac, cedar 1-3” dbh @500/ac, balsam fir 1-3” dbh @1000/ac. Very little other ground vegetation. Cedar in the 0-1” dbh class appeared to have very poor vigor



Site 3. FPn63 canopy, east of Stand #664 tamarack/black spruce/cedar

FPn63 ground cover, including balsam fir 0-1” dbh @2750/ac, balsam fir 1-3” dbh @500/ac, cedar 0-1” dbh @500/ac, cedar 1-3” dbh @500/ac, paper birch 1-3” dbh @500/ac, sphagnum, twinflower, bunchberry, naked miterwort

Site 3. FPn63 Canopy surrounding a small gap, east of Stand 664 tamarack/bspruce, cedar

FPn63 ground cover included cedar 0-1” dbh @ 750/ac, balsam fir 0-1”dbh @ 500/ac, tamarack 0-1” @ 500/ac, plus sphagnum, red osier dogwood, Labrador tea, goldenrods, dwarf raspberry and willow species.

Site 1. FPn63 canopy, south of Stand # 276 (SW quadrant) tamarack/black spruce

FPn63 ground cover included cedar 0-1”dbh @750/ac, tamarack 1-3”dbh @750/ac, sedges, bog birch, red osier dogwood and Labrador tea

Site 1. FPn63 canopy, south of Stand #276 (SW quadrant) tamarack/black spruce

FPn63 ground cover included cedar 0-1”dbh @4750/ac, cedar 1-3”dbh @1000/ac, cedar 3-5”dbh @250/ac, mountain fly honeysuckle, Labrador tea and feather mosses

Site 1. FPn63 canopy, south of Stand #276 (SW quadrant) tamarack/black spruce

FPn63 ground cover included cedar 0-1”dbh @5250/ac, cedar 3-5”dbh @ 500/ac, feather moss, sphapgnum, and Labrador tea

Site 1. FPn63 canopy, SE of Stand #276 (SE quadrant) Wind-created gap; tamarack/black spruce

FPn63 ground cover included cedar 0-1”dbh @2250/ac, paper birch 0-1”dbh @250/ac, balsam fir 0-1”dbh @250/ac, red raspberry and Labrador tea

Site 1. FPn63 canopy over wind created gap, SE of Stand 276; tamarack/b spruce

FPn63 ground cover included cedar 0-1”dbh @6500/ac, paper birch 0-1” dbh @2000/ac, bristly clubmoss, alpine enchanters nightshade

Site 1. FPn63 canopy over a wind created gap, SE of Stand 276; tamarack/b spruce

FPn63 ground cover included cedar 0-1”dbh @3500/ac, paper birch 0-1”dbh @250/ac, red raspberry, sphagnum and sedges

White Cedar Plant Community Restoration Workshop

June 24, 2014

8:00 am to 3:30 pm

St. Mary's Church, Meadowlands, MN

OR

June 25, 2014

8:00 am to 3:30 pm

Big Bog State Park, Waskish, MN,

Workshop Agenda

Morning

- **Introduction and Project Overview**, *Dale Krystosek, BWSR*
- **Description of Demonstration Sites,** *Jerry Stensing, BWSR*
- **White Cedar Research Presentation**, *Dr. Rodney Chimner, Michigan Tech University and Rose Schwartz, Graduate Student*
- **White Cedar Restoration Sites,** *Harvey Tjader, DNR*
- **Phase II Review,** *Dale Krystosek, BWSR*
- **Hydrologic Restoration for White Cedar Communities**, *Dr. Erv Bergland, DNR*

Afternoon

- **White Cedar Restoration Site Visits (busing provided)**

To Register: *Visit the BWSR website*

http://www.bwsr.state.mn.us/training/index.html

Registration fee of $25 includes lunch. Due to bus size, registration is limited to 50 individuals per session.

Workshop Description

Northern white cedar, (*Thuja occidentalis)* is an icon of Minnesota's northern forests. Unfortunately, the species has been declining in Minnesota for decades. The extensive influence of white cedar swamps on northern forest ecosystems has made these communities a high priority for BWSR, the DNR and the University of Minnesota Natural Resource Research Institute. Join us for a one day workshop to learn about the preparation and vegetation restoration techniques being used to restore Northern White Cedar wetland communities in Minnesota. This workshop will introduce participants to the range of factors being investigated through the restoration project, provide an update on the findings to date, and allow for discussion of the questions that remain to be answered.

Minnesota Board of Water & Soil Resources

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Minnesota DEPARTMENT OF NATURAL RESOURCES

Attachment 7
White Cedar Training Sessions

Dr. Rodney Chimner, project consultant lectures on white cedar ecology at the Meadowland, MN training session on June 24, 2014 training session.

The Meadowlands session was attended by staff from county land departments, Soil and Water Conservation Districts, Department of Natural Resources and private consultants.

White cedar workshop participants tour white cedar restoration site in St. Louis County.

Rose Schwartz, graduate student at Michigan Technological University collects groundwater data from monitoring well at one of the St. Louis county white cedar restoration demonstration sites.

Dr. Chimner answers questions from workshop participants at June 24th session in St. Louis County.

Videographer (center, background) captured video of training workshop and tour on June 24th.

Mature white cedar roots exposed due to nearby drainage ditch which caused the peat soils to subside.

Harvey Tjader, DNR Forest Ecologist (left) provided information on how white cedar fits into the DNR's Ecological Classification System.

Example of white cedar seedling protected from browsing by mammals by rigid tree protector (left) and blue flag iris is part of the understory in this white cedar plant community.

Dr. Irv Berglund (right), retired DNR staff and Dr. Rodney Chimner examine peat soils in this white cedar plant community.

Attachment 8 A – Northeast Minnesota White Cedar Plant Community Restoration
Dr. Chimner's Training Presentation

Northeast Minnesota White Cedar Plant Community Restoration:Results from Phase I

Rod A. Chimner and Rose Schwartz
School of Forest Resources
and Environmental Science
Michigan Technological University

MichiganTech

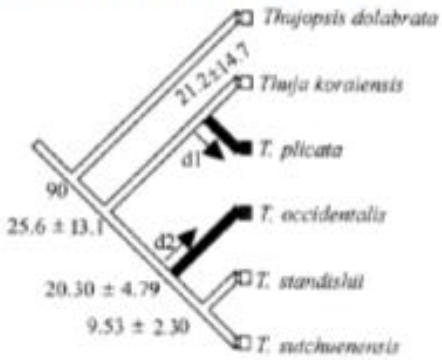
Northern white-cedar

Cupressaceae (*Thuja occidentalis*) L.

- The genus *Thuja* contains about 5 species world-wide native to North America [2] (*T. plicata* and *occidentalis*) and Asia [3] (Japan and China).
- Related to cypress, redwoods, sequoia, western red cedar, fitzroya, juniper, but not cedars (*Cedrus*).
- There are no recognized subspecies, varieties, or forms.
- Arborvitae "tree of life" A awful-tasting tea of cedar reportedly cured early European explorers of scurvy, perhaps, because of a high vitamin C content.

northern white-cedar Cupressaceae (*Thuja occidentalis*) L.

- *Thuja* is an E. Asia - N.A. disjunct species.
- *Thuja* is an old genus (~25 mya)
- *Thuja* originated in Asia and dispersed to NA twice.
  - 1st time 21 mya to Western NA
  - 2nd time 20 mya to Eastern NA



Area:
540,000 ha in MI
(2,085 sq miles)

370,000 ha in UP
(1,429 sq miles)

Importance and Uses

The rot- and termite-resistant wood is used principally for products in contact with water and soil (e.g., fence posts, decks, saunas, furniture, singles, and homes).

It is a widely planted ornamental.

Importance

- Northern white-cedar is valuable for wildlife habitat, particularly for deeryards during severe winters for thermal cover and browse.
- White-cedar is also utilized by such mammals as the snowshoe hare, porcupine, and red squirrel. Its browse is generally rated as highly preferred by hares and is sometimes heavily utilized.

Importance

Birds common in white-cedar stands during the summer include several warblers (northern parula, black-thr… green, blackburnian, black-and-white, and magnolia), white-throated sparrows, and kinglet… The pileated woodpecker commonly excavates cavities in mature white-cedars to feed upon carpenter ants.

Issues

- There continues to be a demand for cedar, but there has been a problem regenerating cedar for over 70 years.
- Cedar is least studied commercial tree in NA
- Goal of talk is to give results of our study and provide guidelines for managing or restoring cedar.

Assessments

- A total of 81 sites were field assessed by managers in Aiken, Itasca, Koochiching counties.

