The Ecology and Management of Atlantic White Cedar (*Chamaecyparis thyoides*)

Atlantic White Cedar Triennial Symposium June 12-14, 2012

Hilton Garden Hotel Suffolk, Virginia

Society for Ecological Restoration International – Mid-Atlantic Chapter

Society for Ecological Restoration – SER New England

Great Dismal Swamp Coalition

Virginia Department of Game & Inland Fisheries

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Field Trip Arrangements:

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Joy Greenwood, Dismal Swamp State Park

Kendall Smith, US Fish and Wildlife Service

David Norris, VA Department of Game and Inland Fisheries

Logistics:

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Symposium Agenda

Presentation titles are followed by presenter name only. Please refer to abstracts sections for full author citation.

Monday, June 11, 2012

5:00 PM to 7:00 PM	Registration desk open in lobby of Hilton Garden Inn

Tuesday, June 12, 2012

7:00 AM	Registration desk opens, located outside Kilby Ballroom
7:00 AM to 8:00 AM	Continental Breakfast (Posters and Exhibitor set up time – Kilby Ballroom)
8:00 AM to 8:15 AM	Welcome, introductions, and announcements by Chris Lowie, Symposium Chair – Meade Ballroom
8:15 AM to 9:15 AM	**Key Note Address by Tim Purinton, Director, State of Massachusetts Division of Ecological Restoration** Holistic ecosystem restoration: Presentation of a working model for advancing Atlantic white cedar (*Chamaecyparis thyoides*) swamp restoration in Massachusetts and beyond.
9:15 AM to 9:40 AM	Eel River headwaters restoration project - 17,000 Atlantic white cedar trees 2 years after. Nick Nelson, Inter-Fluve, Inc.
9:40 AM to 10:05 AM	The effect by hydrologic regimes and shade on Atlantic white cedar (*Chamaecyparis thyoides*) growth in the Cavalier Wildlife Management Area in Chesapeake, Virginia. Justin Weiser, Christopher Newport University
10:05 AM to 10:30 PM	Refreshment break: Exhibits and Posters on display – Kilby Ballroom
10:30 AM to 10:55 AM	Herbivory, tissue nutrient concentrations, and morphometric comparisons of two types of Atlantic white cedar (*Chamaecyparis thyoides*) nursery stocks planted in Chesapeake, VA. Mellony Seidel, Christopher Newport University
10:55 AM to 11:20 AM	Post-fire survival and growth of containerized seedlings, rooted cuttings, and naturally regenerated seedlings of Atlantic white cedar in the Great Dismal Swamp National Wildlife Refuge. Emily Foster, Christopher Newport University
11:20 AM to 11:45 AM	Effect of hydrology on post-fire survival and growth of containerized seedlings, rooted cuttings, and naturally regenerated Atlantic white cedar in the Great Dismal Swamp National Wildlife Refuge. J.W. Bayley Cook, Christopher Newport University
11:45 AM to 12:15 PM	Management of Atlantic white cedar habitat within a changing landscape. Chris Lowie, U.S. Fish and Wildlife Service.
12:15 PM to 1:15 PM	Luncheon buffet provided in the Kilby Ballroom
1:15 PM to 1:40 PM	Real world ecological management of Atlantic white cedar. Bob Williams, Land Dimensions Engineering
1:40 PM to 2:05 PM	Thousands of cedars (*Chamaecyparis thyoides*) dead: An Investigation in Sharon, Massachusetts. Peter C.Fletcher, USDA,NRCS (ret.)
2:05 PM to 2:30 PM	Comparison of harvesting and fire on Atlantic white cedar (*Chamaecyparis thyoides*) restoration through floristic composition in the Great Dismal Swamp National Wildlife Refuge (GDSNWR). Jacqueline D. Roquemore, Christopher Newport University

2:30 PM to 2:55 PM	Post-fire regeneration and growth of Atlantic white cedar after the 2008 South One Fire in the Great Dismal Swamp. Shawn Wurst, Christopher Newport University
2:55 PM to 3:20 PM	Afternoon refreshment break in Kilby Ballroom (Exhibit and Poster Room)
3:20 PM to 3:45 PM	Status and trends of Atlantic white cedar (*Chamaecyparis thyoides*) along the Gulf of Mexico coast. John W. McCoy, National Wetlands Research Center
3:45 PM to 4:45 PM	Restoring Atlantic white cedar in the landscape: Lessons learned from the Longleaf Alliance. Rhett Johnson, The Longleaf Alliance
4:45 PM to 5:10 PM	Final comments for Day 1 and announcement of Field trip logistics
5:10 PM to 7:00 PM	Poster Session, Exhibits, and Happy Hour – Kilby Ballroom Exhibits and Posters take down at 7:00 PM

Wednesday, June 13, 2012

Field trip highlighting the historic Great Dismal Swamp

This field trip will have stops on three different public land sites, viewing Atlantic white cedar restored to a historic site with no extant seed bed, and two areas with natural regeneration and supplemental plantings of seedlings. Attendees will see the Great Dismal Swamp NWR 2011 wildfire area. Attendees will have the option of using short wave radios which provide better hearing as tour presenters describe each stop. Please bring your headphones. Lunch provided.

7:00 AM to 8:00 AM	Continental breakfast, provided in Kilby Ballroom
8:00 AM	Load into vehicles for field trip.

1. Cavalier Wildlife Management Area: The Virginia Department of Game and Inland Fisheries has been actively reforesting Atlantic White Cedar on the Cavalier Wildlife Management Area since 2006. A variety of techniques has been used for site preparation, including herbicide application, controlled burning, and drum chopping. Stops will highlight on-going research and discuss management considerations.

2. Dismal Swamp State Park: The North Carolina State Park system is beginning a management program for the Atlantic White Cedar. There are several locations where remnant mature trees remain. The park is focusing on developing a plan for future management. Stops will highlight the mature trees left in the swamp and discuss expanding the habitat.

