HARDWOOD TREE IMPROVEMENT & REGENERATION CENTER E-NEWSLETTER - June 2018

Volume 11 Issue 1

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Former Senator Richard Lugar Visits Namesake Forestry Farm

Richard Lugar, former US Senator for Indiana and President of The Lugar Center, toured the Richard G. Lugar Forestry Farm on April 30th with HTIRC researchers and staff. The research farm was named in honor of Lugar in 2014 in recognition of his longstanding support of forestry research and his pivotal role in establishing the Hardwood Tree Improvement and Regeneration Center at Purdue. HTIRC staff accompanied Senator Lugar on a tour of projects on the property, including breeding programs for black walnut, black cherry, oaks and chestnut, and research on forest responses to deer browse, environmental stresses, and invasive species.

Senator Lugar and his assistant, Jim Mckenna, Operational Tree Breeder, Dr. Ginzel and Dr. Coggeshall, Co-Directors of HTIRC.

Senator Lugar's interest in forest management comes naturally, as he has been a long-time forestland owner and manager with the help of professional forester Bob Burke, who accompanied him on the tour. In addition to helping establish the HTIRC 20 years ago, Senator Lugar's tree farm in Marion County hosts several HTIRC research and breeding plantings.

The HTIRC is grateful for Senator Lugar's continued support and cooperation.

Butternut Trees for Citizen Science

The American butternut is a tree in trouble. Butternut canker disease is a fungal pathogen gradually killing native butternut across its range. In addition, butternut needs full sunlight to regenerate and is relatively short-lived, normally less than 100 years. With minimal forest disturbance to provide sunlight and growing space, disease pressure, and a short lifespan, the future of butternut in native woodlands is in question. The HTIRC has been working on a butternut disease resistance breeding program utilizing native butternuts and naturally occurring butternut-Japanese walnut hybrids and back-crosses. Butternuts and hybrids in our collection are intentionally infected with the fungus to check for disease resistance. The fungal disease will then naturally spread in the plantings. One of the interesting observations made by Jim McKenna, HTIRC Plant Breeder, was that disease spread was much lower and slower in our upland plantings as compared to bottomland plantings, even among native butternut thought to be highly susceptible to the disease. If this trend holds true across the landscape, it may provide an opportunity to plant butternut in locations where they will live long enough to reproduce.

To take a first step towards testing this idea, Jim McKenna, using funding from a USDA Forest Service grant, worked with Bob Hawkins at the Indiana DNR Division of Forestry Vallonia Tree Nursery, to grow butternut seedlings originating in southern Indiana and Ohio and part of the breeding program. Vallonia State Tree Nursery, Chris Thornton with the Hoosier National Forest, Stephen Rist with the Ohio Department of Natural Resources, and personnel at the Southeast and Southern Indiana Purdue Agricultural Centers helped distribute American butternut to landowners in southern Indiana and Ohio. The Landowners agreed to plant the butternut in both upland and bottomland sites and provide the locations of the plantings to the HTIRC. Landowners and HTIRC personnel will monitor the plantings to evaluate butternut canker disease presence and spread to see if there are differences in disease activity between bottomland and upland plantings.

The cooperation of our partners and landowners allows more trees to be planted across a much broader range of sites than we could accomplish ourselves. In addition, landowners maintaining and monitoring their plantings provides an educational experience for landowners and greatly assists our staff in data collection. This is an example of citizen-science where landowners work with scientists to collect and share observations and evaluate the results. With time, we hope these plantings will

provide information we can use to develop better planting and management recommendations for butternut restoration.

Maximizing the Competitive Ability of Underplanted Oak Seedlings

By Graham Frank, Ron Rathfon, and Dr. Mike Saunders

Forests dominated by oak species are valued for their timber, aesthetic qualities, and provide the foundation for ecosystems that include healthy wildlife populations and a diverse array of plant species. Unfortunately, oak is likely to cede dominance to more shade tolerant trees in the future, without concerted management efforts to regenerate oak species. Regenerating oak forests hinges on adequate stocking of oak seedlings and saplings in the forest understory before final overstory removal. Moreover, it is critical that this "advance reproduction" is large enough to be competitive with the surrounding vegetation. Supplementing naturally occurring oak seedlings with underplanted seedlings can help to ensure sufficient advance reproduction and can allow more flexibility in the timing of management, rather than working around yearly fluctuations in acorn production.

