CURRENT DEVELOPMENT WITH ATLANTIC WHITE-CEDAR MANAGEMENT

1 - 3 AUGUST 199~~3~~5 GOLDSBORO AND WASHINGTON, NC

Wednesday 2 August, Washington Civic Center

0800 - 0830	**Workshop Registration**	
0830	**Introduction of Program**	Summerville
0835	**Welcome**	Adams
	AWC Management Objectives	Moderator: Bill Gardner
0850	Area History	Lilly
0900	Alligator River NWR	Johnson
0910	Weyerhaeuser Company	Hughes
0920	Great Dismal Swamp NWR	Brownlie
0930	US Air Force Dare Range	S. Smith
0940	Pocosin Lake NWR	Savery
0950	Questions and Break	
	Cones & Seed Moderator:	Warren Boyette
1000	Seed Germination	Bonner
1010	Seed Propagation	Kuser
1020	Seed Dormancy	Bainchetti
1030	Nursery Bed Study	Summerville
1040	Seedling Growth	Jull
1050	Questions	
	Seedling and Rooted Cuttings	
1100	Greenhouse Production	Greenwood
1110	Rooted-Cuttings	Hinesley
1120	Seedling Standard	Summerville
1130	Transplanted Seedlings	Hinesley
1140	Plant Propagation	Kuser
1150	Questions	
1200 - 1330	**Lunch**	Civic Center

	Stand Establishment	Moderator:	Bob Kellison
1330	Site Requirements/Plant Growth		Gardner
1340	Site Inventory		L. Smith
1350	Site Preparation vs. Species		Hinesley
1400	Natural Regeneration		Moore
1410	Stand Establishment		Kuser
1420	Questions		
1430	Water Quality Project		Wicker
1440	Hardwood Conversion		Zimmermann
1450	Wetland Restoration		Hinesley
1500	Deer Browse		Zimmermann
1510	Herbicide Evaluation		Summerville
1520	Questions and Break		
	Stand Establishment (con't)	Moderator:	Warren Boyette
1540	Logging Slash		Zimmermann
1550	Provenance Study		Summerville
1600	Allozyme		Kuser
1610	Additional Research Needs		Summerville
1620	Problem Areas in Management (Open to floor)		Gardner

Adjourn

ATLANTIC WHITE CEDAR
SITE ADAPTATION AND HISTORICAL PERSPECTIVE

J. Paul Lilly

Atlantic White Cedar (Chamaecyparis thyoides) (AWC) is found only in freshwater wetlands along the eastern coast of the United States. In North Carolina it occurs most often on deep organic soils associated with pocosin type wetlands, depressional wetlands such as Carolina bays, and with stream valleys that have accumulated organic deposits as sea level has risen. It is also found in flood plains and on some wet sandy soils. Flood plains and flooded stream systems are probably the most stable environments due to dependable water supplies and less wildfire pressure.

Present AWC communities are mostly limited to rather inaccessible swamplands, and these are almost invariably the lands with the deepest organic soils. Historically, the easily accessible trees would have been harvested first, and the easily drained lands would have suffered more wildfire and more conversion to other users. There was undoubtedly much more AWC at the time of first settlement than existed by the mid 1800s. Ruffin (1861) records that all of the Juniper lands in the Great Dismal Swamp were destroyed by fire in about 1839 and that the area had not recovered by the 1850s. Otte (1982) said that nearly all pocosins in North Carolina are of relatively recent development, and that the only two areas that appear to be relatively old are the pocosins of the southern Dare County mainland and the pocosins of Croatan national Forest. Based on the few records that do exist and the effects of more recent fires, I believe that at as much as one half or more of the original peat is gone. This has strong implications for wetland restoration and reversion, especially for AWC. A site that has lost a thick organic surface cannot revert to a deep peat pocosin. The recent vegetation on a forested wetland is often a poor indicator of the historical vegetation. All peatlands and associated wetlands can be viewed as successional stages in a process of wetland development (Daniel, 1981). As organic debris accumulates, wet flats of gums or oaks give way to species adapted to wetter environments, and these in turn are replaced by still other species. Once the organic accumulation is significant, AWC is more common. Pocosin vegetation is closely linked with wildfire frequency, and severe wildfire can reset the successional clock.

AWC has been exploited extensively, and the rate of harvest accelerated after the Civil War. In 1894 the largest remaining area of unexploited swampland forest was the Albemarle Peninsula. Ashe estimated that out of 405,000 hectares of swamp on the Peninsula there remained 16,200 hectares of white cedar. In 1907 the Roper Lumber Company was cutting 100,000 board feet of AWC shingles daily from the western part of the Peninsula (American Lumberman, 1907). Richmond Cedar Works originally logged the eastern part of the Peninsula, and in recent years second or third growth AWC was again harvested there.

ALLIGATOR RIVER NATIONAL WILDLIFE REFUGE'S APPROACH TO ATLANTIC WHITE-CEDAR MANAGEMENT

Jim C. Johnson

Alligator River National Wildlife Refuge's interest in Atlantic white cedar restoration and management is multi-fold. One of the primary objectives for this refuge is wetland restoration (both hydrological and forest community re-establishment). Ample evidence exists indicating that cedar was a major component of the wetland forests of this area, therefore, reestablishment of this species in the 8,000 plus acres of clearcuts inherited from prior landowners has been made a priority. The U.S. Fish and Wildlife Service as an agency has endorsed protection and reestablishment of the cedar community as a integral part of the wetland forest community. Research scientists with the National Biological Survey recently listed Atlantic white cedar as one of the "critically endangered ecosystems of the United States" (Biological Report 28, February 1995). Finally, wetland restoration on refuges in this area, including Atlantic white cedar, has been identified as a management priority in the ecosystem plan developed collectively by most of the Service field stations in Virginia and North Carolina.

One of the major management efforts initiated by the refuge in 1991 was attempting hydrological restoration by installing water control structures in the outlets of canals constructed by prior landowners. In most cases, these canals have resulted in a gradual drying out of site conditions and changes in forest community compositions. This effort is noteworthy because these hydrological changes may be in part responsible for the lack of cedar regeneration in a significant part of the clearcut areas the refuge inherited. In other cases, logging access roads constructed without any regard to drainage has resulted in some areas becoming too wet for cedar regeneration establishment since these areas have standing water present during virtually the entire year. The refuge has taken the position that before large scale cedar reforestation efforts can be started, this problem must be dealt with to the best of our abilities. To date, 10 structures have been installed that provides primary water control capabilities on about 30,000 acres, including some 1500 acres of cedar clearcuts.

Reproduction surveys in over 30 refuge cedar clearcuts were completed in 1986-88. The presence of adequate stocking levels of cedar was found to be very spotty. Follow-up surveys in '91-92 of the same areas confirmed this general trend but also identified several other factors of interest: reproduction continues to occur on the clearcut areas where it was occurring in '86-'88; those areas without reproduction in '86-88 had been totally captured by shrubs.

