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Localized Ecological and Educational Effects of
Environmental Service-Learning in Portland, Oregon

by

Steven Matthew Braun

A dissertation submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy
in
Earth, Environment and Society

Dissertation Committee:
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Portland State University
2015

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Environmental Service-Learning in Portland, Oregon
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Abstract

Environmental service-learning is an intentional educational experience(s) wherein learners engage in meaningful activities designed to serve the environment. Environmental service-learning activities vary according to their learning and service goals and include ecomanagement, persuasion, legal action, economic action and political action. The purpose of this mixed methods research was to explore the ecological and educational impacts of grades 6-12 environmental education, with special attention to environmental service-learning throughout Portland, Oregon.

Ecological impacts considered restoration and conservation outcomes of several environmental service-learning programs including plant communities, soils, litter removal and trail maintenance. Educational outcomes considered aspects of environmental literacy including locus of control, environmental sensitivity, indicated environmentally responsible behaviors, investigating environmental issues and knowledge of physical systems. The relative influence of some significant life experiences on youths' response to environmental education, including environmental service-learning, was also considered. Telephone surveys were used to gather data from 22 Portland metropolitan area environmental education programs. Data included 2014 annual biophysical impacts (e.g., area of invasive species removed, pounds of litter removed) and information on programming (e.g., length of program, % time outside). Eleven programs administered a 33-question environmental literacy assessment to participants of their programs (n=393). The assessment included the New Environmental

Paradigm, the Inclusion of Nature in Self, questions from Environmental Identity Scale and self-constructed questions. One 8th grade program was identified for a detailed case study. In this 8th grade programs, slight variations in educational activities occurred among three treatment groups which varied the amount of time youth spent engaged in ecomanagement. Youth from the three treatment groups and a control group were administered the environmental literacy assessment at the beginning and end of the program. Qualitative data for the youth in the treatment groups were gathered to further consider how environmental literacy was impacted by participation in the program.

Stronger associational correlations to environmental literacy occurred for the percentage of time an environmental education program spent outdoors rather than the percentage of time an environmental education program engaged in environmental service-learning (e.g., “With other people, I can work to make a positive impact on the environment.” rho: .276 vs. “I have the skills necessary to make a positive impact on the environment.” rho: .176). Random forests indicated that environmental education program features and some significant life experiences could predict collapsed environmental literacy variables (locus of control, environmental sensitivity and environmentally responsible behaviors). 22.4% of the variance in a collapsed environmental sensitivity variable was explained by nine predictor variables; those variables with the strongest influence were youth response to “Before this program, how frequently did you spend time in the outdoors,” age and the presence of a positive adult role model who cares for the environment. Youth participating in environmental education programs showed higher environmental literacy than control groups (e.g., “I

feel an important part of my life would be missing if I couldn't get out and enjoy nature from time to time” U: 3642.500, p: 0.025). Youth with significant formative life experiences (e.g., those indicating previous environmental education or a positive adult role model that cares for the environment) responded better (higher environmental literacy) to environmental education than those youth without (“I pay special attention to things outdoors.” chi 10.633, p: 0.031).

This research provides insight on the efficacy of environmental service-learning. Environmental service-learning positively affected environmental literacy, but outdoor environmental education was more effective in terms of environmental literacy. Results corroborate the body of literature regarding significant life experiences. Further, results suggest that significant life experiences are a critical development milestone necessary for youth to respond to environmental education on a developmental trajectory to empowered environmentally literate citizens.

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Chapter 1 – Contextualizing Environmental Service-Learning within Environmental Education in Portland, Oregon

Environmental Education and Environmental Literacy

Environmental Education (EE) teaches children and adults how to learn about and investigate their environment, and to make intelligent, informed decisions about how they can take care of it (NAAEE, 2011). Environmental education can take place in formal and informal settings. Formal education occurs where the institution (i.e. school) directs the objectives and means of learning (Mocker and Spear as cited in Heimlich, 1993). Informal education involves the learner controlling the means, but not the objective (i.e. the practitioner directs what will be learned and the learner directs how that will be learned) (Mocker and Spear as cited in Heimlich, 1993). Formal environmental education takes place in classrooms by trained educators, while informal environmental education settings include: zoos, nature centers, urban stewardship programs, summer programs and family outings. There is a large body of research on formal environmental education, yet a relative paucity of research on informal environmental education (Rickinson 2001; Flowers et al., 2009). Moreover, research evaluating the effects of informal and formal environmental education indicates that people who engage in pro-environmental endeavors often reference informal education as having profound effects on their decision to engage in pro-environmental endeavors (Palmer et al. 1996;

Chawla,1998). The research which follows considers formal and informal environmental education programs.

The Tbilisi Declaration (UNESCO 1977) makes clear the goals of environmental education: foster awareness and concern for the environment, provide opportunities for acquiring knowledge, commitment and skills to protect the environment and create new patterns of behavior towards the environment. Prior Tbilisi, Donaldson and Donaldson (1958) called for “education 'in', 'about' and 'for' the outdoors.” William Stapp (1969) indicated that “environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associate problems, and motivated to work toward their solution.” The goal of environmental education is, essentially, to cultivate environmental literacy, a term coined by Charles Roth in the *Massachusetts Audubon* in 1968 (Roth 1968). Environmental literacy refers to an individual's knowledge about and attitudes toward the environment and environmental issues, skills and motivation to work toward the resolution of environmental problems and active involvement in working towards the maintenance of dynamic equilibrium between the quality of life and quality of environment (Roth, C.E., 1992). More recently, Hollweg et al. (2011) described environmental literacy as “consisting of knowledge and understanding of a wide range of environmental concepts, problems, and issues, a set of cognitive and affective dispositions, a set of cognitive skills and abilities, and the appropriate behavioral strategies to apply such knowledge and understanding in order to make sound and effective decisions in a range of environmental contexts.” Literacy in traditional subject matters involves competence and knowledge. However,

environmental literacy extends the traditional definition of literacy and includes affective dispositions, which Roth, the originator of the term, refers to as motivations. The NAAEE (Hollweg et al. 2011) considers environmental literacy in terms of competencies, dispositions, knowledge and behaviors. The theoretical background utilized by NAAEE¹ was used to inform this research project when considering environmental literacy.

Environmental literacy has been conceptualized to have three levels with corresponding variables or predictors. The three levels are entry, operational and empowerment (Hungerford, H. R., & Volk, T. L. 1990; Roth 1992)². Environmentally responsible behavior (previously considered responsible environmental behavior), has been identified as the ultimate goal of environmental education (Hungerford, H. R., & Volk, T. L. 1990). More recent definitions of environmental literacy identify environmentally responsible behavior as one of four domains which all interact (Hollweg et al. 2011). Regardless of the theoretical juxtaposition of environmentally responsible behavior to other variables or domains, several relationships have been identified. Reviewing three studies, Marcinkowski (2001) identified five important predictive variables to environmentally responsible behavior: “environmental sensitivity, knowledge of citizenship action strategies, skill in using citizenship action strategies, individual locus of control and group locus of control” (Hungerford et al. 2001 Editors' Note). Hsu (2004) identified associated environmental literacy variables: responsible environmental behavior, locus of control, environmental responsibility, intention to act, perceived

1 See Figure 1.1 The Domain of Environmental Literacy on page 188

2 See Figure 1.2 The Stages of Environmental Literacy on page 189

knowledge of environmental issues and perceived knowledge of and skills in using environmental action strategies.

Hollweg et al. (2011) identify essential components within the four domains of environmental literacy; domains influence one another. There are five essential types of knowledge: “physical and ecological systems; social, cultural and political systems; environmental issues; solutions to environmental issues; and citizen participation and action strategies.” (Hollweg et al. 2011) The domain of dispositions includes: “sensitivity; attitudes, concern and worldview; personal responsibility; locus of control/self-efficacy; and motivations and intentions.” (Hollweg et al. 2011) Competencies involve one's ability to: “identify environmental issues, ask relevant questions, analyze environmental issues, investigate environmental issues, evaluate and make personal judgements about environmental issues, use evidence and knowledge to select and defend positions and create and evaluate plans to resolve environmental issues.” (Hollweg et al. 2011) Environmentally responsible behaviors are categorized: “eco-management, persuasion, consumer/economic action, political action and legal action.” (Hungerford and Peyton 1980 as cited in Hollweg et al. 2011)

Environmental Service-Learning

The term “environmental service-learning” is a relatively new term lacking a clear and operationalized definition in existing literature (Curry et al. 2002; Tedesco 2006; Leege and Cawthorn 2008; Kelly and Abel 2012; Singletary 2013). England and

Marcinkowski (2007) provide one of the clearest definitions. In “environmental service-learning, students combine academic study and community work related to environmental protection and restoration.” What constitutes environmental service-learning may be difficult to distinguish. Legee and Cawthorn (2008) address this distinction, stating that building houses with Habitat for Humanity was not environmental service-learning, while storm drain stenciling was environmental service-learning. The distinction was helpful, yet did not fully clarify other activities. For example, environmental monitoring would not qualify as environmental service-learning using this definition, unless, as is the case of the Calvin Environmental Assessment Program (Curry et al. 2002), the monitoring directly informs invasive species restoration and native plant species preservation.

What follows is an attempt to operationalize 'environmental service-learning.' A definition is provided and grounded within the context of two fields: environmental education and service-learning. The subsequent research (chapters 2-4) is focused on environmental service-learning. Throughout the study, it became apparent that environmental education practitioners had different definitions of what qualified as environmental service-learning. Further, there appears to be ambiguity within both fields (environmental education and service-learning). For the purpose of this study the following definition is proposed - environmental service-learning: intentional educational experience(s) wherein learners engage in meaningful activities designed to serve (intentionally benefit, support, promote, protect, restore, repair) the environment.

Environmental education and service-learning are largely seen as two distinct fields with bodies of literature that provide theoretical underpinnings for operationalizing environmental service-learning. The intersection of these two fields, where the outcomes, pedagogies, and rhetoric align may be considered environmental service-learning.³ However, how you qualify or define, develop/institute (pedagogy & learning activities) and quantify (goals & objectives) environmental service-learning depends on which theoretical background you originate from: service-learning or environmental education. For this research, environmental service-learning can be identified as an environmental education pedagogy wherein learners engage in meaningful activities which are connected to curriculum and related to environmental protection or improvement. Considered from the service-learning perspective, environmental service-learning “involves opportunities for youth and students to address needs in meaningful ways starting in their own homes, schools, and communities” (Corporation for National and Community Service) specific to the environment.