Recent results are now available from a demonstration study examining combinations of commonly recommended management prescriptions to maximize the competitive ability of underplanted northern red oak (*Quercus rubra*) seedlings. Specifically, the study examined the effects of deer fencing and controlled release fertilizer for seedlings planted beneath a light crown thinning, midstory removal, or both silvicultural treatments in combination. The light crown thinning treatment was similar to many timber sales that occur on privately owned forest land in the Midwest, and the results of this study will be especially applicable to landowners and managers using underplantings to promote oak regeneration after a timber sale.

Overall, the highest rates of height and diameter growth, survival, and seedling competitiveness (based on seedling height relative to surrounding vegetation) occurred in plantings beneath midstory removal treatments—either alone or in combination with light thinning—and protected with fencing to exclude deer. Fertilization had few detectable effects, but did increase rates of seedling competitiveness relative to unfertilized seedlings if deer fencing was not installed. While the combination of deer fencing and midstory removal together was most effective, the installation of fencing was more important than midstory removal for promoting seedling survival and competitiveness.

This study was installed by Ron Rathfon, Purdue University Extension Forester, in collaboration with The Nature Conservancy's Forest Bank program. The Forest Bank is a program available in priority conservation areas in Indiana and provides an economic return to private forest landowners while protecting forest habitat. More information is available here.

Figure 1. Purdue Extension Forester Ron Rathfon shows the height of a planted northern red oak seedling (pink flag), dwarfed by the adjacent tulip poplar from the same cohort (left). Fast growing species such as tulip poplar can outcompete slower growing oaks in environments with high light levels.

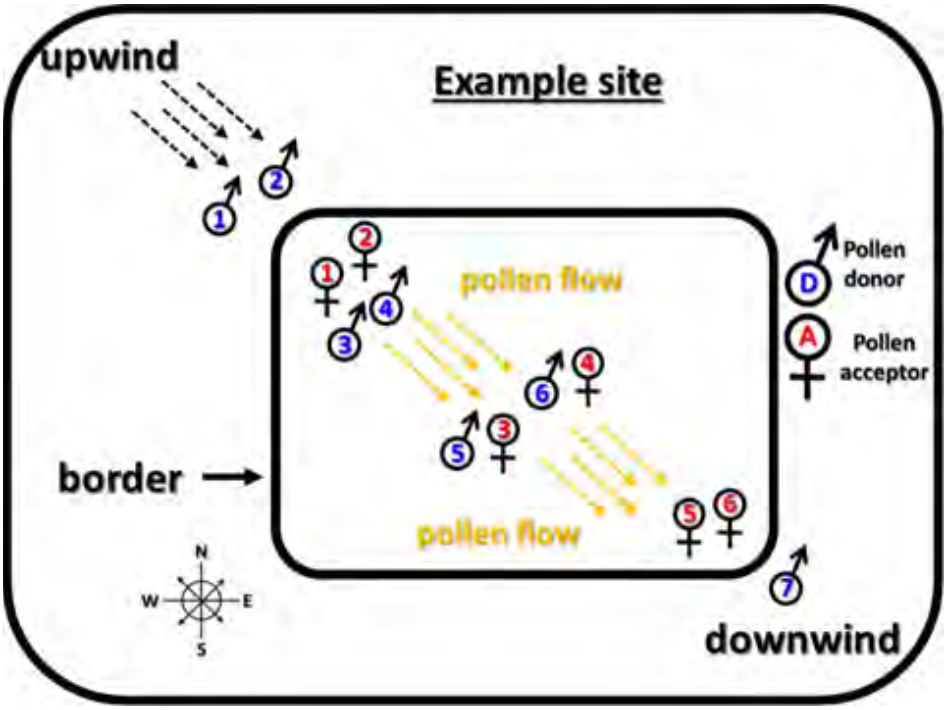
A Glimpse of Pollen Flow in Isolated and Non-isolated Seed Orchards

By Dr. Shaneka Lawson and Aziz Ebrahimi

Predictions of pollen flow within seed orchards have been attempted for decades. The advancement of science in providing methods for genotyping individual trees has allowed researchers to accurately identify the parents of a particular black walnut (*Juglans nigra*) seedling. Tree breeders have nearly perfected the “breeding without breeding” approach as is shown in a recent study within HTIRC. Seeds (walnuts) were collected from known mother trees and sown at a local nursery. The resultant seedings were planted at another location. Parent trees and progeny within the seed orchards were genotyped to identify pollen donor.