In 1992, the Dare County Air Force Range (DOD Air Force) received special project funding to attempt large scale regeneration of cedar on cutover areas. A cooperative project was developed including the refuge staff, Dare Range forestry staff, and the North Carolina Division of Forest Resources. Following initial discussions, it became apparent to all involved that a lot of the basic knowledge needed to implement this project was simply unavailable. A brief synopsis the efforts undertaken as part of this project include a cooperative agreement with the USDA Forest Service Seed Lab at Miss. State Univ.to develop seed extraction techniques and test viability of seed from various age classes (3-4 yr to 70-80 yr old stems), contributing funding and seed to the N.C. Division of Forest Resource Nursery to attempt developing nursery cultural practices, implementing test plots to evaluate the effectiveness of herbicide treatment for cedar seedling release/site prep, entered into a cooperative agreement with N.C. State Univ. Forestry Dept to conduct basic research on identification of parameters that resulted in encouraging or retarding cedar regeneration in some 15 clearcuts on the refuge and range, planted in excess of 100 acres of cedar including a 5 acre genetics study tract and a 5 acre site for use as a cone production area, finalized study plot design to test various combinations of mechanical/herbicide/fire treatments as site prep methods in 8-10 yr old clearcuts on typical cedar sites, spent almost a staff year in collecting cedar cones, and initiated seedling inventories to determine existing stocking levels, if any, on the 3000 acres of clearcuts identified for regeneration.

Weyerhaeuser Company Is Helping With the Effort to Restore Atlantic White Cedar in Coastal North Carolina

Joseph H. Hughes

Historical Importance. Atlantic white cedar, known locally as Juniper or Boat Juniper, is a minor but commercially important species which grows in bogs and fresh water wetlands on the Atlantic and Gulf coastal plains from New England to southern Mississippi. Historically, the largest concentrations of white cedar occurred in North Carolina, supplying a thriving lumber industry during the sawmilling boom at the turn of this century. The strong, lightweight, decay resistant, aromatic wood was preferred for boat planks, house siding, shingles, tank boards and fencing.

Globally Endangered. Unfortunately, white cedar almost never regenerates naturally after timber harvest, due to blocked drainage, elimination of wildfires, replacement by competing vegetation or clearing for agriculture. As a result, the acreage of white cedar has declined by more than 90% from its original area in North Carolina. To compound the problem, there continues to be a strong market for white cedar for boat building and for appearance lumber in housing. In 1989 Atlantic white cedar was listed as globally endangered by the Nature Conservancy because it exists in only a shadow of its original area, because it does not regenerate well and continues to be harvested. The endangered status reflects concern not only for the survival of the species, but also for the wetlands and wildlife habitat provided by cedar bogs and for the future supply of white cedar lumber.

Weyerhaeuser Company Involvement. Why is the Company involved in white cedar conservation and restoration? Our ***Weyerhaeuser Forestry*** Stewardship Statement commits the Company to protect, maintain or enhance important environmental values, such as: --- plant and animal species diversity --- on our lands and in the geographies where we operate. White cedar is a species of concern in our North Carolina operating area. We can enhance white cedar by using some of the nursery and tree growing skills and technology that we have developed for loblolly pine. Our primary motivation for working with white cedar is to fulfill the commitment to species diversity made in the ***Weyerhaeuser Forestry*** Stewardship Statement. White cedar has almost no commercial value to Weyerhaeuser. The Company owns insignificant volumes of white cedar timber. No Company mills produce white cedar products. The opportunity for our nursery business to sell white cedar rooted cuttings is real, but modest.

Conservation and Restoration Activities. The few Atlantic white cedar groves that remain on Weyerhaeuser land are reserved for gene conservation of this globally threatened species. North Carolina Forest Service, North Carolina State University Forestry Extension, Weyerhaeuser Company and several public and private land owners began an informal white cedar regeneration cooperative in 1988. Demonstration areas on public and private lands across a range of soil types and with various cultural treatments were planted in 1989, 1990 and 1991. Weyerhaeuser made a 12 acre white cedar planting at Pocosin Lakes National Wildlife Refuge in December, 1991 as a ***Celebration North Carolina*** gift to the people of this state. We continue to give technical and on-the-ground assistance for white cedar research plantings at the Refuge. The Company gives away about 10,000 white cedar rooted cuttings each year at various festivals in North Carolina to inform the public about this interesting and important tree. Our regeneration business has grown a range of from 25,000 to 200,000 containerized rooted cuttings per year, primarily for the restoration and mitigation markets, during the last four years. The 100,000+ rooted cutting crop for 1996 will include, for the first time, about 30,000 bare-root rooted cuttings. Improvements in rooted cutting technology, including the efficient production of bare-roots, bodes well for the future of Atlantic white cedar restoration planting.

Atlantic White Cedar Ecosystem Restoration Dare County Air Force Range

Scott B. Smith
Installation Forester
August 1995

Dare County Air Force Range was established in 1964 in northeastern North Carolina. It is centered on a peninsula bordered by the Alligator River, Pamilco Sound, and Croatan Sound. 46,000 acres are managed under multiple-use policies.

Air Force purchased the timber rights in 1981 which included approximately 1,500 acres of Atlantic white cedar forest in cutover condition. Adjacent to the Range, the U.S. Fish and Wildlife Service inherited a similar situation on the Alligator River National Wildlife Refuge with approximately 1,500 acres of cutover land. Funding for any regeneration efforts was not possible until Congress created the Department of Defense Legacy Resource Management Program. Applicable legislative purposes include the protection and restoration of significant biological systems. The Legacy Program provided the opportunity for the Air Force to become a proactive steward of its natural resources. Genetic and species preservation, enhanced biological diversity, wetland restoration, and increased esthetic considerations are benefits to be gained from this project.

A steering committee of partners was organized in 1992 with representatives from Dare County Air Force Range, Alligator River National Wildlife Refuge, N.C. Division of Forest Resources, and N.C. State University. The committee developed the following elements of the strategy plan:

a) Research the silvicultural history
b) Review available literature
c) Inventory cutover for natural regeneration
d) Inventory remnant white cedar stands
e) Implement a Geographic Information System
f) Establish a Differential GPS
g) Develop methods to release regeneration
h) Determine natural regeneration requirements
i) Develop seed and seedling sources
j) Develop artificial regeneration methods
k) Reclaim roads for access to project area
l) Establish water management capability
m) Study stand dynamics on various soil types

SEED CONDITIONING AND SEED QUALITY OF ATLANTIC WHITE-CEDAR

Frank Bonner
USDA, Forest Service, Southern Research Station

Seed Extraction - Cones open easily, but to recover 90% or more of seeds from cones air-dried at room temperature, wetting/redrying treatments must be used. Dry until cones open; shake and collect seeds; then wet cones by spraying with or immersion in tapwater for a few hours.(Immersion is quicker, easier, and does not harm the seeds.) Then redry, shake again, and rewet (if necessary). Moderate heat (95 or 110 °F) will speed the process and reduce the amount of rewetting/redrying necessary. Only one cycle was needed with drying at 110. Germination tests showed no damage to seed quality from any of the above.