Drawing on the field of service-learning, operationalizing environmental service-learning requires consideration of the K-12 Service-Learning Standards For Quality Practice (National Youth Leadership Council, 2008) . The K-12 Standards and Indicators for Quality Service-Learning Practice are: “duration and intensity, link to curriculum, partnerships, meaningful service, youth voice, diversity, reflection and progress monitoring.” Drawing on the field of environmental education, operationalizing environmental service-learning requires consideration of the North American Association for Environmental Education's (NAAEE) framework of Environmental Literacy

3 See Figure 1.3 Environmental Service-Learning on page 190

(Hollweg et al., 2011) and the NAAEE's Guidelines for Excellence in Environmental Education (Simmons et al. 2004). Furthermore, environmental problem solving, project based learning and authentic education provide additional background in how to define, develop and quantify environmental service-learning. Contributions and relevant theoretical underpinnings from the fields of environmental education and service-learning which are necessary to operationalize the term environmental service-learning are listed in Table 1.1.

Table 1.1 Environmental Service-Learning Theoretical Underpinnings Table provides relevant theoretical underpinnings for operationalizing environmental service-learning.

Considerations	Field of Origin	Influence on ES-L	Relevant Citations
Level of Integrity: Thin to thick	Service-Learning	Significant influence on how ES-L is: - quantified (outcomes along a continuum)	Morton 1995
Types of Service Engagement: Direct, Indirect, Research, Advocacy	Service-Learning	Significant influence on how ES-L is: - developed (pedagogy & learning activities) - defined	
Goal driven Service Learning typology: s l, S-l, s-L, S-L	Service-Learning	Significant influence on how ES-L is: - developed (pedagogy & learning activities) - defined	Sigmon 1979, Furco 1996
Service-Learning Standards For Quality Practice; Principles of Good Practice	Service-Learning	Significant influence on how ES-L is: - developed (pedagogy & learning activities) - defined	National Youth Leadership Council, 2008; Honnet and Poulsen 1989
Environmental Literacy: Domain and Stages	Environmental Education	Significant influence on how ES-L is: - quantified (outcomes along a continuum: Nominal, Functional, Operational)	McBride 2014, Hollweg et al 2011, Roth 1992, Hungerford & Volk 1990)
Environmental Education Goals	Environmental Education	Significant influence on how ES-L is: - developed (pedagogy & learning activities) - quantified	Hungerford & Volk 1990
Guidelines for Excellence	Environmental Education	Significant influence on how ES-L is: - developed (pedagogy & learning activities)	National Project for Excellence in Environmental Education
Environmentally	Environmental	Significant influence on how ES-L is:	Jensen 2002

Responsible Behavior (ERB): Action vs Behavior	Education	- developed (pedagogy & learning activities)	
Five types of ERB: (ecomangement, economic action, persuasion, political action, legal action)	Environmental Education	Significant influence on how ES-L is: - developed (pedagogy & learning activities)	Hungerford and Peyton 1980, McBride 2014

Environmental Service-Learning: Considered from Service-Learning

Service-learning is recognized as having 'theoretical roots' in John Dewey's educational and social philosophy (Giles, D. E., & Eyler, J. 1994). A continuum of service has been proposed with three stages: charity, project and social change. Charity is seen as the beginning of the continuum with low investment in relationships and low concern with root causes. Project is in the middle and social change at the end, each with progressively higher investment and concern (Elden 1993, Jones 1991, McKnight 1989, Lackey 1987 and Illitch 1968 as cited in Morton 1995). Morton (1995) argues that service does not follow a continuum where individuals progress, rather that service may range from thin or thick and each of the continuum's levels are paradigms. Charity, providing direct service yourself to someone less fortunate, could range from thin (wealthy person providing financial contribution) to thick (forgoing ones needs regularly to support another based on core values). In the paradigm of charity, 'thin' environmental service might involve supporting an environmental group's fundraiser, while 'thick' environmental service may involve starting and leading the environmental group. In the social change paradigm, 'thin' environmental service might involve voting

or attending a rally, while 'thick' environmental service may involve organizing a rally and serving on relevant governmental committees.

Service-learning can be defined by its activities: direct, indirect, advocacy and research. Indirect service-learning involves broad issues with clear benefits to the community. Direct service-learning involves face-to-face projects directly impacting individuals. Advocacy service-learning involves projects to create awareness and action. Research-based service-learning involves gathering and presenting needed information. Within an environmental context the differences between direct and indirect service-learning may be blurred. Service-learning programs often list environmental projects as examples of indirect service-learning. These types of service-learning activities may impact how environmental service-learning is defined and developed.

Service-learning can be considered according to its goals. Developing a definition for service-learning, Sigmon (1994, as cited in Furco 1996) developed a four part typology. Programs fall into one of four categories based on their goals. These are: “Service-LEARNING (learning goals primary; service outcomes secondary), SERVICE-learning (service outcomes primary; learning goals secondary), service learning (service and learning goals completely separate) and SERVICE-LEARNING (service and learning goals of equal weight and each enhances the other for all participants).” (Sigmon 1994, as cited in Furco 1996) Environmental service-learning can be considered within the same typology. For example, Environmental SERVICE-learning might involve students clearing a large natural area of invasive species, spending significant amounts of time dedicated to this purpose and much less learning about invasive ecology. The

primary goal would be service (clearing the natural area) and the secondary goal would be learning. A SERVICE-LEARNING example: students identify air quality concerns on their schoolyard campus. Students research causes of poor air quality, investigate the science of air quality including chemistry and physics, identify local regulations and propose solutions to improve their air quality. Students implement these solutions with strategies like organizing group bike to school rides, posting no idling signs, organizing carpools, launching a bus riding promotional campaign and planting trees as air quality buffers between the school and roadways. These types of service-learning may impact how environmental service-learning is defined and developed.

Service-learning, an instructional strategy, has established standards for developing quality practice. Service-learning standards are not content standards (e.g., Next Generation Science Standards, National Geography Standards). The service-learning standards are recognized as eight “effective principles” to meet learning goals and content standards (National Youth Leadership Council 2008). There are eight principles: 1.) duration and intensity, 2.) link to curriculum, 3.) partnerships, 4.) meaningful service, 5.) youth voice, 6.) diversity, 7.) reflection; 8.) progress monitoring (National Youth Leadership Council 2008). An earlier consideration of service learning identified ten Principles of Good Practice for Combining Service and Learning (Honnet and Poulsen 1989). Both guiding documents resemble one another, though the more recent K-12 standards are used here. The eight standards and their subsequent indicators can be applied to environmental service-learning. The example provided in Table 1.2, Thin and Thick Direct Examples of Environmental Service-Learning Aligned with K-12

Standards, considers an environmental service-learning experience based around restoration ecology with a 'thin vs thick' (Morton 1995) conceptualization. The example, considered within this framework, illustrates the necessity of reflection in environmental service-learning. The standard reflection indicates that “service-learning incorporates multiple challenging reflection activities that are ongoing and that prompt deep thinking about oneself and one's relationship to society.” (National Youth Leadership Council 2008) Of course, reflection speaks more to the 'learning' aspects of service-learning; if Sigmon's typology was applied, the 'thick' example would be labeled 'Environmental SERVICE-LEARNING.' Both the thin and thick examples would be considered 'direct' types of environmental service-learning. The example activities in the thin-thick conceptualization for each of the service-learning standards are synthesized in Table 1.2.

Table 1.2 Thin and Thick Examples of Direct Environmental Service-Learning Aligned with K-12 Standards Table summarizes eight K-12 standards and indicators for quality service-learning practice (National Youth Leadership Council 2008) within a thin vs thick conceptualization (Morton 1995) of environmental service-learning.

Service-Learning Standard (National Youth Leadership Council)	Environmental Service-Learning Example (Restoration Ecology)	
	Thin (Morton 1995)	Thick (Morton 1995)
Duration and Intensity - investigate community needs - concentrated blocks of time - ample time to address needs	Practitioner directed one day weed pull and native planting.	Youth, with input from community, identify nearby natural area for restoration. Youth remove invasive species, plant natives and make interpretive signage. Youth and community have celebration event in natural area.
Link to Curriculum - clearly articulated goals - aligned with academic curriculum - knowledge transfer across settings - formally recognized by school board, if school based	Youth in a science class with minimal connection to ecology (e.g., basic chemistry) plant trees on a field trip.	Youth are enrolled in a environmental science through restoration ecology course. Learning objectives are clear and involve soil science, plant ecology and hydrology. Investigations and service occur at a nearby natural area being restored by youth.

Partnerships - variety of partnerships - regular, informed communication - shared vision/common goals - collaborative implementation - share knowledge, needs, resources	Youth and practitioner restore natural area on school grounds with no connection or partnerships within the community. Other practitioners are not involved. Classroom funds are used for materials.	Youth collaborate with several groups (NGOs, local gov, business, volunteers) to restore and maintain natural area. Materials and expertise are shared or donated. Restoration and maintenance plans are collaboratively developed and implemented by youth and partnering organizations. Regular meetings and work occurs.
Meaningful Service - age and developmental appropriate - personally relevant - interesting and engaging - contextualized within larger issue - valued and visible outcomes	Youth lack interest in restoration project and may view their activities as free labor. Activities have no context (e.g., connections to biodiversity). Outcomes of restoration project are unrecognizable to youth.	Youth are interested and engaged with restoration project. Improvements to natural area are evident (ivy desert to native plant garden). Project is relevant, improving a natural in their neighborhood where they choose to spend time. Activities are contextualized to regional biodiversity and invasive species issues.
Youth Voice - youth plan, implement, evaluate - decision making involves youth - open expression of ideas - enhanced youth leadership - youth evaluate service-learning	Practitioner identifies and develops natural area restoration plan and activities which youth carry out. Youth have no input in planning or evaluation of their service-learning experience	Youth develop, with guidance from collaborating adults, natural area restoration plan. Critical decisions regarding planting, soils, outreach and funding meaningfully involves youth. Youth are encouraged to take leadership role with partnering organizations.
Diversity - multiple perspectives analyzed - interpersonal skills developed - diverse backgrounds are valued - stereotypes recognized	Youth engage in restoration of natural area in isolation from community needs and values. No consideration of multiple perspectives occurs. Practitioners' value sets guide the process.	Community needs are gathered and considered by youth when developing a restoration plan. Youth engage with different ideas for the natural area (preservation, ball fields, community garden). Youth and community identifies relevant values and stereotypes in efforts to reach consensus on restoration plan.
Reflection - multimodal - before, during, after - deep thinking: problems & solutions - deep thinking: citizen responsibilities - connections to policy & civic life	Youth restore natural area with no structured or encouraged reflection activities. Little preparation or conclusion to the activities occurs	Before, during and after natural area is restored youth engage in reflection activities to connect to value of biodiversity, relevant environmental action (stewardship), relevant environmental issues (invasive species, soil erosion) and citizen responsibilities. Activities are multimodal (e.g., verbal,

		kinesthetic, musical, interpersonal, intrapersonal, artistic).
Progress Monitoring - service goals & learning objectives - participants collect evidence - improvement of experiences - communication of evidence	No evidence is collected on the progress of a natural restoration project or the quality of the environmental service-learning experience for the youth.	Youth monitor the progress of a restoration project and the quality of the environmental service-learning experience. Youth utilize these data to guide the restoration activities and improve the environmental service-learning experience. Data and findings are communicated to existing partners.