What was found in this study was fascinating. Using the terms pollen donor (D) and pollen acceptor (A) from the illustrative example site below we can describe what the larger, soon to be published study denoted. Looking at prevailing wind direction (black/yellow arrows), one would expect pollen to flow from D1 and D2 to A1 and A2 or for pollen from D7 to not reach females***** within the orchard. The authors of this black walnut pollen flow study revealed that prevailing wind direction did not significantly interfere with gene flow as pollen persisted in moving throughout the orchard. Several instances were observed where males (i.e. D3, D4) were able to pollinate females a significant distance away (i.e. A5, A6) skipping over other potential mates. This implied pollen can travel great distances and receptivity plays a major role in developing a successful seed orchard where progeny parentage can be determined.

In a companion study, the up- or downwind location of known mother trees was examined to indicate whether pollen from outside the orchard (wild trees) could be a primary source for trees within isolated (all wild trees surrounding the site were removed) and non-isolated (no wild trees removed) seed orchard sites. Results suggested that pollen contamination for up-wind trees versus down-wind trees was not significant. However, influx of wild pollen in the non-isolated orchard occurred at a rate four times that of the isolated orchard. These data showed isolated orchards could be vital for maintaining the integrity of breeding and improvement programs.



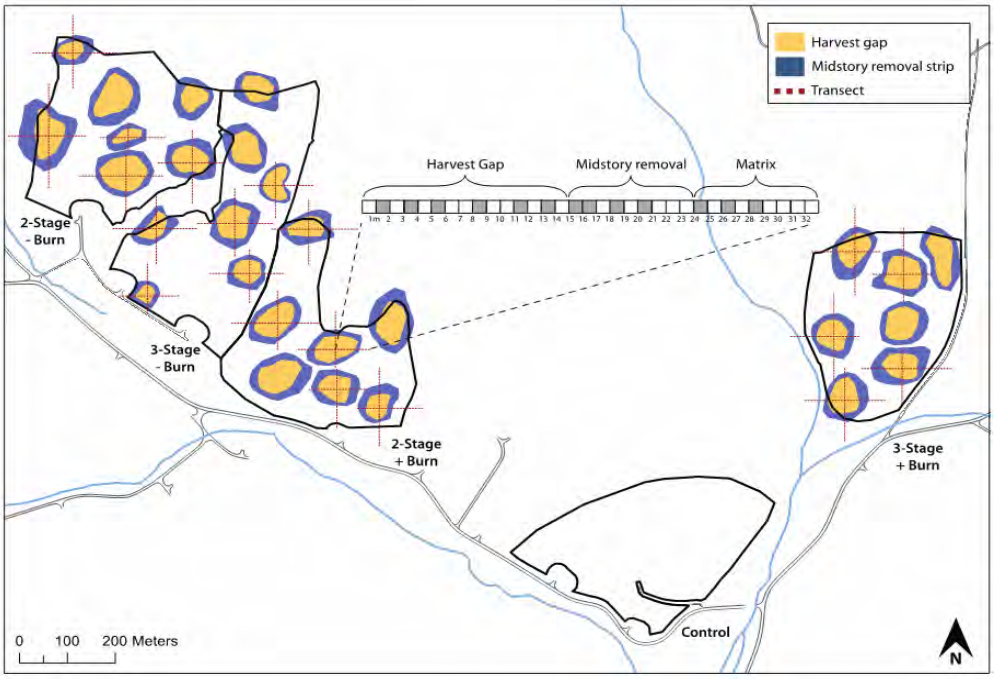
*

**Please note that use of the male and female symbols is for clarification purposes. Black walnut is monoicous, possessing both male and female flowers on the same tree. Few black walnuts self-fertilize as timing of male and female flowers (on the same tree) receptivity rarely overlaps.*

German *Femelschlag* Harvests Hold Promise for Oak Regeneration in Indiana

By Skye Greenler and Dr. Mike Saunders

Establishing natural oak regeneration following timber harvests in the Central Hardwood Region can be deceptively tricky. In many unharvested or lightly harvested forests, shade tolerant species such as maple and beech dominate the regeneration layer. In stands with complete or very heavy overstory removal, oaks are outcompeted by faster growing species such as tulip poplar and



sassafras. There is some evidence that oaks may regenerate outside of harvest gaps, but managers and researchers often don't survey what is happening outside of the canopy openings.
Figure 1: Map depicting replicate one with five treatment stands; initial harvest gaps in yellow; areas with only the midstory removed in purple; and potential future harvest arrangements in grey.