Ownership	# of Stands	Total Area (ac)	% of Total
Federal	0	0	0
State	23	354.8	26.2
Private	13	291	21.5
Industry	1*	4	0.3
Tribal	0	0	0
County	46	696	51.4
Other	1	7	0.5

Overall Condition	Count	%	Restoration Priority	Count	%
Excellent	7	8.4	Very High	13	16.0
Good	45	54.2	High	10	12.3
Fair	23	27.7	Moderate	19	23.5
Poor	8	9.6	Low	39	48.1

Category	Count	%
Road	29	23.4
Forestry	11	8.9
Drainage ditch	5	4.0
Grazing	1	0.8
Animal	28	22.6
4x4	6	4.8
Recreation	9	7.3
Utilities	5	4.0
Other	3	2.4
None/Unknown	27	21.8

What you need to know to regenerate cedar

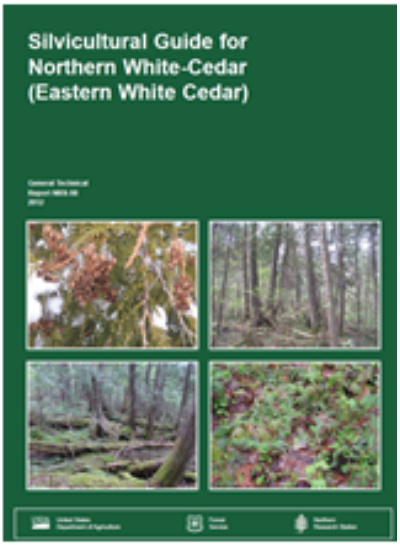
1. What type of habitat-peat, mesic, riparian…
    1. Seed source, hydrology, mycorrhizae, ect.
2. Basic cedar ecology
    1. Seed timing, cold stratified, distance, substrate
3. Hydrology
    1. Microtopography, light
4. Herbivory
    1. Fencing, tubes, snow depths

Silvicultural Guide for NW Cedar

GT Report NRS-98, 2012

1. Upland-shallow mineral soils, outcrops
2. Upland-deep, well drained
3. Lowland-deep mineral soils
4. Lowland-organic soils

*Why does this matter? Seed source, hydrology, microtopography, mycorrhizae, silvicultural and harvesting techniques, management…



State of Minnesota

Native Plant Community Classification

1) Northern Wet Cedar Forest- WFn53
2) Northern Cedar Swamp- FPn63.
3) Northern Very Wet Ash Swamp- WFn64
4) Northern Mesic Hardwood (Cedar) Forest- MHn45

Soils

- Northern white-cedar is dominant in rich swamps that have a strong flow of moderately mineral-rich soil water. The organic soil (peat) is usually moderately to well decomposed (sapric), 0.3 to 1.8 m (1 to 6 ft) thick, and often contains rotted wood **(Carbondale and Tawas Mucks)**.
- Northern white-cedar generally grows best on limestone-derived soils that are neutral or slightly alkaline and moist but well drained.
- Nevertheless, most commercial stands are in swamps, where northern white-cedar can compete well with its associates.

Table 9. Average calcium, specific conductivity and pH levels of the study site compared to Glaser et al. (1981, 1990) levels.

Peatland type	pH	Specific Cond (uS cm-1)	Calcium (mg/l)
Extremely Rich Fen	>6.8	>82	>20
Rich Fen	6.0-6.8	23-82	10-20
Poor Fen	4.3-6.0		3-10
Bog	<4.3	12-27	<3
Cedar site (Chimner 1994)	7.31	295	44.4

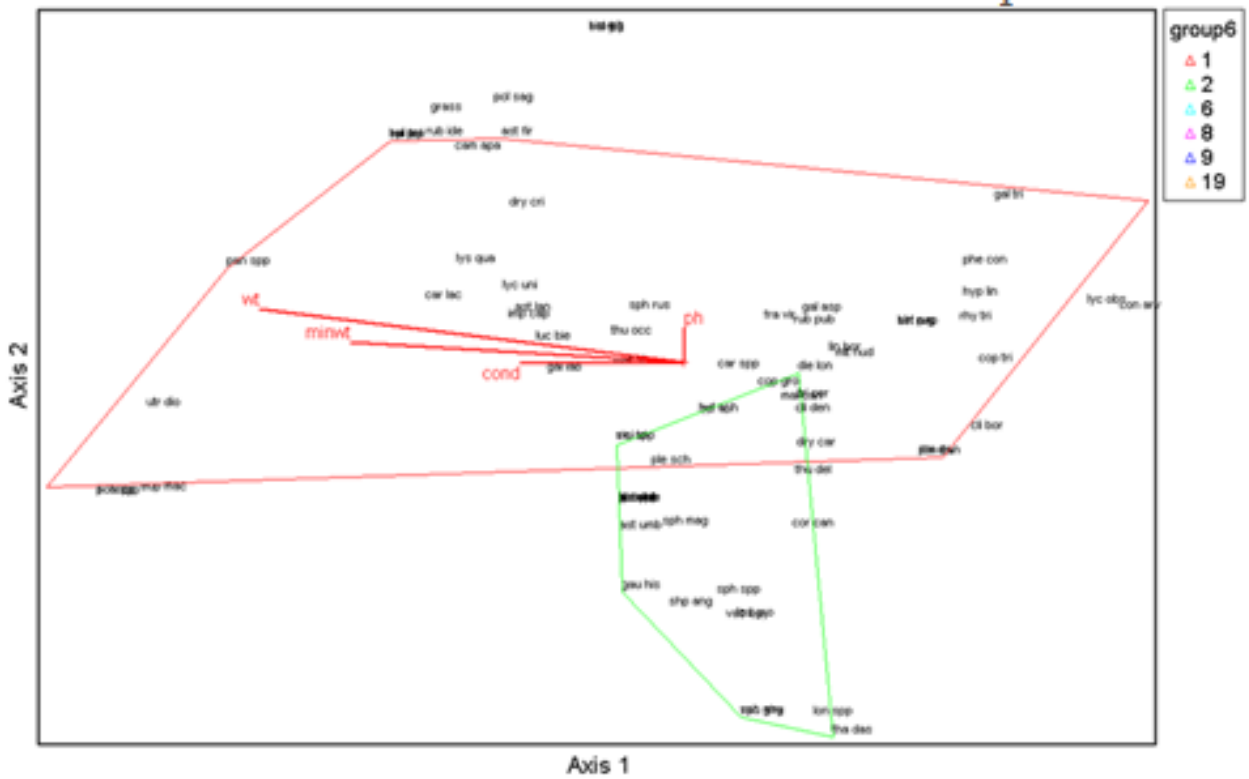
Environmental conditions of our sites

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

Site	pH	Specific Conductivity (uS cm)	Average Water Table (cm)	Minimum Water Table (cm)
#649	6.12	99	30	**80**
#664	6.97	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	6.52	107	9	**42**
#9	6.90	166	15	**60**

Initial Vegetation

- 81 vascular species
- 20 moss species



Initial Basal Area

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**

Initial Tree Density

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**

Initial Tree Regeneration

Species/	#9	#28	#117	#649	#664	#664-Ref
Size class (<137 cm)	stems/ha	stems/ha	stems/ha	stems/ha	stems/ha	stems/ha
Abies balsamea	3800				500	1200
Acer spicatum	700					
Alnus incana	1000		400			
Amelanchier sp.	700					
Aronia melanocarpa			200			
Betula pumila			300		200	
Cornus Spp				23400	4900	
Corylus cornuta			100			
Fraxinus nigra	200					
Salix sp.			3400			
Thuja occidentalis	100					3500
TOTAL	**6500**	**0**	**4400**	**23400**	**5600**	**4700**

What you need to know to regenerate cedar

1. What type of habitat-peat, mesic, riparian…
    1. Seed source, hydrology, mycorrhizae, ect.
2. Basic cedar ecology
    1. Seed timing, cold stratified, distance, substrate
3. Hydrology
    1. Microtopography, light
4. Herbivory
    1. Fencing, tubes, snow depths

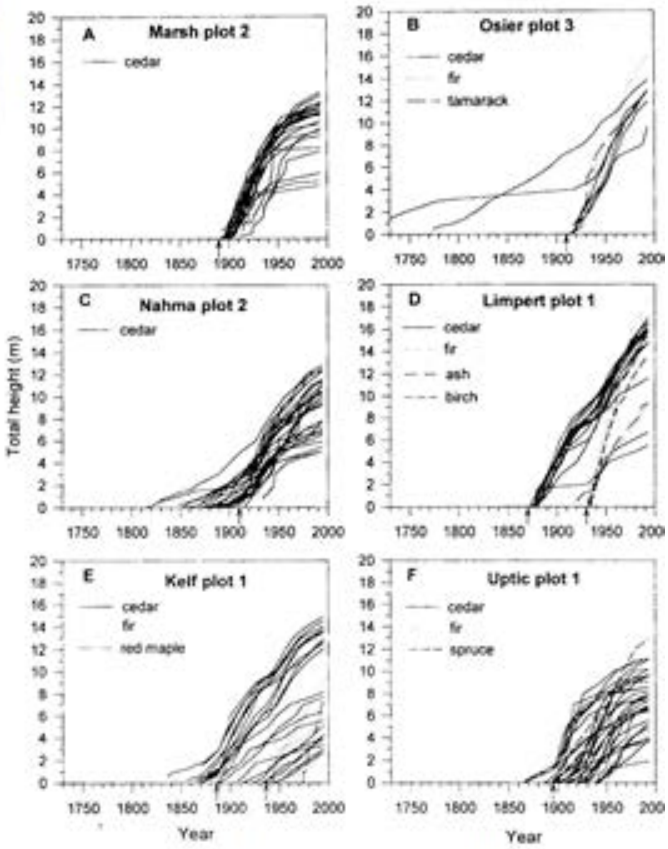
Ecology

- Cedar are shade tolerant, slow growing and long-lived pioneer trees.
  - Do not fit traditional successional models
  - Can be pioneer and climax species!
  - Maybe better to think of them as stress-tolerant, not shade tolerant (xeric-hydric)
- Very slow growing, especially in swamps
- Reproduction by vegetative and seeds
- Can reproduce in canopy gaps or stand replacing disturbances

Most of the current cedar came in after large disturbance events (logging) between 1870 and 1935. Only 3% of all cedar established after 1945.

