PENNSTATE

College of Agricultural Sciences

L.W. SCHATZ CENTER FOR TREE MOLECULAR GENETICS

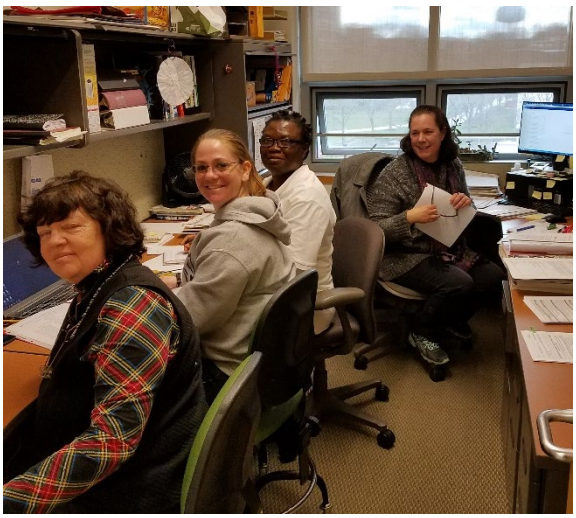
ANNUAL REPORT

July 2018 – June 2019

Prepared August 19, 2019, by

John Carlson, Professor of Molecular Genetics and
Director, Schatz Center for Tree Molecular Genetics
Department of Ecosystem Science and Management,
Pennsylvania State University, University Park, PA 16802

L to R: Casey Weathers (PhD student), John Carlson, Nicole Zembower, Maureen Mailander (undergraduate student), (not shown Di Wu, PhD student).



L to R: Research Associate Professor Tatyana Zhebentyayeva, Masters student Krystle Swarz, Visiting Scientist Dorothy Tchapda Tchatchoua, Lab Manager Nicole Zembower.

L.W. SCHATZ CENTER FOR TREE MOLECULAR GENETICS
ANNUAL REPORT, 2018-2019

For over 16 years, The Louis W. Schatz Center for Tree Molecular Genetics at Penn State has been a major contributor to forest genetics and genomics research, due to the generosity and foresight of Dr. Schatz' who provided gift endowments, as well as the continued support and interest of the Schatz family. The endowment supports research projects, post-doctoral fellows, visiting scholars, undergraduate researchers, student field trips, faculty travel and supplies for ongoing and novel research projects. The Schatz Center Colloquium fund at the Mont Alto campus also continues to make a large impact on the forest genetics community through the sponsorship of meetings on important forest genetics topics. We are pleased to provide this update on activities and accomplishments in The Schatz Center for the 2018-2019 academic year.

UNIVERSITY PARK CAMPUS ENDOWMENTS

THE LOUIS W. SCHATZ CENTER FOR TREE MOLECULAR GENETICS ENDOWMENT:

This new fund was created on May 24, 2018, by combining three previously separate endowments: the Schatz Undergraduate Research Awards, the Schatz Visiting Scholars fund, and the Schatz Post-Doctoral Fellowship in Tree Genetics fund. The combination of these funds into a single endowment provides greater flexibility and impact in the center's research and training activities. The endowment still supports undergrad' student research, visiting scientists, and post-doctoral fellows, along with support for other important elements such as technical support, publication costs, field support, and supplies to initiate new areas of research

Undergraduate Research: In the 2018/2019 academic year, three students in the Horticulture undergraduate program participated in research projects in the S Mailander, Adam Bettinger, and Brian Betz. Maureen Mailander completed her research project on soil 'microbiomes' associated with switchgrass bioenergy plants which was funded through her College of Agricultural Sciences undergraduate research grant. She presented a poster on her project at the College's Gamma Sigma Delta Research Exposition on March 27, 2019. Adam Bettinger and Brian Betz have not yet conducted independent research projects, but they made significant contributions and gained valuable experience assisting us in transferring of our poplar tissue cultures, maintenance of our green ash and poplar field trials, and collection of bud break, height and diameter data at our green ash progeny (seedling) trial on campus.