For many decades, foresters in Europe have been using *Femelschlag*, or expanding group shelterwood, harvests to regenerate diverse stands that contain trees with many different shade-tolerances. *Femelschlag* harvests remove small percentages of a stand in a series of expanding gaps creating small- to medium-sized openings in the canopy, similar to those caused naturally by wind or tree fall (Figure 1) Since *Femelschlag* harvests have a high edge-to-forest interior ratio, they may promote oak regeneration in the intact forest directly outside of harvest gaps in the area slated for future harvests (Figure 2).

Beginning in 2014, we began a new study on Crane Naval Base in Southern Indiana to see if we could combine *Femelschlag* harvests with prescribed fire to produce the light conditions needed to promote oak regeneration. We are testing four different treatments (See Box 1 below for treatment details). By fall 2018, there will be four replicates of each set of treatments across the base.

Figure 2: Photograph of a harvest gap with intermediate light levels on gap edges.

Regeneration surveys on the first two replicates yielded interesting results. As we suspected, tulip poplar regeneration dominates the inside of the harvest gaps, however there is a substantial amount of competitive oak regeneration just outside the gaps underneath the intact forest canopy, where light filters through the gap opening and into the adjacent forest. Similar to light level variation on hills with different aspects, the amount of light that filters through the gap and into the forest is affected by edge orientation. In our more xeric replicate, we found levels of competitive oak regeneration on the east and west sides of the gap where light levels are intermediate, and very little oak regeneration along the south side of gaps where light levels are lowest (Figure 3). On our more mesic replicate, oak response was significantly less and tulip poplar and maples were much more dominant (data not shown).

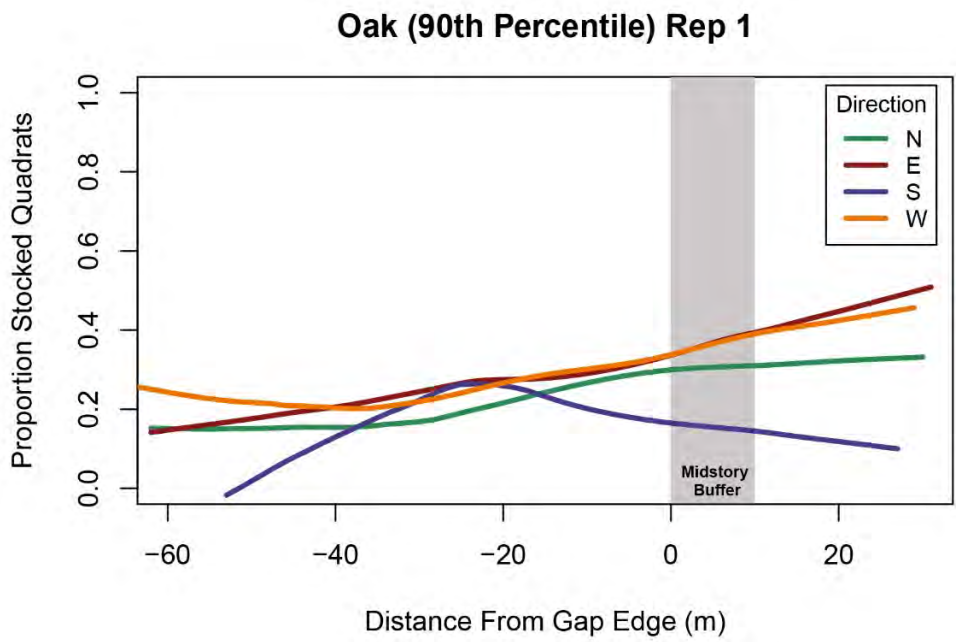


Figure 3: Stocking of competitive oak (ie., >90% of height of tallest competing seedling) as affected by cardinal direction from gap center and distance from gap edge. Lines represent smoothed averages. Distances are based on gap edge; negative numbers inside gap and positive numbers outside gap.

However, the high amount of oak regeneration measured just outside the harvested gaps on xeric sites should be well-established when the overstory is removed in those areas in 10 years. So this regeneration system may hold promise on certain sites in the Central Hardwood Region. Installation of further replicates at Crane on differing aspects and collection of longer-term data in future years may confirm these early patterns and suggest a viable strategy for oak regeneration for small woodland owners.

