Ecology in the cloud

undergraduate students driving inter-institutional, collaborative research

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EREN
ECOLOGICAL RESEARCH AS EDUCATION NETWORK

Inter-institutional, multi-investigator collaborations have become the norm for many ecological studies because they facilitate efficient use of limited resources, lead to synergistic outcomes, and use research as a pedagogical tool (e.g., Ecological Research as Education Network, EREN).

Our goal was to increase student exposure to skills necessary for ecological research beyond traditional field and lab activities. We developed a model for collaboration among students from different undergraduate institutions using the Permanent Forest Plot Project (PFPP, EREN) as a platform.

As instructors:

- Regular communication by phone and email
- Served as role models for demonstrating collaborative skills
- Mentored team members in design, data collection, analysis, and presentation

Photos courtesy of the Center for Invasive Species and Ecosystem Health

"Working with students from another location was great because we could present different ideas that one of us might not have thought of on our own."

"Future cross-institutional cooperation could be done differently… research teams had limited face-to-face interaction. The only cooperative time spent between UF and W&J was during data collection rather than working on interpreting the outcome of the study, presentation preparation, or development of the manuscript"

"Differences in institutional curriculum also served as a disadvantage because students had varying levels of background in biology and were working under different time constraints"

"The biggest challenge with working in a group from another location was definitely communication."

Inter-institutional teams of students enrolled in research credit courses for semester-long research:

- Student teams from The University of Findlay (OH; *n*=2 students) and Washington & Jefferson College (PA; *n*=4 students) were formed in Sept 2012
- Teams met at both institutions over weekends in Sept 2012 to develop research hypotheses, to establish field plots, and to begin data collection
- Members of each team continued field work through the semester at their respective institution's sites and communicated on a semi-regular basis to share data, complete analyses, and generate scientific poster
- Team members presented collaborative posters at their schools' respective research symposia and two regional symposia for undergraduate research

Our model for collaborative research…

Collaborate

Collaborate

Google Drive
Paper drafts available to all students and faculty

Campus Visits
Meet & Greet, overnight stay
field work training

Zotero
online reference database, used at UF only

Literature Review

Hypothesis generation
Campus visit brainstorming sessions

Field Sampling
within institution

Species ID

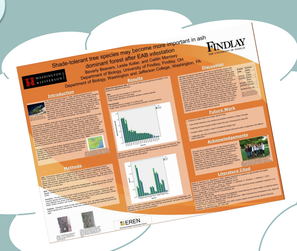
Unhelpful Tools
email
texting
Blackboard & Moodle
No inter-campus operability

Software we might try in the future:
- Dropbox
- Hangouts
- Zotero Shared Libraries

Data analysis

Manuscripts
(for course credit)

Presentations



Ohio Academy of Science

Symposium for Scholarship & Creativity (UF)

Student Projects Poster Session (W&J)

Western PA Undergraduate Biology Symposium

What we would do for future collaborations:

- Provide training for online tools
- Use e-tools that allow instructor oversight (avoid email and texting)
- Develop consistent deadlines for all students
- Use online collaboration tools earlier in the process (idea generation)
- Hold mandatory weekly group meetings (Skype, Facetime, Google Hangouts)
- Emphasize that e-communication is an important skill that augments face-to-face interaction
- Not presume that students will collaborate effectively online

How do your undergrads collaborate between institutions?

Share your experiences
and your contact info

BIO 412 Long-term Forest Monitoring – Syllabus Fall 2012

Instructor: Dr. Jason Kilgore
Office: Dieter-Porter 315
Email: jkilgore@washjeff.edu
Phone: office 724-223-6117; cell 724-678-3996, if emergency
Office Hrs: by appointment

Course Objectives: In this course, you will become become familiar with introductory forest ecology, the theory and methods for long-term monitoring of woody plants, and current projects at the international, national, and local level. We will meet these objectives through readings, discussions, library research, and a research project. This project will focus on questions related to the ongoing NSF-funded Ecological Research as Education Network (EREN) by establishing and monitoring additional plots within the Permanent Forest Plot Project (PFPP). In addition, we will foster cross-institutional collaboration by working with investigators from the University of Findlay.

Learning Outcomes: At the conclusion of this course, you will:

1) Understand basic forest ecology, mensuration, and monitoring practices;
2) Be familiar with historical and current long-term forest monitoring projects;
3) Improve skills in critically reading and discussing primary literature on ecological theory, methods, and analyses for forest monitoring;
4) Be more comfortable establishing forest plots and conducting monitoring activities;
5) Be able to identify woody plant species in southwestern Pennsylvania; and
6) Hone intra- and interinstitutional teamwork skills through working on a group research project, which will include maintaining communications among team members, researching online databases for primary literature, developing a proposal, collecting and analyzing data, practicing quality control in data entry, contributing to a national database, generating figures and tables, writing a coherent manuscript appropriate for publication, and developing and presenting a scientific poster.