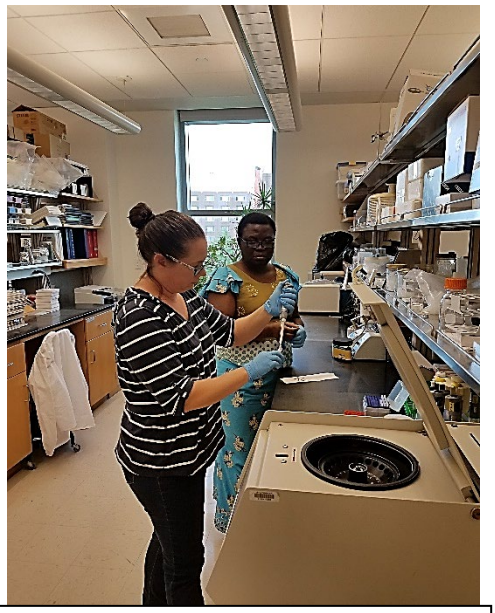
Maureen and Adam in the lab

Maureen Mailander
Schatz Center period: March 2016 – present
Penn State Major: Horticulture (Arboriculture minor)
Projects: 1) Assisted with maintaining and collection of data from our green ash genetics field trial; 2) Isolated soil DNA for sequencing to determine microbial community composition in switchgrass cultivar trials; 3) Had primary responsibility for regeneration of poplar plants from tissue culture and transplanting of them to our bioenergy field trial.
Plans: Graduate School or employment in the area of plant propagation.

Adam Bettinger
Schatz Center period: March 2019 – present
Penn State Major: Horticulture
Projects: 1) Assisted with collection of growth and bud break data from green ash genetics field trial; 2) Responsible for maintaining our green ash and hybrid poplar field trials (planting, weeding, mowing, pest management); 3) Assisted in regenerating and conditioning poplar plants from tissue culture, and for transplanting of to our bioenergy field trial.
Plans: TBD.

Brian Betz
Schatz Center period: June 2019 – present
Penn State Major: Horticulture
Projects: 1) Assists with maintaining our green ash and hybrid poplar field trials; 2) Assists with collecting growth data from our field trials.
Plans: Seeking employment in the agriculture-related industries.

The Schatz Visiting Scholars: The Schatz Center serves the important role in of providing training and collaborative research opportunities for scholars and scientists from industry and academia around the world. **During the 2018-19 academic year, The Schatz Visiting Scholar was Dr. Dorothy Tchapda Tchatchoua.** Dr. Dorothy Tchatchoua is a faculty member from the Department of Agriculture in the University of Maroua of Cameroon. She held the distinction of a Fulbright Scholarship for her visit at Penn State. Dr. Tchatchoua visited the Schatz Center from August 1, 2018, to April 30, 2019, to conduct research into genetic diversity in the important African acacia tree species *Faidherbia albida*. She and her students made extensive seed collections from natural populations of 'white acacia' across central and eastern Africa prior to study in the Schatz Center. Dr. Tchatchoua received training in all steps of the process from lab techniques for testing DNA markers, extracting DNA, and conducting PCR assays, to QC of raw data, scoring for allelic variation, use of software for statistical analyses, and evaluation of results. Her research with us was quite successful and our results should represent a major step forward in understanding natural variation in this species. We hope to soon publish a manuscript with Dr. Tchatchoua and continue to collaborate with her.



Nicole demonstrating molecular techniques to Dorothy Tchatchoua.

The Schatz Visiting Scholars program is also supporting a new senior investigator in the center, **Dr. Tatyana Zhebentyayeva**, who serves as Research Associate Professor in the Schatz Center for 3 years. Dr. Zhebentyayeva joined the Schatz Center on August 1, 2018, after almost 20 years' service as a scientists and research faculty member in Genomics, Computational Biology, and Horticulture at Clemson University. Dr. Zhebentyayeva has extensive experience in molecular genetics with trees, including research into the restoration of American chestnut. Dr. Zhebentyayeva will provide a vital role in maintaining the high profile and productivity of the Schatz Center during Director John Carlson's transition into retirement. In her first year with us, Dr. Zhebentyayeva has already submitted multiple grant applications and has published 4 outstanding papers in major peer-reviewed research journals.