3. Great Dismal Swamp NWR: The refuge has been actively managing/restoring AWC since the early 1990s. Hurricane Isabel damaged most remaining stands of mature AWC in 2003. An aggressive salvage project was rewarded with excellent natural regeneration on over 1100 acres. Much of this acreage was lost to major wildfires in 2008 and 2011. Field stops will look at restoration success after both fire and salvage operations. A final stop will focus on damage from recent wildfires and prompt participants to provide input on the future of AWC on these sites.

4:00 PM to 5:00 PM	Return trip to Hilton Garden Inn in Suffolk, VA
	Dinner on your own

Thursday, June 14, 2012

7:00 AM to 8:00 AM	Registration Desk Open Continental breakfast – rear of Meade Ballroom
8:00 AM to 8:15 AM	Welcome, Introductions and Announcements – Meade Ballroom
8:15 AM to 8:40 AM	Soil Properties in burned and unburned Atlantic white cedar stands as a means to quantify impacts from recent fires in the Great Dismal Swamp. Kristina M. Kowalski, Christopher Newport University
8:40 AM to 9:05 AM	Mercury in Atlantic white cedar (*Chamaecyparis thyoides*) tree rings from Great Dismal Swamp National Wildlife Refuge: Analysis of concentrations accumulated across time. Crystal Levenson, Christopher Newport University
9:05 AM to 9:30 AM	Mercury in recently-exposed logs from the Great Dismal Swamp National Wildlife Refuge. Catherine A. Lavagnino, Christopher Newport University
9:30 AM to 9:55 AM	Radial growth of Atlantic white cedar (*Chamaecyparis thyoides*) in the Great Dismal Swamp National Wildlife Refuge and its association with Lake Drummond Water Levels. Craig Lee Patterson, Christopher Newport University
9:55 AM to 10:20 AM	Morning refreshment break – rear of Meade Ballroom
10:20 AM to 10:45 AM	Comparisons of ground plot and LiDAR data to evaluate the impacts of deer browse and silvicultural treatments on the vertical forest structure of Atlantic white cedar. George Zimmerman, Richard Stockton College of New Jersey
10:45 AM to 11:10 AM	Comparison of terpene profiles of *Chamaecyparis thyoides* foliage at various levels of deer browse from long term study sites. Kristen. A. Hallock-Waters, The Richard Stockton College of New Jersey
11:10 AM to 11:35 AM	Atlantic white cedar Site comparisons and implications for sustainability. John McCoy, National Wetlands Research Center
11:45 AM to 12:10 PM	Planning AWC Symposium 2015. Group Discussion
12:10 PM to 12:30 PM	Final comments and wrap up. Chris Lowie
12:30 PM	Symposium adjourns

Abstracts for oral presentations
listed in alphabetical order by first author

Holistic Ecosystem Restoration: Presentation of a working model for advancing Atlantic white cedar (*Chamaecyparis thyoides*) swamp restoration in Massachusetts and beyond.

Author: Tim Purinton, Massachusetts Department of Fish and Game's Division of Ecological Restoration

How the creation of an integrated ecosystem restoration agency is helping to expand the distribution of Atlantic white cedar swamps (and other aquatic habitats), address climate change adaption, and encouraging the growth of a restoration economy.

Massachusetts with thousands of acres of abandoned (or soon to be) cranberry bogs presents an incredible opportunity to advance Atlantic white cedar swamp restoration and to do it within the context of watershed-scale restoration. Recently completed projects including the multi-million Eel River Headwaters restoration underscore this opportunity.

Keywords: Atlantic white cedar, swamp restoration, ecosystem, climate change, watershed, Eel River headwaters

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Eel River Headwaters Restoration Project - 17,000 Atlantic White Cedar Trees 2 Years After

Authors: Nick Nelson, Inter-Fluve, Inc. and Keith Underwood, Underwood & Associates

Eel River is a small, spring-fed stream draining to the Cape Cod Bay in Plymouth, MA. Logging of AWC trees and the construction of small mill dams in the 1600 and 1700s transformed the native swamp and wetland ecosystem of the headwaters. By the late 1800s, more than 40 acres of wetland were converted to cranberry bogs. For cranberry bog management, all vegetation was cleared, ditches were dug to drain the wetlands and manage flows, berms were built across the wetlands in numerous places to control water, and sand was spread on top of the native peat to stimulate cranberry growth.

In 2005, the design of the restoration of more than 40 acres of cranberry bogs and removal of all fish passage barriers, including a historic stone dam and impoundment, commenced. While many design components were included in this restoration project, the establishment of an AWC-dominated wetland was one of the most important. Inter-Fluve collaborated with bog and AWC experts at the University of Laval in Quebec, Underwood & Associates, and the Woods Hole Swamp Institute to develop designs and propagation methods for AWC restoration. In 2006, more than 17,000 AWC trees were grown from seed collected within 10 miles of the project site. After four years of growth in greenhouses, installation of the trees at the restoration site took multiple weeks with up to 10 planting crew members in the spring of 2010. The planted trees were approximately 3 ft. in height and today range from 4 to 6 ft. in height.

One and two years after they were planted, the AWC trees were surveyed in 2011 and 2012 to monitor success, effects of browse, and growth. While browse and girdling was observed on some plants, the 2011 monitoring revealed greater than 85% survival rate. We conclude that the restoration design and its implementation successfully reestablished AWC with implications for future efforts in similar environments.

Keywords: Atlantic White Cedar, Restoration, Eel River Headwaters, Restoration Monitoring

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The effect by hydrologic regimes and shade on Atlantic white cedar (*Chamaecyparis thyoides*) growth in the Cavalier Wildlife Management Area in Chesapeake, Virginia.