Environmental Service-Learning: Considered from Environmental Education

Developing environmental literacy is understood as a goal of environmental education (Roth 1992). The stages (nominal or entry, functional or ownership, operational or empowerment) of environmental literacy can be applied to environmental education practices in general and environmental service-learning in particular. First, quality instruction should be taught to learners' Zone of Proximal Development (Vygotsky, as cited in Chaiklin 2003) where learning objectives must be within a reasonable 'distance' from the learner to be achieved. Achieving environmental literacy objectives may also require environmental education is within learners' Zone of Proximal Development. The three stages of environmental literacy and their associated variables⁴ provide a developmentally appropriate frame for “changing learners' environmental literacy through environmental education.” (Hungerford and Volk 1990)⁵ Roth (1992) writes that “nominally environmentally literate individuals demonstrate activities and

4 See Figure 1.2 Stages of Environmental Literacy on page 189

5 Phrase originally appears as “changing learner behavior through environmental education” in seminal work by Hungerford and Volk 1990. The term behavior is replaced for environmental literacy to consider the three other domains of environmental literacy.

habits aimed at maintenance of environmental quality.” He continues, noting that “the functionally environmentally literate moves to action through selected lifestyle activities by taking individual and/or group action through persuasion, consumerism, political action, legal action and ecomanagement.” The operationally environmentally literate person “demonstrates leadership in the resolution of problems and issues including evaluating actions with respect to their impact on the quality of life and environment and working to maintain biological and social diversity.” The stages can be used to design, assess and discuss environmental service-learning. An entry level environmental service-learning experience may involve students composting kitchen scraps at home in a worm box and learning about decomposition. A functional environmental service-learning activity may involve the same home composting experience but also involve public demonstrations and a letter writing campaign to support a municipal compost program. An operational environmental service-learning activity may place students in a leadership position where they identified strategies for limiting home waste production.

The domains of environmental literacy (knowledge, dispositions, behaviors and competencies) can be applied to environmental education in general and environmental service-learning in particular. Previously considered awareness, knowledge, attitudes, skills and participation (UNESCO 1977), the current conceptualization of environmental literacy considers paralleled terms: dispositions, knowledge, competencies and behaviors (Hollweg et al. 2011). Regardless of the language, the domains of environmental literacy are interconnected and influence one another (Roth 1992; Hollweg et al. 2011). While the domains are interconnected, environmental education instruction may be more or less

focused on developing a particular domain of environmental literacy (e.g., nature writing to affect dispositions; letter writing to affect competencies and behaviors; science inquiry to affect knowledge and competencies). Likewise, environmental service-learning activities can be more focused on developing a particular domain of environmental literacy. Of course, by definition environmental service-learning must include some focus on both 'knowledge' and 'behavior' (i.e. 'service' and 'learning'). Table 1.3 details four examples of environmental service-learning activities and qualifies them according to their focus for each of the domains of environmental literacy.

Table 1.3 Environmental Service-Learning Activities and The Domains of Environmental Literacy
Table provides examples of environmental service-learning activities and qualifies them according to their focus on each of the domains of environmental literacy.

Example Environmental Service-learning Activity	Environmental Literacy Domain			
	Disposition	Knowledge	Competency	Behavior
Youth engage in creative nature writing (poetry, public service announcements, letters to the editor and short stories celebrating nature and urging nature protection). Writing is disseminated by practitioner.	High Focus	Mid Focus	Mid Focus	Low Focus
Youth engage in regular ecomanagement (invasive removal, native planting) of nearby natural area. Plant identification is taught.	?	Low Focus	Mid Focus	High Focus
Youth identify and reflect on an issue they care about. They organize rallies and fundraisers, develop a school club and serve on relevant governmental or citizen advisory committees.	High Focus	?	High Focus	High Focus
Youth identify air quality concerns on their schoolyard campus. Student research causes of poor air quality, investigate the science of air quality including chemistry and physics, identify local regulations and propose solutions to improve the air quality on campus. Students implement these solutions with strategies like organizing group bike to school rides, posting no idling signs, organizing carpools, launching a bus riding promotional campaign and planting trees as air quality buffers between the school and roadways.	?	High Focus	High Focus	High Focus

Environmental education, as a field, has professional Guidelines for Excellence. The goals of the Guidelines for Excellence include “setting a standard for high quality environmental education” (NAAEE 2010), providing “recommendations for developing high quality nonformal environmental education programs” (NAAEE 2009) and providing “a set of recommendations for developing and selecting environmental education materials.” (NAAEE 2009). Especially relevant to environmental service-learning are the:

- Guidelines for Learning strands (NAAEE 1999);
 - questioning, analysis and interpretation skills;
 - knowledge of environmental processes and systems;
 - skills for understanding and addressing environmental issues;
 - personal and civic responsibility;
- Environmental Education Materials (NAAEE 2009);
 - fairness and accuracy;
 - depth;
 - emphasis on skills building;
 - action orientation;
 - instructional soundness; and
 - usability.

Applying the Guidelines to environmental service-learning, an activity may be considered according to which 'strand' is the focus (NAAEE 1999). An environmental service-learning activity involving inquiry and service (e.g., water quality monitoring of

multiple water bodies to determine drivers of stream insect assemblages and identify and report critical thresholds to local government), may be focused on two strands: 1.) questioning, analysis and interpretation skills and 2.) knowledge of environmental processes and systems. On the other hand, an environmental service-learning activity involving environmental issues (e.g., water quality issues considering point and non-point sources, citizen and industry rights and responsibilities), may be focused on two other strands: 3.) skills for understanding and addressing environmental issues and 4.) personal and civic responsibility. The Environmental Education Materials Guidelines, albeit created for materials, can, in some case, be used for evaluating and developing environmental service-learning activities. Substituting 'materials' for 'activities' in Materials Guidelines #1 we see that “[activities] should be fair and accurate in describing environmental problems, issues and conditions, and in reflecting the diversity of perspectives on them.” Furthermore, in Materials Guidelines #3 we see that “[activities] should build lifelong skills that enable learners to address environmental issues.”

Environmental problem solving is an instructional approach which is grounded in theory and provided opportunities within the field of environmental education (Bardwell 1994). Several models of environmental problem solving exist. John Ramsey (Hungerford et al. 2001) contrast four models but recognizes that “all models view education as change...and attempt to achieve empowerment via an investigative problem solving process.” Essentially, environmental problem solving involves students in a repeating cycle where they: plan, observe, act and reflect; education is framed within the context of an authentic environmental problem. Environmental service-learning which

follows a similar process as environmental problem solving may involve students to identify an environmental problem and frame their service-learning experiences around that problem.

Behavior, a focus of environmental education, can be conceptualized in several manners and thus impacts how environmental education is discussed and implemented. Several distinct terms exist. Hollweg et al. (2011) define 'environmentally responsible behavior' as the “expression of knowledge, dispositions, and competencies within a context.” Kollmuss and Agyeman (2002) define 'pro-environmental behavior' as “behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world.” Jensen (2002) draws a distinction between environmental action and pro-environmental behavior, clarifying Kollmuss and Agyeman's (2002) definition that “behavior only refers to those personal actions that are directly related to environmental improvement.” According to Jensen (2002), there are four types of environmental action: direct individual actions, indirect individual actions, direct collective actions and indirect collective actions. Environmental service-learning activities can be considered with a similar four-part typology. A direct individual environmental-service learning activity may involve one youth maintaining a natural area, while an indirect collective environmental service-learning activity may involve a natural area stewardship advocacy campaign by an entire class. As previously discussed, service-learning uses a similar typology, only using direct, indirect, advocacy and research. However, the types of service-learning do not consider collective vs individual actions and advocacy and research are expanded from Jensen's 'indirect' actions.

Further conceptualizations of behavior provide context for environmental service-learning. Stern (2000) defines 'environmentally significant behavior' "by its impact: the extent to which it changes the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere itself." Stern distinguishes the types of environmentally significant behaviors: environmental activism, non-activist behaviors in the public sphere, private-sphere environmentalism and other environmentally significant behaviors. Hungerford and Peyton (1980) categorize behavior as: ecomanagement, persuasion, consumer/economic action, political action and legal action. Environmental service-learning activities can be designed according to either of these categories.

Drawing on the fields of service-learning and environmental education, environmental service-learning can be further qualified. As previously stated, environmental service-learning is defined as intentional educational experience(s) wherein learners engage in meaningful activities designed to serve the environment. Environmental service-learning activities can involve individual and collective, direct and indirect, public and private-sphere actions which involve activism, ecomanagement, persuasion, consumer/economic action, political action and legal action. These activities may vary according to their duration and intensity, link to the curriculum, partnerships, degree of meaningfulness, youth voice, role of diversity, reflection and progress monitoring. Learning foci may range across environmental literacy domains: behaviors, dispositions, competencies and knowledge with a range of activities from thin to thick.

In order to further clarify the multidimensionality of environmental service-learning, Table 1.4 is presented. The table synthesizes relevant literature from both fields: environmental education and service-learning. Environmental service-learning is considered in terms of: qualities, extent, types, pedagogical considerations and learning goals/outcomes which are presented as columns. Each column can be considered a category. Within each category is one or more dimensions necessary to consider environmental service-learning. For example, qualities of environmental service-learning activities contains three separate dichotomized dimensions: public or private-sphere, direct or indirect, individual or collective. While the literature discussed here has consistently dichotomized each of these 'dimensions,' it is clear that larger environmental service-learning activities (e.g., units) may consist of several smaller activities (e.g., lessons) which involve both qualities (e.g., a private-sphere and public-sphere activity). The extent of environmental service-learning contains three dimensions which are scaled (e.g., ranging from thin to thick). Variation in the degree of environmental impact may be difficult to quantify (biophysical impact of environmental service-learning is measured in chapters 2 & 4). Furthermore, considering the 'degree of environmental impact' replaces Furco's (1996) consideration of 'service' as a goal in his four part typology. The table below does not consider environmental service-learning as defined by its goals rather considers the degree of environmental impact as one of three dimensions particular to extent. Six different types of environmental service-learning are listed and are considered as one categorical dimension. Eight pedagogical considerations are listed and occur on a scalar dimension. Learning goals are considered in terms of environmental

literacy which can be separated into two separate dimensions, both categorical, which consider the degree (functional, operational and empowerment) and domains (knowledge, dispositions, competencies and environmentally responsible behavior).

