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Connecting to Nature, Community, and Self: A Conservation Corps Approach to Re-engaging At-Risk Youth in Science Education

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by

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Abstract

The social and environmental challenges of the coming decades will require that individuals possess environmental literacy: the understanding of natural systems combined with a sense of care for the earth, and the confidence and competency to act on its behalf. At the same time, disengaged youth need education environments that foster belonging and promote affective outcomes. The youth conservation corps model provides a natural context for engaging academically at-risk youth in environmental science education, while fostering connection to nature and student self-efficacy in ways that are experiential, relevant, and relationship-based. The focus of this study was a conservation corps program that integrates habitat restoration fieldwork and environmental science curriculum. The participants of this study were eight high school seniors who participated in the program for credit toward their high school diplomas. Data were collected through both quantitative and qualitative measures. Students completed a pre-test to assess their understanding and application of conceptual knowledge in ecosystem relationships and biodiversity. Upon completion of a six-week curriculum, they completed a post-test assessing knowledge in the same areas, two retrospective pre-post surveys measuring connection to nature and self-efficacy, and a post-evaluation measuring affective outcomes. Individual interviews were conducted in order to provide further insights and to identify elements of the program that contributed to positive outcomes. Results showed statistically significant increases in all outcome areas as well as positive student evaluation of affective

outcomes. The outdoor and experiential components of the program were found to contribute most significantly to the positive outcomes.

Dedication

This study and thesis is dedicated to the memory of my mother, Sheila Linden, and to the healing of our world and the welfare of all living beings. May we all find our way home.

Acknowledgements

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Introduction

The world in which we live becomes increasingly complex with each passing day, with change happening faster than ever before in human history. In many ways, we are experiencing the end of one chapter while entering into one that holds much uncertainty. Exponential growth of the human population increases demands on natural systems that are already being pushed to the brink. Climate change and species extinction threaten to undermine the integrity of the systems upon which all life depends (Orr, 2011). These issues intertwine with social and economic inequities, as those hit hardest by the consequences of ecological decline are those who lack access to the privileges of the modern world that precipitate the imbalance (Goldenberg, 2014). In the face of such challenges, incredible responses and opportunities are emerging. In communities throughout the world, people are rising together to face threats that are insurmountable without collective effort. Creative solutions are being implemented that recognize the systemic nature of the problems. Many are waking up to the gravity of these realities, and responding with creativity and grace (Hawken, 2007).

The system of education is a microcosm of this larger pattern, where challenges and opportunities weave together as two sides of the same coin. The 20th century model of education, where the teacher is the authority and students approached as empty vessels to be filled, is outdated and ineffective (Sterling, 2001). Despite efforts to set high academic standards for all students, many young people continue to disengage

from the schools and communities in which they live (Umholtz, 2013). While many wring their hands over the students left behind and the insufficiency of the last decade's efforts to return them to the fold, there are quiet revolutions occurring in education, creative approaches that engage, inspire, and educate the young people who have the opportunity to participate in them. The interconnections between the collective problems within ecological, socioeconomic, and educational systems likewise require solutions that emerge from a systems approach (Colucci-Gray, Camino, Barbiero, & Gray, 2006). Such solutions must take into account the complex relationships between disciplines, between humans and the natural world, between students' cognitive performance and affective needs, and between the learning environment and student success.

The only truth that can be predicted with full certainty is that the coming decades will hold changes unforeseen, which will arguably take the full force of human adaptability and ingenuity to respond. The role of education must change in response. If young people are to be prepared to encounter the world as it is and as it will be, not as it was in the 20th century, it is necessary to cultivate students' awareness, understanding, compassion, and capabilities to engage with the challenges and opportunities that lie ahead (Sterling, 2001). If the intent of education is to engage and empower *all* students, this will require pedagogical approaches that inspire motivation, interest, and self-efficacy (Alfassi, 2003; McMillan & Reed, 1994; Catalano et al., 2004; Umhotlz, 2013). The purpose of this study is to investigate whether an alternative education program that integrates theory and practices from positive youth

development with content and approaches of sustainability education and place-based learning can empower previously struggling students with the knowledge, skills, and values needed to act as environmentally literate citizens in their communities. A secondary purpose is to identify the elements of the program that contribute to positive outcomes.

The focus of this study is an environmental science-based youth conservation corps program. It was founded in 1992 and moved between various schools before finding its current home at a large suburban high school south of Portland, Oregon in 2002. I have served in the role of crew leader, teacher, and program coordinator for the program since 2011, and acted in all of these capacities, along with that of the researcher, during the study period. This program is based on the youth conservation corps model, which provides meaningful work experience to young people while meeting conservation goals of local organizations and community agencies. This model evolved from the Civilian Conservation Corps, created in 1933 by Franklin D. Roosevelt in response to the parallel issues of natural resources decline and mass unemployment during the Depression. Since that time, there have been a number of federally supported programs bridging these two areas, including the Student Conservation Program (which eventually became the Student Conservation Association), Job Corps, and AmeriCorps (CCC Legacy, 2014). Oregon Youth Conservation Corps, created in 1987 by the Oregon legislature, is the umbrella organization that provides funding, training, and support to the program that is the focus of this study, and to similar programs throughout the state of Oregon. The purpose of OYCC is to provide work opportunities

for disadvantaged and at-risk youth in the realm of conservation and protection of natural and cultural resources, while providing youth with education and training (OYCC, 2014).

Although the main focus of most conservation corps programs is to provide employment and work experience to youth, the model offers a unique context to provide participants with authentic science and sustainability education through direct experience with the natural world and participation in local conservation efforts. The goal of the program in this study is to give students an alternative path to academic success, one that allows them to gain work experience and skills in a team setting, provides them opportunities to learn and apply scientific concepts while connecting to the natural world, and empowers them to take action as valuable members of their larger communities. Conservation projects center around the ecological restoration of urban and suburban natural areas. The education curriculum focuses on environmental science, which integrates ecology, botany, and other earth sciences with the study of human interaction and impact on natural systems, and the solutions to environmental problems. The educational framework of this program draws inspiration from models of sustainability education and place-based learning to provide the context for authentic experience around standards-based science content (National Research Council, 2012) and connection to the natural world. The program structure derives from research on positive youth development and academic engagement for at-risk students, with the intention of providing the context and support for students to meet academic

expectations through experiential approaches that emphasize connection, competence, and other affective outcomes.

Sustainability education focuses on the interplay between natural and human systems, and aims to equip young people to grapple with the environmental, economic, and social complexities of the 21st century (Burns, 2011). Young people are well aware of the enormity of the problems that we collectively face, but often lack a deep understanding of the issues (Sterling, 2001), let alone the tools needed to address them. On a broader cultural level, there is recognition that old ways of thinking and learning are not sufficient to address these issues (Burns, 2011), and many people are asking questions about what tools students need in order to skillfully participate in the efforts toward a more sustainable world. In response to this, David Orr (2011) and many others champion the concept of ecological or environmental literacy: an understanding of how natural systems work, paired with a personal connection to nature and the skills to take action. Orr (2011) calls this outcome "that quality of mind that seeks out connections... The ecologically literate person has the *knowledge* necessary to comprehend interrelatedness, and an *attitude of care* or stewardship. Such a person would also have the *practical competence* required to act on the basis of this knowledge and feeling" (p. 258, emphasis added). Closer to home, the Oregon Environmental Literacy Plan, which emerged from the No Child Left Inside Act (HB 2544) passed by Oregon legislature in 2009, defines environmental literacy as “[a]n individual’s *understanding, skills, and motivation* to make responsible decisions that consider his or her relationships to natural systems, communities, and future generations” (Oregon

Environmental Literacy Task Force, 2013, p. 4, emphasis added). Sustainability education in general, and environmental literacy more specifically, draws on scientific concepts that are inherently interdisciplinary and experiential, but with the added aim to cultivate capacities that are not always explicitly acknowledged in traditional education settings. It requires that educators engage students not only on the intellectual level, but that they also work to foster the faculties of compassion and connection to the natural world, as well as the confidence and competence to act on its behalf (Burns, 2011; Littledyke, 2008). These three key components of environmental literacy are the main focus of this study: ecological understanding, connection to nature, and competency skills.

The knowledge, skills, and values that define environmental literacy are best developed through the direct experience of one's ecological place (Oregon Environmental Literacy Task Force, 2013; Athman & Munroe, 2004; Burns, 2011). Place-based learning is an educational theory in its own right. This approach uses the local community and environment as the context for educational experiences, emphasizing hands-on learning through authentic projects, interdisciplinary instruction, cooperative learning, and integration of student interests and skills (Knapp, 2005; Athman & Munroe, 2004; Lieberman & Hoody, 1999). If students are to develop a deep understanding of ecological principles, a personal connection to nature, and the practical skills to engage in making change, the local environment provides the ideal context to cultivate all of these qualities.

The place-based approach dovetails especially well with science education. National science standards are changing to reflect new understandings of living systems (NGSS Lead States, 2013; National Research Council, 2012), and the recognition that society and science, and humans and nature, are profoundly interconnected (Colucci-Gray, et al., 2006). Engaging students with local issues in place-based education has been shown to increase academic achievement in science and other content areas (Lieberman & Hoody, 1999; Hamilton-Ekeke, 2007). Beyond this, it has also been shown to improve students' higher order cognitive skills—Including creative and critical thinking, problem solving, and systems thinking—and interpersonal skills such as the ability to collaborate in a group effort and improved communication with other students (Lieberman & Hoody, 1999; Athman & Munroe, 2004), all of which align with the competency aspect of environmental literacy. The place-based approach to science education has the potential to increase student interest and engagement while fostering a personal connection to nature (Littledyke, 2008).

An approach to science education that increases interest and engagement is of benefit to all students, but especially those who have struggled in the traditional school and classroom settings. An increasing number of students are lumped into the broad category of “at-risk”. There are a number of factors that influence students’ abilities to succeed in school and life. Certain predisposing factors, including social and economic demographics, family background, and previous school experiences, increase the odds that students will disconnect from school (Alfassi, 2003). The students in this study range the spectrum of these factors, but all of them can be considered “academically at-

risk," in that they have experienced difficulties as learners, and are at risk of school failure, dropout, or delinquency (Tobin & Sprague, 1999).

The emergence of both in- and out-of-school programs to meet the needs of youth who are at risk of school failure and/or engaging in problem behaviors is a response to the clear need for a positive approach to re-engaging and fostering the strengths of these young people. Alternative education programs recognize that many students have learning styles and needs that are not met within the context of a traditional classroom, and aim to create learning environments that better assist these students in meeting academic goals (Tobin and Sprague, 1999; Johnson, 1994). The broader positive youth development movement includes programs that seek to develop positive capacities and behaviors in youth (Catalano et al., 2004; Umholtz, 2013). A common recognition in the literature in these realms is that the affective dimension must be a foundational focus when working with these young people. That is, it is essential to address students' emotional needs and foster psychological growth in order for them to successfully engage at the cognitive level. This can be accomplished through creating an environment that promotes individual attributes such as positive attitude, motivation, self-determination, autonomy, personal responsibility, and self-efficacy (McMillan & Reed, 1994; Jensen, 2009; Alfassi, 2003; Catalano et al., 2004; Umholtz, 2013; Saxton et al., 2014). It also includes the need for a supportive environment that cultivates positive relationships and a sense of belonging (Catalano et al., 2004; Jensen, 2009; Tobin & Sprague, 1999).

Sustainability and place-based education provide a natural framework for engaging at-risk students in science education. Through an examination of the literature in these areas, three significant overlapping themes become apparent (see Appendix A). Academically at-risk youth benefit from pedagogical approaches that are experiential, relevant, and relationship-based, and which engage students on both cognitive and affective levels. These very same practices define the approaches of sustainability education and place-based learning. These three pedagogical approaches were thoughtfully integrated into the curriculum and culture of the conservation corps program over the six-week curriculum period. Student participation in the program includes two days per week working as a team on habitat restoration projects in the community, as well as one day per week participating in environmental science-focused educational activities in the classroom and outdoors. The field and class components intertwine to create an integrated curriculum that is experiential, relevant, and relationship-based. Although there is some theory (Umholtz, 2013) and evidence (Lieberman & Hoody, 1999) that place-based and sustainability education programs can improve engagement and academic success of at-risk youth, there is little on-the-ground application and research that explores this overlap, especially in the realm of science education.

My aim is to contribute to this conversation through exploring the effectiveness of this program in meeting the desired outcomes of sustainability education and positive youth development, and to identify the program elements that contributed to these outcomes. The independent variable of the study was the program experience,

which included a six-week environmental science curriculum that integrated the fieldwork component with class activities. The dependent variables include students' environmental literacy and positive affective outcomes. Environmental literacy was assessed by measuring students' ecological understanding, connection to nature, and self-efficacy. To assess ecological understanding, students completed an application of conceptual knowledge pre-test prior to the curriculum period and a similar post-test at the end of the six weeks to determine whether there was a change in scores. Students' connection to nature was measured with a retrospective pre-post survey that assessed their cognitive, affective, and experiential attitudes about the natural world. An adapted retrospective pre-post survey assessing general self-efficacy was used as a measure of student competency skills. Affective outcomes included students' sense of belonging, interest in and perceived relevance of the content and experience, and motivation and engagement in both the field and class components. These elements were measured through a post-treatment evaluation survey. Additionally, I conducted individual interviews with all of the participating students to provide greater insight into the quantitative data, and to identify the elements of the program that contributed to positive outcomes. Figure 1 below shows a visual representation of the theoretical foundation, dependent variables, sub-constructs, and measurement instruments for this study.

The research questions that this study seeks to answer are: In what ways does an environmental science-based youth conservation corps program impact academically at-risk high school students' environmental literacy and affective outcomes? What are

the specific elements of this program that contribute to positive student outcomes? The hypothesis of this study is that participation in the study program will increase students' ecological understanding, connection to nature, and self-efficacy, while contributing to positive affective outcomes.

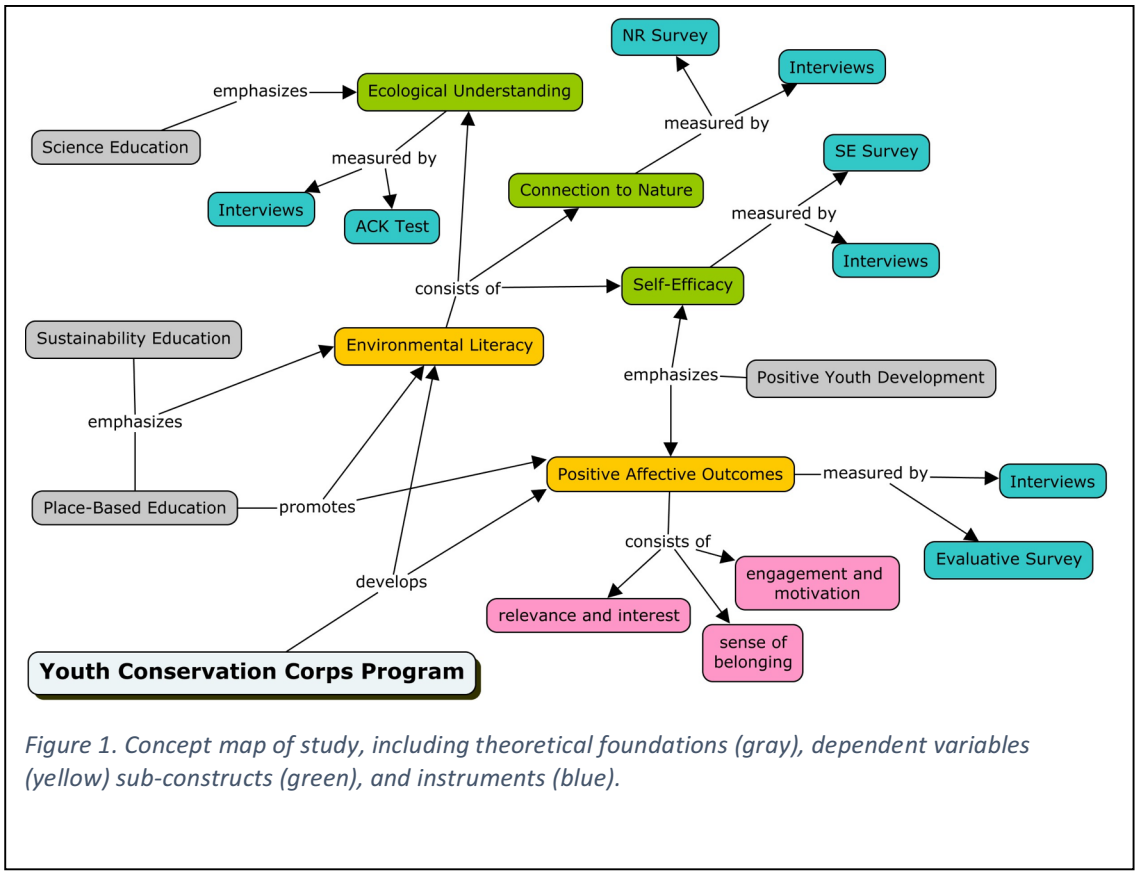

Figure 1. Concept map of study, including theoretical foundations (gray), dependent variables (yellow) sub-constructs (green), and instruments (blue).

Literature Review

The educational framework of the youth conservation corps program in this study draws from existing research in the areas of sustainability education and place-based learning to provide the context for authentic experience around science content and connection to the natural world. The program structure derives from research on positive youth development and academic engagement for at-risk students, with the intention of providing support for students to meet academic expectations through approaches that emphasize affective outcomes. The following review examines the existing literature in these three areas: sustainability education, place-based learning, and positive youth development. It also provides summaries of the instruments that were used to measure the outcomes in this study.

Sustainability Education

The environmental literacy outcomes measured in this study derive from sustainability education (Orr, 2011; Oregon Environmental Literacy Taskforce, 2013). Literature in this area lends insights into systems-based learning processes and pedagogical approaches (Burns, 2011; Colucci-Gray et al., 2006; Blatt, 2012), as well as the connections between sustainability education and science education (Colucci-Gray et al., 2006; Littledyke, 2008). The treatment of this study directly derives from the literature in sustainability education, specifically through the use of socio-environmental themes as the framework for teaching science, as well as the use of instructional

approaches that engage students on the cognitive and affective levels, and which include participatory action in the issues being studied.

Burns (2011) provides a pedagogical framework for sustainability education that directly reflects these themes. She emphasizes transformative learning approaches to replace traditional transmissive methods of teaching, and which empower students to participate in the transformation of unsustainable systems. The model is rooted in ecological principles and has five dimensions. These include 1) thematic and multidisciplinary content that increases students' systemic understanding of sustainability issues, 2) consideration of complex issues from diverse perspectives and critical reflection on dominant paradigms, 3) active and experiential learning that allows students to directly engage with issues and participate in solutions, 4) a place-based context that allows for direct observation and investigation of the surrounding natural and human communities, and 5) an ecologically-based design process that weaves together the other four dimensions. This design process is based on permaculture design, and includes the cyclical stages of observation, visioning, planning, development, and implementation. This framework and design process directly influenced the development of the curriculum for this study.

The curriculum and instructional approaches of the study treatment were likewise influenced by Colucci-Gray, Camino, Barbiero, and Gray (2006), in which the researchers provide a research-based approach to teaching science education through the lens of socio-environmental issues. Their discussion of the changing context of science education and specific methods for educators to respond to this change

provided support for the content and instructional approaches used in the treatment in this study. These researchers developed an educational approach intended to engage students with complex and controversial socio-environmental issues, through a review of existing literature and implementation of a two-part action research project. The main question that they explore is what role science education plays in preparing students to act in the new global context, and whether the aims of science education must be reevaluated in light of this. They discuss the elements of this new context, including the emergence of systems thinking, the complexity of global socio-environmental issues, and the insufficiency of old approaches (scientific and otherwise) to addressing these. Noting the central role of complexity, the authors propose three levels of engagement: the study of complex and controversial issues, the use of complex teaching methods, and the involvement of the affective dimension of feelings, values, and opinions in addition to the cognitive aspects of traditional science education. Over the course of ten years, the authors developed and modified a role-play simulation that explores complex socio-environmental topics through a dialectical process. These simulations were implemented in various contexts, including secondary classrooms, university courses, and teacher professional development courses. The first phase of the role-play activity was modeled around the structure of public debates, where contrasting opinions were presented to a panel of judges, and the outcome of which favored one solution. The researchers found that students participating in the first phase were engaged in the competitive setting, and the motivation to speak for their solution increased their knowledge about the issue. However, students' intentions were

to defend their position or attack others. This method of role-play did not encourage students to engage with others' points of view. After assessing the outcomes of this format, they modified the model of the role-plays from the more typical 'win-lose' situation to one that reflected the complex reality of a multiplicity of views and practices of nonviolent resolution. The format of the role-play shifted from a debate to a dialogue, and the focus shifted from the *outcome* of a solution to the *process* of handling the conflict. This format provoked student reflection on deeply held values and beliefs about themselves, their relationships with others, and their relationships to conflict. Rather than arguing for their perspective as the 'truth', participants each offered a contribution to a full picture of the problem at hand, which required close listening and openness to others' contributions. They propose this model as a systemic approach to problem-solving, where all stakeholders have the right to express themselves and possess a legitimate and unique point of view which contributes to a clearer picture of a complex issue. The study of complex socio-environmental issues in science education requires the use of alternative teaching strategies that engage students on the affective as well as cognitive levels and provoke students to reflect on a personal level.

Blatt (2012) also examines the integration of science education with sustainability themes, through the study of an issues-based environmental science class. Her study provides further support for the integration of science and sustainability content, as well as the instructional approaches of the youth conservation corps curriculum that is the treatment of this study. Her outcomes were somewhat different

from mine, but relate closely to the nature connection outcome. Blatt (2012) assessed the changes in high school students' environmental identities and resultant environmental behaviors over the course of a semester-long issues-based environmental science class. Environmental identity here is defined as the different ways people construe themselves in relationship to the earth as manifested in personality, values, actions, and sense of self. She discusses the complexity of identity as a factor influencing personal, social, and political behavior, noting that we each inhabit multiple identities simultaneously, express different identities in different contexts, and may experience conflicts between them. Reviewing the literature around pro-environmental behavior, she notes the progression of environmental identity formation: 1) increased awareness of environmental issues (the *salience* stage), 2) empowerment to act in ways that make positive change for the environment (*empowerment* stage), and 3) regular engagement in environmental practices, often with a mentor or in a community (the *activist* stage). This qualitative study included observations, interviews, cogenerative dialogue (group discussions among stakeholders, including students, teachers, and administrators), and videotaping of a class of seventeen eleventh and twelfth graders in a semester-long Environmental Science course. The class was chosen for the teacher's issues-based approach to the content, which incorporates political, social, and cultural dimensions rather than a purely science-based focus. The researcher interviewed ten students, and seven participated in the cogenerative dialogues. She used open coding to generate codes and categories from the interviews. The themes that emerged were: environmental background,

openness to new environmental information, critical thinking about the issues, environmental behaviors prior to the class, changes in environmental behaviors, ideas about environmentalism, attitudes towards school, relationships with teacher and with peers, and influence of the research. From the widely varying experiences of the students in the class she draws several conclusions. Students' environmental identities prior to the class were influenced by experiences in nature, environmental background of the family, cultural norms, school experience related to environment, and their existing environmental practices. Students entered the class at various stages of environmental identity. As students participated in the class, four major areas of identity emerged and interacted: environmental, consumer-materialist, social, and student. The strength or quality of the three latter identities influenced students' willingness or ability to accept the information encountered in class, and dissonance between identities (i.e. environmental and consumer-materialist) often provoked negative emotion in students. However, students reported positive emotions when their environmental identity was affirmed in class and many students showed progression in the stages of environmental identity formation. Findings also revealed two additional factors related to changes in student identity and behavior: openness to learning and accepting new knowledge, and willingness to critically reflect on new knowledge. The author makes a number of suggestions for teaching issues-based environmental science classes. Offering a balanced and multi-sided presentation of the issues encourages students to be open to other perspectives, practice their argument assessment skills, and critically reflect on their own views. Teachers should consider

ways to foster openness to new ideas and critical reflection through teaching strategies and the class environment. Acknowledging that certain activities and topics may provoke emotional responses as students' identities are affirmed or disconfirmed, it is necessary to provide space for these emotions to be expressed, and balance the class with activities that evoke positive emotions. Giving students opportunities to actively participate in positive actions can contribute to these positive emotions, as well as student empowerment and sense of self-efficacy. These suggestions directly influenced the development of the activities and assignments for the class component of this study.

