THE EFFECT OF VARYING GLYPHOSATE AND SURFACTANT RATES ON THE CONTROL OF ORIENTAL BITTERSWEET

Terry L. Burhans, Jr. and David W. McGill[1]

Oriental bittersweet (*Celastrus orbiculatus*) is an invasive climbing, twining vine that can grow up into the forest canopy effectively inhibiting growth and light exposure on affected trees. A local landowner who treated bittersweet with various rates of a glyphosate-based herbicide claimed that higher than recommended rates of herbicide were needed to effectively control the invasive plant. Our study assessed the validity of this claim and explored the interaction of glyphosate and surfactant effects on the efficacy of bittersweet control. Our goal was to determine an ideal treatment of herbicide and surfactant rates for the effective chemical control of oriental bittersweet. Four rates of glyphosate herbicide in the form of Accord® (Dow Chemical Company) (0%, 2.5%, 5%, and 10% volume to volume) were crossed with four rates of a common surfactant (Cide-Kick® [Brewer International]; 0%, 0.5%, 1%, and 2%) to create 16 treatments. Treatments were randomly assigned to individual plants growing in the understory of two forested areas in northern West Virginia. Five replicates for each treatment at each site were separated into discrete blocks to account for any microsite variation that might be present within the treatment area. Apart from the surfactant only treatments, all glyphosate treatments were highly effective in defoliating the bittersweet stems. Our poster reports first-year results of the study and provides a glimpse of attributes that occur on this invasive species as a result of herbicide toxicity.

[1]Graduate Research Assistant (TLB), West Virginia University, Appalachian Hardwood Center, P.O. Box 6125, Morgantown, WV 26506; and Professor and Extension Specialist (DWM) West Virginia University, Appalachian Hardwood Center. DWM is corresponding author: to contact, call 304-293-5930 or email at dmcgill@wvu.edu.

COFIRING TORREFIED WOODY BIOMASS WITH COAL: A NEW CHALLENGE FOR POWER GENERATION

Juan C. Carrasco, Gloria S. Oporto, and Jingxin Wang[1]

Biomass is currently used up to 20 percent in co-combustion with coal in power plants. This feasibility has emerged as an excellent option for voluntary reduction in CO_2 emissions, however, biomass presents several limitations that are associated with its low energy density compared to fossil fuels, grinding energy, variability in moisture content, and it is microbiological degradable during storing. Today, it is possible to improve all biomass disadvantages through the torrefaction process. Preliminary results obtained in our laboratories demonstrated that red oak (*Quercus rubra* L.) can be efficiently torrefied in a fluidized bed reactor giving a yield between 0 and 60 percent corresponding to calorific values that vary between 17 and 23 MJ/kg. The experiment was performed in an inert environment with the following conditions: particle size of the raw material between 0.7 and 1.4 mm, temperature of the system between 220 ºC and 260 ºC, and the reaction time between 5 and 10 minutes. Torrefied red oak has demonstrated potential to be used in co-combustion with coal. In this research, we will study the cofiring of torrefied red oak with coal focusing on the kinetic study and reaction mechanisms. That is, the evaluation of the blending effect, terminal velocity of the particles, precombustion reactions, competition for oxygen, oxidizing and reducing reactions of carbon, hydrogen, and oxygen, combustion efficiency, thermochemical formation of ashes and gases, and pollutant emissions.

[1]Graduate Student (JCC), West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506; Assistant Professor (GSO), West Virginia University, Division of Forestry and Natural Resources; Professor (JW), West Virginia University, Division of Forestry and Natural Resources. GSO is the corresponding author: to contact, call 304-293-7648 or email at gloria.oporto@mail.wvu.edu.

THREE-YEAR RESULTS FROM THE FIRST FIELD TESTS OF AMERICAN CHESTNUT (*CASTANEA DENTATA*) BRED FOR BLIGHT RESISTANCE

Stacy L. Clark, Scott E. Schlarbaum, Arnold M. Saxton, and Fred Hebard[1]

An exotic fungus, the chestnut blight (*Cryphonectria parasitica* Murr. Barr), decimated the American chestnut tree (*Castanea dentata* Marsh. Borkh.) throughout eastern North America in the first half of the 20th century. The chestnut's demise had significant consequences on forest ecosystem processes and utilitarian values. The U.S. Department of Agriculture, Forest Service (FS), the University of Tennessee, and the American Chestnut Foundation (TACF) are collaborating on chestnut restoration research on National Forest System lands. In autumn 2007, TACF used their back-cross breeding program to produce chestnut trees that are predicted to be American chestnut in character with blight resistance from Chinese chestnut (*Castanea mollissima* Blume). Chestnut seedlings were grown as bare root 1-0 seedlings and then out-planted on three southern National Forests in 2009. We present 3-year results from these plantings that indicate chestnuts are capable of fast growth but may be susceptible to animal, insect, and disease pressure. Early indications are that the putatively blight-resistant generation, commonly referred to as the BC3F3 generation, resembles pure American seedlings in growth and phenology. We also report silvicultural considerations for field tests and reforestation efforts as well as partnerships that contributed to these activities.

[1]Research Forester (SLC), U.S. Forest Service, Southern Research Station, Ellington Plant Sciences Building, 2431 Joe Johnson Drive, Knoxville, TN 37996; Professor (SES), University of Tennessee, Department of Forestry, Wildlife, and Fisheries; Professor (AMS), University of Tennessee, Animal Science Department; Chief Scientist (FH), American Chestnut Foundation. SLC is corresponding author: to contact, call 865-974-0932 or email at stacyclark@fs.fed.us.

USING THE DENDROCHRONOLOGY PROGRAM LIBRARY (dplR) TO DOCUMENT THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON TREE GROWTH IN A KENTUCKY FOREST

Jared M. Craig, John M. Lhotka, and Jeffrey W. Stringer[1]

Dendrochronology is one of the most valuable methods of examining historical changes in forest growth and development. This study utilized manual dating techniques and statistical packages in conjunction with climatic data and forest records to assess the response of oak stands given various environmental conditions and disturbances. Three related sites located in the Knobs region of Kentucky were used for the study. All sites were oak-dominated stands typical of the area with a mean site index of 64 feet and average age of 110 years. Using the dendrochronology program library (dplR) for the R statistical language, cores were cross-dated, annual growth was standardized, and a master chronology was constructed. Historic weather data were then combined with forest records to create a timeline of site and regional-level events that occurred over the life of the stand. This timeline was then compared to the ring-width index value for each year within the master chronology to evaluate the response of stands to the historic environmental conditions and disturbances present in the study area.

[1]Graduate Research Assistant (JMC), University of Kentucky, Department of Forestry, 210 Thomas Poe Cooper Forestry Building, Lexington, KY 40546; Assistant Professor (JML) and Extension Professor (JWS), University of Kentucky, Department of Forestry. JML is corresponding author: to contact, call 859-257-9701 or email at john.lhotka@uky.edu.

SYNTHESIS OF UNDERPLANTING OAKS TO SUSTAIN FUTURE OAK STOCKING

Daniel C. Dey, Emile S. Gardiner, Callie Schweitzer, John M. Kabrick, and Douglass F. Jacobs[1]

Oaks (*Quercus* spp.) are one of the most important tree taxa in the northern hemisphere with about 600 species. Although they are dominant in mixed-species forests and widely distributed, there are reports of regeneration failures worldwide and sustaining or increasing levels of oak stocking is problematic. Their ecological and economic value is almost unsurpassed by any other single genus, and forest succession to non-oak species is of great conservation concern.

