International Journal of Early Childhood Environmental Education

ISSN: 2331-0464 (online)

Using Picture Books to Enhance Ecoliteracy of First-Grade Students

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Submitted October 5, 2018; accepted March 14, 2019

ABSTRACT

Picture books have the potential to engage students in multimodal ways of learning in early education setting. This pilot study aims to investigate the efficacy of using picture books specifically written to convey increasingly complex ecosystem concepts and their influence on introducing ecoliteracy to first-grade students. Under the central theme of "ecoliteracy" the books introducing four sub-themes (nature, cycles in nature, biodiversity in the rain forest, introducing the phenomenon of bioluminescence) were presented at two-week intervals. The picture books were read aloud and followed by student responses to the text in writing. The questions examined in this pilot study are: What ecoliteracy competencies are highlighted in student responses? How do students demonstrate learning using ecoliteracy-rich books? The texts produced by students were analyzed to understand how students represented ecoliteracy concepts with respect to ecoliteracy domains. Student responses predominantly fell into the cognitive domain as opposed to emotional domain. These responses demonstrated how students extended learning by applying the knowledge to events in daily life, and a willingness to play with concepts. Elaborated in the discussion are the need for matching books with appropriate curriculum to meet the ecoliteracy goals, the significance of producing texts by young readers, and constraints for developing ecoliteracy.

Keywords: ecoliteracy, domains, picture books, cognition, student text

Ecoliteracy is linked to human survival and the planetary well-being (OECD, 2009). Ecoliteracy is the ability to "read" the environment and "act" with the goal of being sustainable with all our needs. This literacy reaches a critical level when we understand the limited resources that we rely on for our comforts. Rivers, fed by snow or glaciers, provide us with transportation, hydroelectricity, and food. We power our gadgets using electricity that may be produced by water, nuclear power, or coal. We fuel our cars and warm our homes, with natural gas and petroleum that is mined from the Earth. Thus, we rely on the limited supply of natural resources to meet many of our basic needs. Due to overuse, we are in danger of depleting critical resources such as petroleum and gas as the Earth is past the peak production capacity of those resources (Wood, 2004). All major rivers in the world are contaminated by pollution and many rivers do not reach the sea due to diversion of water for human consumption (Maybeck, 2013). Deforestation or the removal of forest cover is happening at a rapid pace to meet the needs of the consumers for products such as food, paper and wood. (Hansen et al., 2013). Ecoliteracy is therefore considered to be a critical knowledge and mindset to ensure planetary and human survival. Thus, ecoliteracy should be introduced to students at a young age to build awareness of our limited resources and to encourage thoughtful consideration of planetary health and well-being (Cutter-Mackenzie & Edwards, 2014). This pilot study examines the potential of initiating ecoliteracy study with young children, first-grade students, using familiar tools such as picture books.

Ecoliteracy and Its Significance

The concept of ecoliteracy, first coined by Capra (1997) in his book *The web of life*, suggests that the principles of ecology are applicable to the organization of all living systems. The discourse on ecoliteracy gradually came to include many prominent thinkers across the Humanities (e.g., Capra, 2002; Cutter-Mackenzie & Smith, 2003; Orr,

1992; Wooltorton, 2006) and developed in focus toward the creation of sustainable human communities and society. The Center for Ecoliteracy (2013) was created as a result and distinguished competencies in ecoliteracy that would align people toward ecoliteracy and embracing sustainable behaviors. These competencies fall within four domains.

Domain #1: Head/ Cognitive: the ability to analyze, assess, think critically, and envision long-term impacts of a behavior's impact on the environment.

Domain #2: Heart/ Emotional: concern, love, respect, and empathy for all beings.

Domain #3: Hands/ Action: creativity and making of tools, adjustment in energy, and actions that promote sustainability.

Domain #4: Spirit/ Connection: experiencing wonder and awe toward the natural world.

These four domains are of limited impact to the environment if they are not applied across a range of situations or skill sets within the population at large. As such, Goleman, Bennett, and Barlow (2012) provided a scaffolded series of fifteen core competencies that aligned to these domains of ecoliteracy and demonstrate how a broad range of responses can have an impact. These essential competencies are grouped within the four major domains listed above (Center for Ecoliteracy 2013).

In the context of this study, the competency in Domain #1 refers to a person's understanding of the fundamental ecological principles such as nature, interdependence, species, and ecosystems. Domain #2 refers to the competencies that impel a person to feel concern, empathy, and respect for living things and other people. Domain #3 refers to the skills and competencies that support ecoliteracy and include the ability to create and use tools, objects, and procedures that effectively lead to sustainable communities. Finally, Domain #4 refers to the spiritual competency that enables one to experience wonder and awe towards nature and implies feeling inspired just by the sight of nature.

McBride, Brewer, Berkowitz, and Borrie (2013) note that the last competency, the Spirit/Connection domain, sets ecoliteracy apart from ecological literacy and environmental literacy. Thus, the end goals of each of these fields are slightly different and it is important to recognize the foundations for each of these fields. A person with a mature ecoliteracy competency has well-rounded abilities of the head, heart, hands, and spirit and can serve as an effective member of a sustainable society because such a person understands the interconnections in nature. Ecoliteracy, one could conclude, is a more holistic response to the environment.

Recent studies show that environmental education can be increased in the early childhood years introduce more ecoliteracy-related content into the classroom (Elliot & Davis, 2009; Pilgrim, Smith, & Pretty, 2007; Torquati, Culter, Gilkerson, & Sarver, 2013). While nature play has been advocated as a method for introducing ecoliteracy to young children (Moonstone, 2016) some experts are critical of this being emphasized as an alternative for early childhood ecoliteracy education. They suggest it reinforces the notion that children are incapable of understanding sustainability issues (Elliott & Young, 2016). In their article detailing the resistance to ecoliteracy education, Elliott and Davis (2009) note that early childhood environmental education experiences were overly focused on nature play to the detriment of sustainability education, even though sustainability education can be provided in an age appropriate manner.

Sustainability education can teach children how resources can be sustainable and provide them an awareness of how natural resource are used in their daily lives. Sustainability is a complex, interconnected issue, deemed a 'wicked problem' (Frame, 2008). Stated simply, the goal of various kinds of environmental literacy is to enable citizens of all ages to become aware of the finite nature of their resources. Capra (1997) and Wilson (1984) emphasize that human life and survival are deeply intertwined with the natural world. Because our natural resources are finite, citizens—even young ones—benefit from being critical and careful about the kinds of resources they use and exhaust.