The integration of the affective dimension of student experience with active engagement with socio-environmental issues is likewise reflected in the conceptual framework provided by Littledyke (2008). He shows how science education can integrate both the cognitive and affective domains in order to increase student engagement in science, foster environmental care and responsibility, and inform action. These are the three elements of environmental literacy that were measured in this study, and his work provided additional support for the development of the class curriculum. Littledyke (2008) writes that while the cognitive dimension is engaged through improving understanding of scientific principles, the affective dimension is incorporated through developing a sense of relationship with and positive attitudes toward the natural world. Approaches to science education in the last century were largely fact-based, abstract, reductionist, and unemotional. Science in this approach is difficult for individuals to relate to their real lives, interests, and experiences, and the resulting attitudes toward science are often negative. This perception is countered by

constructivist postmodernism, which embraces the cognitive and affective features of science and science education, and emphasizes an experiential, process- and inquiry-based curriculum that bridges disciplines. The cognitive features of learning include using methods and ideas of science to interpret and understand the world, creating meaningful personal frameworks for understanding science, critically analyzing and applying ideas to develop scientific validity, and critically evaluating the social and environmental implications of this application. Affective features include a sense of interest, enjoyment, and excitement in learning science, as well as the inclusion of a sense of beauty, respect, reverence, and wonder in understanding the world and the human place within it. Science education for environmental action must connect with experience, empower students in their learning, and link directly with environmental issues. The emphasis here is on a constructivist approach, in which learning is understood as a personal process influenced by prior experience and contextual settings, and which takes place in social situations. Constructivist methods draw on learner's interests and experiences to increase motivation and independent learning. Science education in this approach incorporates positive attitudes toward the environment (biophilia), exploration of students' personal views and ideas, direct experience of living organisms and natural environments, examination of controversial issues, and drawing explicit connections between actions and consequences. The big ideas of science provide an integrating framework to explore science concepts in relation to life experiences, and emphasizes the interrelations between all living organisms and their environments. The youth conservation corps curriculum that was

the focus of this study, as well as the environmental literacy outcomes, align with and were influenced by this conceptual framework.

Two elements of environmental literacy include one's capacity engage in systems thinking, as well as connection to nature. Leong, Fischer, and McClure (2014) examined the relationship between these two variables through their study that asked the question: "Are cognitive styles—e.g., innovative and holistic thinking—associated with connectedness with nature?" Previous studies on nature connection have focused on its effects in the areas of environmental behavior, positive affect, and vitality levels. The areas of overlap between innovative thinkers and nature lovers, including the use of divergent thinking and openness to new experiences, leads the authors to propose that having a sense of connection with nature increases peoples' innovative thinking style. The correlation between holistic thinking (which emphasizes the interrelationships between objects/people and their surroundings) and the interconnectedness within nature and knowledge of nature leads to the hypothesis that connectedness with nature has a positive relationship with a holistic thinking style. Two studies were undertaken to measure these variables. The first study was conducted through online surveys with 138 secondary school students in Singapore (ages 13-17). Connection to nature was measured with two instruments: the connectedness to nature (CNS) scale, and the nature relatedness (NR) scale (with three subscales focusing on the affective, cognitive, and experiential aspects). The instruments used to measure cognitive styles were the Analysis-Holism Scale (AHS), which measures analytic versus holistic thinking, and the Kirton's Adaption-Innovation Inventory (KAI) scale, which

assesses preferred creative style on a spectrum from innovative to adaptive. Researchers found statistically significant relationships between nature connectedness and both cognitive styles. Innovative thinking, as measured by KAI, showed a positive correlation with all nature connectedness subscales (both CNS and NR), while holistic thinking, measured using AHS, showed significant correlation only with the affective dimensions of CNS and NR. The second study aimed to replicate the findings of the first, using a different survey mode (pen and paper). Also, researchers wanted to control for well-being (as previous research showed a correlation between nature connectedness and well-being, and between emotions and cognitive styles) and demographics. In the second study, 185 Singapore secondary students (ages 13-16) participated, and the same instruments were used for nature connectedness and cognitive style. Mood was measured with the Positive and Negative Affect Scale, and well-being with the General Health Questionnaire and Warwick-Edinburgh Mental Well-being Scale. Even with the control variables of well-being and demographics, the results of the second study replicated the first: there was a significant relationship between individuals' connectedness to nature and both the innovative and holistic cognitive styles. The control data revealed a positive correlation between connectedness to nature and positive mood and well-being. These findings affirm the importance of nature connection, and have practical implications for the development of students' cognitive functioning in the education setting. The authors recommend that schools and educators consider methods to foster student connectedness to nature. Although this study does not isolate nature connection as a causal mechanism for cognitive

abilities, the correlation between these variables supports this recommendation. The instrument used to measure connection to nature is the same scale used in this study, and the results of their study provide support for the importance and influence of this capacity in students in relation to cognitive (and therefore academic) goals.

The overarching goal of sustainability education is to cultivate in students the knowledge, values, and behaviors that will contribute to a regenerative and life-sustaining society in the years to come. This study examines the ability of a specific youth conservation corps program in meeting a specific iteration of this goal, which can broadly be referred to as environmental literacy (Orr, 2011). The literature in sustainability education provides insights into developing educational experiences that promote this outcome. While the approach draws on and integrates insights and tools from various disciplines and traditions (Burns, 2011; Colucci-Gray et al., 2006, Blatt, 2012), science education can play a key role in engaging students in issues (Colucci-Gray et al., 2006; Blatt, 2012; Littledyke, 2008). The discourse in this field acknowledges the intricate magnitude of the challenges, and calls for opportunities to engage learners in ways that allow them to grapple with the complexities of the issues, approaches, and perspectives (Burns, 2011; Colucci-Gray et al., 2006; Blatt, 2012). Closely related to this is an emerging recognition of the necessary interplay between the cognitive and affective dimensions in this type of education. Students often have strong emotional responses in the process of developing critical awareness around the problems (Blatt, 2012), and conflict is a probable result of the process of engaging diverse, subjective perspectives around complex topics (Colucci-Gray et al., 2006). Developing a personal

connection to nature, and a sense of wonder, respect, and interest in understanding the human place within the world, is an element of sustainability education that transcends intellectual understanding and increases student interest and engagement (Littledyke, 2008; Orr, 2011). This affinity for the natural world that often equates to environmental behaviors has likewise been shown to have a relationship with the attributes of holistic thinking and creativity, two types of higher-level cognitive skills (Leong et al., 2014). Sustainability education provides a comprehensive framework that accounts for content, pedagogy, and context.

Place-Based Learning

The context of sustainability education is necessarily place-based, as the engagement with the local environment and community allows students to directly participate in issues (Burns, 2011), while providing opportunities to develop the personal connection to nature that is a key element of environmental literacy (Oregon Environmental Literacy Task Force, 2013). The conservation corps program that is the focus of this study is inherently place-based. The literature in the realm of place-based learning supports the academic benefits of this approach and provides insights to the development of class activities that further reinforce this aspect of the program.

Knapp (2005) summarizes the characteristics and approaches of place-based learning and defines place-based education as a "curricular and instructional approach designed to help students learn about the immediate surroundings by capitalizing on their lived experiences" (p. 278). The five approaches to place-based education that he

proposes include 1) studies of local cultural or historical phenomena, 2) natural investigations such as wildlife observations, water-quality testing, or riparian habitat restoration, 3) real-world problem-solving, where students and teachers identify, study, and propose solutions to local issues, 4) internship or career opportunities and local economics, and 5) student participation in community decision-making. He identifies a number of characteristics of place-based programs: use of surrounding area as the context for curriculum development; active student-directed learning, in which students' questions and interests influence what is studied; shift of teacher role to co-learner and facilitator; permeability of walls between the school and community; and assessment of student work based on contributions to community well-being and sustainability. Additional characteristics include multidisciplinary curriculum, extension of curriculum goals beyond economic aims, and integration of multiple systems and layers of the community, including ecological, economic, generational, and cultural. Knapp draws on the work of Aldo Leopold, the author who introduced the concept of the 'land ethic' to the American cultural imagination, to offer a "pedagogy of place" that includes ten practices to incorporate into place-based education. These include 1) wondering and questioning, 2) knowing local history, 3) observing seasonal changes, 4) listening intently, 5) counting and measuring, 6) empathizing with and personifying nature, 7) connecting elements in cycles, 8) finding beauty, 9) seeking solitude for reflection, and 10) improving land health. This theoretical and practical framework provided support for the development of the curriculum of this study.

While Knapp (2005) provides a broad overview of place-based learning, Lieberman and Hoody (1999) reveal the academic benefits that this approach can provide. The authors present the results of a comprehensive study of a number of schools with Environment as an Integrating Context (EIC) programs, which use the local natural and socio-cultural environment as the context for education. The purpose of the study was to describe the common features of EIC programs, to identify EIC best practices, to examine factors that allowed success, and to compile data on student academic achievement. The study included 40 schools that use the EIC approach: 15 elementary, 13 middle, and 12 high school. Schools ranged across the socioeconomic spectrum with 73% in higher middle to highest income and 27% in lower middle to lowest income. A researcher visited each school and made observations; interviewed teachers, students, and administrators; and gathered samples of curricular materials and student work. Fourteen schools provided comparative analyses of data for EIC students and traditional students, which included standardized tests, grade point averages, student attitude measures, disciplinary referrals, and attendance. In addition to interviews, individuals completed four surveys assessing the effects of EIC. These included 1) general site survey, which looked at student and teacher participation, program history, and school characteristics, 2) learning survey, assessing students and learning, 3) teaching survey, concerning teachers and instruction, and 4) domains survey, exploring effects on student knowledge, skills, retention, and attitudes toward learning. The total number of interviews was 655, which included 252 teachers and 403 students. The common characteristics of these forty programs included an

interdisciplinary approach to subject matter that allowed students to recognize how systems fit together; collaborative instruction that included teachers from different disciplines as well as parents or specialists from the community; emphasis on problem-solving and projects that appeal to a variety of learning styles provide authentic experiences; combination of cooperative and independent learning that allowed students to demonstrate their unique skills and abilities, and benefit from those of fellow students; and learner-centered and teacher-facilitated instruction. Findings from the qualitative measures indicate that students in EIC programs showed better performance on academic achievement, fewer discipline and classroom management issues, increased engagement and enthusiasm for learning, and greater sense of pride and ownership in accomplishments. EIC programs showed increased success for at-risk students—those who had previously exhibited difficulty in focusing on academic work—through providing a higher diversity of educational experiences that accounted for a range of learning styles. Academic improvements were noted across a number of disciplines, including language arts, math, social studies, and science. In science, students showed increased knowledge and understanding of content, concepts, processes, and principles; better ability to apply science to real-world situations; higher engagement, enthusiasm, and interest in science; and deeper understanding of the relation of science to their everyday lives. EIC programs also offered improvements in cognitive skills, including creative thinking, problem solving, and systems thinking. Finally, through the emphasis on student and teacher collaboration, students in EIC programs showed better ability to function in groups and improved

communication with fellow students, and experienced a sense of belonging and community. This study provides strong evidence to support the claim that place-based learning programs can promote academic outcomes in participating students. This reinforces a hypothesis of this study, which posits that a place-based program can promote academic outcomes in participating youth.

The relationship between place-based learning and outcomes that promote academic success is further explored by Athman and Munroe (2004). These researchers explore the relationship between environment-based education and high school students' critical thinking skills and disposition toward critical thinking. Environment-based education describes formal instructional programs that use the local environment as the context for student learning. Characteristics include interdisciplinary learning, project- and issue-based experiences, learner-centered instruction, and constructivist methods. This study examined programs in eleven Florida schools which met the defining characteristics of environment-based education, were established for at least two years, and represented a diversity of socioeconomic status, achievement level, geographic location, and program activities. Two methods were used to establish control groups: ideally, students in traditional environmental science courses at the same schools were used. When such courses were not available, students from schools with similar socioeconomic status, state assessment achievement, and geographic setting were used for the control group. The researchers collected data from 165 ninth graders and 239 twelfth graders over the course of the 2001-2002 school year. They used the Cornell Critical Thinking test to measure general critical thinking skills, and the

California Measure of Mental Motivation to examine disposition toward critical thinking. While *critical thinking* describes the cognitive process of solving problems, making decisions, or evaluating ideas, and the skills necessary to do so, *disposition toward critical thinking* is an individual's inclination to use critical thinking when faced with the opportunity to do so. In addition to the quantitative data, Athman and Munroe interviewed students and teachers in the treatment group to identify program characteristics influencing students' success. The results of the study indicate that, when controlling for achievement level, gender and ethnicity, there was a significant positive effect of environment-based programs on both ninth and twelfth grade students' critical thinking skills. Controlling for the same variables, there was no statistically significant change in ninth grade students' disposition toward critical thinking, while twelfth grade students' showed a significant positive effect. The characteristics that emerged from the qualitative data as significant influences on student critical thinking and disposition toward critical thinking included: integration of multiple disciplines around a common environmental theme; open-ended projects requiring hypothesizing, investigating issues, and conducting research; students empowered and responsible for their own learning; and incorporation of reflection on experiences and learning, allowing students to make the connection to the purpose of their efforts. Based on the results of this study, the researchers make a number of recommendations for environment-based programs: include students of all achievement levels, structure programs for participation over multiple years, and provide educators with the opportunity and freedom to choose this

approach. Additionally, they emphasize the systemic nature of environment-based education: that is, using traditional teaching methods in the local environment does not have the same impact on critical thinking as a program which integrates all of the characteristics of environment-based education. This study provides further evidence to support the use of place-based learning to promote academic outcomes, and the authors' recommendations for such programs were taken into account in the development of the curriculum for the youth conservation corps program study.

While these two studies examined place-based learning from an interdisciplinary perspective, Hamilton-Ekeke (2007) examined outcomes specific to science education. She compared student conceptual knowledge in ecology through the use of expository teaching methods in the classroom and investigative teaching methods in a field trip setting. She asked the question: what is the achievement of students in ecology before and after they were taught, using the expository and field trip methods of teaching? Three secondary schools in the Ogbia school district in the Niger Delta Region of Nigeria were randomly designated as Group A, which received the field trip method, Group B, which received the expository method, and Group C, which were not taught but possessed some knowledge of ecology. Twenty boys and girls (age equivalent 11th grade) were randomly selected in each school, with a total sample size of 120 biology students (60 boys and 60 girls). A pre-test was administered to all students. Researchers in both groups taught the same six ecology units in 70 minute lessons over the course of three weeks, and students in both groups worked in teams of four. The field trip method included taking students outdoors to the school farm, or to a

nearby stream, pond, and forest behind the farm. This method included three types of outdoor teaching: fieldwork and outdoor visits, outdoor adventure education, and school grounds/community projects. The expository method taught the same units in the classroom, using methods of explaining and describing. The researcher developed the instrument of study, the Ecology Achievement Test, which consisted of twenty questions, 18 multiple choice and two sentence completion items. The pre-test results for all three groups showed similar results, indicating that the three groups were intellectually homogenous in the area of ecology. The post-test results showed significant differences between the three groups. The mean score for Group A was significantly higher than that of Group B, which showed a slight increase from the pre-test. Results for Group C showed no change. The results of this study indicate that the field trip method is superior to the expository method in improving student achievement in ecology. Given that the academic focus of the youth conservation corps study is on environmental science, this study supports the effort to use place-based methods to promote outcomes in more specifically focused content.

Place-based learning may be called by many names and take on many forms, but the term encompasses any educational program that takes place within the context of the community and landscape in which it is situated (Knapp, 2005; Lieberman & Hoody, 1999; Athman & Munroe, 2004). There is an inherent degree of variation between place-based curricula, but common themes emerge throughout the literature. Place-based learning includes experiential, project-based activities in which students assume the role of active participants. Much of the learning takes place outside of the

classroom, in the natural and cultural locales of the community, and capitalizes on local resources and opportunities (Knapp, 2005; Lieberman & Hoody, 1999; Athman & Munroe, 2004; Hamilton-Ekeke, 2007). Place-based learning can involve one class studying one particular unit (Hamilton-Ekeke, 2007), but is richest when it takes advantage of the multidisciplinary complexity of the issues and opportunities that are unique to local communities (Knapp, 2005; Lieberman & Hoody, 1999; Athman & Munroe, 2004). This approach has shown increases in student achievement, understanding, and interest in all disciplines when they were incorporated into this framework (Lieberman & Hoody, 1999). Even when the place-based approach is limited to a single discipline, as in Hamilton-Ekeke's (2007) study in which students used the school farm and nearby natural areas to learn ecology, students show significant gains in academic achievement compared to those learning the same concepts in a classroom setting. Additionally, place-based learning has been shown to increase cognitive skills such as creative thinking, problem solving, systems thinking (Lieberman & Hoody, 1999) and critical thinking (Athman & Munroe, 2004), as well as social and affective outcomes such as ability to work in a group, communication skills, and sense of belonging (Lieberman & Hoody, 1999). The theoretical framework and instructional approaches outlined in the literature directly influenced the curriculum design of this study, and the existing research in this area provides support for the hypothesis that a place-based program can promote academic outcomes for youth.

At-Risk Youth and Positive Youth Development

The third research focus for this study was on promoting positive outcomes for academically at-risk youth, which can be collectively referred to as Positive Youth Development (Catalano et al., 2004; Umholtz, 2013. The participants of this study are all considered academically at-risk, which means that they are at risk of school failure, dropout, or delinquency (Tobin & Sprague, 1999). The literature in this area was assessed specifically for theoretical and practical insights on promoting academic success for this population, with specific attention given to the approaches that overlapped with sustainability education and place-based learning.

Johnson (1998) synthesizes the existing literature on effective classroom practices for at-risk students into twenty principles of instruction to promote academic success for this population. While there is a large amount of attention given to administrative, curricular, policy, and funding initiatives to increase at-risk student success, the instructional practices of classroom teachers are a key element in achieving this outcome. Given at-risk students' unique learning demands, the following practices are suggested. Maintain high expectations; make use of praise; capitalize on learning technologies; balance direct instruction with challenging activities; teach learning strategies; accommodate student learning styles; establish an experiential base for learning; focus on meaningful skills, concepts and activities; use examples and demonstrations; actively involve the students; encourage cooperative learning; ask and encourage questions; teach self-monitoring and self-management; provide creative opportunities for practice and review; integrate skills and concepts throughout the

curriculum; build student interest and enthusiasm; manage the instructional process efficiently; celebrate cultural diversity in the classroom; and facilitate parental involvement with the school. Most of these practices are recognized by educators as sound instructional practices for all students, but can especially increase the academic success of at-risk students. A number of these approaches were directly integrated into the program experience of this study.

Expanding from the classroom to the program level, Tobin and Sprague (1999) offer definitions and broader best practices for alternative education programs, based on existing literature. These programs provide alternatives for students at risk of school failure, dropout, or delinquency. The overall goal of alternative programs is to assist students to meet academic and behavioral goals in flexible learning situations. The authors offer best practices for alternative programs: low student-to-teacher ratio, which allows more time for each student and higher quality of instruction; positive reinforcement for desired behaviors rather than punitive emphasis; and social skills instruction in small group settings, including problem solving, vocational social skills, and conflict resolution and empathy. High quality academic instruction for alternative programs includes controlling for difficulty of instruction, group collaboration, and directed responses and questioning of students. The practices in this review reinforce a number of the existing characteristics of the youth conservation corps program of this study, and provided insights for development of the curriculum and refinement of the program culture.

Alfassi (2003) explores the relationship between academic achievement and self-efficacy in a learner-centered academic program for academically at-risk students. Prior research has shown the role that academic self-efficacy—personal beliefs about one's capabilities to take courses of action to attain desired educational outcomes—has on student motivation, behavior, emotional states, and ultimately, academic success. The practical application of self-efficacy research includes creating opportunities for students to experience academic success through authentic mastery experience. The author explores one model of this approach, studying 37 academically at-risk students at an Israeli remedial high school. She used a group of 15 students enrolled in a conventional remedial school as a control group. Students in both groups were characterized as potential dropouts, and both alternative programs served a school system composed mainly of students with low socioeconomic status. Age ranged from 14 to 17. The experimental program was a learner-centered, structured academic program. Teachers worked closely with students to detect their strengths and weaknesses, and to construct individualized educational programs (IEPs) that adapted to the personal needs and interests of the student. Students were evaluated and assessed frequently, and results were used to develop further learning goals and materials. The control group program also used IEPs, but these included only instructional goals. Assessments were used to place students in homogenous classes, where instruction and learning materials were determined according to selected textbooks and lecture methods. Alfassi used three academic skill tests to measure student academic ability in math and language arts. She also used the Academic Self-Efficacy Scale in both

subjects, and the Intrinsic versus Extrinsic Orientation Scale to measure learning motivation. Her results show significant differences between the experimental and control groups, with the experimental group scoring higher for both academic proficiency and self-efficacy. She found significant positive correlation between the two measures. Students in the experimental group showed higher internal motivational orientation. While results did not indicate that motivational orientation impacted achievement scores, there was a significant positive correlation between measures of self-efficacy and motivational orientation. This indicates that student confidence in a given subject area relates to a mindset that perceives difficulty as a challenge to be mastered rather than a threat to be avoided. The findings of the study indicate that a program developed with the intention of fostering self-efficacy (competence and confidence) in academically at-risk students through individualized, learner-centered approaches that allow students opportunities to experience success through authentic mastery experiences can directly contribute to both academic achievement and student motivation. Although the self-efficacy construct in this youth conservation corps study assessed a broader construct, the findings of this study contributed to the instructional approaches used in the program treatment.

Further expanding on the research focusing on promoting academic outcomes for at-risk youth, McMillan and Reed (1994) integrate findings from existing literature and their own studies on resiliency to identify factors that promote academic success among students who may be classified as at-risk, but who are doing well in school despite the odds against them. The authors examine nine sources, including six studies,

to distinguish themes around academic success and resiliency. The four factors they identify are: individual attributes (such as positive attitude, high intrinsic motivation and internal locus of control, and clear goals), positive use of time (including extracurricular activities, hobbies and creative interests, and helping others), family factors (having at least one close bond to an adult family member who lends love and support), and school factors (usually teachers who offer emotional connection and high academic expectations, as well as school activities that provide a sense of belonging). The authors suggest that teachers implement instructional strategies that promote the individual attributes of self-efficacy, optimism, internal locus of control, and sense of personal responsibility, as well as create opportunities for goal setting. Teachers should maintain high academic expectations, while stressing the relationship between success and effort. Creating an environment of support and belonging, both in the teacher-student relationship and between students, can contribute further to student success. Again, the results and emerging recommendations of this study contributed to the design of the treatment of the youth conservation corps study.

Extending beyond academic outcomes, Catalano et al. (2004) examined twenty-five positive youth development program evaluations and summarized the outcomes. They give an overview of the history of youth programs, which have shifted from addressing specific problem behaviors to focusing on preventative and protective factors that promote positive youth development. Positive youth development programs seek to achieve one or more of 15 outcomes. These include: promote bonding (the emotional attachment to social relationships in various settings); foster

resilience (capacity for adapting to change); promote social, emotional, cognitive, behavioral, and moral competence; foster self-determination (ability to think for oneself and take action from that thought); foster spirituality; fosters clear and positive identity (a coherent sense of self); foster belief in the future; provide recognition for positive behavior; provide opportunities for prosocial involvement; and promote prosocial norms. The programs included in this review addressed five or more of the above constructs in one or more social domains, and involved youth between 6-20 years old who were either in the general population or at risk (i.e. not in treatment settings). Out of 161 programs originally identified, 77 had evaluations that met criteria for analysis. These were reduced to twenty-five programs that met the above criteria; had strong evaluation designs, acceptable statistical validity, and adequate methodological detail; and evidenced positive effects on youth outcomes. Of these, eight focused on one social domain, eight on two domains, and nine on three domains. The most common social domains included school, family, and community, while two studies included church and workplace, respectively. Nineteen programs showed improvements in positive youth behaviors, and twenty-four showed declines in problem behaviors. The common characteristics of these successful youth development programs included use of methods to strengthen social, emotional, behavioral, cognitive, and moral competencies; build self-efficacy; create clear standards for behavior from social domains; increase healthy bonding with peers, adults, and younger children; expand youth opportunities and recognition; and provide structure and consistency. The results

of this review reinforce the importance of affective outcomes mentioned in the literature on at-risk youth.

More specifically related to the content and context of the youth conservation corps program in this study, Umholtz (2013) provides a research-based theoretical framework that connects positive youth development with environmental-based experiential curriculum. He notes the alienation and disconnection that many youth experience, especially those who are economically or culturally marginalized, and asks what educational strategies might empower these students in their own learning and as members of their own communities. Positive youth development programs aim to support youth in building positive qualities, and environmental education provides a natural context for these outcomes. The author summarizes the basic concepts of the Environment as an Integrating Context model, which include experiential learning through problem-solving or project-based activities in local communities, interdisciplinary instruction, cooperative and independent learning, recognition of individual students' unique skills and abilities, and the development of knowledge and appreciation for the environment and surrounding community. Additionally, he emphasizes the need for critical reflection and action, in order to develop awareness of the complexities and connections between environmental and social problems, and the systems of domination and oppression that perpetuate them. The integration of these educational approaches can give disempowered youth a sense of connection and meaning, opportunities to develop positive relationships, and the experience of making positive change in their local communities. This integration of place-based learning and

positive youth development provides a theoretical basis that reinforces the marriage of these two research areas.