The development of an adequate population of large oak advance reproduction is a critical prerequisite to successful oak regeneration, and hence sustainability of oak. The current state of many oak forests is that they lack oak advance reproduction, it is present but sparse, or it is abundant but small in size. Silvicultural practices that increase oak's regeneration potential permit oak seedlings to accumulate in the forest understory and to grow in size, and in particular root mass before the final regeneration harvest is done. Light in the understory is often cited as a limiting factor to accumulation and growth of oak advance reproduction, often occurring at levels at or below the light compensation point for oak. Light levels (20 to 50% +) sufficient for biomass production in oak reproduction results through management of the overstory, midstory, and understory density and composition. Stand thinning, shelterwood and group selection harvesting, and midstory removal have been used to promote development of oak advance reproduction. Artificial regeneration of oak by underplanting in thinned stands or in shelterwoods is done to supplement natural populations of oak seedlings or to introduce oak in stands where it is missing. Various stock types have been tested and the importance of stock quality is well-established. We review and synthesize the literature on silvicultural approaches to using artificial regeneration to obtain successful oak regeneration that is grounded in fundamental principles of oak biology and ecology.

[1]Research Forester (DCD), U.S. Forest Service, Northern Research Station, 202 Natural Resources Building, Columbia, MO 65211; Research Forester (ESG and CS), U.S. Forest Service, Southern Research Station; Research Forester (JMK), U.S. Forest Service, Northern Research Station; Professor (DFJ), Purdue University, Department of Forestry and Natural Resources. DCD is corresponding author: to contact, call 573-875-5341 or email at ddey@fs.fed.us.

IMPACTS OF EMERALD ASH BORER ON FOREST VEGETATION STRUCTURE AND DIVERSITY IN HANCOCK COUNTY, OHIO

Benjamin Dolan[1]

Emerald ash borer (*Agrilus planipennis*) is an Asian beetle that was first discovered in Detroit, Michigan, in 2002. Emerald ash borer (EAB) was most likely transported in ash (*Fraxinus* spp.) wood that was used for stabilizing cargo in ships. The beetle has been spreading throughout the Central Hardwood Region since its introduction, and the ash population has been declining in response. EAB larvae feed on ash phloem and leave feeding grooves that impede nutrient and water transport, leading to mortality. EAB was identified in Hancock County, Ohio, in 2007, and the succession of vegetation that will occur after the disappearance of ash is unknown. It is hypothesized that vegetation diversity will decrease, sugar maple (*Acer saccharum*) will become dominant, and invasive plant species abundance will increase as a result of gaps created by ash tree mortality. Sites selected for this study include mature forests typical of northwest Ohio and are characterized by beech-maple and elm-ash forests. Vegetation sampling began in May 2010, prior to EAB-induced mortality, and will continue annually as ash succumbs to the invasive insect. Models predicting the potential change in vegetation indicate that sugar maple will become dominant immediately following ash death and will remain dominant over time in all but riparian and drier locations. Preliminary results indicate that green ash (*F. pennsylvanica*) is a generalist that binds divergent communities, which become more distinct upon removal of ash. Future composition of forest vegetation in northwest Ohio will be predicted with community succession models.

[1]Assistant Professor, University of Findlay, Department of Natural Sciences, 2218 300 Davis St., Findlay, OH 45840. To contact, call 419-434-5530 or email at dolan@findlay.edu.

DEMAND DRIVEN INDICATORS AND INNOVATIONS FOR THE GREEN BUILDING SECTOR

Greg Estep and David B. DeVallance [1]

Housing starts in the United States have decreased from approximately 2 million in 2005 to fewer than 600,000 in 2010. Products such as flooring, cabinetry, and mouldings produced from Appalachian hardwoods are heavily tied to new housing starts and consequently have suffered a similar decrease in demand. Opportunity exists in the Nation as the green building sector's market value is expected to increase by approximately 19.5 percent annually over the next 5 years. Much of the demand in the green building market is fueled from individual and corporate recognition of the environmental and energy savings associated with these standards of building. Green building standards require some form of forest certification, such as FSC, SFI or ATFS, to count the use of wood products towards meeting green building certification. However, supplying certified wood products to the green building market is not necessarily enough to ensure utilization of the material. For Appalachian hardwood producers to effectively penetrate green market sectors, it is important to fully understand the preferences and needs of the material specifiers of green building projects. Our study aims to determine the preferences and needs of green material specifiers within the Appalachian region through a direct mail survey. Survey results will relay material specifiers' views and ability to source green wood products within their region. Current and future demands for green wood products will be presented.

[1]Graduate Research Assistant (GE), and Assistant Professor (DBD), West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506; DBD is corresponding author: to contact, call 304-293-0029 or email at david.devallance@mail.wvu.edu.

ADVANCED OAK SEEDLING DEVELOPMENT AS INFLUENCED BY SHELTERWOOD TREATMENTS, FERN CONTROL, DEER FENCING, AND PRESCRIBED FIRE

Kurt W. Gottschalk, Gary W. Miller, and Patrick H. Brose[1]

Advanced northern red oak (*Quercus rubrum*) seedlings in an 80-year-old forest located in north-central Pennsylvania were observed for 8 years after manipulation of overstory density, herbicide control of interfering plants, exclusion of deer by fencing, and application of a single prescribed fire. Twenty-four treatment combinations including untreated controls were studied on 72 permanent plots. Published dominance probabilities for site index 70 were applied to the average size and number of tagged advanced seedlings in each plot to determine which treatments produced the greatest predicted number of codominant oaks in the next stand after final harvest. Exclusion of deer by fencing combined with a moderate (30% of basal area) to high (50% of basal area) removal of the overstory and herbicide control of hayscented fern (Dennstaedtia spp.) led to the most promising development of advanced oak seedlings in preparation for final overstory removal. Two of the 24 treatments met the SILVAH guidelines for overstory removal after 10 years, but just over half of the treatments would provide adequate oak regeneration using dominance probabilities to project success. Oak seedling development and suggestions for writing silvicultural prescriptions to prepare for successful oak regeneration are discussed.

[1]Research Forester and Project Leader (KWG), U.S. Forest Service, Northern Research Station, 180 Canfield Street, Morgantown, WV 26505; Research Foresters (GWM and PHB), U.S. Forest Service, Northern Research Station. KWG is corresponding author: to contact, call 304-285-1598 or email at kgottschalk@fs.fed.us.

FIVE- AND SEVEN-YEAR DOMINANCE PROBABILITIES FOR OAK SEEDLINGS AND STUMP SPROUTS IN PENNSYLVANIA

Kurt W. Gottschalk, Gary W. Miller, and Patrick H. Brose[1]

The probability of survival and dominance of advanced oak regeneration stems and stump sprouts at 5 or 10 years postharvest is correlated with their preharvest size and vigor. A study was designed to: 1) determine the survival and dominance probabilities of oak advanced regeneration and stump sprouts for 5, 7, and 10 years after final removal cuts, and 2) determine if these probabilities vary significantly by ecological classification. Thirty-one timber sales in Pennsylvania state forests and Collins Pine property are included in the study, representing 6,235 tagged seedlings and 1,776 tagged stumps in four ecological sections. The 5-year data shows that 75 percent of the advance regeneration is still alive. Stump sprouts had higher losses with 66 percent mortality at 5 years. The surviving stumps had 5-year dominance probabilities of 0.38 and 7-year probabilities of 0.30 with smaller stumps having higher probabilities than larger stumps.

Classifying oak advanced regeneration as new seedlings (<0.25 in. root collar diameter [RCD]), established seedlings (RCD ≥0.25 in. and <0.75 in.), and competitive seedlings (RCD ≥0.75 in.), the larger the initial size of the seedling, the taller the 5-year old stem and the greater its dominance probability (new = 0.34, established = 0.57, competitive = 0.69). For 7-year-old seedlings, dominance probabilities were new=0.22, established=0.43, and competitive=0.62. Dominance probabilities reported here are greater than published values for other areas but will probably decline as crown closure occurs. A more conservative measure, free-to-grow produced much lower probabilities at age 5 years (new=0.04, established=0.13, competitive=0.27) and for age 7 years (new =0.1, established =0.16, competitive=0.3). Five-year and 7-year heights for the largest group of seedlings are on pace to match Schnur's site index curves for eastern oak forests (Schnur 1937).