Authors: Justin Weiser, Jackie Roquemore, Brittany Bowen, and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

The Virginia Department of Game Inland Fisheries began restoring a 1538-ha Atlantic white cedar (AWC) Swamp in Chesapeake, Virginia in 2007. Reestablishment of AWC is the most critical step in restoration of this globally- threatened ecosystem, and several variables may influence success including planting type, hydrologic regime, and shade intensity. The purpose of this study is to compare morphometric parameters of two tree planting types, propagated seedlings and rooted cuttings, at two locations characterized by hydric and mesic hydrologic regimes, which were assigned via prevalence index of wetland indicator status for non-cedar vegetation. In August 2010 and 2011, field crews quantified survivorship and growth (estimated by morphometric parameters including height, canopy diameter and stem diameter), and shade intensity at each location. Data were analyzed using t-tests and linear regressions. Growth was significantly greater ($p<0.05$) for rooted cuttings than propagated seedlings over one growing season and shade negatively impacted all growth indices. Growth in hydric hydrologic regime for all three morphometric parameters was less than in mesic plots (*p* height <0.050, canopy <0.001, stem diameter < 0.001). Rooted cuttings had greater mean growth than propagated seedlings and shade is greater in the hydric plots. Reestablishment of AWC may be effective in sites that have a prevalence index of between 2.5 and 3.5; however, mesic sites might lack the self- maintenance capacity in that seeds could be destroyed by fire.

Keywords: Atlantic white cedar, Restoration, Morphometrics, Prevalence index of wetland indicator status

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Herbivory, tissue nutrient concentrations, and morphometric comparisons of two types of Atlantic White Cedar (*Chamaecyparis thyoides*) nursery stocks planted in Chesapeake, VA

Authors: Mellony Seidel, Jackie Roquemore and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Herbivory by white-tailed deer, Odocoileus virginianus, is an impediment to afforestation and reforestation projects in general and to projects involving Atlantic white cedar (AWC) in particular. This study evaluated herbivory intensity at Cavalier Wildlife Management Area , in Chesapeake, VA, as related to planting type, tissue nitrogen content, and three morphometric parameters as indicators of growth. In the summer of 2010, seedlings from two nursery stock sources (rooted cuttings and propagated seedlings, 180 of each type) were planted in 10 plots and tissue samples were obtained in summer 2011. To deter herbivory Capsaicin and VaporGuard DI-I-P menthene were aerially applied in April of 2010 and 2011. Morphometric indicators of growth, and herbivory intensity were assessed in Fall 2011. Planted seedlings were more heavily browsed than rooted cuttings ($p < 0.001$). However total nitrogen content did not differ among planting types ($p > 0.05$). Rooted cutting exhibited greater height, canopy diameter, and stem diameter than planted seedlings ($p < 0.001$for each). However when predated trees were removed from calculations, rooted cutting and propagated seedlings had similar height, canopy diameter, and stem diameter ($p > 0.05$). The relationship between herbivory score and distance from the forest edge might also play a factor in herbivory patterns i.e., Herbivory was greater near forests ($R^2=0.47$). Type of planting stock, size of planting stock type, or other tissue nutrients might influence herbivory and should be considered in restoration plans.

Keywords: Herbivory, Tissue Nutrients, Morphometrics

Post-fire survival and growth of containerized seedlings, rooted cuttings, and naturally regenerated seedlings of Atlantic white cedar in the Great Dismal Swamp National Wildlife Refuge

Authors: Emily Foster, James Cook, and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Atlantic white cedar (AWC), *Chamaecyparis thyoides*, peat swamps are a globally-threatened ecosystem. The Great Dismal Swamp National Wildlife Refuge (GDSNWR) contained some of the largest remaining AWC stands in the world until August 2003 when Hurricane Isabel caused extensive blow-down. In 2008, the South One Fire began during salvage logging operations and burned approximately 1,887 ha. The purpose of this study was to assess effectiveness of AWC reestablishment techniques by evaluating survival and growth of three types of AWC including rooted cuttings (RC), containerized seedlings (CS), and naturally regenerating seedlings (NR) in salvage-logged portions of the GDSNWR. In May 2010 rooted RC and CS were planted in thirty-two 10 m x 10 m plots. In August 2010 and 2011, height, canopy diameter, stem diameter, shade intensity and browse severity were measured for all planted trees (n = 828) and for up to 18 randomly selected NR in each study plot (n = 330). RC survived better and grew larger than CS ($P < 0.001$). Higher shade intensity was associated with less growth for each tree type ($P < 0.001$), and RC grew larger than CS when exposed to moderate and high shade levels. Deer browsing did not significantly affect survival, though browsed trees exhibited significantly less height growth by the end of the study than un-browsed trees ($P = 0.001$). The results of this study have management implications for establishment of AWC where similar conditions occur.

Keywords: *Chamaecyparis thyoides*, Great Dismal Swamp National Wildlife Refuge, rooted cuttings, containerized propagated seedlings, deer browsing, shade intensity

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Effect of hydrology on post-fire survival and growth of containerized seedlings, rooted cuttings, and naturally regenerated Atlantic white cedar in the Great Dismal Swamp National Wildlife Refuge

Authors: J.W. Bayley Cook, Emily M. Foster, Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation.

Atlantic white cedar (AWC) peat swamps are globally threatened ecosystems and the acreage of this swamp type has been reduced by drainage and logging. The Great Dismal Swamp National Wildlife Refuge contained extensive stands of AWC that were severely damaged by Hurricane Isabel and in 2008 by the South One Fire. In 2010, thirty two 10 m2 plots were established throughout the Refuge, and rooted cuttings (RC) and containerized seedlings (CS) were planted in June. They were monitored in August, along with natural regenerants (NR), and survival and growth were quantified again in 2011. The effect of soil saturation and inundation on survival and morphometric growth indicators including height, canopy diameter, and stem diameter were quantified. Inundation during the growing season and non-growing season reduced survival. The highest survival occurred with 55 days of inundation during the non-growing season and 28 days during the growing season. Survival of CS was more negatively impacted by inundation than were either RC or NR. Saturation was generally negatively related to growth. These findings emphasize the importance of water level management to improve initial AWC recruitment and establishment.