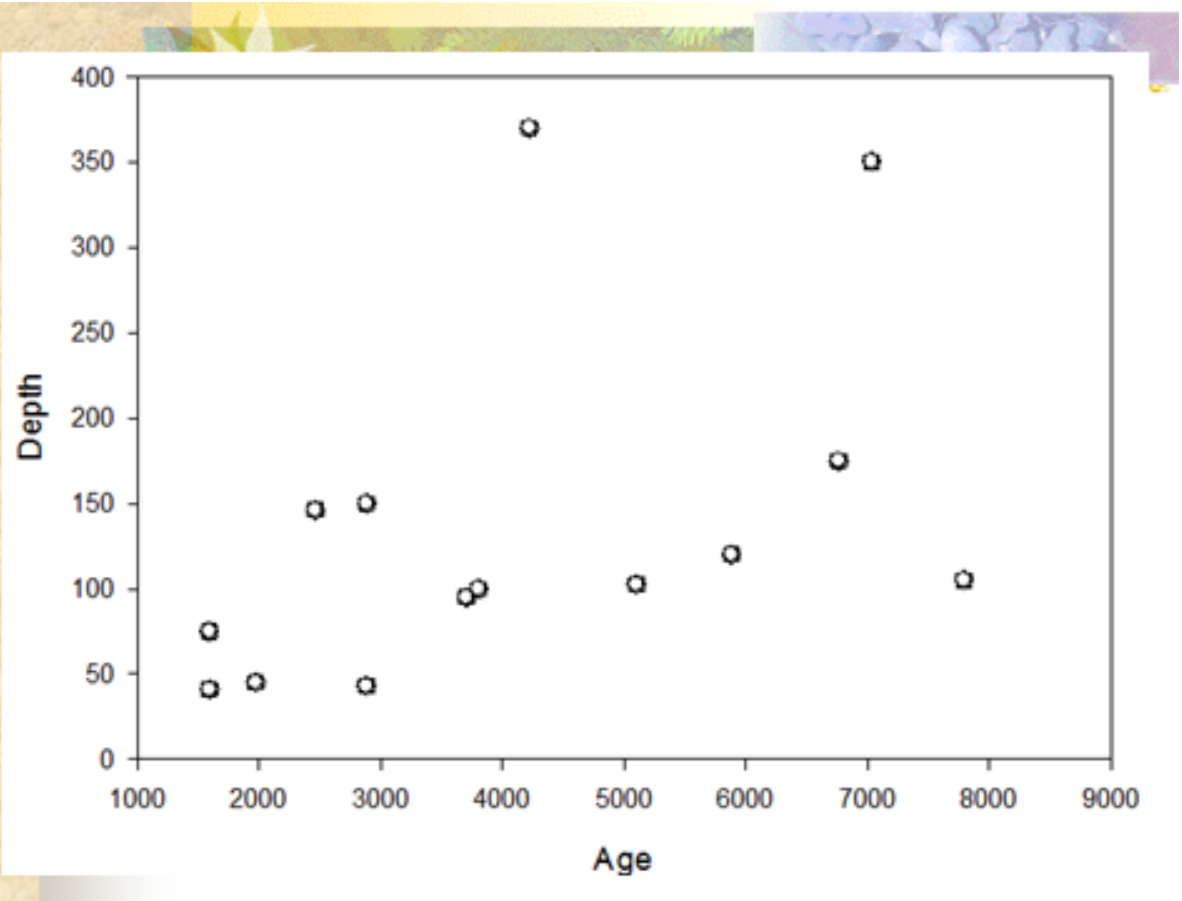
Likely disturbance released existing seedlings/saplings

What was the pre-logging forest like?



Data from Heitzman et al. 1997

How old are cedar swamps?



Vegetative Reproduction

- Northern white-cedar can send out roots from any part of a branch or stem if moisture conditions are favorable **(adventitious rooting).**
- Layering generally accounts for more than half the stems of white-cedar reproduction in northern Michigan swamps.
- Cedar also reproduce asexually by tree fall leaving a straight line of trees.

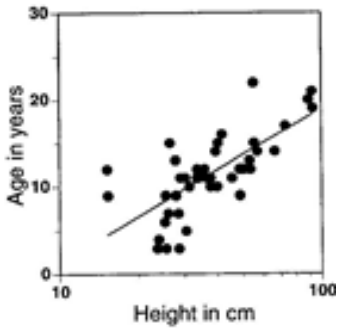
Seeds

- Seed production starts ~30 years old and is best after 75 years (60,000 to 260,000 seeds).
- Seeds have only slight internal dormancy (winter).
- Viable in the forest floor ~1 year.
- Seeds dispersal range <200', 60' optimal (wind)
- Seeds germinate readily on decayed nurselogs, decayed litter, peat or humus, mineral soil, and *Sphagnum* moss.
- Decayed nurselogs account for more than 70 percent of the seedlings.
- Hummocks can be very important in lowlands!
- Can have difficulties with thick feathermosses.

Results from our seeding

Seedlings

- Seedlings are very susceptible to drought
- Prefer an intermediate light level (~50 crown cover?).
- Seedling growth is slow. Annual height growth averages 3 inches (8 cm) in the first few years.
- Can withstand suppression for many year, and still respond to being released (but not always)
- Very susceptible to herbivory (>25% of foliage browsed can result in mortality)



Silvicultural Management Options

- Site Preparations: Recommended treatments include:
  - Burning (reduce moss cover, blacken soil, bare soil, pH)
  - Mechanical scarification (grind and mix soil)
  - Micro site modification (bedding, furrowing and mounding)
  - Drainage (increased aeration, but dries out soil)
  - pH and fertility adjustments
  - Light

Caveat: These methods have been poorly tested and outcomes are unknown.

Silvicultural Management Options

- Harvesting:

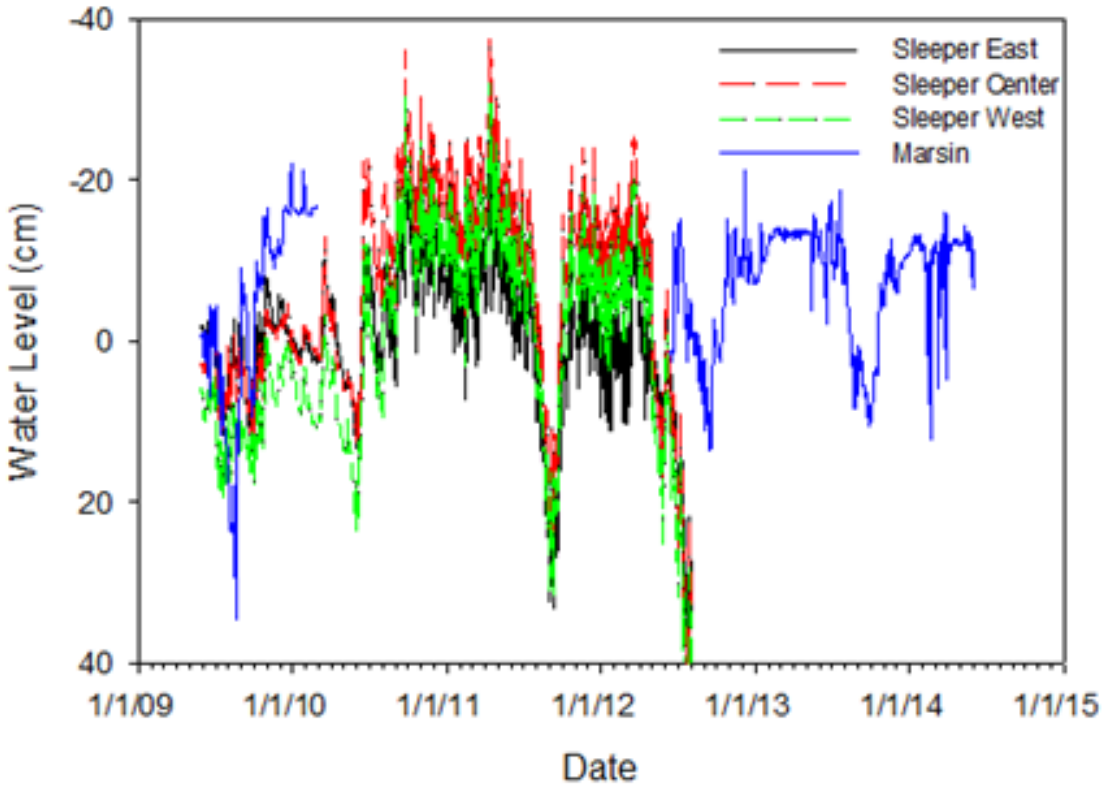
Recommended treatments include:

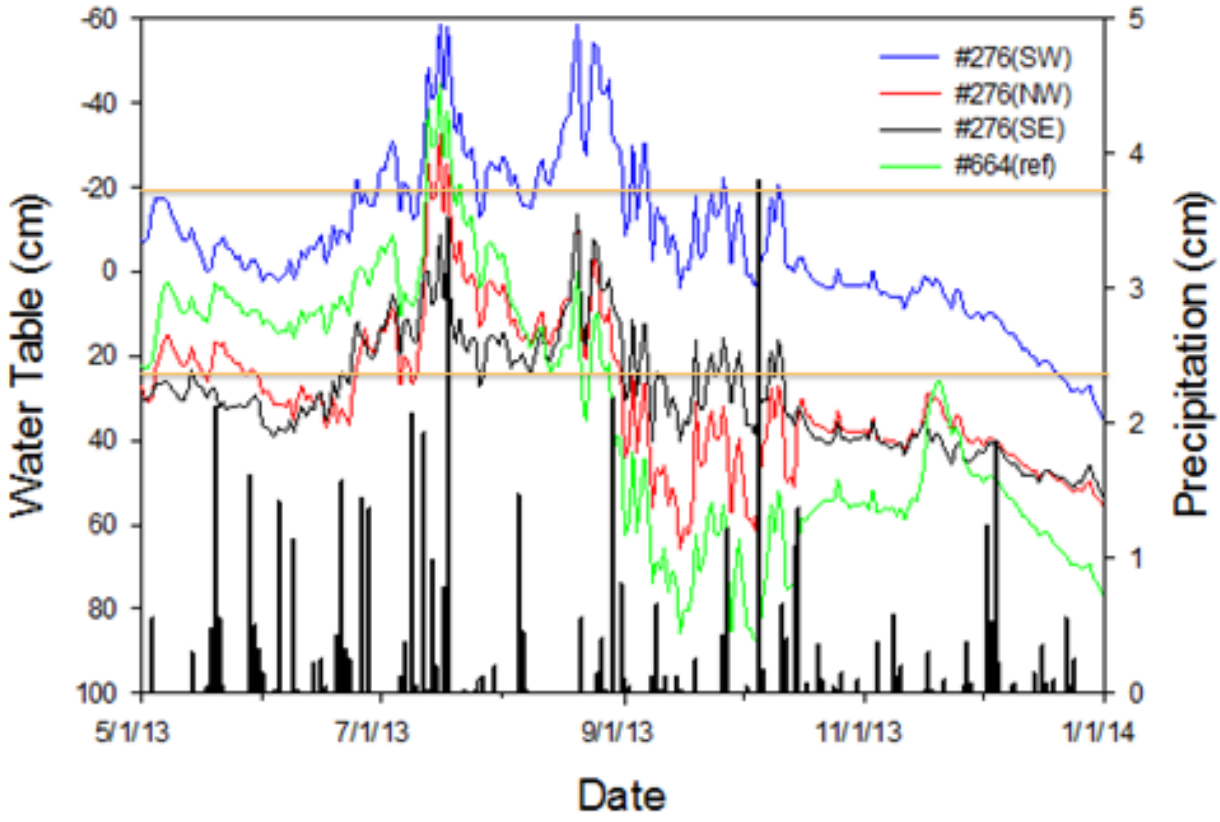
- Clearcutting
  - small blocks
  - narrow strips
  - rotating clear cuts
- Uneven age selection methods
- Partial cutting, group selection, and diameter limit cutting is discouraged in deer yards because they reduce available browse
- Thinning
- Be careful with introducing invasive species into opened canopies!

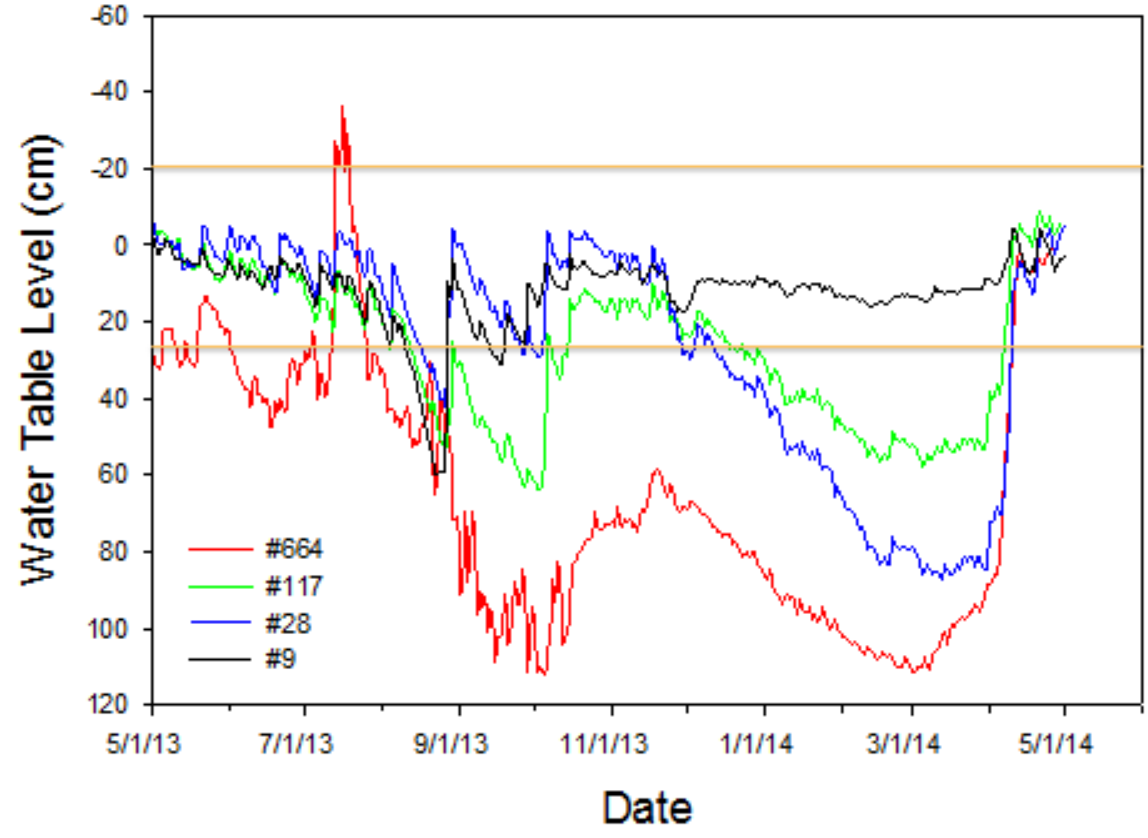
What you need to know to regenerate cedar

1. What type of habitat-peat, mesic, riparian…
    1. Seed source, hydrology, mycorrhizae, ect.
2. Basic cedar ecology
    1. Seed timing, cold stratified, distance, substrate
3. Hydrology
    1. Microtopography, light
4. Herbivory
    1. Fencing, tubes, snow depths

Reference Hydrology




Water Table (cm)
Precipitation (cm)
Date
#276(SW)
#276(NW)
#276(SE)
#664(ref)
-60
-40
-20
0
20
40
60
80
100
5
4
3
2
1
0
5/1/13
7/1/13
9/1/13
11/1/13
1/1/14


Water Table Level (cm)
Date
#664
#117
#28
#9
-60
-40
-20
0
20
40
60
80
100
120
5/1/13
7/1/13
9/1/13
11/1/13
1/1/14
3/1/14
5/1/14

Beltrami County Sites-#276


How do you restore hydrology?