Approaches to fostering positive outcomes for academically at-risk youth can be collectively referred to as Positive Youth Development (Catalano et al., 2004; Umholtz, 2013). There is recognition in the literature that the factors influencing student academic success or failure are multifaceted and include a complex interplay between self-concept, family and home life, social and community context, and school factors (Alfassi, 2003; McMillan & Reed, 1994). Methods to support youth in achieving success must likewise work on various levels, accounting for the cognitive as well as the affective dimensions of the individual. On the cognitive level, it is important to maintain high academic expectations while providing structure, consistency, and positive reinforcement (McMillan & Reed, 1994, Johnson, 1998; Alfassi, 2003; Tobin & Sprague, 1999). When introducing content, it is important to teach to a number of different learning styles (Johnson, 1998; Tobin & Sprague, 1999). Relevant and experiential lessons and activities, active learning that allows students to take ownership of their education and accounts for student interests, and cooperative learning (Johnson, 1998; Tobin & Sprague, 1999; Umholtz, 2013) are some of the instructional methods that may contribute to student success. Providing opportunities for students to experience authentic mastery experiences can increase academic competence and confidence (Alfassi, 2003). There is a connection throughout the literature between student academic success and students' internal constructs such as self-efficacy, personal responsibility, motivation, self-determination, attitude, and perceived locus of control

(Alfassi, 2003; McMillan & Reed, 1994; Catalano et al., 2004; Umholtz, 2013). There is also a clear need to create an environment of belonging that allows students to develop positive relationships with one another and with supportive adults (Johnson, 1998; Tobin & Sprague, 1999; McMillan & Reed, 1994; Catalano et al., 2004; Umholtz, 2013). These themes that emerged from the literature in this research area were used to reinforce existing elements of the youth conservation corps program, refine the instructional approaches of the treatment curriculum, and refine the instrument used to evaluate student affective outcomes.

Instruments

The outcomes of this study directly emerged from the literature in sustainability education and positive youth development. The instruments used to assess these outcomes were drawn from a number of existing sources, all of which have their own research base.

The instruments used to assess student outcomes in the realm of environmental science, the ecological understanding construct of environmental literacy, as well as the affective outcome evaluation, were developed with instruments based on the research of Saxton et al. (2014). These authors propose a common measurement system for STEM education that accounts for the interconnections between variables in complex school systems. They describe a theoretical framework developed by the Portland Metro STEM Partnership, a collective impact partnership, which includes four leverage points for improving STEM education as well as the sub-factors within them,

relationships between them, and instruments (either existing or in development) to assess them. The first leverage point is student learning. This includes 1) application of conceptual knowledge, which emphasizes deep content knowledge and application rather than isolated facts, definitions and formulas; 2) higher order cognitive skills, including problem-solving, developing evidence-based arguments, oral and written communication, and metacognitive skills; and 3) academic identity and motivational resilience, or students views of themselves and their potential to succeed in STEM fields as well as persistence in the face of challenging coursework. The second leverage point is teacher practices, which has three sub-factors. First, STEM pedagogical content knowledge, or teachers specialized knowledge about teaching STEM topics. Second, specific instructional practices: 1) facilitating active student engagement, 2) emphasis on deep content knowledge and higher-order cognitive skills, 3) creating and implementing multiple and diverse opportunities for students to develop these skills, 4) use of frequent formative assessments, and 5) use of learning activities that are relevant and connected to students' lives. Third, supportive teacher-student relationships, which include fostering positive relationships, holding high academic expectations, and including students in the decision-making process. The third leverage point is teacher professional development, which includes focus on developing STEM pedagogical content knowledge, effective instructional practices, and teacher self-efficacy. The fourth leverage point accounts for school level variables and includes collective teacher efficacy and transformational leadership. The STEM Partnership is developing research-

based instruments or adopting existing instruments to measure each of the variables contained within the four leverage areas.

The nature connection construct of environmental literacy in this study was assessed with the instrument developed by Nisbet, Zelenski, and Murphy (2008). They conducted two studies to test the reliability, construct validity, and correlates of the Nature Relatedness (NR) scale. The researchers used existing environmental measures, literature, and their concept of nature relatedness to develop an initial questionnaire of 30 items to assess the affective, cognitive, and experiential aspects of individuals' connection to nature. In the first study, 831 Canadian undergraduate psychology students responded to the NR items, as well as a number of other scales assessing environmental attitudes, values, and beliefs, as well as personality measures. From these initial responses, 184 participants were randomly selected for a follow-up session. In this second phase of the study, the students answered questions about various environmental behaviors and attitudes, including: vegetarianism, pet ownership, organic and fair-trade purchases, participation in environmental organizations, self-definition as an environmentalist, and frequency and type of outdoor, nature-related activities. Data from both phases of the initial study was analyzed for internal reliability and construct validity, and the initial list of 30 items was refined to 21. These resulting items were separated into three categories. NR-Self reflects an internalized identification with nature, including feelings and thoughts about an individual's personal connection to the natural world. NR-Perspective represents an external, nature-related worldview and a sense of agency and awareness around human actions and their impact

on nature. NR-Experience is the physical familiarity and comfort with, and the desire to be out in, the natural world. Statistical analysis showed moderate correlation between the measure of NR-Self with the other two measures, while the correlation between the latter two was weak. The correlation between differences in NR and participants' environmental behaviors and attitudes was statistically significant for each variable; that is, those who showed higher measures of NR were more likely to participate in the behaviors and attitudes listed above. Additionally, the researchers used further statistical analysis to compare this scale to others that purport to measure environmental attitudes and found NR to be unique in its ability to predict environmental behaviors. These results support both the construct and discriminant validity of the NR scale. In the second study, 145 Canadian executives completed a baseline survey, including the NR scale and personality measures. Following the initial survey, participants reported frequency of time spent outdoors and in nature in biweekly surveys collected over a period of eight weeks. Resulting data showed a positive correlation between nature relatedness and frequency of time spent outdoors and in nature. The combined results of the two studies show an overall correlation between nature relatedness as assessed with the 21-question survey and measures of environmental behaviors and attitudes, as well as time spent outdoors and in nature. These findings show that this tool is a reliable and valid measure of individuals' connection with nature.

The third environmental literacy construct in this study is self-efficacy, which was measured through a general self-efficacy scale adapted from Sherer et al. (1982). These

researchers developed a measure of general self-efficacy based on self-efficacy theory, which says individuals' expectancies in two areas influence behavior. These are outcome expectancies, or the belief that certain behaviors will lead to certain outcomes, and self-efficacy expectancy, which is the belief that an individual can successfully perform the behavior. Although self-efficacy had previously been conceived as situation-specific, the authors note evidence that experiences of mastery may generalize to areas beyond the action in question. That is, varied experiences of success or failure may contribute to a broader sense of self-efficacy that an individual carries into new situations. The original survey was developed to assess this broader measure of self-efficacy, and focused on three areas: "(a) willingness to initiate behavior, (b) willingness to expend effort in completing the behavior, and (c) persistence in the face of adversity" (Sherer et al., 1982, p. 665). In order to determine the validity and reliability of this survey, the researcher conducted two surveys. The first included 376 psychology undergraduates, who completed the original 36-statement survey alongside six additional personality measures. Upon analysis, the original 36 statements were reduced to 17 measuring general self-efficacy. Construct validity was determined through correlations with other personality measures, including locus of control, personal control, social desirability, ego strength, interpersonal competence, and self-esteem. The purpose of the second study was to provide evidence of criterion validity through positive correlation of the self-efficacy measure with past mastery experiences. The study included 150 veteran inpatients in an alcoholism treatment program, who completed the self-efficacy survey and a demographic questionnaire

designed to measure success in vocational, educational, and military areas. Both studies confirmed the hypothesized relationships between self-efficacy and other personality measures, as well as past successes.

Summary

The literature in the realms of sustainability education, place-based learning, and positive youth development all emphasize the importance of recognizing students as whole people who have unique and diverse learning needs and perspectives, engage with the world through emotional connections and psychological constructs, and are nested within the context of the larger group, community, and natural world. There are a number of other common threads that weave through these three areas, and which provide the framework for a rich and rewarding learning experience.

Sustainability education calls for a systems approach that engages students' emotions as well as their minds and challenges them to think critically and reflect openly about complex issues, while empowering them to participate in solutions to complex socio-environmental issues. Place-based learning has the potential to meet the goals of education in a non-traditional way, taking education out of the classroom and putting it in the context of the greater community. It is experiential and relevant, draws on students' interests and curiosities, and creates opportunities to engage with the real-world complexities of local communities. Students at risk of disconnecting from school and falling short of their academic potential need hands-on, meaningful experiences in

emotionally supportive environments that empower them to actively engage in their education.

The best practices that emerge from research in sustainability education, place-based learning, and promoting positive outcomes for academically at-risk youth point to a natural integration of the three (see Appendix A). There is, however, little research that focuses on the effectiveness of place-based and sustainability education as it relates to students considered academically at-risk. In an educational system that sees increasing numbers of students placed in this category, this integration may provide a practical model for reconnecting youth to meaningful educational experiences.

The purpose of this research study is to explore whether a program that integrates strategies and instructional approaches from these three realms contributes to the environmental literacy and affective outcomes of students in this population. Environmental literacy here includes the traditionally academic area of environmental science (ecological understanding), as well as students' connection to nature and self-efficacy. The instruments used in this study to measure the three outcome areas of environmental literacy include a test based on the PMSP Application of Conceptual Knowledge framework (Saxton et al., 2014), and surveys adapted from the Nature Relatedness (Nisbet et al., 2008) and General Self-Efficacy (Sherer et al., 1982) scales. The PMSP Academic Identity and Motivational Resilience survey (Portland Metro STEM Partnership, 2015) was adapted to assess student affective outcomes.

Methods

The following section thoroughly outlines this study, including a general overview as well as detailed descriptions of the participant group, the study treatment, and the instruments used to measure the dependent variables. A summary of the study procedure provides a chronological overview.

Overview

This study is a quasi-experimental mixed-method single group evaluative study with a research component. Given the small sample size (eight students), it also has characteristics of a case study. In this study, I explore two research questions: In what ways does an environmental science-based youth conservation corps program impact academically at-risk high school students' environmental literacy and affective outcomes? What are the specific elements of this program that contribute to positive student outcomes? Environmental literacy is measured through the lens of three constructs: 1) application of conceptual knowledge in ecosystem relationships and biodiversity, 2) nature relatedness, and 3) general self-efficacy. The hypothesis of this study is that the integration of a curriculum and culture grounded in research-based pedagogical approaches with active participation in habitat restoration efforts will increase students' abilities to understand and apply environmental science concepts, deepen their connection to the natural world, and increase self-efficacy, while influencing positive affective outcomes.

The independent variable in this research study is a six-week research-based environmental science curriculum integrated into a youth conservation corps program. This program uses the context of community habitat restoration to create opportunities for students to learn concepts in environmental science, develop leadership and life skills, and gain work experience. It provides an experiential, relevant, and relationship-based academic option for high school seniors who have previously struggled in the traditional academic setting. Students spend two days per week with a team of peers, working together on local habitat restoration projects provided by community partners. Weekly education days integrate field experiences with science content, and take place both in the classroom and outdoors. During the study period, I acted as crew leader and teacher, designing and implementing the program curriculum while also conducting the research with participating students.

The dependent variables in this study include environmental literacy and affective outcomes of participating students. Environmental literacy was assessed through the measurement of three outcome areas: ecological understanding, connection to nature, and self-efficacy. Understanding and application of student knowledge in the content area of ecosystem interactions and biodiversity was assessed before and after the study period, with a test developed using the Portland Metro STEM Partnership (2014) framework as a guide. Individual student connection to nature was measured with the Nature Relatedness (NR) Scale (Nisbet et al., 2008), which measures the affective, cognitive, and experiential dimensions of nature connectedness. Sherer et al.'s (1982) General Self-Efficacy Scale was adapted to assess students' self-efficacy. An

affective evaluation survey, modified from the Portland Metro STEM Partnership's (2015) existing instrument, was used to measure affective outcomes including students' sense of belonging, achievement value, engagement, and motivation. To provide a more comprehensive picture of students' experiences in the program, semi-structured personal interviews were used to complement the data in all four focus areas. The interview portion of the study was also intended to discern the elements of the program that individual students found to be most beneficial in contributing to their conceptual understanding, skills, and connection to nature. The chart below (Figure 2) shows a visual representation of the study design.

	2 Weeks Prior	Week 1-6	Week 6	Week 7	Week 8-10
N	O_1	X	O_1	$O_{2,3,4}$	O_5

Key:

N: Non-randomized group

X: Treatment

O_1: Application of Conceptual Knowledge Test

O_2: Connection to Nature retrospective pre-post survey

O_3: Self-Efficacy retrospective pre-post survey

O_4: Affective Evaluation post-survey

O_5: Individual student interviews

Figure 2. Notation of study design.

Participants

The youth involved in this study were eight academically at-risk high school seniors enrolled in an internship-based alternative program housed within a large suburban high school who were participating in the conservation corps program for credit toward their high school diploma. These students came from a variety of racial and cultural backgrounds and socioeconomic levels. All of them were behind on credits and at risk of not graduating from high school, although the reasons for this common characteristic were as diverse as the students themselves. Some of them had been diagnosed with learning disabilities, others had complications in their home and personal lives, others made poor choices in school when they were younger and were catching up with the consequences. The youth conservation corps program that is the focus of this study was an internship option for students enrolled in the larger alternative program.

Students come to participate in the conservation corps program through a multi-step process. The alternative program requires interested students to apply, followed by an interview with the two learning directors (licensed teachers who run the program and work with students), and at least one parent. Within the first two weeks of the program, students are required to take and pass a drug test. Although it is not a requirement that participating students show evidence of school failure, the large majority of students enrolled at any time are those who have struggled in the traditional classroom setting and/or are not on track to graduate. Many students are referred by

school counselors or learn of the option through fellow students who have met with success in the program.

While enrolled in this alternative program, students are required to participate in internships in the local community. Most of the internships are individual placements in local businesses and organizations, where students spend two class periods a day, four days per week. Interns remain in their placement for the course of 1-2 months. During this time, students may be enrolled in classes at the high school while working on individualized coursework to meet their remaining credit needs with the support of two licensed teachers.

The conservation corps program that is the focus of this study is an internship option for students enrolled in this alternative program. It differs from other internships in its team-based structure, direct relevance to science education, modified weekly schedule, and duration of placement. In addition to the career-related elective credits received through any of the available internships, participants also earn general science credits. Individuals are eligible for the program based on their credit needs, class schedules, and personal interest. A second interview process occurs for enrollment in the program, followed by a two-week probation period to determine whether the student is a good fit. The minimum length of enrollment is two internship cycles (about two months), but students may participate for up to an entire school year. Average length of participation is 4-5 months. In addition to high school credit, students may earn college elective credit through a dual enrollment agreement with a local community college. They also earn scholarship monies through a funding

partnership with Oregon Youth Conservation Corps: students who participate for a minimum of three months and meet program expectations receive $125 per month for up to $1,125. All names used in this document are pseudonyms used to protect students' real identities.

Treatment

The treatment of this study was a six-week curriculum within the conservation corps program, which integrated authentic work experience on community habitat restoration projects with place-based environmental science education. Two days per week, participating students worked together on restoration projects in the local community, within the Tualatin and Willamette River watersheds. One day per week students engaged in educational activities intended to contextualize the restoration experience within larger ecological and social systems. Acting in the dual roles of researcher and educator, I designed the science curriculum and served as the teacher and crew leader for the duration of the study period. The science content of the curriculum comes from the National Research Council's *Framework for K-12 Science Education* (2012), namely section LS2: Ecosystems: Interactions, Energy, and Dynamics, and LS4.D: Biodiversity and Humans.

Classroom component. The classroom component of the curriculum explored the content area of ecosystem relationships and biodiversity. The full outline of daily activities and assignments, including a number of student handouts, can be found in Appendix B.

Students were assigned readings from various sources. The primary source was the Biodiversity Guide for the Greater Portland-Vancouver Area (The Intertwine Alliance, 2012), a collaborative scientific document that underlies the Regional Conservation Strategy for the Portland Metro Area, and which outlines regional habitat types, threats to biodiversity, and conservation strategies. Students applied the information and concepts from these readings in classroom activities, including creating interactive webs of different local habitats, and developing and manipulating models of ecosystems. Biodiversity concepts were grounded in experiential study, through a survey of aquatic invertebrate species at two riparian sites. This study took place at Brown's Ferry Park, a nearby suburban natural area park where students had earlier in the year been involved in developing and implementing a restoration project plan. The second half of the curriculum period focused on threats to biodiversity and local solutions. Students watched the video "Call of Life" (Van Burg & Thompson, 2010) and engaged in group discussion around the film, including voicing their own emotional responses to the challenging content. They then worked together in groups of 2-3 on a "Solution Project" engineering design assignment, where they were given the task of developing an actionable response to the problem of biodiversity decline in the local community, which allowed them to apply the concepts they had gained over the study period to a real-life scenario. Other elements of the curriculum included short videos, comprehension worksheets, written reflection, and partner discussions. Additional readings were used to expand on understanding of ecological systems, biodiversity, and ecosystem services.

In addition to the readings, students were given an ongoing out-of-school assignment for the study period. They were asked to find a nearby outdoor spot to visit weekly for 20-30 minutes, where they could make observations and connect content to direct experience. Students completed a weekly journal reflection of their "sit spot" experience, and participated in a check-in at the beginning of each weekly class day, where they shared their observations and thoughts with other students.

Field component. Place-based education that emphasizes service learning through the conservation corps model allows students to participate in local solutions to ecological problems, while recognizing their place in the web of life, and identifying both human dependence and impact on healthy ecosystems. During the course of participation, students spent two days per week working together on local habitat restoration projects for community agency partners who contract for student work and pay a nominal daily fee. Students filled individual job roles on the team and were responsible for ensuring the day-to-day operation of the program.

Each field day began by circling up and each student leading a stretch and sharing something that they were grateful for. After we received the day's project plan and site orientation from the sponsor, I would facilitate a conversation with students to set daily goals and develop strategies for achieving them. After lunch, we checked in to determine the team progress toward the goals we had set in the morning, and to discuss whether the goals or strategies needed any revision. At the end of each work day, students gathered in the classroom for a group reflection discussion, which included recording the project outcomes for the day, noting challenges and successes as

well as opportunities for improvement, and listing a daily account of the different species of plants and wildlife encountered and identified.

During the period of this study, students participated in a variety of restoration projects at sites throughout Washington County and the Portland Metro area. Projects included installing protective tubing on a new native restoration planting adjacent to Tualatin River Wildlife Refuge; planting trees at a neighboring park for Arbor Day with fellow students and teachers, city maintenance staff, and the town mayor; sorting, culling, and transplanting rare native plants at the Metro Regional Government Native Plant Center and Clean Water Services' Tualatin River Farm; mulching new native plants at a Beaverton homeowner's association site in partnership with Clean Water Services; canoeing on the Willamette River to the recently reclaimed industrial site on Ross Island where students identified and removed invasive garlic mustard plants (which included one overturned canoe); planting wetland species at Fernhill Wetlands; and maintaining established plantings at various Wetlands Conservancy sites. At each of these projects, spontaneous opportunities arose for students to learn about and connect to the natural world, including spotting nesting birds, catching frogs, spotting wildlife tracks, and finding beaver skulls.

Pedagogical approaches. The integrated curriculum of this program was grounded in theory from literature and research in sustainability education, place-based learning, and positive youth development (see Appendix A). The unique combination of field and classroom learning allowed for a program curriculum that was experiential, relevant, and relationship-based. Each of the activities of the class component of the

curriculum were intentionally chosen and crafted to be experiential, relevant, or relationship-based, and most of them were intended to meet all three criteria simultaneously when possible. For example, the biodiversity Jenga activity gave students a hands-on challenge (experiential) based on local river and forest habitats (relevant) that they had to work together to complete (relationship-based), and which included data collection and reflection. The field component of the program naturally integrated the three: students had to work with one another (relationship-based) on hands-on projects (experiential) that were defined by community sponsors and which directly supported environmental quality goals (relevant). The following section outlines more specifically how the curriculum incorporated each of these pedagogical approaches.

Experiential learning includes hands-on activities that allow students opportunities to directly and actively engage with content, followed by critical reflection and application to new scenarios (Burns, 2011; Kolb et al., 2014). The field component of the curriculum was inherently experiential, allowing students the opportunity to directly participate in service experiences in their local watershed in response to authentic needs of community partners. This bi-weekly experience was followed by the daily group debrief. Class activities were designed to be largely experiential, giving students opportunities to directly interact with the content rather than simply ingesting abstract ideas. Examples from the class curriculum include collecting and interpreting data from aquatic invertebrate biodiversity surveys, applying content with biodiversity Jenga, exploring ecosystem relationships through a river web activity where students

took on the role of different ecosystem elements and mapped their connections, and visiting individual sit spots every week and reflecting on these experiences individually and with the group.

The experiential aspect of the program integrates directly with the *relevance* of the curriculum content. Relevance includes both a connection to real-world concepts as well as to students' individual lives and experiences. The field component of the curriculum allowed students the opportunity to engage with conservation professionals doing authentic work in the local community, while giving them first-hand experiences in the natural world and with restoration solutions. This direct experience allowed a personal reference point for the environmental science content of the class curriculum. The sit spot assignment allowed them to develop a personal connection to a specific place of their choosing, which they then observed through the lens of the science content, and shared with fellow students. The group discussion that took place after students watched the hard-hitting documentary on biodiversity decline (Van Burg & Thompson, 2010) allowed the space for students to express their personal emotional responses, and to acknowledge that this content is not removed and abstract but directly impacts human life. The solution project assignment that concluded the curriculum period allowed students to directly apply their understanding of the science content to a real scenario in their community of their choosing.

The team focus and small size of the program created a valuable context for students to *build relationships* with one another. Students engaged in shared experiences, worked together on field projects, and engaged in regular group

collaboration, reflection, and discussion. The majority of activities during class included collaboration with other students, and students communicated and set group goals during field projects.

Efforts to build relationships and create a space of belonging began before the curriculum period of this study, and were also intentionally woven into the informal culture of the program. All of the students were in the program for at least one month before the study period, during which time I created a number of experiences to foster connection between students and establish a culture of acceptance and growth. This included intentional teambuilding when new students transitioned in, and the establishment of implicit and explicit group norms when a large turnover occurred. These were promoted through facilitating a number of initiatives and activities that allowed students to interact, work together, and connect, while exploring ideas around making mistakes, growing through stepping out of one's comfort zone, and promoting positive group dynamics.

There are a number of small, subtle techniques used in this program to promote relationships and a culture of belonging. Each day, whether in the classroom or in the field, started with a circle in which each person had a chance to share something personal to them, whether a story about their sit spot, a highlight of their weekend, or something they were grateful for. I was an equal participant in these circles, sitting with students and sharing with them. Developing group norms at the beginning of the groups' time together, and subsequent discussion norms specific to class conversations, were two other techniques used for creating a culture of support and acceptance: these

were not imposed by myself, but discussed and determined by the students. When developing a strategy for approaching our field work projects, I encouraged (but did not require) students to work together on tasks so that they might engage in casual conversations that are often the foundation of building relationships.

Instruments

This study aims to measure the desired outcomes of sustainability education (environmental literacy) and positive youth development (affective outcomes). Environmental literacy includes the three outcome areas of understanding of ecological concepts, connection to nature, and competency skills. Changes in these three areas were measured through the three constructs of application of conceptual knowledge in environmental science, nature relatedness, and general self-efficacy, respectively. Student affective outcomes were measured with evaluative survey. Lastly, I conducted a one-on-one interview with each student to augment the quantitative data, to provide insights into aspects of student experience not indicated by other instruments, and to help identify specific elements of the curriculum that contributed to positive outcomes. Table 1, below, shows the five outcome areas and the corresponding instruments used to measure them.

Table 1.

Dependent variables of study, with corresponding instruments and sources.