Oak advanced regeneration dominance probabilities vary with initial seedling size with larger seedlings having higher probabilities. Five and 7 years postharvest is too early for final probabilities as crown closure has not been reached.

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[1]Research Forester and Project Leader (KWG), U.S. Forest Service, Northern Research Station, 180 Canfield Street, Morgantown, WV 26505; Research Forester (GWM and PHB), U.S. Forest Service, Northern Research Station. KWG is corresponding author: to contact, call 304-285-1598 or email at kgottschalk@fs.fed.us.

CAN A PREHARVEST HERBICIDE TREATMENT FAVOR OAK REGENERATION IN A SHELTERWOOD HARVEST?

Todd F. Hutchinson, Joanne Rebbeck, and Daniel A. Yaussy[1]

In 2005, we began a study of tree regeneration in mixed-oak forests at three sites in southern Ohio. At each site, all non-oak+hickory competitors >2 inches diameter at breast height (d.b.h.) were stem-injected with herbicide (A.I. glyphosate 54%) in two of four 20-acre units, prior to shelterwood harvest. Five years after the harvest, we recorded the abundance of stump sprouts and advance reproduction by species in twelve 0.08-acre plots per unit (144 total plots). In nonherbicide units, stump sprouts of competing species (primarily red maple) were two times more abundant (97 sprouting stumps/acre) than that of oaks+hickories (44/acre). By contrast, stump sprouts of competitors (45/acre) and oaks+hickories (52/acre) were equally abundant in herbicide-treated units. For tall advance reproduction (stems >4.5 feet tall), competitors were about six times more abundant than oaks+hickories, regardless of herbicide treatment. The major competitors were red maple, yellow-poplar, blackgum, and sassafras. Smaller oak+hickory advance reproduction (1 to 4.5 feet tall) was moderately abundant on both nonherbicide (2,444 stems/acre) and herbicide-treated plots (1,735 stems/acre) but was typically overtopped. We concluded that, although herbicide treatments reduced the abundance of competing stump sprouts, oak+hickory advance reproduction was still being outcompeted and additional treatments such as prescribed fire are needed to retain oak dominance in the future stands.

[1]Research Ecologist (TFH), Research Plant Physiologist (JR), and Research Forester, retired (DAY), U.S. Forest Service, Northern Research Station, 359 Main Road, Delaware, OH 43015. TFH is corresponding author: to contact, call 740-368-0064 or email at thutchinson@fs.fed.us.

RESTORING BOTTOMLAND HARDWOODS: A SYNTHESIS OF TECHNIQUES AND METHODS

John M. Kabrick, Daniel C. Dey, J.W. Van Sambeek, Kyle L. Steele, Dawn E. Henderson, and Douglass F. Jacobs[1]

Restoring bottomland hardwoods in former agricultural fields has remained a challenge, and a number of Federal and statewide efforts to re-establish bottomland hardwoods have largely met with failure. High tree mortality due to herbivory, flooding, and intense competition by other native and invasive plant species has plagued management efforts. Here we summarize the findings from a number of studies conducted throughout the central United States to determine specific management methods and techniques for successful tree establishment. In these studies we examined the influence of native and invasive ground flora, cover crops, slow-release nitrogen fertilizers, animal browse, soil bedding, planting stock type, flooding, and species suitability on the survival and growth of hardwood seedlings. Most flora recolonizing abandoned crop fields were invasive agricultural species including Johnsongrass (*Sorghum halepense* [L.] Pers.), reed canarygrass (*Phalaris arundinacea* L.), hedge false bindweed (*Calystegia sepium* [L.] R. Br.), lambsquarter (*Chenopodium album* L.), and pigweed (*Amaranthus* L.). Redtop grass (*Agrostis gigantea* Roth) as a cover crop reduced recolonization of both native and invasive species but had the added benefit of reducing herbivory. Application of slow-release nitrogen fertilizers on the alkaline soils failed to improve sapling growth. Restoring microtopography through soil bedding improved drainage and other soil properties but only increased the growth of seedlings in clayey, poorly-drained soils. Containerized planting stock consistently had higher survival than bare-root stock under a variety of hydrologic conditions. Surprisingly, most bottomland oaks are fairly tolerant to short-duration growing season floods. Collectively, these findings provide a variety of techniques and methods than can be tailored to the site conditions to optimize the establishment of bottomland hardwood seedlings.

[1]Research Foresters (JMK and DCD) and Research Plant Physiologist (JWV), U.S. Forest Service, Northern Research Station, 202 Natural Resources Building, University of Missouri, Columbia, MO 65211; Ecological Site Inventory Specialist (KLS), U.S. Natural Resources Conservation Service; Ecologist (DEH), Missouri Department of Conservation; Professor (DFJ), Purdue University, Department of Forestry and Natural Resources. JMK is corresponding author: to contact, call 573-875-5341 or email at jkabrick@fs.fed.us.

QUANTIFYING SEEDLING FLOOD TOLERANCE IN AN OUTDOOR FLOOD TOLERANCE LABORATORY

John M. Kabrick, Daniel C. Dey, J.W. Van Sambeek, Mark V. Coggeshall, and Douglass F. Jacobs[1]

Ensuring successful hardwood tree establishment requires matching the ecological requirements and tolerances of the species to the environmental conditions of the planting site. In bottomlands, it is particularly important that the planted seedlings are tolerant of the present-day flood regime. Although much is known about the factors that influence flood tolerance, flood tolerance ratings remain largely qualitative. Here we report on an effort to more quantitatively examine flood tolerance by measuring the survival and growth after flooding of six bottomland species common throughout much of eastern North America in a state-of-the-science outdoor flood tolerance laboratory that allows for the control of the timing, duration, and nature of flooding. We evaluated 600 plants each of six species including eastern cottonwood (*Populus deltoides*), pin oak (*Quercus palustris*), swamp white oak (*Q. bicolor*), bur oak (*Q. macrocarpa*), black walnut (*Juglans nigra*), and pecan (*Carya illinoensis*). All stock was from the Missouri State Nursery and included cuttings for cottonwood and 1-0 bareroot stock for all other species. Flood treatments included partial inundation to 15 to 20 cm for 5-week flowing, 5-week stagnant, 3-week flowing, and control and were replicated in space and time. For each experiment, plants were established in April, flood treatments were initiated in May, and seedling survival and growth (including shoot length, the number of flushes, and the cumulative flush length) were evaluated at the end of the growing season in September. Survival data were analyzed using logistic regression and growth was analyzed using linear models. Cottonwood maintained moderate survival probability (0.62) and high growth but had a significant basal diameter growth reduction with increased flood duration. Bur oak, swamp white oak, and pin oak each had greater survival probabilities than cottonwood, exceeding 0.77 regardless of treatment. Swamp white oak maintained positive growth and maintained healthy dark green foliage in all treatments and bur oak and pin oak suffered shoot growth losses and exhibited chlorotic foliage in flood treatments. Pecan maintained high survival (0.78) but suffered dieback. Black walnut had the lowest survival (0.11) and growth with increasing flood duration. Our findings show both consistencies and discrepancies with published flood tolerance ratings for these species. There generally is good agreement in the literature that black walnut is intolerant and eastern cottonwood is tolerant to very tolerant of flooding, as our findings confirm. Higher cottonwood survival probabilities may have been achieved with planted seedlings rather than with cuttings. However, the published flood tolerances of the bottomland oaks that we examined ranged from intolerant to tolerant and no single species consistently was rated in the literature as more tolerant than the others. Our findings strongly suggested that swamp white oak is more tolerant to flooding than are the other oaks we examined and appears to tolerate flood treatments better than did eastern cottonwood cuttings, suggesting its suitability for planting in a variety of bottomlands.