In addition, The Schatz Center's endowment supported the Center's **lab manager, Nicole Zembower**. Ms. Zembower provided administrative and research support to the Center's Director and to the Visiting Scholar, making arrangements for travel, housing, university appointments, safety training, ordering supplies, and research assistance. Ms. Zembower also served as direct supervisor of our undergraduate research assistants and provided training in protocols to not our students but students from other labs as well. She organized the Schatz Center's extensive greenhouse and field trials, including transplanting of seedlings and endless vegetation management (mowing).

Dr. Albert Abbott continued to serve as a part-time consultant to the Schatz Center for the 2018-19 fiscal year. Dr. Abbott also serves on a part-time basis as co-Director of the Forest Health Research and Education Center at The University of Kentucky. With Dr. Abbott's assistance, Schatz Center Director Carlson and Research Associate Professor Tatyana Zhebentyayeva are establishing strong research collaborations with the Forest Health Research and Education Center at the University of Kentucky. We have jointly prepared several research publications and grant proposals together and have just started an exciting new project together to sequence the genome of white oak, an important native tree species across the eastern US.

We held off on recruiting a Schatz Post-Doctoral Fellow during the 2018-2019 year while our Ph.D. students were completing their theses. The Schatz Center fund provided Ph.D. students Nathaniel Cannon, Di Wu, and Casey Weathers with assistantships to complete their dissertations. Di Wu successfully defended her thesis and graduated in August 2018 with a Ph.D. in Bioinformatics and Genomics. Dr. Wu accepted a position as research scientist in the Genomics Research Core of the Cedars-Sinai Medical Center in Los Angeles, CA. She continues to work closely with Dr. Carlson and Dr. Zhebentyayeva on manuscripts for publication. Casey Weathers defended successfully his Ph.D. thesis on conservation genetics of brook trout, graduating on August 5, 2019. Dr. Weathers has accepted a position as a Research Scientist with the US Fish & Wildlife Service's Southwestern Native Aquatic Resources and Recovery Center in Dexter, NM. Nathaniel Cannon started a teaching faculty position in Biology at Southern Utah University in September 2018. Now that the last of Dr. Carlson's graduate students have finished, a search should be initiated by early 2020 for a new post-doctoral fellow.

SCHATZ FACULTY TRAVEL FUND:

The Louis and Merry Schatz Faculty Travel Fund supported several trips in the 2018-2019 fiscal year by Dr. Carlson and Dr. Zhebentyayeva to participate in research meetings relevant to the Schatz Center goals. Attending such meetings is an important national and international outreach component of the Schatz Center. We inform the research community about results from the projects underway in the Schatz Center, we learn the latest research results and approaches from other forestry and molecular genetics groups, and we meet with colleagues to plan current and future projects. Dr. Carlson attended and presented talks at: the International Union of Forest Research Organizations International Workshop on Tree Resistance to Insects & Diseases at Mt. Sterling, Ohio, August 5 - 10, 2018; the USDA NE-1333 Multistate Research Project Meeting at Pennsylvania State University, September 7, 2018; the "Plants and Animals: Bridging the Gap in Breeding Research Symposium" meeting at the Center for Integrated Breeding Research, Georg-August-University, in Goettingen, Germany, October 10 - 11, 2018; the Annual Meeting of the American Chestnut Foundation, Huntsville, Alabama, October 25-27, 2018; and the "Plant 2019" International Conference on Plant Science Research, Baltimore, MD, March 4-6, 2019. Dr. Zhebentyayeva attended and presented talks at: the International Union of Forest Research Organizations International Workshop on Tree Resistance to Insects & Diseases at Mt. Sterling, Ohio, August 5 - 10, 2018; the USDA NE-1333 Multistate Research Project annual meeting at Pennsylvania State University, September 7, 2018; the Annual Meeting of the American Chestnut Foundation, Huntsville, Alabama, October 25-27, 2018; the Plant and Animal Genome XXVI Conference, San Diego, CA, Jan. 12-16, 2019; and the Southern Forest Tree Improvement Conference, at the University of Kentucky, Lexington, KY, June 4-8, 2019.

