



Coloring for Conservation: Outreach Science for Eastern Hellbender Salamanders

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Abstract

Engaging K-5 future citizen scientists is a challenge which balances effective outreach science and curriculum development, as well as in and out-of-classroom experiences. Environmental education programs should be designed to both engage and inform the public on important conservation issues related to local biodiversity. Amphibians, especially salamanders, are experiencing worldwide declines, but are relatively overlooked by the public when compared with frogs and other more charismatic species. To this end, we developed a hellbender-focused, outreach-education coloring book, which was provided to either stream visitors as part of ongoing education programming or in classroom/summer camp settings, in two states where eastern hellbender salamanders occur. We assessed whether this coloring book activity engaged and informed K-5 level participants by performing a short, post-implementation survey. Results indicate that the hellbender coloring book was effective as an educational tool and provided an engaging experience for participants, while concomitantly teaching that moving rocks within streams can be potentially harmful for aquatic organisms, including larval hellbenders. We recommend conservation managers from state and federal agencies work closely with community educators to implement similar programs to inform the local general public on environmental programs using conservation themed coloring books.

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Introduction

Environmental education (EE) programs should be designed to raise awareness about conservation issues, incorporate strategies for conservation outcomes (Hughes, 2012), and actively engage participants to be effective stewards for conservation (Duvall & Zint, 2007). The more educational tools environmental educators and science teachers implement in their activities, the more likely their efforts will result in successfully informing students and the general public about conservation issues (Breuer & Mavinga, 2009; Strickland et al., 2021). Visual narratives, including comics, animations, and coloring books, have increasingly become utilized for science education to a wide audience across age groups and cultural backgrounds (Farinella, 2018). Comics, or visual graphic stories, provide a potential valuable tool to concomitantly engage, inform, promote scientific literacy, and communicate science education (Rota & Izquierdo, 2003; Tatalovic, 2009; Kachorsky & Reid, 2022). Similar to comics, coloring books can also be developed which allow EE programs utilizing this visual media form to reach wide, diverse, and younger audiences regarding conservation.

Educated-themed coloring/comic books that graphically present information using a narrative format of minimal text juxtaposed with visual images have been used in both formal and informal education settings for teaching a variety of scientific topics (Warinner & Hendy, 2017; Morel et al., 2019). This type of easily disseminated media can lead to discussion of scientific theories (Cheesman, 2006), shape attitudes of non-majors towards evolutionary scientific concepts (Hosler & Boomer, 2011), and increase student attitudes toward conservation (Sukri et al., 2020). Coloring and comic books have also been used to teach technically challenging subjects such as medical health (Spiegel et al., 2013; Inaoka et al., 2022) and science technology (Lin et al., 2015). Science and environmental educators have implemented the use of coloring books to promote species awareness for insects (Knowlton et al., 2019), invasive species (Maggioli, 2022), freshwater fish (Loury et al., 2021), and environmental pollution (Mitchell et al., 1992; Baga et al., 2022) and local biodiversity knowledge (McGuire et al., 2009). Moreover, comics have been utilized for informing the general public on environmental issues, including water use (Hihara, 2016). However, there has been relatively little regarding research on the use of comics to teach science at the elementary grade level (Pantaleo, 2021). This may be due to lack of availability of discipline specific materials, i.e., scientific content in popular comics or manga (Septaria & Fatharani, 2022). Therefore, further work is needed to investigate the potential for visual graphic

based environmental education opportunities to inform the general public, including younger audiences, about species of conservation concern.

Amphibians are currently facing declines worldwide (Beebee & Griffiths, 2005). Salamanders are an important and often overlooked group of amphibians which provide ecosystem services, yet many salamanders are experiencing population declines (Wheeler et al., 2003; Rovito et al., 2009). Outreach-education programs involving amphibians highlight the need for biodiversity-based programs to focus on a small number of species starting in primary school (Randler et al., 2005) and the need for programs to use a hands-on, pedagogical approach when developing activities for amphibian conservation to positively change attitudes (Sousa et al., 2016). Education activities which include hands-on approaches can help improve student attitudes and perceptions of native herpetofauna in elementary schools (Toenjes, 2018).