Course Format: This course will be dense, active, interactive (even outside W&J!), and vibrant with assigned readings from primary and secondary literature, discussions about these readings, and an interinstitutional project conducted at Abernathy Field Station (AFS) and the Rieck Center for Habitat Studies at the University of Findlay. As a Biology major, successful completion of this course will fulfill your Capstone project requirement in Biology (if applicable).

This class is scheduled for 8-11am every Tuesday and Thursday for the duration of the semester. Due to two Saturday events that are required for this course, some other sessions will not start until 9am (see **Schedule**). On-campus meetings will occur in DP 311, while field meetings will start in DP 311 before leaving for AFS. You will be expected to complete readings, prepare for discussion, and do research project tasks outside of this class time, as well.

Your course grade will depend on your demonstrated completion of all assigned course readings, participation in class discussions, participation in the research project, and completion of all requirements for the research project.

Course Readings and Supplies: All readings will be posted to Sakai or distributed in class for students to read prior to the discussion session; no text is required for this course. You will need a field databook, such as the ~$3 books available at the W&J Bookstore. If you do not already own *Trees of Pennsylvania* (Rhoads and Block 2005), you may wish to purchase this valuable field guide.

You will be expected to complete all readings assigned for the particular day and to participate in the discussions. Lack of participation and indicators of ill preparedness will affect your course score. You should criticially read, summarize, and be prepared to discuss the readings; I am not planning to give lectures in this course.

Since we will be working in the field almost every day, rain or shine, you are responsible for determining appropriate clothing for the weather and location. I strongly recommend long pants, field shoes or boots, and rainwear for every day in the field. You should also pack your own drinking water and food in a daypack in which you will also carry field equipment. Confidentially notify the instructor if you have any medical conditions that could affect your or others' experience in this course.

Research Project: All students will participate in a research project in collaboration with students from the laboratory of Dr. Ben Dolan at the University of Findlay. This research project will involve installing long-term forest monitoring plots at AFS and at the Rieck Center for Habitat Studies at the University of Findlay, collecting data at both sites, and using these data to address a research question. Ideally, students from both institutions will work in smaller groups to collaboratively develop the research proposal, collect and analyze the data, and prepare professional summaries of the project in paper and poster form. Consequently, students from both institutions will be expected to regularly communicate and share data and documents. This venture mimics the real world of how science is conducted and should foster long-term connections between the students.

The body of the proposal will include a short but relevant review of the literature, the hypothesis being tested, an outline of the data required to test the hypothesis, the proposed statistical methods, a prediction graph, a schedule, and a literature cited section. The proposal should be 2-3 pages (11-pt Arial font, 1" margins, double-spaced). Citation format must follow the journal *Ecology*. The proposal may be coauthored with students from University of Findlay and is due by Oct 18.

The poster will be modeled after a scientific conference poster and should serve as a stand-alone presentation, although you will present this poster at the Student Projects Poster Session in December, the Western Pennsylvania Undergraduate Biology Symposium in Spring 2013, and possibly at an EREN or BSA meeting. The poster may be coauthored with students from University of Findlay and is due Nov 20.

The final paper will be modeled after a scientific journal manuscript and will include all of the appropriate sections of the paper. This paper should be 15-20 pages (11-pt Arial font, 1" margins, double-spaced) and must follow formatting by the journal *Ecology*. The final paper may be coauthored with students from University of Findlay and is due by Dec 6; failure to submit data files and book will result in no credit for the paper.

Course Grade:

Assessments	**%**
Completion of all assigned readings and participation in discussions	10
Participation in class projects	25
Research Project	
Proposal	15
Poster and presentation	25
Paper (with data files and databook)	25
Total	**100**

Final grades will be based on your cumulative percentage points earned: A, 93-100%; A-, 90-92%; B+, 87-89%; B, 83-86%; B-, 80-82%; C+, 77-79%; C, 73-76%; C-, 70-72%; D+, 67-69%; D, 63-66%; D-, 60-62%; F, <60%. Grades are based on individual performance and not on the class 'average.'

Student Responsibilities:

Official method of contact: Email sent to your "jay.washjeff.edu" email account is the official method of communication for all courses and administrative purposes at W&J. Checking your W&J email account on a regular basis is your responsibility. We will also set up a phone tree for emergency purposes.

Preparation: You must be prepared for all sessions related to this course. All assignments and readings assigned for a particular session should be completed prior to the session unless otherwise instructed.

Attendance: You are required to attend all class sessions and field trips, with exceptions made only in cases of illness ('written doctor's excuse' required), death in the family (requires notification by the Office of Student Life), or other extreme emergencies (requires notification by Office of Student Life). Notify Dr. Kilgore of an excused absence as early as possible, preferably prior to your absence. Notification is your responsibility, and you are responsible for all course material covered during your absence.

In the event of an unexcused absence, you will receive '0' points for the session. Excused absences will be managed on an individual basis.

