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Ecology-Centered Experiences Among Children and Adolescents: A Qualitative and Quantitative Analysis

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ACCEPTANCE

This dissertation, ECOLOGY-CENTERED EXPERIENCES AMONG CHILDREN AND ADOLESCENTS: A QUALITATIVE AND QUANTITATIVE ANALYSIS, by JUDY ORTON, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements of the degree, Doctor of Philosophy, in the College of Education, Georgia State University.

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ABSTRACT

ECOLOGY-CENTERED EXPERIENCES AMONG CHILDREN
AND ADOLESCENTS: A QUALITATIVE
AND QUANTITATIVE ANALYSIS
by
Judy Orton

The present research involved two studies that considered *ecology-centered experiences* (i.e., experiences with living things) as a factor in children's environmental attitudes and behaviors and adolescents' ecological understanding. The first study (Study 1) examined how a community garden provides children in an urban setting the opportunity to learn about ecology through ecology-centered experiences. To do this, I carried out a yearlong ethnographic study at an urban community garden located in a large city in the Southeastern United States. Through participant observations and informal interviews of community garden staff and participants, I found children had opportunities to learn about ecology through ecology-centered experiences (e.g., interaction with animals) along with other experiences (e.g., playing games, reading books). In light of previous research that shows urban children have diminished ecological thought—a pattern of thought that privileges the relationship between living things—because of their lack of ecology-centered experiences (Coley, 2012), the present study may have implications for urban children to learn about ecology.

As an extension of Study 1, I carried out a second study (Study 2) to investigate how ecology-centered experiences contribute to adolescents' environmental attitudes and behaviors in light of other contextual factors, namely environmental responsibility support, ecological thought, age and gender. Study 2 addressed three research questions. First, does ecological thought—a pattern of thought that privileges the relationship between living

things—predict environmental attitudes and behaviors (EAB)? Results showed ecological thought did not predict EAB, an important finding considering the latent assumptions of previous research about the relationship between these two factors (e.g., Brugger, Kaiser, & Roczen, 2011). Second, do two types of contextual support, *ecology-centered experiences* (i.e., experiences with living things) and *environmental responsibility support* (i.e., support through the availability of environmentally responsible models) predict EAB? As predicted, results showed that ecology-centered experiences predicted EAB; yet, when environmental responsibility support was taken into consideration, ecology-centered experiences no longer predicted EAB. These findings suggested environmental responsibility support was a stronger predictor than ecology-centered experiences. Finally, do age and gender predict EAB? Consistent with previous research (e.g., Alp, Ertepiner, Tekkaya, & Yilmaz, 2006), age and gender significantly predicted EAB.

ECOLOGY-CENTERED EXPERIENCES AMONG CHILDREN AND ADOLESCENTS: A QUALITATIVE AND QUANTITATIVE ANALYSIS

by

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ABBREVIATIONS

EAB	Environmental Attitudes and Behaviors

CHAPTER 1
ECOLOGY-CENTERED EXPERIENCES AMONG CHILDREN: A QUALITATIVE ANALYSIS

Within the last century, as the number of people living within urban areas has skyrocketed (Population Reference Bureau, 2012), people's relationships with living things have dramatically changed. Whereas people once regularly engaged in outdoor activities, such activities have been replaced with technologically dependent ones, such as video games, television, the internet (Karsten, 2005). As a result, the relationship many people in urban areas have with plants and animals has become limited to domesticated pets and manicured parks and lawns.

The shift from intimate contact with nature to lack thereof has left children living in urban settings not only physically removed from the natural world, but cognitively removed, as well. Put another way, children's lack of experience with nature has had a negative impact on the way they think about living things. For example, research has revealed that children living in urban settings are more likely to draw similarities between non-human animals (e.g., a bee) and humans than with other non-human animals (e.g., a bug; Carey, 1985). This anthropocentric way of thinking, in which humans are overrepresented in the category of living things, is due to children's lack of experiences with non-human living things (e.g., Coley, Medin, & James, 1999; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993; Inagaki, 1990; Inagaki & Hatano, 1996; Waxman & Medin, 2007). Anthropocentric thinking limits children's ability to reason about the relationships among living things. Specifically, anthropocentric thinking makes it difficult to project properties from humans to plants since humans and plants are members of different kingdoms in the biological world (Herrmann, Waxman, & Medin, 2010).

Of particular interest to the present research, children who are frequently exposed to natural environments—e.g., those living in rural settings—are more likely to reason *ecologically* about living things than children living in urban settings, where experiences with nature are less common (Atran, Medin, & Ross, 2002; Coley, 2012; Ross, Medin, Coley, & Atran, 2003). This means that children who have experiences with nature tend to think about *ecological relationships* between living things as opposed to strictly taxonomic (i.e., kinship) relationships between species. On one hand, children who have a number of experiences with living things (e.g., who live in a rural setting) may think about a bee in relation to a bear (e.g., the bear eats the bee's honey). On the other hand, children living in urban settings may think about the taxonomical relationship between the bee and the bear -- that they are both animals (Medin & Atran, 2004).

When we consider the potential impact ecological thinking could have on children's ability to learn about science in the classroom, we should think of ways children living in urban settings can experience living things locally. *Community gardens* are one way children living in urban settings can experience a variety of plants and animals. Community gardens are typically gardens in urban settings that are worked together by a group of people, and they are rife with opportunities for children to experience a medley of plant and animal life.

Although community gardens allow children to learn about science, no previous research explains *how* children can learn about ecology through participation in community garden activities. In the present paper I focus on the ways one urban community garden provides children opportunities to learn about ecology through a combination of formal and informal learning opportunities. The paper is based upon a yearlong ethnographic study at an urban community garden in a large city in the Southeastern United States[1]. The study addressed the following questions: How does a community garden provide children living in urban settings with opportunities to learn about ecology? Relatedly, what activities shape opportunities to learn about ecology at a community garden?

Background

Informal Science Learning

The basis of the present paper is that community gardens serve as spaces where children engage in informal science learning, namely where they can learn about ecology. The definition for informal science learning, though, is vague (Hofstein & Rosenfeld, 1996). For example, informal science learning can take place in museums, at homes, on late afternoon walks, or at a summer camp. In an attempt to provide characteristics of informal learning, however, it is helpful to compare it to formal learning, as they exist on a continuum of formal-informal learning. Formal learning is compulsory, structured, assessed, curriculum-based, and teacher directed, whereas informal learning is voluntary, unstructured, non-assessed, non-curriculum based, and is learner directed (modified from Hofstein & Rosenfeld 1996:89 in turn modified from Wellington 1991:365 and based on Rommey & Gassert 1994). Although strict informal and formal learning serve opposite sides of a continuum, they do not necessarily contrast in concrete or theoretical contexts (Allen, 2004).

Informal science learning can be divided into two broad categories: spontaneous and deliberate (National Research Council, 2009). *Spontaneous learning opportunities* are

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[1] In order to protect the identity of the participants in the present study, the name of the community garden is withheld.

ubiquitous and include activities such as conversations about science. For example, a family discussing the hummingbirds hovering at the feeder in the window is an instance of spontaneous science learning. *Deliberate learning opportunities*, on the other hand, are focused pursuits of learning and occur less often. Deliberate pursuits are systematic and are specific in their goal of sustained learning. For example, a child may enroll in a science education program, which has a specific learning goal and activities that address this goal.

Research about informal science learning has focused largely on deliberate learning opportunities; however, there is evidence that spontaneous learning also provides meaningful, rich learning opportunities. For example, conversations between parents and children allow children to search for causal explanations about biological phenomena (Frazier, Gelman, & Wellman, 2009). In fact, parent-child conversations are helpful during deliberate learning activities, such as museum visits, as parents guide their children's construction of scientific thought through conversation (Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2000). Parent-child conversations are also important ways for adults to transfer culturally relevant ways of thinking about living things (e.g., Gelman, Chesnick, & Waxman, 2005).

Deliberate and spontaneous learning opportunities for science can occur in one of any of the following three settings: everyday, designed, and program settings (National Research Council, 2009). *Everyday settings* are particularly informal and may include activities such as fishing, berry picking, books, dinnertime conversations, family walks, and use of technology. *Designed settings* are environments that are intentionally designed for learning about science, such as science museums. They are informal because they are navigated freely by learners and are learner directed. Finally, *program settings* are informal learning settings that have formal, objective organizational goals to achieve curricular ends. Therefore, although programs are considered informal, they have many attributes in common with formal settings.

Of particular interest in the present paper, community gardens serve as spaces where youth can engage in deliberate and spontaneous science learning (Rahm, 2002). Further, as will be highlighted further in the next section, community gardens can act as everyday, designed, and program settings (e.g., Krasny & Tidball, 2009b). In doing so, community gardens can serve as places of informal (and formal) science learning. Because of their inherent diversity, community gardens are places where children can learn about science through multiple approaches.

Community Gardens

What is a community garden? Community gardens are extremely diverse in their function, so it is difficult to pinpoint the true essence of a community garden. For the purposes of this paper, though, I will use the definition provided by the American Community Garden Association (ACGA; 2010), which defines a community garden as "any piece of land gardened by a group of people." Further, as can be inferred from the name, a community garden is situated within a community; therefore, the "piece of land" and the "group of people" will vary according to the type of community in which the garden is situated. Since communities are inherently diverse, the vast range of community gardens tends to reflect this diversity (Holland, 2004).

The range of purposes community gardens have is equally diverse. Community gardens can range from leisure-based neighborhood gardens to education-based school gardens, and there are many types in between. No matter the purpose of the garden, though, community gardens provide a broad spectrum of benefits, both intended and unintended. The American Community Garden Association (2010) outlines a number of community garden benefits on their website, including neighborhood and community development, social interaction, encouragement of self-reliance, neighborhood beautification, production of nutritious food, lower family food cost, conservation of resources, recreation, exercise, therapy, education, crime reduction, greenspace preservation, income opportunities, economic development, reduction of city heat, and opportunities for intergenerational and cross-cultural connections. These benefits typically do not exist in isolation, and community gardens oftentimes provide several benefits at once. For instance a school garden designed primarily for educational use may offer the unanticipated, yet fully welcomed benefit of relaxation to its visitors.

Due to a lack of rigorous research (Draper & Freedman, 2010) and the broad description of community gardens, our current understanding of community gardens is relatively limited. There is fortunately a growing interest in community gardens in research communities, which is reflected by the growing number of empirical studies conducted on community gardens (see Draper & Freeman, 2010 for a review). Part of the rise of interest in community gardens may reflect the growing number of community gardens in urban communities. In recent years there has been a resurgence in the preservation and creation of natural spaces in (mostly urban) communities around the world, which is part of the larger "green movement" that is taking place at the global level. As part of the movement, community members and concerned citizens have been making efforts to promote environmental sustainability and a reconnection with the natural world in their cities and communities. As a result of this shift in global focus on preserving green-spaces, community gardens have sprung up in neighborhoods around the world, including the United Kingdom (Holland, 2004) and Australia (e.g., Corkery, 2004) as community members turn otherwise unused spaces into vibrant, green spaces for children and adults to enjoy.

Community gardens as spaces of informal science learning. There is evidence that community gardens are spaces where children can learn about science informally through hands-on participation in community garden activities (Fusco, 2001; Rahm, 2002) and through socio-cultural learning (Krasny & Tidball, 2009b; Rahm, 2002). Through socio-cultural learning, learners become immersed in a culture of science learning and learn through observation and conversation with others at the garden.

Garden Mosaics, a NSF-funded international gardening program provided both spontaneous and deliberate learning through their gardens that focused on science (Krasny & Tidball, 2009b). Krasny and Tidball (2009b) investigated the effectiveness of Garden Mosaics by asking children to draw a picture of a garden before and after their participation in a Garden Mosaics community garden summer program. When the researchers compared the pre- and post-test drawings, they found that 19 out of 23 youth added at least one new element (e.g., flower, tree, fruit) to their garden pictures. Krasny and Tidball also asked participants, “What does a garden need to grow and thrive?” and “What does a garden give back to you?” They found 88% and 94% of the lists respectively had at least one new component. The authors presented this as evidence that the children learned about science while at the garden. Krasny and Tidball’s (2009b) study was an important step toward uncovering the effect community gardens have on children’s understanding of plants and animals. Their study also highlighted the importance of hands-on participation in community garden activities and socio-cultural learning through observation of adults at the community garden.

Even if the focus of a community garden is not explicitly on science, science learning can emerge through children's participation in a community garden. For example, Rahm (2002) argued that community gardens are a key environment where children can learn about science through their interaction with the garden and through spontaneous conversations with garden staff about science. Positing that people and their environments are inseparable, and thus learning should concentrate on the learner as participator, Rahm focused largely on experience and environment rather than science learning as an outcome for children at a community garden. Rahm found that six youth, ages 11-14, engaged in sense-making about science through conversation with adults and peers, observations, and participation in garden activities. For example, through a spontaneous, causal conversation about flies, children were able to learn about the role of flies in the composting process. Rahm’s study is another valuable contribution to our understanding of the ways community gardens can teach youth about science through spontaneous opportunities, such as through conversation and informal interaction with the garden.

The informal nature of learning science at a community garden does not necessarily mean that participants are not meeting formal science standards. Similar to Rahm’s (2002) focus on the socio-cultural aspects of learning science, Fusco (2001) proposed community gardens can foster opportunities for youth to participate in “cultures of science learning.” By participating in community garden activities, Fusco claimed, youth practice science culture, identify with science, and subsequently begin to incorporate science into their everyday lives. Fusco analyzed the scientific practices and learning of youth, ages 12-16 (many of whom were homeless), through an action research project in which they transformed an abandoned lot into a community garden. Fusco found that through their participation in the community garden, participants met several science standards, such as forming science connections, thinking scientifically, using scientific tools, and communicating scientifically.

Community gardens can also offer formal learning opportunities, such as activities that purposefully align with specific science learning standards. Formalized garden-based learning, however, is more commonly found within school gardens. I am more interested in community gardens here because of a fundamental difference between the learning approaches of community and school gardens. On the one hand, school gardens typically provide curriculum-based learning guided by specific learning standards (Blair, 2009). In these gardens children engage in semi-structured or structured garden activities that are aligned to specific science standards. On the other hand, community gardens are typically less formal and allow children a type of "free-choice" learning through which they freely explore and participate in garden activities (Falk, 2001). For example, whereas a school garden may allow a group of students to come out into the garden to plant seeds as part of a lesson about how seeds grow, a community garden allows children to not only plant seeds, but to also freely explore the plants that are in the garden. Free exploration is an important aspect of the way that children can learn about ecological relationships between living things (Coley, 2012).

By connecting activities to learning standards and by offering opportunities for free-exploration, a community garden can transverse the informal-formal learning continuum. As evidenced by the research outlined above, community gardens are unique because they offer spontaneous and deliberate learning opportunities, and depending on their purpose, they can serve as everyday, designed, and program settings. In the present research, I illustrate how a community garden can embody many of these aspects in a single space. I argue that through these different approaches, a community garden can serve as a space for children to learn about ecology. I also explain a community garden as a space for learning that is negotiated by garden staff, including teachers.

Method

Purpose

The purpose of the present study was twofold:

1. To examine the opportunities a community garden provides children living in urban settings to learn about ecology
2. To investigate how a community gardens provides opportunities for formal and informal science learning to children

Context

The community garden at the center of the present study is located in a large city in the southeastern United States. The garden is free and open to the public, though garden memberships are available. Those who choose to be members (by paying a yearly membership fee) have year-round access to a small garden plot, where they can grow plants of their choosing. There are several areas, though, that have been reserved for garden classes, where class attendees can plant and harvest plants as part of the class's activities. The garden has a variety of wildlife areas, including a wooded area designated for native trees of the region, a garden pond home to several frogs, fish, and water plants, a recently constructed greenhouse, a chicken pen with 13 chickens (all hens), bee houses, a carnivorous bog, and a bamboo and tree-lined creek running on the north-end of the garden.