Seed Cleaning - Air-screen cleaners or hand screens with the same range of hole sizes are essential. Cones and large debris can be removed with a round-hole #10 1/2 (4.2 mm) screen, and smaller trash (primarily needles) can be removed with a round-hole #7 (2.8 mm) screen. Two or three passes over the #7 are required to get most of the fine needle fragments. Seed sizes can vary among lots, and other screen sizes may be more suitable with some lots. Very fine trash and empty seeds can be removed from small lots with laboratory blowers (South Dakota, Stults, or General ER). Large lots could probably be cleaned with larger aspirators, but we never had enough seed on hand to test it. There is no reason why lots cannot be upgraded to 80% filled seeds with air separation, although some filled seeds would have to be sacrificed to get it.

Seed Yield Data - Tree age made no difference in seed yield or seed quality. Older trees from two sites on ARNWR averaged 9.4 and 7.6 seeds/cone, with 1.0 and 0.6 filled seeds/cone in 1992. Collections from young trees (8 to 10 years old) in 1992 from around North Carolina, both plantations and natural stands, yielded a range of 2.1 to 10.2 total seeds/cone and <0.1 to 1.4 filled seeds. Similar results were found in 1993 collections from many of these same stands. Pollen supply and weather are probably the most important factors in determining seed yield. Insects may have a local impact also, but we never found significant damage. Cleaned seeds ran about 1,100 per gram. This figure would be slightly lower if empty seeds were removed, but embryo weights are quite small.

Germination - This species displays variable dormancy; some lots germinate easily without stratification, while other lots need it. Under optimum conditions in the laboratory, all viable seeds in our tests usually germinated within 6 weeks. For seedling production, however, quick, rapid germination is what we want. We ran five different tests on stratification with seedlots from different sources and different ages. Without a doubt, 4 weeks stratification was best overall; it gave the most uniform germination at the highest rates. In two of the tests, more than 4 weeks had a detrimental effect on germination. Light was not a limiting factor in germination of stratified seeds. Germination tests on a two-way thermogradient plate showed that this species did not do well at cool temperatures (compared to other southern trees), and that germination was faster at alternating temperatures than a constant temperatures (just like other southern trees).

<u>Soil Seedbank</u> - Soil/litter "squares" (4x4x2 inches) removed from two sites on the ARNWR in 1992 showed that there were plenty of viable seeds in the top 2 inches of the forest "floor". The Sycamore Road site averaged 585 viable seeds per square meter, while the Miltail Creek site had 325. Buried seed plots are in place to determine how long seeds will survive in these conditions. On Sycamore Road, seeds that germinated 17% originally were 7.1% viable after 1 year, and 6.6% after 2 years. On Miltail Creek, germination fell from an original 59% to 30.8% after 1 year; 2-year samples will not be retrieved until 1996. The test continues, but we know that some seeds will survive for at least 2 years without losing viability.

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Able assistance has been supplied in this study by K.O. Summerville of the North Carolina Division of Forest Resources, Jim Johnson and his staff of the Alligator River National Wildlife Refuge, and personnel of the Dare County Air Force Range, DOD.

This research is supported by: USDI, Fish and Wildlife Service.

White-cedar Genetics, Propagation and Establishment in New Jersey

John E. Kuser
Cook College
Rutgers University
New Brunswick, NJ

Genetics

Isozyme frequency analyses show fewer polymorphic loci at High Point, an outlier swamp in northwestern NJ, than in two main-range swamps in southern NJ and two in eastern NC. A few fresh High Point seeds germinated on 10h day in 1992, whereas seeds from other swamps wouldn't. High Point cedars, including rooted cuttings, look bluer.

Propagation

Seed: cones ripen in November; seed crops vary from year to year. Seed viability varies from swamp to swamp, usually 10%-60%; can be determined by tetrazolium test or seed dissection. Fresh seed needs either 16 h day length or 30 d stratification to germinate. Seed must not be buried, but lie atop moist medium (keep moist!), and will sprout in c. 2 weeks.

Cuttings: will root at almost any time of year; fresh twigs can be stored in ziplocs at 0°-4°C for several weeks. We use 10 cm cuttings to fit handily in Leach tubes, but 5 cm-25 cm will root; wound 1 side lightly 0.5-1.0 cm, dip in Hormodin 3 powder, stick in Pro-Mix BX under mist 6 sec every 6 m, will root in 3-6 weeks. Comparing seedlings vs. stecklings: preliminary expt. showed seedlings avgd. 86 cm, cuttings 84 cm after 3 yrs. in swamp. Current progeny test will compare 3 swamps X 4 clones/swamp, cuttings vs. seedlings, mature tree crown cuttings vs juvenile tree (<2m) cuttings.

Establishment

Swamps: plant on hummocks not low enough to drown, or high enough to dry out. Match the sites where you see native seedlings. Sandpit reclamation: imitate where native seedlings appear, i.e. 60-90cm above lake level in flooded pit, within 3 m of water's edge along bank sloping 30°-45°. We're trying some in 100m-wide sand flats 30-60 cm above water table. Protect with electric fence or vexar collars 60-90 cm high x 20 cm diam, control brush with herbicide as necessary.

NURSERY BED SOIL AMENDMENTS EFFECTS ON SEEDLING PRODUCTION

K. O. Summerville

In past years bare-root seedling nursery production of Atlantic White-cedar has been inconsistent from year to year. This study is an attempt to determine some factors effecting seed germination and subsequent seedling growth.

Nursery bed surface was treated with five different soil amendments (no amendment, peat moss incorporated, peat moss on top, 50/50 peat/vermiculite mix on top, and pine straw mulch on top). In each replication these treatments were under shade cloth (approximately 50%) or in full sun. Six replications were established. Within each treatment 4 square plots were randomly assigned on a one foot grid pattern. Each treatment was 20 square feet of surface area (4x5 ft.). Seed were sown for a bed density of 35 seedlings per square foot. After germination started, seedling counts were made 3 times at weekly intervals. The shade cloth was removed after 4 weeks of germination to provide access for fertilization and other cultural practices.

This study will be conducted for two growing seasons. Preliminary data from 1994 indicates that shade enhanced seed germination in 4 out of 5 treatments and this same trend continues thru to final seedling numbers at lifting time. Early indications are that treatment 2 (peat incorporated) yielded best results in total number of plants with treatments 4 (peat/vermiculite on top) and 3 (peat on top) being a close 2 and 3 in total plants. The 1995 preliminary data shows that the combinations of shade and treatment 2 have the highest number of plants for germination.

A second objective of this study was to determine the effect of these treatments of production of plantable seedlings. At the time of seedling lifting the trees were separated into 6 height classes 0-5 cm, 5.1-1.0 cm, 10.1-1.5 cm, 15.1-20 cm, 20.1-25 cm and >25 cm. Ten centimeters is approximately 4 inches from root collar to tip of top growth and this has been used as a seedling standard by the N. C. Forest Service nursery system in past years. All treatments grown under shade yielded a higher number of 10 cm and greater seedlings than no shade (full sun). This procedure will be followed with the 1995 test.

This separation of seedlings was used in a follow-up outplanting to determine these seedlings size growth response on a reforestation site. Results from this will be made in a separate report.