There will be no 'make-up' sessions scheduled for any absence. More than one missed session may result in either an incomplete (excused absences) or a failing grade (unexcused absence) for the course. The Office of Academic Affairs will be notified of any unexcused absences.

Plagiarism and academic honesty: You are expected to follow W&J's policies/guidelines concerning plagiarism and academic honesty. You are responsible for reading and understanding the information in the College Academic Honesty Policy found in the Academic Regulations wiki linked from Sakai. You will be required to sign an Academic Honesty Agreement; please see me if you have any questions or concerns.

Cases of 'plagiarism' are sometimes due to not knowing how to correctly cite, paraphrase, or describe someone else's work. If you are unsure how to correctly reference the work of others,

don't hesitate to ask! Whether intentional or unintentional, plagiarism and other acts of academic dishonesty will result in a failing grade for the assignment/exam or a failing grade for the course. Examples of how to cite and reference the intellectual property of others will be presented throughout the course.

Electronic devices: All cell phones, music players, and PDA's must be turned off during all class sessions, except in the field when cell phones may be used to maintain communication between separated groups or instructor. Ringing cell phones will result in a warning and then a 1% reduction in your course grade for each subsequent occurrence. Answering a call or texting for non-class issues during an active class session will result in your being asked to leave, and you will receive a '0' for any work missed during your absence. If you are expecting an important phone call related to a family emergency or job offer, please see me before the session begins for the day.

Activity schedule: *<subject to change with announcements in class, by email, or posted to Sakai>*

Date	**Day**	**Activities (location)**	**For this session…**
Sept 4	Tue	Introduction to course, forest ecology, and emerald ash borers (8:30am, 311 DP)	Read Barnes et al. (1998, Ch.1,6); Barbour et al. (1999); McCullough and Roberts (2002), Cappaert et al. (2005), Kovacs et al. (2010)
Sept 6	Thur	Introduction to Permanent Forest Plot Project (PFPP) in Ecological Research as Education Network (EREN); Revisit Plot 1 and identify additional plot location(s) (8am; 311 DP, AFS)	Read Anderson et al. (1999), Bowne et al. (2011), Kuers et al. (2012), erenweb.org
Sept 7-8	Fri-Sat	University of Findlay students arrive Fri evening; Remeasure Plot 1 and set up addtl PFPP plot(s) at AFS all day Saturday	Read Dosch (2012); Arrange for guests to sleep and eat with you
Sept 11	Tue	Physical environment: Landscape position, soil, and nutrient cycling (9am; 311 DP)	Read Barnes et al. (1998, Ch. 10,11,19)
Sept 13	Thur	Additional PFPP plot selection and installation (8am; 311 DP, AFS)	
Sept 18	Tue	Physical environment: Climate, light, and temperature (9am; 311 DP)	Read Barnes et al. (1998, Ch. 7,8,9)
Sept 20	Thur	Additional PFPP plot selection and installation (8am; 311 DP, AFS)	
Sept 21-22	Fri-Sat	Leave at 6pm for U. Findlay; Set up PFPP plots at Rieck Center for Habitat Studies all day Saturday; Return to W&J in late evening	Take sleeping bag, pillow, field clothing, and food money

Date	**Day**	**Activities (location)**	**For this session…**
Sept 25	Tue	Herbivory (9am; 311 DP)	Read Gurevitch et al. (2002, Ch. 11), Hausman et al. (2010), Ellison et al. (2010)
Sept 27	Thur	Additional PFPP plot selection and installation (8am; 311 DP, AFS)	
Oct 2	Tue	Population growth (9am; 311 DP)	Read Gurevitch et al. (2002, Ch. 7)
Oct 4	Thur	Additional PFPP plot selection and installation (8am; 311 DP, AFS)	
Oct 9	Tue	Community properties (9am; 311 DP)	Read Gurevitch et al. (2002, Ch. 12,14)
Oct 11	Thur	Additional PFPP plot selection and installation (8am; 311 DP, AFS)	
Oct 16	***Tue***	***Fall Break***	Explore www.usanpn.org/
Oct 18	Thur	Additional PFPP plot selection and installation, or start National Phenology Network monitoring (8am; 311 DP, AFS)	Submit research project proposal
Oct 23	Tue	Succession & disturbance (9am; 311 DP)	Read Gurevitch et al. (2002, Ch. 13)
Oct 25	Thur	National Phenology Network monitoring (8am; 311 DP, AFS)	Morisette et al. (2009), Miller-Rushing et al. (2008)
Oct 30	Tue	Forest monitoring: values and methods (9am; 311 DP)	Read Youngblood and Palik (2011), Elliott and Vose (2011), Wetzel et al. (2011), Underwood (1994), Lindenmayer and Likens (2009), selections from Lindenmayer and Likens (2010)
Nov 1	Thur	QA/QC; Work on project (≤9am; 311 DP)	Read LoGiudice (2012)
Nov 6	Tue	Long-term forest monitoring programs (LTER, NEON, EREN) (9am; 311 DP)	Explore program websites
Nov 8	Thur	Work on project (≤9am; 311 DP)	
Nov 13	Tue	Work on project (≤9am; 311 DP)	Upload draft poster (.pdf) to Sakai Dropbox
Nov 15	Thur	Work on project (≤9am; 311 DP)	Upload draft poster (.pdf) to Sakai Dropbox