Variable(s) Measured	Instrument	Type	Source
Environmental literacy: Understanding of ecological concepts	Application of Conceptual Knowledge: Ecosystem Relationships and Biodiversity	Pre-post test	Portland Metro STEM Partnership (2014)
Environmental literacy: Connection to nature	Nature-Relatedness Scale	Retrospective pre-post survey	Nisbet et al. (2008)
Environmental literacy: Self-efficacy	General Self-Efficacy Scale (adapted)	Retrospective pre-post survey	Sherer et al. (1982)
Affective outcomes: Achievement value, belonging, motivation, and engagement	Affective Evaluation	Post-survey	Portland Metro STEM Partnership (2015)
Environmental literacy, affective outcomes, other outcomes, program elements contributing to positive outcomes	Student Interviews	Semi-structured interviews	--

Understanding of ecological concepts. The Application of Conceptual Knowledge instrument accounts for the ecological understanding construct of environmental literacy, and was used to assess student learning gains in the content area of ecosystem relationships and biodiversity. The content focus of the curriculum, and the corresponding assessment, aligns with three of the five learning strands of the Oregon Environmental Literacy Plan: systems thinking, understanding of living systems, and interconnectedness of people and the environment (Oregon Environmental Literacy Task Force, 2013).

This study distinguishes between conceptual understanding as a basic grasp of content, and application of conceptual knowledge as the ability to extend this understanding to draw conclusions or make predictions. The assessment for this study was created using the guidelines, task category framework, and rubric developed by the

Portland Metro STEM Partnership (2014). As outlined in Saxton et al. (2014), the partnership is a collaborative impact effort focused on improving formal and informal STEM education through identifying and developing a common measurement system for four leverage points for change. The first of these four leverage areas is student learning, of which this instrument is a part. The PMSP approach to the application of conceptual knowledge measure emphasizes deep content knowledge and application rather than memorization and recall of isolated facts, definitions and formulas (Saxton et al., 2014). Rather than a fact-based test, this assessment consisted of three multi-part constructed response questions designed to allow students to demonstrate their understanding and application of concepts explored during the curriculum period. It also included two multiple choice with open response questions that were designed to assess student understanding around common misconceptions in environmental science.

Students were given a pre-test to assess their proficiency in the content area of ecosystem relationships and biodiversity before the curriculum period began. This test served as both a baseline measure of student knowledge as well as a formative assessment used to refine the curriculum. At the end of the six-week period, students completed a post-test, which measured understanding and application of the same conceptual knowledge as the pre-test. The pre- and post-tests were identical except for one question, which asked students to predict impacts on individual elements of a river ecosystem in a given scenario. In order to assess their abilities to apply content knowledge in a novel context, students were given different scenarios in the pre- and

post-test. Both tests were scored using a rubric and scoring guide developed from the PMSP general rubric, which assessed student proficiency for each question on a scale from 1 (developing) to 4 (highly proficient). The final score for each student was determined by averaging the scores of all five questions. Tests were scored by four other individuals in addition to myself in order to improve reliability and decrease bias. We then compared and discussed scores in order to arrive at the most accurate results. Appendix C includes the full pre- and post-tests, as well as the rubric and scoring guide.

Connection to nature. The connection to nature construct of environmental literacy was measured using an existing scale developed by Nisbet, Zelenski, and Murphy (2008), with slight modifications. These researchers developed the Nature Relatedness (NR) scale in response to the need for an instrument to assess the multi-dimensional construct of nature connection, and it has been tested for reliability, construct validity, and correlates in several studies.

The NR survey consists of three parts, which reflect the affective, cognitive, and experiential aspects of nature connection. NR-Self reflects an internalized identification with nature, including feelings and thoughts about an individual's personal connection to the natural world. NR-Perspective represents a nature-related worldview and a sense of agency and awareness around human actions and their impact on nature. NR-Experience is the physical familiarity and comfort with, and the desire to be out in, the natural world. The original survey was modified to include two additional statements in the NR-Perspective section regarding collective and individual efficacy in addressing

Nature Relatedness Scale (adapted from Nisbet et al., 2008)

Students respond with a 1-5 scale, from strongly disagree to strongly agree.

NR-Self
My relationship to nature is an important part of who I am
I feel very connected to all living things and the earth
I am not separate from nature, but a part of nature
I always think about how my actions affect the environment
I am very aware of environmental issues
I think a lot about the suffering of animals
Even in the middle of the city, I notice nature around me
My feelings about nature affect how I live my life
My connection to nature and the environment is a part of my spirituality
NR-Perspective
Humans have the right to use natural resources any way we want
Human efforts to protect nature are unnecessary because nature is strong enough to recover from any negative human impact
Animals, birds and plants have fewer rights than humans
Some species are just meant to die out or become extinct
Nothing I do individually will change environmental problems in other places on the planet
Nothing I do individually will change environmental problems in my community*
Working together with others, I can change environmental problems in my community *
The health of non-human species is an indicator of the future for humans
NR-Experience
I enjoy being outdoors, even in unpleasant weather.
I don't often go out in nature
I enjoy digging in the earth and getting dirt on my hands
I take notice of wildlife wherever I am
The thought of being deep in the woods, away from civilization, is frightening
My ideal vacation spot would be a remote, wilderness area
*Statements added for the purposes of this study

environmental problems, as these are key components of the study program. Collective efficacy refers to beliefs about the ability of a group to produce desired results (Bandura, 2000); in this measure it is the belief that the coordinated efforts of a group of people can make positive environmental change. Additionally, because of the place-

based nature of the program, a statement was added about belief in individual ability to effect change on the local level (see Figure 3, above, for the complete survey, including added questions).

The NR scale was administered to students as a retrospective pre-post survey, in order to get an accurate picture of changes that occurred for students over the course of their entire time in the program. Although all eight students participated for the entire six-week curriculum period, the total enrollment period for each student varied over the course of the year. Some students were in the program from the beginning of the school year, others enrolled at the semester, and still others began just before the study period. The retrospective approach accounted for the changes that may have taken place over diverse participation periods.

Self-efficacy. Self-efficacy was chosen as the competency skill measure for environmental literacy for this study for a number of reasons. As a person's belief in his or her capabilities to take a course of action to attain desired outcomes, self-efficacy is not a specific skill but rather an internal construct. However, this belief is foundational to one's sense of personal agency, and a prerequisite for acting for environmental change. In Bandura's (2000) words: "Among the mechanisms of human agency, none is more focal or pervading than the belief of personal efficacy. This core belief is the foundation of human agency. Unless people believe that they can produce desired effects and forestall undesired ones by their actions, they have little incentive to act" (p. 75). The Oregon Environmental Literacy Task Force (2013) discusses self-efficacy in the environmental literacy strand of personal and civic responsibility, specifically as it

relates to how individual and collective action affects environmental quality and sustainability. There is an overlap here with the literature on positive youth development, in which self-efficacy is often noted as a key outcome of effective programs (Alfassi, 2003; McMillan & Reed, 1994; Catalano et al., 2004). This importance in both sustainability education and positive youth development, combined with the fact that it is a desired outcome of this specific program, make self-efficacy an important variable in this study.

The self-efficacy measure was adapted from the General Self-Efficacy Scale developed by Sherer et al. (1982), a valid and reliable instrument which assesses an individual's outcome expectancy, or belief that certain behaviors will lead to certain outcomes, and self-efficacy expectancy, the belief that they can successfully perform the behavior. The instrument for this construct was a retrospective pre-post survey intended to assess students' development of self-efficacy over the course of their participation in the program. The original survey was adapted to account for the specific outcomes of this conservation corps program (see Figure 4, below, for full survey). Of the original 17 questions measuring general self-efficacy, eight were included in their original wording, two were reworded to the positive, and seven were excluded. Seven statements specific to the intended self-efficacy outcomes of the program were added: four are measures of collective self-efficacy and three emphasize willingness to take risks and make mistakes, openness to new experiences, and confidence in ability to face complicated tasks.

Self-Efficacy Scale (adapted from Sherer et al., 1982)

Students respond with a 1-5 scale, from strongly disagree to strongly agree

- When I make plans, I am certain I can make them work.
- If I can't do a job the first time. I keep trying until I can.
- I can set goals for myself and work to achieve them.*(+)
- I give up on things before completing them.
- I am good at working with others to accomplish a task.*(C)
- I avoid facing difficulties.
- I can communicate with others to set group goals.*(C)
- When I have something unpleasant to do, I stick to it until I finish it.
- When I decide to do something, I go right to work on it.
- When trying to learn something new, I soon give up if I am not initially successful.
- I enjoy working on a team.*(C)
- When unexpected problems occur, I can adapt and solve them.*(+)
- I avoid trying to learn new things when they look too difficult for me.
- I am willing to take risks and make mistakes in order to get better at something.*(A)
- I enjoy doing new things, even if they are challenging.*(A)
- When faced with a complicated task to complete, I am confident that I can figure out how to do it.*(A)
- I prefer working alone to working with others.*(C)

*Adapted from original scale. +: original statement modified to the positive; C: new statement measuring collective self-efficacy; A: statement added

Figure 4. Self-efficacy survey questions.

Affective evaluation. An evaluative survey was used to assess the affective, or emotional, dimension of student experience in the conservation corps program, measuring constructs of achievement value, belonging, motivation, and engagement (see Appendix D for full survey). Affective constructs are recognized throughout the literature on at-risk youth and positive youth development as being crucial to student success (Johnson, 1998; Alfassi, 2003; McMillan & Reed, 1994; Catalano et al., 2004).

Achievement value here is broadly adapted from the definition from Wigfield and Cambria (2010): the value that an individual places on an activity, such as learning about a topic. This includes the relevance to an individual's own life and future, a sense of purpose in the context of the world at large, and how meaningful and interesting the student finds the activity. For this construct, statements were adapted from the Portland Metro STEM Partnership's (2015) "purpose" subscale from the Academic Identity and Motivational Resilience survey, and from the achievement value scales reviewed in the Wigfield and Cambria (2010) study.

Belonging is the sense of social inclusion and acceptance, and emotional attachment to others (Catalano et al., 2004), that individuals experience within a given setting. The scale measuring the sub-construct of belonging was adapted from the Portland Metro STEM Partnership's (2015) "relatedness" subscale from the Academic Identity and Motivational Resilience survey, and Richer and Vallerand's (1996) Need for Relatedness scale, with four statements added that directly reflect the belonging goals of the program.

The motivation and engagement constructs are separated into "field" and "class" experiences. Although these two areas are integrated, they are temporally distinct elements of the program curriculum. The motivation subscales measure students' personal reasons for participating in activities, with statements measuring internal and external motivators. While achievement value measures students' assessment of the overall importance of an activity or subject area, motivation is the causal force that incites a student to act or participate. The statements in this subscale

were adapted from the Portland Metro STEM Partnership's (2015) "autonomy" subscale in the Academic Identity and Motivational Resilience survey.

The definition of engagement here is adapted from Saxton et al. (2014): "high quality participation in… work, including effort (hard work, exertion, follow-through) and enthusiasm (interest, curiosity)" (p. 23), in both the field and class settings. All of the statements from the original Portland Metro STEM Partnership (2015) academic engagement subscale were included, with slight rewording to suit the specific context of the study program.

The affective evaluation was administered to students as a post-survey, after completion of the research period. Using a 1-5 Likert scale, students reported the degree to which they agreed with various statements such as "[this program] is a good place for students like me" and "I look forward to work days." Internal validity for all measures was increased through the inclusion of several questions for each value concept and the use of both positive and negative statements.

Interviews. In addition to these measures, I interviewed each student individually, to provide a deeper understanding of their experiences in the program and to expand on the quantitative data in the areas of environmental literacy and affective outcomes. After the completion of the conceptual knowledge tests and the nature relatedness, self-efficacy, and affective evaluation surveys, all eight participants were interviewed. Interviews lasted 30-60 minutes, and included open-ended questions crafted to elicit a full picture of students' experience of the program, and to identify the

factors that contributed to positive outcomes. Interviews were semi-structured, with predetermined questions used as a starting point, and spontaneous follow-up questions asked to probe more deeply into student responses. Figure 5, below, shows the interview questions.

Interview Questions

1. What did you like best about this program?
2. What did you like least about this program?
3. Have you changed since you've been in the program?
    - If yes, how?
4. What do you consider to be the most important concept/idea that you learned in this program?
    - What parts of the program contributed to your learning this?)

    (allow for spontaneous answer, then have them sort notecards*)
5. What do you consider to be the most important skill that you developed?
    - What parts of the program contributed to your learning this?

    (allow them to answer spontaneously, then show them notecards*)
6. What skills or ideas that you gain during this program do you think will help you most in your future?
7. Have you spent time in nature before participating in this program?
    - Tell me about it.
8. Did the program experience change your feelings about nature?
    - If yes, how did your feelings change?
    - If yes, what about the program contributed to that change?
9. How would you describe your feelings about nature now?
10. Do you think you will get involved with efforts to improve habitat or biodiversity after you are out of school?

*Notecards: field work projects, spontaneous learning during work projects, group debrief of work projects, class activities, sit spot assignment, in-class videos, and readings.

Figure 5. Interview Questions.

For three of these open-ended questions, I asked students to rank different elements of the curriculum in regard to how these contributed to the outcomes that they voiced. These three questions corresponded with the three elements of environmental literacy: conceptual knowledge, relationship with nature, and practical skills. Students were given seven notecards and asked to put them in order from most

to least important in influencing the outcomes that they noted for each question. These included elements of the field component (work projects, group debrief at end of project days, spontaneous learning during project days) and the class component (class activities, videos, readings, sit spot assignment). I took notes on student responses during the conversation and later transcribed the full interviews from audio recordings. These transcriptions were analyzed using qualitative methods (Corbin & Strauss, 1990) to determine themes or categories of responses that emerged for each interview question. Some themes were further split into sub-themes based on similar student responses. These emergent categories were quantified and ranked based on frequency of mention (see Appendix E for a full list of themes that emerged from student interviews).

Procedure

This study took place over the course of ten weeks during the spring of 2015. The week before spring break, students completed a pre-test to measure their understanding and application of conceptual knowledge in ecosystem relationships and biodiversity, the science content areas that were the focus of the treatment. The study curriculum began when students returned after spring break, and spanned six weeks. During this time, students worked as a team on habitat restoration projects in the local community two days per week. One day per week, they participated in indoor and outdoor class activities that used local habitats as the context for exploring concepts in ecosystem relationships and biodiversity. During the study period, students spent 12

total days working on field projects, and six days engaged in educational activities. At the end of the curriculum period (week six), students were given a conceptual knowledge post-test similar to the one that they completed at the beginning of the study, in order to obtain comparison data and measure gains in this area.

The week after the curriculum period ended, all students completed the nature relatedness, self-efficacy, and affective evaluation surveys. In the two weeks following, I conducted personal interviews with each of the eight students in order to expand on the quantitative data and to identify the specific elements of the program that contributed to positive student outcomes. The qualitative data were transcribed and coded after the interviews, and quantified by the themes that emerged. I analyzed the quantitative data using a Wilcoxon Rank-Sum Test to determine whether there were statistically significant changes from pre- to post-treatment, and calculated average difference between pre- and post-scores. The evaluation data were analyzed by determining average student ranking for each affective sub-construct. I examined and compared individual student scores for each outcome area in order to distinguish themes or patterns in the data. These results were examined to draw a number of conclusions that may inform both this program and other educational programs. The following sections outline these results and conclusions in detail.

Results

The purpose of this study is to examine how an environmental science-based youth conservation corps program impacts academically at-risk students' environmental literacy and affective outcomes, and to identify the elements of the program that contribute to positive outcomes. The following sections describe the results of this study in detail, including the quantitative results of the three environmental literacy measures—application of conceptual knowledge, nature relatedness, and general self-efficacy—and the student affective evaluation, as well as the qualitative findings of student interviews. These are followed by two case studies that examine the specific data in all of the measures for two individual students.

The results of this study reveal statistically significant changes across all three measures of environmental literacy, as well as a positive evaluation of student affective outcomes during the program experience. The semi-structured interviews revealed additional student outcomes not included in other measures, and allowed insight into the elements of the program contributing to positive outcomes.

Environmental Literacy

The quantitative measures for each of the three construct areas of environmental literacy—ecological understanding as measured by application of conceptual knowledge, connection to nature as measured with the nature relatedness scale, and competency skills as measured with the general self-efficacy scale—were analyzed using the same statistical method. For each of these, students' pre- and post-

scores were compared using a Wilcoxon rank-sum test (see Table 1, below). This test is used with small samples (n<30) to test the null hypothesis against an alternative hypothesis, in order to determine whether significant differences exist between two sample groups. In the quasi-experimental design of this study, the two samples include the same group (n=8) before and after the study treatment. All three measures of environmental literacy showed statistically significant changes over the course of participation in the program, with p-values for each measure less than 0.05. This allows for a rejection of the null hypothesis: there will be no change in student environmental literacy after participation in the treatment. This allows us to accept the alternative hypothesis: there is a positive relationship between student participation in the conservation corps program and their understanding of ecological concepts, connection to nature, and self-efficacy.

Table 2

Wilcoxon Rank-Sum Test: Environmental Literacy Constructs

	ACK	NR	SE
Level of Significance	0.05	0.05	0.05
Sample Size n	8	8	8
Intermediate Calculations			
T1 Test Statistic	36	41.5	47
T1 Mean	68	68	68
Standard Error of T1	9.521905	9.521905	9.521905
Z Test Statistic	-3.36067	-2.78306	-2.20544
Lower-Tail Test			
Lower Critical Value	**-1.64485**	**-1.64485**	**-1.64485**
p-Value	**0.000389**	**0.002692**	**0.013712**

Application of Conceptual Knowledge. Students' ecological understanding was measured with a pre- and post-test assessing application of conceptual knowledge in the content area of ecosystem interactions and biodiversity (see Appendix C for the complete test). Despite challenges and adaptations in the development of this test, alignment with treatment curriculum, and reliability of scoring (see Discussion section, below), students showed significant improvement in test scores over the study period (see Figure 6, below). The largest single change was an improvement of two points, from 1.4 to 3.4 (on a 1-4 scale, discussed in the Instruments section, above). The student who showed the least improvement (0.4 points) had the highest pre-score (2.4) and a below-average post-score (2.8). The average difference in student scores was 1.2, with a pre-score average of 1.85 and a post-score average of 3.05.

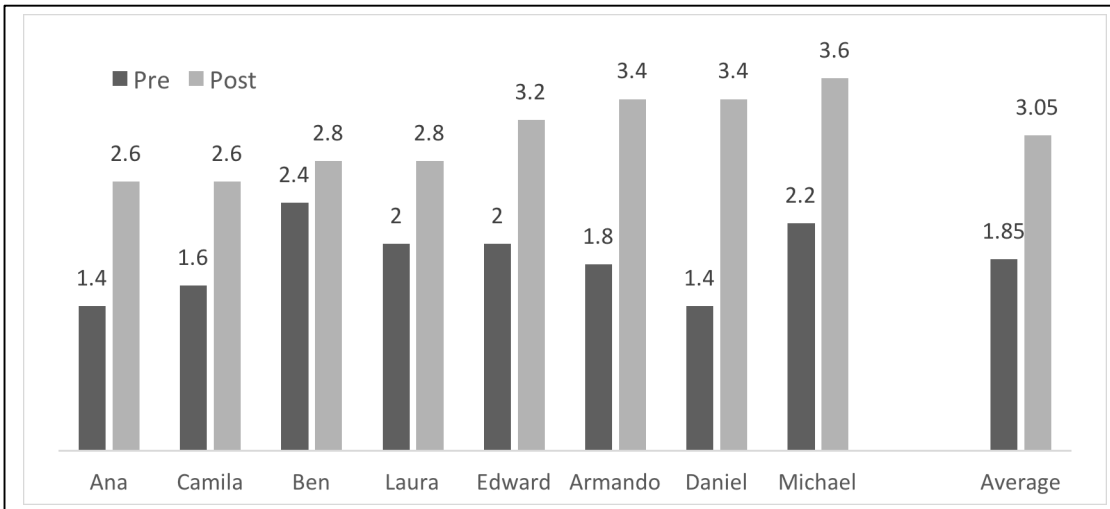

Figure 6. Application of Conceptual Knowledge test results.

Nature Relatedness. As shown in Table 3 below, students showed significant differences across all three of the sub-constructs of the Nature Relatedness Scale, which allows us to make the claim that participation in this program is correlated with

students' connection to nature. Results of the Wilcoxon rank-sum test reveal the most significant change in the sub-construct of NR-Perspective, which describes an individuals' worldview and sense of agency and awareness of human actions and their impact on nature.

Table 3.

Wilcoxon Rank Sum Test: Nature Relatedness Constructs

	NR-E	NR-P	NR-S	Overall
Level of Significance	0.05	0.05	0.05	0.05
Total Sample Size n	16	16	16	16
Intermediate Calculations				
T1 Test Statistic	48.5	37	40.5	41.5
T1 Mean	68	68	68	68
Standard Error of T1	9.5219	9.5219	9.5219	9.5219
Z Test Statistic	-2.0479	-3.2557	-2.8881	-2.7831
Lower-Tail Test				
Lower Critical Value	-1.6449	-1.6449	-1.6449	-1.6449
p-Value	0.0203	0.0006	0.0019	0.0027

Examination of the individual results of the overall nature relatedness scores (Figure 7, below) shows a range of student experience, both before and after participation in the program. Two of the students entered into the program with a high initial connection to nature (with scores of 85 and 75), while five students reported relatively low values (ranging between 47 and 55) before they began the program. All students reported increases in nature connection after participation in the program. The largest difference in pre- to post-scores was 47 points, the smallest difference was 12 points, and the average across all students was 26 points. The two students who showed the highest initial connection to nature (Michael and Laura) reported the highest scores upon completion of the program (99). The students who reported the

three lowest initial connection to nature scores (Camila, Daniel, and Armando, with scores of 47, 51, and 52 respectively) showed the largest increases. It is of interest to note that these three individuals also had the next three highest post-scores, after Michael and Laura.

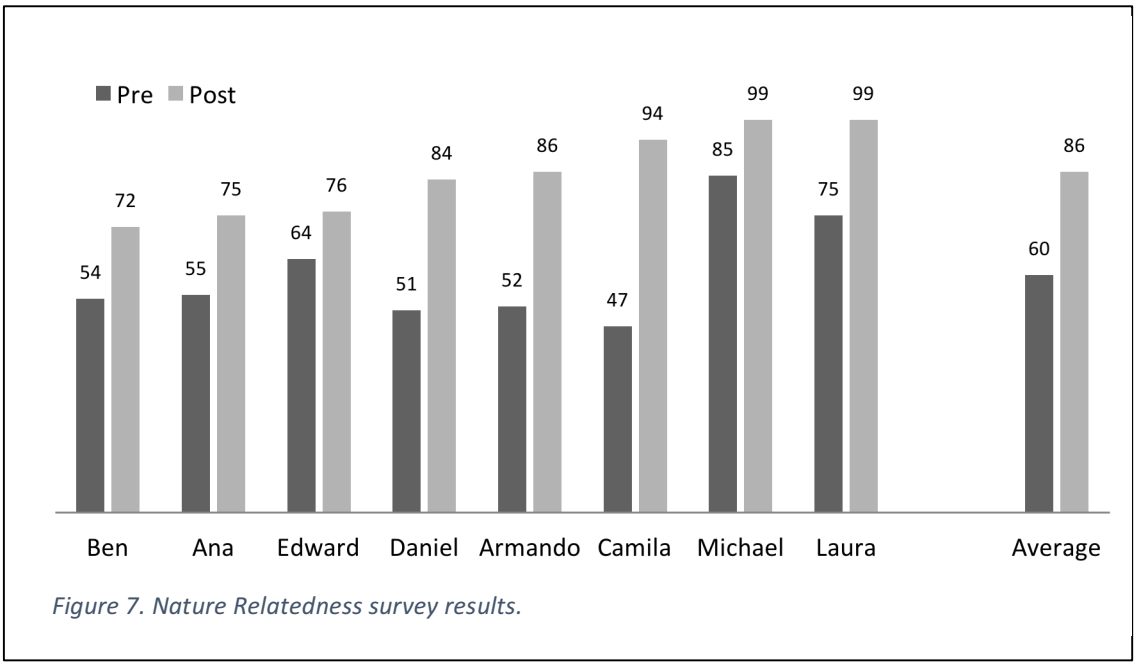

Figure 7. Nature Relatedness survey results.

Self-Efficacy. Students were given the adapted General Self-Efficacy Scale as a retrospective pre-post survey upon completion of the study period. Results (Figure 8, below) show statistically significant differences between pre- and post-scores, likewise justifying the hypothesis that participation in the conservation corps program is related to this element of environmental literacy. All students reported increases in self-efficacy after participating in the program, with an average increase of 16 points. The three individuals with the highest self-efficacy at the end of the program (Ben, Michael, and Laura, with respective post-scores of 75, 73, and 69) showed the highest pre-scores (at

67, 71, and 50). Ben and Michael, the students with the highest two scores, showed the smallest increase overall (2 and 8 points). The students who showed the largest increase were those with the lowest initial self-efficacy scores (Camila, Edward, and Daniel, with increases of 26, 24, and 22 points respectively).