Table 1.4 Multiple Dimensions Applicable to Environmental Service-Learning Table lists five categories for operationalizing environmental service-learning which are listed at the top of the table in bold. Within each category is one or more dimensions necessary to consider environmental service-learning (e.g., public vs private-sphere, ranging from thick to thin, considers stages of environmental literacy). In the third column, only one category is presented (types of ES-L) which can be conceptualized as its own dimension with seven categories. The fourth category, pedagogical considerations lists eight 'considerations' all which occur on a scale.

Qualities of ES-L Activities	Extent of ES-L	Types of ES-L	Pedagogical Considerations for ES-L Activities	Learning Goals/Outcomes (Environmental Literacy) of ES-L Activities
<i>Public or Private Sphere</i>	Ranges from <i>Thin</i> to <i>Thick</i>	Include: <i>Ecomanagement</i> <i>Persuasion (advocacy)</i>	May vary in respect to each of the following: <i>Link to curriculum</i> <i>Partnerships</i>	Varies According to Stages: <i>Functional</i> <i>Operational</i> <i>Empowerment</i>
<i>Direct or Indirect</i>	Varies in <i>Duration</i> and <i>Intensity</i>	<i>Consumer or Economic Action</i> <i>Political Action</i>	<i>Meaningfulness</i> <i>Youth Voice</i> <i>Role of Diversity</i>	Addresses Domains: <i>Knowledge</i> <i>Dispositions</i>
<i>Individual or Collective</i>	Varies in <i>Degree of Impact on Environment</i>	<i>Legal Action</i> <i>Research</i>	<i>Reflection</i> <i>Progress Monitoring</i> <i>Connection to Problems</i>	<i>Competencies</i> <i>ERB</i>

Considering environmental service-learning is, using the above conceptualization, a complex process. For each of the five categories (top row), the dimensions below can be applied when considering environmental service-learning activities. For example, an environmental service-learning activity may occur in the public-sphere, be direct and occur at the individual level (e.g., one person planting trees in a park). This example is ecomanagement and would be labeled, in terms of extent as thin, of limited duration and intensity and have little impact on the environment. Table 1.5 considers a previous

model environmental service-learning activity in order to further clarify the complexity of ascribing dimensional values for each of the categories.

Table 1.5 Multiple Dimensions Applied to Environmental Service-Learning Example Table applies theoretical framework for understanding the multiple dimensions of environmental service-learning to example activity.

Example Environmental Service-Learning Activity: Youth identify air quality concerns on their schoolyard campus. Student research causes of poor air quality, investigate the science of air quality including chemistry and physics, identify local regulations and propose solutions to improve the air quality on campus. Students implement these solutions with strategies like organizing group bike to school rides, posting no idling signs, organizing carpools, launching a bus riding promotional campaign and planting trees as air quality buffers between the school and roadways.				
Qualities of ES-L Activities	Extent of ES-L	Types of ES-L	Pedagogical Considerations for ES-L Activities	Learning Goals/Outcomes of ES-L
<i>Public Sphere</i>	<i>Substantially Thick</i>	Includes: <i>Ecomanagement</i> <i>Persuasion (advocacy)</i> <i>Political Action</i> <i>Research</i>	Varies in respect to the following:	Occurs at two levels: <i>Operational</i>
			Substantial <i>Link to curriculum</i>	<i>Empowerment</i>
			Moderate <i>Partnerships</i>	Addresses Three Domains: <i>Knowledge</i> <i>Competencies</i> <i>ERB</i>
<i>Direct and Indirect</i>	<i>Substantial Duration and Intensity</i>		Substantial <i>Meaningfulness</i>	
			Substantial <i>Youth Voice</i>	
			Unclear <i>Role of Diversity</i>	
			Limited <i>Reflection</i>	
<i>Collective</i>	<i>Substantial Impact on Environment</i>		Unclear <i>Progress Monitoring</i>	
			Substantial <i>Connection to Problems</i>	

Table 1.6 briefly describes the environmental service-learning activity which is detailed in chapters three and four. The table ascribes values for each of the multiple dimensions provided in this framework. Details among treatment groups which are described later and central to the research questions are not considered. Rather, the

framework is applied to demonstrate the relevance of this multidimensional theoretical framework when considering environmental service-learning, particularly the program described in detail in chapters three and four. The program is further described in *Teaching About Invasive Species*, a Green Teacher publication for environmental education practitioners titled “From Removal To Restoration” (Braun 2014).

Table 1.6 Multiple Dimensions Applied to Evergreen Middle School's Environmental Service-Learning Activity Table applies theoretical framework for understanding the multiple dimensions of environmental service-learning to environmental service-learning program described in chapters 3 and 4.

Environmental Service-Learning Activity (chapter three): 8 th grade students engaged in a yearlong project to create and an environmental science laboratory on school grounds. Area was originally ivy desert and students restored the area (invasive species removal, native plantings, soil amendments). Project and subsequent lessons were identified by and planned by practitioners. Classroom instruction focused on environmental science (soils, plants, water, ecosystems) within the context of restoration ecology. Students engaged in inquiry activities particular to the efficacy restoration and presented their findings at a professional science conference. Several partners provided support (materials & instructional). Diverse land management techniques were used and evaluated, but all were considered in terms of ecological metrics. Assessment of student understanding and interest occurred and was considered, but did not drive the activities.				
Qualities of ES-L Activities	Extent of ES-L	Types of ES-L	Pedagogical Considerations for ES-L Activities	Learning Goals/Outcomes (Environmental Literacy) of ES-L Activities
<i>Public Sphere</i>	Occurred in the Middle Range of <i>Thin</i> to <i>Thick</i>	Included: <i>Ecomanagement Research</i>	Varied in respect to the following:	Varies According to Stages: <i>Functional</i>
			Substantial <i>Link to curriculum</i>	<i>Operational</i>
			Moderate <i>Partnerships</i>	<i>Empowerment</i>
<i>Direct and Indirect</i>	Substantial <i>Duration</i> and Moderate <i>Intensity</i>		Moderate <i>Meaningfulness</i>	Addresses Domains:
			Limited <i>Youth Voice</i>	<i>Knowledge</i>
			Moderate <i>Role of Diversity</i>	<i>Dispositions</i>
<i>Collective</i>	Moderate Degree of <i>Impact on Environment</i>		Moderate <i>Reflection</i>	<i>Competencies</i>
			Moderate <i>Progress Monitoring</i>	<i>ERB</i>
			Moderate <i>Connection to Problems</i>	

Environmental Service-Learning: Additional Considerations

Environmental service-learning involves elements of what has been termed “authentic” education. Authentic pedagogy requires: 1.) students construct meaning and produce knowledge, 2.) students use disciplined inquiry to construct meaning and 3.) students aim their work toward the production of discourse, products and performances that have meaning beyond school (Newmann and Wehlage, 1993). Environmental service-learning allows learners to construct meaning in that they interact with real-world ecological systems by influencing these systems for an assumed ecological benefit. Learners may see, in a rich and textured way, how they have affected a system. Inquiry does not always happen during environmental service-learning. However, in some cases learners may be a part of the planning and assessment process or involved in research. In such cases, inquiry would take place. Environmental service-learning has meaning beyond school, as it addresses social and ecological needs.

Project-based learning provides additional context for considering environmental service-learning. The essential elements of project-based learning, as described by the Buck Institute for Education (BIE 2015), include significant content, 21st century competencies, in-depth inquiry, driving question, need to know, voice and choice, critique and revision and public audience. The essential elements of project-based learning are similar to elements of authentic education and the service-learning standards for quality practice (National Youth Leadership Council 2008). This research draws upon the theoretical backgrounds of project-based learning and authentic education yet

does not explicitly evaluate the degree of authenticity of nor determine if essential project-based elements occurred in participating environmental education programs.

The Effectiveness of Environmental Education in Improving Environmental Quality

Multiple disciplines recognize the need to consider human (e.g., educational) and ecological elements to understand a system. Within the field of environmental education, the Environmental Protection Agency states a strategic goal – assess the effectiveness of environmental education in improving environmental quality (Potter, G. 2009). The field of restoration ecology advocates for research on the sociological impacts of environmental restoration (Higgs 2003; Palmer et al. 2005). The research which follows considered some ecological effects of environmental education (including environmental service-learning) in addition to robust analysis of educational effects (environmental literacy).

Restoration ecology provides a framework to consider ecological effects of environmental service-learning. When discussing river restoration, Palmer et al. (2005) state that the most effective restoration involves three types of success: ecological success, stakeholder success and learning success. Ecological success requires a restoration project have a guiding image, ecological improvement occurs, the site is self-sustaining, no lasting harm is done and that assessment was completed. Further, restoration ecologists may evaluate environmental parameters (soils and plants in this study) to establish a trajectory for a particular restoration site in relation to reference sites

(Thom et al. 2002; Steen et al. 2013). Trajectories recognize that restored sites are not well established. Biotic and abiotic components may change substantially in a relatively short time span compared to more established reference sites. A trajectory allows a restoration practitioner to extrapolate and consider in what direction a restored site is heading. Environmental service-learning activities which utilize ecomanagement (e.g., restoration) and occur in a short period of time can be analyzed with a restoration ecology framework.

Study Area – Oregon and the Metropolitan Area of Portland, Oregon

The population of the metropolitan area of Portland, Oregon has a strong environmental ethic which is demonstrated by a large volunteer population (Civic Life in America 2010; Dresner et al. 2014). This ethic is demonstrated in the Parks 2020 Vision (Portland Parks and Recreation) which calls for education about and engagement for natural spaces. Furthermore, there are many environmental education organizations (formal and non-formal) throughout the region. The Environmental Education Association of Oregon (EEAO) lists over 150 service-learning opportunities in their online environmental education directory for the state of Oregon; many are located within the Portland metropolitan region⁶. Portland is the largest metropolitan region in Oregon, which in 2010 became the third state to develop an environmental literacy plan (Oregon Environmental Literacy Task Force 2010). In 2009, the Oregon Legislature passed the

⁶ www.eeao.org accessed on 10/2013

No Oregon Child Left Inside Act, Oregon House Bill 2544. The bill outlines the goals of the plan (Oregon Environmental Literacy Task Force 2010):

- Prepare students to understand and address the major environmental challenges facing this state and country, including the relationship of the environment to national security, energy sources, climate change, health risks and natural disasters.
- Contribute to students establishing a healthy lifestyle by making outdoor experiences part of the regular school curriculum and creating programs that promote healthy lifestyles through outdoor recreation and sound nutrition.
- Create opportunities for enhanced and ongoing professional development of teachers by improving teachers knowledge of environmental issues, skills in teaching environmental issues in the classroom and skill teaching environmental issues in settings outside of the classroom.