Keywords: morphometric parameters, hydrology, growth, seedling survival, restoration, *Chamaecyparis thyoides*

Thousands of Cedars (*Chamaecyparis thyoides*) Dead: An Investigation in Sharon, Massachusetts, USA

Authors: Peter C.Fletcher, USDA,NRCS(ret.); Aimlee D. Laderman, Swamp Research Center, Woods Hole; Pamela T. Polloni, Botanical Consultant; and Greg Meister, Sharon Massachusetts Conservation Commission.

Sharon Great Cedar Swamp (GCS) is a >250acre wetland surrounded by a small New England town. Our team was called in to discover the cause(s) of the death of the thriving Atlantic White Cedars (AWC)(*Chamaecyparis thyoides*) that formerly dominated the area, and to restore the AWC forest. This report summarizes 5 yrs of observations and measurements documenting severe degradation of the hydrology, geomorphology and vegetation. Monitoring of 46 wells and an engineering survey of surface elevations revealed that in ~1/3 of the area, groundwater levels have dropped 2-4 ft below the surface. Soil subsidence of up to 3ft and large expanses of exposed roots arched high above the lowered forest floor reflect extensive oxidation and decomposition of the peat substrate. The AWC swamp's characteristic tree, shrub and groundcover vegetation is greatly altered and is now documented to be a facultative wetland assemblage, with areas in transition to a dryland community. Thousands of snags and criss-crossed fallen dead AWC are remnants of the former cedar dominants, with no AWC regeneration in >1/2 of the GCS. Ancillary damage: 1) The large accumulation of dry woody debris and drained dry peat poses a severe fire hazard. 2) Deterioration of town water well quality and quantity are important consequences of the GCS dehydration. We conclude that the major cause of the cedar deaths is a ~1.25 mile-long drainage ditch dug to protect a residential subdivision over ½ century ago, now extending up to 10ft deep and 30 ft wide. Additional contributing factors are 1) 6 municipal wells with GCS as the major water source, and 2) the AMTRAK railroad bed which cuts across the wetland and restricts groundwater flow.

Keywords: Atlantic White Cedar, *Chamaecyparis thyoides*, forested wetland, swamp hydrology, vegetation, soils, wetland drying, wetland deterioration, wetland restoration, Sharon Massachusetts, wetlands USA

Ecological Management of Atlantic white cedar (*Chamaecyparis thyoides* (L.) B.S.P.)

Author: Robert Williams, Land Dimensions Engineering

Since publication of the Atlantic White-Cedar Best Management Practices Manual (New Jersey Department of Environmental Protection) in 2000, new information has been brought to light, and more experience gained in AWC conservation. Economics and regulations must be taken into account as well as the science. Projects I have done in the past 20 years in New Jersey will illustrate the interaction of science with economics and socio-political constraints in ecological management of white cedar in a variety of initial site conditions and settings including clear-cut of existing stand and subsequent regeneration, conversion to AWC from swamp hardwoods, agriculture conversions, blow-downs, commercial thinning, and harvest of mature stands. Case studies show how these interact with varying landowner objectives and other factors such as threatened and endangered species, disease, local regulations, and economic conditions. To successfully manage AWC on the landscape scale we must first be successful in restoring it on the tens of thousands of acres lost. Given that scale, and the current economic conditions, a practical economic/political management model is needed that uses the science as well as the wisdom gained on a much wider scale and across diverse contexts.

Keywords: ecological forest management Atlantic white cedar, economics, thinning, case studies, best management practices

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Management of Atlantic White Cedar Habitat within a Changing Landscape

Authors: Chris Lowie, U.S. Fish and Wildlife Service, Great Dismal Swamp National Wildlife Refuge and Sara Ward, U.S. Fish and Wildlife Service, Raleigh Ecological Services Field Office

Forested wetland habitats across the range of Atlantic white cedar (AWC) (*Chamaecyparis thyoides* (L.) B.S.P.) have been influenced by centuries of human perturbations such as logging, ditching and draining. In North Carolina and Virginia, the construction of canals and ditches has dramatically altered the natural hydrology, and drained these wetland habitats. More recently, these drained wetlands have been extremely vulnerable to prolonged ground fires. During these fires, several feet of peat soil has been lost, which has resulted in dramatic changes in habitat conditions. These changes across the landscape require managers and practitioners to think more broadly and long-term than ever before to ensure ecosystem resiliency and reduce the likelihood of further catastrophic change.

These landscape changes affect management of AWC habitat at National Wildlife Refuges in North Carolina and Virginia. To increase the resiliency of peatland/pocosin habitats, including those that support AWC, the recent focus seeks to reestablish more natural hydrological conditions. Improving the ability to control water levels and re-wet peat soils can increase suitability for peat accumulation and reduce the impacts of wildfires. The higher water levels will also help retain diverse native habitats and vegetative communities such as AWC. These strategies may simultaneously enhance biodiversity values and increase carbon sequestration potential.

Keywords: Ecological resiliency, carbon sequestration, wildfire, Pocosin

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Comparison of Harvesting and Fire on Atlantic white cedar (*Chamaecyparis thyoides*) Restoration through Floristic Composition in the Great Dismal Swamp National Wildlife Refuge (GDSNWR)