Hellbenders are large, fully aquatic salamanders found in cool flowing streams (Petranka, 1998). They include two recognized subspecies, the Eastern Hellbender, *Cryptobranchus alleganiensis*, found across the eastern and middle United States, and the Ozark Hellbender, *Cryptobranchus alleganiensis bishopi*, a federally endangered subspecies only found in Missouri and Arkansas. Population declines for both have been documented throughout their range (Wheeler et al., 2003; Burgmeier et al. 2011). Presently, direct conservation management activities include captive husbandry (Ettling et al., 2013) and reintroductions (Bodinof et al., 2012; Burgmeier et al., 2022), both of which may increase instream populations and offset dramatic declines. Previous published research on eastern hellbender education has focused on either developing zoo exhibits (Rollins & Watson, 2017) or using the hellbender as a case study in conservation genetics, with an emphasis on the high school level (Chudyk et al., 2014). However, many K-12 grade level students are both curious about amphibians and reptiles, yet also have many misconceptions or myths about amphibians and reptiles (Tomasek et al., 2005). Previous research highlighted that increased familiarity with hellbender salamanders, led to more positive attitudes toward this unique salamander by the general public (Mullendore et al., 2014). Interestingly, presenting cartoon images compared to photographs of hellbenders has been found to elicit a more positive response (Osinki et al., 2019), indicating the potential for hellbender coloring books to appeal to a wide audience. Developing hellbender-focused outreach programs targeting the general public is crucial for ensuring an understanding of the species and future conservation success, potentially eliciting buy in for conservation efforts of the species.

To address the potential for science outreach to effectively target a younger audience, students and recreationalist on hellbender conservation, we developed a coloring book to present the natural history and conservation issues for this enigmatic aquatic species. This study focuses on a potentially transformative and engaging activity, developing and implementing a concise activity at the K-5 level, whereby future citizen

scientists participate in coloring for conservation and learn about a unique North American salamander, the Eastern Hellbender. Specifically, we report on participant feedback of whether this activity was informative, fun, and if participants learned that moving rocks in streams can negatively impact these salamanders, which is a potential threat to the species (Unger et al., 2017; Unger et al., 2020). We further explore the impact outreach environmental education (O&E) can impart when utilized to inform the public. Finally, we discuss our findings in the context of how similar programming can be developed for amphibian conservation at broad, as well as for other local or federally imperiled species.

Method

Development and Deployment of Coloring Books

A coloring book was developed for outreach education to promote conservation and to inform the general public (Figure 1; Figure 2). The coloring book was aimed at a younger audience, ages 5-12, with the main goals of providing a fun, yet informative method for learning about what hellbender salamanders are, some of their natural history and biology, where they are typically found, and why moving rocks is a potential threat to their stream habitat. The coloring book included a maze (www.mazegenerator.net) and a QR code (generated by www.qr-code-generator.com), which linked to a newly developed website on hellbender conservation, (www.helpthehellbender.com). This project was conducted as a partnership between federal and state agencies, universities, and schools from two areas within the range of the species. Comic book available here: <https://ag.purdue.edu/department/extension/hellbender/teachers.html>. It followed ethical guidelines from the Wingate University Research Review Board.



Figure 1. Selected Images (*pages*) of Coloring Book Given to K-5 Participants

Outreach education events were identified to target this K-5 audience in Indiana and North Carolina, two states with active hellbender management programs. Declines have been noted in Indiana, whereas North Carolina is thought to include many stable populations. In Indiana, coloring books were deployed in an elementary school grade 3 (W.E. Wilson Elementary School, Jeffersonville, Indiana) on 9/30/22, where as in North Carolina coloring books were deployed as part of summer camp (range of camp participant ages 4-8, 11-15, 8-12 & 7-13) at Rob Wallace Park and Frank Liske Park, located in Midland, Cabarrus County, North Carolina. Coloring books were also deployed as part of the Pisgah River Rangers program in Pisgah Forest, where outreach events aimed at the general public (National Forest visitors/ participant ages 5-10) were performed in a location where hellbenders are commonly found on site in a tributary of the French Broad River, near Brevard, North Carolina.

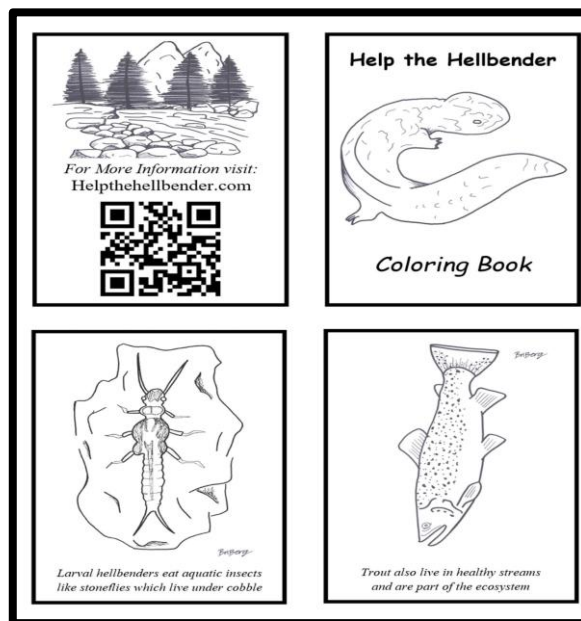


Figure 2. Additional Images (*Pages*) of Coloring Book Given to K-5 Participants

Follow up Survey on Hellbender Coloring Book:

1) Have you ever heard of a "Hellbender" salamander before today?
 Circle one: YES NO

2) Did you learn any new facts about hellbenders and streams?
 Circle one: YES NO

3) Is *stacking rocks* good or bad for animals in the stream?
 Circle one: BAD GOOD

4) Was the *coloring book* a fun way to learn about hellbenders?
 Circle one:

😊	😐	😞
Yes!	It was OK	No!

5) Any other comments you want to provide about the hellbender coloring book?

Figure 3. Follow-up Survey Following Hellbender Coloring Book Activity

For each event, coloring books were passed out, and participants were instructed to color for ~10 to 15 minutes while they read through the book. Crayons were distributed with coloring books. Immediately following this, a short post-implementation survey with several questions was given to the participants (Figure 3), as time precluded doing pre-implementation surveying. The survey was followed by a reflection discussion (led by educators and including participants) on the importance of hellbender salamanders to the river ecosystem and the problem of moving rocks and how it can impact the conservation of this species. When doing group outreach events, the post-implementation survey was conducted by a show of hands for all questions. As part of the Pisgah River Range program, an additional question included home town/state, to ascertain where the National Forest visitors were from (i.e., home state, etc.), as many visitors to the recreational area are likely from out of town.

Data Collection and Analysis

Data collected from participants was compiled, following Wingate University Research Review Board standard protocols for keeping names and data anonymous. We summarized participant survey data in Microsoft® Excel® and calculated percent responses for each survey question, **Q1-Q4** (Figure 3). We ran a Chi-squared analysis on responses with a significance level of 0.05. We primarily present descriptive statistics for all questions and include feedback responses (written reflections) from participants for responses from **Q5**.

Results

Perspectives from Youth Participants

We collected responses from 163 total study participants. Across all outreach events using the comic book, responses for **Q1**: “Have you ever heard of a salamander before today?”, 40.5% responded YES, with 59.5% responding NO. For **Q2**: “Did you learn any new facts about hellbenders and streams?”, 92% responded YES, with only 8% responding NO. For **Q3**: “Is stacking rocks good or bad for animals in the streams?”, 97.5% responded BAD, with only 2.5% responding as GOOD. Lastly for **Q4**: “Was the coloring book a fun way to learn about hellbenders?”, 88.3% responded YES, 8% responded OK, and only 3.7% responded NO (Table 1; Figure 4). Results for analysis of survey questions were variable, with Chi-squared analysis for **Q1** being non-significant, $X^2(1, N = 163) = 3.168, p = 0.075$. Responses for **Q2** were significant, $X^2(1, N = 163) = 69.123, p < 0.001$. **Q3** responses were also significant, $X^2(1, N = 163) = 94.355, p < 0.001$, and for **Q4**, responses were also significant, $X^2(1, N = 163) = 103.294, p < 0.001$.

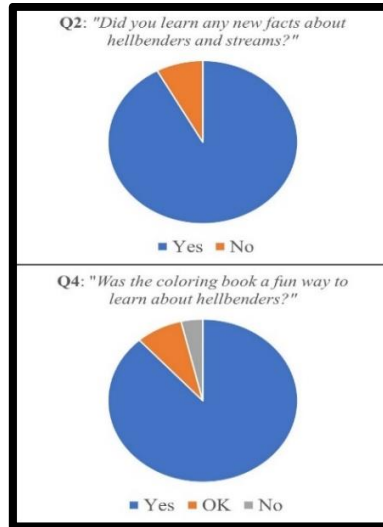


Figure 4. Pie Charts of Q2 and Q4.

Example comments given by participants include a range of primarily positive feedback including “*I learned that stacking rocks is bad,*” “*I liked learning that the males guard eggs under large rocks,*” “*Great illustrations and I love how interactive the coloring book is while I learn,*” and “*I can’t wait to use it more and keep coloring*” (Table 1). One comment included a suggestion for improving the coloring book, mentioning “*Beautifully illustrated, factual, would suggest including illustration to show a map.*” Another participant commented, “*You could maybe add a life cycle picture and more details or information.*” Therefore, written comments given by participants largely mirrored responses to Q4.