The No Oregon Child Left Inside Act is “relating to environmental education; and declaring an emergency” (OR HB 2544) and may be considered an indication of shared values within the state. The Oregon Environmental Literacy Plan is recognized as a guiding document for the environmental education programs within in the state; some of these programs were subjects in the research that follows.

Dissertation Research Questions

The research which follows was guided by two overarching research questions. The research considered ecological and educational effects of environmental education programs in the Portland metropolitan area. There was a particular focus on the effects of environmental service-learning as a pedagogical technique. The two overarching research questions which guided this research were:

- How does the quantity and quality of time spent engaged in environmental education, including environmental service-learning, affect participants' environmental literacy (i.e. educational outcomes)?
- How does the quantity and quality of time associated with environmental service-learning programs affect the ecology of the areas where the program occurs (i.e. biophysical outcomes)?

The primary focus of this research was how environmental service-learning affected environmental literacy when compared to other environmental education pedagogical techniques. The secondary focus was how environmental service-learning activities which included ecomanagement affected local ecology.

Outcomes and Variables Identified for Study

The environmental education programs studied in this research were primarily considered in terms of their impact on elements of youths' environmental literacy.

Conceptualizations of environmental literacy provided a useful framework to consider educational impacts (i.e. learning outcomes) of environmental service-learning programs. As indicated in the preceding discussion, service-learning, as a field, has a conceptualization to consider goals and outcomes service-learning activities. Goals and outcomes are considered in terms of the relative importance of 'service' and 'learning' (Furco 1996). Environmental literacy expands traditional conceptualizations of literacy which consider only knowledge and skills. Furthermore, this research which analyzes environmental service-learning is considered from the field of environmental education.⁷

Important variables within the construct of environmental literacy were identified and assessed qualitatively (e.g., work samples, observation, teacher/student interview) and quantitatively (e.g., survey, test scores). Variables were identified within each of the four domains of environmental literacy: knowledge, dispositions, competencies and environmentally responsible behaviors. Variables within the knowledge domain were knowledge of physical and ecological systems, knowledge of environmental issues and knowledge of citizen participation and action strategies. Variables within the disposition domain were locus of control/efficacy, environmental sensitivity, intention to act and environmental worldview. Variables within the competencies domain were identify environmental issues, ask relevant questions about environmental conditions and issues, analyze environmental issues, investigate environmental issues, create and evaluate plans at various scales to resolve environmental issues. Variables within the domain of environmentally responsible behaviors were not identified. The aforementioned variables were measured as a response to a treatment or other independent variable (e.g.,

⁷ See Fig 1.3 Environmental Service-Learning on page 190

percentage of time program engaged in environmental service learning). See the Methods section in chapters two and three for a discussion of 'how' these variables were measured (e.g., survey, work samples). The following is an explanation as to 'why' these variables were chosen to measure environmental literacy.

Assessing all variables within each of the four domains of environmental literacy was beyond the scope of this research. The National Environmental Literacy Assessment Project demonstrates the herculean task of a comprehensive quantitative assessment of several variables particular to environmental literacy. The Middle School Environmental Literacy Survey is a 75-question test designed to take over a 50-minute period which still does not measure several of environmental literacy's components (McBeth, W., & Volk, T. L. 2009). And thus, in lieu of such a comprehensive assessment, variables within the four domains of environmental literacy (dispositions, competencies, behavior and knowledge) were identified and chosen for study.

Hollweg et al. (2011) provide an extensive review of literature which demonstrates the importance of the aforementioned variables and clarifies their meaning. A brief explanation of these important variables follows and begins with variables within the disposition domain. Locus of control is a disposition which “refers to the extent to which people expect to be positively reinforced by the outcomes of their actions” (Peyton & Miller, 1980 as cited in Hollweg et al. 2011). Roth (1992) states that a functionally environmentally literate person has internal locus of control and that an operationally literate person has a strong locus of control. In the NAAEE's *Developing a Framework For Assessing Environmental Literacy*, locus of control and efficacy are considered

collectively and shown to be a developmentally appropriate construct for middle, secondary and adult-level assessment (Horvat and Voelker, 1976; Champeau 1983; Sia 1985 all as cited in Holleg et al. 2011). Locus of control and efficacy are especially relevant to assessing the impact of environmental service-learning, which, according to the National Youth Leadership Council (2008), should be meaningful (engaging, visible outcomes and contextualized within larger issue). Locus of control and efficacy capture some of the aspects of meaningfulness, youth voice (youth evaluate service-learning) and reflection.

Sensitivity is “the expression of caring and positive feelings toward the environment” (Hollweg et al. 2011). Early conceptualizations of the elements of environmental literacy consider awareness and sensitivity together (UNESCO 1977). Awareness involves perception and may involve concern. Sensitivity and awareness were considered collectively in this study. Roth (1992) states that environmental sensitivity is one of the six major areas of environmental literacy, which along with values and attitudes he subsumes under 'affects.' The term 'affects' parallels 'dispositions,' which is the current term used by the NAAEE (Hollweg et al. 2011). Sensitivity is a developmentally appropriate construct for elementary, middle, secondary and adult-level assessment (Asche 1973; Moyer 1975; Sia 1985; Leeming et al. 1995 all as cited in Hollweg et al. 2011). Sensitivity, a longstanding variable in environmental education, also considers the thin-thick range within a particular paradigm, in this case environmental paradigm. Youth do, of course, engage to different degrees with educational activities. An individual with high environmental sensitivity engages does,

by definition engage in environmental service-learning activities in a relatively thicker way than one with a low environmental sensitivity. The thin-thick conceptualization of service learning considers worldview, awareness, sensitivity and values (Morton 1995).

A goal of environmental service-learning is to improve or protect aspects of the environment. Intention to act is the expression of motivations and is a strong correlate and predictor of actual behaviors (Hollweg et al. 2011). It is often difficult for researchers to assess actual behaviors, given that behaviors occur in contexts outside of learning environments. Therefore, motivation, intention and reported behaviors are often used to deduce actual environmentally responsible behaviors as they are strong correlates and predictors (Hines et al. 1986/7, as cited in Hollweg et al. 2011). Motivation and intention to act represent an individual's assumption of personal responsibility. Intended behaviors were identified that explicitly related to environmental service-learning activities that were common in programs which were to be studied. The behaviors were volunteer ecomanagement in a natural area, environmental monitoring for watershed health, environmental career goals, dedicating time or money to the environment. These four 'intended behaviors' were directly related to the environmental service-learning activities. Behavioral intention was identified to determine if the environmental service-learning activities which occurred in the 'educational' context would likely occur in other, future contexts.

Environmental worldview is related to concern and attitudes which reflect youth's interests and disinterests. Environmental worldview involves a general environmental outlook, while concern and attitudes involve particular aspects of the environment or

environmental issues (Dunlap, 2008 as cited in Hollweg et al. 2011). Environmental worldview, like sensitivity, measures aspects of thin or thickness in environmental service-learning. In addition the importance of environmental worldview within environmental literacy and environmental service-learning, the variable was assessed because a complete 10-point scale, the New Environmental Paradigm, was available to use for study. The New Environmental Paradigm is developmentally appropriate, correlates with environmentally responsible behavior and completely assesses three subscales within environmental worldview: rights of nature, human exemptionalism and eco-crises (Dunlap et al. 2000).

Within the domain of knowledge, three components were considered. They were knowledge of physical and ecological systems, knowledge of environmental issues and knowledge of citizen participation and action strategies (Hollweg et al. 2011). Roth (1992) identifies knowledge is one of the six major areas of environmental literacy. Knowledge provides facts, information and understanding which may be drawn upon to respond to situations or issues which arise. The knowledge of physical and ecological systems was particularly relevant to environmental service-learning activities. Several programs engaged in eco-management and thorough understanding of how these youth were impacting a system was central to their learning. Quality environmental service-learning should be linked to the curriculum (National Youth Leadership Council 2008). Further, understanding physical systems is a 'strand' of the Oregon Environmental Literacy Plan (OELP) and science standard with the Next Generation Science Standards (NGSSs). Both the OELP and NGSSs drive environmental education in Oregon.

Knowledge of environmental issues, which has two sorts of knowledge, was limited to knowledge of “the variety of environmental problems that arise from biophysical impacts in the natural world and the causes and effects of those impacts” (Hollweg et al. 2011). Environmental service-learning activities studied in this research were often directed by 'problems' (Environmental Problem Solving) or issues and thus, an understanding of these problems was particularly relevant to study.

Knowledge of actions strategies was considered for two main reasons. The first, being that environmental service-learning is an example of an action strategy. It was important to determine if youth understood the 'actions' occurring in their environmental service-learning activities and the potential impacts of those actions. Assessing knowledge of actions strategies helps to understand whether youth are contextualizing the environmental service-learning activities. Secondly, knowledge of actions strategies beyond environmental service-learning activities is pivotal for further environmentally responsible behaviors to occur. These future behaviors could not be measured. Of particular importance to this variable (albeit true of all the variables discussed), is the tacit understanding that promoting environmentally responsible behavior is a central goal of environmental education and thus environmental service-learning. The Tbilisi Declaration states a goal of environmental education: “to create new patterns of behavior of individuals, groups and society as a whole towards the environment” (UNESCO 1977).

Multiple aspects of competencies were considered which were identified in the conceptual framework for the domain of environmental literacy (Hollweg et al. 2011).

They were: identify environmental issues, ask relevant questions about environmental conditions and issues, analyze environmental issues, investigate environmental issues, create and evaluate plans at various scales to resolve environmental issues.

Competencies, previously considered skills, are one's "skills and abilities that you know how and when to apply" (UNESCO 1977; Roth 1992; Hollweg et al. 2011). These competencies are central to quality environment service-learning. Identification, questioning and analysis can all be considered predecessors to quality environmental service. Issues, problems or needs are identified, considered (questioning) and analyzed before service occurs. Thoughtful planning likely occurs prior to service, which may include investigation and evaluation. Environmental service learning activities associated with chapters three and four involved students practicing these competencies throughout the schoolyear. Roth (1992) states that identification occurs at the nominal environmentally literate level. Along with identification, investigation, evaluation and analysis all occur at the functional environmentally literate level (Roth 1992). All of the competencies are represented at the operational environmentally literate level.

Environmentally responsible behavior is the "involvement in intentional and habitual behaviors individually or as a group, that work towards solving current problems and preventing new ones" (Hollweg et al. 2011). Environmentally responsible behavior is a central variable to environmental education and thus environmental service learning (UNESCO 1977; Sia 1986; Hungerford and Peyton 1980; Stern 2000; Jensen 2002; Kollmuss and Agyeman 2002). Five developmentally appropriate behaviors were identified to assess: I recycle, I pick up litter/trash, I talk to others about environmental

issues, I engage in restoration as part of school and I engage in restoration outside of school. The term restoration was used in lieu of ecomanagement to facilitate youth comprehension. The two questions about restoration (at school and outside of school) were particularly relevant to most participating environmental service-learning programs which spent at least some time engaged in ecomanagement. Variables not directly related to environmental service-learning activities were identified to determine if a 'spillover' effect may occur. The idea that taking up a new environmentally responsible behavior (eco-management via environmental service-learning) might lead to the adoption of other similar behaviors (recycling, talking to others about environmental issues) has been termed 'spillover effect' by Whitmarsh and O'Neill (2010), as cited in Dresner et al. (2014).