[1]Research Forester (JMK), Research Forester (DCD), and Research Plant Physiologist (JWV), U.S. Forest Service, Northern Research Station, 202 Natural Resources Building, University of Missouri, Columbia, MO 65211; Research Assistant Professor (MVC) University of Missouri, Center for Agroforestry; and Professor (DFJ), Purdue University, Department of Forestry and Natural Resources. JMK is corresponding author: to contact, call 573-875-5341 or email at jkabrick@fs.fed.us.

COMPARISON OF TWO STEM INJECTION TREATMENTS APPLIED TO AMERICAN BEECH IN CENTRAL WEST VIRGINIA

Jeffrey D. Kochenderfer, Gary W. Miller, and James N. Kochenderfer[1]

Efficacies for two herbicide stem injection treatments on American beech (*Fagus gandifolia* Ehrh.) and impacts to nontarget residual trees were evaluated in central West Virginia. The treatments consisted of hack-and-squirt injection of all beech stems >1.0 in. to 9.9 in. diameter at breast height (d.b.h.) with either imazapyr as Arsenal® (28.7%) or glyphosate as Razor® Pro (41%) in water carriers. The treatments were applied in September 2008 and evaluated 12 months after treatment. Complete control of injected stems was achieved with both treatments, however, treatment efficacy on untreated beech stems >1.0-ft tall and >0.9 in. d.b.h. was higher on the Arsenal® treatments. No damage occurred to any desirable overstory species such as black cherry (*Prunus serotina* Ehrh.) or red maple (*Acer rubrum* L.) trees that were located on all the treatment plots. Land managers can use the hack-and-squirt injection treatments described in this study to control injected trees and a large proportion of smaller beech root sprouts associated with them.

[1]Silviculturist (JDK), U.S. Forest Service, Monongahela National Forest, Petersburg, WV; Research Forester (GWM), U.S. Forest Service, Northern Research Station; Retired Research Forester (JNK), U.S. Forest Service, Northern Research Station. GWM is corresponding author: to contact, call 304-285-1521 or email at gwmiller@fs.fed.us

INVASION AND SPREAD OF INVASIVE PLANTS IS A MAJOR PROBLEM WITHIN FORESTED ECOSYSTEMS

Chris B. LeDoux, Danielle K. Martin, and Cynthia D. Huebner[1]

Invasive plants can displace existing vegetation and in some cases take over the site entirely. With the displacement of native vegetation comes ecosystem changes that may jeopardize ecological processes and functions and habitat for wildlife. The disturbance caused during timber harvesting processes creates conditions whereby invasive plants may get established and/or spread. The machinery and traffic movement within a job site may serve to introduce and spread seeds, roots, and plant parts from one job site to another. In an upcoming general technical report (LeDoux and Martin, in press) to be published by the U.S. Forest Service, Northern Research Station, we address the timber harvesting processes and the disturbance that is created, how seeds, roots, and plant parts of invasive plants can be spread, and propose voluntary BMPs for invasive plant mitigation during timber harvesting operations.

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[1]Industrial Engineer (CBL), U.S. Forest Service, Northern Research Station, 180 Canfield Street, Morgantown, WV 26505; Plant Pathologist (DKM), U.S. Forest Service, Northeastern Area State & Private Forestry; Research Botanist (CDH), U.S. Forest Service, Northern Research Station. CBL is corresponding author: to contact, call 304-285-1572 or email at cledoux@fs.fed.us.

RESPONSES OF NORTHERN RED OAK SEEDLINGS TO LIME AND DEER EXCLOSURE FENCING IN PENNSYLVANIA

Robert P. Long, Patrick H. Brose, and Stephen B. Horsley[1]

In Pennsylvania, two hypotheses compete for explaining the chronic oak (*Quercus* spp.) regeneration problem: excessive deer browsing and soil cation depletion. We tested these hypotheses by evaluating the effect of forest liming and deer exclosure fencing on northern red oak (*Q. rubra*) seedling growth and nutrition in five oak shelterwood stands in Pennsylvania over 6 years. In each stand, four planting plots were located inside of a 2.4 m high woven wire fence and another four were established outside of the fence. About 225 northern red oak acorns were planted in each plot in spring 2004. Dolomitic limestone was applied to randomly selected plots at rates of 0, 4.5, 9.0, and 13.5 Mg ha^{-1} during May 2004. There were no statistically significant ($P \leq 0.05$) growth responses to lime applications. The only significant growth responses resulted from the fence versus no fence treatment. A significant ($P < 0.003$) fence-by-year interaction for seedling height and root collar diameter indicates differential impacts of deer browsing. By 2009, height of seedlings inside fences averaged 32 cm while seedlings outside of fences averaged 17 cm. Similarly, root collar diameter averaged 6.6 mm outside of fences and 9.1 mm inside fences. Fencing had a significant effect on seedling biomass components evaluated at the conclusion of the study, with seedlings inside fences having greater root length and total dry weight biomass than seedlings grown outside of fences. Application of up to 13.5 Mg ha^{-1} lime will not accelerate northern red oak seedling growth.

[1]Research Plant Pathologist (RPL), Research Forester (PHB), and Research Plant Physiologist, retired (SBH), U.S. Forest Service, Northern Research Station, P.O. Box 267, Irvine, PA 16329. RPL is corresponding author: to contact, call 814-563-1040 or email at rlong@fs.fed.us.

TWO DECADES OF CHANGE IN THE COMPOSITION AND STRUCTURE OF OLD-GROWTH FORESTS IN THE CENTRAL HARDWOOD REGION

Christy Lowney, Michael Jenkins, Martin Spetich, Stephen Shifley, and Bradley Graham[1]

The Central Hardwood Region has historically been dominated by oak forests, woodlands, and savannas. Through the clearing of land for agriculture and infrastructure, the amount of forested land in Indiana has been reduced, leaving small patches of remnant oak and oak/hickory old-growth forests often less than 30 ha in size. Fragmentation coupled with the removal of fire from the landscape is resulting in a compositional shift in these forests. Forests previously dominated by oak (*Quercus*) and hickory (*Carya*) species are shifting to dominance by maple (*Acer saccharum* and *A. rubrum*) and American beech (*Fagus grandifolia*). To gain a better understanding of long-term changes in old-growth forests of the Central Hardwood Region, permanent plots were established in five remnant old-growth forests throughout Indiana in 1992-93 and remeasured in 2011. Thirty plots were sampled in each forest. At each site, data were collected to assess changes in ground cover, seedlings, saplings, shrubs, and trees. Data from these five forests will be used to examine overstory mortality, with a focus on the dominant oak cohort, and compare changes in the density and basal area between 1992-93 and 2011. At most of the sites, preliminary results show an increase in overstory sugar maple (stems ≥10 cm diameter at breast height), suggesting that these stands will be dominated by shade-tolerant species in the future.

[1]Graduate student (CL and BG), Associate Professor (MJ), Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN 47907; Research Forester (MS), U.S. Forest Service, Southern Research Station; Research Forester (SS), U.S. Forest Service, Northern Research Station. MJ is corresponding author: to contact, call 765-494-3602 or email at at jenkinma@purdue.edu.