Initial Seedling Growth of Atlantic White Cedar as Influenced by Temperature and Photoperiod

Laura G. Jull, Frank A. Blazich, and L. E. Hinesley

Due to accelerated loss of natural stands and efforts directed at wetlands reclamation, there is currently great interest in propagation, culture, and field establishment of Atlantic white cedar. The objective of this study was to determine the optimum photoperiod and day/night temperature for initial seedling growth.

On Mar. 24, 1994, uniform seedlings of a Bladen Co., N. C. provenance were transplanted individually into RLC-4 Ray Leach Cone-tainers containing a medium of 1 peat : 1 perlite : 1 vermiculite (v/v) amended with Osmocote 18-6-12 at 2.1 $kg \cdot m^{-3}$ (3.6 $lb \cdot yd^{-3}$) and were grown under greenhouse conditions for 1 month. On April 19, 1994, uniform seedlings were then transferred to the N. C. State University Phytotron and the experiment was initiated. Initially, plant heights and stem diameters were recorded. In addition, six plants were harvested to determine total root lengths and root areas. Initial top and root dry weights (dried at 70°C for 72 hr) were also recorded. Temperature treatments were then initiated using growth chambers.

The study was a completely randomized design with a 4 x 4 x 2 factorial arrangement of treatments consisting of four, 9-hr day temperatures of 18°, 22°, 26°, or 30°C (64°, 72°, 79°, or 86°F), four, 16-hr night temperatures of 14°, 18°, 22°, or 26°C (57°, 64°, 72°, or 79°F) and two photoperiods [a short day (9-hr) or a long day (9-hr day with a 3-hr daily night interruption from 11:00 PM to 2:00 AM]. There were 10 single plant replications per treatment. Plants were moved between chambers at 7:30 AM and 4:30 PM daily to maintain appropriate day/night temperatures. Seedlings were fertilized twice weekly with the standard Phytotron nutrient solution and watered with deionized water on remaining days. Plant heights were recorded every 2 weeks.

Seventy-nine days after treatment initiation, final heights and stem diameters were recorded in addition to crown width which consisted of two branch measurements at a 90° angle. Roots were washed free of medium and seedlings were separated into tops and roots. Before drying at 70°C for 72 hr, total root length, and root area of three plants per treatment grown under long days were measured.

Dry matter production was influenced by day and night temperatures and photoperiod. Significant day temperature x photoperiod interactions occurred for caliper, crown width, and top dry weight. There were no significant interactions for root dry weight, root area, or root length. Optimum day temperature for top and root dry weight was 30°C whether seedlings were grown under short or long days. Root area and total root length were also maximized at days of 30°C for long day seedlings. Greatest caliper and height were also realized at days of 30°C. Long day plants had greater values for all growth measurements than short day plants except for caliper ($P < 0.05$). Short day plants had slightly greater caliper at 26°C than long day plants ($P < 0.05$). A quadratic response to increasing day temperatures was noted for crown width for long day plants with a maximum at 22°C. A similar response was observed for short day plants with a maximum at 26°C.

Significant night temperature x photoperiod interactions occurred for crown width and top dry weight. Optimum night temperature for top and root dry weight of seedlings was 26°C whether grown under short or long days. Regardless of night temperature, top and root dry weights were lowest at days of 18°C. Greatest caliper, height, root area, and root length were also realized at nights of 26°C. With regard to crown width, long day plants had a quadratic response to increasing night temperatures as a maximum occurred at 22°C. A linear response was noted for short day plants with maximum crown width at nights of 26°C. Data indicate that optimal seedling growth of Atlantic white cedar can be achieved by utilizing a day/night cycle of 30°/26°C with long days.

GREENHOUSE PRODUCTION OF ATLANTIC WHITE-CEDAR SEEDLINGS

Synopsis of results from research toward requirements for Master's degree
by Laura Lee Greenwood, under the direction of Dr. Robert C. Kellison.

Germination and early growth requirements of Atlantic white-cedar (Chamaecyparis thyoides (L) BSP) were examined in four separate experiments. In two experiments, germination rates of cedar seeds were quantified on several different media. Nitrogen requirements for seedling growth were determined in another study, and phosphorus requirements and differences, as affected by two seed sources, were assessed in another.

Experiment # 1

Two soils (a Lakeland sand and a Wickham loamy sand), a soil-peat combination (3:1 loam sand:peat) and four soil-less media (peat, composted pine bark, 1:1 bark:peat and 1:1:1 peat:perlite:vermiculite) were evaluated. Germination percentages were highest in peat moss and 1:1:1 peat:perlite:vermiculite.

Experiment # 2

One soil (Wickham loamy sand), two soil-peat combinations (1:1 peat:loamy sand and 2.5 cm peat over loamy sand) and three soil-less mixtures (peat, 3:1 peat:perlite and 1:1 peat:vermiculite) were evaluated. Peat:vermiculite (1:1) yielding the best germination percentage. Both soil-peat combinations resulted in significantly higher germination percentages than soil alone. Tetrazolium tests overestimated germination percentages. For containerized production, 1:1 peat:vermiculite is the best germination media of those surveyed.

Experiment # 3

Seedlings from the first germination experiment were fertilized with nitrogen from $(NH_4) NO_3$ at 0, 75, 150, or 300 ppm. At the end of 6-months, the seedlings grown in peat moss with 300 ppm N applied weekly were the tallest and had the greatest dry weight and stem diameter. Seedling response to N depended on growing medium composition. The four growth indices measured (dry weight, diameter, height and root:shoot ratio) for seedlings in each medium increased with increasing levels of N. Response curves indicated weekly N fertilization between 160 and 250 ppm should elicit 90-95% of maximum growth in any of the five media. Peat moss was the best of the media surveyed, and loamy sand amended with peat was better than the soil alone. Peat should be the major component of any artificial medium, and should probably be added to nursery soils low in organic matter.

Experiment # 4

Seedlings from two seed sources were grown on 1:1:1 peat:perlite:vermiculite at 0, 25, 50, 100, or 200 ppm phosphorus from H_3PO_4. The seedlings grown at Ø ppm had reddish foliage and lower heights, dry weights and diameters than those grown at the other concentrations. There were no significant differences among seedlings grown at the other four concentrations of P. Height and diameter differed between seed lots, but dry weights were similar. Weekly liquid fertilizer applications containing 25 ppm P are adequate for Atlantic white-cedar seedlings.

Rooting Atlantic White Cedar Stem Cuttings Outdoors

Eric Hinesley
N. C. State University

Introduction. More AWC planting stock is needed, and vegetative propagation is one means for increasing the supply. Several field plantings indicate that vegetative propagation is commercially feasible. Because AWC roots easily, I believe that it can be rooted outdoors, without a greenhouse. The objective of this work is to look at several factors that would influence the success of such an endeavor.