Finally, four variables particular to 'significant life experiences' literature, typically recognized within the field of environmental education, were considered (Tanner, T. 1980; Chawla 2006). Methods within the significant life experiences literature involve individuals considering past formative experiences which had significant impact on their decisions related to the environment (e.g., decision to work in environmental field). Previous environmental education experiences, having a positive adult role model that cares for the environment, witnessing environmental harm and previous outdoor experiences have all been recognized as significant formative experiences influencing environmentally responsible behavior (Chawla 1998; Chawla 2006). While the participating environmental service-learning programs had little

influence over these four variables, it was important to see how these variables co-varied with all other variables particular to environmental literacy.

Chapter 2 – A Coarse-Scale Analysis of Grade 6-12 Environmental Education Programs' Educational and Ecological Outcomes

This chapter evaluated several environmental education programs in terms of their educational and ecological outcomes. Programs were compared according to time spent engaged in environmental service-learning with response variables including environmental literacy scores and reported biophysical outcomes of the program. Data were quantitative and the analysis was coarse-scale. This chapter addressed the two overarching research questions: *How does the quantity and quality of time spent engaged in environmental education, including environmental service-learning, affect participants' environmental literacy?* and *How does the quantity and quality of time associated with environmental service-learning programs affect the ecology of the areas where the program occurs?*

Chapter 2 – Research Questions (RQ):

RQ 2.1: What impacts do Portland metropolitan area environmental education programs have in terms of their short-term effects on the biophysical environment?

- **RQ 2.1 A:** Which environmental education programs have biophysical metrics of success or accomplishment?
- **RQ 2.1 B:** Of the programs that use biophysical metrics of success or accomplishment that are comparable, how do these outcomes differ across a

continuum of foci⁸?

- **RQ 2.1 C:** What is the combined direct impact of environmental service-learning activities (i.e. ecomanagement) to the local ecology of the Portland metropolitan region for 2014?

RQ 2.2: Recognizing that environmental education programs' foci lie on a continuum⁹, what impacts do programs with an environmental service-learning focus (one side of the continuum) have on students' environmental literacy¹⁰ compared to programs with an environmental learning focus (the other side of the continuum)?

- **RQ 2.2 A:** What programatic features significantly affect participants' environmental literacy?
- **RQ 2.2 B:** How are programatic features, percentage of time spent engaged in environmental service-learning and percentage of time spent outdoors, associated with participants' environmental literacy?

RQ 2.3: What are the impacts of environmental education programs in the Portland metropolitan region in terms of environmental literacy?

- **RQ 2.3A:** In what ways do students reporting previous environmental education experiences differ from those without?

8 See Fig. 2.1: Continuum of Environmental Education Programs' Foci on page 191

9 See Fig. 2.1: Continuum of Environmental Education Programs' Foci on page 191

10 Environmental literacy assessment evaluates student beliefs and motivations on the rights of nature, human exemptionalism, environmental identity, place attachment, environmental behaviors and the utilization of nature. It is derived from: New Ecological Paradigm Revised, The Inclusion of Nature in Self and Environmental Identity scales, taken from Dunlap et al 2000, Schultz 2001 and Clayton 2003 respectively. See Appendix C for Assessment Tool

Chapter 2 – Introduction: Theoretical Background to Hypotheses Regarding Ecomanagement, Environmental Literacy and Environmental Service-Learning

Ecomanagement is a component of some environmental service-learning. By definition, there is a direct relationship between ecomanagement and changes to ecology. Therefore, it was expected that environmental education programs that employed environmental service-learning would have higher biophysical outcomes than programs which did not employ environmental service-learning.

Environmental literacy consists of four domains: behaviors, dispositions, skills and knowledge. Programs that provided environmental service-learning were expected to teach to all of these domains. Environmental learning programs were expected to teach to dispositions and knowledge, presumably relying on the Knowledge-Attitude-Behavior model of early environmental education. Moreover, programs which did not have a behavioral component like environmental service-learning were expected to forego important environmental literacy variables such as locus of control and efficacy.

Environmental education improves environmental literacy (Volk, T. L., & McBeth, W. C. (1997). Therefore, youth who indicated having received previous environmental education were expected to have higher environmental literacy than youth who did not.

Chapter 2 – Hypotheses:

Hypothesis 2.1B: Biophysical outcomes will be greater for programs that employ environmental service-learning than those programs without an environmental service-learning focus.

Hypothesis 2.2: Students in programs that employ environmental service-learning will have significantly greater scores in the environmental literacy assessment than students engaged solely in environmental learning.

Hypothesis 2.3: Students indicating previous environmental education experiences will have higher environmental literacy than students indicating they had no previous environmental education experiences.

Chapter 2 – Methodology:

Research Phase One: Portland Area Environmental Education Census and Practitioner Telephone Surveys

There were two research phases employed to assess the educational and ecological impacts of environmental education organizations in the Portland/Vancouver metropolitan region. First, the population of environmental education programs that

served the region was identified. Operationalizing environmental education for the purpose of this study referenced the NAAEE definition of environmental education¹¹ and the Oregon Environmental Literacy Plan¹². Organizations that met these two definitions were considered environmental education organizations. Performing a census on all organizations which met these criteria was beyond the scope of this research. Five criteria were used to determine if environmental education organizations would be considered in this study. To be included, organizations must:

- Have environmental education objectives, identify as an environmental education program or state that they provide environmental education.
- Be based in the Portland/Vancouver metropolitan area.
- Serve youth that reside in the Portland/Vancouver metropolitan area.
- Serve youth in 6-12 grade (~11-19 years old).
- Have environmental education programs which spend significant time with students (more than one school-day or eight hours).
- Spend at least 15% of instructional time out of the typical classroom setting.¹³

Upon definition of the population, the research performed a census and counted the environmental education programs from which a sample was subsequently taken. The population was identified via online database (Environmental Education Association of Oregon's (EEAO) list of programs¹⁴) and relevant search engines terms (environmental

11 Environmental education teaches children and adults how to learn about and investigate their environment, and to make intelligent, informed decisions about how they can take care of it.

12 Education which promotes an individual's understanding, skills and motivation to make responsible decisions that consider his or her relationships to natural systems, communities and future generations.

13 Time spent outdoors seen as a significant predictor of change in attitude and knowledge

14 <http://www.eeao.org/>

education program Portland Oregon Vancouver Washington). At this phase, the census, programs were identified because they delivered formal or informal environmental education, outdoor education, environmentally based experiential education, science education, geography education or environmental service-learning to 6-12 grade students (~11-19 years old) for at least eight hours. A subgroup of administrators from the identified organizations reviewed and made additions to the list of programs in the region. A complete snowball method for identifying organizations was proposed but ultimately, abandoned. Regional environmental education leaders indicated survey fatigue among local environmental education providers. Additionally, it was deemed that requesting further information from providers (i.e. review a list of 100+ programs) may negatively impact participation rate in the second phase of this research. One hundred and forty nine possible organizations were identified and many had multiple programs. Several environmental education organizations were not counted because they clearly did not qualify for the study. Further analysis of each of these 149 organizations' programming via their online materials found that 52 programs offered extended environmental education (≥ 8 hours) to students at least in 6th grade. Next, the research surveyed administrators about their program(s). Two email requests to participate in the research, initial and follow-up, yielded a 42.3% response rate. Telephone interviews were conducted and data were collected for 22 different programs, some from the same organization. The programs that participated in this phase of the research are listed in Table 2.1.

Table 2.1 Phase One: Participating Programs Table displays the organization that agreed to be identified and participated in phase two of this research, a telephone interview regarding their program.

Phase One: Participating Environmental Education Programs			
- Cascade Education Corps	- Portland State University/National Science Foundation	- Terra Nova High School Farm Education Program	- Tsuga Community Commission: Oregon Summer Star Program
- Center for Agriculture, Science and Environmental Education	Grades K-12 Cascades to Coast Program	- Trackers Earth	-Friends of Tryon Creek Assistant Counselor programatics
- Multnomah Education Service District's Outdoor School	- Mount Hood Community College Project YESS Youth Conservation Corps	- TreeSong	- Wilderness International
- Portland Parks and Recreation Grunt Program	- SOLVE Green Team	- Tsuga Community Commission: PLACE program	- Zenger Farm

Telephone interviews with program administrators (n = 22) discovered significant variation among the programs. Ten to fifteen minute telephone surveys¹⁵ regarding programatics gathered data regarding:

- The extent of environmental education programs (location and service area).
- The length of environmental education programs in hours.
- The percentage of time participants spend indoors vs outdoors.
- The incentives for participation (e.g., credit/no credit, financial, internship).
- The percentage of time participants spent engaged in environmental service-learning activities.
- The utilization of biophysical metrics of success.
- Programs' biophysical success, whatever their metrics.

Program activities varied significantly throughout the region. One program delivered

¹⁵ See Portland/Vancouver Area Environmental Education Census: Practitioner Data Collection Outline in Appendix A

environmental education focused on organic farming and food systems, while another program focused on restoration of plant and soil communities. Another program placed their students in leadership positions where they acted as environmental educators to younger students. Yet, another program combined outdoor recreation with environmental service-learning focused on eco-management. These programs served students from the entire region. Program administrators (interviewees) indicated a wide range in the socioeconomic backgrounds of their students. Program recruitment included school visits, adjudication, social media, brochures, tabling at school age events, offering school credit, internships, community driven, inter-organization contracts, advertisements in periodicals, online databases, student in house referrals and educator referrals. Sixty-one percent of these programs provided options for students to receive school credit. One program provided direct financial incentives (paid internship) and two other programs offered job opportunities upon completion of their program. Funding sources for these programs varied significantly: federal, state, city, school, grants, tuition, philanthropy and volunteer. Several organizations had multiple funding sources.

Participating programs' length of time ranged from 12 contact hours to 450 contact hours; the median length of time was 46.5 hours. The relative time spent indoors and outdoors ranged from 0% indoors and 100% outdoors to 66% indoors and 34% outdoors; the median was 10% indoors and 90% outdoors. The total time spent indoors ranged from 0 hours to 297 hours; the median was 12 hours. The total time spent outdoors ranged from 11 to 240 hours; the median was 43 hours. The relative time spent engaged with environmental service-learning ranged from 0% to 98%; the median was

25%. Summary statistics for these programs are listed in Table 2.2.