Date	**Day**	**Activities (location)**	**For this session…**
Nov 20	Tue	Complete final poster (≤9am; 311 DP)	Upload final poster (.pdf) to Sakai Dropbox for ITS plotting
Nov 22	***Thur***	***Thanksgiving Recess***	
Nov 27	Tue	Forest growth & classification (9am; 311 DP)	Read Barnes et al. (1998, Ch. 13)
Nov 29	Thur	Data archiving; Submit final data to EREN online database (≤9am; 311 DP)	Read Whitlock (2011)
Dec 4	Tue	Submit final data to NPN online database (9am; 311 DP)	
Dec 6	Thur	Practice poster presentation (≤9am; 311 DP)	Upload final paper (.docx) to Sakai Dropbox and submit all data books/sheets to Dr. Kilgore
Dec 7	**Fri**	**Poster session (3:30-6:30pm)**	
Dec 12	**Wed**	**Final Exam (2-5pm) Meeting**	
Dec 15	**Mon**	**Complete post-course CURE survey**	

Readings *(additional readings to be assigned during the semester)***:**

Anderson, L.J., M.F. Hoopes, and J.A. Simmons. 1999. Collaborative research at primarily undergraduate institutions. Frontiers in Ecology and the Environment 7:343.

Barbour, M.G., J.H. Burk,, W.D. Pitts, F.S. Gilliam, and M.W. Schwartz. 1999. Deciduous forests. Pages 594-607 *in* Terrestrial Plant Ecology, Third Edition. Benjamin/Cummings, Menlo Park, California, USA.

Barnes, B.V., D.R. Zak, S.R. Denton, and S.H. Spurr. 1998. Forest Ecology, 4th Edition. John Wiley & Sons, Inc., New York, New York, USA.

Bowne, D.R., A.L. Downing, M.F. Hoopes, K. LoGiudice, C.L. Thomas, L.J. Anderson, T.B. Gartner, D.J. Hornbach, K. Kuers, J.-L. Machado, B.R. Pohlad, and K.L. Shea. 2011. Transforming ecological science at primarily undergraduate institutions through collaborative networks. BioScience 61(5):386-392.

Cappaert, D., D.G. McCullough, T.M. Poland, and N.W. Siegert. 2005. Emerald ash borer in North America: a research and regulatory challenge. American Entomologist 51(3):152-165.

Dosch, J. 2012. Group Contract and Ground Rules, Permanent Forest Plot Project, Ecological Research as Education Network (EREN). Available from http://erenweb.org/wp-content/uploads/2011/08/PFPP-group-contract-ground-rules1.pdf

Elliott, K.J., and J.M. Vose. 2011. The contribution of the Coweeta Hydrologic Laboratory to developing an understanding of long-term (1934–2008) changes in managed and unmanaged forests. Forest Ecology and Management 261(5):900-910.

Ellison, A.M., A.A. Barker-Plotkin, D.R. Foster, and D.A. Orwig. 2010. Experimentally testing the role of foundation species in forests: the Harvard Forest Hemlock Removal Experiment. Methods in Ecology & Evolution 1:168-179.

Gurevitch, J., S.M. Scheiner, and G.A. Fox. 2002. The Ecology of Plants. Sinauer Associates, Inc., Sunderland, Massachusetts, USA.

Hausman, C.E., J.F. Jaeger, and O.J. Rocha. 2010. Impacts of the emerald ash borer (EAB) eradication and tree mortality: potential for a secondary spread of invasive plant species. Biological Invasions 12:2013–2023.

Knight, K.S., J.P. Brown, and R.P. Long. 2012. Factors affecting the survival of ash (*Fraxinus* spp.) trees infested by emerald ash borer (*Agrilus planipennis*). Biological Invasions Online First, 9 August 2012, DOI: 10.1007/s10530-012-0292-z.

Kuers, K., E. Lindquist, J. Dosch, K. Shea, J.-L. Machado, K. LoGiudice, J. Simmons, and L. Anderson. 2012. Permanent Forest Plot Project (PFPP), Version 1.05, (Complete Version with Appendices). Ecological Research as Education Network. Available from http://erenweb.org/wp-content/uploads/2012/08/EREN-PFPP_Protocol_Forms_Appen_30July2012v1-05.pdf

Kovacs, K.F., R.G. Haight, D.G. McCullough, R.J. Mercader, N.W. Siegert, and A.M. Liebhold. 2010. Cost of potential emerald ash borer damage in U.S. communities, 2009–2019. Ecological Economics 69:569–578.