COMPOSITION AND STRUCTURE OF EASTERN HEMLOCK FOREST ECOSYSTEMS OF NORTHEASTERN OHIO PRIOR TO HEMLOCK WOOLLY ADELGID INFESTATION

Thomas D. Macy, David M. Hix, and P. Charles Goebel[1]

Ohio's eastern hemlock (*Tsuga canadensis* L.) forest ecosystems provide important ecological and economic benefits to the State. Since its introduction in the 1950s, hemlock woolly adelgid (*Adelges tsugae* Annand; HWA), an invasive insect native to Japan, has been causing widespread mortality of eastern hemlock in an expanding portion of its range. In January 2012, the first known HWA infestation in Ohio was discovered in the southeastern portion of the state. Before this introduced pest reaches eastern hemlock swamp forests of the Erie Lake Plain and stream-ravine forests of the glaciated Allegheny Plateau in northeastern Ohio, understanding their current composition and structure is critical for predicting potential pathways of stand development in response to the possible decline of eastern hemlock. Vegetation (trees, saplings, and ground flora), down woody debris, and canopy closure (via hemispherical photography) data were measured on 0.2-hectare plots at seven sites throughout northeastern Ohio. Samples of the soil seed bank were also collected to determine plant species present in the forest floor. Preliminary analyses show that the importance value of eastern hemlock at these sites ranges from 33 to 95 percent. On 94 percent of the plots, eastern hemlock was the only coniferous tree species present, meaning the potential loss of this foundation species would drastically affect species composition and functional processes. Future development patterns are being examined using the Forest Vegetation Simulator in conjunction with the Hemlock Woolly Adelgid Event Monitor to simulate HWA-induced mortality and predict stand growth and development.

[1]Graduate student (TDM), Associate Professor (DMH), Ohio State University, School of Environment and Natural Resources, Columbus, OH 43210; Associate Professor (PCG), Ohio State University, Agricultural Research and Development Center. DMH is corresponding author: to contact, call 614-292-1394 or email at hix.6@osu.edu.

TO WHAT EXTENT ARE WOODLAND NEIGHBORS TALKING? AN ASSESSMENT OF INTERACTIONS BETWEEN ADJACENT WOODLAND OWNERS

Megan McCuen and David W. McGill[1]

Most of West Virginia's forested land is owned by private landowners. When combined, individually owned woodlands significantly impact the whole landscape. Working across property boundaries is one way to promote enhanced environmental quality and to make woodland activities more financially rewarding. As natural resources management agencies focus on landscape-scale conservation, cross-boundary cooperation becomes increasingly important. We developed a survey to assess the extent, frequency, content, and quality of communication and cooperation among adjacent woodland owners. The purpose of the survey is to gain knowledge about West Virginia woodland owners, what they do in their woodlands, and their experiences working with their neighbors. Results will be published in McCuen et al. (in press).

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[1]Graduate Research Assistant (MM) and Professor and Extension Specialist (DWM), West Virginia University, Appalachian Hardwood Center, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506. DWM is corresponding author: to contact, call 304-293-5930 or email at dmcgill@wvu.edu.

ASSESSING PAST EPICORMIC DYNAMICS IN POLE-SIZE WHITE OAK LOGS WITH CT SCANNING

Andrew Meier, Rado Gazo, Charles H. Michler, and Michael R. Saunders[1]

White oak (*Quercus alba* L.) is one of the most valuable and ubiquitous species in the Central Hardwoods Forest Region (Rogers 1990). It is also well-known for its tendency to form epicormic sprouts (Johnson et al. 1998), potentially leading to decreased log value. Epicormic branching is a phenomenon that is still poorly understood (Meadows 1995), though there is strong evidence that both genetics (Bowersox and Ward 1968) and tree vigor (Johnson et al. 1998) are important factors that influence sprouting in individual trees. Many studies have assessed external epicormic characteristics, however, there is increasing evidence that prior epicormic development may be an important determinant of current epicormic status (Colin et al. 2010, Morisset et al. 2012). The objective of this study was to quantify the number and development of epicormic bud traces evident in white oak logs in terms of genetics and tree vigor, using computed tomography (CT) scanning as a tool to rapidly assess a large sample of logs (Colin et al. 2010, Morisset et al. 2012). We also hoped to determine whether there was a correlation between regular branch formation and formation of epicormics. White oak logs for this study were removed as part of a crop tree release treatment in two 28-year-old white oak progeny tests in Indiana, at the Jasper-Pulaski Fish and Wildlife Area (JP) and the Harrison-Crawford State Forest (HC). In 2006, all trees in the plantations were ranked qualitatively for epicormic branching; family averages for these rankings were calculated and families with the highest, lowest and median values were assigned to corresponding epicormic classes (EpiC). A subset of families from these classes was selected for study. Within selected families, individuals were identified based on canopy classes (Can), with the objective of selecting trees of high and low vigor from each family for analysis. External counts of epicormic branches were made on the bottom 12-foot section of each selected tree in January and February of 2010; trees were then felled and the second 4-foot section was removed for CT scanning. Logs were scanned using a GE Lightspeed QX/i multislice helical CT scanner (General Electric, Fairfield, CT) at the Purdue University College of Veterinary Medicine. Resulting images were analyzed manually using open access ImageJ software with the cell-counter plug-in. Epicormic structures were characterized by their size and development. They were also classified as primary or secondary, with primary traces originating at the pith of the main stem and secondary traces originating at the pith of another branch. Distinctions were based largely on the descriptions of epicormic structures from Fontaine et al. (1999) and Colin et al. (2010). In general, the number of epicormic traces per tree was quite variable and not significantly different between sites, about 55 (sd = 24.4) at JP and 47 at HC (sd = 27.3). The number of regular branches per tree was identical at both sites (21.3; JP sd = 3.8, HC sd = 4.6) and did not differ between EpiC or Can. It is therefore improbable that the number of regular branches can explain tree-to-tree variation in epicormics. No significant differences were detected between either Can or EpiC in either the total number of epicormic traces or PS. For EpiC, both the percent of unsprouted traces (Pr > chi-square = 0.04) and the number of large epicormic traces (maximum diameter >2.5 inches) (Pr > chi-square = 0.01) were significantly different between classes, suggesting that there may be some genetic difference in epicormic sprouting and branch persistence. Further analyses will relate growth parameters, such as radial increment, tree diameter, and crown volume with the internal development of epicormic structures.

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[1]Forest Project Coordinator (AM), Professor (RG), and Assistant Professor (MRS), Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN 47907; Program Manager (CHM), U.S. Forest Service, Northern Research Station. AM is corresponding author: to contact, call 765-494-1472 or email at meiera@purdue.edu.

SURFACE ENERGY ANALYSIS ON HOT-WATER EXTRACTED AND TORREFIED APPALACHIAN WOOD SPECIES FOR PELLET PRODUCTION

Gloria S. Oporto, Juan C. Carrasco, Tuhua Zhong, David B. DeVallance, and R.H. Jara[1]

Our research evaluated the surface area and surface energy properties of pretreated underutilized renewable biomass composed of red oak (*Quercus rubra*) and yellow-poplar (*Liriodendron tulipifera*.) regarding their feasibility to be densified. The pretreatments consisted of hot water extraction and torrefaction processes. The extraction process was performed at different temperatures and times and the final measurements included extraction yield (weight loss), sugars, and lignin determination. Torrefaction process was performed using two particle sizes of material at two different temperatures and times. Characterization of the torrefied material included calorific value and proximate and ultimate analysis. Nonextracted, extracted, and torrefied material were pelletized at a fixed temperature and time, and mechanical evaluation through flexure measurements on pellets was performed. The surface properties of the pretreated material to evaluate their feasibility for pellet production were evaluated using inverse gas chromatography. Surface area was determined using nonane as a probe and surface energy, i.e., dispersion and acid-base component, was determined through the exposition of all different materials to low vapor concentrations of nonpolar (decane, nonane, octane, heptane) and polar (ethyl acetate, dichloromethane, acetone, 1-propanol) probes. Results indicate that the surface area and surface energy is playing an important role in the final properties of the material which are directly related to the processing and mechanical properties of the wood pellet.