Treatment Overview	Treatment Details
All shelterwood variants: • Gap Size: ~0.9 ac (~7 gaps/stand) • Entries every 10 years • Approximately 20% of the stand harvested per entry Each replicate contains five 25-acre stands: • Burned and unburned 2-stage shelterwood • Burned and unburned 3-stage shelterwood • Unburned and unharvested control	2-Stage Shelterwood variant: • Entry 1: midstory removal • Entry 2: compete overstory removal 3-Stage Shelterwood variant: • Entry 1: midstory removal • Entry 2: 50% overstory removal • Entry 3: 100% overstory removal *For the first harvest entry stage 1 and 2 occurred simultaneously, but for future entries they will occur 10 years apart

Box 1: Treatment specifics for the Femelschlag harvests and shelterwood variants used in this study.

From Trash to Trees

By Drs. Douglass Jacobs and Owen Burney

While some in the college try to find a home for excess vegetation, others are addressing the opposite problem. Douglass Jacobs, Fred M. van Eck Professor of Forest Biology, and Owen Burney, his former doctoral student, often find themselves in places such as Haiti and Afghanistan where trees are desperately needed.

“The amount of land that is being deforested and not replanted is still growing,” says Burney, now an assistant professor at New Mexico State University. “There is a significant need for an improvement of the nursery system that then translates to reforestation.”

Growing in a container that's not ideal causes tree roots to curl. Photo by Doug Jacobs.

Growing in a container that’s not ideal causes tree roots to curl. Photo by Doug Jacobs.

Jacobs and Burney developed the Bottles to Trees program in response. With a few cuts and modifications, a discarded plastic soda bottle can work nearly as well to grow tree seedlings as the best technology on the market – and far better than the one-time-use seedling bags prevalent in these countries. The result has the added benefit of repurposing plastic that would otherwise contribute to local litter accumulation.

“Typically these bottles are just used once, and in many of these underdeveloped countries, they’re not even recycled because there is no market for recycling,” Jacobs says. “It’s quite possible we could produce forest tree seedlings in these plastic beverage bottles of higher quality than those in the bags that we see around the world.”

The seedling bags are cheap but cause seedling roots to spiral. When the roots reach the smooth sides of the bags, they grow horizontally in circles. That can choke plants and leads to shallow root systems and less viable trees.

The best seedling containers have ridges inside, which train roots to grow downward. But they can cost more than $1 per unit, and shipping them to remote places can cost far more than the container itself.

In a more ideal container, tree seedling roots grow straight down into the soil, instead of curling.

Jacobs and Burney remove the tops of bottles, poke holes in the bottom for drainage and cut three slits along the sides. When roots reach the open air at those slits, they stop growing and don't spiral. Using epoxy to add ridges to the insides of bottles has proven even better for root development. Jacobs and Burney hope to find industry partners, such as beverage companies or bottle makers, who might redesign their own bottles to include ridges, making them even easier to use as tree planters.

Adding epoxy ridges inside the bottle or cutting slits in the sides of the bottle can encourage the roots to grow correctly. Photos by Owen Burney.

"Deforestation is a serious problem, but there is a solution," Jacobs says. "And using these plastic bottles, we can solve this problem without even having to spend a lot of money. That's the beauty of this."

Plastic bottle litter can be used to create efficient seedling planters in nations where reforestation is a priority and commercial planters are expensive or unavailable. Learn how at *bottlestotrees.com*. Learn more about the Purdue scientists finding new ways to use the unused – and see our step-by-step video showing you how to make plastic bottle planters at purdue.ag/unused

New Lesson Plans for Middle School Students about Forest Management

By Skye Greenler and Dr. Mike Saunders

Purdue Extension just published a unit of three lesson plans, where students use real scientific data to investigate how different forest animals respond to timber harvesting.

It's a great way to introduce students to sustainable forestry and the benefits and trade offs associated with timber harvesting, and it's free! The lesson plans use active, inquiry-based, and contextual learning approaches so they are engaging for students and meet the new Indiana Science and Engineering Process Standards. If you know of teachers who might be interested in teaching about forest management or want material relevant to Indiana students, please pass along the new lesson! It can be downloaded at https://mdc.itap.purdue.edu/item.asp?Item_Number=FNR-549-W, or on the Purdue *Nature of Teaching* website.