Methods. The expt. was established outdoors at Claridge Nursery (N. C. Forest Serv.) in Goldsboro. There were six mist schedules (once every 8 min up to once each hr), and main-plots (pallets, 4 ft x 4 ft) received one of the six mist treatments during the day. There were 24 pallets (4 reps x 6 mist schedules). Each pallet had two mist nozzles (3 ft apart, 18 in above pallet surface), and trays containing the cuttings were located between the two mist nozzles. Pallets were 8-10 ft apart, covered by 50% black saran shade cloth, and separated by plastic dividers to prevent drift.

The remaining treatments (sub-plots) were (1) container type, (2) media, (3) type of cutting, and (4) concentration of rooting hormone. Containers were (1) Spencer-Lemaire root trainers (Hilson, cell vol. = 10 in^3, 32 cells per tray), and (2) Multi-pot row packs (45 cells per tray, cell vol. = 6 in^3). Media were (1) 1: 1: 1.5 peat:perlite:coarse vermiculite (v/v/v), and (2) 1:1 peat:perlite (v/v). Cuttings 12-14" long were taken from branch tips and divided into proximal and distal segments of equal length. The basal 1.5 cm was treated with IBA at concentrations of 0, 1500, or 3000 ppm in 50% isopropyl alcohol. Cuttings were collected on 6 June 1995, and stuck during the following 3 days.

Results. Rooting has not been evaluated, but some observations are warranted. Mist schedules of 8 min and 15 min look promising; most cuttings subjected to these intervals are doing well after 6 weeks. Results are more variable, and less successful at the longer intervals. Using a Mist-a-Matic (turns on when the surface of a metal screen dries) has not worked. Spencer-Lemaire trays dry faster than the Multi-pot row packs, and would be more trouble to use in a containerized operation. It's too early to comment on the effect of hormone concentration, media, or type of cutting.

ATLANTIC WHITE-CEDAR BARE-ROOT SEEDLING STANDARD EVALUATION

K. O. Summerville and Eric Hinesley

This study is designed to help determine the seedling size best suited for reforestation practices. Seedlings for this study were derived from the separation and analysis of seedlings produced by the nursery bed soil amendment study. The six height classes used in that study were carried forward to this study and field planted on 2 sites, an organic and a wet mineral soil.

The study is designed to have 8 replication with a 5 tree row for each treatment. The treatments are randomly assigned within each replication. The treatments are 0-5 cm, 5.1-10 cm, 10.1-15 cm, 15.1-20 cm, 20.1-25 cm and >25 cm in height. Seedlings were lifted 19 and 20 January 1995 and planted on 2 and 9 February 1995.

A mid-summer check at the wet-mineral site indicates that survival is ranging from 95 - 100% no treatment effect was evident. Browse damage has occurred and deer appear to be the causal agent. The peat site has been flooded for several days in June and this may impact survival. Data will be collected at both sites during the dormant part of the growing season. Height and diameter growth will be followed for several growing seasons. A second year's planting of this study is planned from the 1995 nursery bed study.

BARE-ROOT VS. CONTAINER SEEDLINGS

K. O. Summerville

This study is an attempt to determine which seedling production method yields the best plant for reforestation: bare-root or container grown seedlings. Two container sizes with different soil mix capacities were used, 3 and 5.5 cubic inch root capacity volume. Parameters used to determine value of one system over another were survived, and subsequent height and root collar growth.

The study was planted on three sites, one peat soil and two wet mineral (clay/loam old fields) in eastern North Carolina. The bare-root seedlings were 1-0 and the containers were 9 months old when planted in February and March 1990. Survival and growth measurement were taken at 1, 2 and 3 years of age.

The study design is 3 treatments (tmt 1, 5.5 cubic inch; tmt 2, 3.0 cubic inch; bare-root) with 10 tree rows per replication and 10 replications. the treatments within a replication are randomly assigned. Soil samples were taken on each site and analyzed for mineral/organic content, CEC, BS %, pH, phosphorus, potassium, calcium, magnesium, manganese, zinc and copper.

Survival has been good on all three sites by all treatments with the exception of one site where browse damage reduced survival below the other two. Diameter and height growth preliminary data indicates that all treatments are developing equally well in any year of measurement across sites.

Production of Atlantic White Cedar Transplants

Eric Hinesley
N. C. State University

There has been some speculation that large planting stock might better survive the viscitudes of the field environment (e.g., deer browsing, high water, drought, competition) the first year after planting. This work was undertaken to look at the performance of AWC in transplant beds, and to follow up with a study in the field to compare growth and survival of transplants with that of seedlings.

Methods. One-year-old AWC seedlings were grouped into two height classes: 2-4" and 5-7". On 19 Apr. 1995, seedlings were hand planted in a transplant bed at the N. C. Forest Serv. nursery in Goldsboro. Prior to planting, fertilizer (10-10-10 with micronutrients; 10 lbs/100 ft) was tilled into all plots.

There were eight treatments (2 seedlings heights x 2 peat treatments x 2 shade treatments). Shade treatments were (1) no shade, or (2) 30% black saran shade cloth. Peat treatments were (1) none; or (2) one 4-ft^3 bale per 20 ft of bed, tilled in prior to planting. The experimental design was a randomized complete block with four reps and 8 treatments (32 plots). There were 20 plants per plot: (4 rows x 5 plants) at a 6" x 6" spacing in the center of each plot.

Plots were mulched with chopped pine straw following planting. Plants were irrigated twice daily during the first few weeks after planting, and once daily during the remainder of the summer. Summer of 1995 was also relatively wet. Fertilizer (10-10-10 at 5 lbs/100ft) was also surface applied by hand on 5 July 1995.

Results. Although too early for detailed measurements, some general observations can be made. At mid-July, the large seedlings were 12-15" tall, with a few up to 18". Small seedlings were mostly 8-12" tall. Survival is virtually 100%, and plants have excellent vigor. AWC puts on considerable growth in the fall, so their final size should be much larger. In mid-July, there were no obvious differences between shade treatments or peat treatments.

Future Plans. Transplants will be dug and measured during the early spring of 1996. A field study will evaluate early performance of transplants relative to 1-0 seedlings.

Reintroduction of Atlantic white-cedar in the Lower Coastal Plain

W. E. Gardner, K. O. Summerville and J. P. Lilly

In 1989, NCSU Extension Forestry, in cooperation with the NC Division of Forest Resources and Weyerhaeuser Company, began series of test plantings of Atlantic white-cedar. Both bare-root seedlings and containerized rooted cuttings were planted for three consecutive years in five locations selected to represent a range of site conditions across eastern North Carolina. Survival, early growth and preliminary observations on several site variables have been reported.