Table 1. Responses of Participants, N = 163

Survey Questions	Participant Responses
Q1) Have you ever heard of a “Hellbender” salamander before today?	40.5% YES: 59.5% NO
Q2) Did you learn any new facts about hellbenders and streams?	92% YES: 8% NO
Q3) Is <i>stacking rocks</i> good or bad for animals in the stream?	97.5% BAD: 2.5% GOOD
Q4) Was the <i>coloring book</i> a fun way to learn about hellbenders?	88.3% YES: 8% OK: 3.7% NO
Q5) Representative Comments	<p>“<i>Fun, cool, pretty drawings, something to do when I get back to my campsite</i>”</p> <p>“<i>Activity was cute</i>”</p> <p>“<i>Can’t wait to use it more and keep coloring!</i>”</p> <p>“<i>Excited and will use it on the way home</i>”</p> <p>“<i>Great Illustrations, I love how interactive the coloring book is while I learn</i>”</p> <p>“<i>Well done, love it</i>”</p> <p><i>Beautifully illustrated, factual</i>”</p> <p>“<i>I learned that stacking rocks is bad</i>”</p> <p>“<i>I liked learning that the males guard eggs under large rocks</i>”</p> <p>“<i>I liked the maze and coloring book</i>”</p>

Discussion

The primary results of our study indicate that designing and deploying graphic media aimed at a younger, general, citizen science audience can be both well received and serve as a valuable tool for conservation education, especially for amphibians, many of which are facing declines. We received largely positive feedback on coloring books that were distributed, which in the short-term, appear to provide an avenue for O & E to teach conservation. When taken together, the positive comments and participant responses tell a story of implementing a fun activity that can link together future citizen scientists to learn about important conservation issues related to hellbenders in streams. We recommend this coloring book be handed out at events where hellbenders occur as part of environmental festivals and also elementary schools. Non-traditional forms of literature in the classrooms, such as comics and coloring books, can be successfully implemented into classroom instruction on science using standard question and answer, reading out loud, reflection, and even having students draw their own comics (Kachorsky & Reid, 2022). Developing comics for conservation and environmental education can be applied to not only K-5 elementary school levels but also to the general public. Digital comics have been used to teach concepts at the university level (Sahin & Erol, 2022), indicating the potential for future illustrated educational materials to target a wider audience in addition to younger, emerging citizen scientists. Moreover, alternative methods for dissemination of educational material on hellbender conservation could include developing web-based animation for outreach education for elementary schools, as has been performed for other environmental topics (Safitri et al., 2021), and can provide a follow-up method for learning about the conservation of amphibians or other local species of conservation concern.

Written feedback provided by participants alongside survey responses to **Q1-Q4**, highlight the efficacy of using relatively short outreach interactions with physical copies of the coloring book distributed to communicate the importance of amphibian conservation and local biodiversity and potentially not only inform but also change attitude towards hellbenders. This species has a history of exploitation, removal, and harvesting by the public (Nickerson & Briggler, 2007) stemming from common myths that hellbenders “eat all of the fish” or are “poisonous” (Nickerson & Mays, 1973). Therefore, outreach efforts with emphasis on issue-based programming and species-specific activities have the potential to increase societal awareness of declining herpetofauna (Olson & Pilliod, 2022). However, we recommend these coloring books be part of a larger education effort by schools and land managers in close collaboration with researchers to practice active conservation of specific habitats (i.e. wetlands, streams, forests, etc.) and include natural history information on a variety of special status species (i.e. locally threatened or endangered species). This is especially important as management includes removal of recreational dams in National Forests in North Carolina (Figure 5), which may be detrimental to in-stream habitat. Documenting trends of amphibian decline naturally leads to phases of management involving education to the general public.