Microtopography

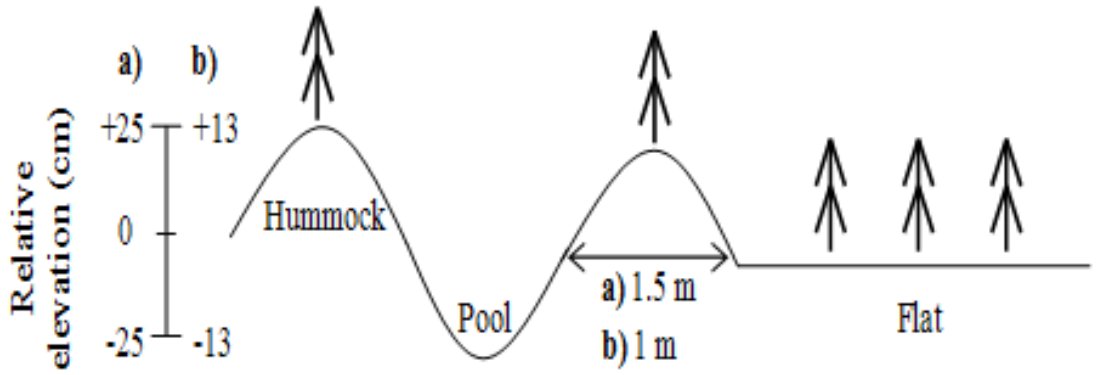
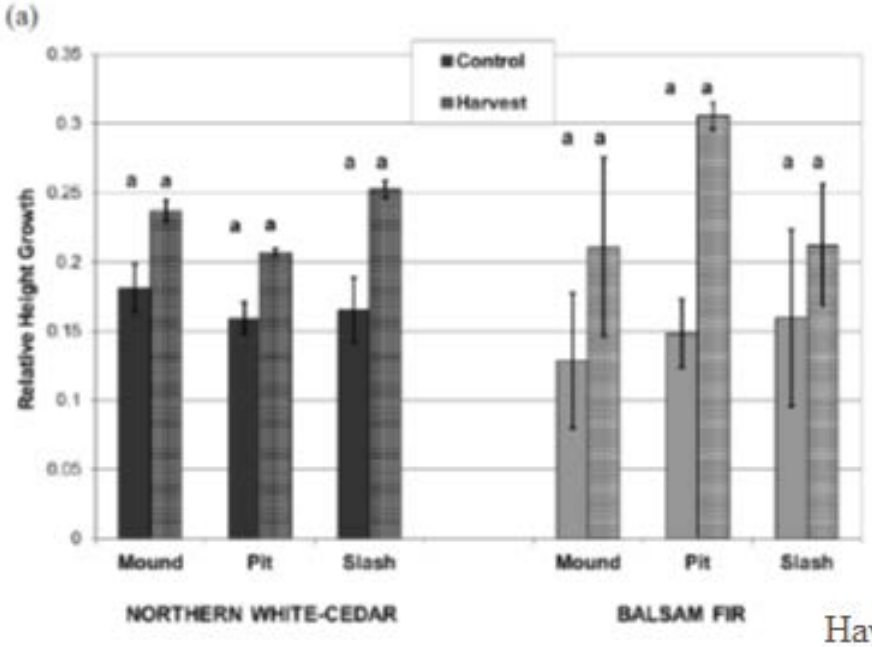
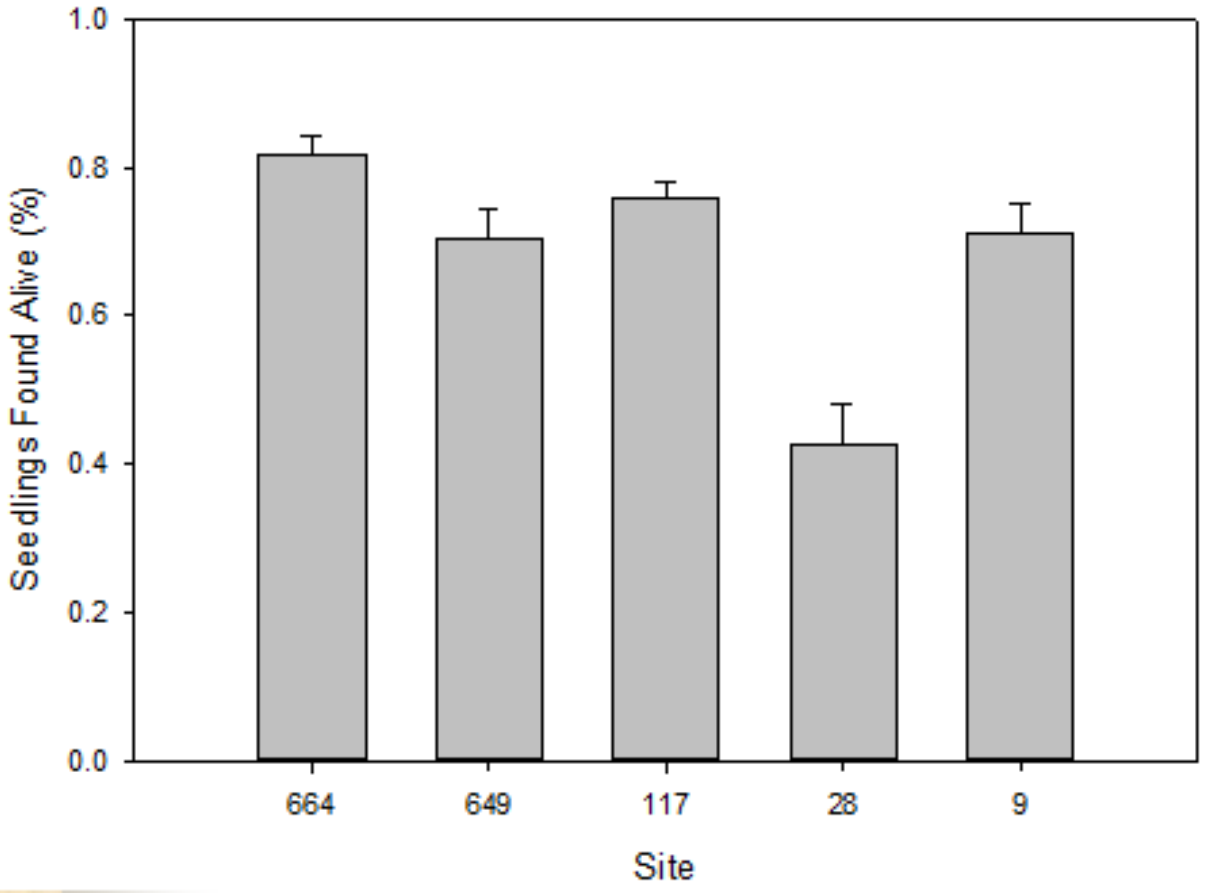
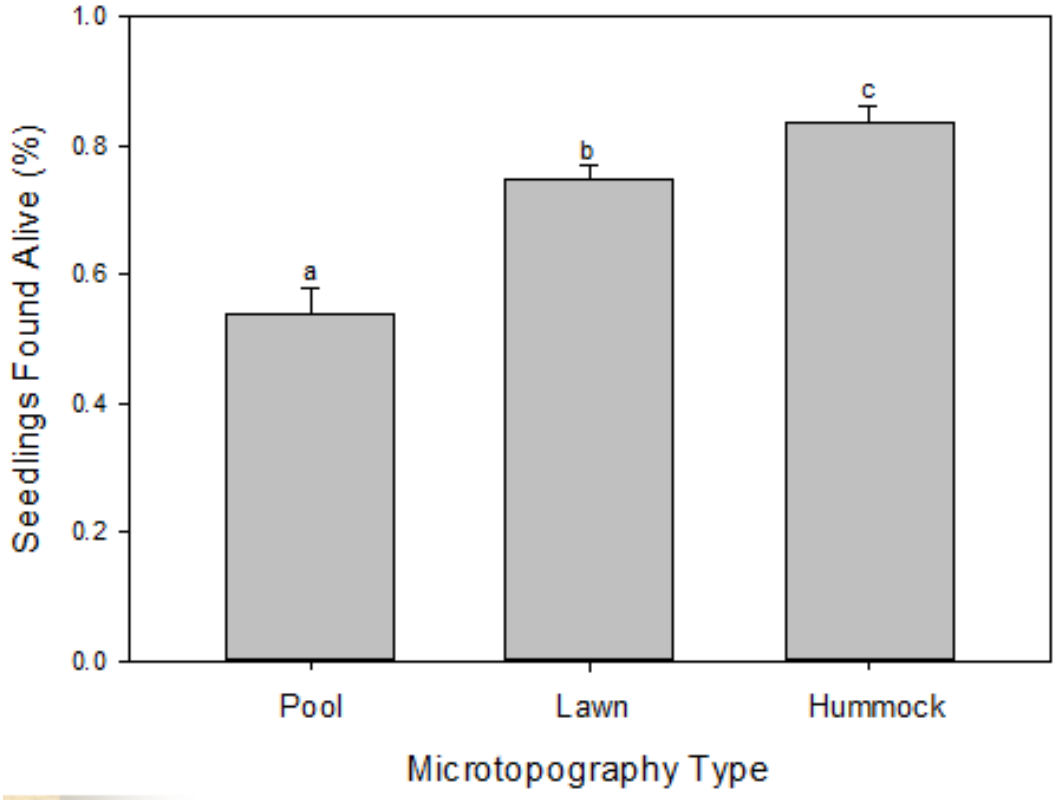


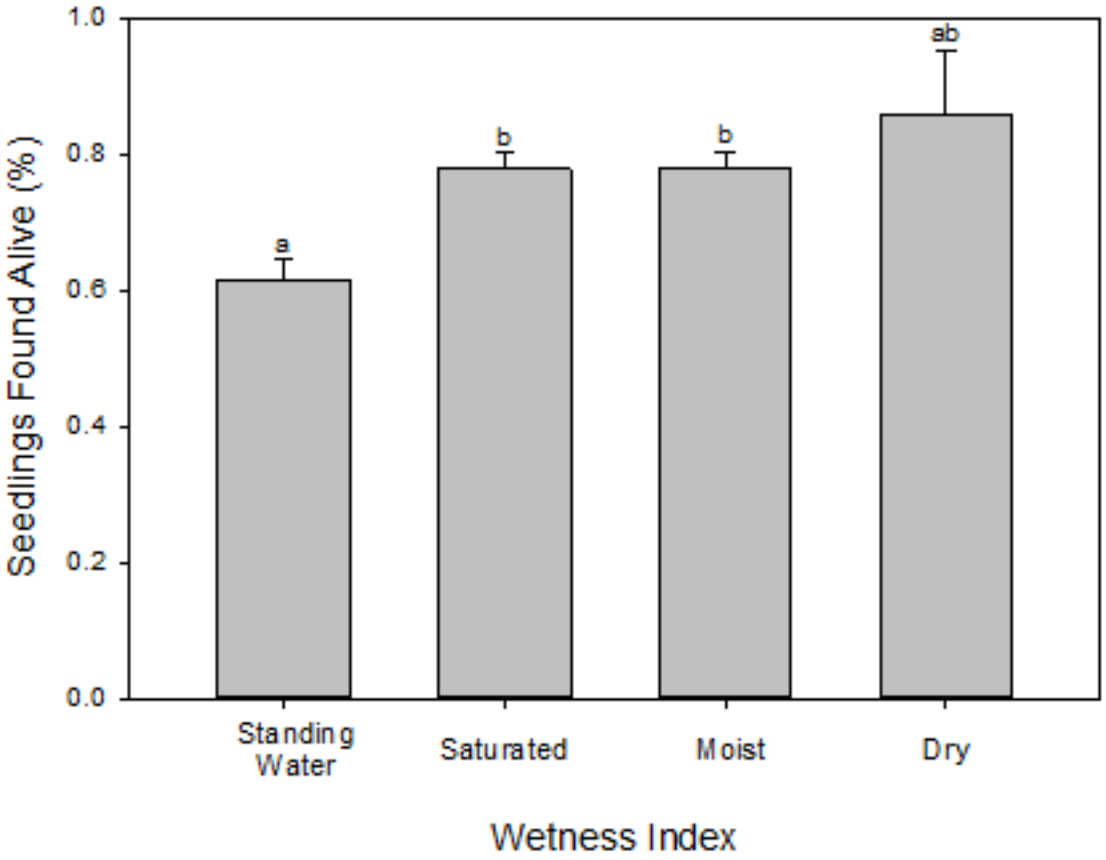
Figure 2.8. Control vs. Harvest comparison after four years in the field of northern white-cedar and balsam fir seedling growth in overstory x microsite interactions for (a) relative height growth and (b) relative diameter growth. Tukey's HSD test for means was performed between columns; means with the same letter (A,B; a,b) are not significantly different (n = 2 or 3, α = 0.05).