Observations include:

Location	Soil Series	pH	% Organic	Previous use Site preparation	Height(in)* Sdlg	Cuttings	Survival(%)* Sdlg	Cuttings
Farmville Pitt Co	**Rains**	**6.9**	**6-9**	**harvested forestland drained; pasture 1980 bedded**	56	52	19	5
Lewiston Bertie Co	**Johnston**	**4.4**	**7-12**	**drained; cultivated cropland sod cover herbicide, ripped & planted**	80	89	21	29
Bunch Tract Chowan Co	**Roanoke**	**4.4**	**4-5**	**harvested forestland sheared, windrowed, planted**	79	73	57	44
Camp LeJeune Onslow Co	**Torhunta**	**4.0**	**7-11**	**drained, harvested forestland windrowed, bedded 1984 burned 1988**	75	53	88	92
Hofmann Forest Onslow Co	**Croatan**	**3.2**	**25-55**	**drained, cutover pocosin sheared, windrowed 1986 flat, bedded**	107 115	94 99	97 92	93 97

***1989 plantings, after 4 growing seasons**

These test plantings have produced considerable evidence that Atlantic white-cedar can be successfully established--especially on acidic, organic soils. Both bare-root seedlings and containerized rooted cuttings appear to have similar potential for artificial regeneration. Although predation by deer and other mammals may in some cases be a serious threat to plantation establishment, it is not a problem in all years on all sites, even where local populations are known to exist. Appropriate release techniques, where weed competition is pre-existing or particularly aggressive, will undoubtedly produce better survival and early growth.

Regeneration of *Chameacyparis thyoides* (L.) B.S.P. at the Alligator River National Wildlife Refuge and Dare County Air Force Bombing Range

Synopsis of results from research toward requirements for Master's Degree by Lenwood E. Smith II, under the direction of Dr. Robert C. Kellison.

Since colonial times *Chamaecyparis thyoides* (L.) B.S. P., commonly known as Atlantic white cedar (AWC) or Juniper, has been a highly prized species. As a result of heavy logging, agricultural drainage, and fire control, the species has become less available for use as timber.

This study was conducted in 1993 and 1994 to evaluate the success of natural regeneration of AWC in stands logged between 1982 and 1984, and to develop guidelines for the future management of AWC in the Alligator River drainage area.

Ten stands were sampled ranging in size from 4.6 to 22.9 hectares. A total of 215 plots were installed. Eight of these stands were located on Belhaven or Pungo muck, and were either winter or summer logged; they were included in the final analyses. The 200 m^2 plots, containing subplots of 50 m^2, 12.5 m^2 and 4 m^2, were systematically located to characterize the vegetation of the sampled stands. Soil parameters were also measured in each of the 200 m^2 plots.

Preliminary statistical analyses indicated that AWC regeneration was most probable on soils having greater than 63% organic matter. For this reason the Hyde silt loam stand, with lesser amounts of AWC, was eliminated from the final analyses. The Roper muck stand was also eliminated from the final analyses due to the lack of comparative stands winter logged.

No correlation was found between the presence of AWC and any other species. Of the stands used in the final analyses, two consisted of pure AWC, five of the stands were adequately stocked with AWC, but the control of hardwoods is needed to ensure their success. Atlantic white cedar was not successful in only one of the stands used in the final analyses.

Regeneration was found to be more probable on Belhaven or Pungo mucks logged in winter. Soil acidity and percent base saturation were good predictors of AWC trees or saplings in both soil types which had been winter logged. Hydrology may be critical to AWC success on Pungo muck soils where different sediment deposits are found beneath the organic layer.

General observations indicated that the presence of *Sphagnum* moss may be linked to the success of AWC. Microrelief also appears to play an important role in AWC success. Bear predation on AWC was observed in one of the stands sampled.

Site Prep x Species Interactions

Eric Hinesley
N. C. State University

The objective of this work was to examine various site preparation treatments and to screen various species on a peat site.

Methods. The site was prepared in Nov. and Dec. 1994. Site prep. treatments were as follows: natural (stand of broom sedge), mow, fire plow, bed, roll and chop, light disk, and heavy disk. Bedding was done by Weyerhaeuser. Tree species were: Atlantic white cedar, bald cypress, pond pine, coastal loblolly pine, swamp blackgum, water oak, willow oak, overcup oak, and cherrybark oak. No herbicides or fertilizers were used.

The expt. is a split-plot with four replications. Each main plot (site prep) is a row about 450 ft long. Rows are 10 ft apart. Each sub-plot (species) contains five consecutive plants, spaced 10 ft apart. Atlantic white cedars were first-year rooted cuttings from Weyerhaeuser Co. Remaining plants were 1-0 seedlings grown by the NC Forest Serv. at Goldsboro and Morganton. The site was prepared in December 1994, and planted in mid-January 1995.

Results. Initial survival and growth have not been measured, but some general observations are warranted. Fire plowing disrupts the surface, and brings up numerous logs and stumps. Also, the trenches tend to fill with water, which hinders planting and might cause plants to drown. Heavy disking caused the surface to be undesirably loose, but it was much firmer by planting time in March. Bedding is good when there is danger of flooding (e.g., June 1995), and facilitates planting by hand. However, deer and rabbits can walk down a bed like a bread line. Rolling and chopping is easy, maintains a firm soil surface, does not impede subsequent access, and leaves a mulch on the surface. Planting into broom sedge is simple, but this method is most susceptible to fire. It is possible, however, that leaving the natural vegetation makes it more difficult for deer to find and browse plants during the first year.

Although the area was fenced the first year, the planting experienced major damage from deer. This also included the pines, which were frequently pulled out of the ground. Flooding in June probably also killed some trees. Other trees have died back to the root crown, and are producing sprouts. Only time will reveal the ultimate suitability of these species on this site.

NATURAL REGENERATION OF ATLANTIC WHITE-CEDAR

Doctoral Research by Susan E. Moore under direction of Dr. Robert C. Kellison

The purpose of this research is to determine how to manage for adequate germination and early survival of cedar seedlings. The study will take place in the Great Dismal Swamp National Wildlife Refuge, at the border of southeastern Virginia and northeastern North Carolina and comprise 107,000 acres of forested wetlands, including a remaining 7,200 acre forest of Atlantic white-cedar. A basic purpose of the refuge is to restore the natural biological diversity of the Great Dismal Swamp and managing the Atlantic White-cedar forest type will help meet that goal.

The results of this study will promote development of replacement stands of cedar, helping the U.S. Fish and Wildlife Service meet their objective of restoring 2,400 acres of cedar and maintaining an existing 7,200 acres of natural cedar stands. These results may also be applicable for Atlantic white-cedar management throughout North Carolina and Virginia.

The objectives of this research are:

1. To determine how cedar seedling growth and survival relate to light competition. This experiment will be conducted on a site where cedar was regenerated 4 years ago. Twenty-four 9 m^2 treatment plots will be established and located where cedar seedlings are abundant and uniformly distributed. Three different treatments will be imposed:
    1. Control: all vegetation is left to grow freely (cedar subjected to both light and root competition).
    2. Clip plots: all vegetation except the cedar seedlings is clipped by hand, with repeated hand clipping every two weeks throughout the growing season (effectively eliminates light competition). Root competition from outside the plots will be eliminated by trenching into the ground with a shovel around the perimeter of the plot.
    3. Clip plots with shade cloth: all competing vegetation is clipped by hand, and the plot is covered with 55% shade cloth at a height of 30 cm above the tallest cedar seedling (cedar subjected to controlled light reduction). Hand clipping is repeated every two weeks. Root competition outside the plot will be eliminated by perimeter trenching.