The garden was founded in 1996 by two neighbors, who were interested in offering local children the opportunity to experience nature without going beyond the city limits. Since then, the garden has transformed into a central feature of the community through the assistance of ground-up initiatives by staff and volunteers and grant funding. As the garden developed, it began offering more classes to children and adults on a wide variety of topics ranging from basic gardening methods to crafting classes. Now, the garden offers several classes per month.

I observed a range of activities during my participant observations at the garden, but I most often observed children's classes. Thus, it was these classes that provided much of the data for the present paper. The classes I observed were geared toward 2- to 10-year olds, with classes grouped in three ways: classes for 2-3 year olds, for 4-5 year olds, and for 4 year olds and older. Many classes operated around a theme, such as "Circle of Life", "Insects", or "Seeds." Other classes, however, were more open-ended and did not have a specific theme (whether classes had a theme was determined by the teacher of the class). There were two main types of classes I observed while at the garden: single-day classes, which typically lasted less than two hours, and multiple-day classes, which also lasted less than two hours, but extended over the course of a week or several weeks.

Participants

I focused on children ages 2- to 10-years old who visited the community garden. Participants were mostly children who attended classes at the community garden, and to a much lesser extent, those who informally visited the garden with their families (e.g., during morning walks). Because children's relatives (i.e., parents and grandparents) sometimes accompanied children during garden classes, adults—including class teachers—were included in the analysis. By including both children and adults, I was able to capture important child-adult interactions at the community garden, which were key in understanding adult-guided learning opportunities for children to learn about ecological relationships of plants and animals. To protect the identity of participants, participants were not identified by name.

The majority of the participants in the present study lived in neighborhoods near the community garden. Participants in the present study were predominantly white. All participants were from middle- to upper-class economic backgrounds, which was reflective of the neighborhood in which the garden was situated. Parents paid on average $80 for a six-class session and $15 for a single class. Some visitors walked to the garden, while others drove their own vehicles.

Procedure

The present report is based upon a yearlong qualitative, ethnographic case study carried out at the garden. Over the course of more than a year (October 2011-November 2012), I visited the garden 26 times and wrote more than 400 pages of field notes based on my visits. Visits typically lasted between one and three hours. I conducted participant observations in the present study, which allowed me to focus on the setting, as well as informally talk with people at the garden.

My role as participant observer. During my observations of the community garden, I typically served as a volunteer assistant for children's classes at the garden. As a class assistant, I was able to not only observe, but also participate in garden activities, which is in-line with the participant observer role commonly found in anthropological fieldwork (Gold, 1958). In addition to serving as a children's class assistant, I also worked as a general volunteer at the garden, during which I provided general garden maintenance, such as pulling weeds, spreading mulch, and transplanting seedlings. In this role, I was able to observe and talk with families who visited the garden, garden staff, and other volunteers. Although this was a valuable role, I was not able to work as closely with children as when I was a class volunteer. Therefore, most of the data reported in the present paper was collected while I served as a class assistant.

Data Analysis

I used qualitative techniques to analyze data (i.e., field notes) for this study. Specifically, I used a phenomenological approach to analyze my data (Husserl, 1931; Hycner, 1985). As part of my analysis, I utilized bracketing, which involves setting aside preconceptions during data analysis (Husserl, 1931). To bracket my preconceptions, I wrote memos about my previous experiences that may have influenced my research at the community garden and by including lengthy observer's comments throughout my field notes describing my perception of the scenario or phenomenon. Through memos and observers' comments, I made an attempt to objectify my thoughts and set them to the side, physically in the sense that they were removed from my main field notes, and figuratively by setting aside my expectations in an attempt to approach the data with a level of “freshness.”[2]

Following bracketing, I reviewed my field notes to gain a general sense of the transcripts (Hycner, 1985). In doing this, I began to delineate *units of general meaning*, which were the initial emergent codes. This proved to be the most time-consuming and

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2 Note that although I attempted to bracket my thoughts, I could not do so completely. Thus, the present study has been at least in part subjected to my own beliefs and prior experiences, including a personal interest in nature and outdoor activities. I have lived and worked on a family farm for most of my life. Also, over the course of the study, I developed relationships with garden staff as a colleague and researcher. Bracketing was challenging—rather than desert my own beliefs, I remained conscious of them throughout the study.

meticulous task of data analysis. I combed through the transcripts as they were collected, coding everything that seemed interesting—all people, objects, events, verbal and non-verbal communication, and activities. I did this openly, without focusing specifically on those aspects of the data that I thought might be examples of or at least be related to learning at the garden.

The next step was delineating *units of relevant meaning* (Hycner, 1985). These units were constructed by applying my general research question to each of the units of general meaning. I asked of each unit of general meaning, how does this relate to learning at the community garden? I noted the relationship between each unit and the research question if it had one as well as the type of relationship it had to the question. Therefore, not all units of general meaning became units of relevant meaning.

Next, I began to cluster the units of relevant meaning. The clusters were not mutually exclusive, and several units of general meaning fell into several clusters of relevant meaning. During this stage, I attempted to bracket my preconceptions again, though it was much more difficult to do for several reasons. First, I did not have the time to set aside the fieldnotes for any significant period of time, making it more difficult to attain a fresh perspective. Second, I had already combed through the data and formed units of relevant meaning, which brought me closer to the data.

The units of relevant meaning were then clustered based on common themes. If certain units appeared to be related to other units, they would be clustered together according to this common aspect, or theme. These themes were emergent and were not imposed on the data. After identifying themes of clustered units of relevant meaning, I continued to broaden my search for meaning in the data by identifying themes between clusters of meaning. I identified only 4 sets of cluster themes, and then two overarching themes that seemed to run through the cluster themes (Table 1). Hence, I was able to identify the two overarching themes that guide the present study through a bottom-up process, which is central to phenomenological analysis.

Findings

The focus of the present study emerged over time through the collection and analysis of data. At the outset of the study, my general focus was on learning opportunities for children at a community garden; however, over time, as I wrote and analyzed my data, two major themes emerged:

(1) Children had opportunities to learn about ecological relationships between living things at the community garden through their involvement in community garden activities. Learning was not defined as a cognitive change, but rather as their excitement, engagement, and motivation to learn more about ecology at and beyond the garden, which is consistent with informal science learning (National Research Council, 2009). Children learned about various types of ecological relationships, including micro-ecology, shared habitat, food-chain relationships, multi-level relationships, utility relationships, and names of organisms.

(2) The community garden served as both a space for formal and informal science learning. Formal and informal learning did not compete but rather occurred in tandem at the garden. For instance, children often displayed informal learning through self-guided exploration and inquiry during formal activities (e.g., filling out worksheets). Over the course of the study, I witnessed a shift from

informal to formal learning opportunities at the garden, as staff began to privilege formal over informal learning opportunities.

The way these central themes emerged from units of relevant meaning into clustered themes of relevant meaning is illustrated in Table 1.

Table 1

Emergent Themes of Learning at the Community Garden

Units of relevant meaning	**Clustered themes**	**Central themes**
Ecological relationships between: micro-organisms plants and other plants plants and non-human animals non-human animals and other non-human animals Names of plants and animals Relationships between humans and other living things	Micro-ecology Macro-ecology • Shared habitat relationships • Food-chain relationships • Multi-level relationships • Utility relationships	Opportunities for children to learn about ecology
Gardening activities Hands-on activities with nature Garden walks Interaction with animals Books Games	Informal science learning	Garden as a space for formal and informal science learning
Planned activities Guided instruction Garden rules	Formal science learning	

Learning about Ecology

Ecology involves the relationship between various living things, including plants, humans, and non-human animals. During their visits to the community garden, children were able to learn about a variety of different types of relationships between humans, non-human animals, and plants. These included food-chain/predator-prey relationships, shared habitat relationships, multi-level relationships between living things, and the way plants and animals can benefit human beings, which are called utility relationships here.

Micro-ecology. Children learned about micro-ecology, which were relationships between very small, microscopic living things, such as bacteria, during their visits to the garden. They often learned about micro-ecology when learning about compost. For example, during a class for 4-6 year olds, the teacher explained, “There are all kinds of things living in the compost, like worms and bugs, and there are also bugs that you can't see living in there.” By saying “bugs that you can’t see living in there”, the teacher was teaching the children about microorganisms. Further, consider the following instance highlighted in my field notes that also occurred during a class for 4-6 year olds:

> The wheelbarrow was pulled close to the bed and was filled to the brim with compost. The teacher reached into the wheelbarrow with her hands and pulled out a handful of compost. “We are going to put the compost in the bed here,” she explained, putting the compost in the bed. The children gathered around the wheelbarrow to get the compost to put into the bed. As they did, she explained to the children what the compost was. “You see this compost. This is more for adults, but there are microorganisms in there that are good for you. They help you release serotonin, or at least that's what I've read.”

This example demonstrates how teachers at the garden sometimes hesitated when teaching young children about microorganisms (“This is more for adults.”). Lessons about micro-ecology, such as the role of microorganisms in compost at the garden were typically reserved for teaching adults, rather than children. To give another example, during a family composting class, in which children and adults learned about compost, the teacher explained the relationships between the types of bacteria in the compost. I noticed the adults were engaged during the class, but the children were not; many of them were sitting on the ground, playing with sticks, while the adults talked about compost overhead. Overall, it appeared that ecological relationships at the micro-level were highlighted occasionally; however, they were not often emphasized among children and were instead reserved mainly for adults.

Shared habitat. As illustrated above, children had opportunities, albeit relatively brief and superficial, to learn about ecological relationships at the micro-level. Ecological relationships at the macro-level, though, were far more common. One specific macro-level relationship between living things was how living things share a common habitat. One clear example is the relationship between the chickens and bees at the garden. The beehives at the garden were located inside the chicken pen so that the chickens could eat the hive beetles that plague the beehives. A teacher pointed out the purpose for this arrangement once during a garden class for 2-3 year olds. The teacher pointed to the beehives inside the chicken pen and said "The chickens are good neighbors to the bees. They come through the open gate and eat the little critters that harm the bees." By saying this, the teacher highlighted that the bees and the chickens shared a habitat, and each benefited from the other.

Plants and animals could also benefit each other, such as illustrated in this example from my field notes with monarch butterflies and milkweed plants.

> When near the milkweed plant, the teacher pulled back the plant to look under the leaf. "Let's see if there are any eggs here," she said, pulling the leaf back so that she could look underneath. There did not appear to be any eggs. She walked over to a few other plants to look under their leaves. "If there were any eggs, they would be under the leaf. They would be little orange eggs.

Maybe it's not the right time of year."

In this example, the children were able to witness the relationship between a plant (milkweed) and an animal (a monarch butterfly). They observed firsthand that these two organisms share a common space, which is a good example of an opportunity to learn about shared habitats.

Children were also able to see pollinators firsthand at the garden. Pollinators represent another way plants and animals can mutually benefit one another in a shared habitat. Pollinators included bees, many of which lived at the garden in their hives, and other insects, such as wasps and butterflies. Oftentimes, these pollinators were perched on top of the flowers they were pollinating when children encountered them. Frequently, while walking around the garden, the teacher would point out a bee on top of a flower. "Here are the flowers," one teacher explained to a group of children. "They help the plant grow for next year." She pointed to a cluster of small red flowers with at least a dozen bees climbing on top of the red flowers. In addition to observing pollinators from afar, children also caught butterflies with nets, and many of their most successful catches were when the butterflies were resting atop a flower.

Finally, children were able to witness how plants shared a habitat with other plants, as evidenced by this excerpt from my field notes about a gardening activity I observed.

> "So, now we're going to put the radish seeds in between the garlic, like right here," the teacher said, pointing to a space between four sticks that marked garlic. "We are going to dig a small hole and then put our seeds in there," she instructed. When some of the children put the radish holes too close to the garlic holes, the teacher explained, "You don't want them too close, because they will fight." "What does that mean?" one of the children asked. "That means that they will have to compete for the same things, which we don't want."

In this example, the teacher explained to the children why it was important to spread apart the seeds in the garden to prevent plants from competing for resources. By doing this, she highlighted how plants in the garden share a common habitat. Additionally, this example illustrates how not all shared habitats are beneficial to the living things that are involved.

Food-chain relationships. Related to shared-habitat relationships, children had opportunities to witness food-chain relationships, which typically occurred between plants and non-human animals and between non-human animals. For example, during one class session for 2- to 3-year olds, the teacher pointed out that a squirrel had eaten a fig from the tree in the garden.

> There were a couple of mothers clustered near the teacher, who was standing near the fig tree. "Oh my! It looks like someone had a snack last night!" the teacher said excitedly, her eyes widening and her voice becoming soft. "Oh wow, come look," a couple of mothers exclaimed, attempting to reign their children in to look at the partially eaten fig the teacher had plucked from the tree. "Come look at what the squirrel ate," the teacher repeated. The teacher then walked around, showing several of the children up close the partially eaten fig. When she was finished, she tossed the fig onto the ground by the tree.

By pointing out the partially eaten fig, the teacher highlighted how non-human animals eat the plants and fruits in the garden. Children also encountered predator-prey relationships between non-human animals at the garden. Children witnessed birds carry worms across the garden in their mouths and chickens eat worms and soldier fly larvae. During one class, the teacher removed several soldier fly larvae from the bottom of a soldier fly trap and threw the larvae over the fence to the chickens, which quickly ate the larvae in front of an audience of children. Other times children witnessed predators without prey, such as on one occasion when children witnessed a hawk fly overhead and on another occasion when children saw a snake. Although the hawk did not have anything in its grip, and they did not witness the snake eat anything, these were still opportunities for children to observe predators at the garden. Teachers did not point out these relationships as “predator-prey” relationships or the hawk or snake as “predators”, so it is unclear whether the children understood them as such. Nonetheless, these opportunities provided an important foundation of experience for the children to subsequently learn more about predator-prey relationships.

Multi-level relationships. Multi-level relationships were defined as relationships between several levels of living things. Perhaps the most salient example of multi-level relationships between living things involved compost. Compost involves a cycle between plants, humans, animals, and plants: plants are placed in a compost bin and break down over time, yielding compost. The compost is then placed on garden plots, which ultimately provide food for people to eat. After eating food, people can put the leftover food scraps into the compost bin, and so the cycle continues. Below is an example from my field notes in which a teacher highlighted the composting cycle during a class for 4-6 year olds.

> “Does anyone know what this is called?” the teacher asked. One of the boys yelled, “Compost!” “That's right! You are so smart! This is compost. Give me a high five.” The boy put out his hand and she gave him a high five. “Can everyone else say that word with me? *Compost.”* The other children said in unison with her, “*Compost.*” The teacher asked, “What do we put in the compost?” Some of the children responded that you can put food in there. “What do we do with the compost?” she asked. Some of the children responded that you put it in your garden. “That's right! So, what does compost help give us?” she asked. “Food!” some of the children said. “You are so smart! That's right, it gives us food. So, it's all connected like in a cycle,” she said, drawing a large circle in the air in front of her.

Here, the teacher demonstrated that compost is a vital part of providing people food by asking questions (“What do we do with the compost?”) to lead children to understand the complex role compost plays in the garden. She also used her body (drawing a large circle in the air) to illustrate this relationship.

In another example, a teacher demonstrates to a group of 2-3 year olds the mutual, relatively complex relationship between plants and humans: plants provide food to humans and humans in turn take care of plants.