[1]Assistant Professor (GSO), West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506-6125; Graduate Students (JCC and TZ), and Assistant Professor (DBD), West Virginia University, Division of Forestry and Natural Resources; and (RHJ) Unidad de Desarrollo Tecnológico-Universidad de Concepción, Coronel, Chile. GSO is the corresponding author: to contact, call 304-293-2941 or email at gloria.oporto@mail.wvu.edu.

PREDICTING THE IMPORTANCE OF PRESCRIBED FIRE AND MANAGEMENT ACTIVITIES ON THE PRESENCE AND ABUNDANCE OF *AILANTHUS ALTISSIMA* WITHIN FORESTED LANDSCAPES

Joanne Rebbeck[1]

Ailanthus altissima, a highly invasive tree, is present in many forested landscapes in the eastern United States. Although managers often observe an expansion in *Ailanthus* populations following forest disturbances such as harvesting and prescribed burning, there is little empirical data available to confirm. Seed-bearing female *Ailanthus* were aerially mapped (N=98) during the 2008-2009 dormant season within 3,885 ha of Tar Hollow State Forest located in southern Ohio. During the 2009 growing season, a systematic georeferenced 400-m grid of 280 plots was sampled to quantify *Ailanthus* abundance and demography and stand attributes. Harvest and fire disturbance indices were developed by summarizing past timber harvest records over ~65 years and evaluating vegetation impacts of dormant season prescribed burns from 2000 to 2008. A geographic information system (GIS) database of these disturbance indices plus potential seed dispersal patterns, overstory composition and density, distances to seed sources and roads (e.g., skid, logging, hiking, primary, secondary, etc.), and soil moisture was developed. Multiple statistical analyses were performed on distance-time dimensions to determine the extent to which harvesting and/or burning favors the spread of the *Ailanthus*. Classification and regression trees (CART) and Random Forests were used to uncover relationships among these diverse sets of variables. Preliminary analyses found that seed-bearing trees within the forested landscape were more common in areas that had any type of past harvesting activity (81.6%) compared with those in uncut areas (18.4%).

[1]Research Plant Physiologist, U.S. Forest Service, Northern Research Station, 359 Main Road, Delaware, OH 43015. To contact, call 740-368-0054 or email at jrebbeck@fs.fed.us.

EFFECTS OF SHELTERWOOD HARVESTS, PRESCRIBED BURNING, AND DIAMETER-LIMIT CUTTING ON NORTHERN RED OAK (*QUERCUS RUBRA*) UNDERPLANTINGS

Adam Regula, David W. McGill, and Cynthia D. Huebner[1]

Despite the dominance of oak in much of the Central Hardwood Region, there has been a significant and documented decline in regeneration over the past 40 years. As many oak species are of significant ecological, economic, and cultural value, this decline has been the subject of substantial research. Ultimately, management for oak entails the establishment of advanced reproduction of sufficient size and density to provide a high probability of ascendancy to dominant and codominant status. Potential prescriptions for achieving this include manipulating light infiltration and controlling competing vegetation through shelterwood harvests and prescribed burning. Diameter-limit cutting is a primary harvest method used on private forests in the region and creates diverse postharvest conditions which can favor fast growing, shade intolerant competition or shade tolerant species depending on the initial structure of the harvested stand and the minimum diameter harvested. Our study examines the effect of five management regimes on northern red oak (*Quercus rubra*) artificial reproduction through a 2-year assessment of the survival and growth of 1-0 planted bare root seedlings. Treatments consist of: 1) control sites with no disturbance for at least 50 years; 2) a single prescribed burn; 3) repeat prescribed burns; 4) shelterwood harvests (average 40% residual basal area); and 5) diameter-limit cuts removing merchantable trees >16 inches diameter at breast height. Each treatment is replicated on four sites, two within the Allegheny Plateau province and two within the Ridge and Valley province. Transects are established in such a way that each site has two blocks, a northeast and southwest aspect. This allows for comparison across these existing environmental gradients. Seedlings were planted during April and May 2011. Survival was 70 percent overall, with higher survival in the Ridge and Valley (73%) than Allegheny Plateau (64%). Among management regimes, survival was highest under shelterwood harvests (86%) and lowest on control sites (54%). No strong pattern appeared among management regimes regarding height growth. Average height growth was 15 cm in the Allegheny Plateau and 11.8 cm in the Ridge and Valley.

[1]Graduate Research Assistant (AR), Professor and Extension Specialist (DWM), West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506; Research Botanist (CDH), U.S. Forest Service, Northern Research Station. DWM is corresponding author: to contact, call 304-293-5930 or email at dmcgill@wvu.edu.

SEEDBANK COMPOSITION ON FORMER HOME SITES IN A HIGHLY DISTURBED OAK-HICKORY-PINE FOREST

Jamie L. Schuler[1]

The primary mandate of the Hot Springs National Park (HOSP) is the protection and preservation of the geothermal springs and their recharge zones. Since the 1970s, HOSP has acquired and removed structures from more than 300 old home sites within the semi-forested geothermal recharge zone. These former home sites were then allowed to naturally revegetate with the goal of establishing new areas of native upland oak-hickory-pine forests. However, several species of invasive, nonnative plants have aggressively colonized these disturbed lands, are out-competing native vegetation, and are threatening the overall health, structure, and functions of the upland forest ecosystem. Initial management activities have focused on the targeted removal of the invasive species, often without consideration of the subsequent recruitment potential of native species. To assess the likelihood that native species will regenerate if the existing nonnative species are removed, the soil seedbank was sampled in stands representing three time periods: <10 yr, 10 to 20 yr, and 60+ yr after disturbance. Results indicate that stands on the recently (<10 yr) disturbed home sites had moderate numbers of nonnative woody germinants, while stands that were disturbed 10 to 20 yr ago had high numbers of nonnative germinants. By contrast, the seedbank sampled from native forests that were undisturbed for more than 60 yr contained almost no nonnative species. The results highlight the significant problems associated with managing established, nonnative species in recently disturbed landscapes.

[1]Assistant Professor, West Virginia University, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506. To contact, call 304-293-3896 or email at jamie.schuler@mail.wvu.edu.

USING ECOLOGICAL SITES TO GUIDE SPECIES SELECTION IN BOTTOMLAND HARDWOOD PLANTINGS

Kyle L. Steele, Jason L. Villwock, John M. Kabrick, and Randy G. Jensen[1]

In bottomland afforestation efforts, site conditions related to flood duration, soil drainage, and nutrient supply greatly affect tree seedling survival and growth. Ecological classification systems group land units by site conditions resulting from different soil properties on varying landform positions into ecological sites that greatly influence tree seedling establishment success. Here we report the first-year survival and growth of 12 bottomland species planted on five different ecological sites. Results to date show that both seedling survival and growth (diameter and height) were not different across ecological sites. Most species responded similarly to ecological site, with the exception of cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), and river birch (*Betula nigra*). All 12 species planted had survival between 88 and 95 percent with the exception of cottonwood which had 41 percent. However, surviving cottonwood had significantly greater ($P<0.01$) height and diameter growth compared to all species. After cottonwood, both sycamore and river birch had significantly ($P<0.01$) greater height and diameter growth. For species by treatment effects, sycamore had significantly greater ($P<0.01$) diameter growth on mesic high-elevation floodplains while cottonwood had significantly greater ($P<0.01$) diameter growth on mesic terrace landforms (both contain silty-textured soils). These findings complement several research projects in Missouri that have studied specific management techniques to improve the success of old field bottomland reforestation including evaluating seedling stock type, use of cover-crops, use of various herbicides, tree species, seedling flood tolerance, soil mounding, and seedling caging. This information is useful to field managers who are interested in making bottomland reforestation efforts most successful by selecting the appropriate species for sites with varying soil moisture, texture and flooding frequencies. Early results appear to show that ecological sites having silty-textured soil occurring on high floodplains and terraces provide optimal growing conditions for survival and growth of planted seedlings. Other ecological sites may require additional management input.