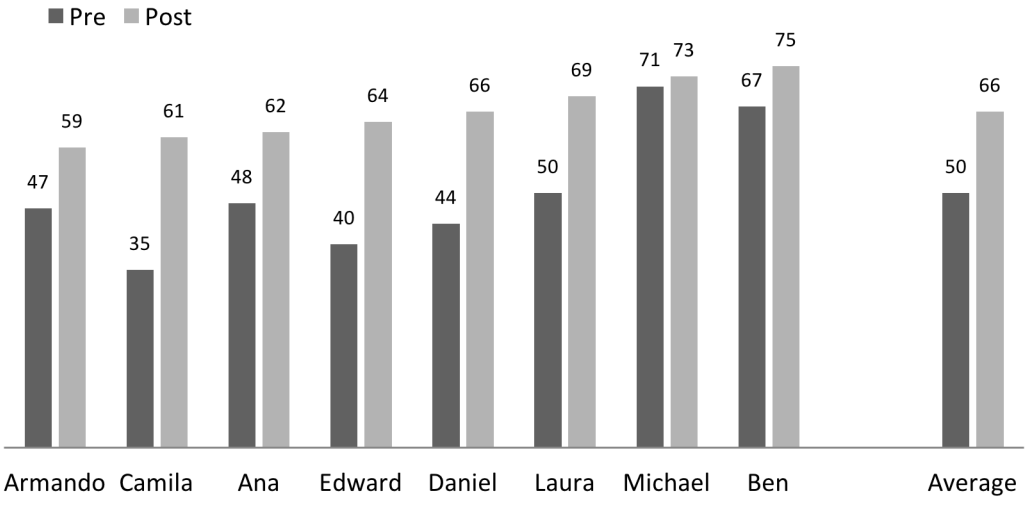

Figure 8. Self-Efficacy survey results.

Affective Evaluation

This survey was crafted to assess students' affective outcomes while in the program, which differs from the pre-post format of the other quantitative measures. The affective evaluation measured six sub-constructs: achievement value, belonging, field motivation, field engagement, class motivation, and class engagement. Students rated each statement from 1 (strongly disagree) to 5 (strongly agree), on a Likert scale. Figure 9, below, shows the resulting student averages for the affective survey, which reveal average positive to strong positive (between 4 and 5) responses for all of the six

sub-constructs. The sub-construct that students scored highest was belonging, and the lowest was motivation and engagement in the class setting.

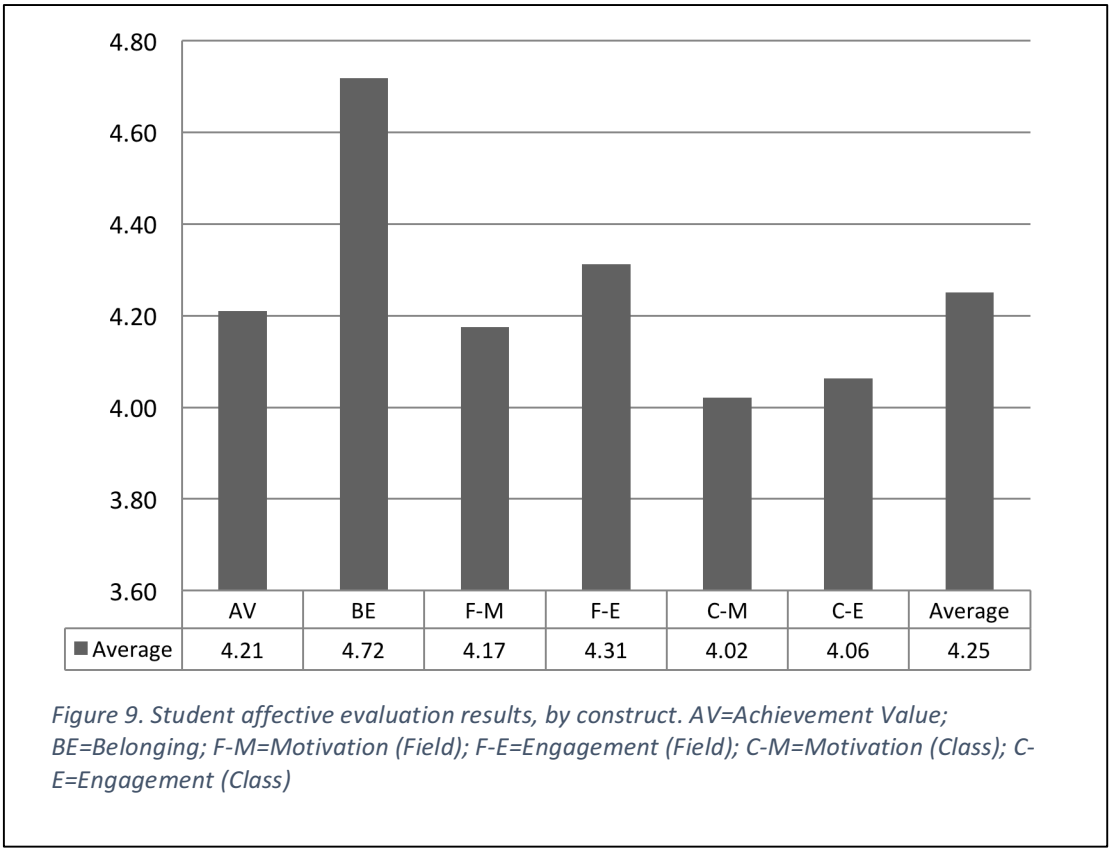

Figure 9. Student affective evaluation results, by construct. AV=Achievement Value; BE=Belonging; F-M=Motivation (Field); F-E=Engagement (Field); C-M=Motivation (Class); C-E=Engagement (Class)

Interviews

Conversations with students during the interview portion of this study revealed dimensions of their experience not measured in the quantitative data, which adds depth and insight into these results and lends further evidence to support the claim that students' environmental literacy increases with participation in the conservation corps program. A number of students reported positive affective outcomes that support the

claim that this program is successful in fostering this dimension in participants. See Appendix E for a table representing interview data.

The first three questions of each conversation were more general and open-ended than subsequent questions, to elicit students' first and most genuine responses. These questions prompted the students to consider what they liked best about being in the program, what they liked least, and whether and how they had changed since being in the program. There were four main themes that emerged from student responses.

Regarding what they enjoyed most, participants mentioned 1) interpersonal relationships; 2) learning about, caring for, and being in nature; 3) novelty and variety; and 4) relevance to their personal future. Six students spoke about the interpersonal element as a highlight of their experience, both in terms of working with others on a team and the personal connections that were made. One student stated that he enjoyed "the experience working with other people, being able to experience things with other people. I liked working with them, seeing how they worked, what kind of ideas they had, how they dealt with problems." Another noted the overlap between connecting with others and the ability to work as a team:

> "whenever were out on site and working, communication was key to keeping a project working or running nice and smooth and clear so everybody knows what they're doing. And communication between... just having a conversation, it just makes it run faster, makes the job feel a little bit more easier, knowing you can talk to somebody and have a conversation, if you have weird questions to ask and weird answers and everyone laughing and smiling and having a good time."

Five students mentioned the program focus on the natural world as a highlight of their experience, from a number of angles. Three noted that they enjoyed learning

about the environment, and two of them connected this to care for or helping nature in the same breath. This dimension of service was mentioned by one other student: “I like knowing that every day we would get up and we'd be doing something different but it would still be beneficial to the environment.” Three students also specifically stated that actually being outside in nature was a highlight for them.

Half of the students (four) responded that they enjoyed the novelty and variety of the experience, that it was “never the same thing twice” and “there’s something new to do every day.” Four students also mentioned the personal relevance of the program, specifically to developing the skills and experience that they could use in future work positions. Two lesser themes were also revealed, with two students each mentioning that they like being out of the classroom, and the physical nature of the experience.

When asked what they liked least about the program, four general answers were revealed: dealing with the weather, doing hard physical work, tedious tasks, and the challenges of working with others. Each theme was mentioned by three students. It is interesting to note that three of these themes also emerged in some form in response to the first question, which regarded what students enjoyed about the program: being outside, physical activity, and working with others.

All of the participants responded that they changed over the course of their participation in the program. Seven students noted that they had experienced some sort of personal growth, with four specifically mentioning emotional growth. Their statements reveal the areas of growth: “I have become an overall better person,” “[I’m more] open to trying new things,” “I’ve actually worked on my anger issues,” “The way I

think, the way I see things [has changed]; I want to see things more positive," "I don't really think about what others think now, I just focus on my goals and what I want to achieve." A second theme that emerged from student responses was increased interpersonal skills and ability to work with and connect to others, mentioned by six students. "I'm more personable. I feel less judgmental, I've accepted everyone in the group; being in here I can be my actual self and I don't have to put up walls." A third theme emerged with three students noting changes in how they relate to nature: one mentioned an increased appreciation for nature, another said that she spends more time in natural areas, and a third noted that he takes more time in his daily life to observe the natural world.

The next few questions in the interview were focused more specifically around environmental literacy outcomes, but also were crafted to be open enough to elicit students' genuine responses. I asked students what was the most important concept or idea that they learned; what they considered to be the most important skills that they gained, as well as the skills that they believed would help them most in the future; and whether they had spent much time in nature before being in the program, if and how this experience changed their feelings about nature, and how they would describe their relationship with nature now. For each of these outcome areas—concepts, skills, and connection to nature—I asked students what parts of the program contributed to the change.

There were four main themes that emerged from students' responses to the question regarding the most important idea or concept that they learned. First, five

students mentioned the idea of taking action to make change, and their words elicit the spirit of the concept: “I learned that we *can* do it, just cause we're little people doesn't mean we can’t make a big change,” “we have to start somewhere; if you try to make a difference you might set an example,” “everyone should know they're making a huge impact on the earth, not just earth but everybody on it just planting one tree.” Closely connected to this, but invoking more specifically the emotional motivation underlying such action, is the second theme of care for the earth, mentioned by three students. Third, three students noted humans’ impact on nature as a major idea, with two students specifically recognizing the interconnectedness between human action and environmental problems:

> “It's so [much easier] to destroy a site than it is to repair a site, it's pretty insane and it makes you think about every action you take, finally realize what kind of damage you can do, what kind of damage it does to the entire ecosystem of the planet. You realize how one little thing can affect so many different things, the chain of things that interact with each other.”

Local ecology was the fourth theme that emerged, with four students mentioning birds, native and invasive plants, and trees, as well the roles they play and functions they serve in the ecosystem. When asked which aspects of the program contributed to learning these ideas and concepts, students first responded spontaneously: seven students mentioned being out in the field, while four cited class activities.

In the area of skill development, students responded resoundingly that the interpersonal skills that they gained while in the program were both the most important and would serve them most in the future. Two questions were asked about skills: one

asked students what they considered to be the most important skill that they learned in the program, and the other asked them which skills they gained did they think would serve them most in the future. Seven students responded that learning how to work with others was the most important skill, with three students further specifying communication skills, and two indicating leadership. Five students indicated teamwork and four mentioned the emotional skills of relating to others as the skills that would help them most in the future. All eight students mentioned teamwork skills in response to one or both of these questions. Another theme of student skill gains that emerged from the interview data was problem solving and goal setting, with four students mentioning putting ideas into action, "working out a good efficient system to get the job done," learning how to set goals, and working together to plan and execute goals. Four students also indicated personal skills that they'd gained as those that would help them in the future, mentioning character, self-awareness, mental and physical resilience and stamina, being out of one's comfort zone, patience, and initiative.

In the realm of nature connection, four students stated that they hadn't spent much time in nature before their time in the program, while one student said that he had when he was younger, but not much since then. Three claimed that they had spent a significant amount of time in nature before the program. Two of these three students showed the highest pre-scores on the nature relatedness scale, and also mentioned that nature offered them retreat of sorts. Laura said that nature is "a great little escape" for her, and Michael said, "I love being outdoors. It's kind of like my own vacation but for free."

When asked whether and how their time in the program changed their feelings about nature, and how they would describe their current relationship to the natural world, four specific themes under the broad umbrella of nature connection emerged. First, six students noted some manifestation of a personal connection or sense of belonging to nature:

> "There's the *wow,* our soul is with these creatures, too, and we're supposed to take care of them… I am one with nature… Just being out there, actually being in nature, and having time to just be part of it, it's calming to me, it's peaceful."
>
> "I feel closer to it… want to be a part of it more. [I realize] how nice and friendly everything is, it's not anything to be afraid of."
>
> "I care about it a *lot* more. I've grown attachment to it. I acknowledge it more and care more about it now."
>
> "You can't treat it like it's a tree, you gotta treat it like it's a friend."

What can be described as an increased awareness of nature, the second theme in nature connection, was mentioned by six students. Four mentioned that they pay more attention to nature in their daily lives, appreciating, observing, and embracing the nature that exists in their local area. Four noted an increased understanding of ecology and the natural world: "Before I just saw it as a wetland, sometimes I saw animals in there. Now I see all the plants and what the water's doing, what's in the water, the color the water is, you know?" Two students who indicated an increased awareness of nature also mentioned that they share their knowledge or passion with others when they're out in world, indicating a potential ripple effect of nature awareness into the community. Closely connected is the third theme of gaining of respect or appreciation for nature, mentioned by four students. Lastly, five students indicated a deeper

awareness of the big picture of human-nature interactions, both in increased understanding of human impact (mentioned by three) and an increased sense of personal responsibility to act on nature's behalf (mentioned by four).

When asked what parts of the program contributed to the change in their relationship to nature, students indicated that being out in nature—on work days, class days, and/or at their sit spots—was a major factor (four students). Classroom activities and learning the conceptual content, especially through connecting to field experiences as well as watching videos, were mentioned by four students. Two students also mentioned the relationships that they have in the program as being factors in contributing to their nature connection outcomes, both with myself and with fellow students.

After reporting the changes they experienced in the three environmental literacy areas—concepts, skills, and connection to nature—I gave students a set of six notecards with one general program elements written on each and asked them to rank these in order of contribution to the outcomes that they had stated. Figure 10 reveals student responses, based on the frequency with which each was mentioned in students' top four elements of importance.

Students resoundingly ranked field work projects as the element of the program contributing most to outcomes in all three areas, with eight students reporting it in the top four for developing concepts and skills, and seven ranking it as a key factor in changing their relationship with nature. For conceptual outcomes, students noted spontaneous learning in the field as the next highest element of influence, with seven

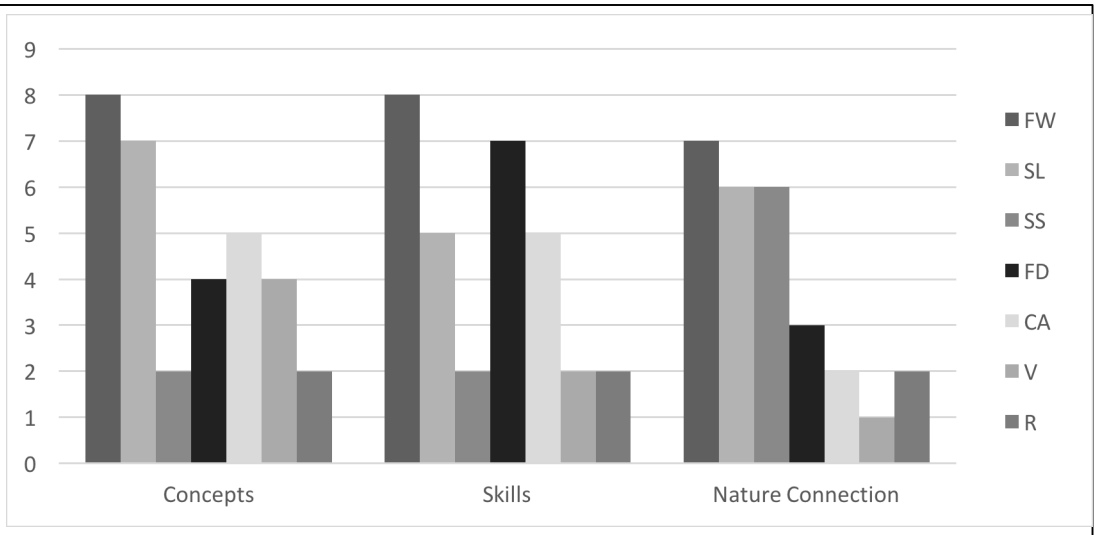

Figure 10. Program elements contributing to environmental literacy outcomes. FW: field work projects, SL: spontaneous learning in the field; SS: sit spot assignment; FD: field project debrief; CA: class activities; V: videos; R: readings

students ranking this in their top four. This was followed by class activities (five students), and equal ranking of field project debrief and in-class videos (four students each). In the area of skill development, the field project debrief was ranked next highest (seven students), followed by equal mention of spontaneous learning and class activities (five students). Nature connection outcomes showed three clear factors of influence, with field work projects followed closely by spontaneous learning and the sit spot assignment (each ranked by six students in their top four). These outcomes reveal that, by and large, the outdoor and experiential components of the program contribute most to environmental literacy outcomes, as reported by students. The class readings were consistently ranked the lowest, with only two students ranking these in their top four for each outcome area.

Note in Figure 10 that the elements are ordered by context, with the first three (field work projects, spontaneous learning, and sit spot) taking place outdoors, the next

two (field debrief and class activities) marked by the integration or combination of outdoor and indoor activity, while the last two (videos and readings) take place indoors. Conceptual outcomes were influenced by elements in all three settings, skills development appears to emerge from outdoor and indoor/outdoor elements of the program, and nature connection outcomes show strong bias toward the outdoor experience.

Case Study: Camila

A closer examination of two students' individual experiences reveal the value of this program in promoting environmental literacy and affective outcomes, and how this shows up differently for different students.

Camila entered the program at the beginning of the second semester, with some initial resistance. As she noted in her open response at the end of the quantitative survey, "I honestly thought I was going to have a miserable time. My mindset was to just do the work and not care or pay attention to anyone on the crew and just get my science credit." Camila's scores on the retrospective pre-post surveys reflect a low initial inclination to the type of experiences emphasized in the program: she reported a low sense of self-efficacy and little connection to nature upon enrollment in the program. Her self-reported scores for both of these constructs were the lowest of all participants. She also showed low proficiency in ecological understanding as measured in the application of conceptual knowledge pre-test.

As revealed in the post-tests and quotes from our interview conversation, Camila experienced significant changes through her participation in the program. After an initial aversion to "going out and… getting dirty, I got used to it, and that was my favorite thing. I looked forward to it during the week." When I asked her what changed that for her, she revealed that it wasn't just the work, but the meaning behind it that she valued: "I think it was just the conversations we've had, just about the environment. I think I just got a little more knowledge about nature, like I didn't really know a lot of this stuff or just how bad the pollution was or global warming. Now it just makes me really think about like what we need to do, so now I care about it a lot more." This shift in perspective and change in her relationship with the natural world was revealed in the difference in her scores on the nature relatedness survey. After showing the lowest initial connection to nature with a score of 47 points, she reported the third highest post-score at 94: a drastic doubling of 47 points. During our interview, she mentioned that she had found solace in nature, a reprieve from the stresses of "life and work and school and what we go through every day… I got into nature and I learned these are just creatures, they don't worry about stuff… I still do my sit spot all the time just to sit there and just not care…And I think I'm gonna use that a lot in life." Throughout her descriptions of her feelings about nature, she used words like care, attachment, and love, and talked about an increased recognition, appreciation, and responsibility.

> I feel like I'm responsible for it, like we're all responsible for it. I care about it now because we've helped it grow and helped restore a lot of places… I acknowledge it more and care more about it now and feel like we should do more about it to help it. Because nature isn't people: it can't say we need this or

> we need that, so I feel the need to know what it needs and help it, I feel like we should be that voice.

She further revealed that she considered herself in an active role as that voice. Before participating in the program, she had aspirations of being a writer, “but now I don't want to be stuck inside writing… I've been thinking about putting it together, just going out and writing about nature, just writing about what we need to do.”

The other areas where Camila reported significant changes were in the areas of self-efficacy and other competency skills, especially as they related to the affective construct of belonging. The increase in self-efficacy that she reported was likewise the largest difference among all eight students, from an initial score of 35 to a post-score of 61. When asked what she considered the most important skill that she gained while in the program, she responded, “it taught me how to make goals, and how to find a new way to get to goal; I never really made goals before, I just went with the flow and that's how I got behind in a lot of stuff. So now I know if I make a goal I can achieve it if I just focus on it.” A large part of her increase in self-efficacy appears to have emerged through the context of collaborative efforts:

> It’s easier to make goals when there's a team; if it was me by myself making a goal I wouldn't be so on top of things with myself, but because I'm working with people, I feel like I need to get the work done, and I should get the work done, and I *can* get the work done with all their help… I learned that I work better with people getting a task done.

She noted self-efficacy in affecting change as the most important concept that she gained from the program, and indicated a sense of the collective in her use of plural pronouns: “I learned that we can do it, just because we're little people doesn't mean we

can't make a big change... Just because we're small we can still make a difference, we can still do what we need to do and do what we *should* do."

Camila's scores on the application of conceptual test showed the average improvement of 1.2 points, from an initial score of 1.4 to a score of 2.6. Through her scores on the other instruments, and the interview data, it seems that the significance of the program for her leaned more toward the nature connection and competency skills realms of environmental literacy than the understanding of ecological concepts. Further, the sense of belonging and emotional growth that she experienced were important affective outcomes. The full text of her open response from the survey offers a beautiful summary of her experience:

> My experience in [the program] wasn't what I expected it to be. I honestly thought I was going to have a miserable time. My mindset was to just do the work and not care or pay attention to anyone on the crew and just get my science credit. As time went by I started realizing how comfortable my teammates made me feel being myself, and how honest I can be to the crew leader Jo. Before entering [the program], I was going through a lot, I still am but now I know how to cope with problems and pick myself back up. I definitely fell in love with nature, before I never took a second glance at nature nor did I respect it and appreciate it. Now I find myself looking for natives/invasives while just going about my days. I probably annoy my friends and family with all the info I learn about the environment. [This program] has been one of the best things I've decided to do and has made me certain of how I want my future to be.

While Camila's experience reveals significant affective gains while in the program, Daniel's survey and interview data tell a somewhat different story.

Case Study: Daniel

A self-proclaimed loner before participating in this program, Daniel had spent little time in nature: “about the closest I got was going outside to go to the store.” Similar to Camila, Daniel showed distinctively low pre-scores in all areas, with the second-lowest nature relatedness score, the third-lowest self-efficacy score, and the lowest application of conceptual knowledge pre-test proficiency score. Through his participation in the program, he showed significant changes in all of these construct measures, with interview data lending further insight into his experience.

Also similar to Camila and many others in the program, Daniel cited working with others and the personal connections that developed between participants as distinctive benefits of the program. He said that he most enjoyed “working with other people, being able to experience things with other people. I liked working with them, seeing how they worked, what kind of ideas they had, how they dealt with problems.” He noted the connections as being especially important, and that he now “spend[s} more time with other people.” Teamwork, he said, was the most important skills that he gained: “I don't have a huge amount of experience working in a team before this, so it was nice to learn how to do that and be more open to that, because usually before I just preferred to work by myself.” The time spent working together on field projects, “working out a good efficient system to get the job done,” as well as teambuilding activities in class, were the elements that he mentioned that contributed to this change. He reported a strong sense of belonging in the affective evaluation, with an average ranking of five for this construct.

In the areas of environmental literacy, Daniel showed distinctive gains in all three areas. His post-scores in the areas of nature connection and self-efficacy were not of the highest in the group, but the differences between pre- and post-scores were, showing significant personal gains from initially low reported scores in both of these areas. His nature relatedness score improved from 51 to 84 and self-efficacy from 44 points to 66. Ecological understanding, as measured by the application of conceptual knowledge test, was the area where he showed the most change. Daniel showed the largest improvement of all students on the test assessing proficiency in ecosystem relationships and biodiversity, with a two-point change from 1.4 (the lowest pre-score) to 3.4 (the second highest post-score). In his interview he repeatedly mentioned learning about local ecology and habitat restoration as significant aspects of his experience: “I liked learning a lot about how habitat restoration works: the native and non-native and invasive plants, learning what those are, what they're called, how to identify them, learning what functions things serve in the ecosystems.” This understanding had a direct influence on his sense of connection to nature, informing a heightened awareness of the natural world around him. “Before I just saw it as a wetland, sometimes I saw animals in there, now I see all the plants and what the water's doing, what's in the water, the color the water is, you know. If I'm with someone I point out what I see. Most commonly the red-winged blackbird is the most obvious thing in the city.” When talking about his relationship with nature, he spoke thoughtfully: “I feel closer to it, it's much more important than I realized. I like having it around a lot more, noticing it more.” That change occurred, he said, partly through learning about how

nature works, “learning the roles everything did and learning how important everything was.” And the element of the program that contributed most to learning those concepts was the time spent outdoors. “The class time helped… but a lot of the best learning was out in field, where you could actually see everything up close and ask questions and everything.”