In the context of this study and in consideration of how to address sustainability in a way that would be appropriate for the study population, students in this study were expected to gain two fundamental understandings: the first was to recognize that nature is the source for many of the resources they use on a regular basis; and the second was to know that there are many processes and phenomenon in the natural world that surrounds them.

Interestingly, educating young children in sustainability offers some useful examples of ways that early interventions can provide real-life experiences in practicing sustainable options. In constructing the pilot randomized trial, teachers and researchers took advantage of the "funds of knowledge" of the students and the preference of many young children for fast food. The team built twenty-four learning modules that summarized the flow of resources required in assembling fast-food (Edwards et al., 2016). The study resulted in high engagement from the children. Researchers anticipate that this successful engagement and the children's experiences with the research could have the benefit of facilitating obesity prevention, developing a stronger connection with sustainability, and influencing their everyday choices and practices.

Use of Picture Books as Mentor Texts

There are significant advantages in using picture books as mentor texts for children in early elementary education. The juxtaposition of pictures and words engage and challenge young learners to acquire knowledge in multiple ways. Studies show that using picture books in early childhood can stimulate cognitive development (Debby, 2007; Tien & Wu, 2010). Based on strong ties between cognitive development and the use of picture books, as reported by researchers, Kümmerling-Meibauer and Meibauer (2013) suggest a cognitive theory of picture books. Picture books serve as a perfect tool for both learning and cognitive engagement in young children (Cleveland, 2015). Use of picture books has also been linked with enhanced language development. Debby (2007) noted that thinking and speaking about the pictures and then expressing opinions or emotions about them improved language acquisition. Picture books have also been used successfully for interventions that encourage language development in children. For instance, language development in children from low-income backgrounds greatly improved when they were provided picture book reading intervention sessions (Kim, Lee, & Pae, 2013). Several studies report the successful use of picture books for providing environmental education. Hsiao & Shih (2016) used eight picture books to instruct environmental concepts, especially the problems and the overuse of resources resulting from human activities. As an outcome of the project, children learned to conserve resources by bringing their handkerchiefs to school to replace disposable tissues, using less water while washing their hands and brushing their teeth, and reducing the amount of drawing paper they used for doodling. While their use of plastic bags did not change, the students in this study responded overall by undertaking several important pro-environmental actions. Wordless picture books also promote a special and symbolic relationship between humans and nature (Ramos & Ramos, 2011).

Young children tend to have a positive attitude towards nature and science (Osborne, Simon, & Collins, 2003). Thus, there are more picture books about nature and animals for young children than books about either engineering or technology (Cleveland, 2015). This positive attitude can be leveraged with the use of picture books to tutor critical thinking skills at an early age (Roche, 2014).

Producing Text Output

Child development experts agree that though there are no fixed developmental patterns, oral skills (listening and speaking) mature before written skills (reading and writing skills) (Piaget, 2013; Vygotsky, 1978). Thus, many children with poor or delayed oral language or with a reduced vocabulary may write using fewer words and simpler, shorter sentences. Alternatively, this could also mean that their ideas are simpler and less precise. A recent study (Hooper, Roberts, Nelson, Zeisel, & Kasambira-Fannin, 2010) concluded that the output of oral language frequency was tied to student writing skills. Similarly, children's reading skills have also been linked to their potential writing skills (Abbott & Berninger, 1993; Berninger, 1994). Researchers have reported connections between reading and writing (Abbott, Berninger, & Fayor, 2010) and significant correlations between reading-related and writing-related skills (Berninger, 2000). Children who were poor readers also tended to be poor writers (Chall & Jacobs, 1983; Juel, 1988). Writing is a high cognitive activity involving various skills. Based on these findings, the current study sought student responses in writing to enable students to respond at whatever skill level they had achieved.

Purpose of the Present Study

The purpose of the present pilot study was to examine the effect of specially constructed picture books in conveying increasingly sophisticated ideas that introduce ecoliteracy to young children and, thereby, to determine the way the connections across ecoliteracy domains are built when children assimilate information about nature. There is scant research examining the efficacy of picture books in developing ecoliteracy to young children. So this study addresses the gaps in current research by examining understandings of ecoliteracy in children and determining how picture books support children's attainment of ecoliteracy through the composition of a short text in response to a prompt.

The central questions explored in this paper are: What are the ecoliteracy competencies of the students for each of the four books presented? How do students show a broad representation of the ecoliteracy domains in their responses? In what ways do students demonstrate learning about ecoliteracy using specially constructed books?

METHODS

Creation of Mentor Texts

The author of this study created four original mentor texts (Table 1) written in traditional picture book format for the purposes of this study. They were subsequently illustrated using color photographs. The books presented increasingly complex topics in ecoliteracy at a level appropriate to first grade students. In recent years, research has shown that picture books are an effective medium for this age group because pictures evoke a broader category of responses than books with text alone (Ware, Gelman & Kleinberg, 2013) and because they engage the readers cognitively in making connections between text and images (Kummerling-Meibauer & Meibauer, 2013). These texts were constructed specifically for this study to avoid any artifact introduced by previous familiarity with the book. In a classroom with diverse students, this is an important consideration. Students who have the background, knowledge, and experience with a familiar mentor book might produce detailed and thorough feedback, while students with no familiarity could be synthesizing and grasping it. Research by Horst, Parsons and Bryan (2011) and Horst (2013) showed that repeated reading enables young readers to develop accurate and immediate recall as well as retain the details of the story longer term. Unfamiliar mentor texts minimized the familiarity bias in the study and gave all participants an opportunity to produce unique responses.

Vivid, dynamic, and closeup photographs were used to illustrate the words and themes of the topic presented. Where the pictures provided the students a sense of the place or visual experience of the topic presented, the words explained the concept directly. Photographs take readers closer to the object or place. They also enlarge the background and clarify the context in which the information is situated. Another reason to use photographs is their ability to facilitate easy labelling of objects. Researchers have observed that children are more often able to extend the labels between pictures and objects when realistic photographs and drawings are depicted rather than cartoons, which are less realistic (Ganea, Pickard & DeLoache, 2008; Tare, Chiong, Ganea, & DeLoache, 2010).