[1]Ecological Site Inventory Specialist (KLS), U.S. Natural Resources Conservation Service, MLRA Region 10, 1400 West Main Street, Albert Lea, MN 56007; Resource Forester (JLV), Missouri Department of Conservation; Research Forester (JMK), U.S. Forest Service, Northern Research Station; Resource Scientist (RGJ), Missouri Department of Conservation. KLS is corresponding author: to contact, call 507-373-7960 or email at kyle.steele@usda.gov.

BEST MANAGEMENT OPPORTUNITY MODEL USED FOR RESTORING CHESTNUT TO THE LANDSCAPE

Scott Tepke, Veronica A. Lopez, and Jeanne M. Hickey[1]

American chestnut (*Castenea dentata*), once common to forests of the eastern United States, has been nearly extirpated by a fungal disease called the chestnut blight (*Cryphonectria parasitica*). Efforts by the American Chestnut Foundation have led to sixth generation hybrid chestnut trees with an increase in resistance to the blight. To increase the opportunity for chestnut to grow and reproduce on the landscape, selecting optimal sites to grow chestnut is imperative. A model was developed to aid in selecting sites. A literature review indicated that American chestnut performance is tied to soil type characteristics. To create a model that would select optimal site characteristics, data layers were ranked. Soil types were ranked by soil drainage characteristics, and forest types were ranked by association with American chestnut. A 200-foot buffer was applied to drainages to avoid soil inclusions and water quality issues. Aspect and slope data were used to refine the model within each optimal site. The study area, the Millsteck Project in the southern part of the Allegheny National Forest, was used to test and verify the model. Allegheny National Forest geographic information system (GIS) specialists analyzed the data and created a map of optimal sites within watersheds, and then overlaid the Millsteck silviculture treatment areas. Treatment areas proposed for regeneration treatments that overlaid best management sites were selected for field evaluation. Sites were visited to evaluate the feasibility of establishing chestnut restoration sites and seed production plantings. By modeling the best opportunity areas, land managers will be able to improve the success rates of chestnut restoration efforts.

[1]Forester (ST), U.S. Forest Service, Allegheny National Forest, 131 Smokey Lane, Marienville, PA 16239; GIS Specialist (VAL) and GIS Coordinator (JMH), U.S. Forest Service, Allegheny National Forest. ST is the corresponding author: to contact, call 814-927-6628 or email at stepke@fs.fed.us.

WHEN ONE IS NOT A LONELY NUMBER: INITIAL COLONIZATION DYNAMICS OF HEMLOCK WOOLLY ADELGID (*ADELGES TSUGAE*)

Patrick C. Tobin, Richard M. Turcotte, and Daniel Snider[1]

A central and ongoing question in invasion ecology is why establishment success in a new environment varies so markedly among and within species. In many low-density populations of invading insects, establishment success can be challenged by stochasticity and Allee effects, which can arise due to the inability to find suitable mates, saturate natural enemies, and overcome host plant defenses in sparse populations. The hemlock woolly adelgid, *Adelges tsugae*, is a nonnative species that attacks and kills eastern North American species of hemlock. However, there is little information regarding its invasion success at low densities. Because *A. tsugae* reproduces asexually and natural enemies are rare or absent in expanding populations, many of the documented causes of an Allee effect in insect populations are not relevant to its invasion dynamics. We inoculated hemlock trees with varying densities of *A. tsugae* over 2 years and observed a positive relationship between density and colonization success. In some cases with an initial density of one ovisac per tree, we observed successful establishment, development, and the initiation of a subsequent generation. Understanding the drivers of initial establishment success could be useful in developing more effective management strategies against this nonnative pest.

[1]Research Entomologist (PCT), U.S. Forest Service, Northern Research Station, 180 Canfield Street, Morgantown, WV 26505; Entomologist (RMT) and Forester (DS), U.S. Forest Service, Northeastern Area, State and Private Forestry. PCT is corresponding author: to contact, call 304-285-1514 or email at ptobin@fs.fed.us.

NATURAL REGENERATION IN WEST VIRGINIA: SURVEY OF ISSUES FACING NATURAL RESOURCES PROFESSIONALS

Ellen Voss and David W. McGill[1]

Most forest regeneration in West Virginia is natural hardwood regeneration. A lack of information about problems with forest regeneration has been identified as a significant data gap by the West Virginia Division of Forestry. A great deal of anecdotal information has come from field foresters and other natural resource professionals who are observing changes in the quality of regeneration.

Invasive species, excessive deer herbivory, timber harvest practices, and wildfire are among the concerns that are frequently expressed at professional trainings and informal walks in the woods.

Our research project involves a mailed survey to about 600 natural resource professionals to determine their level of satisfaction with the quality of forest regeneration in West Virginia. The survey will begin the process of documenting the types of concerns related to regeneration and examining the geographic locations and spatial variability of regeneration issues. Surveys were mailed to members of the West Virginia Division of Society of American Foresters, certified foresters and forestry technicians registered with the West Virginia Board of Registered Foresters, wildlife biologists employed by the State, and various other ecologists and natural resource professionals employed by the U.S Forest Service, U.S. Fish and Wildlife Service, and nonprofit organizations. Results are published in Voss 2012.

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[1]Graduate Research Assistant (EV), West Virginia University, Appalachian Hardwood Center, Division of Forestry and Natural Resources, P.O. Box 6125, Morgantown, WV 26506; and Professor and Extension Specialist (DWM), West Virginia University, Appalachian Hardwood Center. DWM is corresponding author: to contact, call 304-293-5930 or email at dmcgill@wvu.edu.

INTERSPECIFIC VARIATION IN TREE SEEDLING HEIGHT GROWTH RESPONSES TO HARVEST GAP SIZE: IMPLICATIONS FOR INCREASING TREE DIVERSITY IN MESIC NORTHERN TEMPERATE FORESTS

Michael B. Walters, John L. Willis, and Kurt W. Gottschalk[1]

Tree species diversity in northern hardwood forests may be declining due to white-tailed deer (*Odocoileus virginianus*) herbivory, catastrophic forest health epidemics, harvest legacies, and other factors. Bottlenecks may be particularly strong for trees < 1.5 m tall as this corresponds to the maximum height of both competing nontree vegetation and browsing deer's reach. Thus, encouraging fast growing species in environments that foster that potential (high light and soil resources) may be effective means of increasing tree diversity. Alternatively, greater resources could promote greater growth of competing nontree vegetation. For weeded plots with 14 species of planted tree seedlings and adjacent unweeded, unplanted plots distributed over a range of harvest gap sizes, we predicted: 1) seedling growth and competing nontree vegetation density will increase in response to canopy gap size/light and soil resources (water and nitrogen); 2) tree seedling responses will be unique and related to shade tolerance classifications; and 3) variation in tree species and competing vegetation responses to resources can be used to help inform restoration practices. Light ranged from 2.5 percent of open sky light in undisturbed understory to > 30 percent in multitree gaps exceeding 900 m^2. Competing nontree vegetation responded to harvest gap light such that light levels beneath competing vegetation across all gap sizes could be as low as in undisturbed understory plots. However, levels were variable due to the positive impacts of water on competing vegetation and variation in water availability among gaps. Height growth varied greatly among species, with shade intolerant species and midtolerant American elm (*Ulmus americana*) and yellow birch (*Betula alleghaniensis*) generally growing faster than tolerant species. Shade intolerant species also generally responded to soil nitrate availability, tolerant species to ammonium, and no tree species responded to water. In conclusion, in larger, greater light gaps with high soil nitrogen availability, many species, especially those less tolerant, can attain heights beyond which they escape the potential for deer browse and interference from competing nontree vegetation. Tree seedling growth is unresponsive to water, whereas competing vegetation density increases with water; suggesting that tree seedlings may more likely escape nontree competition in drier gaps. Supporting this notion, the density of naturally established pine and cherry seedlings emergent from the competing vegetation canopy was greater in drier gaps. Thus, tree diversity restoration efforts could be aimed at creating larger gaps on drier sites with potentially less competing vegetation and perhaps planting species with rapid height growth where necessary.

