

Abstract

Earthworms Across Kansas (EAK) is a citizen science outreach project designed to involve K-12 students (primarily from middle and high schools) in real scientific research. Approximately one-third of earthworm species in the US are not native to North America, ultimately being transported here by humans from Europe and Asia. Many of these species cause great harm to native ecosystems especially in regions where native earthworms have not existed since they were glaciated 15,000-20,000 years ago. Engaging students in research allowed us to meet our goals of educating students about invasive species and the consequences of invasive species for ecosystems and conservation, while also increasing their enthusiasm for science and simultaneously improving knowledge about earthworm diversity and distribution in Kansas. These were accomplished by distributing free earthworm collecting kits to teachers who were interested in participating in the project. Teachers took their students to collect earthworms, educated them about invasive earthworms, and shipped the specimens back to K-State via a pre-paid shipping label. Undergraduate technicians learned to properly collect tissue samples, preserve, identify, and label earthworms for permanent museum collection. All of the data was posted online in interactive maps for students and the public to explore. EAK has been very successful: nearly 300 teachers at the pre-K, elementary, middle, and high school levels from home school, public, and private institutions were engaged in the project. Although only one-third of those teachers returned their kits, over 3,000 earthworms were received and we collected ~450 tissue samples for future genetic research. This has led to a tremendous increase in knowledge of the earthworm diversity and distribution in Kansas, including at least seven non-native earthworm species newly recorded from Kansas (an expansion of the known fauna by 35%) and further analyses of these data will continue to improve our understanding of earthworm invasions.

The Partnership

EAK was funded by the Center for Engagement and Community Development in January 2010. Bruce A. Snyder (Instructor in Biology) is the principle investigator of the project, creating the website and content; maintaining the Facebook page; selecting, training, and supervising undergraduate technicians; managing the budget; and communicating with teachers, partners, and other interested parties. He has been aided by several critical on- and off-campus partners: a) Chris Lavergne (former Instructor in Ag Communications, now with NRCS) assisted with layout and production of materials for collecting kits and assembly of survey instrument, b) Greg Zolnerowich (Associate Professor in Entomology) provided work space and storage space in the Museum of Entomological and Prairie Arthropod Research, c) Mac Callaham (Research Ecologist, USDA Forest Service) assisted with content of materials for the collecting kit and website, d) Sam James (formerly with Kansas University Biodiversity Institute, now Adjunct Associate Professor, University of Iowa) provided guidance on processing, preservation, and identification of specimens, e) two undergraduate technicians completed the majority of specimen processing and identification, and f) staff of the Division of Biology and Ag Communications/Research and Extension provided logistical support.

During 2010, EAK was publicized via K-State press releases, a Facebook page, the EAK website, and information letters that were sent first to school principals and shortly thereafter to science instructors throughout the state. Interested teachers were instructed to visit the website and fill out a short form to register to receive a collecting kit at the beginning of the 2010-2011

academic year. The true community partners are these teachers and their students. In August 2010, 210 kits were shipped and we continued to send kits to new registrants and additional supplies as requested. Each kit contained a) brief instructions, b) an EAK pencil, c) four labels, d) four collection vials in appropriate packing materials, and e) a return shipping label. Available on the website were detailed instructions on how to collect, a Spanish translation of the instruction book, an identification key to Kansas earthworms, and a sample lesson plan written for a specific grade level and state standard. The website also contained maps of participating institutions and of all previously published earthworm records. Teachers were asked to collect earthworms anytime during academic year 2010-2011 and return the earthworm specimens immediately after collecting. We began receiving earthworms almost immediately and hired our first undergraduate technician in September 2010. The last earthworms arrived September 2011 and we completed processing, identification, and uploading of the data in December 2011. We are currently evaluating the project's effectiveness with a survey of all registered participants.

In addition to communication via the web, Dr. Snyder has had email and phone conversations with teachers throughout the project. He has presented the project in an Ecology and Evolutionary Biology (section of the Division of Biology) seminar in Spring 2010 and visited Delaware Ridge Elementary School (Fall 2010) to talk to 3rd grade students and field their questions. The project has also been presented to Organismic Biology (BIOL 201) as part of lab activities on earthworms (by Snyder, Spring 2011) and in their lecture on earthworms (by Brett Sandercock, Fall 2011). Snyder will present EAK results in a Spring 2012 Entomology seminar.