Haworth 2011


1.0
0.8
0.6
0.4
0.2
0.0
Seedlings Found Alive (%)
664
649
117
28
9
Site


1.0
0.8
0.6
0.4
0.2
0.0
Seedlings Found Alive (%)
a
b
c
Pool
Lawn
Hummock
Microtopography Type



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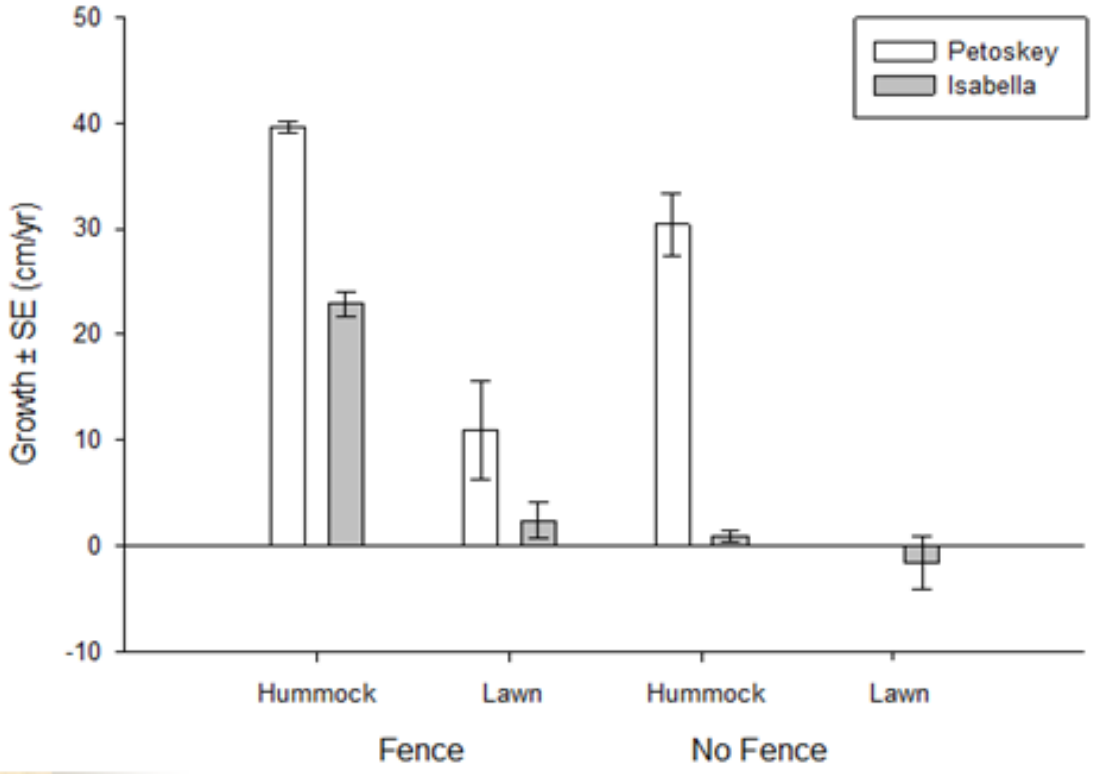
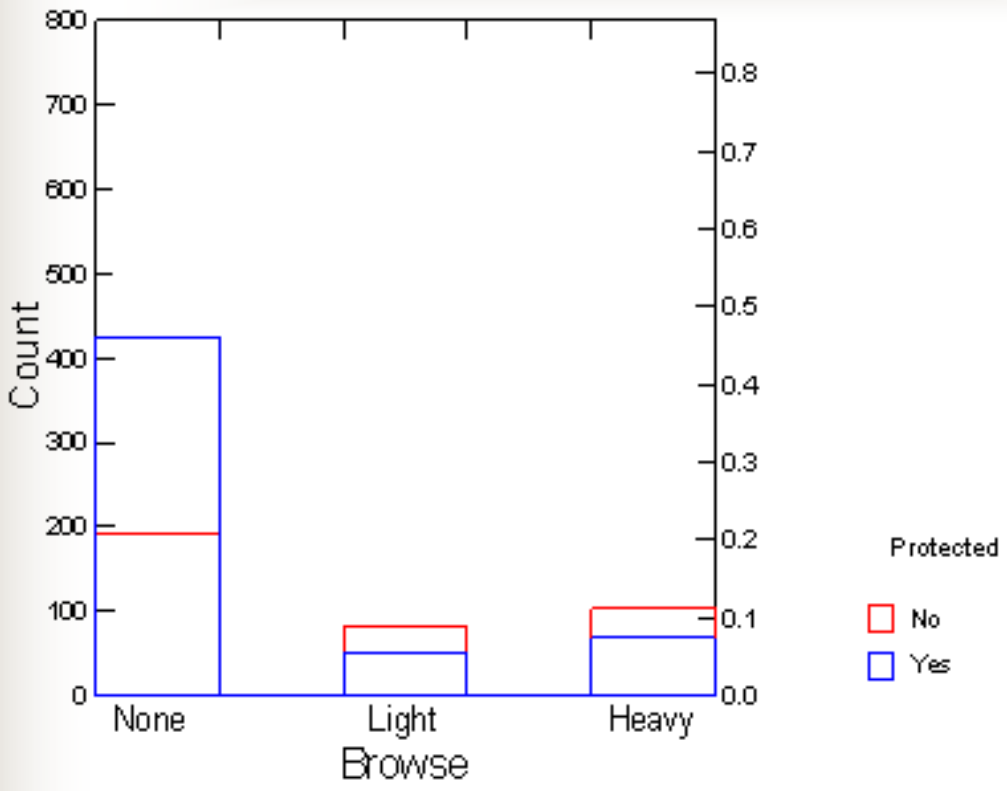
    1. Microtopography, light
4. Herbivory
    1. Fencing, tubes, snow depths



Management Options

- Wildlife Control: Recommended treatments include:
  - Exclosures
    - Large
    - Single tree
  - Lure animals away by feeding
  - Reduce populations
  - Introduce predators

Herbivory



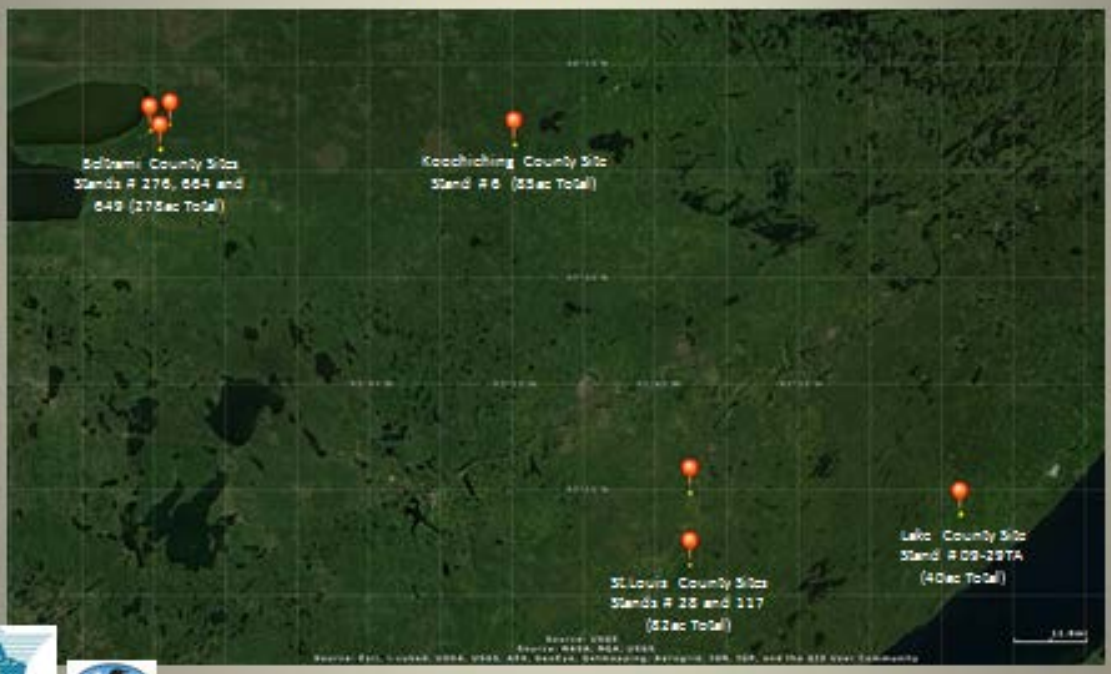
Summary

1. Hydrology is important to cedar swamps
2. Direct seeding maybe successful in some cases
3. In areas of high herbivory, cedar must be protected if planted or natural regeneration
4. Site preparation may increase cedar regeneration is some instances
5. Plantings may be successful
6. Stay tuned…..

Attachment 9 – Northeast Minnesota White Cedar Plant Community Restoration
Plant Materials – Restoration Process *(presentation at training session)*

Northeast Minnesota White Cedar Plant Community Restoration Project

DEMONSTRATION SITES



Purpose

Demonstrate various methods of tree establishment.

Demonstrate various methods of tree protection.

Demonstrate protected tree survival vs. unprotected tree survival

Demonstrate effects of shade in cedar development.