The books were printed in color on standard A4 sized pages, illustrated with photographs, and formatted in 32-page standard trade format. The books were assembled in a binder with page protectors. The odd pages faced the reader and the even pages were placed right behind the odd pages. The books were retained in the classroom allowing students to read the texts as many times as they wanted.

The books were written to introduce a series of concepts that ranged from simple to complex so as to consider students with little previous ecological knowledge. For instance, the first book in the series, introducing the concept of nature, titled, *Nature is…*, was more functional than the rest of the books. This book introduced flora and fauna, and the physical, atmospheric aspects of nature. The second book in the series introduced the water cycle. Titled, *A cycle forever*, the book detailed the water cycle using scientific vocabulary. The most complex idea of the set, biodiversity, was presented to the students through a depiction of a *Rain forest*. The last book in the series. *Fifi's Challenge*, introduced the phenomenon of bioluminescence in the form of a brain teaser. More details about the wordcount and the grade level of the texts can be found in Table 1.

Presentation of Mentor Texts

The Institutional Review Board approved the study as being of minimal risk to the students. The teacher presented the mentor texts to students in the following sequence:

> **Transition activity (10 minutes)**. Most mornings began with a math worksheet activity in the classroom. Because working on mathematics provides a high cognitive load for the participants, a break was necessary between the morning tasks and the study. This break was facilitated when the teacher led the students to do yoga postures or jumping jacks, thus preparing them to transition into reading and giving them a break in their mental processing prior to the study activity.
>
> **Presentation of clues (5 minutes)**. First, the teacher instructed the students to sit on the reading carpet. Next, the teacher presented clues about the topic of the day and invited students to guess the topic. For example, to introduce the concept of bioluminescence, the teacher asked the students: "Have you seen anything glow in nature?"
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> **Warm-up discussion (5-10 minutes).** The students responded variously to the clues provided by the teacher. For example, one student said, "I have seen stars glow in the night." Another student said, "I think the sun glows too." Yet another student said, "I know some bugs can glow." The teacher then asked the students, "Have any of you seen bugs glow?" Followed by questions such as, "Where did you see it?" The teacher provided opportunities for all students to participate if they so wished. The teacher also encouraged participation of shy students by acknowledging their body actions and initiating a dialogue with them in response to their perceived interest. However, it was not necessary that all students participate in the discussion. There were no penalties associated with non-participation.
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> **Reading the book (5-10 minutes)**. After students discussed the topic and when no new ideas emerged, the teacher said, "I loved our discussion. Today we are going to read a book on bioluminescence. Can you all say the word?" The teacher then wrote the word on the chart board. Next, the teacher encouraged the students to repeat the word three to five times. The teacher paid close attention to English language learners in the classroom and let them repeat the word many more times. The teacher used student questions to lead them into readings. For example, a student asked the next question, "What is bioluminescence?" The teacher said, "Let us read and find out."
>
> **Reflection time (15-25 minutes).** After reading the book, the teacher instructed the students: "Please draw what you understood about the book we read today. You can use the crayons on your desk or use markers to draw. Please write what your drawing is about." Students returned to their desks and completed a drawing on a sheet of paper and then wrote about their drawing on the reverse side of the page. Students could draw and write for as long as they wanted. They could check their spelling and vocabulary book to assist them in writing their text. Students could also request adults to write for them. Only analysis of that text that was prepared by students is discussed in this manuscript. Analysis of the images produced will be analyzed in another manuscript.

Teacher-student demography

The study was conducted in a public-school in the inland northwest region of Washington State. Of the 25 students in the classroom, one student was not in the class during the time of the study. The students were from varied backgrounds and races, and they spoke many different primary languages. They were six to seven years of age.

Data Analysis/Standardization of Student Text

All texts produced by the students in this study were entered on a spreadsheet (Figure 1). Student texts were corrected for spelling errors and sentences were corrected for proper grammatical format. No effort was made to complete incomplete sentences in student writing. However, such sentences have clarifications added in

parentheses so that the coders could understand the context. Single words were interpreted as sentences produced by students. For example, while explaining the water cycle, students often used one-word sentences such as *Next*. *Evaporate*.

Mapping the Mentor and Student Texts

To allow for comparison between the mentor text and student writing, the mentor text, was read aloud to the students, and the student texts were mapped separately to the domains by using competencies associated with each domain. The texts were organized into themes that answered the research questions by using the constant comparison technique (Strauss & Corbin, 1990). According to Dey (1993), the data can be categorized, organized, and conceptualized based on groups or clusters created by the researcher. Patton (1990) advocates careful judgments that are critical and crucial for appropriate classification of the data in order to derive meaning from it. The redundancy and reliability of coding was established by the author who repeated the coding three times. Both mentor texts and student texts were re-coded during every repetition. Average values of the three coding sessions are presented in this paper. Adjustments to codes were made during these trails. After the reliability was established at $\geq$90%, the rubric was given to an interrater and trained in establishing the norming. The interrater checked one full text of a book and all student responses for the selected book. For the other three books, spot checks with 10% of the responses and original texts were performed. When the interrater reliability was < 80%, the author retrained the interrater and the coding was repeated. If the repeated coding also yielded <80% reliability the coding was revisited. The interrater reliability in coding for the study was about 95% and fell within the average categories coded by the author.

Coding for the Domains

Coding was undertaken from the subjective understanding and perspective of the author. When coding the texts, the author identified the domain under which a response would fall. To eliminate bias in the coding, and capture a range of subjective variations, coding was repeated three times. Each coding episode was repeated after a gap of a week.

The **Cognition** domain was identified when sentences or phrases or words explained a fundamental ecological principle. All sentences were individually counted. When sentences were split into two or three parts (because they represented more than one domain), each part was designated under appropriate domain. A rule of thumb was to code all facts under the cognition domain. For example: **The water** *flows* **through the Earth** *washing* **minerals and** *watering* **plants**. In this example, all text in bold was coded as cognition and lighter text in italics was coded for action.

Emotions were coded when words or phrases or sentences conveyed concern, empathy, or respect for other people and living things. Some of these phrases also indicated a part of the process, not as a fact, but as an experience. For example, *Icy rocks* in the context was considered as conveying an experience, while *hail* was considered as a fact and coded under cognition. Possessiveness and possessions, in the context which invoked or involved feeling, were also classified under emotions.