Overall, the quantitative and qualitative data reveal significant changes in student outcomes over the course of participation in the program study period. Students showed increases in all three areas of environmental literacy, as well as positive evaluation of affective outcomes. The elements of the program shown to influence positive outcomes included the outdoor and experiential aspects of the curriculum. As the case studies reveal, the specific changes varied between students, with some showing more growth in some areas than others. Although this variation is present, overall change is significant enough to affirm the hypothesis that participation in this program increases students’ environmental literacy and leads to positive affective outcomes.

Discussion

The results of this study show statistically significant increases in the three outcome areas of environmental literacy, as well as positive student evaluation of affective outcomes. The first environmental literacy outcome, ecological understanding, was measured with a pre-post test measuring application of conceptual knowledge in the content area of ecosystem relationships and biodiversity. Average student improvement was 1.2 points on a 1-4 proficiency scale. Second, nature connection was measured with the Nature Relatedness Scale. With a wide range of student pre-scores, all participants showed increases and the average increase was 26 points, while the largest individual increase was 47. The third outcome area was self-efficacy. A modified version of the General Self-Efficacy Scale measured this variable, which revealed an average student increase of 16 points, while the largest individual increase was 26. The student affective evaluation showed positive to strong positive ranking for all outcome areas, with belonging ranked highest with an average score of 4.72 and class motivation ranked lowest at 4.02 (on a scale of 1-5).

Interview data emphasized a number of themes, including development of interpersonal skills and relationships; learning about, caring for, and being in nature; and individual personal growth. Students mentioned acting on behalf of and caring for the earth as well as gaining deeper understanding of human impact and ecological concepts as the most important ideas that they gained in the program. Interpersonal skills (i.e. teamwork, emotional connection, communication, and leadership) and personal growth were noted by students as the skills gained that they valued most.

Nature connection showed a layered complexity, with students voicing increased attention, understanding, responsibility, and sense of belonging in the natural world, and heightened awareness of the impact of human actions on the health of natural systems. Students ranked the outdoor elements of the program as having the most significant influence on all three environmental literacy outcomes, with field work projects ranked highest and spontaneous learning in the field ranked highly for all three outcomes.

Conclusions

These results, as well as the specific data examined in the two case studies above, allow us to propose a number of answers to the two research questions of this study: In what ways does an environmental science-based youth conservation corps program impact academically at-risk high school students' environmental literacy and affective outcomes? Further, what specific elements of the program contribute to positive outcomes? Using the data, we can draw four major conclusions from this study: the strengths of this program are in the areas of belonging and nature connection, those students not initially inclined toward this program may benefit from it the most, the three areas of environmental literacy are interdependent, and the outdoor and experiential elements of the program contributed most to positive outcomes.

Existing program strengths. First, through an examination of the quantitative data, supplemented by the themes that emerged from student interviews, it becomes

apparent that this program impacts students most distinctly in the affective outcome of belonging and in the environmental literacy area of nature connection. Belonging in this study is defined as the sense of social inclusion and acceptance, as well as emotional attachment to others (Catalano et al., 2004). Of the six constructs measured in the affective evaluation, students ranked belonging the highest, with an average ranking of 4.72 out of 5. Belonging had a strong presence in the interview data as well, showing up in student mention of developing relationships and connections, embracing and accepting difference, teamwork, and learning interpersonal skills. Six students mentioned connecting and working with others as a highlight of the program, and six noted it as an area of growth for themselves. All eight students citied interpersonal skills as the most important skill gained in the program or a skill likely to help them in the future. They specifically mentioned teamwork skills such as communication and leadership, but also social-emotional skills: being there for others, having patience and nurturing others, accepting people's strengths and weaknesses, and "being able to talk to people and open up." These results likewise reflect the 'relationship-based' pedagogical approach of the program curriculum, which is emphasized in the theoretical framework of sustainability education, place-based learning, and positive youth development (see Appendix A).

Nature connection also showed up as a significant outcome of the program. When comparing the statistical data in the three realms of environmental literacy, the most significant change occurred in the area of ecological understanding ($p=0.0004$), followed by nature connection ($p=0.0027$), and then self-efficacy ($p=0.0137$). However,

student responses during interviews leaned heavily toward the affective dimension of environmental literacy, the sense of connection and appreciation that they developed toward the natural world, and their motivation and agency to act on its behalf. When asked what they considered to be most important idea or concept they gained, four students noted some aspect of ecological understanding, mentioning either local ecology or human interconnectedness with nature. Seven students, however, responded with a reflection of care for the earth or some version of taking action, using terms like "make a difference," "make a big change," "give back and help out," "helping nature." These responses reflect the sub-construct of NR-Perspective in the nature relatedness scale: the sense of agency around humans' actions and their impact on nature. Of the three sub-constructs measured in this scale, students in this program showed the most significant increase in this area ($p=0.0006$). All of the students mentioned some aspect of nature relatedness as an outcome of their experience in the program, especially when describing the ways that their experience changed their feelings about nature. Additionally, an examination of the individual data from the overall nature relatedness survey reveals a distinct pattern. While all students showed increases in this realm (the highest difference from pre- to post-treatment was 47, the lowest was 18, and the average was 26), the three students with the lowest pre-scores on the NR survey showed the largest gains upon completion. They also showed high post-scores relative to other students, after the two students who reported high initial affinity for nature (see Figure 3, above). Two of the students with initial low NR scores

(Camila and Armando) mentioned being in, learning about, and caring for nature as their favorite part of the program during interviews.

Program benefits. This pattern in the nature connection data points to the second potential claim that can be drawn from this study: this program may be of most benefit to students who are may not be initially inclined toward participating in it. Participants spend a significant amount of time outdoors in all sorts of weather on both field work days and some class days, are required to work with others to complete work projects that involve physical work and focused effort, and spend time studying nature and how humans impact and interact with it. Some students are more interested in participating in these activities than others. However, the data show that some of the students with the lowest initial scores on each of the measures showed some of the highest post-scores, and this was often the case for the same student across multiple measures. On nearly all of the environmental literacy measures, the students who showed the highest pre-scores of the group also had the highest post scores, but because their scores were higher to begin with, the difference was less significant. This is especially true for the nature connection and self-efficacy measures. However, the students who ended up in the middle of the board, just behind these high scorers, were often those who showed the lowest initial scores. This is the case for the nature relatedness data, outlined above. In the self-efficacy measure, Edward and Daniel, with two of the lowest initial scores (at 40 and 44, respectively), showed large increases and ended up in the middle of the group in their post-scores. The ecological understanding measure is slightly different, because it assessed student knowledge rather than a more

personal self-concept, tendency, or affinity, such as self-efficacy and nature connection. However, a similar pattern emerged: the students who showed the second-highest proficiency score on the application of conceptual knowledge post-test (at 3.4) had initial scores of less than two. Given the small sample size of this study, it is not possible to make a broad claim from the data, but the observation of similar patterns across environmental literacy constructs lend credence to this conclusion, and can inform the development of this program in the future.

Environmental literacy constructs. The three elements of environmental literacy—ecological understanding, nature connection, and self-efficacy—were separated into three measurable constructs for the purposes of this study. However, the results suggest that the lines between the three may be less distinct than these measures presuppose, leading to the third conclusion that emerged from this study. The interview data reveal substantial overlaps between these three realms, indicating that the three are interconnected, potentially interdependent, and that each may serve to foster the others. Many students mentioned learning more about how nature works (ecological understanding) in connection with an increased appreciation and respect for the natural world (nature connection). Others mentioned their developing awareness of human impacts on nature (ecological understanding) alongside a developing sense of personal responsibility to take action (nature connection) and the belief in their ability and motivation to do so (self-efficacy). For example, Camila said that going out and doing the field work became her favorite part of the program, despite being her least

favorite when she started. When asked how that changed, she revealed that it was learning about the purpose of the work that shifted:

> I just got a little more knowledge about nature, like I didn't really know a lot of this stuff or just how bad the pollution was or global warming; now it just makes me really think about like what we need to do, so now I care about it a lot more… Getting out there, we started making changes, even if it was small. I learned that we *can* do it, just because we're little people doesn't mean we can't make a big change. And I think that's a big idea that we should keep in mind. Just because we're small we can still make a difference, we can still do what we need to do and do what we *should* do.

That this was a repeated theme throughout the interviews suggests that there may be causal or correlational relationships between the three areas of environmental literacy, which is supported by and reinforces some existing literature (Littledyke, 2008; Leong et al., 2014). Even within the individual Nature Relatedness Scale (Nisbet et al. 2008), which is a research-based, validated instrument, there are suggestions of the other two elements. The sub-construct measuring NR-Perspective, on which students in this study showed the most significant change, shows this especially. Questions such as "human efforts to protect nature are unnecessary because nature is strong enough to recover from any negative human impact" are influenced by one's ecological understanding, and others like "nothing I do individually will change environmental problems in other places on the planet" reflect one's self-efficacy beliefs.

Program elements that contribute to positive outcomes. Even if the distinctions between the three areas of environmental literacy are largely academic, students in this study showed significant positive changes in all of them. When asked what elements of the conservation corps program contributed to these positive outcomes, students

resoundingly responded that the outdoor and experiential aspects were the most influential. This allows us to draw a fourth conclusion, which also answers the second research question. The most valuable element of this program, for all three outcome areas, are the field work projects (see Figure 10, above). This reinforces the foundational focus of this program, and bolsters the claim that this type of work-based program is beneficial to at-risk students and can offer a unique model for science and sustainability education. The second-most highly ranked element of the program was the spontaneous learning that occurred during field work projects, the moments when someone would find a bug or a nest or spot a bird, and the attention of the group would momentarily divert from the work to the curiosities and fascinations of the natural world. The remaining elements varied in ranking between each environmental literacy construct, and may inform the specific benefits of each. For example, the sit spot assignment was rated relatively low for concepts and skills, but was highly ranked for nature connection, showing that it is a valuable instructional approach for this outcome, and suggesting further redesign in order to better meet ecological understanding outcomes. The field debrief element of the program was ranked high for skills outcomes, which was at first somewhat perplexing. This is the time at the end of project days where the group came together to reflect on work outcomes, to discuss what worked well and what challenges arose, and to record the plant and wildlife species that were encountered in the field. This reflection time is an integral element of the experiential learning process, which includes participation in an activity followed by reflection and application to future scenarios (Kolb et al., 2014). This datum suggests

that this element is nearly as important to the ongoing development of competency skills as the actual hands-on field experience.

Connecting to Existing Literature

The results of this study support the existing literature in the realms of sustainability education, place-based learning, and positive youth development in two major ways: students benefit from curriculum that uses pedagogical approaches from these three areas, and programs that foster affective outcomes can serve academically at-risk youth. The data revealed in the quantitative measures as well as interview responses show that students benefitted from curriculum that was relationship-based, relevant, and experiential, and that this can contribute to positive academic outcomes. These pedagogical approaches emerged as overlapping themes from the literature in the three areas of the theoretical framework of this study (see table in Appendix A). The approaches were intentionally woven through the curriculum of this study (see Treatment section, above), and are inherent in the model of the conservation corps program. As mentioned previously, belonging and interpersonal skills were shown to be a key outcome of this study: this reflects the *relationship-based* approach, which emphasizes collaborative and collective effort. Likewise, students referred to the *relevance* of the program activities in a number of contexts. The 'achievement value' sub-construct of the affective evaluation measured not only student interest in the content area, but also the relevance of the program content to one's own life and future, and in the bigger-picture context of the larger world (Wigfield & Cambria, 2010).

Students' scored this highly, with an average of 4.21 out of five. When asked during interviews what they enjoyed about the program, a number of students referred to both the personal relevance and the larger context. Four students said that it gave them an experience would help them in the future. Five mentioned learning about and/or participating in the bigger picture: they referred to helping the earth, doing something good for the world, and gaining knowledge about nature and "what we need to do." The *experiential* aspect of the program was noted by students as well, with four students noting being in nature, being out of the classroom, or participating in physical activity as highlights of the program. That students ranked the field work projects as the most influential factor for developing environmental literacy outcomes also supports this claim: during field projects, students must collaborate with one another (relationship-based) on hands-on projects (experiential) that are defined by community sponsors and which directly support environmental quality goals (relevant). Although this study did not examine the specific relationship between these approaches and academic outcomes, the statistically significant change in students' ecological understanding scores, the content-based element of environmental literacy, shows that programs that are experiential, relevant, and relationship-based may promote academic outcomes.

This study also supports the claim that a program that emphasizes and fosters affective outcomes is beneficial for academically at-risk students, a major factor in the theoretical framework of positive youth development programs (Tobin & Sprague, 1999; Catalano et al., 2004; Jensen, 2008; Umholtz, 2013; McMillan & Reed, 1994). The

results of the affective evaluation measure show high positive outcomes among participating students, with each sub-construct rated above four on a scale of one to five. This shows that the program meets the desired affective outcomes for positive youth development: students report a strong sense of belonging, interest in and personal relevance of the experience, and high internal motivation and engagement in both the field and in class. These data emerged alongside positive environmental literacy outcomes, which supports the claim that programs that meet students' affective needs may contribute to gains in academic and other areas (McMillan & Reed, 1994; Alfassi, 2003).

Challenges and Limitations

Inevitably, there were challenges that arose during the course of this study, as well as limitations that may influence the generalizability of the results. The greatest challenge was in the development of the treatment and instrument for the ecological understanding variable of environmental literacy, while the three broad limitations include potential researcher bias or influence, lack of evidence for causal inference, and small sample size.

The development, implementation, and modification of both the ecological understanding instrument and the treatment curriculum was a significant challenge of this study. As outlined in the instruments section above, the test used to assess the ecological understanding outcome of environmental literacy was developed using the Portland Metro STEM Partnership (2014) application of conceptual knowledge

framework, a research-based but relatively new approach to assessing student learning outcomes in science. Given that this measurement system is in ongoing development, there exists some discrepancy among PMSP partners and individual science educators as to its implementation. Rather than simply measuring students' capacity to memorize and recite facts and generalizations, this approach seeks to assess their ability to apply scientific content in unique situations. This required that the pre- and post-test be somewhat different, to give students the opportunity to apply their knowledge to novel scenarios. This raises the question of reliability: is a pre-post test that asks different questions an accurate representation of the change in students' knowledge? What if one of the questions is inherently more difficult than the other?

In order to account for this difference, a faculty advisor suggested that I include two scenario questions, and give half of the students one question on the pre-test (i.e. Question A) and the other question (Question B) on the post-test, and vice versa for the other half. The challenge was then to write two questions that assessed the same content information (ecosystem relationships and biodiversity), but which did not require specific background knowledge. Of the initial two questions that I wrote for the pre-test, I determined that one of them did not meet these criteria. The question asked students to apply their knowledge to predict how sedimentation runoff would impact a river ecosystem. Upon review, I determined that a thorough response to this question required an understanding of how suspended solids impact water quality, content that would be outside of the curriculum focus for the study period. I modified the question for the post-test in order to better assess students' ability to apply the content of the

unit to a novel scenario (see Appendix C for complete versions of each of the tests used, including the original and modified questions). The new question tested for the same general content application but used a scenario that focused on stormwater runoff. The original question was scored for student application of knowledge in the area of ecosystem relationships and biodiversity, not sedimentation specifically: although an imperfect question, it still provides a strong pre-assessment of student knowledge in the content area.

An additional challenge that arose with this instrument was in scoring. The application of conceptual knowledge framework allows students to respond to questions in a more qualitative manner through constructed response questions. This accounts for diversity of student thinking but makes it more challenging to achieve inter-rater reliability in scoring. The Portland Metro STEM Partnership (2014) rubric provided a starting point, but on a trial run of scoring did not provide reliably consistent results. To address this challenge, I created a thorough rubric specific to this test, as well as a supplemental scoring guide. This addressed the issue of reliability and provided consistent results across scorers. Four other individuals (fellow graduate students and faculty advisors) also scored the tests.

Closely related to the development of the ecological understanding instrument was the emergent design and implementation of the treatment curriculum. This was a challenge both from an instructional and a research perspective. This was a new curriculum, one that I designed specifically for this research period, and which had a number of activities and content that I was facilitating and teaching for the first time.

This six-week classroom curriculum was specific to the content of the ecological understanding measure, while the other variables measured in this study—nature connection, self-efficacy, and affective outcomes—are interwoven through the culture of the program that I had worked to develop over the past three years. This was my first opportunity as an educator to engage in the process of designing curriculum and developing a valid and reliable test to accurately assess students' learning. As with any task undertaken for the first time, there were a number of changes I would make to both the curriculum and the assessment in order to improve them, given the chance. An ideal situation would have allowed for the development and piloting of the treatment and instrument with one group of students, followed by a revision of the curriculum and assessment (including using the above-mentioned revised question for both pre- and post-tests), and a second run of the treatment to be used for collection of data. However, the circumstances and the time constraints of both my degree program and the conservation corps program did not allow for this.

There were three areas of potential limitation of this study. Throughout the study period, I acted in the roles of researcher, curriculum developer, and educator. This blending of roles may have introduced bias into this study that may not have been present had I acted only as researcher. However, while the fact that I am so close to this study may be a limitation in some ways, it also allows me to perceive many of the nuanced elements of the program that may contribute to the positive outcomes of this study that are worthy of reflection.

In the time that I have been acting as crew leader and educator in this program, I have changed and refined my approach in working with students and have developed certain characteristics that I believe support students. First, I have seen over time how important the cohesion of the group is, and that this can make or break the program. This has become a cornerstone of my approach as an educator and an integral part of this program: building community through games and initiatives as well as seeking ways for students to access and learn content while collaborating in initiative-like activities. Second, I work to communicate clearly with students, set clear boundaries and expectations, and create flows of information and feedback in both directions. Some of the ways I do this include providing students with access to all of the information that a sponsor gives me about a project, creating clear learning targets and providing a thorough syllabus, communicating the class plan at the beginning of each day, and having students complete 'exit slips' and other formative assessments to assess their progress toward learning targets. Last, I strive to create an egalitarian structure in which students' voices are valued and honored, and they are given chances to take ownership for their own experience and for the success of the group as a whole. I recognize the imbalance of power and authority that I have as a teacher and leader, and am constantly seeking ways to empower students through a more democratic approach to education, moving from a 'power over' dynamic to a more emergent and synergistic 'power with'. This is a constantly unfolding process and an area where I still have much room to grow. Part of my efforts to promote relationships, foster clear communication, and balance power includes developing my own personal relationships with each of the

students. This relationship may have served as a limitation, by influencing student responses to the survey and interview questions, but it may also be an important element of the study treatment overall. Further research that includes variables external to the program, such as student attendance, academic performance, or disciplinary history in other classes prior to or concurrent with study treatment, would serve to minimize researcher bias and provide a baseline of comparison for these outcomes.

The other two potential limitations of this study include causality and sample size. This study examined a number of outcome variables, including the three elements of environmental literacy as well as affective outcomes. These were each examined independently, which limits our ability to draw definitive conclusions about the causal relationships between variables. Lastly, given the small sample of this study (n=8), the results serve more as suggestions for improvements and changes to this specific program. They do, however, offer enough evidence to suggest the potential of such programs to foster science learning in students who have struggled in traditional education settings, and to encourage further research in this area.

Implications

Despite the challenges and limitations of this study, the results support the claim that place-based, sustainability education can provide a natural context for academically at-risk students to develop environmental literacy, which includes learning environmental science. These results especially provide valuable insights into the

ongoing improvement and development of this particular program. The data reveal the strengths of this program in the areas of belonging and nature connection, which reinforces the existing activities and elements that promote these outcomes. This provides a valuable opportunity to leverage these strengths to bolster other outcome areas, especially in the area of science education. Existing research points to belonging as a strong factor in promoting academic success in at-risk youth (Johnson, 1998; Tobin & Sprague, 1999; McMillan & Reed, 1994; Umholtz, 2013). There is some evidence in this study and other research that nature connection influences the other areas of environmental literacy (Leong et al., 2014) including the more academic construct of ecological understanding (Littledyke, 2008). These strengths, as well as the outdoor and experiential elements of the program that were shown to promote all outcomes, provide a solid foundation on which to build a more robust, integrated curriculum that promotes science learning while empowering students to take action in their community. In the coming year, I will continue to seek ways to strengthen the program through this approach. This will include developing more comprehensive science outcomes that align the learning in this program with efforts toward improving science education on the national level, through integration of disciplinary core ideas, science and engineering practices, and crosscutting concepts outlined in the Framework for K-12 Science Education (National Research Council, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). With a thematic focus on environmental and life sciences content, I will also aim to continue to integrate pedagogical elements of sustainability education in the program curriculum, especially through incorporating

diverse and non-dominant perspectives around sustainability issues (Burns, 2011).

Two other insights that I gained from the process and outcomes of this study are in the realms of student recruitment and designing assessments. There is evidence that this program most benefits students like Camila and Daniel, who were not initially inclined to participate. This provides incentive for me to reach out to students who may not be inherently interested in the program, in order to open the door to those who may need it the most. Also, designing quality assessments that reliably measure student proficiency in science content areas continues to be an area of growth for me, personally, and for the betterment of the program as a whole.

While the results of this study have strong implications for this program in particular, they can also be extrapolated to provide broader insights for existing youth conservation corps programs as well as traditional science education more generally. The integration of the place-based and outdoor approaches (such as those used in this study) with formal science education shows strong potential for closing the science achievement gap (Lieberman and Hoody, 1998). There are a number of youth conservation corps programs that currently exist throughout the country: each has its own culture and outcome goals, and is colored by the local community in which it is nested. These existing programs could integrate science into the experience in a unique and inherently place-based way. Many of these programs already have a strong base of skill development and affective outcomes, which this study and broader research in positive youth development show to be beneficial (McMillan & Reed, 1994; Tobin & Sprague, 1999; Catalano et al., 2004), if not crucial, to positive academic outcomes for

at-risk youth. This study showed that field work projects and spontaneous learning during these projects were the most influential elements in promoting positive outcomes in environmental literacy: existing conservation corps programs already have this key element in place.

This study has implications for more traditional education settings as well. Integrating more outdoor and experiential elements may help to close the achievement gap in science classrooms for students who struggle with traditional approaches (Lieberman & Hoody, 1998). Also, using instructional approaches that are experiential, relevant, and relationship-based may serve to promote learning among students in this population (see Appendix A). The interconnections between the three areas of environmental literacy that arose in the interview data suggest that the integration of activities and assignments that emphasize nature connection and competency skills may help to promote the more academic outcome of ecological understanding (Littledyke, 2008). Although more research is needed to draw definitive correlations between these three areas, providing students with opportunities to develop a relationship with the natural world, and to participate in the solutions to environmental problems, may serve to increase the relevance of environmental science content (Burns, 2001; Blatt, 2012). The recent emergence of the Next Generation Science Standards, which reflect integrative content, science and engineering practices, and crosscutting concepts (NGSS Lead States, 2013) dovetails well with the approaches used in this study. Specifically, disciplinary core ideas and performance expectations in the Life Sciences (especially LS2: Ecosystems and LS4: Biological Evolution) and Earth Sciences (ESS3: Earth and Human

Activity) could be explored through place-based and outdoor approaches that allow students opportunities to directly engage in environmental issues in their communities. Habitat restoration provides an elegant application of engineering design (ETS1) in the Life Sciences, a content area where engineering is less immediately apparent than the other sciences. The findings of this study provide support for future development of experiential and place-based programs that can offer unique opportunities for struggling students to develop the skills, knowledge, and values that define environmental literacy and promote science education. This should include comprehensive research to assess the effectiveness of such programs in promoting academic and affective outcomes (Saxton et al., 2014), especially in light of the introduction of Next Generation Science Standards into classrooms throughout the nation.