For the 2019-20 fiscal year, Dr. Carlson will, as always, entertain requests for travel support from any faculty member in the ESM department. In the event of no such requests Dr. Carlson will use the funds to attend the international Plant and Animal Genome Conference in San Diego in January 2020, and/or relevant meetings such as The American Chestnut Foundation annual meeting and the USDA NE-1833 Multistate Research Project annual meeting.

SCHATZ STUDENT FIELD TRIP FUND:

FY 2018-2019 - No expenditures.

- The balance of will be applied to the next trip to visit Gordon and Karen Schatz and The L.W. Schatz Demonstration Tree Farm at Humboldt State University in 2020.

SCHATZ TREE GENETICS COLLOQUIUM FUND, MONT ALTO CAMPUS

Dr. Carlson and The Schatz Center hosted the 2018 annual **NE-1333 Technical Committee Meeting of the USDA regional multi-state project** "Biological Improvement of Chestnut through Technologies that Address Management of the Species, its Pathogens and Pests." The meeting was held at the Nittany Lion Inn, on the University Park campus of Penn State University, on September 7-9, 2018. The meeting was attended by 43 researchers from 14 states. It featured 9 Agriculture Experiment Stations reports, and 22 research talks on advancements in areas ranging from chestnut genomics, blight and root-rot resistance genes, hypovirulence, and field trials to endophytic microbiomes. The annual business meeting

launched the renewed 5-year funding from USDA for the multi-state project, which has the new project number NE-1833. The Schatz Colloquium fund covered the costs of meeting rooms, meals, reception, coffee breaks, and the field trip to visit plantings. Attendees expressed their sincere appreciation for the Schatz Center's support of a very successful meeting.

Dr. Carlson and The Schatz Center were recognized several times at The American Chestnut Foundation's 35th annual meeting for our support of the meeting, which was held at the very impressive facilities of The HudsonAlpha Biotechnology Institute in Huntsville, Alabama, on October 26 and 27, 2018. The meeting featured advancements being made in the sequencing of the American chestnut genome, and in use of genomic resources to track progress in TACF's backcross-breeding program to transfer blight and root-rot resistance genes from Chinese chestnut into American chestnut. Dr. Carlson presented a poster on the Schatz Center's sequence for the Chinese chestnut genome. Dr. Jeremy Schmutz hosted the meeting. Dr. Schmutz is the lead scientist for all of the plant genome sequencing projects conducted by the US Department of Energy's Joint Genome Sequencing program.

The Schatz Center's Tree Genetics Colloquium fund will be the major sponsor of The American Chestnut Foundation's 36th annual meeting to be held October 18 and 19, 2019, in Gettysburg, PA. This TACF meeting will be hosted by faculty at the Penn State Mont Alto campus. Dr, Carlson will help get the meeting started with a presentation on the Schatz Center.

SCHATZ CENTER RESEARCH PROGRESS UPDATE FOR 2018-2019

During the past year, The Schatz Center completed assembly and characterization of the Chinese chestnut Vanuxem cultivar genome, which was reported as a manuscript at the preprint journal bioRxiv. With American Chestnut Foundation support, we also developed a high-quality reference genome sequence for the Chinese chestnut Mahogany cultivar, which has played a major role as a source of disease resistance genes for American Chestnut restoration. We will obtain publication in peer-reviewed publication next. We continue to work with The American Chestnut Foundation to integrate our genomic s tools into TACF's blight resistance breeding program.