Table 2.2 Programmatics of Participating Environmental Education Programs Table displays summary statistics for 22 participating environmental education programs.

Statistic	Program Length (hours) n = 22 programs	Percentage of Time		Total Time		Percentage of Time		Total Time	
		Inside	Outside	Inside	Outside	ES-L	Other EE	ES-L	Other EE
min	12	0	34	0	11.4	0	2	0	1
median	46.5	10	90	12	43.3	25	75	15	33
max	450	66	100	297	240	98	100	216	360
range	438	66	66	297	229	98	98	216	359
mean	104	20.7	79.3	24.9	79.5	42.3	57.7	46.4	58.1
S.D.	112	21.2	21.2	62.2	76.6	37.3	37.3	70	80.1

Research Question 2.1: *What impacts do Portland metropolitan area environmental education programs have in terms of their short-term effects on the biophysical environment?* was investigated with self-reported data from environmental education practitioners. Data were considered in commensurate terms and arranged graphically. Seven of the twenty-two programs which participated in this phase of the research provided data on biophysical gains directly resulting from their program. Data were provided for the 2014 calendar year.

There were potentially confounding factors that may have occurred within phase one of this research. For example, practitioners may have had a different understanding of what qualified as environmental service-learning and therefore may have over or underestimated the percentage of time engaged with environmental service-learning. During telephone surveys, conversations occurred between the researcher and practitioner in an attempt to clarify what constituted environmental service-learning. Furthermore, a

subset of environmental education programs may not have been identified for the study given the sampling procedure which utilized an internet based methodology.

Research Phase Two: Surveying Participants of Portland Area Environmental Education Programs

In the second phase of this research posttest surveys were administered to environmental education programs' participants. Youth took this 33-question survey which measured aspects of environmental literacy at the end of their respective programs. Surveys were administered by practitioners from the respective programs. Survey administrators (practitioners) were provided with an administration script to limit interviewer and observer bias.¹⁶ Eleven of the twenty-two programs from phase one administered the posttest surveys. There was significant variation in the type of programming which occurred for the students in these programs. For example, some programs engaged almost entirely in eco-management, focusing on the behavioral domain of environmental education: removing invasive species, building and improving trails, planting native species and removing trash. Other programs focused more on the knowledge and disposition domains: cultivating environmental sensitivity, awareness and knowledge of physical systems. Three-hundred and ninety-three students took the posttest environmental literacy survey. These students came from all across the metropolitan region. Given the large variety of programming and students' background the analysis which occurred is recognized as coarse-scale. Potentially confounding

¹⁶ For administration script, see Appendix A

factors are considered in the discussion. A fine-scale analysis which considered similar question relating to environmental service-learning in the Portland, Oregon metropolitan region occurred in chapter three of this document.

The amount of students in each program varied greatly and ranged from 4 to 111 per program; the median number of students per program was 18, the average was 35. Students age ranged from 11-19; the median age was 14. Of the students that indicated gender, 186 males and 183 females took the survey. Frequency distributions for all environmental literacy assessment questions were completed for all students collectively (n=393).¹⁷ These distributions were organized according to the domain of environmental literacy which they assessed. This organization was supported by a principal component analysis explained in forthcoming pages and according to a priori theoretical framework (Hollweg et al. 2011). These data were examined statistically for normal distribution using the Shapiro-Wilk test. Student responses were not normally distributed; all Shapiro-Wilk tests were significant.

Statistical analyses of students' post-test survey responses progressed with several methods supporting subsequent analysis. First, a principal component analysis occurred with survey data (n=393) to determine if any questions measured the same underlying construct. Survey data from the students in a participating environmental education were used. Four reverse coded questions were excluded. The four questions which did not show homogeneity of variance among the eleven participating programs were included. A principal component analysis does not assume homogeneity of variance. Factors which emerged from the principal component analysis were not used when considering

¹⁷ See Figs 2.2a-f for frequency distributions on pages 193-198

differences between the treatment and control groups. Preliminary analysis created a correlation matrix determinant to check for multicollinearity ($3.166 \times 10^{-5} > .000001$). No correlations were too high (>0.90) and it was determined that multicollinearity was not a problem for these data. Sampling adequacy was met (KMO: 0.911) and Bartlett's test of sphericity (2978.656, df: 325, Sig.000) confirmed that the correlation matrix was not an identity matrix. Varimax rotation was used and five factors emerged which explained 60% of the total variance. Cronbach's alpha was computed to measure internal consistency. All questions for each of the five factors had coefficients greater than 0.70 except one factor relating to environmental worldview (cronbach's α : .597). That factor was combined with another similar factor which emerged during the principal component analysis. When these two factors were combined their coefficient was greater than 0.70. Questions from these two factors were taken from an established environmental education assessment, the New Environmental Paradigm which measures environmental worldview (Dunlap et al. 2000). There was inconsistency in the results of the principal component analysis and existing research supporting particular sub-constructs of environmental worldview. The New Environmental Paradigm contains questions that measure three sub-constructs: rights of nature, human exemptionalism and eco-crisis. However the corresponding questions for these sub-constructs did not align with the principal component analysis which further supported combining the two factors related to environmental worldview into one condensed variable. Ultimately, four collapsed variables emerged: locus of control (cronbach's α : .821), environmental worldview (cronbach's α : .713), environmentally responsible behavior (cronbach's α : .709) and

environmental sensitivity and awareness (cronbach's α : .748). The four variables confirmed a priori coding and align with the domains of environmental literacy (Hollweg et al. 2011). The collapsed variables or underlying latent factors and corresponding test questions are listed below in Table 2.3.

Table 2.3 Collapsed Variables/Latent Factors Table shows the six factors which emerged from the principal component analysis and their corresponding questions with weights. Cronbach's α is listed for all factors and including cronbach's α for both environmental worldview factors separately and the cronbach's α for the combined environmental worldview.

Factor and cronbach's α		Assessment Questions (weight)
Locus of Control (.821)		<ul style="list-style-type: none"> - By myself, I can make a positive impact on the environment. (.710) - With others, I can make a positive impact on the environment. (.670) - I plan to volunteer in a natural area (tree planting, invasive species removal). (.666) - I am interested in a career working to make a positive impact on the environment. (.646) - I have the skills necessary to make a positive impact on the environment. (.631) - I would like to collect environmental data for local government, so they can monitor the environmental health of our watershed. (.585)
Combined Environmental Worldview (.713)	Environmental Worldview I (.749)	<ul style="list-style-type: none"> - People must obey the laws of nature. (.777) - When people mess with nature it has bad results. (.724) - Plants and animals have as much right as people to live. (.703)
	Environmental Worldview II (.597)	<ul style="list-style-type: none"> - People are treating nature badly. (.743) - If things don't change we will have a big disaster soon. (.727) - There are too many (or almost) too many people on earth. (.621)
Environmentally Responsible Behavior (.709)		<ul style="list-style-type: none"> - I pick up trash. (.713) - I talk to other about environmental issues. (.687) - I engage in restoration outside of school. (.639) - I recycle. (.511)
Environmental Sensitivity and Awareness (.708)		<ul style="list-style-type: none"> - I enjoy spending time in natural settings. (.735) - I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time (.699) - the Inclusion of Nature In Self scale (.614)

Differences among student collapsed scores scores were investigated. Box-plots were constructed¹⁸ and they show environmental worldview and environmental sensitivity and awareness higher than ERB: Environmentally Responsible Behavior and

¹⁸ See Fig 2.3 Domains of Environmental Literacy: Dispositions and Behaviors on page 199

LOC: Locus of Control. Paired sample t-tests were run between ERB, LOC and worldview. Environmental sensitivity and awareness was omitted from this analysis because it includes student responses to the Inclusion of Nature in Self scale (Schultz 2001) which is on a seven-point scale. The collapsed environmental sensitivity and awareness variable has a larger scale and is not suitable for comparison among collapsed variables. Wilcoxon Signed Ranks Tests indicated that environmental worldview was significantly higher than locus of control (Z: 12.332, p: 0.000, n=384) and environmentally responsible behaviors (Z: 14.511, p: 0.000, n=391). Locus of control was significantly higher than environmentally responsible behaviors (Z: 7.127, p: 0.000, n=384). Results from the principal component analysis supported creating four collapsed variables (discussed in results section).

In order to answer *Research Question 2.2 A: What programatic features significantly affect participants' environmental literacy?* Random forests were generated with all data points (n = 393) to confirm the relative impact of nine covarying predictor variables which emerged from the Principal Component Analysis (Breiman, L. 2001; Lydersen, J. M., North, M. P., & Collins, B. M. 2014). Random forests have been shown as suitable tools for analyzing imbalanced and hierarchical datasets (Khalilia, M., Chakraborty, S., & Popescu, M. 2011; Svetnik, V., Liaw, A., Tong, C., Culberson, J. C., Sheridan, R. P., & Feuston, B. P. 2003). Random forest were utilized because they are robust do not require homogeneity of variances or normal distributions and can cope with “complex intereactions and highly correlated predictor variables” (Strobl, C., Boulesteix, A. L., Kneib, T., Augustin, T., & Zeileis, A. 2008). Four random forests, one for each of

collapsed variables, were generated each with nine predictor variables:

- age (11-19);
- gender (male/female);
- length of EE program (0-340 hours);
- percentage of time EE program spent outdoors (0-100%);
- percentage of time EE program engaged in environmental service-learning (0-100%);
- student response to: “Have you received any other outdoor environmental education?” (yes/no);
- student response to: “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?” (yes/no);
- student response to: “Have you seen something bad happen to the environment before?” (yes/no); and
- student response to: “Before this program how frequently did you spend time in the outdoors?” (never/infrequently/sometimes/frequently/very frequently).

Random Forests confirmed that the percentage of time EE programs spent engaged in environmental service-learning and relative impact of the percentage of time EE programs spent outdoors were significant predictors of the collapsed variables which emerged from the principal component analysis. Results from the random forests confirmed the relevance of *Research Question 2.2 B: How are programmatic features, percentage of time spent engaged in environmental service-learning and percentage of time spent outdoors, associated with participants' environmental literacy?*

Analysis of students' posttest survey responses considered how diverse environmental education programs may have affected students' environmental literacy. Analysis explicitly considered pseudo-replication. Appropriate degrees of freedom, precise p-values and sample sizes were reported (Lazic, S. 2009) for all statistical tests. Three hundred and ninety three students took the environmental literacy survey and these students came from one of eleven programs.