Lindenmayer, D.B., and G.E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24(9):482-486.

Lindenmayer, D.B., and G.E. Likens. 2010. Effective Ecological Monitoring. Earthscan, Washington, DC, USA.

LoGiudice, K. 2012. Tips for Encouraging Accuracy in Data Entry by Students: Permanent Forest Plot Project, Ecological Research as Education Network (EREN). Available from http://erenweb.org/wp-content/uploads/2011/08/PFPP-Data_Quality_Assurance-LoGiudice-revised1.pdf

McCullough, D.G., and D.L. Roberts. 2002. Pest Alert: Emerald Ash Borer. NA-PR-07-02, United States Department of Agriculture Forest Service Northeastern Area, Newtown Square, Pennsylvania, USA.

Miller-Rushing, A.J., D.W. Inouye, and R.B. Primack. 2008. How well do first flowering dates measure plant responses to climate change? The effects of population size and sampling frequency. Journal of Ecology 96:1289-1296.

Morisette, J.T., A.D. Richardson, A.K. Knapp, J.I. Fisher, E.A. Graham, J. Abatzoglou, B.E. Wilson, D.D. Breshears, G.M. Henebry, J.M. Hanes, and L. Liang. 2009. Tracking the rhythm of the seasons in the face of global change: phenological research in the 21st century. Frontiers in Ecology and the Environment 7:253-260.

Underwood, A.J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4(1):3-15.

Wetzel, S., D.E. Swift, D. Burgess, and C. Robinson. 2011. Research in Canada's National Research Forests—Past, present and future. Forest Ecology and Management 261(5):893-899.

Whitlock, M.C. 2011. Data archiving in ecology and evolution: best practices. Trends in Ecology and Evolution 26(2):61-65.

Youngblood, A., and B. Palik. 2011. Ecological lessons from long-term studies in experimental forests. Forest Ecology and Management 261(5):889-892.

Shade-tolerant tree species may become more important in ash dominant forests after EAB infestation

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Introduction

Figure 1. Adult emerald ash borer found on bark of ash tree. http://www.nyis.info/?action=eab

The emerald ash borer (Fig. 1; EAB, *Agrilus planipennis*) is an iridescent green beetle from northeastern China, Korea, Japan, Mongolia, Taiwan, and eastern Russia that was first detected in North America in 2002 near Detroit, MI. EAB is specific to ash trees (*Fraxinus* spp.) and has spread to many forests in North America (Fig. 2). Female EABs lay eggs in ash bark crevices, and, following hatching, the larvae chew their way through the bark and feed on the phloem and outer sapwood. Once fully grown, EAB adults exit the tree leaving their telltale sign of infestation, the D-shaped exit holes (Fig. 3). EAB infestation leads to complete ash mortality in 2-3 years (McCullough and Roberts, 2002).

Following EAB infestation, dead ash trees fall and leave a canopy opening that allows more light to the understory (Banal *et al.,* 2007). With increased light exposure, forest compositional changes may occur as shade-tolerant trees are recruited. For example, sugar maple (*Acer saccharum*) aggregates in association with fallen elm (*Ulmus* spp.) trees killed by Dutch elm disease (*Ophiostoma ulmi*) (Lin and Augspurger, 2008). Other less shade-tolerant species, such as black cherry (*Prunus serotina*), white pine (*Pinus strobus*), red maple (*A. rubrum*), red oak (*Quercus rubra*), and white ash (*F. americana*), can also aggregate and recruit into the gap (Banal *et al.,* 2007).

Figure 2. Distribution of ash trees (green shade) and EAB (red dots). The solid red line is the EAB Federal Ash Quarantine boundaries. The black star indicates the initial location of the EAB infestation.

Figure 3. The D-shaped exit holes created by adult EAB are left behind after the tree was infested with EAB (Kuers *et al.,* 2012).

American chestnut (*Castanea dentata*), which was almost completely eliminated from eastern forests due to chestnut blight (*Cryphonectria parasitca*), was predicted to be replaced by oak (*Quercus* spp.) and hickory (*Carya* spp.), both intermediate shade-tolerant genera, in predominantly oak-chestnut forests (McCormick and Platt, 1980).

Our objective was to predict whether significant forest compositional changes might occur following EAB infestation in two forested sites that differ in levels of overstory ash. We expect a shift towards dominance by shade-tolerant species that will benefit from gaps created by loss of ash in the overstory in the more ash-dominated site. The global null hypothesis is all IVs are the same across species and whether in the presence or absence of ash trees.

Methods

Study Sites: Six 400-m^2 plots were established in each of the two mixed mesophytic forests with varying ash overstory: 1) Abernathy Field Station (AFS), W&J College, Washington County, PA (40.13^o N, 80.18^o W); and 2) Rieck Field Center (RFC), University of Findlay, Hancock County, OH (40.96^o N, 83.55^o W).