Dr. Carlson was awarded a $1million grant from the USDA National Institute of Food and Agriculture to lead the project "Breeding resilient, disease-resistant switchgrass cultivars for marginal lands", with Co-PIs Jesse Lasky, Terry Bell, and Marvin Hall at Penn State, Stacy Bonos at Rutgers, and Donald Viands at Cornell University. The award period is December 2018 to November 2021. This systems biology project investigates the genetic basis of interactions between growing sites, switchgrass genotypes, and soil microbiome structure.

Dr. Carlson is also serving as advisor on 2 projects led by Dr. Michael Jacobson at Penn State - "Case Study to Assess the Costs of the Appalachian Regional Reforestation Initiative's Forest Reclamation Approach" and "Building a food-water-energy nexus community for transformative and convergent research".

During the 2018-2019 academic year, Dr. Carlson, Dr. Zhebentyayeva and Schatz Center members produced the following scientific papers, invited talks and conference posters:

Peer-reviewed publications:

1. Kim HS, Park W, Lim HG, Eom S, Lee JH, Carlson JE, Ahn SJ. 2019. NaCl-induced CsRCI2E and CsRCI2F interact with aquaporin CsPIP2;1 to reduce water transport in *Camelina sativa* L. Biochemical and biophysical research communications, 513(1):213-8.
2. Terrence Bell, Kevin L. Hockett, Ricardo I. Alcalá-Briseño, Mary Barbercheck, Gwyn A.

Beattie, Mary Ann Brun, John Carlson, Taejung Chung, Alyssa Collins, Bryan Emmett, Paul Esker, Karen A. Garrett, Leland Glenna, Beth Gugino, Maria del mar Jimenez-Gasco, Linda Kinkel, Jasna Kovac, Kurt P. Kowalski, Gretchen Kuldau, Johan H.J. Leveau, Matthew J. Michalska-Smith, Jessica Myrick, Kari Peter, Ashley Shade, Nejc Stopnisek, Xiaoqing Tan, Amy T. Welty, Kyle Wickings, Etienne Yergeau. 2019. Manipulating Wild and Tamed Phytobiomes: Challenges and Opportunities. Phytobiomes Journal 3:3-21.

3. Wu D, Koch J, Coggeshall M, Carlson J. 2019. The first genetic linkage map for *Fraxinus pennsylvanica* and syntenic relationships with four related species. Plant Molecular Biology, 99 (3):251–264, DOI: 10.1007/s11103-018-0815-9.
4. Tuskan GA, Groover AT, Schmutz J, DiFazio SP, Myburg A, Grattapaglia D, Smart LB, Yin T, Aury JM, Kremer A, Leroy T, Le Provost G, Plomion C, Carlson JE, Randall, J, Westbrook J, Grimwood J, Muchero W, Jacobson D, Michener JK. 2018. Hardwood tree genomics: Unlocking woody plant biology. Frontiers in Plant Science, 9, p.1799, doi:10.3389/fpls.2018.01799, 9 pages.
5. Weathers TC, Kazyak DC, Stauffer JR, Jr., Kulp MA, Moore SE, King TL, Carlson JE. 2018. Neutral Genetic and Phenotypic Variation Within and Among Isolated Headwater Brook Trout Populations, Transactions of the American Fisheries Society, 148(1) 58-72, https://doi.org/10.1002/tafs.10115, 15 pages.
6. Conrad AO, Yu J, Staton ME, Audergon JM, Roch G, Decroocq V, Knagge K, Chen H, Zhebentyayeva T, Liu Z, Dardick C. 2019. Association of the phenylpropanoid pathway with dormancy and adaptive trait variation in apricot (Prunus armeniaca). Tree Physiology, 39(7): 1136–1148.
7. Zhebentyayeva TN, Sisco PH, Georgi LL, Jeffers SN, Perkins MT, James JB, Hebard FV, Saski C, Nelson CD, Abbott AG. 2019. Dissecting Resistance to Phytophthora cinnamomi in Interspecific Hybrid Chestnut Crosses Using Sequence-Based Genotyping and QTL Mapping. Phytopathology, July, pp. PHYTO-11.
8. Zhebentyayeva T, Shankar V, Scorza R, Callahan A, Ravelonandro M, Castro S, DeJong T, Saski CA, Dardick C. 2019. Genetic characterization of worldwide *Prunus domestica* (plum) germplasm using sequence-based genotyping. Horticulture Research. 6(1):12.
9. Irisarri P, Zhebentyayeva T, Errea P, Pina A. 2019. Inheritance of self-and graft-incompatibility traits in an F1 apricot progeny. PloS one. 14(5):e0216371.