Action was conveyed using verbs and the creation and use of tools, objects, and process. Although in the context of ecoliteracy, actions refer to choices towards sustainability, in this study, it has been extended to include the characteristics of the text production. Parts of a sentence or the whole sentence was listed under this domain if students conveyed the context of action. For example, in the phrase *Clinging* moss, clinging was considered an action in the context of the text.

Spirit was coded when the context evoked an experience that conveyed wonder and awe towards nature. These could be conveyed in words, phrases or sentences. Each instance of conveying awe towards nature was coded. The coding for spirit and emotions was differentiated based upon the result. If the experience evoked awe, it was coded as representing the spiritual domain. If the experience evoked concern, empathy, and respect for other people and living things, it was coded under emotion, as it fell under the purview of the emotional domain as indicated earlier.

For example, the phrase, *such abundance of life* was coded under spirit. The coding was also dependent upon the context. Entire sentences could be marked to bear a spiritual meaning or parts of the text. Single words could also be used to convey the context.

The data on ecoliteracy domains were analyzed for both the mentor texts and the student texts and compared using a chi-square. Non-analytical word frequency word-spread representations of mentor and student text were made using the free online software program Wordle. This word-spread enabled the viewing of mentor and response texts and the highlighting of the major themes of each group.

Analysis and Discussion of Student Responses

Student attendance for the day determined if students were able to participate in the reading and response session. Further, some students did not respond in writing during some weeks. In sum, students produced 1,282 words and 225 sentences describing their responses to the mentor texts. The mentor texts had a total of 1,002 words and 122 sentences.

Ecoliteracy Competencies for Each of the Four Texts Presented

Both the mentor texts and student writing were represented in all the ecoliteracy domains. Except for one mentor book, *Rain forest*, all other mentor books had a higher frequency of ideas presented in the cognitive domain than the student texts. *Rain forest* had a greater number of examples in the emotion domain. Student texts had a higher representation in the cognitive domain (Table 1). For *Rain forest*, the cognitive responses were higher than the mentor text (Figure 2). The domain of the spirit was poorly represented in student texts, while action was highlighted in responses to two mentor texts- *A cycle forever* and *Fifi's challenge*.

Statistical analysis comparing the averages of coding across domains for the mentor texts and student texts did not show any significant difference. Although the texts had similar representations, the student responses varied across the domains and did not always mirror the mentor texts (Figure 2). The differences were mainly noted in the degree of complexity of the texts produced by the students. Other studies also confirm that young children are capable of crafting complex information when given the opportunity (Duke & Kays, 1998; Newkirk, 1989; Pappas, 1993). Yopp and Yopp (2012) note that young children's exposure to informational text is limited, potentially hindering their response and participation when presented with this type of literature.

In this study, an opportunity for stratified free form response was presented to the participants for the text *Fifi's challenge*. The response was stratified as the students were asked to create their own riddle as a response. The frequency of responses across domains produced from this activity shows a high response in the cognition domain, followed next by the action domain (Table 2). Since the mentor texts had ecology-based themes, the result of high cognitive responses could also be due to the content of the texts. A study by Collado, Staats and Corraliza (2013) showed that when children attended nature camps and were enriched by their immersion in nature, they experienced cognitive and emotional changes in their affinity towards the environment, and thus engaged in pro-environmental activities. With some affinity to the study by Collado et al., (2013), the present study provided an immersion experience in nature visually through the reading of a book with realistic nature photographs. This shows the possibility of expanding the role of picture books to provide high cognitive priming. This finding represents an area for potential future study, as discussed later in this paper.

The Broad Representation of the Ecoliteracy Domains in Student Responses

This study analyzes how sentences were coded for their representation across multiple domains. As indicated in the methods section, the sentences have information that is spread across the domains. Table 3 summarizes the analysis of data pertaining to the number of domain combinations and the words produced by the student responses. During coding, when student texts were found to have representations in more than two domains, the text was marked as "complex." This study shows that student responses become complex when familiar topics are introduced. To illustrate, the author analyzed the mentor texts and their corresponding student responses. The first mentor text

Nature is… introduced the concept of nature. The students in this classroom had heard this word nature on many different occasions from the teacher. They had also heard it from her in somewhat different contexts, although the students might not have understood the subtle differences. Thus, nature was a familiar topic to the students in the classroom. When a familiar topic was presented to the students, they produced richer and more complex texts than the mentor text. The second text *A cycle forever* covered a newly introduced topic, the water cycle. The students produced rich and complex texts but did not quite match the complexity of the mentor text. The *Rain forest* text provided them with many challenges. None of the students had been to a rain forest. Consequently, their experience with the ecosystem was limited and probably resulted in weak conceptualization. When students provided responses without prior knowledge, the texts were less complex as compared to the other two books. For the final text, *Fifi's challenge*, several aspects were stimulating for the students. The concept of bioluminescence is typically introduced in fifth grade or middle school. The students' lack of familiarity of the concept combined with the challenging format of this particular text presented as a riddle or puzzle—likely explains why— this was the most difficult text for the students in the study. Despite these challenges, the cumulative student text output matched the complexity of the mentor book as indicated by a significant relationship between words in text and the number of domain combinations.

To explore other contexts of textual complexity, the author conducted a deeper analysis of the domain combinations in student responses. This analysis revealed the dynamic and diverse student thought process in the form of unique combinations of domains in their text production became evident in this analysis. The student responses showed several unique domain combinations that were not presented in the mentor text as summarized in Table 4.

For the text, *Nature is*…, students produced texts in two novel constructs by combining action-spirit and emotion-spirit domains. However, they did not produce any text with the combination of action and emotion, even as this combination was present in the mentor text. *A cycle forever*, introducing the concept of the water cycle, did not have matching representations in the four domain combinations, but showed one novel construct. Student responses to the title *Rain forest* had four combined domains that were not represented in the mentor text. The unique domain combinations involved presentation of text with action-cognition-spirit domains. This domain was also dominantly represented in the title *Fifi's challenge*.

The samples of complex student text for all mentor texts are presented in Table 5. The analysis demonstrates that young students can generate texts that convey complex information. Given a mentor text, students can produce novel constructs generated from their understanding, and, add to the richness of the materials presented. There is a paucity of studies that analyze the text creation across the domains common to ecoliteracy. Tracy and Headley (2013) report a successful intervention workshop to introduce nonfiction text to young readers. In their study, they reported that success of the intervention was marked by the vocabulary that students shared, and the strategies used by students. Donovan (2001) reports that even the youngest students in kindergarten successfully identified and understood the differences in genre and managed to produce texts with some degree of complexity. Production of complex texts by students demonstrates their ability to extend the skills to create novel meaning within ecoliteracy domains.