Lesson Learned and Best Practices

EAK has faced challenges from both the scientific and educational perspectives. The largest concern with citizen science, purely from the scientific perspective, is ensuring that data is collected properly. EAK data took two forms: collection information (specifically when, where, and by whom specimens were collected) and the specimens themselves. The partnership between Ag Communications and Biology ensured that the directions were well-written and as a result few specimens were submitted with poor location information. We were able to foresee some potential problems and avoid them with clear instructions. For example, how to write dates such that they can be interpreted many years from now: "2/5/11" in a museum specimen could mean May 2, 1811, whereas "5 February 2011" leaves little doubt.

A larger problem was that our directions for treatment of collection labels (the paper which contains this critical information and remains with the specimens in perpetuity) were not always followed to the letter. These labels should be written in pencil (thus we provided one with the kit) and placed inside vials with the earthworm in alcohol. However, many participants either taped the label to the outside of the vial, wrote in pen, or both. This was problematic because collection information can wash away, get destroyed, or get separated from the specimen - in all cases rendering the specimen useless for research. No data was lost in this manner, but we have learned which areas need instructions to be written differently or emphasized.

Permanent, museum-quality preservation of earthworm specimens requires the use of formaldehyde. It was not feasible to send formaldehyde in our kits for safety reasons, instead using dilute alcohol to kill and temporarily preserve specimens until arrival at K-State. Problems could potentially arise if too many specimens were put into a vial or specimens sat in alcohol for a long time; in both cases this would cause degradation of the specimens. We did not limit the number of specimens in our instructions. Overall, specimens arrived in good condition and the time between collection and formaldehyde preservation was acceptable. Preservation takes 2-3 days, and the timing of earthworms arriving at K-State created a backlog which delayed preservation during part of the project. This can be avoided in future expansions of EAK with

earlier hiring of technicians, who can also be trained faster because the preservation workflow is well-defined. We will also have an easily interpretable limit on the number or volume of earthworms, as some specimens were lower quality due to overloading the vials.

From the educational perspective, it was a challenge for EAK and teachers to communicate with each other. An important aspect of the project is posting the data online so that teachers and students can see their submission. However, the backlog in preservation (and subsequent identification) of specimens delayed posting information on the website, and we started to receive inquiries about specific collections. We were able to ameliorate some of this by posting information about submissions before they had been identified, so students could see that we had received their earthworms. In our preliminary survey results, not being able to see the data over a period of time was cited several times as a reason why students lost interest or were disappointed. Some participants did not know that they could visit the website to see the data or were unsure how to do so. Additionally, some teachers did not collect earthworms because they forgot as the year progressed. These issues can be overcome in future iterations of EAK by improving communication from EAK to the participants in four ways: i) more frequent mass emails to all participants; ii) individual notification as specimens are processed, identified, and data is posted; iii) improved website design to make finding results easier; and iv) additional resources on the website to make interpreting results a class activity.

EAK had significant benefits for teachers. Although only 57% of 124 survey respondents submitted earthworm specimens, 83% of respondents said EAK was beneficial to student learning and 62% said EAK increased their teaching effectiveness. Over 86% would participate again and recommend it to colleagues. Several commented that they would participate annually if they could. EAK was certainly successful at facilitating interactions between researchers, K-12 teachers, and their students. Teachers were made more aware of citizen science projects, many students were able to contribute to real science, and community members are more aware of the presence of invasive species and the threats these species can pose to ecosystems and conservation of native species. At the university level, two technicians were trained in citizen science, collections-based research, and earthworm identification.

This project has been very successful: 292 individuals at educational institutions were engaged in the project, ~450 tissue samples have been preserved for future genetic studies, and 3,083 earthworms were received. Knowledge and awareness of earthworm diversity and distribution in Kansas has increased greatly. At least seven non-native earthworm species have been newly recorded from Kansas (a 35% expansion of the known fauna). Some of these are possibly new to the United States, but further research is needed to confirm the identifications. All historic (published) and new (EAK) earthworm distribution records have been made available on the EAK website. Peer-reviewed publications will be prepared in the coming year to describe the success of the project and formally document the new records.

The ability to explore how to conduct a citizen science project on a relatively small scale has been incredibly beneficial. Citizens science projects typically collect data and can collect quality data if supervised or instructed properly. However, few projects have used citizen scientists to collect specimens. EAK has functioned as a pilot project, establishing that it is possible for middle and high school students to collect high quality collection data and specimens, and learn in the process. The methodology is now ready to be applied to broader temporal and geographic scales, where even more flexibility can be added to what teachers can do with their classes. I envision these collecting kits in every high school across the US, and the success of *Earthworms Across Kansas* has shown it is logistically feasible and generates useful data.