> After the children had been poking around for a few minutes, the teacher announced, "So what we're going to do now is shovel some dirt in here so we can feed the plants. Plants need to eat, too," she explained. "So we feed the plants, the plants grow, then they give *us* food!" she said, demonstrating with her voice, eyebrows, and hands, which were getting higher and higher as though a plant was growing.

In this example, the teacher explicitly told the children the different steps of the composting cycle. She did so in language that 2-3 year olds might appreciate, such as "plants need to eat, too." By telling the young children that people feed the plants and then the plants feed people, she clearly illustrated the cycle between plants and human beings.

Utility relationships. The ways in which plants and animals could be used for the benefit of human beings was frequently highlighted during children's visits to the garden. I call these relationships "utility relationships" here because of the valuable resources they provide to people. In terms of plants, children learned about plants they could eat and how plants could be used as medicine and bug repellant. When learning about the plants they could eat, oftentimes children picked and then ate plants from the garden, such as when a group of 2-3 year old children picked herbs to eat during snack time.

> The children picked a few basil leaves next and made their way back to the table with their cups of herbs, chives, and a stalk of rosemary. The teacher announced, "We are going to chop these herbs with our hands. We're going to use our hands like knives." The teacher had brought eggs to scramble and to put the herbs in so that the children could taste the herbs, as well as eat something that they picked and chopped themselves.

Here, the children were able to witness firsthand where their food came from. After the herbs were chopped, they were placed in scrambled eggs, which the children ate during snack time. Rather than just talking about food, the children were able to pick, chop, and eat the food in one setting, galvanizing the use of plants as food.

In another, more spontaneous instance, a group of 4-6 year old children discovered a sweet potato in the garden bed when pulling up weeds. As my field notes explained,

> There were still some weeds there, so the teacher pulled them up. One of them had a large tuber on the end. “Oh my goodness! Look what we pulled up! Does anyone know what this is?” The teacher answered her own question. “It's a sweet potato!” They asked her what they were going to do with the sweet potato. “I am going to take it home and cook it and bring it in tomorrow,” she explained.

The teacher brought the sweet potato to the next class session along with a few more potatoes she bought from the store and served them during snack time. Like the example with the herbs, the children were able to witness and play a key role in where their food came from. This way, children learned firsthand how plants at the garden benefit people by providing food.

Children also had opportunities to learn about the ways animals provide benefits to people. During a class about chickens, the teacher asked the children about the ways chickens could benefit human beings. As captured in my field notes, the teacher led a question and answer session about the many advantages of chickens.

> “Who can tell me what chickens are good for?” One girl raised her hand and said, “Eggs.” “That's right! We get eggs from our chickens that we use to make breakfast.” She continued, “What else do we get from chickens?” There was a moment's hesitation with the crowd, but then an 8-year-old girl raised her hand, “They make our breakfasts.” The teacher replied, “Well, they give us the eggs to make breakfast with, but they don't actually make our breakfasts for us…Does anyone know?” An elderly woman spoke up, “They eat bugs.” “That's right. They eat bugs in our yard. What else do chickens give us?” One of the women raised their hands and said chicken litter. “Yep! Chickens poop! We use that chicken litter to put in the compost just before it's ready so we can put it on our gardens. So, chickens help us get food another way, by helping plants grow with the litter.” She counted off the things that

> had been named with her fingers, “So chickens give us eggs, bug control, and litter. What else do chickens give us?” No one spoke up, until the man in the back with his wife said, “Chicken!” The teacher smiled and said, “That's right! If you have ever eaten a McNugget, that meat comes from chickens that look just like this.” A young child piped up, “What about a chicken sandwich?” “Yep, that is ground-up chicken meat from chickens like this. That's chicken, too. So, some people actually raise chickens in their yard so they eat them. They let the chickens roam around in the garden so they live a happy life before they are eaten. So, those are the things that chickens give us- eggs, bug control, poop, and meat.”

In this example, the teacher uses the garden class as a forum to teach children about how chickens can provide multiple benefits to people. This opportunity, as well as the others described above may provide children the unique opportunity to learn about the role plants and animals play in people’s lives.

Names. Not all instances of learning about ecology involved learning about ecological relationships. An additional, yet very important aspect of learning about ecology at the garden involves learning the names of plants and animals at the garden. After children learn the names of living things at the garden, they may gain a more sophisticated understanding of ecological relationships, as they can use names to describe the units in the ecological relationships. For example, consider my exchange with a 3-year-old boy during a garden class for 2-3 year olds:

> Standing next to a bed of lettuce, he asked, “What kind is the purple kind?” I responded, “You know, I don't know what the purple one is. I’ll have to look at the tag here.” I bent over to look at the white tag stuck in the ground. “It says that it's 'red choi'.” “Red choi,” he echoed.

Before our exchange, the young boy (and I) did not know the name of the plant in the garden bed. However, after reading the tag that labeled the plant, we then understood that the plant was “red choi.” Labels were therefore an important way for children to learn the names of plants at the garden.

Whereas in the above example, an adult used a label to provide a name for a plant, other times, adults deliberately stated the names, such as the teacher who pulled off a small, green fig from the tree and held it out to the kids to see. “This is called a *fig*,” she told the children. Still, other times teachers told children the name of an entity through more spontaneous interaction, such as when during a class about stream life, a teacher asked a young boy, “Have you ever seen a salamander or a crawfish before?” The boy replied enthusiastically, “I've never even *heard* of either of those before!” Hence, children could learn the names of plants and animals through deliberate and spontaneous opportunities at the garden. The purpose of the next section is to outline in more detail the types of opportunities children had to learn about ecology.

Informal and Formal Opportunities for Science Learning at the Community Garden

Learning about ecology at the community garden involved a combination of informal and formal learning opportunities. Below, I outline both types of opportunities, including specific examples of how these opportunities played out at the garden. Before continuing, it is noteworthy that although I have set up formal and informal learning opportunities into two separate categories, recall that these two types of learning occur on a continuum (modified from Hofstein & Rosenfeld 1996:89 in turn modified from Wellington 1991:365 and based on Rommey & Gassert 1994). Therefore, it is not my intention to set them up as competing forces, but rather I acknowledge that they exist in tandem and often take place simultaneously during activities. Still, it was important to highlight each type of opportunity independently because of their unique contributions for children to learn about ecology.

Informal learning opportunities. Informal opportunities to learn about ecology emerged during gardening activities, hands-on experiences with nature, reading books, games, walks through the garden, and interaction with animals. All of the opportunities occurred during children's classes at the garden.

Gardening activities. Children learned about the microcosm of a garden through their participation in gardening activities. During my visits to the garden, children participated in all stages of gardening activities, including weeding, planting seeds, and watering plants. If the class lasted over the course of several weeks, sometimes the children witnessed the plants grow. The following excerpt represents a typical gardening activity for children.

> The teacher asked for the seeds and tore a hole in the bag so she could retrieve seeds for the children to plant. "I am going to give each of you two seeds, like I did yesterday. I want you to go over there and pick out a trowel and dig a small hole and drop your two seeds inside," she instructed. She began handing out two seeds to each of the children. I asked if I could take a small handful to pass around to the children on the other side of the table. I walked around, dropping two seeds into each of the children's hands. When each of the children had two seeds, they got up and got trowels from the basket that was on top of the bench where the nets were sitting. Of the children who arrived first, I instructed the one with the trowel to dig a small hole in the ground for his seeds, which he did. "Okay, that's probably good," I said. He stopped digging and dropped his two seeds in the same hole. He took the trowel and covered up the seeds by dragging dirt over the seeds.

Following this planting session, the children also watered the plants, and during later class sessions they came back to see that the plants had grown. Through their gardening activities, the children were able to see that by watering and taking care of the plants, the plants will grow, thereby learning the ingredients for plant growth: seeds, water, soil, and sunshine.

Hands-on activities with nature. In addition to gaining hands-on experience with gardening activities, children were also able to engage in hands-on activities with other forms of nature, such as in the stream that ran behind the community garden. One class I observed taught children about stream life and streams as habitats for animals, such as salamander and crawfish. The following is a description of a stream-based activity that took place during the class.

> Once we walked a few feet, one of the teachers turned around and told the kids that they were going to catch some salamanders and crawfish. He pulled out the seine and showed them how they should lay it down about half way so that they could get into the seine. He then explained and showed them how to stir up the water in front of the seine so to move the things into the seine. He asked for a couple volunteers. Hands and an excited "Ooh, ooh!" rang out. The man selected two helpers for the activity. He allowed each of them take hold of one side of the seine, showing them how to hold it. He then asked for two more volunteers. He asked the new volunteers if they could kick up the rocks in the stream, showing them how to kick to stir up the rocks and sediment at the bottom of the stream. The kids followed suit, kicking and walking toward the seine. After about a minute of kicking, he instructed the kids to pull up the seine, helping them. The seine was full of leaves, sticks, small rocks, and stream-goo. All of the children peered over the seine. Several of the children tried to sift through the debris in order to uncover something.

During the class, the two teachers led the children through a guided tour of the stream, letting the children gain firsthand experience with the stream, including how to seine. Through their hands-on activities with nature, the children were able to interact with nature, not be just passive observers. Their interaction provided rich opportunities to understand the stream characteristics, such as the plants and animals that live in and near the stream.

Garden walks. Garden walks were another way for children to experience living things at the garden. Garden walks were a common activity during garden classes, as teachers used it for a way for the children to explore the garden. For example, one day the teacher took the children for a "mycelium walk" during which the children looked for mycelium, a type of fungus. In another previously mentioned example, the teacher took the children out to look for monarch eggs on the underside of milkweed leaves.

Garden walks did not always yield positive interaction with animals, though, such as when during a walk several children were stung by yellow jackets. Albeit negative, the children's experience with the yellow jackets was an opportunity for the children to understand that yellow jackets live in wooded areas and will sting when they are disturbed.

Interaction with animals. Interaction with animals happened during different types of activities, including gardening activities and hands-on activities with nature, but their prevalence at the garden made them an independent theme of how children learn about ecology. Children experienced different types of animals at the garden, including chickens, yellow jackets, butterflies, worms, "roly-polies," and aquatic animals, such as salamanders, fish, and tadpoles.

Chickens were popular animals among children at the garden. The chicken pen was located in the center of the garden and was a main attraction for child (and adult) visitors. As such, children interacted with chickens during many of the class sessions. Interaction was usually in the form of feeding chickens, whether it was scraps from their snack or weeds pulled up from the garden. As noted in my field notes, children were able to do both during one class session.

> When snacks were put up and the table was relatively clear, the kids went outside to feed the chickens. When I went outside, the children were over by the chicken pen. They were holding sunflower seeds in the palm of their hands and were letting the chickens eat out of their hands from inside the fence. The children giggled as the chickens stuck their heads out of the fence and pecked the food that was in their hands. The teacher had told the children to also find clovers to give to the chickens.

Children often saved their food scraps to feed to the chickens, and it was commonplace for teachers to place a bowl at the center of the table for children to save the food they did not eat for the chickens. By feeding the scraps to the chickens, the children witnessed firsthand the relationships between chickens and food and perhaps saw themselves as mediators between the chickens and their food.

Children also experience worms and "roly-polies" firsthand in the garden. These garden animals were most often encountered during gardening activities, when children were digging in the dirt. For example, one day when the children were digging in the dirt, a few of them found roly-polies. "Look, a baby roly-poly!" one of the boys exclaimed. The children then picked up the bugs and held them in their hands. This example also illustrates that some of the children came to garden classes with prior knowledge about insects and animals. Another example from my field notes illustrates how children encountered worms as they gardened.

> Another child saw a worm in the soil, which caused a mini-ruckus. The child picked up the worm and held it in his hand. The other children came around to look at the worm. As other children found worms in the dirt, they would pick them up, too. If a child hadn't had a turn holding a worm, he would ask the children who did have a worm if he could hold it.

This example highlights how children became *excited* about seeing an animal in the garden and how they each wanted to hold a worm. Oftentimes, as was the case for worms and roly-polies, the discovery of an animal in the garden came as a surprise, and the children often reacted emotionally to their discovery. This is clearly highlighted when children discovered animals in their seine after pulling it up from the stream during the stream-based class mentioned earlier.

> This time, when they pulled up the seine, it was apparent that there was at least one salamander in the seine. The kids screamed out excitedly, "*Oh look! A salamander!*" The kids clamored around the seine to see it, some of them reaching out to touch it. We continued down the stream, seining several times. One time, they caught a very small fish (less than 1" big), and one of the boys screamed excitedly, looking up with large eyes. "*A fish!*" he exclaimed. Eventually, one of the times that they pulled up the seine, there was a crawfish inside. The kids shrieked excitedly again at the sight of the crawfish, several of them trying to touch it.

Similarly, another class session further illustrated how children became excited about the discovery of an animal. In this example, the teacher fished out several tadpoles from a small pond at the garden with a net.

> The teacher dipped the net into the pond and dumped the catch into a long, white plastic container. "*Oh! Look! Tadpoles!"* the kids screamed about the tadpoles that were in the white container. The three children on my side couldn't see the tadpoles, so they went around to the other side of the pond so that they could get a better look. "Don't touch them, because your fingers will hurt their skins," the teacher instructed. She handed the container to me to carry back to the picnic tables so that the children could get a closer look. As I walked across the green space, a boy pulled at my arm, "Let me see!" he said. "Let's wait to get to the table so that you can look with everyone else," I said. He asked again, but then when we got to the table, all of the children sat down around the container so that they could look in. "Look, that one has legs!" one of the boys said. They all held their heads just a few inches from the water. None of them touched the tadpoles, but instead just looked. Several of them got the small, plastic magnifying glasses so they could see more closely. They held them up to the tadpoles to look at them. The teacher returned with two small clear plastic containers with more tadpoles. We put them down the table so that children could spread out and see the catch from the pond. "So, what do you all see in there?" The teacher asked the children. "Tadpoles!" they said. "What else?" she quizzed. "What is that little clear worm right there?" she said, pointing to a clear worm that was only a couple centimeters long that squiggled around in the water. "There's a worm!" one of the kids said, pointing to a very thin worm that squiggled around in the water. "You're right. That is a worm," The teacher said. "There's some bugs, too," she said, pointing to very small bugs that were in the water.

This example clearly illustrates children's interest and excitement about seeing and interacting with animals and the garden. Within the span of just a few minutes, children were able to interact with tadpoles (in various stages of development), worms, and "very small bugs" in the water.

Several of the above examples illustrate another interesting aspect of informal learning: learning from peers during interaction with animals. When a child exclaimed about the discovery of a roly-poly, the child already knew the name of the creature and was teaching his peers about the animal. In another example in which the children were peering into a container full of creatures they had caught from the stream, one of the children pointed out that the frog had legs. The child pointed out an interesting, morphological feature of the tadpole—that it had legs—thereby teaching other children (albeit indirectly) an important feature of metamorphosis.

Further, as illustrated in these different examples, firsthand experiences with animals allowed children to witness various characteristics about animals, such as where they live (e.g., in a pond, in a stream, in the ground) and other animals that share their habitat (e.g., other terrestrial or aquatic animals). Experiences with animals did not take place independently of other garden activities, but rather occurred in the context of other informal activities, such as garden walks and hands-on activities with nature.

Books and games. Reading books and playing games provided opportunities to learn about ecology while at the garden, albeit not through direct experience with nature (as was the case with gardening activities, garden walks, hands-on experiences with nature, and experiences with animals). Books and games were more indirect opportunities for children to learn about ecology, as they did not require any engagement with nature.

Not all teachers utilized books and games during their class sessions. Only one teacher who I observed used books and games, and she did so consistently in her classroom. In fact, the books and games were carefully selected so that they related to the day’s theme. The excerpt below shows how the teacher used the book to talk about that day’s theme, seeds.