Learning by Using Ecoliteracy-Rich Texts

Data demonstrating various aspects of learning as experienced by students shows that students in the study cultivated a well-rounded appreciation of nature and its interconnections. This is demonstrated in many ways: their relationship with nature, their knowledge of the water cycle, their ability to situate and apply the concept in daily life, their grasp of the concept of biodiversity, and their understanding of a playful learning moment in the form of a puzzle. Additionally, students practiced traditional literacy skills such as recalling the text, composing text, the act of writing, and seeking to express their thoughts and ideas. Many of these tasks fall under high cognitive domains, which involve diverse processes. These connections are important to investigate as they constitute the ecoliteracy of young students.

Overall understanding of the mentor texts

In three of the four texts, the dominant themes presented in both the mentor books and the student responses were similar. *Nature is*… , the main theme, was mirrored in the student responses, although the content was not the same (Figure 3). For the book *A cycle forever*, the students were clear in their understanding of the water cycle. With *Rain forest*, responses indicated that students understood trees to be a part of rain forests, but otherwise, they connected with bananas. Student responses also indicated some understanding of the complexity of the layers and diversity of rain forest life. For example, students listed tree, vines, bush, and bamboo as life forms. The most surprising response was for *Fifi's challenge* in which the mentor text emphasized using clues presented as a word play. The responses indicated that students understood the idea, and composed their puzzles based on what they knew. The visual, non-analytical representation of the data comparison of mentor text and student responses is indicated in the Word Map presented in Figure 3.

Connection with nature

Qualitative analysis of student response to the text *Nature is*… reports many kinds of associations with nature as indicated in Table 6. The five top frequent words in the mentor text were *nature*, *every*, *many*, *made*, and *none*. Interestingly, the most frequently used student response word matched the theme of the mentor text, nature, followed by emotion words such as *love* and *like*. This was followed by action as indicated by dynamic nature phenomena such as *volcano*. The responses also substantiated the children's claims using conjunction words such as "because." Technically speaking, the use of subordinating conjunctions like "because" fits the definition of complex sentences (Salsbury, Personal communication). The students' basic connection to nature among students was mediated through the emotional domain.

This is similar to the findings from Capaldi, Dopko and Zelenski (2014), who noted a strong connection between happiness and being connected with nature. In another study, younger children were shown to be more connected with nature than older children (Liefländer, Fröhlich, Bogner, & Schultz, 2013). Several studies point out that pro-environmental attitudes and behaviors are strongly influenced by the nature connection (Cheng & Monroe, 2012; Mayer, Frantz, Bruehlman-Senecal & Dolliver, 2009). Ernst and Theimer (2011) note that more cognitive activities are required in order to develop pro-environmental behavior. The emotional connection of children with nature requires closer examination.

Knowledge and extension of the water cycle

The frequent use of the words *water*, *magic*, and *cloud* were highlighted in the analysis of the book, while *water*, *cycle*, *cloud*, *first*, *next*, *goes*, and *bird* were highlighted for the student response texts (Figure 3). The concept of evaporation was highlighted in student responses on at least two occasions. Natural elements that contribute to the water cycle such as sun, rain, mountain, cloud, ocean, and air were also mentioned in the responses. Surprisingly, the connection to extinction without water was also articulated in the student responses. Animals (e.g. butterfly, egg, dinosaurs, bird, and bear) and their life cycles also appeared more frequently. Age, human-managed areas (lawn), and human activities such as hunting were also juxtaposed in students' understandings of the water cycle. The ability of students to extend their knowledge to other situations indicates that their knowledge was in an advanced phase.

Ever since the seminal study by Piaget (1930), which used the water cycle to demonstrate children's cognitive progression, the topic of the water cycle has been well studied in both science and teaching (Taiwo, Ray, Motswiri, & Masene, 1999; Shepardson, Wee, Priddy, Schellenberger, & Harbor 2009). However, few studies explore the learning of this concept from the perspective of ecoliteracy. In the student responses, the extension of the concept was noted by transference to objects (water wheel), gender roles (mother gets them born, father gets them food), routine activities (mowing the lawn and grass re-growing), and the life cycle of the organisms as representing the water cycle. Many of these themes also concur with the emotional connections' students made with the texts.

Conceptualization of biodiversity

The foremost connection indicated by the mentor text is between *water*, *rain forest*, *tree*, *rivers*, and *birds*. In the students' response, *bananas*, *rain forest*, and *trees* are frequent themes (Figure 3). Diverse creatures were also highlighted in the student responses: raccoon, turtle, goat, leopard, deer, turkey, rabbit, bird, monkeys, panda, fish, and wolf. Plant life was represented by vines, tree, bamboo, bushes, apple tree, and simply as plants. Diversity of fruits such as apple, banana, and chocolate (presumably it was meant to be cocoa), were also represented in the texts.

Unlike the responses for the water cycle book, responses were muted for the book *Rain forest*. No text response was provided by six students and most responses included some form of a list. A point of significance to note is that one student unexpectedly explained using a non-biological concept, and as an extension of the student's personal world, reflecting, "My forest is diverse because it is a rainbow forest." The term diversity was not provided in the mentor text, although the concept was elaborated. Finding this term and explanation of the concept in a non-biological fashion is unexpected. It indicates an extension of a student's imagination to understand biodiversity. In another study, it was found that the complex characteristics and function of the rain forest was difficult even for 13-year old students to comprehend (Dove, 2012).

Playing with concepts

Student participation and enthusiasm indicated that they liked the playful approach of using riddles in their mentor text. Riddles have been popularly used in teaching and learning in both traditional and nontraditional situations (Jirata, 2012; Çaya, 2015). Riddles play a significant role in developing children's cognitive skills (Gučienė, 2016). The use of riddles in this study led to considerable engagement by the students and allowed them to show their background knowledge and their learning as was evident in their response to the last mentor text, *Fifi's Challenge*. Their output included diverse themes such as word play, functions of nature, celebrations, day of the week and people. Only one student did not engage declaring, "*I do not know what is a riddle*." Another student creatively produced two riddles or a two-step riddle in response, "I can be built in one season. Can you guess who I am? If you can't move to the next question. I wear a hat. What am I?"