Further research on environmental literacy is needed to determine the effectiveness of different approaches in promoting this outcome, the connections between outcome areas, and whether it meets the goals of sustainability education. This study examined the three main areas of environmental literacy, but each of these three areas is itself a potential area for more focused research. The measures chosen for this study were mere slivers of the complex and multifaceted realms of ecological understanding, nature connection, and competency skills. More research into the development of each of these, as well as the relationship between them, is needed (Oregon Environmental Literacy Task Force, 2013). If the ultimate goal of sustainability education is to empower students to act as agents of change in transforming systems

(Burns, 2011) to create a sustainable future (Oregon Environmental Literacy Task Force, 2013), attention must be given to the competency skills aspect of environmental literacy. Self-efficacy was chosen as the construct to represent competency skills in this study, as it encompasses individuals' beliefs in their abilities to affect change in their lives (Sherer et al., 1982) and is an area of overlap between the research areas of sustainability education and positive youth development. Research on competency skills as they apply specifically to environmental literacy should include an expansion of the range of competencies and internal constructs that are necessary for an individual to feel empowered to take action on environmental and social issues. These may include problem solving, critical thinking, goal setting, communication, teamwork, and other skills. Further research in this area would also benefit from focus on self-efficacy in the specific realms of environmental or social justice action. This should include an individual's belief in their ability to affect positive social change in widening circles of influence: from within oneself, to one's community, up to the global scale.

As the 21st century continues to unfold and educational structures evolve to meet the needs of a changing world, science and sustainability education and environmental literacy become increasingly important areas of focus. The challenges of meeting the needs of diverse learners while preparing them to engage with a complex world as capable citizens requires educators to look beyond traditional approaches to learning (Umholtz, 2013). A more holistic view is necessary, to account for the complexity of individuals, of human and natural systems, and the relationship of the parts to the whole (Sterling, 2001). The conservation corps model provides a unique

educational context to engage students' heads, hands, and hearts in preparing them for the uncertainty and opportunity in the decades to come. The development of connection to nature and to each other, an increased understanding and awareness of ecological systems and human impact, and a sense of purpose and empowerment in taking action to foster a sustainable world: these are the promising outcomes that this program and others like it can offer. In a world where the winds of change cannot be predicted, these may be the best tools that we can offer to the young people who will be the ones to navigate us into a more sustainable future.

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Appendix A: Pedagogical Approaches from Literature

Sustainability Education			
Burns (2011)	Experiential learning, active learning, participatory, service learning, critical reflection	Problem-based learning, service learning; thematic and interdisciplinary content	Collaborative group work, relationships, co-creation of meaning, dialogue/discussion
Colucci-Gray et al. (2006)	Active role-play scenarios followed by deep reflection	Issues-based problem solving	Peer-to-peer interaction, dialogue around complex issues incl. listening; non-violent communication
Blatt (2012)	Active participation in positive actions; critical reflection on own views	Issues-based, interdisciplinary focus; direct connection to students lives	Dialogue and debate
Littledyke (2008)	Direct experiences with nature; emphasis on informed action; start with learner's experiences	Linking scientific ideas to real life phenomena and experiences; 'big ideas' provide integrating function	Empathy/care of self, others, and environment
Place-Based Learning			
Knapp (2005)	Capitalizes on lived experience; natural investigations	Real-world problem solving; student participation in community decision-making; interdisciplinary	Contribution to community well-being
Athman and Munroe (2004)	Project-based learning; reflection on experiences	Project/issues-based learning, meaningful tasks	
Lieberman and Hoody (1999)	Hands-on experiences, often through problem-solving and project-based activities	Interdisciplinary, project-based, engaging with local issues in community	Cooperative learning; increases abilities to work with group and communicate with others; sense of belonging and community

Positive Youth Development			
Umholtz (2013)	Experiential learning through problem-solving or project-based activities; making positive change	Engaging in projects in local community; foster connection and meaning	Cooperative learning; chance to develop positive relationships
Tobin and Sprague (1999)		Increase student interest	Low student-teacher ratio; group collaboration; teaching social skills: problem solving, communication and conflict resolution, empathy, vocational social skills
Johnson (1994)	Establish experiential base for learning; incorporate challenging activities	Meaningful skills, concepts, activities; integrate skills and content	Cooperative learning
Alfassi (2003)		Success through authentic mastery experiences	Positive interpersonal climate
Catalano et al. (2004)			Strengthen social and emotional competencies; increase healthy bonding
Jensen (2009)	Project-based learning, incorporate movement and sensory activities; interaction with physical world	Participate in real-life activities, project-based learning; teach content in small chunks; use conceptual organizer; focus on patterns within content + thematically related information	Relationship building: between students and with teacher; low student-teacher ratio; cooperative learning; build social and emotional assets; students prefer debate/discussion

Appendix B: Class Curriculum

Figure numbers given in parentheses indicate student handouts included below curriculum table, some of which have been modified from their original formatting to fit the formatting requirements of this document. The resources listed either provided direct materials or supplemental insights into the development of an activity.

Week	Class Activities	Resource
1	**Habitat Webs** *How do organisms interact with the living and non-living environment to obtain matter and energy?*	
	HW: Reading: Regional Habitats + Worksheet: Portland Biodiversity Guide	Intertwine Alliance, 2012
	Circle check-in: highlights from spring break	
	(1.1) Sit spot check-in: where is your spot, what's there, what did you observe? Discuss with partner first, partner shares with large group. Each person writes three questions they have about others' sit spot on a sticky note.	Young, Haas, & McGown, 2010
	(1.2) Habitat webs: three groups, each group reads about one habitat (PBG) - Rivers, Streams, and Open Waters; Riparian Forests; Shrub habitat (Portland Biodiversity Guide) - Worksheet: pull out elements that make up this ecosystem: living and non-living, services or functions it provides, human impacts, how it will be affected by climate change, conservation strategies - Draw a diagram web with all of the organisms, arrows indicating relationships between them - Share with group	Intertwine Alliance, 2012
	Interactive lecture: Ecology concepts and terms	
	Exit slip: - The most important or interesting thing I learned today was… - I would like to learn more about… - I am confused about…	
2	**Macroinvertebrate Survey** *Which macroinvertebrates are present at Brown's Ferry Park?* *What can macroinvertebrate diversity tell us about the health of the aquatic ecosystems?*	
	HW: Macroinvertebrate reading	Wolftree, Inc., 2004
	(2.1) Introduce macroinvertebrate surveys, split into groups, students decide group roles	
	(2.2) Macroinvertebrate surveys: Brown's Ferry Park - Group roles before out in field - Two groups: one in wetland, one in stream	Wolftree, Inc., 2004

	- Demonstrate sampling - Sorting and identifying, filling in data sheets - Reflection worksheet	
	Exit Slip - The most important or interesting thing I learned today was… - I would like to learn more about… - I am confused about…	
3	**Biodiversity** *What are different ways that organisms interact with each other?* *What is biodiversity and how does it relate to habitat health?*	
	Sit spot check-in: what kinds of interactions have you observed at your spot? Discuss with partner first, partner shares with large group. Each person writes three questions they have about others' sit spot on a sticky note.	
	In-class reading: Ecological Interactions + Terms worksheet	Kahn Academy, 2015
	Video: Ecosystem Interactions	Kahn Academy, 2015
	Web of life activity: each person draws a notecard with a species in a river ecosystem, go around the circle and use ecological terms to describe their organism. Pass a string around the circle to map the interactions between all of the individuals in the ecosystem.	
	(3.1) Jenga activity: two groups, two habitats - Students used field guides to explore different species and work together to talk through different species interactions and which ones should go where in stack - Group Discussion: reflected on the challenge of deciding which species were most important, lack of information	Portland Biodiversity Guide (Intertwine Alliance, 2012)
	Exit Slip - The most important or interesting thing I learned today was… - I would like to learn more about… - I am confused about…	
4	**Ecosystem Functions and Services** *How does biodiversity contribute to ecosystem function?* *How do healthy (functioning) ecosystems provide necessary services to humans?* *How does habitat restoration contribute to ecosystem function?*	
	HW: Ecosystem Functions and Services Reading (SEQ Ecosystem Services Framework)	(SEQ Catchments, 2015)
	Sit Spot check-in: what is the biodiversity like at your spot? Discuss with partner first, partner shares with large group. Each person writes three questions they have about others' sit spot on a sticky note.	
	(4.1) Review: revisit where we've been and where we're headed	

	- Note-taking guide	
	Interactive lecture: Ecosystem functions and services	
	Video: Ecosystem Services	Kahn Academy, 2015
	Wetlands Observation Activity and Group Discussion – Cook Park Wetland	
	Video: Ross Island (Oregon Field Guide) - Group discussion: what services did RI offer in the past? What services is it offering now?	Patton, 2015
	Formative Assessment: 1. In your own words, please explain what biodiversity is and how it relates to ecosystem function and services. 2. Use the terms that you described above to explain how habitat restoration improves habitat health.	
5	**Humans and Biodiversity** *How do human actions affect biodiversity?* *What are ideas or approaches that can conserve biodiversity?* *How can we take action in our community to conserve biodiversity?*	
	Sit Spot check-in: what are signs of human presence at your spot? What are the human impacts you have observed? Discuss with partner first, partner shares with large group. Each person writes three questions they have about others' sit spot on a sticky note.	
	Revisit discussion norms (established in past class) - Open discussion: add additional norms that people think are important	
	(5.1) Video: Call of Life documentary - Worksheet during film and individual reflection after film - Partner reflection: sharing individual reflections - Group discussion: started with having students throw out words to describe how they felt while watching film, continue into larger group discussion	Van Burg & Thompson, 2010
	(5.2) Strategies for Taking Action Project - Introduce assignment - Guided visualization: Imagine you woke up tomorrow and lived in a city that supported a diversity of life: what does it look like, what do you see, etc? - Group discussion: Make group list of the qualities or characteristics that they saw in imagination - Choose one and work backwards to practical actions - Pugh chart: discuss as a group the criteria that solutions should meet - Work in partners to start brainstorming project	Macy & Young Brown, 2014
	Note-taking guide: fill in blanks	
6	**Solutions and Taking Action + Unit Review** *How do human actions affect biodiversity?* *What are ideas or approaches that can conserve biodiversity?*	

	How can we take action in our community to conserve biodiversity?	
	HW: Reading: Habitat Restoration and Enhancement (Portland Biodiversity Guide)	Intertwine Alliance, 2012
	Sit spot check-in: how could your spot be changed to improve biodiversity? Discuss with partner first, partner shares with large group. Each person writes three questions they have about others' sit spot on a sticky note.	
	Review: - Revisit terms sheet and notetaking guide (4.1) - Revisit river web, apply terms to web	
	Solutions Projects (5.2): revisit assignment and work together on projects	

1.1 Portland Biodiversity Guide: Habitats

In your small groups, you will create a **visual model** of the information from the short article you read, which you will use to teach the rest of the group about your ecosystem.

Web of Relationships

- On the large piece of paper, write all of the different types of living species (ex: birds, plants, etc.) that are included in the article, as well as the non-living elements (ex: dead wood, water, etc.).
- Using different colors for different kinds of relationships, draw arrows between elements indicating interactions.

These may include interactions between elements for

- Food (ex: bald eagle eats fish)
- Habitat/shelter (ex: woodpecker lives in dead standing tree)
- Reproduction/breeding (ex: bees pollinate flowers)
- Any other ways that species interact with each other and their environment

If you're not sure what something is, what it eats, or where it lives, use your resources! Field guides, the Encyclopedia of Life website (eol.org), and Google can help give you more background about different species.

Teach Us!

After creating your habitat diagram, you will teach the rest of the group about your habitat. Be sure to include the following:

1. General description/definition of your habitat
2. What makes it unique and what makes it important? What ecosystem services does it provide?
3. What are threats or human impacts on this habitat?
4. What are some strategies for improving the health of these habitats?

2.1 Group Roles: Macroinvertebrate Surveys

The Facilitator... • Provides leadership and direction for the group • Reads procedure to collector • Makes sure all steps of procedure are followed • Makes sure that everyone in group is involved • Keeps group focused and on task *"Let's hear from_____next."* *"That's interesting, but let's get back to our task."*	**The Collector...** • Carefully follows procedure to collect survey data • Gets in the water and collects the macroinvertebrates, making sure to collect a thorough sample • Sorts organisms into trays (with all members of group) *"What do I need to do to get a representative sample?"* *"What is the next step?"*
The Recorder and Reporter... • Records data (measurements and calculations) • Checks to be sure that ideas are clear and accurate, asks clarifying questions *"I think I heard you say_____; is that right?"* *"How would you like me to write this?"* *"What measurement did you get?"*	**The Checker...** • Reads procedure carefully and ensures that data is collected according to instructions • Checks for accuracy in measurements and calculations • Pays attention to details and ensures quality of work • Makes sure data sheets are complete *"Does this accurately reflect what we've done today?"* *"Have we left out anything important here?"* *"Do we have all the information we need?"* *"How can we make this better?"*

2.2 Macroinvertebrate Surveys: Reflection Questions

1. What was the dominant **population** in your sample? (Which species were there the most of?)

2. Using the tolerant/intolerant sheets, which group best reflects the **community** found in the habitat you sampled?

   What does this tell you about the health of this **ecosystem**?

3. What human activities in the surrounding area might impact the health of this ecosystem?

4. Choose one species of macroinvertebrate that you found.
   What feeding group is this species in?

   What might it eat in this habitat?

   Draw a simple food chain that shows the species that this macro depends on, and the species that depend on it.
   Ex: sun ⟶ alder tree ⟶ **caddisfly** ⟶ young salmon ⟶ osprey

3.1 Biodiversity Jenga

In this activity, your group will **create a model** that represents an ecosystem. Your goal in creating this model is to use the scientific knowledge that you have to make a model that closely represents a real ecosystem, and which can help you understand the concept of biodiversity and why it is important.

Round 1: Create your model.

1. Each Jenga block represents a species population.
2. Refer to your notes from the Portland Biodiversity Guide reading and the ecosystem webs that we made for open water and riparian forest habitats as a guide to determine the species in your ecosystem. You can pick and choose from these species as you go, or decide on them to begin.
3. Use the sticky dots to label the blocks as certain species.
4. Stack the blocks in a way that best represents the actual ecosystem. Some species are more important than others when it comes to the health of the ecosystem. Where in the stack are the key places of support? Which species would go in these places? Where are areas where removing blocks doesn't have much impact? Which species would go here?
5. Remove one block at a time and set it off to the side.
6. Record your data on the data sheet and make observations.

Round 2: Test your model

1. Stack your blocks again, making any changes that might make it a more accurate model.
2. Again, remove the blocks one at a time and set each one to the side. This time, though, focus on those areas that are the key places of support.
3. Record your data sheet and make observations.

Round 3: Apply concepts to your model

1. Stack your blocks again, making any changes that might make it a more accurate model.
2. This time, when you remove your blocks, instead of setting them off to the side, introduce them as invasive species to your ecosystem. Remove the label, and place them on the top of your stack.
3. Record your data and make observations.

Round 1: Total Number of Levels: _____ Total Number of Blocks: _____

Species Removed	Location in Stack*	Observations
Total # Native Species Removed:		

*Come up with a way to record the specific location of each block that can be recorded numerically. Which level, which position?

Round 2:

Species Removed	Location in Stack*	Observations
Total # Native Species Removed:		

Round 3:

Species Removed	Location in Stack*	Observations
Total # Native Species Removed:		
Total # Invasive Species Added:		

Biodiversity Jenga Reflection Questions

What were the species that you placed in the key places of support? Why did you choose these species?

Describe the results of each of the rounds:
1.)

2.)

3.)

How does this model represent a real ecosystem?

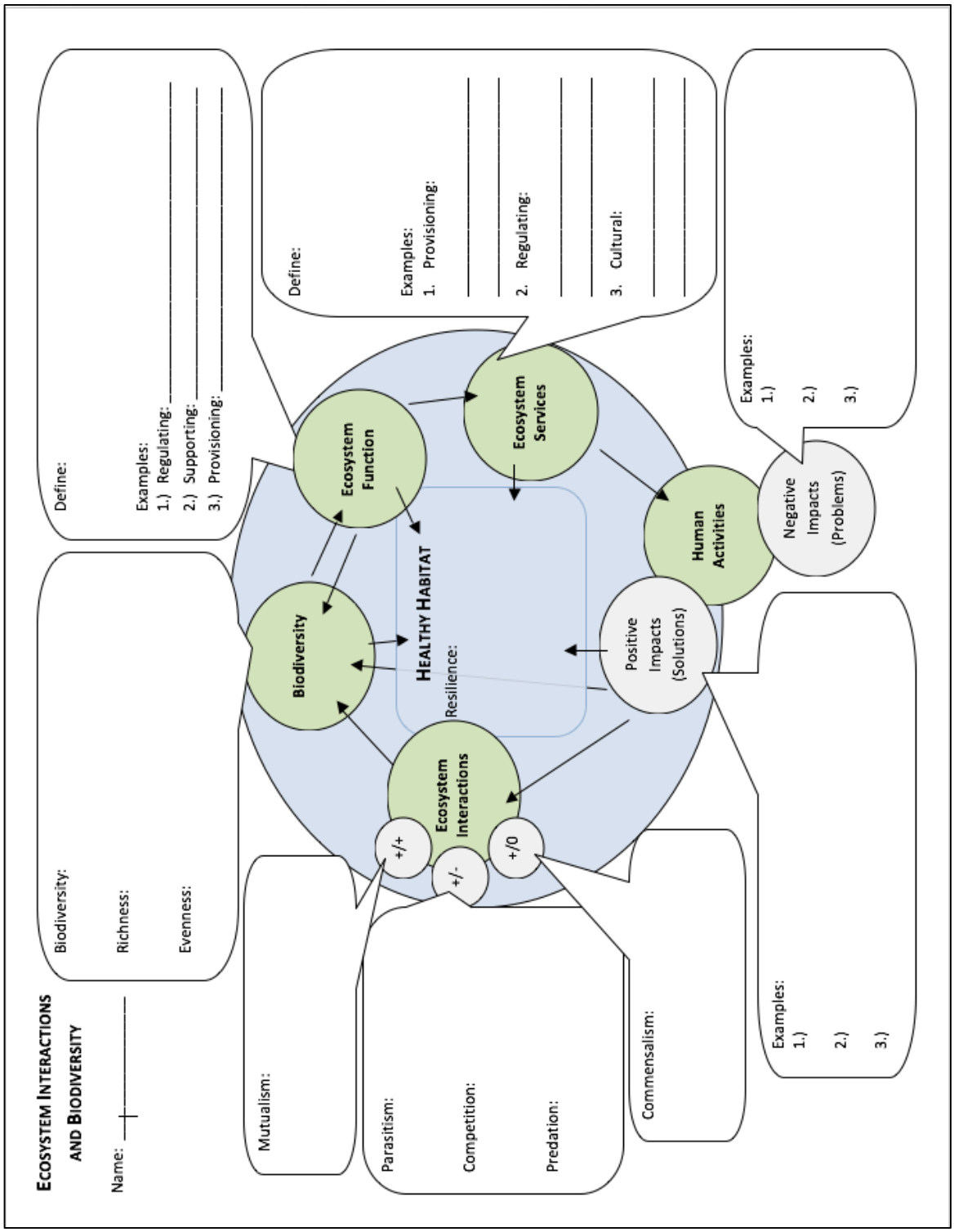
What are the limitations of this model? (i.e. how is it different from a real ecosystem?)

List three things that might cause populations to be removed from ecosystems.
1.)

2.)

3.)

4.1 Note-Taking Guide



5.1 Call of Life Documentary

NAME: _____

What is the natural rate of extinction? _____

Ecosystem Services: List 3 ways humans depend on biodiversity and healthy ecosystems

1. _____
2. _____
3. _____

What percentage of primary nutrients in a watershed are brought back by salmon? _____

Direct Drivers:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Hidden Drivers:

1. _____
2. _____
3. _____

Individual Reflection:

What argument does the film make about why we should be concerned about species extinction and the decline of biodiversity?

What kinds of thoughts and reactions did you have when watching this film?

What do you think are the most important changes that we have to make as humans in order to slow the rate of biodiversity decline?

5.2 Strategies for Taking Action: Conserving Biodiversity

Your Challenge:

Design a solution for reducing the impacts of human activities on biodiversity in your local community.

You and your partner will use your **creativity and imagination** combined with your **scientific understanding of biodiversity and ecosystem function** to design a solution for conserving biodiversity.

Use the templates on the following pages to guide you in the creative process.

Guiding Questions:

How can we use the natural world as inspiration for making more biodiversity-friendly cities?
How can we make cities less destructive to wildlife?
What qualities or features increase presence of biodiversity?
What ideas/approaches/designs already exist that you can use as an inspiration?

Use your resources! Refer to Portland Biodiversity Guide: "Habitat Restoration and Enhancement", do research online, draw from your own experience, knowledge, and ideas about a life-sustaining world.

Assignment *(Due 5/13)*: You will turn in a **2-page typed paper** that describes your design. Be sure to include the following (see template).

1. A description of the problem of biodiversity decline:
    - Why is it a problem?
    - What drivers contribute to the problem?
2. A description of the criteria for a successful solution and why these criteria are important.
3. A detailed description of your solution and the drivers that it addresses.
4. Clearly explain how your solution will address the problem of biodiversity decline.
    - How will the action you take (independent variable) affect the factor you are trying to affect or change (dependent variable)?
    - What evidence or reasoning do you have for this?
5. A list of steps for implementing your solution.
    - What would it take to put your idea into action?
    - Who would have to be involved?
    - What steps would you have to take?
6. Any sketches or drawings that help to communicate your solution.
7. Completed Pugh chart and sketches/explanations that show your design process.

Show your idea by sketching or drawing	**Explain** your idea with words and/or numbers

Show your idea by sketching or drawing	**Explain** your idea with words and/or numbers

Strategies for Taking Action: Conserving Biodiversity (Template)

The problem that we are trying to solve is…
(describe the problem of biodiversity decline and what drivers contribute to it)

The criteria for a successful solution to this problem are…
(describe in detail the criteria that your solution needs to meet)

Our design solution for conserving biodiversity is…
(describe in detail your solution, including the drivers it addresses, and how it meets the above criteria.)

Our solution will address the problem of biodiversity decline by…
(provide scientific reasoning and/or evidence for how your solution will address the problem. How will the action you take (independent variable) affect the factor you are trying to address (dependent variable)?)