[1]Associate Professor (MBW), Michigan State University, Department of Forestry, 210C Natural Resources Building, 480 Wilson Rd., East Lansing, MI 48824; Graduate student (JLW), Michigan State University, Department of Forestry; Research Forester and Project Leader (KWG), U.S. Forest Service, Northern Research Station. MBW is corresponding author: to contact, call 517-355-1762 or email at mwalters@msu.edu.

EFFECTS OF SCARIFICATION AND HARVEST GAP SIZE ON TREE SEEDLING ESTABLISHMENT

John L. Willis, Michael B. Walters, and Kurt W. Gottschalk[1]

Increasing species diversity is becoming an important silvicultural objective. In the managed northern hardwood forest of the Great Lakes region, species diversity may be constrained, in part, by reductions in bare mineral soil and decaying coarse woody debris seedling establishment substrates and by low understory light levels in selection-managed stands. Small-seeded species, including yellow birch (*Betula alleghaniensis*), paper birch (*B. papyrifera*), and eastern hemlock (*Tsuga canadensis*), may be particularly sensitive to some of these factors, as, in carbon-limited understories, they lack the carbohydrate reserves necessary to facilitate root growth and establishment in a broad range of substrates. To identify which factors are currently governing seedling establishment, we are conducting an experiment in Emmet County, Michigan, to quantify the effect of increasing bare mineral soil and coarse woody debris substrates (i.e., favorable substrate) on seedling establishment across a gradient of harvest gap sizes. In May 2011, plots were established in each of 40 harvest gaps and four unharvested locations. Subplots were assigned the treatments: 1) scarification (raking away the organic layer to increase favorable substrate availability) and competing nontree vegetation clipping; 2) scarification only; 3) competing nontree vegetation clipping only; and 4) no treatment. Five hundred seeds of yellow birch, paper birch and eastern hemlock were added to each subplot to augment the natural seed-rain. In August 2011, the first of multiyear measurements of forest floor substrate coverage, competing vegetation and tree seedling numbers were conducted. Preliminary results indicate that seedling establishment of small-seeded species paper birch, hemlock, and pin cherry (*Prunus pensylvanica*) (with its persistent soil seed bank) can be increased with increasing forest floor disturbance and exposure of favorable mineral soil and coarse wood substrates. Seedling establishment increased fourfold for paper birch (2,387 seedlings/ha), elevenfold for hemlock (6,733 seedlings/ha), and twofold for pin cherry (2,955 seedlings/ha) in scarified plots. However, the response of individual species varied across the harvest gap-size gradient. Hemlock was more responsive to scarification in 100-400 m^2 harvesting gaps, while paper birch and pin cherry were more responsive in 500-1200 m^2 harvesting gaps. Seedlings of all species were scarce in harvesting gaps greater than 1200 m^2 independent of scarification. Although preliminary, these results suggest that scarifying the forest floor beneath a range of canopy gap sizes up to 1200 m^2 can initially promote the establishment of a small-seeded species cohort. Continued monitoring, including the consideration of the effects of scarification on competing vegetation, will generate stronger conclusions regarding the efficacy of scarification and weeding on seedling establishment in northern hardwood forests.

[1]Graduate student (JLW), Michigan State University, Department of Forestry, 210C Natural Resources Building, 480 Wilson Road, East Lansing, MI 48824; Associate Professor (MBW), Michigan State University, Department of Forestry; and Research Forester and Project Leader (KWG), U.S. Forest Service, Northern Research Station. JLW is corresponding author: to contact, call 574-210-2504 or email at willis21@msu.edu.

URBANCROWNS: A SOFTWARE TOOL FOR ASSESSING AND MONITORING URBAN TREE CROWNS

Matthew F. Winn, Sang-Mook Lee, and Philip A. Araman[1]

Trees play an important role in urban communities. In addition to the aesthetic benefits they provide, urban trees also filter harmful pollutants from the air and water, lower emissions of volatile organic compounds (VOC), and reduce heating and cooling energy consumption. Two important characteristics used to quantify urban tree benefits are crown size and tree health, both of which can be difficult to ascertain. For this reason, the U.S. Forest Service Southern Research Station has developed a software tool to assist urban foresters, arborists, and community volunteers with assessing and monitoring urban tree crowns. The program analyzes a single, side-view digital photograph of a tree and computes the following crown metrics: height, diameter, ratio, volume, density, and transparency. UrbanCrowns can be used to monitor tree crowns over time to provide early detection of disease, insect, or storm damage. It can also be used to quantify tree benefits related to crown size and density such as rainfall interception and pollution removal.

[1]Forestry Technician (MFW), U.S. Forest Service, Southern Research Station, 1710 Ramble Road, Blacksburg, VA 24060; Post Doctoral Researcher (SML), Virginia Tech University, Bradley Department of Electrical Engineering; Team Leader (PAA), U.S. Forest Service, Southern Research Station. MFW is corresponding author: to contact, call 540-231-8815 or email at mwinn@fs.fed.us.

GROWTH RESPONSE OF INTENSIVELY MANAGED BLACK WALNUT (*JUGLANS NIGRA* L.) TO VARYING INTENSITY PRUNING REGIMES: EARLY RESULTS

Christopher Zellers, Michael R. Saunders, and Charles H. Michler[1]

The high value of black walnut (*Juglans nigra* L.) as a timber tree makes it especially suited to highly intensive plantation management. In such systems, crown expansion occurs rapidly, necessitating the inclusion of green pruning into cultural practices to facilitate good stem form and the production of high quality wood. While more intensive pruning practices may yield improvements in stem form and wood quality, the resulting removal of leaf area could decrease growth rates, thus increasing rotation periods. In this study, we examine the 2-year growth response of an 11-year-old plantation of black walnut as affected by pruning intensity and timing. Pruning intensity treatments included the following: high intensity, in which all branches below 4.0 m high, as well as codominant branches (branches >3 cm with strong branch angles) within the crown were removed; low intensity, where all branches below 2.5 m high were removed; and control. Pruning treatments were applied during either dormancy (late November to early March), leaf expansion (mid to late June), or at maximum leaf area (late July to early August). Leaf area, for both pruned and retained branches, was estimated using allometric models developed in a parallel study. Impacts on growth (height and diameter) were then examined as a function of leaf area reduction. Early results suggested no difference in absolute diameter growth by treatment ($p = 0.772$) or height growth ($p = 0.533$). Therefore, young black walnut may tolerate removals of 40 percent of leaf area without significant loss of growth.

[1]Graduate student (CZ), Purdue University, Department of Forestry and Natural Resources, 715 State Street, West Lafayette, IN 47907; Assistant Professor, (MRS), Purdue University, Department of Forestry; and Program Manager (CHM), U.S. Forest Service, Northern Research Station. MAS is the corresponding author: to contact, call 765-430-1440 or email at msaunder@purdue.edu