    In these plots, all vegetation will be inventoried that falls in a sampling subplot of 2.4 x 2.4 meters within the 9 m^2 plot. It will be identified by species, height class, and percent cover. These measurements will be taken pre-treatment, and at the end of one growing season. In addition, all cedars will be measured to exact height in centimeters at the start and end of the 1994 growing season.
2. To determine an effective method of site preparation to control competition and promote germination and first-year survival of Atlantic white-cedar seedlings. A 6-hectare study will be installed on two sites, a pure, even-aged cedar stand 7-75 years old with a virtually nonexistent shrub layer and understory and a 75 year old mixed cedar/maple/black gum stand with a 40% cedar component and a dense understory and shrub layer. These two sites were chosen to allow evaluation of cedar regeneration in response to site preparation treatments under differing original stand conditions.

    This study will consist of 2 treatments replicated 8 times at each of the two sites. The treatments include:

    a. control: seed tree cut, K-G blade/chain saw.

    b. herbicide: seed tree cut, K-G blade/chain saw, apply Arsenal (imazapyr) to newly emerging competing vegetation in the late summer of the first growing season following harvest.

A 3 ha area will be harvested at each site with treatment plots measuring 20 x 40 m (800 m^2 or .08 ha).

Before harvest, a vegetative inventory of all split plots will be taken. Basal area, height and DBH will be measured using a ten-factor prism. Shrub layer occupants in the understory will be measured in four permanent 4 x 4 meter sampling units within the treatment plots. The sampling units will be located randomly within the subplot. Percent cover for shrub species and vines will be measured by ocular estimation. Heights will be recorded for all saplings less than 2.5 cm DBH and more than 1 m tall. Seedling stocking of all woody competition will be measured for stem height by species for all stems less than 1 m tall. Height classes will include 9-15 cm, 16-30 cm, 31-60 cm, 61 to 90 cm, and 91 cm+. The herbaceous understory including mosses will be measured by ocular estimation of percent ground cover by species.

Following completion of this pre-treatment inventory, the entire 3 hectares at each site (135 x 225 meters) will be mechanically harvested with a K-G blade and chain saws and all remaining understory and shrub layer occupants will be removed with hand tools and brush cutters. Approximately ten cedar seed trees per hectare will be left.

The permanent sampling units established pre-harvest will be remarked for use for future sampling. These same measurements will be repeated after one, two and four years, and thereafter as practicable.

In each subplot, five soil samples will be taken at random from 0-15 cm depth. The samples will be composite for each plot and analyzed for pH, available phosphorus, potassium, exchangeable calcium, magnesium, aluminum, hydrogen, copper, zinc, CEC and percent base saturation.

3. To determine whether germination is dependent on current year's seed fall, or if a seed bank sources are adequate, and what type and quantity of seed are in the seed bank. This research will consist of 16 paired 1-m^2 subplots located randomly with one pair within each of the unburned plots on each site. Within each pair, one subplot will be screened above to catch the falling cones and seed, and the other subplot will be without the screen. The screens will be skirted to prevent floating seed from landing within the 1-m^2 subplot. The seed catch will be removed and counted every two weeks throughout the seed dispersal season to determine the amount of seed excluded. During the growing season after seed fall, cedar seedlings will be counted in both the screened and unscreened plots to assess differences in germination rates resulting from current seed fall exclusion.

To assess the seed bank potential, a seed germination study will be conducted to determine the species identity and quantity in the duff. Samples will be taken in fall, 1994 and spring, 1995. One 15 cm x 15 cm x 5 cm deep block of soil will be removed from the top layer in the direct vicinity of the seed exclusion above for a total of 16 samples from each sample period. These samples will be evaluated in a greenhouse under heat and moisture conditions simulating the swamp environment until spring of 1996. The seedlings germinating will be identified and quantified by species.

Atlantic White Cedar Wetland Project

Mike Wicker
U.S Fish and Wildlife Service

<u>Lead Organization</u>: NC Division of Forest Resources

<u>Cooperating Organizations</u>: NC Division of Environmental Management, NC Nature Conservancy, NC Division of Forest Resources, NC Division of Coastal Management, NC State University, Weyerhauser, US Fish and Wildlife Service, Ducks Unlimited

<u>Project/Program Objective</u>: The project will restore Atlantic white cedar wetlands to 640 acres of prior converted wetlands with peaty soils to achieve non-point reductions of mercury and nitrogen to surface waters which drain into the Pungo River. The site for restoration located south of Lake Phelps is owned by the U.S. Fish and Wildlife Service as part of the Pocosin Lakes Wildlife Refuge. The site selected for planting is an area where natural regeneration has not occurred. Mercury and nitrogen pollution contribute to water quality problems that are reflected in fish consumption advisories in regard to mercury, and fish kills in regard to nitrogen. The restoration site is part of a larger area that was cleared for peat mining and is now covered with broom sedge which creates a significant fire hazard. Large peat fires are not desirable because mercury bound in the peat is released in large amounts to the air and water.

<u>Project</u>: The hydrology to the area will be restored through the placement of a single flashboard riser. Bald cypress and pond pine will also be planted as these trees are commonly found together in natural stands. Some area will be left open to allow for better site evaluation and to allow for long term observation of colonization of those areas from adjacent tracts. Restoration of the hydrology should arrest the oxidation of peat that has occurred since the land was drained and subsequently prevent mercury bound in the peat from polluting surface waters. Surface water and ground water locations will be sampled for nitrite/nitrate and mercury. In addition, ground water elevation will be monitored. Monitoring of tree survival and growth will be conducted by Dr. Eric Hinesley and is described in his sections of this handout.

ATLANTIC WHITE-CEDAR HERBICIDE EVALUATION

K. O. Summerville

Two naturally reseeded Atlantic White-cedar areas were used for application of a herbicide. The objectives were to determine effect on Atlantic White-cedar and competing vegetation. Application of herbicide at each site was by helicopter. A site in Gates County was treated in September 1993 using 3 rates of Arsenal AC (9.6 oz, 12.8 oz. and 16 oz/acre). A site in Dare County was treated in August 1994 using 3 rates of Arsenal AC (8 oz., 16 oz., 24 oz./acre). Both sites were total-tree harvested in the '88 (Dare Co.) and '89 (Gates Co). Each site has a similar peat/muck soil and has regenerated to a mixture of Atlantic White-cedar, Red Maple, Red Bay, Black Gum, Cypress, Waxmyrtle, Pepper bush, Ilex spp., Fetterbrush, Smilax spp. The sites also had a mixture of non-woody plants, sphagnum moss, wool grass, water lily, broom sedge, rush, cattail, and fern.

At each site 1/100 acre circular plots will be established in a random pattern to access effect on plant growth within each treatment flight line. On each 1/100 acre plot 5 dominant Atlantic White-cedar trees will be tagged and numbered. Height and DBH will be recorded. These plots are established by placing a permanent center post for future relocation. Future measurements of these 5 Atlantic White-cedar trees and recording other plant presence will provide information on the long term effect of the herbicide application. The Gates County site will provide the opportunity to make an evaluation after 2 growing seasons and the Dare County after one growing season. Visits to the sites in July 1994 provide observations that reveal no visible effect on the Atlantic White-cedar. Herbicide effect is observable of Red Maple, Black Gum, Red Bay, Ilex spp., Pepper bush, Cypress, Waxmyrtle, Smilax spp., wool grass, cattail, fern, broom sedge, and rush.