The Amazing Race: Survivor Style

By Dr. Shaneka Lawson

Kids today likely spend double or triple the amount of time indoors than just a decade ago. They often fail to appreciate the mental and physical health benefits of daily outdoor activities. Nationwide, the push to get kids outdoors has encouraged youth to explore their greenspaces to gain a healthy appreciation for the world around them, yet few know how to avoid or protect themselves from danger. Unfortunately, without adequate understanding of outdoor dangers, youth exposed to unsafe or unfamiliar situations have no frame of reference for making sound decisions.

In an effort to help newer visitors to the outdoors, Dr. Shaneka Lawson created an interactive game entitled “The Amazing Race: Survivor Style” where a life-sized game is setup outdoors (it can also be played via computer if weather does not permit outdoor activity) to safely expose youth to scenarios likely faced by those visiting forests and shows how youth can safely navigate and overcome those dangers.

A gameboard***** with a variety of ecosystem regions is set up on the ground and students choose an individual or team color and will roll a giant die to determine the number of steps to take on the board. After rolling the die, students are faced with ecosystem-specific scenarios common to the ecosystem in which they have landed. Students will be asked to choose the **best** option between 3 potential responses to a situation such as:

Your family visits a national park and you want to explore the nearby beach. Promising to stay close by, you wander into the water to cool off. You quickly find yourself caught in a riptide. What do you do?

1. Paddle hard and fast to get to the shore.
2. **Swim parallel to shore, across the current.**
3. Swim slowly back to shore, taking frequent breaks.

*The above represents an example of how the electronic version of the game is set up. Each footprint represents the distance traveled by an individual player/group. The first ones to finish the course wins!

Depending on how far you are from shore, **a**. may be faster, but the best option will always be b. Students can work independently or in groups to decide on an answer. The correct answer (bold) will allow them to progress on the gameboard. Other potential scenarios involve exposure to spider bites, ticks, being lost (desert, mountains), sharks, medical emergencies, and food safety. The objective is to complete an around the world circuit and survive. The winners receive prizes such as emergency whistles, reflective / flashing lights for their backpacks, and lightweight string bags for their first aid supplies.
This activity is meant to further educate youth about the outdoors in a way that presents hazardous situations as a learning experience. The advantage to the game is every player will know the correct answers and will learn what the safest response is for each situation. This method makes learning fun, encourages youth to enjoy the outdoors, and helps makes them more responsible and safe when they choose to enter nature. Thus far, test group responses have been overwhelmingly positive and a grant has been written and funded to continue the project on a larger scale.

HTIRC Faculty Highlighted at Purdue College of Agriculture Awards

This year's College of Agriculture awards banquet highlighted the efforts of several of HTIRC's own researchers. Dr. Brady Hardiman, an Assistant Professor of Urban Ecology, was nominated for the Richard L. Kohls Outstanding Early Career Teacher in the College of Agriculture award based on his unique teaching methods. He challenges students to make the connection between scientific

understanding and solving contemporary societal issues. Dr. Douglass Jacobs, Professor in Forest Biology was nominated in the Outstanding Graduate Mentor and Teacher category for being an individual that students can rely on to provide ongoing support and encouragement so that they pursue heights never before imagined. Dr. Shaneka Lawson was awarded the Unsung Diversity Hero award for her support of numerous diversity-focused organizations across Purdue's campus and her plethora of volunteer efforts within the community to foster learning about trees and forestry in K-12 students. Dr. Mike Jenkins was promoted to full professor. Dr. Songlin Fei was selected as a University Faculty Scholar. The University Scholar award recognizes outstanding faculty members who are on an accelerated path of academic distinction. Dr. Douglass Jacobs was awarded the 2018 Corinne Alexander Spirit of the Land Grand Mission Award.

Congratulations to Our Recent HTIRC Graduate Students who Successfully Completed their MS Degrees

- Kalli Dunn successfully defended her M.S. Thesis on February 15, 2018. Kalli is the Assistant Property Manager at Glendale Fish and Wildlife Area under the Indiana DNR division of fish and wildlife.
- Skye Greenler successfully defended her M.S. Thesis on April 11, 2018. She will be attending Oregon State University for her PhD.