> The children sat around the table and listened intently as the teacher read from the book. After she finished, she told the children. “You see, plants can't move. They aren't like you and me in that they can just get up and walk to

> where they want to go. Instead, they have to move in other ways, through their seeds. Plants can move their seeds in different ways. What's one way the book talked about how seeds can move?" One of the children raised his hand and said, "A strong wind!" "That's right—a strong wind can move the seed. What is another way?" The children were mostly silent. "Have you ever had a seed stick to you before?" the teacher asked. All of the children shook their heads and said, "No." "Never? You've never had a little seed stick to your pants when you were walking through a place? Like grass seed?" One of the girls said that she had seeds stuck to her one time. "And it won't come off!" the girl said. "Well, those kinds of seeds are called 'hitchiker seeds'. They stick to you when you are walking by and eventually, they will fall off somewhere and a new plant will grow. That's how seeds move, by moving their seeds," the teacher continued. "What is another way that seeds can move?" The children remained silent. "What happens if a bird ate, oh, I don't know, blueberries and flew off. What is that bird going to do?...What do *we* do after we eat?" When she didn't get a response, the teacher continued. "We digest our food and *poop* it out! If a bird eats a seed and goes somewhere else, the bird is going to poop out the seed and now it can grow."

In this example, the teacher used the book as a segue into a lesson about how seeds travel. After reading the book, she pointed out an ecological relationship between a bird and a seed ("If a bird eats a seed and goes somewhere else, the bird is going to poop out the seed and now it can grow."). Although the children did not witness the bird eating the seed firsthand, they were able to learn about this relationship through a book.

Books were often used as a segue into other activities related to the day's theme. Subsequent activities following book reading typically involved direct, hands-on engagement with nature. For example, after the teacher read the book on seeds, she took the children for a "seed hunt" to pick seeds in the garden. Hence, the book was a platform for hands-on gardening activities.

Children often played *games*, as well, some of which were directly related to the topic of ecology. One game that focused on ecological relationships involved a game of tag in which the children played out predator-prey relationships. As described in my field notes,

> The activity was a game of tag with the theme of the “food web.” The teacher had print outs of animal stickers that she held up. She asked the children whether they knew any predators. Some of the children shouted out responses. “Hawk!” “Snake!” She then asked about prey, and some of the children responded. She explained that they would be playing a game in which they would each be a certain animal or plant. She held up the stickers and asked each of the children which they wanted to be as she held up each sticker. “Who wants to be a fish?” A boy raised his hand, and she handed him the fish sticker. “Who wants to be a mouse?” A girl raised her hand, and she was the mouse. The animals included a couple of snakes, fish, a squirrel, berries, mushroom, a bird of prey, raccoon and a few others. After each of the children had a sticker, the teacher asked the class, “Raise your hand if you're a predator.” Several of the children who were predators raised their hands. “Alright, raise your hand if you're prey,” she asked. Some of the children raised their hands, including some of the children who had already raised their hand, such a boy who had a snake sticker. “That's exactly right,” the teacher confirmed. “You are both predator and prey,” she told the boy. “Now I want you to raise your hand if you are an animal,” The teacher asked. The children raised their hands. “Raise your hand if you're a plant or mushroom,” she asked. Some of the children raised their hands. We began the game. “So, what I want you to do when we begin, is to go and tag the person who has a sticker of something that you *eat.* When you tag that person, you say, 'I eat you!' And that person has to stand still. What you *don't* do is actually eat the person, okay? Alright, let's go!” The children went around the garden tagging one another and yelling, “I eat you!”

This game was a great illustration of how children can learn about ecology by playing games. During this game, the children played out predator-prey relationships, thereby having to distinguish predator from prey and grasping food-chain relationships. Like reading a book, playing a game does not allow children to experience plants and animals directly; however, both reading a book and playing a game were used as ways to facilitate children’s understanding of the relationship between plants and animals at the garden.

In sum, informal opportunities for children to learn about ecology at the garden were prevalent. There was often overlap between the types of opportunities, as illustrated in the combined use of gardening activities, hands-on activities with nature, and interaction with animals. This is not unlike learning at the community garden in general, which integrated different approaches, including informal and formal learning approaches to learning. In the next section, I further consider how the community garden offered formal learning opportunities for children to learn about ecology.

Formal learning opportunities. Formal opportunities to learn about ecology emerged through planned activities, guided learning, and garden rules. Similar to the informal learning opportunities described above, these opportunities occurred during children's classes at the garden.

Planned activities. One of the most formal aspects of learning at the garden was that most activities during children's classes at the garden were planned in advance. Many of the activities described thus far were planned activities: garden walks, hands-on activities with nature (e.g., seining for stream life), and gardening activities. They were planned to the extent that teachers often had these activities in mind at the beginning of each class. Degree of preparation varied across teachers, but one teacher came prepared to each class with a set lesson for the day. Because I served as the class assistant, she often shared with me the day's activities before children arrived to the garden. Thus, even if it appeared on the surface that the activities were spontaneous, the activities were often deliberate and well planned in advance. As the teacher explained to me before the class began,

> "I want to start off reading a book, and then have them paint pots. After they paint their pots, we're going to sift compost and bring it over here so we can put it in our pots. Then, we're going to have a snack and for those who finish their snack early, they can work on their snakes. And then, we're going to come back outside and put the compost in our pots and plant a seed inside and then write in their journals."

Even the specific details of a single activity were well planned in advance, as illustrated by an activity where children walked around the garden to find things that were the color of the rainbow. The teacher told me before the class began, “I'm going to give them baskets and ask that they pick things that are the colors of the rainbow. I'll point out the eggplant that's growing there.” Therefore, the teacher left little room in her daily activities for children to learn about ecology through less structured, more spontaneous approaches. Instead, she preferred deliberate learning, as evidenced by her planned activities.

Guided instruction. Opportunities to learn about ecology during classes at the community garden often occurred through guided instruction. Through guided instruction, adults helped children learn through guided instruction. To help insure that children noticed ecological relationships, teachers guided children’s experiences, most often during garden walks where teachers talked to children about the things around them in the garden. My field notes revealed many instances of guided instruction, including pointing out different plants (e.g., herbs in the herb garden), animals (e.g., bees in the beehives), and other natural features of the garden (e.g., falling leaves). Guided instruction was one of the most common types of learning opportunities I witnessed at the garden, namely because teachers utilized this approach to teach children about the plants and animals in the garden. As with several of the other approaches, guided instruction often took place in conjunction with other learning opportunities.

One teacher often guided children’s learning at the garden during activities. She did this during several activities at the garden, such as when children were writing in their journals at the end of class.

> When the children had finished collecting leaves to press, the teacher passed out the children's books so that they could draw inside. After some sorting out of which book was whose, the teacher spread crayons out onto the table. One of the girls asked me several times what they were supposed to be drawing, and when I didn't respond, she asked the teacher. “I want you to draw a

> picture of a black eye pea, and a flower with a flower, stems, leaves, and roots," the teacher instructed. One of the boys started crying when he said that he couldn't draw a flower. "I'll help you," The teacher replied. One of the children had gotten a leaf and the teacher showed him how to make a leaf outline.

This example demonstrates how guided instruction occurred during structured activities that did not involve direct interaction with plants and animals. In this case, as was the case with games and books, these activities still yielded opportunities for children to learn about aspects of ecology. Here, aspects included the parts of a plant, which are a small unit in the broader scope of ecology.

Garden rules. Rules were an essential aspect of learning at the garden. Therefore, teachers typically explained some basic rules to children before they went out into the garden.

> "Before we go out, let's go over some garden rules," the teacher said. "For those of you who have been to the garden before, can you tell me what the garden rules are?" One of the children raised his hand and said, "Be respectful of people's gardens," he replied. "That's right. And what about other people?" the teacher asked. "Be nice to them," the boy replied. "That's right."

Here, rules of the garden focused on caring for the garden property and other people at the garden.

Rules were sometimes provided after children were engaged in gardening activities. One rule that was referred to often involved the things that children could not touch. For example, during one of the classes, when the children were walking around the garden, they were reminded of the boundaries of where they could and could not walk. As my field notes from that day explained,

> One of the young children pulled at a stick that was a part of the fence that marked the edge of the path. "No, that stick is part of something. Don't pick

> up that one," the teacher instructed. When we were inside the woods at the garden, another boy stepped beyond the boundaries of the path. The teacher asked him to come out. Then yet another boy stepped outside of the path, and the teacher asked him to step out, as well.

The teacher asked the children to stay within the boundaries and to not disturb the boundaries (i.e., sticks) to remain in keeping with one of the main rules at the garden: do not deviate from the clearly marked paths in the garden. In this example, the boundary marked an area where native trees, shrubs, and flowers were growing. Children, like all visitors, were expected to not disrupt the native plants by staying on the path. This rule was similar to the rule that visitors, including children, do not touch or pick from member garden beds. Once, a child visitor, who was part of a summer camp program at the garden, walked up to the children with whom I was gardening and told them that they were not supposed to touch other people's garden beds. I had to explain to the child that we had permission to work in this garden bed because it was part of the class. Sometimes other children, who had likely learned the rules from adults, enforced the garden rules.

Other times, the purpose of garden rules was to keep the children orderly. Consider another example mentioned in my field notes,

> "Winter! Winter! I love winter!" some of the children began to chant. To get them to quiet down, the teacher said, "If you can hear me, clap once." The children clapped once. "If you can hear me, clap twice." The children clapped twice. "If you can hear me, be quiet." The children looked at her a little bemused. Then one of the girls started talking. "Can you not hear me?" the teacher asked the girl. The girl, who appeared to be a little embarrassed, became quiet.

In this example, rules were provided so that children behaved in an orderly manner. They were not provided for children's safety or to implement garden boundaries. It is worth noting that all teachers did not enact such rules. Rather, teaching style often influenced whether rules were used at the garden. The teacher mentioned in the two examples above used rules often during her classes. It is worth noting that she was also the teacher who used more structured activities (e.g., journal writing) and outlined the day's activities at the beginning of each class period. She was also more likely to read books during the class and ask the children to sit down and be quiet as she read, which is another example of a garden rule. If children had questions about the book as she read, she would ask them to hold their questions until the end so that she could continue reading.

Overall, there were a number of formal opportunities for children to learn about ecology at the community garden. Formal opportunities, however, overlapped largely with informal opportunities at the garden. For example, guided instruction (a more formal aspect) occurred frequently during garden walks (a more informal aspect). In the next section, I explain in more detail the ways in which the community garden is a place for informal and formal science learning.

Community Garden Provides Informal and Formal Science Learning Opportunities

Science learning occurs on a continuum, stretching between formal and informal types of learning (modified from Hofstein & Rosenfeld 1996:89 in turn modified from Wellington 1991:365 and based on Rommey & Gassert 1994). The community garden transversed this continuum, offering both semi-formal (e.g., semi-structured classes) and highly informal learning experiences (e.g., free exploration of the garden). There were several examples of how the community garden included both aspects, while maintaining a balance between formal and informal learning. As illustrated above, during children's classes at the garden, a teacher might incorporate formal and informal aspects of learning, such as garden walks and interaction with animals, combined with a structured plan for the garden activities, as laid out at the beginning of a class.

Field trips to the community garden also included formal and informal learning opportunities, as students were able to explore the garden on their own but were at times structured by a learning rubric. For example, during one field trip I witnessed, a garden staff member walk with the preschool aged children around the garden, guiding them to fill in a worksheet on clipboards that were provided by the school. I asked someone with the group what was on the clipboards, and she told me that there were formal objectives outlined for the young children to accomplish. Two of the objectives were for the children to find circles and worms at the garden.

As mentioned in my field notes, the children did not appear to be highly engaged with the learning objectives outlined in the rubric; rather, they appeared to be more interested in free exploration of the garden.

> As the teacher pulled a piece of herb off and handed it to one of the children, she asked the children, "Can anyone find the one that goes in pizza?" She appeared to be asking questions off the piece of paper on the clipboard. The children did not appear to be engaged with her. Instead, many of them were walking around and talking with one another and touching things.

The activities at the garden that day were clearly structured by learning worksheets. Those plans were supplanted, though, by curiosity and self-initiated exploration at the garden, as evidenced in the example above. This point was further echoed in a conversation I had with a woman who was serving as a chaperone during the field trip. When I mentioned that the children appeared to be enjoying their free exploration of the garden more so than following the script, she expressed that free exploration was "the best way for them to learn", citing that they were only three and four. She continued, expressing they were not interested in following an objective sheet. From what I could see, it appeared that the children were indeed interested in doing things other than what was on the worksheets, as evidenced by a small group of children who were jumping up and down underneath a cluster of trees while I spoke with the woman.

Although some children were not interested in meeting the objectives outlined on the rubric, some schoolteachers during the field trip successfully engaged the children in activities outlined on the rubric.

> One of the learning objectives for the field trip was to learn about worms. Instead of having a forced activity of learning about the worms, several children engaged in gardening activities to see worms in action. Near the compost, there were about 5 or 6 children kneeling around a piece of plastic stretched out on the ground with compost on top. They had trowels and were digging in. “Ooh, look, a worm!” one of them exclaimed. There were other children near the compost bins, but I could not overhear what they were talking about or tell what they were doing. They appeared to be one of the more intact groups and the children in that section appeared to be more engaged than the children that were wandering around the rest of the garden.

This excerpt from my field notes represented the way children became engaged in learning at the garden through relatively informal, hands-on participation while still meeting formal objectives. It is also another example of how children's own curiosity directed the type of learning that took place. Their curiosity and excitement caused them to remain engaged in the activity, far more than the other children who were part of the group and were supposed to be filling in worksheets. Overall, the community garden offered both approaches to children visitors.

Community garden as a contested space between formal and informal science learning. Over the course of the year I visited the garden, I witnessed its focus shift from a largely informal to more of a formal learning setting. As part of this shift, the garden offered more classes to the public and began changing the landscape of the garden so it had a more structured, “clean” layout. Members of the garden staff were responsible for shaping the garden’s layout and were at least in part responsible for creating the purpose of the community garden. I noticed the focus of the garden shifted slowly from informal opportunities to offering more formal opportunities as new staff arrived, who brought new influence onto the garden space and purpose.

The transformation came to light during a conversation I had with a staff member about the educational opportunities the garden offered. During our conversation, he emphasized the garden was both a formal and informal place for children to learn. Drawing upon his own informal learning experiences, he explained, “I grew up on an old farm in Mississippi. My whole life was informal learning. I have kids now, and I want them to have an experience similar to what I had, even though they live in an urban area.”

Despite his desire to maintain the informal aspects, the staff member aimed to provide more structure to the garden. “I want people to still have a learning experience, but there needs to be some structure,” he said, arguing that too much unkempt area hindered learning. “I don't want this to be a botanical garden. Not to knock botanical gardens, but I don't want people to feel like they can't touch anything here.”

Yet, not everyone felt this way. One teacher openly expressed her view that the garden was becoming too ordered and there was not enough area for children to freely learn and play. One day, I had a conversation about her opinion on how the garden was changing from more of an informal to more of a formal learning space.

> “Where I used to be able to go around the garden and pick things with the kids, I can't do that anymore. There is *nothing* around the garden. Just nothing. And they told me that I only could use the little herb bed. I can only

> do so much with herbs. That's not my teaching style, either. You have these kids walking around with clipboards, taking inventory of the plants. And the garden is fine for them. They can just look and make notes. But with me, I like for the children to be able to explore."

The disagreement of the garden's structure raised an interesting point—should the community garden be a place where children can freely engage in natural, non-manicured spaces; or should it be a space where children engage in more formal activities, such as planned activities, guided instruction, and rules? On the day of our conversation, the garden did look particularly polished. Whereas before, the garden was typically a lush area with plants growing rather uninhibited, the garden was much more manicured: the grass had been mowed between all of the member beds, and the beds still had large, green, lush plants growing, but nothing appeared out of place.