Authors: Jacqueline D. Roquemore and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Fire is a natural component of many ecosystems and a requirement for natural succession of Atlantic white cedar (AWC) swamps. Moist, peat soils of AWC swamps can provide a seed refugium. However, seeds may be destroyed if fire coincides with low water tables. Harvesting (salvage logging) can be used to simulate effects of stand-clearing fire, but environmental conditions may not be similar to fire-maintained stands. In natural areas, floristic composition is responsive to disturbance and can provide insight about difference in site conditions. The purpose of this study was to evaluate the effects of both salvage logging and fire on stand composition. In summer 1999 aerial cover of all herbaceous vascular species was measured in 54 1-m2 plots nested in 18 larger plots (3 nested subplots per plot) along a transect in a salvage-cut area in south GDSNWR. In summer 2010 aerial cover of all herbaceous vascular species was measured in 75 1-m2 plots adjacent to 25 plots (3 nested subplots per plot) that were burned in the GDS South One Fire in 2008. Plants were identified to species and Modified Importance Value (MIV) was calculated by summing relative cover and relative abundance (totals 200). Species richness in the salvage logging area (17 species) was lower than in the post-fire area (32 species). The Community Coefficient calculated with the Jaccard Similarity Index between the areas was 28.9% suggesting a large disparity in stand composition. The species with the highest MIV in the salvage logging stand was *Toxicodendron radicans* (36.6) and the species with the highest MIV in the post-burn area was *Andropogon virginicu*s (34.9). The MIV of AWC was similar but low in both the salvage logging and the burned area (7.5 and 8.9, respectively) and was lower than reported for natural regenerating AWC swamps. The dissimilarity of floristic composition in the herbaceous layer of the two conditions is indicative of dissimilar environmental conditions. However, the comparable importance of AWC in the floristic compositions suggests that both salvage logging and fire, under certain circumstances, could result in mixed stands of AWC.

Keywords: cedar, harvesting, fire, floristic composition, salvage logging, importance values, vegetation, restoration

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Post-fire regeneration and growth of Atlantic white cedar after the 2008 South One Fire in the Great Dismal Swamp

Authors: Shawn Wurst, Catherine Lavagnino, Jackie Roquemore and Robert B. Atkinson Christopher Newport University, Center for Wetland Conservation

A peat-based seed bank underlies many East Coast Atlantic white cedar (AWC) swamps, and this globally-threatened ecosystem exhibits self-maintenance through high rates of natural regeneration after a stand-clearing fire. AWC stands in the Great Dismal Swamp have been in decline for approximately 200 years at least in part due to the draining of water by ditches. In this study we (1) report the amount of regeneration of AWC in the Great Dismal Swamp after the South One Fire of 2008 and (2) evaluate survival and change in height as an indicator of annual AWC growth. For regeneration in 8-m2 plots during 2009 and 2010, regenerants were counted in 143 and 41 plots, respectively. For evaluation of survivorship and growth, 25 10-m2 plots containing up to 18 AWC regenerants were established and height was measured in 2010 and 2011. Mean regeneration in 2009 (26,500 ± 23,800 stems ha-1) was not significantly different than in 2010 (29,339.8 ± 38,048.8 stems ha-1, Paired t-Test P=0.315). Mean height in 2010 (46.7 ± 11.8 cm) was significantly lower than in 2011 (86.5 ± 13.5 cm, Paired t-Test $P < 0.01$) and survival in 2011 was 95%. Regeneration rates suggest that most regeneration occurred in the first year after the fire, and regenerants that were present in 2010 exhibited high survival and growth. Regeneration rates reported in the literature were much higher for natural AWC swamps and the lower regeneration rate in the current study might be the result of low water tables coincidental with the 2008 fire.

Keywords: Atlantic white cedar, Regeneration, Growth, Seedling survival, Post-fire, Great Dismal Swamp

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Atlantic white cedar site comparisons and implications for sustainability

Authors: John W. McCoy, National Wetlands Research Center / USGS, Lafayette, LA 70506

Atlantic White Cedar (*Chamaecyparis thyoides* (L.) BSP) are found in the Southeastern United States along rivers, creeks, low lying wet areas, and seeps. Substrates are composed of peats, sands, and loams, and usually saturated for most of the year at or within centimeters of the surface. Flooding above soil surface is usually rain-driven and of short duration. Three study sites were established in Mississippi on private and public land at Grand Bay National Wildlife Refuge, Desoto National Forest at Camp Shelby, and the Black Swamp near Wiggins. AWC was the emergent canopy species on all sites, but not the most abundant of all woody species. Shrub layer species typically are broadleaf evergreen and create shade effects accounting for a sparse herbaceous cover. Herbaceous plants include facultative to obligate wetland species that can be found in pitcher plant bogs. Stand characteristics of these swamp sites demonstrate that indicator values for AWC range from 6.7% to 10.5% frequency, 3.8% to 15.8% density, and 8.8% to 17.4% dominance. This fairly narrow range of indicator values may be related to the limited ability of this species to contend with periodic hurricane disturbance and regeneration requirements within narrow hydrological conditions. AWC can grow on a variety of different soils.

Keywords: Atlantic white cedar, Mississippi, sustainability, soils, forest, composition, survival, growth

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Restoring Atlantic White Cedar in the Landscape: Lessons learned from the Longleaf Alliance Experience

Author: Rhett Johnson, The Longleaf Alliance

The longleaf pine resource declined steadily from the advent of European settlement until today, with little or no attention to or concern for that decline until the middle 1990's. Faced with approximately 96% of the original longleaf forest lost, a small group of natural resource professionals and forest landowners coalesced to begin a modest grassroots effort to at least halt the decline, with some hope of reversing that trend. The Longleaf Alliance was born out of that group in 1995 and has galvanized the entire region and made longleaf a national priority forest ecosystem in the interim. From those fledgling beginnings, the Alliance has emerged as the regional leader in "all things longleaf", a success based on a few guiding principles. With about 93% of the forestland in the longleaf range in private ownership, the Alliance recognized that meaningful restoration would necessarily incorporate many of those private lands into the effort. Further, we realized that to make the case for longleaf, we had to make a reasonable economic argument to complement the strong ecological argument to appeal to private landowners. We believed then and now that it was essential that we be "honest brokers" of information; that we present longleaf as an option, not a mandate; and that we treat every landowner with the same attention and respect. Using longleaf's ties to the region's history and culture gave us a hook that appealed to a wide range of audiences and helped build support even among those who were removed from the land. The group has remained small and focused, resisting opportunities to broaden our mission, and allowing us to concentrate all of our efforts on longleaf restoration.