AFS: Paired plots (square) were established following the Permanent Forest Plot Project protocol (PFPP; Kuers *et al.*, 2012) at 5 m ("edge") and 45 m ("interior") from a maintained natural gas right-of-way (ROW). All trees greater than 2.5 cm in diameter at breast height (1.37 m, DBH) were labeled with aluminum tags engraved with "W&J," plot name, and tree number. Tags were either nailed (Figure 4) with aluminum nails 15 cm below diameter measurement height or wired (<5 cm DBH; Figure 5) to each tree.

Figure 4. The pink line indicates where DBH is measured. The tag is placed 6 in below the pink line and placed on the up-hill facing side of the tree.

Figure 5. Trees that were less than 5 cm DBH were tagged using wire.

RFC: Plots (round) were randomly located within forested areas. Trees (>2.5 cm DBH) were not labeled; instead, tree locations within the plot were recorded by compass bearing and distance from the plot center.

Inventory: The tree inventory at both locations followed the PFPP protocol (Kuers *et al*., 2012), including species identification, DBH, number of stems, and stem soundness. Additional data were collected from all ash trees following Dolan and Kilgore (2012); these data included canopy health, branch condition, and number of D-shaped exit holes.

Analysis: After removing vines and dead trees from the data, we used univariate analysis of variance (ANOVA) to detect effects of the presence of ash (fixed factor) and species (fixed factor), and their interaction, on species importance values (IV; dependent variable). IV was calculated by adding relative density and relative basal area for each species in each plot.

Results

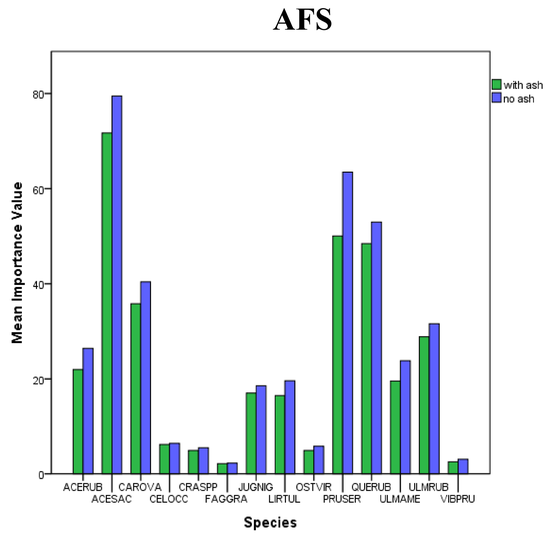


Figure 6. Mean importance values (IVs) of the 14 non-ash tree species inventoried at our Abernathy Field Station forest site in Washington, PA. Green bars represent importance values with ash trees present, and blue bars represent importance values with ash trees absent. IVs were significantly different across species (ANOVA, F = 7.02; d.f. = 13; p = 0.00) and were not significantly different after ash was eliminated (ANOVA, F = 0.25; d.f. = 1; p = 0.62), while the interaction of ash presence and species was not significant (ANOVA, F = 0.06; d.f. = 13; p = 1.00).

Species Code	Scientific Name	Common Name
ACENEG	***Acer negundo***	**boxelder maple**
ACENIG	*Acer nigrum*	black maple
ACERUB	***Acer rubrum***	**red maple**
ACESAC	*Acer saccharum*	sugar maple
AESGLA	***Aesculus glabra***	**Ohio buckeye**
ASITRI	*Asimina triloba*	pawpaw
CARCAR	***Carya carolinae-septentrionalis***	**southern shagbark hickory**
CARCOR	*Carya cordiformis*	bitternut hickory
CAROVA	***Carya ovata***	**shagbark hickory**
CELOCC	*Celtis occidentalis*	hackberry
CRASPP	***Crataegus spp.***	**hawthorn**
FAGGRA	*Fagus grandifolia*	American beech
JUGNIG	***Juglans nigra***	**black walnut**
LIRTUL	*Liriodendron tulipifera*	tulip poplar
OSTVIR	***Ostrya virginiana***	**American hophornbeam**
PRUSER	*Prunus serotina*	wild black cherry
QUEMAC	***Quercus marcocarpa***	**bur oak**
QUERUB	*Quercus rubra*	red oak
TILAME	***Tilia americana***	**American basswood**
ULMAME	*Ulmus americana*	American elm
ULMRUB	***Ulmus rubra***	**slippery elm**
VIBPRU	*Viburnum prunifolium*	black haw