CONCLUSION

Ultimately, the goal of ecoliteracy is to enable holistic experiences with nature based on cognitive understanding, emotional connection, and action in the spirit of honoring these connections. Ecoliteracy can be mediated by any of the domains playing a significant role in facilitating the experience. In the present study, when presented with eco-literacy-rich picture books, students' cognitive responses about nature were mediated through emotional connection. The deeper spiritual connection with nature was absent. It is possible that some maturity is required to establish this connection. However, student actions with nature were both playful and utilitarian, suggesting that deeper connections with nature can be encouraged by active play that can result in a cognitive shift.

This researcher makes a distinction here between the mature ecoliteracy of a person who can embrace sustainability practices in daily life (Goleman et al., 2012) and the first-grade students in this study. The students in this study were not measured for the degree of sustainability in their daily consumption choices. Rather, this study provided them with opportunities to present their current ecoliteracy levels through their responses and connections. This knowledge and understanding of the process is critical for creating programs that support explorations of ecoliteracy in young children.

Book choice and ecoliteracy. Cleveland (2015) showed that reading picture books to children inspired their learning. In this study, in addition to learning, students also expressed their strengths in certain domains of ecoliteracy when they were presented with varied texts. For introducing ecoliteracy, and encouraging further interest in ecology, reading picture books served several functions in the classroom. Books rich in ecoliteracy competencies can be provided to children for general reading to enable informal and spontaneous immersion. Teachers can also use books rich in ecoliteracy to enable students to think or develop mastery over specific areas. These books can be integrated into the regular curriculum so as to establish opportunities for multi-modal. Such multi-modal responses incorporate

aspects of the oral and written channels through which students can articulate their learning. Several studies have suggested that language learning is supported by what students are able to do and is also supported by varied opportunities (Lee, Quinn, & Valdés, 2013). Results of the study show that students are able to present responses that fall in the cognitive domain when the material is presented to them in picture book format. Thus, challenging and stimulating students with picture books is appropriate in the early years. The validity of picture books as a powerful medium has been corroborated in other studies as well (Kiefer, 2015; Lancaster & Flewitt, 2015). Kümmerling-Meibauer and Meibauer (2013) suggest that this connection should be explored with the creation of a cognitive theory of picture books. The choice of picture books to introduce sustainability themes should be made with caution as some books may have erroneous information or convey stereotypical messages (Muthukrishnan & Kelley, 2016).

In the context of this study, it should be noted that although the books provided an enhanced cognitive experience, they cannot replace the importance for students to be outdoors and interact with nature if they are to achieve full ecoliteracy. Several studies show that interaction with nature is far more beneficial for physical health (e.g. Keniger, Gaston, Irvine, & Fuller, 2013), cognitive performance (e.g. Bratman, Hamilton & Daily, 2012), psychological well-being (e.g. Dallimer et al., 2012), social benefits (e.g. ten Brink et al., 2016), and spiritual upliftment (e.g. Russell et al., 2013).

Significance of text production (student writing). The achievements of the young authors are phenomenal. Their combined output produced the same or more input as the mentor text. They demonstrated a grasp of complex ideas as they were presented in pictures and words and they replicated this complexity in pictures and words. Their responses were sophisticated in thought, demonstrated extensions into daily life, or mirrored their confusions when written responses were missing. Students also provided reasons for their thinking and demonstrated an advanced understanding of the water cycle. Lee et al. (2013) underscore the importance of supporting language development and presenting various channels for students to express themselves. Students in this study were able to present complex ideas and thoughts, even if they were unable to produce text that was perfect in terms of grammar or syntax. The author wants to clarify that under the circumstances of this study, there was no expectation that the students would produce grammatically sophisticated text.

The search for a unified theoretical understanding of the translation of thought into written word is not conclusive. Hutchins (1995) noted that translation of the cognition of the thought to word has been problematic historically when the fields of cultural studies, history, and psychology set up boundaries of 'inside' the body and 'outside' the world. In the same line of thinking, the cognition responses provided by the children is not a product of a single activity – that is, reading the mentor texts in this study. Rather, it has been a part of their larger life, provided by various interactions that enabled cognitive effort to be distributed over time. Thus, the output of the students represents a part of the larger cognitive process (Tribble & Sutton, 2012). The absence of understanding rain forests or experience visiting rain forests could be some factors that account for the meager responses to the rainforest book. Matching appropriate texts and scaffolding the students to address the text is also important. From the perspective of ecoliteracy, complex topics could be introduced in a series of books rather than presenting them in a single book in order to account for the limits of possibly unfamiliar and complex topics, as demonstrated by the rainforest book. Despite these drawbacks, students demonstrated learning and extensions from all the mentor texts presented to them.

Barriers to ecoliteracy. Building a strong ecoliteracy foundation for students encourages students to develop a solid connection with nature. Russell et al. (2013) also attribute well-being to interactions with nature. Bratman et al. (2012) note that frequent interactions with nature has a positive influence on mental health and cognition. This facilitates both stress reduction and attention restoration. Dallimer et al. (2012) noted that stress reduction and the attention restorative properties of nature could be attributed to biological diversity. Although children were fascinated by powerful phenomena such as a volcano, they remained cautious about exploring new ecosystems or places. The need for deep personal connection or personalization in response to nature might serve as a pathway for future ecoliteracy studies. The summary of the findings from the study pertaining to each domain of ecoliteracy is presented in Figure 4. To inspire students to be more active, materials can be designed to engage students in personal ways and describe spaces where the personal needs are emphasized. It will be interesting to study at what

point students decide to act and through which route. The results of this study show that an emotional connection is required for establishing and facilitating functionality of all the domains of ecoliteracy. Tam, Lee, and Chao (2013) note that deeper connections were established with nature when nature was presented in an anthropomorphized manner. The sense of connection mediates the conservation behavior of people. Future studies will be able to build on the strengths of this study and work on the areas identified as means for lifting barriers that exist in our attempts to introduce ecoliteracy to young students.