ATLANTIC WHITE-CEDAR PROVENANCE STUDY IN NORTH CAROLINA

K. O. Summerville

A provenance study work plan for North Carolina was developed and put into effect in 1989. Natural sites for Atlantic White-cedar were divided into three categories, peat, wet mineral and stream flood plain. The work plan outlined finding 5 sites in each of these categories and collecting cones from 5 individual trees at each site. Seed extracted from the cones was identified in a manner that would allow separate identity by site category, location and individual tree. Sites were located randomly within the natural range in North Carolina keeping them dispersed in a north/south pattern through the Coastal Plain and Sandhills when possible.

Several objectives were to be accomplished with this work plan:

1. Determine need to keep seed collected form these different site categories separate for nursery seedling production.
2. To provide some basic genetic information about this tree species in North Carolina.
3. Provide an opportunity to collect cones from trees of known origin and growth performance.
4. Provide an opportunity to learn about wood and aromatic oil content of this tree species.
5. Provide an opportunity to identify individual trees of exceptional growth or other characteristics for vegetative propagation.

Cone collections began in 1991 and were completed in 1992. Container seedling production was started in the winter of 1993 with 5 peat category locations including 25 trees, 3 flood plain category locations including 15 trees and 8 wet mineral category locations including 37 trees. Cones were collected from a total of 77 trees ranging in age form approximately 10-60+ years. A 1/2 inch diameter increment core was taken from each tree to determine age and be used for aromatic oil analysis.

Two sites were planted in the Spring of 1993, one peat and one wet mineral category. Deer and rabbit browse damage this first growing season required the construction of a fence to exclude the deer. A solar charged battery powered fence was constructed in the spring of 1994. Survival has been high in spite of the deer and rabbit damage on both sites. Growth measurements have been delayed to allow the plants to recover from the browse damage.

A second crop of container seedling have been produced for 3 additional provenance study plantings, one in each of the site categories.

AWC PROVENANCE STUDY TREE LOCATION

Site Condition	Source Group	County / Location	# Trees
Peat/Muck	1-1	Harnett, south of NC 24 & 27	5
	1-2	Camden, Great Dismal Swamp NWR	5
	1-3	Chowan, Rockyhock	5
	1-4	Brunswick, Waccamaw Forest	5
	1-5	Dare, Air Force Range (Sycamore Trail)	5
Flood Plain	2-1	Onslow, Camp Lejeune	5
	2-2	Scotland, Lumber River	5
	2-3	Columbus, Waccamaw River (Juniper Creek)	5
Wet Mineral	3-1	Jones, Comfort	3
	3-2	Wilson/Nash, US 264	5
	3-3	Cumberland, Harrisons Creek	5
	3-4	Richmond, Hamlet (Hogan Road)	4
	3-5	Sampson, Garland	5
	3-6	Craven, Croatan NF (Catfish Lake)	5
	3-7	Columbus, Gore Farm	5
	3-8	Lee, Juniper Springs Ch	5
		Total # Trees	77

PROVENANCE STUDY TREES ROOTED CUTTINGS

K. O. Summerville and Eric Hinesley

Cones were collected from all available provenance study trees in October-December 1993. The cones were collected by climbing each tree and cutting out branch tips with cones attached. These branch tips with cones attached were placed in plastic bags at the collection site and transported in an iced-down container. Before and after the cones were stripped form the branches they were placed in refrigerated storage until January 1994.

Cuttings from these branch tips were placed in a greenhouse rooting bench under mist water application. Twelve cuttings from 59 provenance study trees were placed in the rooting bench. The cuttings had over 95% rooting by spring 1994. The cuttings were rooted in a soil mix of 1:1 peat/perlite, using 5000 ppm IBA in 2.5 inch (3/4 x 3/4 x 4 inches) containers. During the summer of 1994, the cuttings were moved to outside benches. In October the cuttings were transplanted to a larger container (21.5 cubic inches, 1½ x 2 x 8 inches) and a determination of stem form was made. Approximately 60% of the cuttings were exhibiting lateral top growth. The cuttings were grown thru the winter of 1995 in a greenhouse. A second evaluation on form of stem growth was made in July 1995. At this period of evaluation, the percentage of lateral growth had decreased to approximately 15% of the cuttings.

Three points stand out from this rooting activity.

1. Root success was high from a group of trees ranging in age from approximately 10-80 years of age.
2. Rooting success was high from branch tips taken over a three month period and stored from 2 to 4 months before being placed in a rooting bench.
3. A high percentage of cutting exhibited lateral stem form initially, but change to up-right growth by the second growing season.

These observations will be reported in more detail in a later publication. These rooted cuttings have been used to out-plant 2 sites as cone production areas to provide seed for bare-root seedling production.

ATLANTIC WHITE-CEDAR CONE PRODUCTION AREA

K. O. Summerville

Cone production areas have been established at two locations from plants derived from mature trees used in an Atlantic White-cedar provenance study. The plants used in the cone production area were developed from rooted cuttings of the provenance study trees.

From previous studies of seed it is evident that young Atlantic White-cedar trees produce seed that is as viable as that from mature trees. Observations in Christmas tree growers plantations and older demonstration planting provide evidence that AWC trees at 5 and 6 years of age (8-10 ft. tall) produce adequate quantities of female and male flowers to effect good pollination, thus viable seed. With this in mind a random design of 59 provenance study trees was developed utilizing 3 to 5 rooted cuttings per tree source. An area 150 x 150 feet was used spacing the rooted cuttings 10-feet apart. The planting design ensures that no one tree source is less than 5 or 6 spaces from a plant of the same source. In this way natural pollination will occur among plants of different sources providing opportunities for the seed to have a varied parental background. Good genetic diversity can be maintained by this planting design.

8-3-95

TOUR STOP 1

POCOSIN LAKES NATIONAL WILDLIFE REFUGE

PUNGO EQUIPMENT SHED VICINITY

HYDE COUNTY, NC

Atlantic white-cedar planting given by Weyerhaeuser Company through the Governor's Celebration North Carolina Program

Site:

A 12 acre portion of an organic loam agricultural field that grew a corn crop in 1991

Site Preparation:

Single pass V-blade to winnow cornstalks
Bed and fertilize with 350 pounds per acre rock phosphate in October 1991
Row spacing is about 10 feet

Deer Exclosure:

Gallagher high tension solar powered electric fence
three strands, plus a one-strand offset
installed November 1991

Planting:

White-cedar rooted cuttings produced at Weyerhaeuser's Comfort, NC greenhouse
planted December 3, 1991
726 trees per acre, approximate 10 by 6 foot spacing
Comparison of rooted cuttings grown in 10 cubic inch tubes and 40 cubic inch styro-blocks

Weed Control:

Arsenal herbicide applied in May 1992
band spray at 4 oz per acre