Although the head gardener wanted people to learn during their visits to the garden, his main role at the garden was to be a *gardener.* Therefore, his goal was to make the garden a visually appealing place, not to guarantee learning experiences for visitors (for example, during one visit, I helped the head gardener pull weeds and water plants to prepare for a wedding that would be held at the garden the next day). On the contrary, the teacher's main role at the garden was to *educate.* Therefore, the two staff members' roles at the garden appeared to be in conflict; and because one of the main objectives of the garden was to make a profit to sustain itself, the profit-making goals of education (i.e., garden classes) and beautification (e.g., for weddings) often came into conflict.

Overall, the community garden is not a static setting that is focused on strictly formal or informal science learning. It is instead a space that is subject to the attitudes and beliefs of teachers and garden staff, who shape learning opportunities for children at the garden. These differing attitudes and beliefs construct the garden layout—clean and manicured like a botanical garden or rough and unkempt like a natural space untouched by humans—as well as the type of learning opportunities—informal or formal—available to its visitors.

Discussion

One purpose of the present paper was to demonstrate that community gardens can provide children living in urban contexts the opportunity to learn about ecological relationships through their involvement in community garden activities. The activities I witnessed during my ethnographic observations at the garden were placed into two main categories: informal and formal learning opportunities. Thus, the second purpose of the paper was to illustrate that children can learn about ecological relationships through informal and formal learning opportunities at the garden. I found community garden teachers and staff shaped the layout and learning opportunities for children at the garden; and over the course of the study, I witnessed the garden shift from a largely informal space to learn about living things to a more formal, structured space.

About the Community Garden

There are several things that are worth mentioning about the community garden in this study. First, through my observations of the garden it became apparent that not all types of garden activities were ecologically rich. Rather, some types of interaction with the garden were relatively isolated from the living things at the garden. For example, during my observations I noticed that parents in the neighborhood surrounding the community garden often brought their young children to the garden to play in the "play area" of the garden, which included a sandbox with toys such as shovels, buckets, and dump trucks, and a slide. It is unclear whether playing in a sandbox, which was behind a picket fence, provided children with much opportunity to learn about the relationships between living things. Rather, these types of garden play may have been more beneficial to enriching children's social skills, as they played with other young children in the play area, and allowed children to be active outside.

Similarly, it was unclear whether some activities (e.g., books and games) were always “opportunities for children to learn about ecology.” Nonetheless, I found it important to highlight books and games because (1) these activities often involved ecology-focused lessons and (2) because it was impossible for me to determine whether or not children actually learned about ecology, and therefore I could not negate these activities as ways children might learn about ecology.

Community gardens are highly varied, so the community garden highlighted in the present study is not necessarily representative of other community gardens. Thus, learning at other community gardens may favor one approach more heavily, such as gardens that focus more on maintaining garden plots and do not offer classes to children. In these types of gardens, informal learning approaches, such as hands-on participation, may be more common than learning opportunities that typically appear in a class format (e.g., games and books).

Further, one thing I noticed during garden activities was the lack of explicit explanation describing the relationships between things at the garden. It seemed at times that opportunities for children to learn about the relationship between things were lost when adults did not make the connection. For example, when the children saw worms, they would become excited; however, the teacher did not explain the purpose of the worms in the garden habitat—worms provide much needed oxygen to roots and leave behind excrements that help the plants grow. Nonetheless, while participating in gardening activities, children were able to see animals in the soil, such as worms, ants, and roly-polies, which may still have been a good way for children to appreciate the living entities that make up the microcosm without the direct instruction from teachers.

In addition to learning restrictions, there may have been restrictions that limited some children's ability to visit the community garden. The children in the present study were from a predominantly White, middle-class background, had parents who paid for them to participate in the community garden classes, and had transportation to and from the garden. This is clearly not the situation for all children. Community gardens (including the one in the present study) are not proximal to all children, and unless a garden is located near children's homes, they may not be able to visit because they lack transportation. Even if children do have the means of transportation, another possibility is that the children's parents do not have the time to take them to the garden. This is why it is particularly important for schools or other organizations to provide free field trips to community gardens or to even build a garden on the premises of schools and other community organizations (e.g., Boys and Girls Club). By making visits to gardens compulsory, children would no longer be limited by non-school factors that may hinder their garden visits.

Implications

Children living in urban settings have relatively limited opportunities to experience plants and animals other than urban flora (e.g., lawns) and fauna (e.g., squirrels). Community gardens can serve as a space where children in these settings can experience a broader range of living things, including a variety of plants, such as lettuce, herbs, fruit trees, and vegetable plants, and animals, such as chickens, salamanders, and fish. Granted, community gardens are not necessarily the only place where urban children can experience plants and animals. Children can see animals at zoos, plants at botanical gardens, and watch wildlife television shows and movies. These experiences differ from experiences with community gardens, which allow children to gain firsthand experiences and allow children to interact with plants and animals, which are not characteristic of botanical gardens, zoos, and television shows and movies. Children engaged with plants and animals through a broad range of activities, such as gardening, hands-on experience with nature, garden walks, and interaction with animals. These findings have potential implications on how children reason about living things. Previous research shows that informal interactions with plants and animals are related to children's ability to think *ecologically* about living things (Coley, 2012). In light of this, community gardens may serve as a place where children living in urban settings may learn to reason ecologically about living things.

If community gardens can help children better understand ecology, then educators who are responsible for teaching their students about ecology can use community gardens as a teaching tool in their science classrooms. They may take their children to community gardens on field trips (much like the field trip outlined in the present study) so that children can gain firsthand experience with plants and animals at the garden. It is not clear, though, how much experience children must have in order to reason ecologically, so it is difficult to prescribe an amount of time children should spend in a community garden. What is clear, though, is that through community garden activities, children can learn about plants and animals and how they are part of a larger ecosystem. Children may then draw upon their experiences at the garden when learning about ecological relationships in the future.

Limitations and Future Directions

The present study had several important implications. There were several limitations, as well, which may guide future research about community gardens. One main limitation of the present study was that it was difficult to tell whether children were *learning* (i.e., gaining and retaining conceptual knowledge) about ecology during their activities at the garden. I could not tell because I did not assess learning. This limitation is relatively easy to account for: the focus of the present study was not on whether children learned about ecology, but rather to highlight *opportunities* for children to learn about ecology at the community garden. Future researchers interested in whether children learn about ecology at a community garden may assess ecological learning through an experimental, pre- and post-test design study. If researchers do this, they may assess two groups of children—an experimental group that is participating in a community garden and a control group that is not—and measure their conceptual understanding of ecology. To measure ecological understanding, researchers may ask children to draw food webs of living things at the garden or provide children with pictures of living things at the garden (e.g., chickens, worms, lettuce) and ask that they arrange the cards and justify their arrangement (e.g., Unsworth, 2012).

Another potential limitation involved the method of data collection. I was a participant observer at the garden and mostly carried out my observations during children's classes at the garden. Therefore, I was not able to highlight all types of interaction children had with the garden because I either did not witness them during my visits to the garden or did not observe them in sufficient amount to write a detailed account in my field notes. Other ways children interacted with the garden that I did not observe carefully nor record in great detail in my field notes were home-school visits, birthday parties at the garden, and very young children who visited the garden with their parents and played mostly in the "play area" of the garden (which had a sandbox, slide, and some toys).

Moreover, I would have liked to conduct more interviews with staff, parents, and even children to get additional ideas about opportunities to learn about ecology at the community garden. Future research should be more inclusive of garden participants' attitudes and beliefs (perhaps by adding interviews) if we are to better understand the opportunities for children to learn about ecology at the community garden. Interviews with garden staff may have clarified the purposes of their choice of activities. Were teachers deliberately teaching about ecological relationships? Or did examples of ecological relationships emerge spontaneously out of their instruction? By more clearly understanding the intention of garden staff, we may better understand the focus of the lessons. Similarly, interviews with parents may have shed light on whether their guided instruction deliberately highlighted ecological relationships between living things or whether aspects of highlighting ecology at the garden was an emergent, spontaneous feature of their conversations.

Additionally, due to my ethnographic, observational approach of data collection, there were several instances that I had a difficult time remembering particular instances I witnessed when I sat down to write my field notes. This was particularly apparent during my observations of large groups of children (e.g., during school field trips), in which the sheer number of children who were at the garden and the number of activities at the garden made it difficult to single out instances of learning. With children coming and going, adults calling children, children calling out to others, and children walking in areas that they were not supposed to, I found it almost impossible to single out specific events. Instead during these times, I focused on the gestalt of the activity at the garden, only pointing out specific events occasionally.

Also, children were not the only people who had opportunities to learn about ecology at the garden. Rather, adults were also provided with a number of opportunities to learn about ecological relationships between living things while at the garden. These opportunities were participation in adult garden classes, volunteer opportunities, and while accompanying children at children's garden classes. In future work, I would like to focus on opportunities for adults to learn about ecology while at a community garden.

Conclusions

Overall, a community garden can be a place where children learn more about living things through their experiences with plants and animals. These opportunities to learn about living things are especially important in areas of the world where natural habitats are vanishing in lieu of neighborhood or commercial development. Areas where children of past generations may have spent afternoons climbing trees, today are sprinkled with only decorative trees lining streets. This is worrisome considering the further removed children are from the natural world, the less they may understand its complexities, including its harbored ecosystems. Community gardens are spaces in urban contexts that allow children to obtain this much-needed exposure to nature. Community gardens appear to be part of a growing interest in restoring the connection between people (particularly children) and the natural world. It is important that educators, policy makers, community leaders, and parents understand their role in this environmental movement. Specifically, they should understand the flexibility of community gardens to span informal and formal science learning, as well as places for children to learn about ecology.

References

American Community Garden Association. (2010, August). *About ACGA*. Retrieved from http://www.communitygarden.org/

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. *Science Education, 88*(1), 17-33.

Atran, S., Medin, D. L., & Ross, N. O. (2002). Thinking about biology: Modular constraints on categorization and reasoning in the everyday life of Americans, Maya, and scientists. *Mind and Society: Cognitive Studies in Economics and Social Sciences, 3*(2), 31-63.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *The Journal of Environmental Education, 40*(2), 15-38.

Carey, S. A. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Coley, J. D. (2012). Where the wild things are: Informal experience and ecological reasoning. *Child Development, 83*(3), 992-1006.

Coley, J. D., Medin, D. L., & James, L. (1999, April). *Folk biological induction among Native American Children*. Paper presented at the Biennial Meeting of the Society of Research in Child Development, Albuquerque, NM.

Corkery, L. (2004). Community gardens as a platform for education for sustainability. *Effective Sustainability Education: What Works? Why? Where Next? Linking Research and Practice*, 18-20 February, 2004. Sydney Australia.

Crowley, K., Callanan, M. A., Jipson, J. L., Galco, J., Topping, K., & Shrager, J. (2000). Shared scientific thinking in everyday parent-child activity. *Science Education, 85*(6), 712-732.

Draper, C., & Freedman, D. (2010). Review and analysis of the benefits, purposes, and motivations associated with community gardening in the United States. *Journal of Community Practice, 18*, 458-492.

Falk, J. H. (2001). Free-choice science learning framing the discussion. In J.H. Falk, E. Donovan, & R. Woods (Eds.), Free-Choice Science Education. How We Learn Science Outside of School. New York, NY: Teachers College Press.

Frazier, B. N., Gelman, S. A., & Wellman, H. M. (2009). Preschoolers' search for explanatory information within adult-child conversation. *Child Development, 80*(6), 1592-1611.

Fusco, D. (2001). Creating relevant science through urban planning and gardening. *Journal of Research in Science Teaching, 38*(8), 860-877.

Gelman, S. A., Chesnick, R., & Waxman, S. R. (2005). Mother-child conversations about pictures and objects: Referring to categories and individuals. *Child Development, 76*(6), 1129-1143.

Gold, R. (1958). Roles in sociological field observation. *Social Forces, 36,* 217-223.

Hatano, G., Siegler, R., Richards, D., Inagaki, K., Stavy, R., & Wax, N. (1993). The development of biological knowledge: A multinational study. *Cognitive Development, 8*, 47–62.

Herrmann, P., Waxman, S. R., & Medin, D. L. (2010). Anthropocentrism is not the first step in children's reasoning about the natural world. Proceedings of the National Academy of Sciences 107(22), 9979-9984.

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education, 28,* 87-112.

Holland, L. (2004). Diversity and connections in community gardens: A contribution to local sustainability. *Local Environment*, *9*(3), 285-305.

Husserl, E. (1931). *Ideas: General introduction to pure phenomenology.* London: George Allen & Unwin.

Hycner, R. H. (1985). Some guidelines for the phenomenological analysis of interview data. Human Studies, 8, 279-303.

Inagaki, K. (1990). The effects of raising animals on children's biological knowledge. *British Journal of Developmental Psychology, 8*(2), 119-129.

Inagaki, K., & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development, 67,* 2823-2840.

Karsten, L. (2005). It all used to be better? Different generations on continuity and change in urban children's daily use of space. *Children's Geographies*, *3*(3), 275-290.

Krasny, M. E., & Tidball, K. G. (2009b). Community gardens as contexts for science, stewardship, and civic action learning. *Cities and the Environment, 2*(1).

Medin, D. L., & Atran, S. (2004). The native mind: Biological categorization and reasoning in development across cultures. *Psychological Review, 111*(4), 960-983.

National Research Council (2009). *Learning Science in Informal Environments: People, Places, and Pursuits.* Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, Eds. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Population Reference Bureau. (2012). Human Population: Urbanization. Retrieved from http://www.prb.org/DataFinder/Geography/Data.aspx?loc=241

Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program.

Journal of Research in Science Teaching, 39(2), 164-184.Ross, N. O., Medin, D. L., Coley, J. D., & Atran, S. (2003). Cultural and experiential differences in the development of folkbiological induction. *Cognitive Development, 18,* 25-47.

Unsworth, S. J., Levin, W., Bang, M., Washinawatok, K., Waxman, S. R., & Medin, D. L. (2012). Cultural differences in children's ecological reasoning and psychological closeness to nature: Evidence from Menominee and European American children. *Journal of Cognition and Culture, 12,* 17-29.

Waxman, S. R., & Medin, D. L. (2007). Experience and cultural models matter: Placing firm limits on childhood anthropocentrism. *Human Development, 50,* 23-30.

Wellington, J. (1991). Newspaper science, school science: Friends or enemies? *International Journal of Science Education, 13*(4), 363-372.

CHAPTER 2

ECOLOGY-CENTERED EXPERIENCES AMONG ADOLESCENTS: A QUANTITATIVE ANALYSIS

In recent years, environmentally responsible attitudes and behaviors have received growing attention (e.g., Alp, Ertepiner, Tekkaya, and Yilmaz, 2006; 2008; Deng, Walker, & Swinnerton, 2006; Evans, Brauchle, Haq, Stecker, Wong, & Shapiro, 2007; Kaiser, Oerke, & Bogner, 2007; Leeming, Bracken, & Dwyer, 1995; Milfont & Duckitt, 2004; 2010; Milfont, Duckitt, & Wagner, 2010; Morrone, Mancl, & Carr, 2001; Mussler & Malkus, 1994; Schultz & Zelezny, 1999; Walsh-Daneshmandi, & MacLachlan, 2006). One particular area of interest, and an area of focus in the present research, is the relationship between knowledge of *ecology* (i.e., how living things relate in their shared environment) and environmental attitudes and behaviors (Brugger, Kaiser, & Roczen, 2011; Eisler, Eisler, and Yoshida, 2003; Kaiser & Wilson, 2004; Maloney & Ward, 1973; Maloney, Ward, & Braucht, 1975). In line with these areas, the present research addresses the role of individuals' *ecological thought* in their environmental attitudes and behaviors.