Keywords: longleaf pine, Atlantic white cedar, restoration, forest landowner

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Soil Properties in Burned and Unburned Atlantic White Cedar Stands as a Means to Quantify Impacts from Recent Fires in the Great Dismal Swamp

Authors: Kristina M. Kowalski, Jackie Roquemore and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Peatlands including the Great Dismal Swamp National Wildlife Refuge (GDSNWR) are valuable ecosystems that filter water, sequester carbon, and support biodiversity within unique habitats such as Atlantic white cedar (AWC) swamps. Peat lands exhibit a positive water budget which reduces oxygen concentrations such that the rate of primary production exceeds decomposition resulting in peat accumulation and carbon sequestration. Accumulations as deep as 10 m have developed in GDSNWR since the swamp began to form approximately 10,000 years ago. However ditching during the last 200 years has caused water to drain which introduced oxygen into the soil and facilitated gradual (biological oxidation) and rapid (chemical oxidation) peat loss. This study was conducted to determine the bulk density, nitrogen and carbon content in soils before and after the 2008 South One Fire. In Summer 1999 soil samples were collected from a young AWC stand in GDSNWR that had not burned in at least several decades including nine plots in three stands located south-southwest of Lake Drummond. In Summer 2011 samples were collected from 21 plots in four AWC stands that burned in the 2008 South One Fire and from unburned stands 3.5 km further south (two stands with a total of seven plots). Soil samples for all years and plots were collected at 10-cm depth and were processed and analyzed to find bulk density, total nitrogen and carbon content (percent dry mass). Grand mean bulk density was 0.16 g cc^{-1} in 1999 and in 2011 was 0.21 g cc^{-1} in burned, and 0.17 g cc^{-1} in unburned stands. Grand mean carbon was 47.9% in 1999 and in 2011 were 47.5% in burned and 47.9% in unburned stands. Grand mean total nitrogen was 1.64% in 1999 and in 2011 was 2.10% in burned and 2.37% in unburned stands. These results can be combined with data reported elsewhere regarding depth of soil combustion and volume of unburned logs to determine total carbon emitted. Minimization of peat loss due to fire may be achieved through mechanisms such as water control structures that reverse drainage caused by ditches.

Keywords: Atlantic white cedar, peat, fire, soil properties, carbon, Great Dismal Swamp

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Mercury in Atlantic white cedar (*Chamaecyparis thyoides*) tree rings from Great Dismal Swamp National Wildlife Refuge: Analysis of concentrations over time

Authors: Crystal R. Levenson Catherine A. Lavagnino, Jacqueline D. Roquemore, and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Peatlands, such as the Great Dismal Swamp (GDS), can sequester large quantities of mercury from remote and point source locations. While no point sources are known for the GDS, recent evaluation of several vertebrate species reported that elevated concentrations and mercury can occur after wildfires. Little is known about coarse woody debris as a sink for mercury and the risk of remobilization during fires. Cross-sectional samples of 80-year-old Atlantic White Cedar (AWC) seed trees that blew down following salvage-logging operations in 2003 after Hurricane Isabel were collected from the Great Dismal Swamp National Wildlife Refuge. Sections were analyzed for mercury through atomic absorption spectroscopy using three sets of composited 10-year increments corresponding to 1934-1944, 1964-1974 and 1992-2002 year rings of each tree. Concentrations of mercury within each 10-year increment averaged 6.9+ 2.7 ppb, and ranged from 2.5 to 11.4 ppb. Based on the average concentration of mercury in the wood samples, a single living 65- year-old AWC tree could have as much as 2.84 mg of mercury. These results are consistent with mercury studies of live-wood samples from other species; across several deciduous species, 26% of live wood samples contained 1-2 ppb, and 11% were greater than 8 ppb. These results shed light on the history of mercury in the Great Dismal Swamp and how it is retained in AWC trees as well as the risk for mobilization during fires.

Keywords: Mercury, Atlantic White Cedar, Peatlands, Great Dismal Swamp, Dendrochemistry.

Mercury in recently-exposed logs from the Great Dismal Swamp National Wildlife Refuge

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Atmospheric deposition of mercury, a neurotoxin, occurs in remote locations with no identifiable point source. Peatlands such as the Great Dismal Swamp, methylate and sequester more mercury than they emit annually. Little is known about coarse woody debris as an ephemeral mercury pool even though management actions can influence the risk of re-mobilization via fire and microbial oxidation. Cross- sections were collected from buried logs in the Great Dismal Swamp National Wildlife Refuge after peat ignition (associated with the South-One Fire in 2008) exposed those logs at the new soil surface. Mercury concentration decreased logarithmically as distance to the nearest edge in contact with the peat increased ($p = 0.05$). Concentration at the edge of the logs (0.0295 ppm), though not consistent with tree-ring age, was higher than the two inner portions (0.004 and 0.003 ppm respectively). Estimates of mercury accumulation and retention in buried tree boles will improve modeling of biogeochemical exchange in peatlands and enhance modeling assessment of mercury re-mobilization risks during fires.

Keywords: AWC, cedar, mercury budget, mercury mobilization, exposed logs, Great Dismal Swamp

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Radial growth of peatland Atlantic white cedar (*Chamaecyparis thyoides* (L.) B.S.P.) in Great Dismal Swamp National Wildlife Refuge and its association with Lake Drummond water levels

Authors: Craig L. Patterson and Robert B. Atkinson, Christopher Newport University, Center for Wetland Conservation

Abstract: Over 200 years of commercial logging and drainage coupled with recent natural disasters have eliminated mature Atlantic white cedar (*Chamaecyparis thyoides* (L.) B.S.P.) (AWC) stands from Great Dismal Swamp National Wildlife Refuge (GDSNWR). Regeneration of AWC stands will require hydrologic restoration, and findings from tree-ring studies can contribute to restoration success. Analyses were performed on cross-sections of AWC stems to quantify radial growth and determine associations between ring width and climatic and hydrologic variables from 1919 through 2003. A total of 433 radial-growth series and 29 341 annual rings were measured from 105 AWC stem-cuts and were modeled using a 24-month window of Lake Drummond water levels. Growth was most strongly influenced by water levels in Lake Drummond. This study provided evidence that AWC is responsive to water level changes in GDSNWR.