January 10, 2011

Office of the Provost and
Center for Engagement and Community Development
202 Ahearn
Kansas State University
Manhattan, KS 66506

Dear members of the Excellence in Engagement award review panel,

I am pleased to endorse Bruce Snyder and the Earthworms Across Kansas project for a K-State Excellence in Engagement Award. This project certainly fulfills the criteria for excellence in engaged scholarship and has demonstrated innovation in its approach to outreach.

Earthworms Across Kansas aims to teach Kansas' middle and high school students about earthworm biology and invasive species by engaging them as citizen scientists. The project has involved 292 institutions across Kansas from Liberal to Hiawatha and Atwood to Baxter Springs, and has benefitted K-State undergraduates who have worked with the project. The thousands of earthworms sent to Snyder by K-12 students have significantly increased knowledge of this important group of animals in Kansas. This information has been communicated back to students and their communities via a website, and I am sure that scholarly publications will soon be an outcome of the project.

Snyder has been innovative in his efforts to pursue this project to its fullest extent, by engaging and positively impacting the university and Kansas communities. For this reason I fully support his nomination for the Excellence in Engagement Award and believe that he is an outstanding candidate for this award.

Sincerely,



Brian S. Spooner
University Distinguished Professor and
Director
Division of Biology

Office of the Provost and
Center for Engagement and Community Development
202 Ahearn
Kansas State University
Manhattan, KS 66506

January 12, 2012

Dear members of the Excellence in Engagement Award review panel,

I write this letter in support of the nomination of Dr. Snyder and the Earthworms Across Kansas (EAK) project for a K-State Excellence in Engagement Award. I designed and teach the courses in the Shawnee Mission School District (SMSD) Biotechnology Signature Program. When I received information about the EAK project, I was excited to learn that my students would have an opportunity to participate in “real” research and interact with a “real” researcher. Too many times students in a high school science are so separated from authentic research that learning science might as well be learning science fiction. By that I mean students very seldom have the opportunity to apply science concepts and scientific processes to collect data for actual research. The project gave a much needed hands-on and authentic aspect to teaching science. Students were both excited and motivated as a direct result of the interaction in the research project (EAK) designed by Dr. Snyder.

In fact, the project was so motivational two of the senior students in the SMSD Biotechnology Program designed their own research using the EAK project as a model. The students not only collected earthworms for the project, they also took samples of the earthworm muscle to use for DNA and protein analysis. I can say with confidence that the idea of studying the diversity of earthworms across Kansas never occurred to these students until we learned about EAK. The young scientists designed and implemented their original research with help from Dr. Snyder. Dr. Snyder was available via email to answer students’ questions. His help on the project proved to be instrumental in the success of the student research. Through dialogue with Dr. Snyder, students also learned scientists don’t always have all the answers. When necessary, Dr. Snyder was generous enough to promptly share his expertise along with his resources and network of other scientists with the students.

I have been teaching in Kansas for 33 years and lived my entire life here. Through conversations with Dr. Snyder I learned so much about the ramifications of introduced species. I had no idea there were so many species of earthworms in Kansas. I immediately integrated the information from the EAK project into my curriculum and shared the information and lesson plans with my colleagues at our monthly PLC (Professional Learning Community) meetings. In addition, several teachers are using the information in ecology, biodiversity and evolution units in Biology

and Ecology classes. Like me, students are unaware of the number of species of earthworms in Kansas. The EAK project brought textbook examples to life – earthworms in Kansas are something students can relate to. Too many times the textbook uses examples from places unfamiliar to students. This was the perfect project to “bring home” the concept of introduced species.

In closing, the impact of EAK project in my classrooms was immeasurable. Very few teachers and students truly understand the scientific process as used in the real world. Our involvement in the EAK project provided an opportunity for both students and teachers to conduct research first hand and interact with the scientist. The project had a positive impact on our students and teachers. I will recommend projects of this kind, including the EAK project, as we adopt STEM curriculum in our district.

Sincerely,

A handwritten signature in cursive script that reads "Brenda Bott". The signature is written in black ink and is positioned to the left of the typed name.

Brenda Bott
SMSD Biotechnology Signature Program
Shawnee Mission West High School
8800 W. 85th Street
Overland Park, KS 66212