The steps to implementing this solution are…

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Sketch/Drawing

Problem to be solved:

Each **Solution** is one possible design or way to solve the problem. Sketch or write the solutions in the boxes across the top. Each **Criterion** is one of the elements that you need to consider for each solution, such as cost, size, safety, etc. List below.	Weight each criterion 1-5, where 5 is the most important	SOLUTION A	SOLUTION B	SOLUTION C	SOLUTION D
FOR EACH CRITERION, RANK EACH SOLUTION FROM ZERO UP TO THE WEIGHT NUMBER DEPENDING ON HOW WELL THAT CRITERION IS FULFILLED BY THE SOLUTION					
CRITERION 1 **Cost ($)**					
CRITERION 2 **Scope/Size**					
CRITERION 3					
CRITERION 4					
CRITERION 5					
The weight number is the maximum score if the criterion is covered by that solution, and 0 if the solution doesn't address that criterion at all, then total the scores here:					

Solution Project Rubric

Section	(1)	Emerging (2)	(3)	Proficient (4)
Description of Problem	Not included	Student includes description of the problem, but only one of the questions are explained OR Student is partially able to explain the problem, but some misconceptions are included.	Student includes description of the problem, but only two of the questions are explained OR Student is mostly able to describe the concept, but 1 or 2 misconceptions are included.	Student includes accurate and complete description of the problem, including: 1. What is biodiversity? 2. What human drivers threaten biodiversity? 3. Why is it a problem?
Criteria	Not included	Student includes 1-2 criteria AND/OR Student does not provide explanation for why each criterion is important.	Student includes 3-4 criteria AND/OR Student provides partial explanation for why each criterion is important.	Student includes at least five criteria for a successful solution and provides an explanation for why each criterion is important.
Solution: description	Not included	Student includes partial description of proposed solution, but does not provide enough detail to fully understand proposal. Does not include *either* - How it addresses criteria OR - Drivers addressed	Student includes description of proposed solution, but does not include *either* - Enough detail to fully understand proposal OR - How it addresses the criteria OR - Drivers addressed	Student includes detailed description of their proposed solution. This includes: 1. What is the solution? 2. How well does it address the criteria? 3. What driver(s) does it address?
Solution: explanation	Not included	Student explanation of how solution will improve biodiversity is incomplete or unclear, and does not provide sufficient evidence or reasoning. Some misconceptions may be revealed.	Student includes explanation of how their solution will improve biodiversity, but does not provide sufficient evidence or reasoning. One or two misconceptions may be revealed.	Student includes clear explanation of how their solution will improve biodiversity, including: 1. The factor they are trying to affect or change. 2. How the proposed action will influence this factor. 3. Provide evidence or reasoning for why they predict this change.
Solution: steps	Not Included	Student includes less than five action steps AND/OR	Student includes 5-9 action steps for implementing solution	Student includes at least ten realistic steps for implementing

		Steps include large gaps that make sequence unrealistic.	AND/OR Steps do not start from the present moment or include gaps in action.	solution, starting from the present moment and ending with desired change. Steps follow a realistic sequence.
Visuals (Optional)	N/A	Drawings or sketches are confusing or do not accurately represent solution.	Student provides drawings or sketches that somewhat improve understanding of solution.	Student provides drawings or sketches that allow for deeper understanding of solution.
Format	N/A	Proposal is… - Difficult to understand - Hand-written, messy.	Proposal is… - Mostly clear, with a few unclear statements or sentences. - Neatly hand-written.	Proposal is… - Clearly written - Typed and printed, 12 pt. font, double spaced

Solution Project Self-Assessment

Section	Your Group's Score	1. Justify your score: why did you give yourself this score? 2. How could you improve your score?
Description of Problem		Justify:
		Improve:
Criteria		Justify:
		Improve:
Solution: description		Justify:
		Improve:
Solution: explanation		Justify
		Improve:
Solution: steps		Justify:
		Improve:
Visuals (Optional)		Justify:
		Improve:
Format		Justify:
		Improve:

Appendix C: ACK Test, Scoring Guide, Rubric

(Note: Some elements on these tests resized in order to fit formatting requirements of this document)

Pre-Test

1. Ecological Relationships and Biodiversity in a Riparian (River) Forest Ecosystem

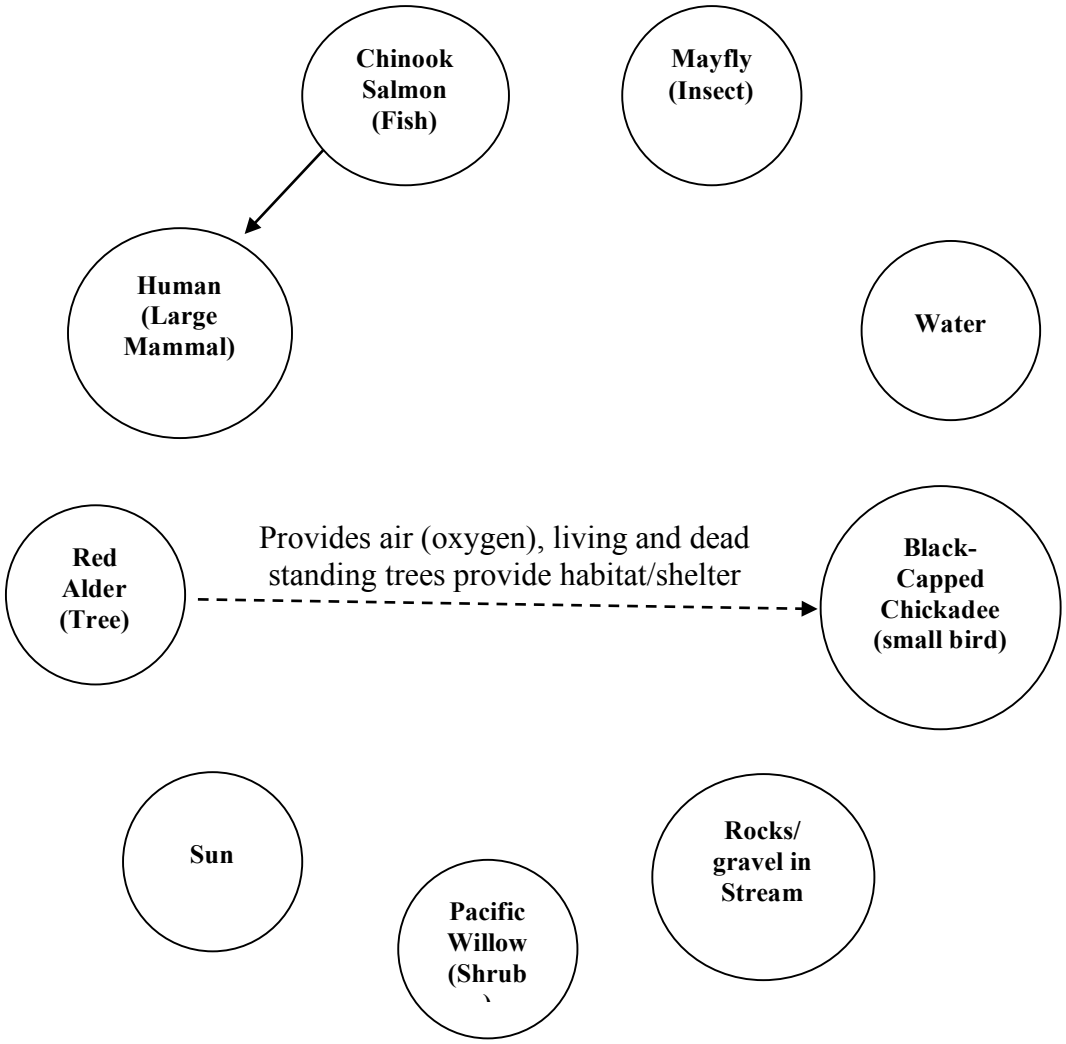
Please draw a web that illustrates all of the different relationships that may exist between the living and non-living elements of this ecosystem. Ecological relationships include all of the ways that individuals might influence, depend on, or interact with each other.

Use the following key (see examples below):

Food relationship ——————→

Other relationship - - - - - - - - - - →

"Other relationships" may include interactions with other elements for habitat/shelter, reproduction, growth and development, or other survival needs. For each dashed arrow you draw, please describe the interaction (see example below)



2A. In what ways does this model that you drew represent a real ecosystem?

2B. In what ways does the model differ from a real ecosystem?

2C. How could you change the model to make it more realistic?

3. (Group A) In the ecosystem you represented, a disease sweeps through and kills off all of the alder trees.

Would this affect the…
Mayfly (insect)? Circle one: Yes No
If yes, how?:
_____
_____
Salmon (fish)? Circle one: Yes No
If yes, how?:
_____
_____
Willow (shrub)? Circle one: Yes No
If yes, how?:
_____
_____
Human (large mammal)? Circle one: Yes No
If yes, how?:
_____
_____
Black-capped chickadee (small bird)? Circle one: Yes No
If yes, how?:
_____
_____
Water? Circle one: Yes No
If yes, how?:
_____
_____
Rocks/gravel in stream? Circle one: Yes No
If yes, how?:
_____
_____
Sun? Circle one: Yes No
If yes, how?:
_____
_____

3. (Group B) In the ecosystem you represented, a housing development is being built upstream. The dirt from the excavation gets washed into the stream.

Would this affect the…
Mayfly (insect)? Circle one: Yes No
If yes, how?:
_____
_____
Salmon (fish)? Circle one: Yes No
If yes, how?:
_____
_____
Willow (shrub)? Circle one: Yes No
If yes, how?:
_____
_____
Human (large mammal)? Circle one: Yes No
If yes, how?:
_____
_____
Black-capped chickadee (small bird)? Circle one: Yes No
If yes, how?:
_____
_____
Water? Circle one: Yes No
If yes, how?:
_____
_____
Rocks/gravel in stream? Circle one: Yes No
If yes, how?:
_____
_____
Sun? Circle one: Yes No
If yes, how?:
_____
_____

4. Four friends visited an island. The island was far away from the mainland. No humans lived on the island. The friends talked about what would happen if all the plants disappeared from the island. This is what they said:

"I think all the animals on the island would eventually die."
"I think the animals that eat plants would eventually die but the animals that eat both plants and animals would live."
"I think only the predators on the island would live."
"I think eventually all the animals on the island will become meat eaters, and they will survive without plants."

Which answer do you agree with? _____ Why do you agree with them?
_____
_____
_____
_____

5. Four friends were talking about nature and how humans interact with it. One of them had the thought, "I wonder what would happen if all the humans disappeared tomorrow?" This is what each of them said in response.

"I think all of the plants would eventually die because there wouldn't be anyone there to take care of them."
"I think some species of plants and animals would die, but eventually nature would adapt."
"I think that invasive species would take over all of the other plants, and most plant and animal species would die."
"I don't think any plants and animals would die if humans disappeared."

Which answer do you agree with? _____ Why do you agree with them?
_____
_____
_____
_____

Post Test

1. Ecological Relationships and Biodiversity in a Riparian (River) Forest Ecosystem

Please draw a web that illustrates all of the different interactions that may exist between the living and non-living elements of this ecosystem. (Hint: Ecological relationships include all of the ways that individuals might influence, depend on, or interact with each other. This includes food relationships as well as interactions for habitat/shelter, reproduction, growth and development, or other survival needs.)

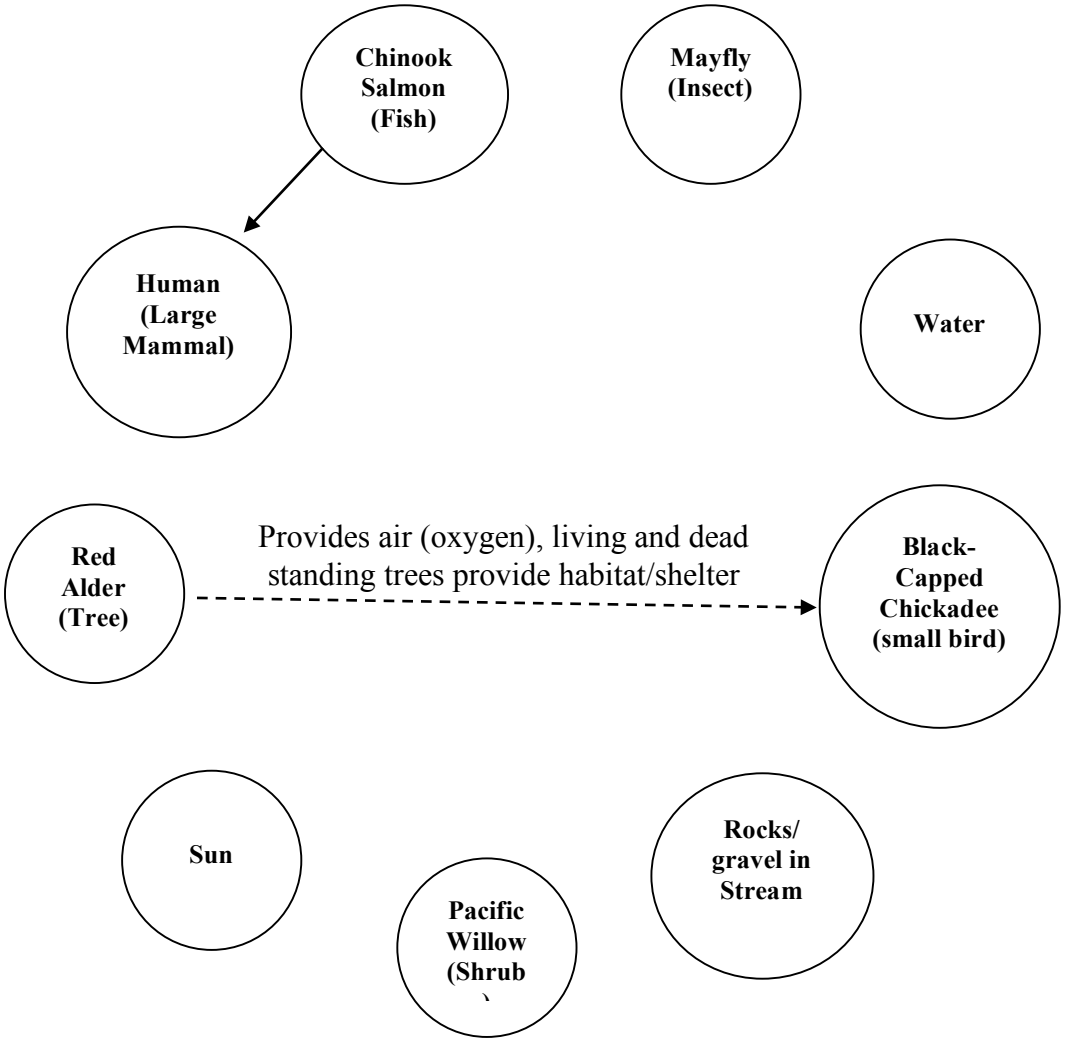
Use the following key (see examples below):

Food relationship ——————→

Other relationship - - - - - - - - - - →

Draw the arrow in the direction of the organism that benefits (i.e. humans benefit from eating salmon.) If both organisms benefit, draw two arrows.

For each dashed arrow you draw, please describe the interaction (see example below)



2A. In what ways does this model that you drew represent a real ecosystem?

_____
_____
_____
_____
_____
_____
_____
_____

2B. In what ways does the model differ from a real ecosystem?

_____
_____
_____
_____
_____
_____
_____
_____

2C. How could you change the model to make it more realistic?

_____
_____
_____
_____
_____
_____
_____
_____

3.(Group A) Refer to your model on page 1 to help you answer the following questions. The area surrounding the ecosystem you represented has a lot of buildings and roads. When it rains, the stormwater washes chemicals and pollutants into the river.

How might this impact each of the biotic elements of this ecosystem? Please be as specific as possible in your answer. (Hint: think about how it would impact the abiotic elements, too!)

Mayfly (insect): _____
_____
_____

Salmon (fish)? _____
_____
_____

Willow (shrub)?: _____
_____
_____

Human (large mammal)? _____
_____
_____

Black-capped chickadee (small bird)? _____
_____
_____

Red alder (tree)? _____
_____
_____

3.(Group B) Refer to your model on page 1 to help you answer the following two questions. In the ecosystem you represented, a disease sweeps through and kills off all of the alder trees.

How might this impact each of the other biotic elements of the ecosystem? Please be as specific as possible in your answer. (Hint: think about how it would impact the abiotic elements, too!)

Mayfly (insect):

_____
_____
_____

Salmon (fish)?

_____
_____
_____

Willow (shrub)?:

_____
_____
_____

Human (large mammal)?

_____
_____
_____

Black-capped chickadee (small bird)?

_____
_____
_____

4. Four friends visited an island. The island was far away from the mainland. No humans lived on the island. The friends talked about what would happen if all the plants disappeared from the island. This is what they said:

"I think all the animals on the island would eventually die."
"I think the animals that eat plants would eventually die but the animals that eat both plants and animals would live."
"I think only the predators on the island would live."
"I think eventually all the animals on the island will become meat eaters, and they will survive without plants."

Which answer do you agree with? _____ Why do you agree with them?
_____
_____
_____
_____

5. Four friends were talking about nature and how humans interact with it. One of them had the thought, "I wonder what would happen if all the humans disappeared tomorrow?" This is what each of them said in response.

"I think all of the plants would eventually die because there wouldn't be anyone there to take care of them."
"I think some species of plants and animals would die, but eventually nature would adapt."
"I think that invasive species would take over all of the other plants, and most plant and animal species would die."
"I don't think any plants and animals would die if humans disappeared."

Which answer do you agree with? _____ Why do you agree with them?
_____
_____
_____
_____

Scoring Rubric

Question	1 (Developing)	2 (Near Proficiency)	3 (Proficient)	4 (Highly Proficient)
1: See key	0-4 primary connections	5-9 primary connections	10-13 primary connections	14-20 primary connections
2: Score each question individually; total score is rounded average	Missing or incorrect	One basic or general (accurate) concept given May reveal misconceptions	Two basic or general concepts/ideas given. May reveal 1-2 minor misconception	2+ basic or general concepts given OR 1-2 more specific/higher level concepts given
3: Use scoring guide for entire answer	Missing or incorrect answers Answers are incomplete (not enough information or not clearly communicated)	Shows simple understanding Predictions show intuition or deduction more than scientific understanding May reveal misconceptions	Draws direct connections (1st degree impact) and/or Predictions show some scientific understanding May reveal 1-2 minor misconceptions	Draws both direct and indirect ecological connections (1st and 2nd degree impact, if present) Predictions are scientifically valid and clearly communicated
4: A 5: B	Missing or incorrect choice No explanation given	Correct choice with no explanation, or explanation incomplete/shows misconception OR Incorrect answer but explanation shows basic understanding	Correct choice Explanation shows general understanding	Correct choice Explanation shows higher level understanding

Scoring Guide

2A.

- Shows the different kinds of relationships, interactions, connections between living and non-living things
- Shows how these individual components of the ecosystem depend on and interact with each other
- Everything is connected to something else
- Different levels of species are present (producers/plants, consumers, omnivores, carnivores, decomposer)
- Includes living and non-living things
- Different kinds of living things are present (trees, shrubs, birds, fish, insects, mammals)

2B.

- Doesn't show the functions or changes in an ecosystem (doesn't show what an ecosystem is doing, only what it is made of)
- Doesn't indicate whether these are individuals or populations: if they are populations, we don't know how many of each (species evenness) are present
- Doesn't have the biodiversity (variety of species) that makes up a real living system: if this ecosystem existed it would not be very stable/couldn't function

2C.

- Incorporate more of different kinds of living things, especially plants (producers) and decomposers
- Include other food sources for the animals in the system so that they don't have only one food source
- Indicate the population sizes of each of the species represented

Question 3: Pre-Test Group B; Post-Test Group A

- Mayfly (insect): short-term increase in food source (decomposes leaves that fall in water) and/or long-term decrease in food source; loss of shade means warmer water, which would cause populations to decline;
- Salmon (fish)? alder provide oxygen, shade to salmon – loss/decline of these; Loss of shade→ warmer water lowers oxygen levels
- Willow (shrub)?: willow and alder may compete for resources, provide similar habitat; reduction in alder decreases competition for water, sunlight, and nutrients; may increase demand on willow for habitat, etc.
- Human (large mammal)? Loss of resources for shelter, warmth, fiber; decline in oxygen levels (if in model this is only source); if salmon populations decline we lose food source
- Black-capped chickadee (small bird)? Loss of habitat may cause decline in population; if mayfly population is affected they would respond to the increase/decrease in food source as well

Question 3: Pre-Test Group A

- Mayfly (insect): increase in sediment would choke rocks/gravel, where mayfly reproduce, decreasing population; dead willows would increase food source (decomposer)
- Salmon (fish)? Loss of mayfly population would impact salmon population; also increase in sediment would choke rocks/gravel, impacting salmon spawning beds; would also impact dissolved oxygen levels in water
- Willow (shrub)?: Loss of salmon would remove nutrients, potentially impacting health of willows – may be more susceptible to disease, stress, some might die
- Human (large mammal)?: Decline in water quality, loss of food source (salmon)
- Black-capped chickadee (small bird)?: Decrease in mayfly population would cause loss of food source

Question 3: Post-Test Group B

- Mayfly (insect): the pollution would cause water quality to decline, which would decrease the mayfly population
- Salmon (fish)? Would lose their food source (mayfly), health would decline due to lower water quality
- Willow (shrub) + Red alder (tree)?: roots absorb/filter chemicals/pollutance → increased stress, declining health with high levels of pollution (may decrease population, make it more susceptible to other disturbances, impact growth); would lose nutrients if salmon population declined
- Human (large mammal)? Loss of food source (salmon) or health impacts from eating toxic fish; decrease in drinking water quality;
- Black-capped chickadee (small bird)? Loss of food source (mayfly)

Question 4

Correct answer: A.

If all plants disappeared, all of the animals that eat plants (herbivores) would eventually die. Without herbivores or plants, the meat-eating animals (carnivores and omnivores) would eventually run out of food and die.

Question 5

Correct answer: B

- Certain domesticated plants and animals depend on humans for survival (like food crops or animals, or pets), and some of these living things would either die or have to adapt.
- Other populations of species that do not depend on humans would likely increase and ecosystems would be healthier.
- Some non-domesticated plants or animals that have adapted to human presence would likely decrease in number.

Appendix D: Affective Evaluation Survey

Survey scored with a Likert scale:

1 = Strongly Disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Strongly Agree

	(AV) Achievement Value
N	I have always been interested in learning about nature.* (measure of change, descriptive)
+	The experience that I get in [program] is important for my future career.
+	The things I learn during class in [program] are important for my future career
-	I don't see the point of anything we learn in [program].
+	I think environmental science is very interesting.
+	I think what we are learning in [program] is important.
+	I find the topics that we learn about in [program] personally meaningful.
+	When I am done with [program], I plan to learn more about these topics.
-	There's no reason to learn about environmental science.
+	I can apply what I have learned in [program] to my life.
+	I believe that environmental science can help make the world a better place.
+	It is important for people to learn about nature.
+	Environmental science can help solve society's problems.
	(BE) Belonging
+	[Program]is a good place for students like me.
	In [program], I feel…
+	Supported
+	Valued
+	Safe
+	Accepted
+	Like I can be myself
+	Like my ideas and opinions matter
+	Close to my teammates
+	Like I can ask for help when I need it
	(FM) Field: Motivation
	I do my work in the field because…
+	It is personally important to me.
-	I have to.
+	It is interesting.
+	I want to improve my skills.
+	It is fun.
-	I would get in trouble if I don't.
+	Practicing the skills I use will help me in the future.
	(FE) Field: Engagement

	Rate the following statements as they relate to your experience on work projects
+	I try hard to do well during work projects.
+	When we work on something in [program], it's pretty interesting.
-	When I'm in [program] on field days, I can't wait for it to be over.
+	I look forward to work days.
-	I don't really care about doing well in [program].
-	When I'm in [program], I feel bored.
+	During work projects, I listen carefully to the crew leader.
+	I enjoy learning new things during work projects
-	I can't stand working on projects in [program].
	(CM) Class: Motivation
	I do my work on class days because…
+	It is personally important to me.
-	I have to.
+	it is interesting.
+	I like learning new things.
+	It is fun.
-	I would get in trouble if I don't.
+	Learning this information will help me in the future.
	(CE) Class: Engagement
	Rate the following statements as they relate to your experience on class days.
+	I try hard to do well on class days.
+	The activities and assignments are interesting.
+	During class days, I listen carefully to the teacher.
+	I look forward to class days.
-	I don't really care about doing well during class days.
-	When I'm in [program] on class days, I feel bored.
+	The activities in this class relate to my life.
-	I can't stand working on activities, assignments, etc. during class days.
+	I enjoy learning new things on class days.
-	When I'm in [program] on class days, I can't wait for it to be over.

Appendix E: Interview Responses

Theme	# Students	
Subtheme	*# Students*	%
Q1: What did you like best?		
Relationship*	6	75
Teamwork	*4*	50
Personal connection	*4*	50
Nature*	5	62.5
Learning about…	*3*	37.5
Caring for..	*3*	37.5
Being in…	*3*	37.5
Novelty and Variety	4	50
Relevance to Future	4	50
Being outside of classroom	2	25
Physical activity	2	25
Q2: What did you like least?		
Weather	3	37.5
Physical Work	3	37.5
Tedium	3	37.5
Challenges of working with others	2	25
Q3: How have you changed?		
Personal growth	7	87.5
Emotional growth	*4*	50
Interpersonal skills	6	75
Appreciation for nature*	3	37.5
Q4: Most importance concept/idea learned?		
Connection between humans and nature	3	37.5
Individual ability to make a difference	5	62.5
Care for the earth	3	37.5
Local ecology	4	50
Habitat restoration	1	12.5
Influencing the community	1	12.5
Teamwork	1	12.5
Equality	1	12.5
What contributed to this? (spontaneous response)		
Field work projects	7	87.5
Class activities	4	50
Hands-on activities	1	12.5

Relationships	1	12.5
Assessments	1	12.5
Q5: Most important skill?		
Interpersonal skills	7	87.5
Teamwork	*7*	87.5
Leadership	*2*	25
Communication	*3*	37.5
Problem solving/goal setting	4	50
Q6: Skills that will help most in future?		
Interpersonal skills	6	75
Teamwork	*5*	62.5
Relationships: emotional growth	*4*	50
Personal emotional growth	4	50
Giving back (service)	2	25
Work experience	2	25
Self-awareness	1	12.5
Connection to nature	1	12.5
Q7: Time in Nature before program?		
No	4	50
Yes	3	37.5
Nature as a retreat	*2*	25
Participation in outdoor activities	5	62.5
When younger	1	12.5
Q8+9: (How) Did program change feelings about nature? Describe feelings about nature now.		
Connected	6	75
Increased respect/appreciation	4	50
Increased awareness of nature	6	75
Attention to nature in daily life	*4*	50
Understanding ecology	*4*	50
Share nature w/others	*2*	25
Human impact	5	62.5
Understanding human impact	*3*	37.5
Increased personal responsibility	*4*	50
What contributed to this? (spontaneous response)		
Being in nature	4	50
Field work projects	*4*	50

Sit spot	2	25
Classroom	4	50
Content	2	25
Integration of class and field	2	25
Videos	2	25
Relationships	2	25
Q10: Will you get involved in improving habitat/biodiversity in future?		
Yes	7	87.5
Maybe	1	12.5
Career plan	4	50
Job in restoration	*2*	25
Integrate into another career field	*2*	25
Volunteering	5	62.5
Being outdoors	2	25
Personal efforts	1	12.5