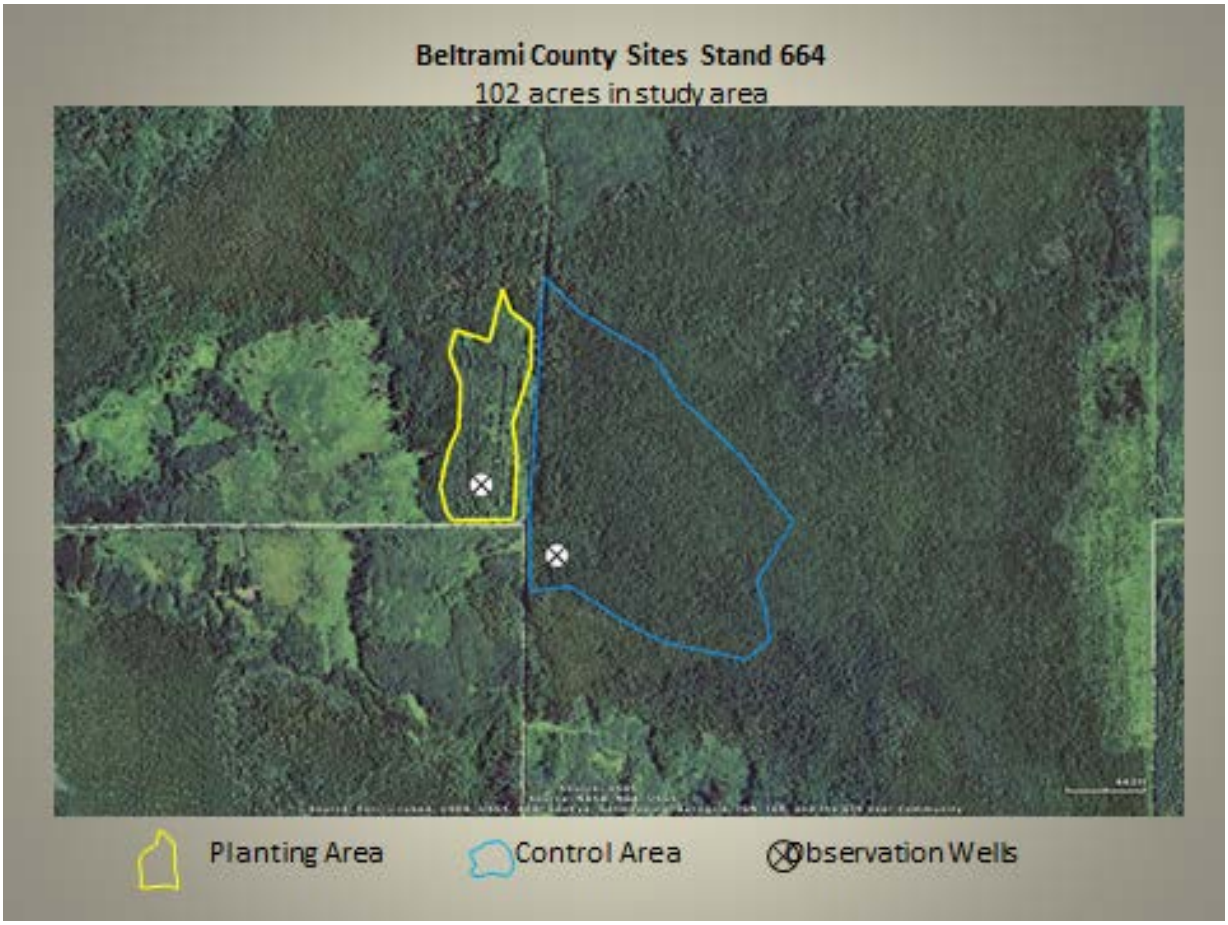
General Goals

Determine effects of hydrologic conditions on regeneration.

Determine effectiveness of tree protection to enable recruitment.

Provide resource managers with information to assist in cedar management.


2012/09/12


Beltrami County Sites Stand 664
102 acres in study area
Planting Area
Control Area
Observation Wells

Seeding

Cedar seeding was performed by hand broadcast and spot application.
Spot application targeted desired seed beds.

Seeding

The seed was gathered at the State Tree Nursery -70% germination rate.
It was like seeding with confetti.

Seeding

Natural regeneration was noted on old stumps and in mossy areas.

Seeding

Spot application of seed targeted locations containing moss.

Plant Materials

Trees were lifted at the nursery on May 21 and shipped on May 30.
The boxes were intercepted at the terminal, cold-tarped and transported to cold storage.
All trees were planted by June 5, and all seedling was completed by June 16.

Plant Materials

The plants were healthy and vigorous.

Plant Materials

The transplants had especially well-developed root systems.

Plant Materials

Nominal root pruning.

Plant Materials

Root pruned, dipped in terrasorb solution, packed in tub with moss-lined bottom, then tops rinsed to remove dirt.

Plant Materials

Thermal cold-tarp covers the load during transport to prevent wind damage.

Plant Materials

Prepped trees arrive at the planting site, are moved to a protected location on-site, and then the planters will "bag-up".

Plant Materials

Prerequisites of a good bag site include shelter from wind and sun, a central location, -

Plant Materials

and a good "sitting log".

Planting

Sharp-shooter planting spade opens a 16-inch deep hole.

Planting

Roots are gently pushed to the bottom, the plant is pulled-up to the correct depth -

Planting

A "dibble" is performed to close first the bottom of the hole, then the top -

Planting

Then a final pack removes any air pockets.

Protection

A percentage of seedlings are protected by installation of rigid protectors.

Protection

Rigid protectors.

Protection

A percentage of transplants are protected by 32-inch diameter wire mesh enclosures.

Protection

A percentage of both seedlings and transplants are left un-protected.

Protection

Demonstration site #117. Site prepped, planted, seeded and protected. Note groundwater observation well.

Education

International Society of Wetland Scientists field visit to demonstration site #28 two days after installation.

White Cedar Plant Community Restoration Workshop
June 24, 2014 Meadowlands, MN/June 25, 2014 Waskish, MN

First Name	Last Name	Organization	Email Address	Phone
Jeff	Anderson	MSA Professional Services	jkanderson@msa-ps.com	(218) 722-3915
Jon	Bergstrand	MnDOT	jon.bergstrand@state.mn.us	218-725-2715
Greg	Bernu	Carlton County	greg.bernu@co.carlton.mn.us	218.384.9179
Tom	Bodell	Lake County Forestry	tom.bodell@co.lake.mn.us	218-834-8340
R. C.	Boheim	South St. Louis SWCD	rc.boheim@southstlouisswcd.org	218-723-4629
Clark	Christenson	Christenson Forestry Consulting, Inc.	christensonforestry@gmail.com	218-464-0363
Anthony	DeMars	Cross River Consulting, LLC	tony@crossriv.com	612-360-0928
Katherine	Disterhaft	NTS	kdisterhaft@netechnical.com	715-340-7340
Jenny	Gieseke	BWSR	jenny.gieseke@state.mn.us	507-276-5119
Richard	Gitar	Fond du Lac Reservation - Office of Water Protection	richardgitar@fdlrez.com	218-878-7122
Shannon	Kesner	Fond du Lac Reservation	shannonkesner@fdlrez.com	218-878-7157
Andy	Kett	MN DNR	andy.kett@state.mn.us	320-592-3248
Brandon	Knopf	MN DNR	brandon.knopf@state.mn.us	218-927-4040 EXT 237
Allyz	Kramer	SEH	akramer@sehinc.com	218.279.3011
Lonnie	Lilly	DNR Forestry	lonnie.lilly@state.mn.us	218-999-7839
Bryan	Lueth	MN DNR Wildlife	bryan.lueth@state.mn.us	651-259-5190
Justin	Mayne	Lake County Forestry	justin.mayne@co.lake.mn.us	218-353-7763
Mark	Pannkuk	St. Louis County Land and Minerals Department	pannkukm@stlouiscountymn.gov	218-625-3700
Lynda	Peterson	BWSR	lynda.peterson@state.mn.us	218-723-4607
Robert	Peterson	LBG	rob.peterson@lbgmn.com	218-206-1418
Robin	Poppe	Pine SWCD	robin.poppe@co.pine.mn.us	320-216-4243
Jodie	Provost	MN DNR - Wildlife	jodie.provost@state.mn.us	218-927-2982 x249
Robert	Rother	Itasca County Land Dept.	robert.rother@co.itasca.mn.us	218-327-7395
Dave	Skurla	St. Louis County Land and Minerals Department	skurlad@stlouiscountymn.gov	218-742-9898
Kelly	Smith	Carlton SWCD	kelly.smith@carltonswcd.org	218-384-3891
Clarissa	Spicer	MN DNR	clarissa.spicer@state.mn.us	218-999-7838
Jessica	VanDuyn	MN DNR	jessica.vanduyn@state.mn.us	218-780-7668
Derek	Wagner	MN DNR	derek.wagner@state.mn.us	218-426-3407

White Cedar Plant Community Restoration Workshop
June 24, 2014 Meadowlands, MN/June 25, 2014 Waskish, MN

Mark	Westphal	Carlton County Land Department	mark.westphal@co.carlton.mn.us	218-384*9179
Natalie	White	SEH	nwhite@sehinc.com	218-279-3003
Kevin	Woizeschke	MNDNR	kevin.woizeschke@state.mn.us	218-833-8729
Daren	Wysocki	MN DNR	daren.wysocki@state.mn.us	218-927-4040 EXT 244
Rose	Schwartz	Michigan Tech University	roses@mtu.edu	
Rod	Chimner	Michigan Tech University	rchimner@mtu.edu	
Rick	Dahlman	DNR Division of Forestry (retired)	rdahlman47@gmail.com	
Dale	Krystosek	Board of Water and Soil Resources	dale.krystosek@state.mn.us	
Jerry	Stensing	Board of Water and Soil Resources	jerry.stensing@state.mn.us	
Kurt	Johnson	U of M, Duluth, NRRI	kjohnson@nrri.umn.edu	
Irv	Berglund	DNR, Division of Waters (retired)		