Preprints:

1. Staton M, Addo-Quaye C, Cannon N, Sun Y, Zhebentyayeva T, Huff M, Fan S, Bellis E, Islam-Faridi N, Yu J, Henry N. 2019. The Chinese chestnut genome: a reference for species restoration. bioRxiv. Jan 1:615047.
2. Perkins MT, Zhebentyayeva T, Sisco PH, Craddock JH. 2019. Genome-wide sequence-based genotyping supports a nonhybrid origin of *Castanea alabamensis*. bioRxiv. Jan 1:680371.

Books, Book Chapters

1. Kerr RA, Zhebentyayeva T, Saski C, Bridges WC, McCarty LB. 2019. Chapter Four - Genetic Diversity of Phenotypically Distinct Goosegrass (*Eleusine Indica* L. Gaertn.) Ecotypes. Goosegrass Biology, Genetic Diversity and Innovative Control Measures. p 48.
2. Merkle, S. A., Vieitez, F. J., Corredoira, E. and Carlson, J.E. 2019. Castanea spp. Chestnut. In R. Litz, F. Alfaro, & J. Hormaza (Eds.), Biotechnology of Fruit and Nut Crops (2nd ed.). CAB International, *In Press*, CABI cat # 9781780648279.

Abstracts for Posters and Presentations at Research Conferences

1. Nelson CD, T Zhebentyayeva, S Fan, LL Georgi, FV Hebard, PH Sisco, SN Jeffers, JB

James, JE Carlson, AG Abbott, 2019, QTL mapping resistance to *Cryphonectria parasitica* and *Phytophthora cinnamomi* in Chinese × American chestnut hybrid families, IUFRO Forest Biotechnology Conference, Raleigh, NV, June 23-28, 2019.