The role of ecological thought in environmental attitudes and behaviors has not been clear. Part of the ambiguity is due to the operational definitions provided for *ecology* in environmental attitudes and behavior research. Specifically, previous research often has conflated ecological thought and environmentally responsible attitudes and behaviors, treating each as having the same underlying definition: understanding of and action toward sustaining a healthy environment on Earth (e.g., Brugger, Kaiser, & Roczen, 2011; Kaiser & Wilson, 2004; Maloney & Ward, 1973; Maloney, Ward, & Braucht, 1975). For example, the Measure of Ecological Attitudes and Knowledge Scale (MEAK; Maloney and Ward, 1973;

Maloney, Ward, & Braucht, 1975) measures knowledge regarding ecology, the environment, and pollution. Yet, not a single question in the MEAK directly targets ecology in terms of the relationships between living things (e.g., "I have switched products for ecological reasons." "I subscribe to ecological publications."). In another study, Brugger, Kaiser, and Roczen (2011) measured ecological behavior by asking environmentally responsible questions, such as, "I buy meat and produce with eco-labels." Last, using the General Ecological Behavior scale (GEB), Kaiser (1998) measured conservation behaviors with questions such as "I wash dirty clothes without prewashing."

The conflated definition of these two terms has limited our understanding about the relationship between ecological thought about *living things* and environmentally responsible attitudes and behaviors. In order to better understand the relationship between children's ecological thought and environmentally responsible attitudes and behaviors, the present research draws upon a definition of ecological thought that commonly is used in cognitive developmental psychology: ecological relations are the relationships that exist between living things as they exist in the environment, such as within a shared habitat, niche, or through interaction with other species (Coley, Freeman, & Blaszczyk, 2003).

The present research directly tests the latent, largely unexamined assumption that ecological thought and environmentally responsible attitudes and behaviors overlap. If so, then people who reason ecologically (as defined here) should also demonstrate environmentally responsible attitudes and behaviors. Common sense might suggest that this is indeed the case—part of understanding environmental issues is understanding the ecological relationship between living things (e.g., planting a tree can reduce the amount of carbon dioxide in the air, which improves the health of humans and other animals). Yet, as noted, this possibility has not been examined empirically.

In addition to examining the role of ecological thought in environmental attitudes and behaviors, the present research considers the impact of two contextual factors on environmental attitudes and behaviors: environmental responsibility support and ecology-centered experiences (Table 2). *Environmental responsibility support* is the contextual support offered to people to engage in environmentally responsible practices, such as recycling, energy and resource conservation, and other sustainable living practices. It provides people with the contextual support to develop environmentally-sensitive attitudes through exposure to environmentally responsible value and belief systems. Those who provide support may not explicitly teach others about the behaviors, but rather are *modeling* the behavior for others (intentionally or unintentionally). Environmental responsibility support may also be influenced by logistics, such as whether a recycling facility is available nearby. *Ecology-centered experiences* involve experiences that allow people to learn about the relationships between living things. These experiences include informal interaction with plants and animals, offered through activities such as gardening and fishing. Previous research has considered how experiences with nature shape ecological thought (Coley, 2012), but no prior research has gone on to consider how these experiences influence environmentally responsible attitudes and behaviors.

Table 2

Ecology-centered Experiences and Environmental Responsibility Support.

Ecology-centered experiences	**Environmental responsibility support**
Camping	Talk with others about how to solve environmental problems
Catch bugs	Ask others to recycle
Feed wildlife	Turn off lights when not in use
Fishing	Turn off water when brushing teeth
Gardening	Written someone about pollution problem
Hunting	Put up a birdhouse near his/her house
Pick up pecans	Read stories about the environment
Raise animals	Ask how can reduce pollution
Ride horses	Separate things at home for recycling
Visit a farm	Leave refrigerator open when decide what to get out (negatively coded)
Walk in woods	Ask not to buy products that harm environment
	Does not let faucet run when not necessary

Specifically, the present research will examine whether these contextual factors—environmental responsibility support and ecology-centered experiences—predict environmental attitudes and behaviors among adolescents. Finally, in the present research I also examine whether two demographic characteristics—age and gender—influence environmental attitudes and behaviors among adolescents, a question that has been addressed in previous research (Alp, Ertepiner, Tekkaya, & Yilmaz, 2006; Eisler, Eisler, & Yoshida, 2003; Larson, Green, & Castleberry, 2009; Leeming, Bracken, & Dwyer, 1995).

Background

Ecological Thought

The way children think about the biological world can be roughly divided into two main categories: *taxonomical* thought and *ecological* thought. The first, taxonomical thought, involves the hierarchical ranking and ordering of living things (Berlin, Breedlove, &

Raven, 1973). Taxonomical thought is a cognitive universal—regardless of language and culture, people across the world think about the natural world according to hierarchical taxonomies (Atran, 1998), suggesting hierarchical, taxonomical thought is innate and deeply rooted in cognitive development.

Taxonomical thinking involves hierarchies of species of living things. These hierarchies have several levels, which include, in descending order, folk-kingdom (e.g., animal, plant), life-form (e.g., bug, fish, bird, mammal, tree, herb/grass, bush), generic-species (e.g., gnat, shark, robin, dog, oak, holly), folk-specific (e.g., poodle, white oak), and folk-varietal (e.g., toy poodle, swamp white oak). Taxonomical relationships are important for organizing knowledge (Coley, 1995; Coley et al., 2002; Keil, 1989). For instance, taxonomical organization of fish might include a gold fish, catfish, shark, and beta fish. Although all of these species live in different ecosystems, they are taxonomically similar at the life-form level—they are all *fish*,

Although taxonomical relations are privileged in biological thought (Coley, 1995; Coley et al., 2002; Keil, 1989), people do not limit their biological thought to strictly taxonomical relations. Rather, people may also rely on ecological thought to conceptually organize the natural world (Coley, 2012; Coley et al., 2003). Unlike taxonomical thought, ecological thought focuses on the *relationships* that exist between living things as they exist in the environment, such as within a shared habitat, niche, or through interaction with other species (Coley et al., 2003). To use the previous example of fish, ecological relationships might include shark, sea horse, seaweed, and dolphin. Although these organisms are different taxonomically (at the folk-kingdom and life-form level), they are ecologically similar—they all *live in the ocean.*

Unlike taxonomical thought, ecological thought requires more abstract thinking ability and is not a cognitive universal. This form of categorization may instead be more sensitive to nature-based practices (Coley, 2012). For example, children who live in rural settings represent a cohort of children who think about the natural world ecologically, presumably because of their extensive experience with living things (Coley et al., 2003).

One reason children with nature-based experiences think ecologically may be due to their having a broader range of possible ways to consider living things. For example, a child who has extensive fishing experience at a pond may understand a catfish in relation to its habitat, which may include frogs, egrets, and lily pads, in addition to more taxonomical relations, such as sharks and beta fish. Indeed, children who participate in informal, unsupervised exploration of nature are more likely to think about ecological relations than children who do not participate in such activities (Coley, 2012). As demonstrated in Chapter 1, this has been the case in community gardens, where children in urban settings can learn about ecology through their interaction with plants and animals. This is not to say that children abandon taxonomical in favor of ecological thought. Rather, children with experience with living things think ecologically *in addition to* taxonomically (Ross, Medin, Coley, & Atran, 2003). It appears, then, that taxonomical thought is the default way to think about biology, and only when people have experiences with the natural world do they begin to think ecologically.

It should be noted that the focus here is on ecological thought, not factual knowledge. Ecological thought, rather than factual knowledge, is measured in the current work in order to examine the patterns of thoughts among adolescents, not adolescents' knowledge base about ecology. Although some factual knowledge is necessary to engage ecological thought patterns (i.e., understand that the hawk [predator] can catch and eat a mouse [prey]), patterns of thought can be carried into novel situations to understand novel relationships between species. Patterns of thoughts were therefore a more fitting analysis for the present study.

Effect of Age and Gender on Environmental Attitudes and Behaviors

A number of factors are believed to shape children and adolescents' environmental attitudes and behaviors. Two main factors are age (Alp, Ertepiner, Tekkaya, & Yilmaz, 2006; Larson, Green, & Castleberry, 2009; Leeming, Bracken, & Dwyer, 1995) and gender (Alp, Ertepiner, Tekkaya, & Yilmaz, 2006; Eisler, Eisler, & Yoshida, 2003). Age, particularly among children and adolescents, appears to play a large factor in the development of environmental attitudes and behaviors. Larson, Green, and Castleberry (2009) found that feelings of connectedness with nature declined significantly with age among 6 to 13-year-olds, with 11- to 13-year-olds feeling less connected with nature than 8- to 10-year-olds. Other studies have found similar results, including Alp, Ertepiner, Tekkaya, and Yilmaz (2006), who found older Turkish students in grades 6-10 displayed lower environmental attitudes than their younger counterparts, and Leeming, Bracken, and Dwyer (1995), who found similar results across children in the United States in grades 1-7.

One reason for the developmental difference may be the different types of outdoor activities in which children versus adolescents are involved. Through interviews regarding involvement in outdoor activities, Larson, Green, and Castleberry (2009) found children younger than 10 reported more unsupervised, informal, independent experiences with nature (i.e., experiences *with* nature) than older children, who reported more examples of playing with friends outside (i.e., experiences *within* nature). Drawing upon Vadala, Bixler, and James (2007), Larson and colleagues claimed that interaction with nature is very different than interaction within nature. Interaction with nature involves more intimate physical and affective contact with natural surroundings (e.g., taking a walk through the woods while noticing the nearby flora and fauna) than interaction *within* nature, which places the natural environment in the background of other activities (e.g., playing a game of tag in the woods with friends). In sum, it appears that younger children are more likely to interact with nature than older children, which leads to differences in eco-affinity (i.e., the feelings of connection with nature) between younger and older children.

Gender also appears to play a key role in environmental attitudes and behaviors. Eisler, Eisler, and Yoshida (2003) found that adult females from United States, Germany, Switzerland, and Japan were more likely to stress the importance of environmental quality of human life, show more environmentally responsible attitudes, and consider environmental risk factors as more serious than their male counterparts. These findings were evident in all four countries, suggesting that gender is a strong factor that influences people's environmental attitudes and behaviors. In another study, Alp, Ertepiner, Tekkaya, and Yilmaz (2006) found that females in Turkey (in this case, 6^{th} through 10^{th} grade students) demonstrated a higher level of environmentally responsible intention, affect, and behaviors than males. Eisler et al. outlined several possible explanations for gender differences, including males demonstrating a higher threshold for environmental damage, which may be related to their higher risk-taking behaviors (Byrnes, Miller, & Schafer, 1999), and males holding a lower sense of appreciation for protecting the natural environment than females.

Present Study

In light of the prior research outlined above, the present study addressed the following three research questions.

Research Question 1. Do ecological thought and environmental attitudes and behaviors overlap? More specifically, does ecological thought predict environmental attitudes and behavior (EAB)?

Hypothesis 1. I expected that ecological thought and environmental attitudes and behaviors represent distinct constructs and therefore do not overlap. That is, ecological thought was not expected to predict EAB. I argue that adolescents who reason ecologically will *not* necessarily demonstrate environmentally responsible attitudes and behaviors.

Research Question 2. Do *ecology-centered experiences* and *environmental responsibility support* predict adolescents' EAB?

Hypothesis 2. Ecology-centered experiences and environmental responsibility support were expected to predict adolescents' EAB, with environmental responsibility support being the stronger predictor. That is, participants who have experiences with plants and animals (i.e., ecology-centered experiences) yet lack the contextual support to think and act in environmentally responsible ways (i.e., environmental responsibility support) will not display environmentally-responsible attitudes and behaviors.

Although seemingly similar at first glance, Hypothesis 2 is different than Hypothesis 1 in at least two major ways. First, Hypothesis 2 involves the relationship between ecology-centered experiences, *not* ecological thought (Hypothesis 1), and environmental attitudes and behaviors. Ecology-centered experiences (like environmental responsibility support) serve as an environmental factor. Ecological thought, on the other hand, is a *cognitive* factor. Second, Hypothesis 2 examines the relationship between environmental responsible support and environmental responsible attitudes and behaviors, a relationship that is ignored in Research Question 1.

Research Question 3. Do age and gender predict EAB?

Hypothesis 3. Consistent with previous research, age and gender will predict EAB.

Method

Participants

Fifty-two sixth grade (M = 11.8, SD = .61, 25 male and 27 female), 55 seventh grade (M = 12.8, SD = .81, 22 male and 33 female), and 43 eighth grade (M = 13.8, SD = .66, 25 male and 18 female) students participated in the present study. The majority of participants were White (n = 119, 79.3%), twelve (8%) were African American, eight (5.3%) were Hispanic, five (3.3%) were Native American, four (2.7%) were multiracial or other, and two participants (1.3%) were Asian/Pacific Islander. Participants were recruited from a middle school located in Georgia that serves a rural community with a population density of 30 people per square mile, far less than the state of Georgia's average population density of 168.4 (U.S. Census Bureau, 2010). Nineteen participants (12.7%) lived on 1-10 acres outside of the county seat, 30 (20%) lived on more than 10 acres outside of the county seat, 77 (51%) lived in the county seat, and 24 (16%) lived in the adjacent large town of 17,000. Of these participants, 19 (12.7%) reported that they lived on farms. In terms of familial backgrounds, the vast majority (91%) of participants were from a Christian background.

Rural participants were intentionally recruited because they were more likely to possess a higher level of ecology-centered experiences than their urban counterparts, and as a result I hypothesized, they would tend to reason ecologically about living things. Although the rural community provided a number of ecology-centered experiences, I anticipated that an equally high level of environmental responsibility support was not available to all participants. For example, participants whose parents were farmers may have learned the ecological importance of crop rotation when planting row-crops; yet, they may have lacked strong environmental responsibility support. Many farmers use pesticides, herbicides, and genetically modified organisms as part of their farming practices, rather than using more environmentally responsible methods, such as using saved seeds and growing food organically. However, I expected this was not the case for all participants. Instead, some participants may grow their own food and have parents who stress the importance of energy and resource conservation.

Adolescents were recruited for two reasons. First, adolescents were likely to possess more control over their EAB than were younger children. Although children as young as first grade can possess EAB (Evans, Brauchle, Haq, Stecker, Wong, & Shapiro, 2007), I argue younger children may not yet possess the individual agency required for autonomous EAB, which adolescents are more likely to possess. Second, adolescents have been ignored for the most part in research that examines children's ecological thought, so the current work will provide an important contribution toward understanding the developmental trajectory of ecological thought among this age group.

Measures

Ecological thought. To capture participants' ecological thought, I used a matched-pairs task typically used in folk biological research (Unsworth, Levin, Bang, Washinawatok, Waxman, & Medin, 2012). During the task, participants were presented with black-and-white images of eleven species pairs (Appendix A) and were asked, “How might a (blank) and (blank) be related?” Participants’ responses were coded according to three main categories: morphological (e.g., “They both fly.”), taxonomical (e.g., “They are both animals.”), and ecological responses (e.g., “The hawk eats the snake.”) (Bang, Medin, &

Atran, 2007). Each pair was orthogonal and could be appropriately answered with each of the 3 coding categories. For example, the Hummingbird-Bee species pair shared ecological ("They both eat nectar."), taxonomical ("They are both living things"), and morphological ("They both have wings") similarities.