Figure 5. Examples of Continued Outreach Programming

Previous conservation outreach efforts by authors include local community presentations to both land owners and local environmental groups to raise awareness, for fund raising activities, for ongoing displays at zoos, and for interactive interpretation programs (Figure 5) which emphasize watershed conservation and the human impact on the environment (Shields & Frederick, 2016). This includes outreach education programs near Brevard, North Carolina in Pisgah National forest, education programming in O'Bannon Woods State Park near Corydon, Indiana, and management of instream habitat such as removal of large human-made rock dams in streams in North Carolina. Moreover, state agencies alongside zoo personnel have documented an increase in encounter reports from stakeholders following advertisement in state regulatory pamphlets combined with popular articles and an online documentary in North Carolina (Williams et al., 2019). Overall attitudes towards hellbenders in Indiana have been found to be neutral based on surveys where respondents reported more positive attitudes if they were more familiar with hellbenders (Reimer et al., 2013). Social media outlets, including Facebook and Twitter, can provide important platforms to promote awareness of hellbender research and conservation as engagements by social media users are largely positive towards hellbender salamanders (Hickman & Unger, 2021). Subsequently, the hellbender coloring book developed for this research on O & E included a QR code to an informative website (www.helpthehellbender.com; Figure 6), where the general public can find interactive materials on this unique species of conservation concern. The coloring book is available at <https://ag.purdue.edu/department/extension/hellbender/teachers.html>, as a six page free pdf download. Lastly, developing partnerships between educators and state managers, can lead to multiple benefits when programming for K-12 teachers is developed. The Purdue Extension and the Indiana Division of State Parks developed such a program and found programming significantly increased knowledge about hellbender

biology, water pollution, reasons for hellbender decline, and what can be done to help hellbenders, etc. (Koetz et al., 2021). Indeed, there are many researchers, educators, students, and other outreach specialists that are working towards improving the general public perceptions of this giant North American salamander. We anticipate that the more educational programming that is implemented across all age groups, both in schools, during outdoor festivals, or as targeted outreach education activities for stream visitors, the more the message will be received about salamanders in streams. Therefore, the future holds much promise for continued efforts centered on the conservation of this unique, large, aquatic salamander across its geographic range.

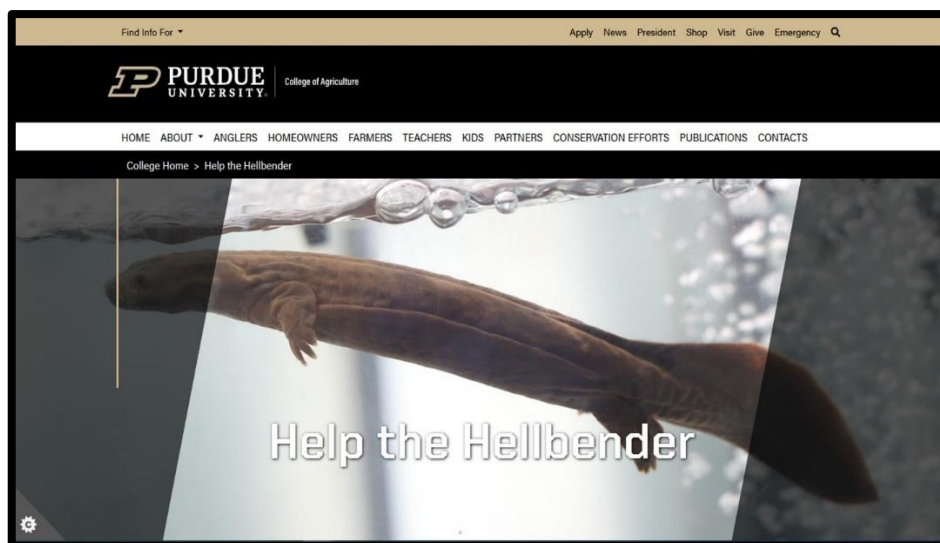


Figure 6. Website about hellbender conservation developed by Purdue University

Conclusion

Our goal for this study was to determine the efficacy of utilizing a coloring book as an educational tool to inform young future citizen scientists about the natural history of hellbenders, how lifting rocks can be detrimental to hellbenders, and to inform future O & E efforts for this unique species of conservation concern. Our findings suggest that coloring for conservation can benefit O & E programming when deployed as part of ongoing citizen science endeavors. There is the further potential outcome of parents learning from children about the importance of conservation by participating in EE programs (Vaughan et al., 2003). Therefore, it is possible that incorporating coloring books, comic books, and other interactive lessons designed for children and younger adults may cross intergenerational boundaries and promote the importance of conservation in local communities of ecosystems and for species of conservation concern. Moreover, the increase in popularity of coloring books for adults, alongside social media campaigns, has raised awareness for library collections (Garner et al., 2016), indicating that coloring books for conservation can further reach communities via social media programs and can even be modified for the online environment.

Recommendations

We recommend educators, state and federal managers, and researchers use similar coloring books to impart EE knowledge on imperiled species conservation and promote the protection of stream and forest habitats. We encourage collaboration among schools and state and federal agencies for developing further outreach education programming which incorporate specific regional conservation goals and additional follow up surveys to gauge public attitudes towards this enigmatic salamander.

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