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Dj	Bakken	Beltrami County	dj.bakken@co.beltrami.mn.us	218-333-8413
Cassandra	Baysal	MNDNR-Forestry Warroad	cassandra.baysal@state.mn.us	218/386-1304
Chris	Bergquist	Koochiching County	christopher.bergquist@co.koochiching.mn.us	218-324-1728
Ed	Clem	Becker SWCD	ejclem@co.becker.mn.us	218-234-8709
Ryan	Heinen	BWSR	ryan.heinen@state.mn.us	218-239-0222
Nicholas	Jensen	MN DNR	nicholas.jensen@state.mn.us	218-308-2636
Samantha	Jones	Beltrami County	samantha.jones@co.beltrami.mn.us	218-333-4210
Blane	Klemek	Minnesota DNR	blane.klemek@state.mn.us	218-308-2674
Glen	Laginess	DNR Forestry	glen.laginess@state.mn.us	(218) 835-3165
Scott	Laudenslager	MN DNR Wildlife	scott.laudenslager@state.mn.us	(218) 634-1705 ext. 231
Doug	Norris	Minnesota Dept. Natural Resources	doug.norris@state.mn.us	651-259-5125
Claire	Olson	Becker SWCD	claire.olson16@gmail.com	218-850-4319
Justin	Pitt	MN DNR - Wildlife	justin.pitt@state.mn.us	218-308-2337
Kathy	Rasch	Clearwater SWCD	kathy.rasch@mn.nacdnet.net	218-694-6845 ext 4
Nick	Ronning	Koochiching County Lands & Forestry	nick.ronning@co.koochiching.mn.us	218-897-5535
Brandon	Schad	MN Department of Natural Resources	brandon.schad@state.mn.us	218-634-1705 x 232
Chad	Severts	BWSR	chad.severts@state.mn.us	218-755-2671
Dan	Shaw	BWSR	dan.shaw@state.mn.us	651-296-0644
Erik	Stoddard	MNDNR-Forestry Warroad	erik.stoddard@state.mn.us	218/386-1304
Josh	Stromlund	Lake of the Woods County	josh_s@co.lake-of-the-woods.mn.us	218-634-1945
Charlie	Tucker	MNDNR	charles.tucker@state.mn.us	218-783-6861
Angela	Yuska	MN DNR Forestry	angela.yuska@state.mn.us	218-276-2237
Rose	Schwartz	Michigan Tech University	roses@mtu.edu	
Rod	Chimner	Michigan Tech University	rchimner@mtu.edu	
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Jerry	Stensing	Board of Water and Soil Resources	jerry.stensing@state.mn.us	
Irv	Berglund	DNR, Division of Waters (retired)		

BWSR and partners restore white cedar in northern Minnesota

December 2013 Snapshots

Close your eyes and picture northern Minnesota. Do images of pristine lakes, abundant forests, white tailed deer, black bear and bobcats come to mind? It is that very picture that the Board of Water and Soil Resources (BWSR) is working to protect through a recent project spanning Beltrami, Koochiching, Lake, Aitkin, Itasca and St. Louis counties.

Society of Wetland Scientists members visit a white cedar demonstration site in St. Louis County.

Northern white cedar, (*Thuja occidentalis)* is one of the icons of northern forests. Unfortunately, the species has been declining in Minnesota for decades. These trees can grow to a height of 25-50 feet, and live for hundreds of years. In addition to being found in wetland communities in northern Minnesota, it is also a native tree to the northeastern United States and southeastern Canada. Cedar is valued throughout its range for its rot-resistant wood and high-quality wildlife habitat.

> *"Northern white cedar is so important for many species, its decline will likely decrease biodiversity and habitat on a landscape scale."*
> Dr. Rodney Chimner

White cedar forests play a vital role in keeping northern wetland communities healthy. These ecosystems help maintain cold groundwater for trout streams and provide important wildlife habitat for black bear, fisher, marten, and numerous song birds such as winter wrens, Swainson's thrush, and Blackburnian warblers. Dr. Rodney Chimner, a project consultant and cedar expert explains "white cedar swamps contain over eighty animal species and provide important habitat for wintering white-tailed deer. The understory in natural northern white-cedar swamps is also noted for its diversity of herbaceous vegetation and bryophytes, including orchids and other rare plants."

The Leaves of a White Cedar

The extensive influence of white cedar swamps on northern forest ecosystems has made these communities a high priority for BWSR and our partners. BWSR, the DNR and the University of Minnesota Natural Resource Research Institute are partnering with several local counties and soil and water conservation districts (SWCDs) to reverse the decline of northern white cedar wetland plant communities in Minnesota.

With funding provided through the Environment and Natural Resources Trust Fund, this group is working on a project to restore northern white cedar through site preparation and vegetation restoration techniques.

Dale Krystosek, BWSR Wetland Special Project Lead, added “We are also evaluating how we can protect the white cedar plant communities from damage due to poorly designed wetland crossings for roads and trails.”

Pam Tomevi, Koochiching SWCD District Manager, recognizes the importance of the white cedar community in a county that is nearly three-fourths wetland. “White cedar is obviously conducive to our area – it’s a wet grower, struggling to regenerate on its own,” Tomevi said. “Koochiching County is very forested, and since forestry and clean water go hand in hand, this project fits into a multitude of goals identified in our water plan.” In addition, Tomevi appreciates how the project fosters great partnership and a shared goal between local SWCDs, counties and the state.

White Cedar Community in St. Louis County

Since the project began in 2011, the project team has finalized plans for establishment of seven demonstration sites. These sites are located in Beltrami County, Koochiching County, St. Louis County and Lake County, and cover 485 acres in area. Restoration and site preparation plans or monitoring plans have been implemented for each of the sites. The Minnesota Conservation Corps has already completed restoration work including site preparation, tree planting, white cedar seeding and the installation of tree protectors (to prevent deer browsing damage) on several of the sites.

The way Dale Krystosek sees it, “This project will provide valuable knowledge about how to best restore and protect northern white cedar plant communities, and will result in benefits to wildlife habitat, water quality as well as the restoration and preservation of an important ecosystem”.

The Legislative-Citizen Commission on Minnesota’s Resources agrees. Earlier this year, BWSR made a second proposal to the LCCMR and the project was selected for a funding recommendation to the 2014 Minnesota Legislature.

SCIENTISTS SEARCH FOR cedar sprouts

Individuals and agencies in the state are working to solve the mysteries of cedar tree reproduction. Young cedar trees have a difficult time getting started and surviving.

Photos courtesy of Dale Krystosek

By Nick Ronning
Contributing Writer

White cedar (Thuja occidentalis) might be the least-studied commercial tree species on the continent. Despite cedar's high economic value when turned into anything from lumber for boats or saunas to carved decoys or even just as fence posts, foresters across the state don't have a lot of answers when it comes to reliably regrowing cedar stands after harvest.

Cedar wetlands, also known as swamps, are some of the most ecologically rich types of forest and provide critical winter cover and browse for white-tailed deer and habitat for 79 other animals such as snowshoe hares, bobcats, black bears, fishers, martens, and numerous songbirds.

In 2004, a collaboration called the White Cedar Working Group reported a 15 percent decline in Minnesota cedar over a 12-year period. Anecdotally, it's widely known that young cedar trees have a hard time getting started and surviving. In most areas, cedar regeneration is so rare that researchers have essentially found no evidence of positive regeneration since the 1930s or 40s.

For these reasons, the Board of Water and Soil Resources spearheaded a grant request to the Legislative-Citizen Commission on Minnesota Resources, which approved the proposal and funded it through the Environment and Natural Resources Trust Fund.

Dubbed the Northeast Minnesota White Cedar Restoration Project, experts and interested parties from the University of Minnesota's Natural Resources Research Institute, DNR, Michigan Technological University, and several county Soil and Water Conservation Districts are working together to solve the mysteries of cedar reproduction.

"Ditching and deer browse appear to be two of the biggest problems, but we don't have all the answers yet. That's why we were fortunate to get funding for phase two of the project," said Dale Krystosek, wetlands special project lead for BWSR and Northeast Minnesota White Cedar Restoration Project manager.

CEDAR

(From Page 22)

reason, the Cedar Restoration Project has reached out to the Minnesota Department of Transportation and county highway engineers in order to look at hydrological restoration potential and ways to minimize hydrological impacts on future projects. So far, the transportation crowd has been supportive of the efforts and the second phase looks to ramp up this outreach.

Second to altered hydrology in the ecosystem, herbivory is the next major hurdle. White cedar can withstand a foliage loss of only 25 percent per year and maintain any hope of survival. Cedar browse is like candy to deer and snowshoe hares, so a little taste is just never enough.

The study was funded in 2011, and the first phase of field work was completed in 2013. Seven demonstration sites were identified throughout the northeastern part of the state and various combinations of management have already taken place. In some instances altered hydrology was restored to natural conditions. On most sites, the Minnesota Conservation Corps was contracted to plant cedar seeds or seedlings. Some sites went through various forms of site preparation, such as leveling or hummock construction.

This summer, researchers will be monitoring the demonstration sites to see how well the cedar is growing. Funding has been secured for only the next three years, but NRRI and MTU have committed to long-term monitoring. The present schedule includes site checks in 2014, 2016, 2018, and 2023.

Despite the major challenges over much of the cedar range, all is not doom and gloom. Parts of Koochiching and northern Beltrami counties have strong cedar stands with good regeneration.

"In the Boundary Waters, I've seen good regeneration, but there are very little hydrologic impacts and lower deer densities," Krystosek said.

Many previous attempts to figure out cedar regeneration have attacked the question from a silvicultural, or forestry, angle. However, the current thinking is that cedar decline is more of a hydrological issue. In the early 1900s, there was a massive effort to ditch and drain forested wetlands in northern Minnesota. Beltrami County alone has more than 1,500 miles of ditches in peat lands.

The motivation was twofold: some people believed the land could be farmed and some foresters believed controlled drainage could boost timber yields. In some cases, both may have been partially correct, but overall, the ditches probably caused more damage than improvement.

The ditches cause dramatic, immediate lowering of the water table, just as was intended. Air replaced water in the soil pores and the soil temperature got warmer. In some cases there was direct tree mortality, but even where the cedars survived, the change in hydrology eliminated the reproduction potential for cedars.

"One thing we know for sure is that white cedar is sensitive to changes in groundwater. If you're messing that up with roads or ditches, you may get germination (of cedar seeds) but it may be short lived if the site is too dry," Krystosek said. "Old stands may appear to be doing well, but there may not be any regeneration, which obviously isn't sustainable."

Where ditches are necessary – such as adjacent to public roads – the hydrology still has been altered. For this

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