Species consisted of a combination of plants and animals, with 2 plant-plant (e.g., oak tree-vine), 7 animal-animal (e.g., snake-hawk), and 2 plant-animal pairings (e.g., oak tree-deer). More animal-animal pairs were selected because these pairs introduced a higher number of *salient* orthogonal categories relative to plant-plant and plant-animal pairs. For instance, whereas the oak tree-flower pair may elicit taxonomic (e.g., both are plants) and morphologic responses (e.g., both are green), ecological relationships (e.g., a deer can eat from both) may not be as salient. All species were commonly found in Georgia.

Because responses were open-ended, participants could give more than one answer. The total number of responses for each category was tallied. Other response categories emerged during data analysis, namely "Nature as Harmful" responses, which were characterized by descriptions of the harmful aspects of nature (e.g., "They could both hurt you.") and "Environmental" responses (e.g., "The air they live in is polluted."). Although interesting, these patterns of thought were not the focus of the present study and therefore not included in data analysis.

Environmentally responsible attitudes and behaviors task. To measure adolescents' EAB, I implemented a sub-scale from the Children's Environmental Attitude and Knowledge Scale (CHEAKS; Maloney, Ward, & Braucht, 1975). The CHEAKS was designed to measure participants' attitudes and knowledge regarding environmental issues. The CHEAKS has been used among middle-school aged participants (Walsh-Daneshmandi

& MacLachlan, 2006), although it was developed for and has also been used among elementary-school aged participants (Leeming, Bracken, & Dwyer, 1995; Maloney, Ward, & Braucht, 1975). Studies examining the psychometric properties of the CHEAKS have deemed the scale reliable and valid across a range of populations, including Irish adolescents (Walsh-Daneshmandi & MacLachlan, 2006) and children in the United States (Leeming, Bracken, & Dwyer, 1995).

Thirty-two items of the CHEAKS Attitudes sub-scale was administered. The sub-scale involved a series of questions concerning adolescents' EAB. Each question was scored on a 5-point Likert Scale (1 = Very false; 5 = Very true). Scores for the Attitudes sub-scale were based upon the 5-point scale Likert responses and thus ranged from 36-180, with pro-environmental responses earning higher scores.

The Attitudes sub-scale contained three domain scales: *Verbal Commitment* (12 questions), *Actual Commitment* (12 questions), and *Affect Commitment* (12 questions). Scores for each domain scale range were based upon a calculation of the 5-point scale Likert responses and thus ranged from 12-60, with pro-environmental responses for each domain scale earning higher scores. Within each of the three domains (*Verbal Commitment*, *Actual Commitment*, and *Affect Commitment*), two items reflected six different sub-domain scales—*animals*, *energy*, *pollution*, *recycling*, *water*, and *general issues*. Scores for each of the six sub-domains ranged from 1-10, with higher sub-domain scores within each of the domains reflecting a stronger pro-environmental attitude or behavior within that domain.

Ecology-centered experiences questionnaire. All participants answered a battery of questions regarding their involvement in ecology-centered experiences (Table 2). I created these questions to measure participants' participation in nature-based activities, such as hunting, fishing, gardening, farming, and interaction with wildlife, all of which are considered to be important in learning about ecological relationships between plants and animals (Atran & Medin, 2008). There were a total of 11 questions, and each question was scored on a 5-point Likert Scale (1 = Never; 5 = Very Often). Final scores therefore ranged from 0-55, with higher scores indicating a higher level of ecology-centered experiences.

Environmental responsibility support questionnaire. The environmental responsibility support questionnaire was used to assess the environmentally responsible behaviors of influential others (i.e., family and community members). Again, questions were drawn from the CHEAKS but were reworded to capture others' (not the participants') participation in environmentally responsible behaviors (Table 2). The survey began with instructions to think about a person whom they care about (i.e., a friend, family member, teacher, or someone else they know) followed by 10 questions about this person's environmentally responsible behaviors. Only ten questions were selected because of time constraints. Each question was scored on a 5-point Likert Scale (1 = Very false; 5 = Very true). Scores therefore ranged from 0-50, with higher scores indicating a higher level of environmental responsibility support.

Demographic questionnaire. A background questionnaire was administered to all participants to establish background characteristics. The questionnaire inquired about demographic background (e.g., gender, age, religious affiliation, highest level of education) of participants and participants' parents and more specifically whether or not participants lived on a farm.

Procedure

All tasks were provided to participants via an online questionnaire designed through the survey software Qualtrics. The matched-pairs task and the CHEAKS were administered first and were counterbalanced across participants. In order to reduce the possibility of a carry-over effect, the ecology-centered experiences questionnaire and environmental responsibility support questionnaire were administered *after* the matched-pairs task and the CHEAKS. The ecology-centered experiences questionnaire and environmental responsibility questionnaire were also counterbalanced across participants. The demographic questionnaires were administered last for all participants. The study took less than 45 minutes to complete, and participants participated during their science class in the school computer lab. The researcher provided participants instructions at the beginning of the study session and remained available to answer questions from participants and teachers during the session.

Results

Before testing my research questions, I first examined whether participants' place of residence (Large town; Small town; 1-10 acres outside of town; More than 10 acres outside of town) was related to participants' (1) environmental attitudes and behaviors (EAB), (2) environmental responsibility support, (3) ecology-centered experiences, and (4) ecological thought. I did this to consider participants' place of residence as a possible covariate that might influence the relationship between EAB, environmental responsibility support, ecology-centered experiences, and ecological thought. Descriptive statistics are outlined in Table 3.

Table 3

Descriptive Statistics for Place of Residence

		EAB		ERS		ECE		ET	
Residence	N	M	SD	M	SD	M	SD	M	SD
Outside of town, 1-10 ac.	19	125.53	28.34	38.58	6.70	33.32	9.15	4.53	3.03
Outside of town, >10 ac.	30	118.00	17.29	36.97	7.50	36.97*	8.48	4.73	2.45
Small town	77	119.58	26.18	36.51	7.25	31.65*	9.14	4.40	2.51
Large town	24	126.50	20.38	37.92	7.82	30.46*	8.53	4.08	2.65

Note: *p<.05; **p<.01; ***p<.001; EAB = Environmental attitudes and behaviors; ERS = Environmental responsibility support; ECE = Ecology-centered experiences; ET = Ecological thought. Tukey post-hoc analysis revealed that participants who live on more than 10 acres of land outside of town had significantly higher levels of ECE than participants who lived in a small town and a large town.

A one way analysis of variance (ANOVA) revealed that participants' place of residence had a significant influence on their level of ecology-centered experiences, $F(3, 146) = 3.18$, $p < .05$. Post-hoc analyses using Tukey post hoc criterion revealed that participants who live on more than 10 acres outside of town ($M = 36.91$, $SD = 8.48$) had more ecology-centered experiences than participants who live in a small town ($M = 31.65$, $SD = 9.14$) and those who live in a large town ($M = 30.46$, $SD = 8.53$). Hence, participants who live on more than 10 acres outside of town participate in the *highest* number of ecology-centered experiences and those who live in a large town participate in the *lowest* number of ecology-centered experiences. Participants' place of residence did not, however, have a significant effect on their EAB, $F(3, 146) = .883$, $p = .45$, environmental responsibility support, $F(3, 146) = .529$, $p = .66$, or ecological thought, $F(3, 146) = .292$, $p = .83$.

In addition to participants' place of residence, I also examined whether living on a farm was related to participants' (1) environmental attitudes and behaviors (EAB), (2) environmental responsibility support, (3) ecology-centered experiences, and (4) ecological thought. Descriptive statistics and analysis results are presented in Table 4.

Table 4

Descriptive Statistics and T-test Results for Whether Participants Live on a Farm

Descriptive statistics									
		EAB		ECE		ET		ERS	
Farm	N	M	SD	M	SD	M	SD	M	SD
Yes	13	125.62	20.38	40.54	6.08	5.00	2.89	38.92	6.65
No	92	125.87	23.30	30.95	8.44	3.90	2.23	38.08	6.77

T-test analysis results	
Variable	*t*
EAB	.037
ECE	-3.95***
ET	-1.60
ERS	-.423

Note: *p<.05; **p<.01; ***p<.001

Thirteen participants lived on a farm, whereas 92 did not live on a farm. Similar to place of residence, t-tests revealed that living on a farm did not influence participants' ecological thought, $t(103) = -1.60$, $p = .11$, environmental responsibility support, $t(103) = -.423$, p = ns, or EAB, $t(103) = .037$, $p = .67$ (Table 4). Like place of residence, however, participants who live on a farm ($n = 13$) had more ecology-centered experiences ($M = 40.54$, $SD = 6.08$) than those who do not ($n = 92$, $M = 30.95$, $SD = 8.44$), $t(103) = -3.95$, $p < .001$. Further, Cohen's effect size value ($d = .27$) suggested a small practical significance.

Does Ecological Thought Predict Environmental Attitudes and Behavior?

Recall, three research questions were addressed in the present study. The first research question examined whether ecological thought was a significant predictor of EAB. Correlation (Table 5) and multiple regression analyses were conducted to examine the relationship ecological thought and environmental attitudes and behaviors. Table 6 summarizes the multiple regression analysis results. Although previous research suggested these two variables are highly interrelated (e.g., Maloney and Ward, 1973), I hypothesized that ecological thought would not be related to EAB. In support of my hypothesis, ecological thought ($M = 4.43$, $SD = 2.57$) and EAB ($M = 121.13$, $SD = 24.07$) were not significantly related, $r = -.005$, $p = .48$.

Table 5

Pearson r Correlation Results for Main Variables

Variable	EAB	ECE	ERS	ET
EAB		.119	.513***	-.005
ECE	.119		.149	.205*
ERS	.513***	.149		.037
ET	-.005	.205*	.037	

Note: *p<.05; **p<.01; ***p<.001; EAB = Environmental attitudes and behaviors; ERS = Environmental responsibility support; ECE = Ecology-centered experiences; ET = Ecological thought.

To further investigate the role of ecological thought in predicting EAB, I conducted a follow-up linear multiple regression analysis that included gender, age, and participants' place of residence as covariate predictors. Note that I did not include whether participants live on a farm as a covariate predictor. I excluded this for two reasons. First, a frequency distribution revealed that participants were more evenly distributed across the categories of place of residence (Table 3) than whether they lived on a farm (Table 4). Second, previous research has established that place of residence is a strong predictor for participants' participation in outdoor activities and ecological thought (Coley, 2012). Hence, place of residence was used as a covariate predictor rather than whether participants live on a farm. Interestingly, a correlation analysis revealed that participants' place of residence and whether participants lived on a farm was *not* related, $R = -.16$, $p = .11$, so a high correlation did not play a part in the selection of covariate variables.

As can be seen in the first model in Table 6, age ($M = 12.65$, $SD = 1.07$) significantly predicted EAB ($M = 121.13$, $SD = 24.07$), $t(148) = -2.90$, $p = .004$; gender approached significance as a predictor, $t(148) = 1.89$, $p = .06$; and place of residence did not significantly predict EAB, $t(148) = -.39$, $p = .70$. In the next model, age, gender, and place of residence were entered as covariates and ecological thought was entered as a predictor variable. After controlling for age, gender, and place of residence, ecological thought (*M* = 4.43, *SD* = 2.57) did not predict EAB, β = .039, *t*(145) = .488, *p* = .63, ΔR^2 = .002, *F*(4, 145) = 3.24, *p* = .014. These results indicate that ecological thought was not related to EAB, after controlling for age, gender, and place of residence. These findings were consistent with my hypothesis that ecological thought does not predict environmental attitudes and behaviors.

Table 6

Regression Results between Ecological Thought and EAB

		Unstandardized Coefficients		Standardized Coefficients	t	F	R	R^2
		B	SE	Beta		4.26**	.28	.08
Model 1	(Constant)	178.51	25.24		7.07***			
	Age	-5.22	1.80	-.233	-2.90**			
	Gender	7.26	3.84	.151	1.89			
	PoR	-.86	2.19	-.032	-.391			
Model 2						3.24*	.29	.08
	(Constant)	178.02	25.33		7.03***			
	Age	-5.34	1.82	-.238	-2.94***			
	Gender	7.39	3.86	.154	1.92			
	PoR	-.82	2.19	-.030	-.370			
	ET	.37	.76	.039	.488			

Note: *p<.05; **p<.01; ***p<.001; PoR = Place of Residence; ET = Ecological Thought; Dependent Variable = Environmental Attitudes and Behaviors

Do Ecology-centered Experiences and Environmental Responsibility Support Predict Adolescents' Environmental Attitudes and Behaviors?

My second research question examined whether ecology-centered experiences and environmental responsibility support predict EAB. I expected both factors would significantly predict EAB; yet, I hypothesized that participants who had experiences with plants and animals (i.e., ecology-centered experiences) but lacked the contextual support to think and act in environmentally responsible ways (i.e., environmental responsibility support) would *not* display EAB. Recall, environmental responsibility support was measured as the frequency someone the participant knew participated in environmentally responsible activities, and ecology-centered experiences was measured as participants' involvement in a variety of outdoor activities (Table 2).

To test Hypothesis 2, I conducted linear multiple regression with age, gender, and place of residence as covariates and ecology-centered experiences as a predictor (see Table 7, Model 1). The regression analysis revealed that, as expected, after controlling for covariates, ecology-centered experiences significantly predicted EAB, β = .169, $t(145) = 2.10$, $p = .04$, $\Delta R^2 = .027$, $F(4, 145) = 4.37$, $p = .002$.

Next, in order to test whether the relationship between ecology-centered experiences and EAB changes when environmental responsibility support is taken into consideration, environmental responsibility support was added as a predictor to the model (see Table 7, Model 2). In this model, ecology-centered experiences (M = 32.73, SD = 9.11) no longer significantly predicted EAB, β = .091, $t(144) = 1.27$, $p = .21$, but environmental responsibility support (M = 37.09, SD = 7.30) did , β = .475, $t(144) = 6.80$, $p < .001$, ΔR^2 = .217, $F(5, 144) = 13.85$, $p < .001$. These findings suggested that, consistent with my hypothesis, environmental responsibility support—not ecology-centered experiences—is the main predictor for EAB.

Table 7

Regression Results between Covariates, Ecology-Centered Experiences, Environmental Responsibility Support, and EAB

Model		Unstandardized Coefficients	Standardized Coefficients		*t*	*F*	*R*	R^2	ΔR^2
		B	SE	Beta		4.26**	.284	.08	
1	(Constant)	178.51	25.24		7.07***				
	Age	-5.22	1.80	-.233	-2.90**				
	Gender	7.26	3.84	.151	1.89				
	PoR	-.86	2.19	-.032	-.39				
2						4.37**	.328	.108	.027
	(Constant)	164.72	25.81		6.38***				
	Age	-5.54	1.79	-.247	-3.11**				
	Gender	8.19	3.82	.171	2.14				
	PoR	-.189	2.19	-.007	-.086				
	ECE	.446	.212	.169	2.10*				
3						13.85***	.507	.325	.217
	(Constant)	98.72	24.53		7.03***				
	Age	-4.32	1.57	-.193	-2.75**				
	Gender	6.96	3.34	.145	2.08*				
	PoR	.18	1.91	.007	.094				
	ECE	.239	.188	.091	1.27				
	ERS	1.57	.23	.475	6.80***				

Note: *p<.05; **p<.01; ***p<.001; PoR = Place of Residence; ECE = Ecology-Centered Experiences; Dependent Variable = Environmental Attitudes and Behaviors

Do Age and Gender Predict Environmental Attitudes and Behaviors?