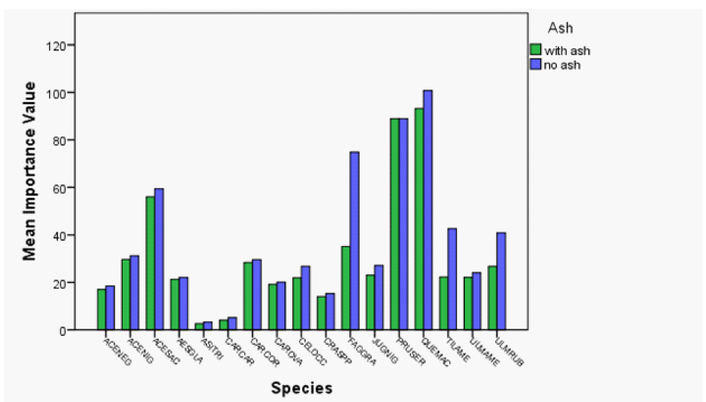


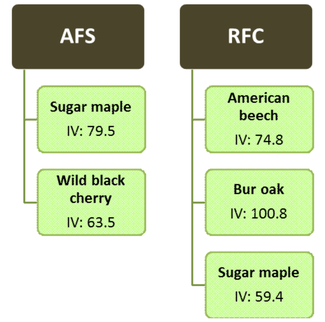
Figure 7. Mean importance values (IVs) of the 17 non-ash tree species inventoried at our Rieck Field Center forest site in Findlay, OH. Green bars represent IVs with ash trees present, and blue bars represent IVs with ash trees absent. IVs were significantly different across species (ANOVA, F = 3.67; d.f. = 16; p = 0.001), were not significantly different after ash were eliminated (ANOVA, F = 0.868; d.f. = 1; p = 0.358), and were not significant for the interaction factor of ash and species (ANOVA, F = 0.106; d.f. = 16; p = 1.00).

Discussion

Although the species IVs did not significantly change at either site after ash were not included in the IV calculations, we predict that dominant species of the canopy that are also shade-tolerant will take advantage of the canopy gaps. When a dominant species is removed from a forest, an episode of increased sapling growth will occur (Banal *et al*., 2007). These saplings are most likely to be shade-tolerant species and to already be a prominent species in the forest.

At AFS, the two dominant canopy species before and after ash are removed are sugar maple and wild black cherry (Fig. 2), and these species are shade-tolerant and intermediate shade-tolerant species, respectively. We predict that these species will remain dominant when the site becomes infested by EAB because they are already dominant in the canopy and well established in the understory.

At RFC, we predict that the shade-tolerant and intermediate shade-tolerant species, American beech (*Fagus grandifolia*) and bur oak (*Quercus macrocarpa*), may become more prominent in the select plots in which they are found. Across all plots, sugar maple will become more important because of its dominance in the canopy and understory.



Future Work

- Continue to monitor EAB infestation at AFS and RFC, including effects on ash and small-stem growth
- Include understory data into our analysis to observe how shrub-sapling competition may be affecting native tree sapling establishment, especially for ash species.
- Increase number of sample sites with varying levels of ash dominacne to observe how the importance of shade-tolerant species is affected.

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Response of Ash Seedling Density to Emerald Ash Borer Infestation

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Introduction

First detected in Michigan in 2002 (Haack *et al.*, 2002), the recently introduced invasive insect, emerald ash borer (EAB, *Agrilus planipennis)*, stresses ash (*Fraxinus* spp.) trees by feeding on their bark phloem, ultimately leading to tree death in 2-5 years (Knight *et al.*, 2012). Infestation is often undetectable until severe and is noted by dieback symptoms, including bark splitting, D-shaped exit holes in the bark, canopy dieback, and epicormic branching (Cappaert *et al.*, 2005).

Adult Emerald Ash Borer. Available from: http://www.inspection.gc.ca/plants/plant-protection/insects/emerald-ash-borer/

Comaparison of a finger and a D-shaped exit hole. Available from: http://hyg.ipm.illinois.edu/article.

Given limited resources and impending death, we predicted that trees stressed by EAB infestation would allocate more resources to seed production in forests where EAB infestation is more severe.

As part of the Permanent Forest Plot Project (PFPP) sponsored by the Ecological Research as Education Network (EREN), we compared the relative abundance of ash seedlings at 2 sites (Hancock County, OH; Washington County, PA) using time since EAB infestation as a proxy for severity. The OH site has higher ash density and has been detectably infested with EAB for 4 years longer than the PA site, therefore we predicted that the OH site would have a higher relative abundance of ash seedlings than the PA site.

Collaboration

EREN Logo. Available from www.erenweb.org

This study was a collaboration between students from the University of Findlay (UF) and Washington & Jefferson College (W&J) through EREN, which is funded by the National Science Foundation's Research Coordination Network program. Students traveled to both of the respective field sites to establish permanent forest plots and to collect data. Intercollegiate teams were formed to propose relevant questions, share and analyze data, and prepare this poster. All of the data will be shared with EREN Members via the PFPP Online Database.

Students from both institutions measuring an ash at DBH at RFC.

Students and professors from the two institutions standing in front of an ash tree at the University of Findlay in Ohio.