Keywords: Tree rings, hydrologic variables, Lake Drummond

Comparisons of Ground Plot and LiDAR Data to Evaluate the Impacts of Deer Browse and Silvicultural Treatments on the Vertical Forest Structure of Atlantic White Cedar

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The effects of differential browsing by deer in regenerating Atlantic white cedar (*Chamaecyparis thyoides* (L.) B.S.P.) communities can have long term consequences such as shifts in species composition and changes in vertical vegetative structure, which in turn can influence edaphic factors such as light and temperature. Ground plot and LiDAR (Light Detection And Ranging) data were collected aerially in 2004 and 2011, and on the ground in 2012 to quantify vertical vegetative structures on silvicultural treatments. Study sites include Wharton State Forest (Penn Swamp site) and Brendan Byrne State Forest ('Colletti' site) in New Jersey which have been studied since 1990. Ground plot data by height classes (0-.29, 0.3-.59, 0.6-1.29, 1.3-2.9, 3-4.9, 5-6.9, and ≥ 7meters) were analyzed by frequency or height diversity indices and confirm significant changes in vertical forest structure especially areas of minimal browse versus controls (full exposure to deer).The Penn Swamp plot data (integrating the three slash load treatments) show the exclusion treatment (fenced-no deer) had 14.9% of its total vegetation in the 5-6.9 and ≥ 7meter vegetation height classes in 2008 versus 0% in those same classes in the control treatment(heavy browse). The height diversity index for the Penn Swamp exclusion treatment was 1.22 versus 1.04 for the control treatment. Aerial LiDAR point cloud data analyzed by the same height classification confirm some treatment differences. Ground plot data or ground based LiDAR may be needed to augment aerial LiDAR data analysis when lower height classes predominate given that aerially collected LiDAR may be confounded by hummock topography and/or closed overhead canopy structure. A total of twenty automated probes were randomly placed in treatments at the Colletti site to record incident light and temperatures at the ground level. The probes showed some significant differences in light and temperature, confirming vertical vegetative structure effects as a consequence of deer browse.

Keywords: Atlantic white cedar, deer browse, vertical vegetation structure, LiDAR, long-term plot data, height diversity indices.

Comparison of Terpene Profiles of *Chamaecyparis thyoides* Foliage at Various Levels of Deer Browse from Long-term Study Sites

Authors: Kristen A. Hallock-Waters, Jessica Favorito, Kimberlee Downey, Amanda Burkert, and George Zimmermann. The Richard Stockton College of New Jersey

Deer browsing has been linked to the production of terpenes in conifers. Browsing may stimulate production of terpenes as a plant defense, but defoliation as a result of heavy browsing may reduce the carbon available for production of the larger terpenes. The relationship between browsing pressure and terpene levels in *Chamaecyparis thyoides* (L.) B.S.P. at long term (>20 years) study sites in the New Jersey Pinelands was investigated. Foliage samples were collected from trees exposed to various levels of deer browsing ranging from unrestricted browsing to essentially no browsing. Gas chromatography/mass spectrometry was used to determine the relative abundance of monoterpenes, sesquiterpenes, and diterpenes in the foliage. The terpene profile is extremely complex, and identification and quantification of specific compounds is ongoing. However, terpene concentration is proportional to chromatographic peak area and the class of compound is easily determined based on the molecular ion of the mass spectrum. In heavily browsed trees, monoterpenes, sesquiterpenes, and diterpenes represented 11%, 74%, and11% of the total chromatographic peak area, respectively. While in unbrowsed trees, monoterpenes, sesquiterpenes, and diterpenes represented 6%, 58%, and 35% of the total chromatographic area, respectively. The greater relative abundance of monoterpenes and sesquiterpenes in heavily browsed trees compared to unbrowsed trees might be indicative of stimulation of plant defense in response to browsing. The lower abundance of diterpenes in heavily browsed trees suggests an inability to produce the larger secondary metabolites possibly due to reduced carbon availability.

Keywords: *Chamaecyparis thyoides*, terpenes, deer browsing, gas chromatography/mass spectrometry.

Status and trends of Atlantic White Cedar (*Chamaecyparis thyoides* (L.) B.S.P) along the Gulf of Mexico Coast

Authors: John W. McCoy and Bobby D. Keeland, National Wetlands Research Center / USGS, Lafayette, LA

Atlantic White Cedar (AWC) is a tree species that is generally restricted to coastal areas from Maine to Florida and then west to Southwest Mississippi. Although AWC was once more common along the Gulf of Mexico coast, the remaining stands are small and scattered. Part of the reduction in AWC abundance has resulted from the high quality of AWC lumber, especially for boat construction. Since the mid 20th century AWC along the Gulf of Mexico coast has become more of a novelty tree, usually existing only as a small component of some coastal forests. AWC is found as scattered individual trees or small mixed stands and not in the dense stands that can be found along the Eastern coast of the United States. AWC found in the national Forest Inventory and Monitoring plots in the southern states show a largest diameter of 29cm and one tree exceeded 20m tall. These scattered AWC trees represent the remnants of what could have been extensive stands in prehistoric times. Isolated AWC in Mississippi may be found near 1 ppt salinity water but multiple cedar trees are not usually associated with salinity. The Gulf of Mexico coast area now presents new challenges and prospects for AWC conservation, growth, reproduction, and restoration.

Keywords: Atlantic white cedar, Gulf of Mexico Coast, Southeast United States, sustainability, soils, forest, composition, survival, growth

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Abstracts of poster presentations listed in alphabetical order by first author

1 Effect of Stem Number on Growth and Yield of Atlantic White Cedar in Bedded Plantations

Authors: Eric Hinesley, North Carolina State University; Bill Pickens, North Carolina Forest Service

Since about 1990, there has been considerable interest in propagating Atlantic white cedar (*Chamaecyparis thyoidies* (L) B.S.P.) from stem cuttings. Although not strictly associated with rooted cuttings, plantings of AWC frequently have a high percentage of seedlings with multiple stems. Compared to many species, AWC is capable of continued growth, without suppression, at high stand densities. The effect of multiple stems on yield of usable wood volume is unknown. In late 2009, a long-term experiment was established in 2-year-old bedded plantations (two sites) on the Broadwell property in Bladen County, NC. On each site, 25 trees were allocated to each of four groups having one, two, three, or four uniform major stems. In April 2012 (four growing seasons in the field), total height was recorded for each tree, and the diameter of each stem was recorded at 1.3 m. Thereafter, height and diameter will be measured periodically to determine the long-term effects of stem number on growth and yield.