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Appendix 1: Tables

Table 1
Details of Mentor Texts Used in This Study

Title	Theme of the book	Grade level of text
Nature is….	Introducing nature	Grade 3
A cycle forever	Introducing natural cycle – water cycle	Grade 3
Rain forest	Introducing biodiversity and human use of biodiversity	Grade 4
Fifi's challenge	Introducing phenomenon of bioluminescence	Grade 1

Table 2
Comparison of Responses of Student Responses across Ecoliteracy Domains for All the Mentor Texts Used in the Study

Domain	*Nature is…* n=23	*A cycle forever* n=20	*Rain forest* n=18	*Fifi's challenge* n=23
Frequency	student (mentor)	student (mentor)	student (mentor)	student (mentor)
Cognition	41 (24)	45 (58)	63 (21)	51 (32)
Emotion	27 (15)	8 (13)	14 (22)	13 (13)
Action	11 (9)	20 (28)	4 (7)	14 (10)
Spirit	3 (10)	1 (14)	2 (3)	1 (5)

Legend: The mentor text frequency is represented in the parenthesis. T-test indicated no significant differences between the observed frequencies of student responses and mentor text. The number of students participating in the study varied per text and is indicated under the mentor texts used in the study.

Table 3
The Complexity of Student Text Production As Measured by the Combinations of the Domains Represented in the Text

Text book	# Words in text	# Words response	# Domain combinations (student)	#Domain combinations (text)
Nature is…	176	420	7	6
A cycle forever	447	304	7	10
Rain forest	132	267	5	6
Fifi's challenge	247	298	6	6

Legend: The values for the #words in text and #words response indicate the cumulative text production for the class. Values for #Domain combination indicate the average of the coding rounds for the mentor book. Chi-square value 142.938, p-value<0. 00001, p< .05 indicates a significant relationship between the variables.

Table 4.
The Deeper Analysis of the Domain Overlap in Student Text Production

Domain	*Nature is…*	*A cycle forever*	*Rain forest*	*Fifi's challenge*
	Response (Book)	Response (Book)	Response (Book)	Response (Book)
Cognition + emotion	13 (9)	2 (2)	5 (10)	4 (1)
Cognition + action	4 (8)	16 (13)	2 (2)	7 (6)
Cognition + spirit	2 (1)	1 (6)	1 (0)	1 (2)
Action + emotion	0 (1)	0 (1)	0 (1)	1 (0)
Action + spirit	1 (0)	0 (1)	0 (0)	0 (0)
Emotion + spirit	1 (0)	3 (1)	0 (1)	0 (1)
Emotion + cognition + action	3 (1)	1 (2)	0 (1)	2 (1)
Cognition + spirit + emotion	2 (1)	0 (2)	1 (1)	0 (1)
Action + cognition + spirit	0 (0)	2 (2)	1 (0)	10 (0)
Action + cognition + spirit + emotion	0 (0)	0 (1)	0 (0)	0 (0)
Emotion + cognition + spirit	0 (0)	1 (0)	0 (0)	0 (0)

Legend: The values indicate the average frequency of three coding rounds. Categories not represented by the text have 0 value.

Table 5
Examples of Coding of Complex Student Text for Information across the Domains

Mentor Text	Text Type	Coding Examples Spirit
Nature is...	Expository	1. *This is a redwood tree*. *I made it because they are* big and I like big things! 2. My family *used to live in the country*. It was fun until we moved *to Pullman*. I love nature. *The end.* 3. It is the evil ways *of the evil good sons and these are his ways*. That happens often in life and He *will be back and he means it*.
A cycle forever	Expository	1. *The life cycle of frog* will keep going. The butterfly is pretty. I like *apples*. 2. *First, there is an ocean*. *Then the water* evaporates *into air*. *Then it* forms *a cloud. Then the cloud pours rain and it flows into the lake and the cycle starts over again*. This is my natural cycle. 3. *Water cycle*. I like the *water cycle because it is* cool *and that it goes around in a O*. *And that O it keeps on* going going going. *Until it stops*. *What is a cycle? A cycle is something goes around in together. End.*
Rain forest;	Expository	1. This is my rain forest. *It has many animals and trees*. *It has a panda* eating *bamboo and a banana tree*. It has a great big water fall. 2. I like the rain forest *because they have* cute *animals and* there are big *and small trees!* 3. *This is a diverse rain forest plant because* I can see ants trapped in it. It smells.
Fifi's challenge	Puzzle	1. *What is the name of the man* who lost a *mitten pair? Letter*. Secret *Letter l I K* 2. *What goes in snow? Can you* figure *it out?* I know you can do it. 3. *I can be* built *in one season*. *Can you guess who I am*? If you can't move *to the next question*. *I wear a hat*. *What am I?*

Legend: Coded for domains for ecoliteracy *Cognition* Emotion Action Spirit Complex texts created represented more than two ecoliteracy domains.

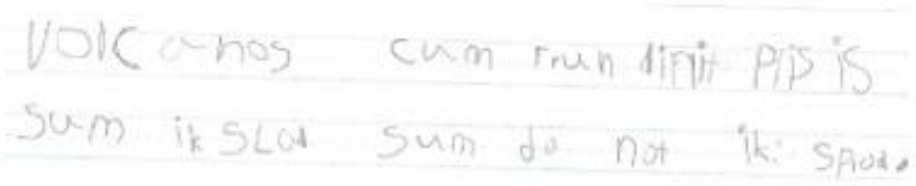
Table 6
Association with Nature as Indicated in Student Texts

Mentor text title	Types of associations	Example words
Nature is…	Playful	Play, Holiday
	Celebration	Fun, Celebration
	Scary	Evil, Spooky
	Awe	Big, Hundreds
	Abundance	Many, More
	Emotional	Love, Like

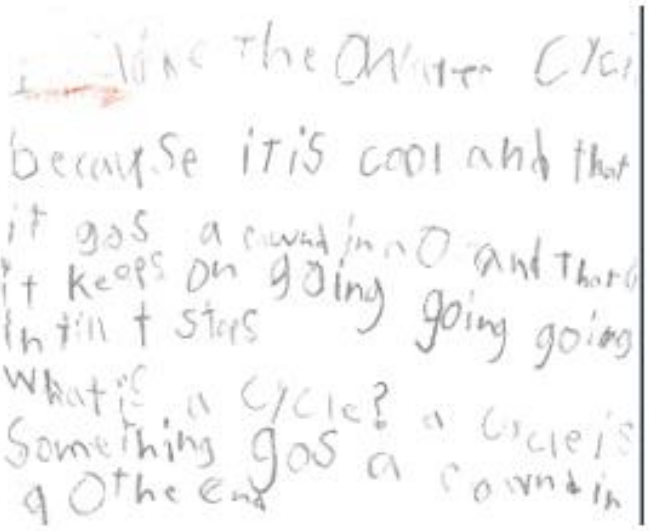
Legend: Student texts showed a range of connection with nature. Emotional words had highest frequency representation.