Methods

Abernathy Field Station (AFS, Washington County, PA)

- Six 400-m^2 plots were established as described by the EREN PFPP protocol (Kuers *et al.*, 2012).
- Paired plots were established along the edge and interior of a natural gas right-of-way.
- Each tree (>2.5 cm dia) was tagged, identified to species, and measured for diameter at 1.37 m (DBH). Basal area for each ash tree was calculated from diameter and then summed for the plot.
- Ash trees were evaluated for EAB exit holes and dieback symptoms (Dolan and Kilgore, 2012).
- Three 1-m^2 mini-plots were randomly located within each plot to sample the understory (forbs; woody plants <0.3 m tall; Dolan and Kilgore, 2012). Ash seedling density was scaled to plot size for analyses.

Rieck Field Center (RFC, Hancock County, OH)

- Six 400-m^2 plots were randomly located using ArcMap.
- Each tree was mapped by compass bearing and distance to plot center, identified to species, and measured for diameter (DBH).Summed basal area was calculated
- Ash trees were evaluated for EAB exit holes and dieback symptoms (Dolan and Kilgore, 2012).
- Three 1-m^2 mini-plots were established 5 m from the plot center at 0°, 120°, and 240° to sample the understory (forbs; woody plants <0.3 m tall; Dolan and Kilgore, 2012). Ash seedling density was scaled to plot size for analyses.

Analyses

To test the hypothesis that time since EAB infestation affects ash seedling abundance, controlling for overstory ash abundance, we used an analysis of variance (ANOVA) with site (fixed factor) representing two levels of time since infestation and overstory ash abundance as the covariate. Ash seedling density and overstory basal area at both sites were approximately normally distributed (Shapiro-Wilk test, p>0.05) and had equal variance (Levene's test, p=0.099).

Tag-wired tree at Washington and Jefferson College.

Results

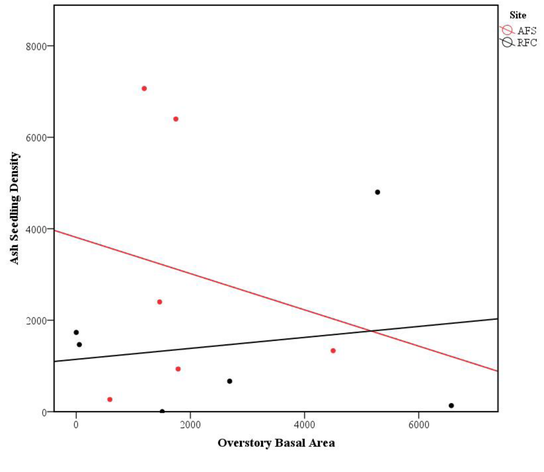

Figure 1. Ash seedling density as a function of ash overstory basal area at AFS and RFC. Neither site (ANOVA, F=1.151, df=1, p=0.311) nor overstory basal area (ANOVA, F=0.002, df=1, p=0.963) had a significant effect on ash seedling density.

Ash seeding available from http://treegrowing.tcv.org.uk/wp-content/uploads/2010/11/special19.jpg

Healthy adult ash . Available from http://richmondtreestewards.wordpress.com/emerald-ash-borer/

EAB induced dieback. Available from http://www.wqed.org/birdblog/wp-content/uploads/2009/11/trees_fpm_invasives_eab_01a_rsz_dcnr.jpg

Discussion

We did not detect a significant influence of time since EAB infestation, controlling for potential seedling production via ash basal area, on ash seedling density. Therefore, we had insufficient evidence to conclude that ash trees increase seed production as a response to EAB stress, assuming that time since infestation represents severity of EAB infestation.

Seedling abundance may not be the best indicator of seed production due to seedling visibility and seedbank contributions. While adult ash trees are easy to locate and identify, ash seedlings are relatively small and may have been undetected due to leaf-drop and covering by leaf litter due to the time of year this study was completed (fall 2012).

Observed seedlings may have originated from the seedbank rather than from recent seed production. Ash trees begin producing seed at 20 yrs and continue until the trees reach 125 yrs, with masting every 1-8 yrs (BenDor *et al.*, 2006). Little is known about ash seed viability in the seed bank (Hausman *et al.*, 2009), yet some evidence indicates that ash seeds remain viable up to 5 yrs (BenDor *et al.*, 2006). Additionally, several factors influence seed emergence, including light, temperature, water, predation, and soil condition (Jinks *et al.*, 2006) (Finch-Savage and Leubner-Metzger, 2006). Due to the effects of resource competition on seedling density (Bazzaz *et al.*, 2009), some seedlings may have perished earlier in the growing season before data was collected.

Limitations due to experimental design

- Sample size and limited levels of EAB severity and ash overstory abundance
- Nonrandom plot selection
- Mini-plots only represented a small fraction of overall plot

Future Work

Testing different areas where EAB infestation has occurred and comparing them to sites that have not yet been hit by EAB would be useful to compare how ash tree seedling density is affected by stress in areas with and without EAB stress.

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