Keywords: growth and yield, plantations, vegetative propagation, Atlantic white cedar, stem number

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2 Gene Conservation of Atlantic White Cedar (*Chamaecyparis thyoides*) in the Eastern United States

Authors: Robert M. Jetton, William S. Dvorak, Gary Hodge, and W. Andrew Whittier, Camcore, Department of Forestry & Environmental Resources, N.C. State University; Barbara S. Crane and Don Duerr, USDA Forest Service

AWC is found most frequently in small dense stands in fresh water swamps and bogs. Prior to European settlement, there were an estimated 202,000 ha (~500,000 ac) of AWC swamps and wetlands in the eastern United States, but today only about 40,000 ha (~100,000 ac) remain. Although AWC is not a federally-listed species, it is listed as threatened or endangered in four states; including Georgia, Maine, New York, and Pennsylvania. AWC is an important commercial species in areas where it is more widespread such as eastern North Carolina, southeastern New Jersey, and the western Florida panhandle where it is harvested for its light-weight and decay-resistant wood. There are also 21 ornamental varieties of AWC available for purchase as landscape and garden plants, and the species is occasionally grown and sold as a Christmas tree. AWC swamps are also of ecological significance, particularly with respect to their role in hydrological processes. AWC swamps stabilize stream flows, store flood waters, help to mitigate the effects of drought, and filter and purify water as it flows through them. They are also home to a great diversity of plant, mammal, amphibian, and bird species, many of them rare and/or threatened and some that are obligates to AWC habitats. With growing public awareness of the importance of these unique wetland ecosystems, efforts to regenerate or restore AWC swamps have increased in the last 20 years. Given the decline of AWC, its patchiness across the range, its exacting site requirements, and its ecological and economic importance, the species is a good candidate for seed collection and genetic resource conservation efforts. This poster will present an outline for a new range-wide AWC genetic resource conservation effort being conducted by Camcore (an international tree breeding and conservation organization at N.C. State University) and the USDA Forest Service. Plans are to make seed collections from 10 AWC mother trees in each of 40 populations, 10 populations in each of 4 climatic zones identified for the species using the FloraMap™ climate modeling software. Collected seeds will be utilized for a variety of purposes including long-term preservation in germplasm repositories and the establishment of new AWC seed orchards.

Keywords: gene conservation, seed collection, long-term preservation, seed orchards

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3 The Effect of Two Site Preparation Treatments on the Survival and Growth of Atlantic White Cedar

Authors: Bill Pickens and Michael Chesnutt, North Carolina Forest Service

In 2009 two site preparation methods, 1) drum chopped and burn 2) mow/mulch and spray, were completed on a drained Carolina Bay site to remove a shrub layer of gallberry(*Ilex glabra* (L.) Gray). Container-grown Atlantic white cedar (*Chamaecyparis thyoides* (L.) B.S.P.) seedlings were hand planted in February 2010 at 900 stems per acre. We recorded tree survival and height in the winter of 2012. There is no statistical difference in the survival and growth of the AWC between the treatments. An average 775 AWC stems per acre survived in the mow/mulch and spray treatment compared to 650 stems per acre in the drum chopped treatment. The height of the AWC was 5.4 feet for the mow/mulch and spray treatment and 5.2 feet for the drum chopped and burn treatment. However, significantly more loblolly pine (*Pinus taeda* L.) invaded the drum-chopped treatment and threatens to dominate the site. Pine stem density and height in the mow/mulch and spray treatment(330 stems per acre, 1.7 feet tall) is significantly lower than in the drum-chopped and burn treatment (1388 stems per acre, 5.6 feet tall) The height of the loblolly pine on the drum chopped and burn treatment is significantly higher (5.6 feet) than the AWC (5.2 feet). Without additional treatment, it is likely the AWC on drum chopped site will become overtopped resulting in a stand dominated by pine.

Keywords: Atlantic White cedar, site preparation

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4 Atlantic White Cedar Restoration on the Nassawango Creek Preserve, Delmarva Peninsula, MD

Authors: David Ray and Deborah Landau, The Nature Conservancy, MD/DC Chapter

Remnant AWC populations on The Nature Conservancy's 10,000-ac Nassawango Creek Preserve (NCP) are being studied to provide baseline information and help inform restoration efforts. Located on the Eastern Shore of MD, the NCP is situated at the approximate center of AWC's historical range. The NCP was established to protect water quality (in the Chesapeake Bay system) and therefore has a substantial proportion of the preserve area in riparian and other wetland habitats suited to AWC. Similar to elsewhere, a combination of past logging practices, hydrologic alteration and poor regeneration due to herbivory and competing vegetation have resulted in either a reduced density or complete absence of AWC within habitats where they once occurred. To help address this situation we are using a combination of ground reconnaissance, historical records, and field measurements to characterize and quantify the extent of remnant and historical AWC populations. This information, in combination with soils maps and related hydrologic restoration projects (e.g. ditch plugging), is being used to identify appropriate locations to focus our efforts. Some specific approaches to AWC restoration we are using and have planned include: large-scale and high-density planting with protection from herbivory and control of competing vegetation; thinning or girdling of overtopping trees in areas of remnant AWC where individual or small groups of AWC are at a competitive disadvantage; and underplanting with protection from herbivory followed by overstory reduction to release established 'clusters' of AWC regeneration.

Keywords: Restoration, Demography, Hydrology