My last research question addressed the effect of age and gender on EAB. I was able to indirectly test this question by the regression analyses conducted above. Consistent with previous research (Alp, Ertepiner, Tekkaya, & Yilmaz, 2006; Larson, Green, & Castleberry, 2009; Eisler, Eisler, & Yoshida, 2003; Leeming, Bracken, & Dwyer, 1995), the models described above revealed that age and gender significantly predicted EAB. A post-hoc t-test revealed that girls (M = 124.94, SD = 25.57) held significantly higher EAB than boys (M = 117, SD = 21.75), $t(148) = -2.04$, $p = .04$. Cohen's effect size value (d = .33) suggested a small practical significance. Further, a correlation analysis revealed that EAB decreased with age, $r = -.24$, $p = .003$.

Discussion and Conclusions

The present study considered adolescents' environmental attitudes and behaviors in light of their ecology-centered experiences, ecological thought, environmental responsibility support, and age and gender. Specifically, the present research addressed three questions. First, I examined whether ecological thought—thought patterns that reflect ecological relationships between living things—predicted environmental attitudes and behaviors, which reflect environmentally responsible attitudes and behaviors. Previous research has oft assumed (at least implicitly) that ecological thought has a direct impact on people's environmental attitudes and behaviors (e.g., Hogan, 2002), yet no research to my knowledge has empirically tested this claim. My results revealed that despite such previous claims, ecological thought had no apparent impact on environmental attitudes and behaviors.

Second, I investigated the effect of two factors—ecology-centered experiences and environmental responsibility support—on environmental attitudes and behaviors. Ecology-centered experiences were experiences with plants and animals, such as gardening and fishing. Environmental responsibility support was the support adolescents receive from another person to engage in environmentally responsible behaviors. Support was measured by behavior modeling (i.e., the environmentally responsible behaviors someone else demonstrated). I hypothesized that both ecology-centered experiences and environmental responsibility support would be related to environmental attitudes and behaviors; yet, environmental responsibility support would be a stronger predictor than ecology-centered experiences. Indeed, ecology-centered experiences were significantly related to environmental attitudes and behaviors; however, as predicted, when environmental responsibility support was entered into the model, ecology-centered experiences no longer predicted environmental attitudes and behaviors. These findings suggest ecology-centered experiences do not impact environmental attitudes and behaviors when environmental responsibility support is present. Moreover, these findings offer support that experiences with plants and animals alone, such as gardening, hunting, and fishing, may not be enough to yield environmentally responsible attitudes and behaviors. Additional contextual support from others may be needed in order to shape adolescents' environmental attitudes and behaviors.

Last, I investigated whether two demographic factors—age and gender—would predict environmental attitudes and behaviors among adolescents. My results were consistent with previous research—age and gender were significant predictors of environmental attitudes and behaviors, with girls possessing more environmentally responsible attitudes and behaviors than boys and younger participants possessing more environmentally responsible attitudes and behaviors than their older counterparts. Citing

Worsley and Skrzypiec (1998), Alp et al. (2006) suggested that “girls' attitudes may be attributed to higher environmental sensitiveness than boys depending on being more likely to experience depressive moods” (p. 220).

Limitations and Future Directions

Despite the current findings and their important implications, the present study was not without limitations. The first limitation involved the way environmental responsibility support was measured. To my knowledge, there is no survey that examines contextual support for environmental attitudes and behaviors. I therefore created a battery of questions to measure contextual support by transforming ten of the questions in the *Behaviors* sub-scale of the CHEAKS (e.g., “To save energy, I have turned off lights at home when they are not in use.”) into questions that measured the behaviors of others (e.g., “To save energy, this person has turned off lights at home when they are not in use.”). By doing this, I hoped to capture the ways other people model environmentally responsible behaviors for adolescents. It is possible, though, that the relationship between these two factors was artificially inflated because of the structure and wording of the questions. In other words, questions used to measure environmental attitudes and behaviors and environmental responsibility support were very similar, and participants’ responses may have reflected this similarity.

One point of evidence against this argument, though, is that although environmental responsibility support and environmental attitudes and behaviors were correlated, they did not surpass the threshold for multicollinearity. In the future, though, a relatively brief scale that examines environmental responsibility support should be developed in order to use in further research. By measuring the validity and reliability of the scale in future studies, researchers can capture more accurately the contextual support others can provide for adolescents to engage in environmentally responsible behavior. Of course, contextual support can be measured in other ways, such as measuring different or even multiple support systems (e.g., religious institutions, involvement in community organizations, availability of recycling in town) or conducting structured-interviews that target specific aspects of support (e.g., Do your parents talk to you about the importance of resource conservation?).

A related avenue of future inquiry regarding environmental responsibility support is to examine the person adolescents thought of while answering questions about environmental responsibility support. Recall, I asked participants to think of a person who they care about from a choice of friend, family member, teacher, or someone else they know and then answer questions about this person's environmentally responsible behaviors. I did not focus on, however, trends in participants' selection of a person. I also did not ask participants who chose "someone else they know" to identify who they were thinking about. It would be interesting to identify this person in the future in order to identify potential developmental trends. In other words, adolescents may be more likely to think of a peer when thinking of someone they know, rather than a parent or teacher, which may be more prevalent among younger children. By understanding who adolescents privilege when thinking of environmental responsibility support, we may better understand how to target adolescents with specific sources of environmental responsibility support, such as through peer groups or clubs.

Another potential limitation may have been the participants themselves. Participants were drawn from a rural setting with a population density of 30 people per square mile (U.S. Census Bureau, 2010). It is possible that rural adolescents hold different environmental attitudes and behaviors than adolescents in urban settings and that another study with urban adolescents would have yielded different results. I argue, however, that rural students were an ideal population due to the relatively high level of variability of the setting in which rural participants lived and the high level of variability of ecology-centered experiences rural adolescents experience relative to their urban counterparts. For instance, despite the low population density, 24 participants (16%) lived in the neighboring large town and only a small percentage of participants (12.7%) reported that they lived on farms. Further, the ecology-centered experiences assessed in the present study—e.g., hunting and fishing—are likely to be more common among rural adolescents than urban adolescents.

Proposed Significance

Given the environmental challenges we currently face, understanding environmental responsibility among the upcoming generation of environmental stewards is of utmost importance. Consider the environmental changes we have experienced in just the past 10 years. In this time our planet has experienced extreme weather patterns at a greater frequency (http://climate.nasa.gov/), including the massive tsunami that ripped through the shores of southeast Asia in 2004, Hurricane Katrina that flooded the gulf coast of the United States in 2005, and more recently, super-storm Sandy that hit the northeastern shores of the United States in 2012. In addition natural resources the world over have become over-polluted by harmful products that litter the land and water and fill landfills, including plastic containing the chemical Bisphenol A, or BPA, which has been linked to neurological and other birth defects in infants and young children (National Toxicology Program, 2008), and an excess of phosphate, a naturally occurring substance that in inordinate amounts can disrupt the life cycle in rivers and streams (Carpenter & Bennett, 2011). Further, our foods have become laced with harmful pesticides and herbicides that have also been linked to birth defects and even cancer (e.g., Dennis, Lynch, Sandler, & Alavanja, 2010; Dich, Zahm, Hanberg, & Adami, 1997).

In light of such extreme occurrences, some pressing questions arise: What actions are people taking to prevent further destruction of the natural environment? What are their attitudes toward maintaining a healthy natural environment? By understanding how people think about and act toward the environment, environmental researchers, educators, and policy makers can more accurately identify the areas that demand action, including further research, educational outreach, and policy change. The present research was a step toward answering these questions by examining environmental attitudes and behaviors among adolescents. Our findings can help science educators, curriculum designers, and cognitive developmental psychologists decide which factors are more important in shaping adolescents' environmental attitudes and behaviors.

For example, consider the role of ecology-centered experiences on EAB. Environmental education programs my include activities that offer opportunities to experience plants and animals (i.e., ecology-centered experiences). My findings revealed that these experiences do predict EAB, yet in order for them to influence EAB, these experiences need to be paired with environmental responsibility support from others. Therefore, environmental educators may decide that in addition to taking a group of students into the woods to explore nature, they should also provide additional, environmentally specific contextual support for students, such as highlighting why it is important to care for the natural environment and modeling environmentally responsible behaviors. Combined, these two types of contextual support can have a greater impact on adolescents' environmental attitudes and behaviors, which is the main goal of environmental education.

References

Alp, E., Ertepinar, H., Tekkaya, C., & Yilmaz, A. (2006). A statistical analysis of children's environmental knowledge and attitudes in Turkey. *International Research in Geographical and Environmental Education, 15*(3), 210-223.

Alp, E., Ertepinar, H., Tekkaya, C., & Yilmaz, A. (2008). A survey on Turkish elementary school students' environmental friendly behaviours and associated variables. *Environmental Education Research, 14*(2), 129-143.

Atran, S. (1998). Folk biology and the anthropology of science: Cognitive universals and cultural particulars. *Behavioral and Brain Sciences*, *21,* 547-609.

Atran, S., & Medin, D. L. (2008). *The native mind and the cultural construction of nature.* Cambridge, MA: MIT Press.

Bang, M. Y., Medin, D. L., & Atran, S. (2007). Cultural mosaics and mental models of nature. *Proceedings of the National Academy of Sciences 104*, 7357-7360.

Berlin, B., Breedlove, D., & Raven, P. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist, 75*(1), 214-242.

Brugger, A., Kaiser, F.G., & Roczen, N. (2011). One for all? Connectedness to nature, inclusion of nature, environmental identity, and implicit association with nature. *European Psychologist, 16*(4), 324-333.

Byrnes, J.P., Miller, D.C., & Schafer, W.D. (1999). Gender differences in risk taking: A meta-analysis. *Psychological Bulletin, 125,* 367-382.

Carpenter, S.R., & Bennett, E.M. (2011). Reconsideration of the planetary boundary for phosphorus. *Environmental Research Letters, 6*(1), doi:10.1088/17489326/6/1/014009

Coley, J. D. (1995). Emerging differentiation of folkbiology and folkpsychology: Attributions of biological and psychological properties to living things. *Child Development, 66,* 1856-1874.

Coley, J. D. (2012). Where the wild things are: Informal experience and ecological reasoning. *Child Development, 83*(3), 992-1006.

Coley, J. D., Freeman, A. C., & Blaszczyk, K. (2003, April). *Taxonomic and ecological relations in urban and rural children's folk biology.* Paper presented at the Biennial Meeting of the Society of Research in Child Development, Tampa, FL.

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. Kahn & S. Kellert (Eds.), *Children and nature: Psychological, sociocultural and evolutionary investigations* (pp. 65-91). Cambridge, MA: MIT Press.

Deng, J., Walker, G. J., & Swinnerton, G. (2006). A comparison of environmental values and attitudes between Chinese in Canada and Anglo-Canadians. *Environment and Behavior, 38*(1), 22-47.

Dennis, L.K., Lynch, C.F., Sandler, D.P., & Alavanja, M.C. (2010). Pesticide use and cutaneous melanoma in pesticide applicators in the Agricultural Health Study. *Environ Health Perspectives, 118*(6), 812-817.

Dich, J., Zahm, S.H., Hanberg, A., & Adami, H.O. (1997). Pesticides and cancer. *Cancer Causes Control, 8*(3), 420-443.

Eisler, A. D., Eisler, H., & Yoshida, M. (2003). Perception of human ecology: cross-cultural and gender comparisons. *Journal of Environmental Psychology, 23,* 89-101.

Evans, G. W., Brauchle, G., Haq, A., Stecker, R., Wong, K., Shapiro, E. (2007). Young children's environmental attitudes and behaviors. *Environment and Behavior, 39*(5), 635-659.

Hogan, K. (2002). Small groups' ecological reasoning while making an environmental management decision. *Journal of Research in Science Teaching, 39*(4), 341-368.

Kaiser, F. (1998). A general measure of ecological behavior. *Journal of Applied Social Psychology, 28*(5), 395-422.

Kaiser, F. G., & Wilson, M. (2004). Goal-directed conservation behavior: The specific composition of a general performance. *Personality and Individual Differences, 36,* 1531-1544.

Kaiser, F. G., Oerke, B., & Bogner, F. X. (2007). Behavior-based environmental attitude: Development of an instrument for adolescents. *Journal of Environmental Psychology, 27,* 242-251.

Keil, F. C. (1989). *Concepts, kinds, & cognitive development.* Cambridge, MA: MIT Press.

Larson, L. R., Green, G. T., & Castleberry, S. B. (2009). “I'm too old to go outside!” Examining age-related differences in children's environmental orientations. *Proceedings of the 2009 Northeastern Recreation Research Symposium*, 42-46.

Leeming, F. C., Bracken, B. A., & Dwyer, W. O. (1995). Children's environmental attitudes and knowledge scale: Construction and validation. *The Journal of Environmental Education, 26*(3), 22-33.

Maloney, M. P., & Ward, M. P. (1973). Ecology: Let's hear from the people. *American Psychologist, 28*(58), 1-586.

Maloney, M. P., Ward, M. P., & Braucht, G. N. (1975). A revised scale for the measurement of ecological attitudes and knowledge. *American Psychologist, 30,* 787-790.

Milfont, T. L., & Duckitt, J. (2004). The structure of environmental attitudes: First- and second-order confirmatory factor analysis. *Journal of Environmental Psychology, 24,* 289-303.

Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology, 30,* 80-94.

Milfont, T. L., Duckitt, J. & Wagner, C. (2010). The higher order structure of environmental attitudes: A cross-cultural examination. *Interamerican Journal of Psychology, 44,* 263-273.

Morrone, M., Mancl, K., & Carr, K. (2001). Development of a metric to test group differences in ecological knowledge as one component of environmental literacy. *The Journal of Environmental Education, 32*(4), 33-42.

Mussler, L. M., & Malkus, A. J. (1994). The children's attitudes toward the environment scale. *Journal of Environmental Education, 25*(3), 22-26.

National Aeronautics and Space Administration. (2013). Global Climate Change. Retrieved from http://climate.nasa.gov/

National Toxicology Program. (2008). U.S. Department of Health and Human Services. Center for the Evaluation of Risks to Human Production. *NTP-CERHR Monograph on the Potential Human Reproductive and Developmental Effects of Bisphenol A.* NIH Publication No. 08-5994.

Ross, N. O., Medin, D. L., Coley, J. D., & Atran, S. (2003). Cultural and experiential differences in the development of folkbiological induction. *Cognitive Development, 18,* 25-47.

Schultz, P. W., & Zelezny, L. C. (1999). Values as predictors of environmental attitudes: Evidence for consistency across 14 countries. *Journal of Environmental Psychology, 19,* 255-265.

Unsworth, S. J., Levin, W., Bang, M., Washinawatok, K., Waxman, S. R., & Medin, D. L. (2012). Cultural differences in children's ecological reasoning and psychological closeness to nature: Evidence from Menominee and European American children. *Journal of Cognition and Culture, 12,* 17-29.

Vadala, C. E., Bixler, R. D., & James, J. J. (2007). Childhood play and environmental interests: Panacea or snake oil? *Journal of Environmental Education, 39*(1), 3-18.

Walsh-Daneshmandi, A., & MacLachlan, M. (2006). Toward effective evaluation of environmental education: Validity of the children's environmental attitudes and knowledge scale using data from a sample of Irish adolescents. *Reports and Research, 37*(2), 13-23.

Worsley, A., & Skrzypiec, G. (1998). Environmental attitudes of senior secondary school students in South Australia. *Global Environmental Change, 8*(3), 209-225.

APPENDIXES

APPENDIX A

Ecology Task Pairs

Plant-Plant	**Plant-Animal**	**Animal-Animal**
Oak tree-Vine	Vine-Snake	Coyote-Hawk
Flower-Oak	Oak tree-Deer	Deer-Turkey
		Fish-Frog
		Hummingbird-Bee
		Rabbit-Snake
		Snake-Hawk
		Deer-Coyote