2. Staton EM, Addo-Quaye C, Cannon N, Zhebentyayeva T, Huff M, Fan S, Bellis E, Islam-Faridi N, Yu J, Henry N, Drautz-Moses DI, Noorai RE, Ficklin S, Saski C, Mandal M, Wagner TK, Zembower N, Bodénès C, Holliday J, Westbrook J, Lasky J, Georgi LL, Hebard FV, Nelson CD, Schuster SC, Abbott AG, Carlson JE, 2019, The Chinese chestnut genome: a reference for species restoration, Southern Forest Tree Improvement Conference, University of Kentucky, Lexington, KY, June 4-8, 2019.
3. Carlson JE, 2019, Genomic Resources for Environmental Resilience and Species Restoration in Hardwood Forest Trees, "Plant 2019" International Conference on Plant Science Research, Baltimore, MD, March 4-6, 2019.
4. Zhebentyayeva TN, Noorai RE, Tharayil N, Gitto AJ, Jeffers SN, Sisco PH, Perkins MT, Craddock JH, Saski CA, Carlson JE, Nelson CD, Abbott AG, 2019, Response to *Phytophthora cinnamomi* in Chestnut Roots: an Integrated QTL-mapping, Transcriptome and Metabolome Approach, Plant and Animal Genome XXVI Conference, San Diego, CA, Jan. 12-16, 2019.
5. T. Dorothy Tchatchou, John E. Carlson, Nicole Zembower, Scott Poethig, Hamadou Oumarou, 2019, Molecular Markers Analysis of *Faidherbia albida* (Del.) A. Chev. Populations from Sub Saharan Africa, Plant and Animal Genome XXVI Conference, San Diego, CA, Jan. 12-16, 2019.
6. Carlson, JE; Staton, ME; Addo-Quaye, C; Cannon, N; Fan, S; Nelson, CD; Henry, N; Yu, J; Huff, M; Zhebentyayeva, T; Conrad, A; Ficklin, S; Saski, C; Mandal, M, Islam-Faridi, N; Zembower, N; Drautz, D; Schuster, SC; Swale, T; Sun, Y; Westbrook, J; Holliday, J; Abbott, AG; Hebard, FV.2018. The Chinese Chestnut Genome V2.0, The Annual Meeting of the American Chestnut Foundation, Huntsville, Alabama, October 25-27, 2018.
7. Zhebentyayeva, TN; Noorai, RE; Gitto, AJ; Jeffers, SN; Sisco, PH; Perkins, MT; Craddock, JH; Saski, CA; Carlson, JE; Nelson, CD; Abbott, AG. 2018. Functional genomics analyses of the resistance/susceptible response in chestnut seedlings to *Phytophthora cinnamomi* infection, The Annual Meeting of the American Chestnut Foundation, Huntsville, Alabama, October 25-27, 2018.
8. John E. Carlson, 2018, Genomics-enabled breeding for forest resilience. Plants and Animals: Bridging the Gap *in* Breeding Research Symposium, Center for Integrated Breeding Research, Georg-August-University Goettingen, October 10 - 11, 2018.
9. Carlson, JE; Staton, ME; Addo-Quaye, C; Cannon, N; Fan, S; Nelson, CD; Henry, N; Yu, J; Huff, M; Zhebentyayeva, T; Conrad, A; Ficklin, S; Saski, C; Mandal, M, Islam-Faridi, N; Zembower, N; Drautz, D; Schuster, SC; Swale, T; Sun, Y; Westbrook, J; Holliday, J; Abbott, AG; Hebard, FV. 2018. Update on the Chinese Chestnut Genome Project, NE-1333 Meeting, Pennsylvania State University, University Park, PA, September 7, 2018.
10. Zhebentyayeva, TN, Noorai, RE, Gitto, AJ, Jeffers, SN, Sisco, PH, Perkins, MT, Craddock, JH, Saski, CA, Carlson, JE, Nelson, CD, Abbott, AG. 2018, Functional genomics analyses of the resistance/susceptible response in chestnut seedlings to *Phytophthora cinnamomi* infection, NE-1333 Meeting, Pennsylvania State University, University Park, PA, Sept 7, 2018.
11. T. Casey Weathers, David C. Kazyak, Matt A. Kulp, Jacob Rash, John E. Carlson, 2018,

Application of Landscape Genetics for Southern Appalachian Brook Trout Conservation, 148th Annual Meeting of the American Fisheries Society – Communicating the Science of Fisheries *C*onservation to Diverse Audiences, Atlantic City, New Jersey, Aug. 19-23, 2018.

12. John E. Carlson, et al, 2018, A major gene for beech bark disease resistance identified in American beech by genome-wide association study, International Union of Forest Research Organizations International Workshop Tree Resistance to Insects & Diseases: Putting Promise into Practice, Mt. Sterling, OH, August 5 - 10, 2018.
13. Carlson, JE; Staton, ME; Addo-Quaye, C; Cannon, N; Zhebentyayeva, T; Islam-Faridi, N; Yu, J; Huff, M; Fan, S; Conrad, A; Schuster, SC; Abbott, AG; Westbrook, J; Holliday, J; Dana, NC; Hebard, FV; 2018, The Chinese Chestnut Genome V2.0, International Union of Forest Research Organizations International Workshop Tree Resistance to Insects & Diseases: Putting Promise into Practice, Mt. Sterling, OH, August 5 - 10, 2018.