Purdue Forestry and Natural Resources Spring Student Awards

Each April the Purdue Department of Forestry & Natural Resources sponsors an awards ceremony to honor deserving students and a spring research symposium featuring student projects. Some highlights of students affiliated with the HTIRC:

- Emily Thyroff earned the Graduate Instructional Development Certificate.
- Emily Thyroff received first place at the Purdue University Forestry and Natural Resources Symposium 2018 in the category M.S. – Research.
- David Mann received second place at the Purdue University and Natural Resources Symposium 2018 in the category M.S. – Research.
- Andrea Brennan and David Mann were awarded the Charles H. Michler Scholarship for the Outstanding Graduate Student Researcher in Forest Biology.
- Andrea Brennan was awarded the Fischer Forestry Fund Graduate Scholarship.

Summer 2018 Events

Walnut Council National Meeting will be held July 29-August 1, 2018 in Dubuque, Iowa, with tours in Wisconsin. The Walnut Council Events webpage is http://www.walnutcouncil.org/events/

Recently Released Extension Publications

Resources and Assistance Available for Planting Hardwood Seedlings
Lenny D. Farlee – FNR-226-W
Costs and Returns of Producing Hops in Established Tree Plantations (PDF 620 KB) 2017. Ha. K., Atallah, S., Benjamin, T., Hoagland, L., Farlee, L., and Woeste, K. Purdue Extension FNR-546W.
The Great Clearcut Controversy
Skye M. Greenler and Michael R. Saunders – FNR-549W – this publication is highlighted in an article in this newsletter.

2017-2018 Research Publications

Population genetics, phylogenomics and hybrid speciation of*Juglans* in China determined from whole chloroplast genomes, transcriptomes, and genotyping-by-sequencing (GBS) (PDF 1MB)2018. Zhao, P., Zhou, H.J., Potter, D., Hu, Y.H., Feng, X.J., Dang, M., Feng, L., Zulfiqar, S., Liu, W.Z., Zhao, G.F., and Woeste, K. Molecular Phylogenetics and Evolution 126:250-265.

Localized gene expression changes during adventitious root formation in black walnut (*Juglans nigra* L.) (PDF 1 MB) 2018. Stevens, M.E., Woeste, K.E., and Pijut, P.M. Tree Physiology 1-18 DOI 10.1093/treephys/tpx 175.

Evaluation of genetic variability among "Early Mature" *Juglans regia* using microsatellite markers and morphological traits (PDF 470 KB) 2017. Ebrahimi, A., Zarei, A., Zamani Fardadonbeh, M., and Lawson, S. PeerJ: DOI 10.7717/peerj.3834.

Completion of the Chloroplast Genomes of Five Chinese *Juglans* and Their Contribution to Chloroplast Phylogeny (PDF 535 KB) 2017. Hu, Y., Woeste, K.E., and Zhao, P. Frontiers in Plant Science 2017 7:1-6 DOI: 10.3389/pls.2016.01955.

Demographically Idiosyncratic Responses to Climate Change and Rapid Pleistocene Diversification of the Walnut Genus *Juglans* (Juglandaceae) Reveals by Whole-genome Sequences (PDF 959 KB) 2017. Bai, W.N., Yan, P.C., Zhang, B.W., Woeste, K.E., Lin, K., and Zhang, D.Y. new Phytologist DOI: 10.1111/nph.14917.

Practical Strategies of Black Walnut Genetic Improvement – An Update (PDF 592 KB) 2017. Rink, G, Van Sambeek, J.W., O'Connor, P., and Coggeshall, M.V. Walnut Council Bulletin 44(2): 1-3, 10-11.

High-quality genetic mapping with ddRADseq in the non-model tree *Quercus rubra* (PDF 886 KB) 2017. Konar, A., Choudhury, O., Bullis, R., Fiedler, L., Kruser, J.M., Stephens, M.T., Gailing, O., Schlarbaum, S., Coggeshall, M.V., Staton, M.E., Carlson, J.E., Emrich, S., and Romero-Severson, J. BMC Genomics 18:417.

Rapid *in vitro* shoot multiplication of the recalcitrant species *Juglans nigra* L. (PDF 503 KB) 2018. Stevens, M.E. and Pijut, P.M. In Vitro Cellular & Developmental Biology-Plant 54:309-317.

HTIRC-Working the Forests for the Future – YouTube Video

Here is the link to the video. (https://youtu.be/fSzVJlJNkCQ)