Appendix 2: Figures

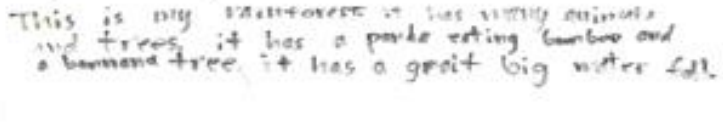
Sample student response to 'Nature is…' text



Sample student response to 'A Cycle Forever' text

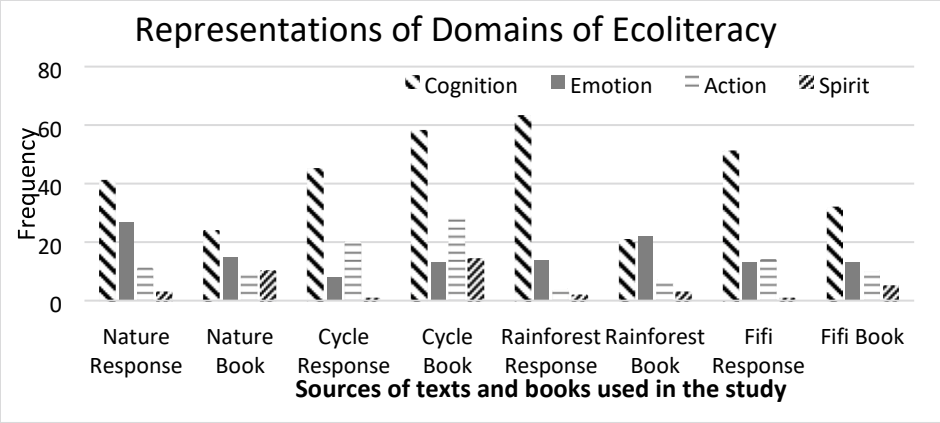


Sample student response to 'Rainforest' text



Sample student respond to 'Fifi's Challenge' text

Figure 1. Sample student responses to various texts



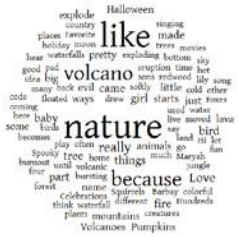
Legend: The student responses to expository texts mirrored the mentor texts provided. Although some domains were represented more frequently in one or the other sample, the differences were not statistically significant.

Figure 2. Visual Representation of the Eco-Literacy Domains Indicated in the Mentor Texts and Student Responses

a. Mentor text title: ***Nature is…***

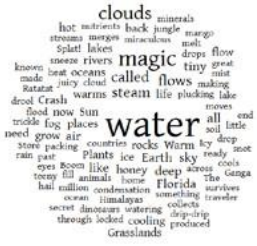
Mentor text representation

Student response representation



b. Mentor text title: ***A cycle forever***

Mentor text representation



Student response representation

c. Mentor text title: ***Rain forest***

Mentor text representation

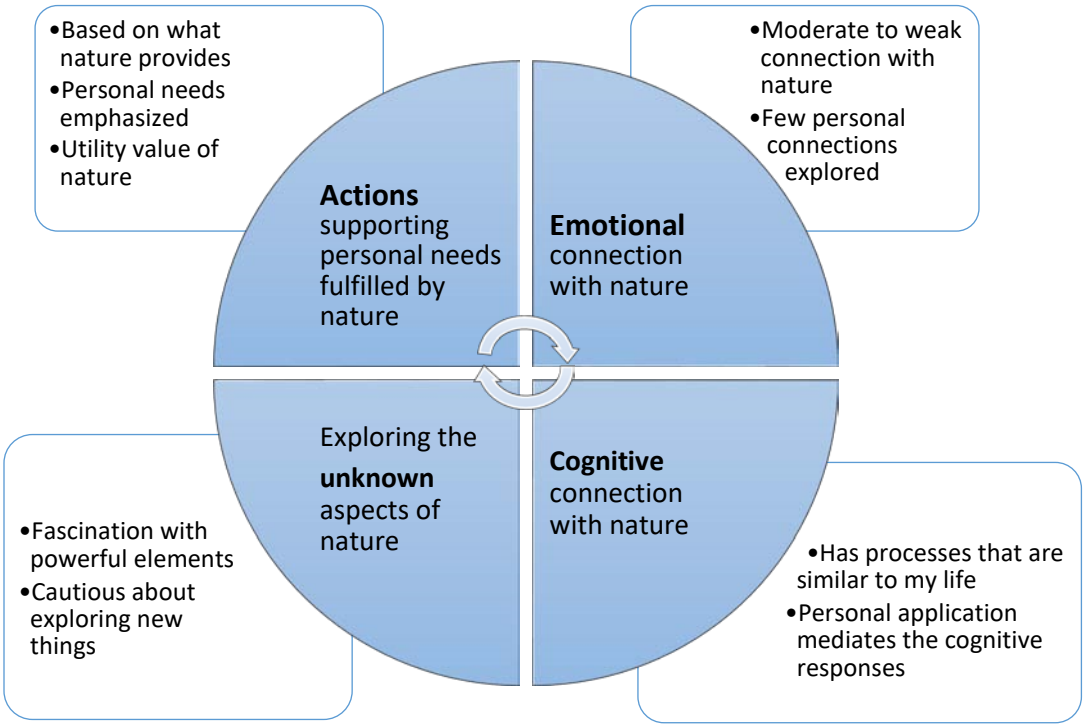
Student response representation

d. Mentor text title: **Fifi's Challenge**

Mentor text representation

Student response representation

Figure 3. Visual Representation of the Text Data



Legend: Barriers to strong ecoliteracy knowledge and practice based on the domains of ecoliteracy. Students displayed contradictory traits such as curiosity and caution in their approach to learning new ideas

Figure 4. Barriers to Strong Ecoliteracy Knowledge and Practice in Students

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Acknowledgements

The author appreciates the support provided by Drs. R. Mincks, J. Kelley, T. Salsbury, and J. Morrison during the study, and Dr. E. Carson for providing editorial advice.

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