Research Question 2.2 B: How are programmatic features, percentage of time spent engaged in environmental service-learning and percentage of time spent outdoors, associated with participants' environmental literacy? was investigated using correlational statistics. Significant correlations were calculated using Spearman's rank correlation to determine if any significant associations existed between each of the collapsed variables, attitudinal and behavioral responses with the percentage of time EE programs spent engaged in environmental service-learning, the percentage of time EE programs spent outdoors and the length of the program. Attitude and behavioral questions which lacked homogeneity of variance among the eleven participating environmental education programs were not included. Spearman's rank correlation considered posttest responses at two different levels of analysis. These levels were:

- The program level which used measures of central tendency of the responses for each of the eleven programs.
- For all of the students (n=393).

These two levels (student level, n = 393 & program level, n = 11) were used to consider the impacts of pseudo-replication (Schank, J. C., & Koehnle, T. J. 2009). When

considering the program level, medians were used for attitudinal and behavioral responses because data was ordinal on a Likert scale (e.g., strongly disagree, disagree, no opinion, agree, strongly disagree). Means were used for collapsed scores from the principal component analysis. Measures of central tendency have been suggested to avoid falsely reporting significant associations due to pseudo-replication (Hurlbert, SH. 1984; Milinski, M. 1997). On the other hand, some researchers dismiss pseudo-replication (Oksanen, L. 2001; Wiley 2003) and suggest pooling (Schank, J. C., & Koehnle, T. J. 2009) to capture variability. Scatterplots with medians were constructed for those variables with significant associations that occurred at either level of analysis.

Research Question 2.3A: In what ways do students reporting previous environmental education experiences differ from those without? was investigated using a control group. Data from two eighth grade science classes were used as a control group (n=61). Assignment to the control group was not random. In this part of the analysis a quasi-experiment occurred with a convenience sample. Students in the control group resided in the study area and attended the same school as students from one of the environmental education programs (treatment group) in this study. The median age was the same for both groups, control and treatment (i.e. eleven environmental education programs), yet the age range was much smaller for the control group, 13-14 rather than 11-19 for the treatment group. In order to determine if the control group was appropriate for comparison with the experimental group, a Levene's test based on medians was performed on survey responses to determine if the two groups (control and experimental) had homogeneity of variances. Levene's tests have been used to determine appropriate

statistical tests of comparison for groups with highly significant response variables for different groups (Bouwman, H., Cooppan, R. M., Reinecke, A. J., & Becker, P. J. 1990). Furthermore, Levene's tests have been used to determine if among-group differences resulted from different sampling methods (Nagelhout, G. E., Willemsen, M. C., Thompson, M. E., Fong, G. T., van den Putte, B., & de Vries, H. 2010). Levene's statistic indicated homogeneity of variances in all but four questions:

- age (F: 19.616, df: 1, p: 0.000);
- “I engage in environmental restoration outside of school” (F: 7.684, df: 1, p: 0.006);
- “Plants and animals have as much right live as humans do.” (F: 3.961, df: 1, p: 0.047); and
- The Inclusion of Nature in Self Scale (F: 10.868, df: 1, p: 0.001).

A second Levene's test on medians occurred to determine if survey responses for each of the eleven programs should be considered collectively (treatment group). Levene's statistic indicated homogeneity of variances in all but four questions:

- age (F 18.181, df: 9, p: 0.000);
- “Before this program, how frequently did you spend time outdoors?” (F: 2.151, df: 9, p: 0.21);
- “If things don't change, we will have a big disaster in the environment soon.” (F: 1.916, df: 9, p: 0.050); and
- “I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time. (F: 2.131, df: 9, p: 0.027).

Given the relative homogeneity of variances, the responses from students in the eleven environmental education programs were combined (Sharma, U. C., Barenbrug, P., Pokharel, S., Dassen, W. R., Pinto, Y. M., & Maessen, J. G. 2004). Sharma et al. reference the *Handbook of Research Synthesis* (Glesser, L & Olkin I. 1994) and utilized Levene's tests to determine 'eligibility' for combining heterogeneous groups, pooling the groups' variances. The four questions lacking homogeneity of variance (11 treatment groups) were excluded from two sections of analysis: treatment v control and associational (Spearman's) analysis discussed above. Moreover, it was concluded that, given the relative homogeneity of variances, responses from students in the control group were sufficiently commensurate with responses from students in the treatment group (eleven environmental education groups combined) for this section of the analysis (treatment vs. control). The four questions lacking homogeneity of variance (treatment vs. control) were also excluded from analysis. In total seven questions (age occurred twice) were excluded from this section of the analysis (treatment v control). Mann Whitney-U tests were performed to determine if significant differences occurred between the control group's responses and students' responses from participating environmental education programs (treatment group). Kruskal Wallis and subsequent post-hoc tests were performed to determine if significant differences occurred for students indicating they had previous environmental education. Control group data were examined in the fine-scale analysis in chapter three of this document.

Appropriately capturing environmental education program participants' environmental literacy necessitated crafting an environmental literacy specific to this

study. The assessment tool crafted for this study incorporated existing conservation psychology tools. They are the New Ecological Paradigm Revised (NEP) (Dunlap et al. 2000), the Inclusion of Nature in Self (INS) (Schultz 2001) and the Environmental Identity Scale (EID) (Clayton 2003). The NEP and INS were used in their entirety, whereas the EID was not. Content validity, construct validity and internal consistency were demonstrated for the widely used NEP (Dunlap et al. 2000). Construct validity and internal reliability were demonstrated for the INS (Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. 2004) and the EID (Olivos, P., & Aragonés, J. I. 2011). The environmental literacy assessment included additional questions created specifically for this research study. Formulation of questions was informed by NAAEE's Framework for Assessing Environmental Literacy (Hollweg et al. 2011). In total, a 33-question survey was created which incorporated questions from existing measures. The final assessment was refined and analyzed for validity and reliability. Questions and their corresponding coding to constructs were refined several times by groups comprising of local environmental education leaders, practitioners, university researchers and hundreds students enrolled in other environmental education programs (Fischer, K. A. 2011; Braun, S., Hart, T. & Ordway, K. 2013). Cronbach's alpha was run to assess the reliability of constructs. With one exception, only values over α : .600 were included. The constructs: rights of nature (α : .649), eco-crisis (α : .633), human exemptionalism (α : .276), locus of control (α : .759), environmental sensitivity and awareness (α : .798), environmentally responsible behaviors (α : .807), intention to act/motivation (α : .807) and efficacy (α : .712)¹⁹. While there was low or questionable internal reliability ($>.700$) for

¹⁹ for environmental literacy coding see Appendix E

rights of nature, human exemptionalism and eco-crisis, the ten questions were retained for the study because they were a complete scale (NEP) regularly used in environmental education research with demonstrated internal reliability (Dunlap et al. 2000).

Chapter 2 – Results:

Research Phase One: Portland Area Environmental Education Census and Practitioner Telephone Surveys

Research Question 2.1: What impacts do Portland metropolitan area environmental education programs have in terms of their short-term effects on the biophysical environment?

Seven environmental education programs provided biophysical data for 2014 which included native plantings, invasive species removal, trail maintenance and litter removal. Simple descriptive statistics were gathered from telephone interviews with environmental education program administrators. Descriptive statistics for the programs that utilized and provided biophysical metrics of success were arranged graphically and displayed on the conceptual diagram²⁰ which guided parts of this research. More complex statistical analysis did not occur because of the small sample size and inconsistency among metrics. Nineteen of the twenty-two programs surveyed indicated

²⁰ See Fig. 2.1a Biophysical Outcomes and Time Spent Engaged with Environmental Service-Learning on page 192

that they used the pedagogy of environmental service-learning. Eleven of the nineteen programs that used environmental service-learning indicated that they kept data on the biophysical metrics of their success or impact. Seven programs provided the data on the biophysical metrics of their success or impact. The types of environmental service-learning included eco-management, sustainable agriculture for community consumption and teaching others. Thus, comparison among programs was difficult because metrics varied greatly including number of plants installed, area of invasive species removed, area of garden beds prepared, pounds of seeds collected, pounds of trash removed, area mulched, length of trail cleared, before and after photos, impact of food grown, changes to soil chemistry, changes to plant diversity and volunteer hours contributed. Several programs reported very specific outcomes (e.g., 2,009 gallon pots, 3,215 bare roots, 200 bulbs, and 3,720 potted plants) that were condensed to a coarser scale, but easier for inter-program comparison (e.g., 9,144 native plants). A summary of the quantifiable biophysical impacts is provided in Table 2.4.

Table 2.4 Combined Biophysical Impact of 22 Environmental Education Programs Table shows reported values for six programs. Eleven of the 22 programs stated they used biophysical metrics of success, but only six were provided during the course of study.

Type of Impact	Outcome
invasive species management	- invasive species removal: 63,091 sq.ft. & 65 plants - invasive species mowed: 140,530 sq.ft.
native plantings	- native plantings: 16,754 items (trees, shrubs, cuttings, potted plants, bulbs)
soils	- compost/mulch application: 6,947 sq.ft. & 200 plants
trash	- trash removal: 3,110 lbs
trails and roads	- trail maintenance: 42,993 ft (clearing, graveling, erosion control) - trail building: 5,280 ft. - roadside cleared: 240 sq.ft.

garden, farm, nursery	<ul style="list-style-type: none"> - general weeding/clearing: 4,250 sq.ft., 2,530 pots/trays & 912 dead plants - plant protection: 621 items (caging or coffee bagging plants) - plant nursery work: 4,173 items (transplanting, sorting, watering) - native seeds: 75 lbs (cleaning & collecting) - sustainable agriculture: 43,560 sq.ft.
other maintenance	<ul style="list-style-type: none"> - stream bioengineering: 120 ft - sensitive species identification: 300 egg masses

Research Phase Two: Analysis of the Survey Responses for Participants in Select Portland Area Environmental Education Programs

Research Question 2.1A: What programmatic features significantly affect participants' environmental literacy?

Of the measured 'predictor' variables, the frequency of youths' previous outdoor experiences, age, the percentage of time EE programs spent outdoors and the presence of an adult role model that cares for the environment had the strongest influence on youths' environmental literacy. A random forest for the collapsed locus of control variable explained 12% of the variance and indicated the most important variables as age, percentage of time EE programs spent outdoors, the frequency of previous outdoor experiences and the percentage of time the EE program spent engaged in environmental service-learning. Five hundred trees were generated and error rates leveled out near the 100th tree at 0.45 error. A random forest for the collapsed environmentally responsible behavior variable explained 12.8% of the variance and indicated the most important variables as the frequency of previous outdoor experiences, age, percentage of time EE

programs spent outdoors, and indication of a positive adult role model who cares for the environment. Five hundred trees were generated and error rates leveled out near the 100th tree at 0.55 error. A random forest for the collapsed environmental worldview variable explained 0% of the variance. Five hundred trees were generated and error rates leveled out near the 200th tree at 0.41 error. A random forest for the collapsed environmental sensitivity and awareness variable explained 22.4% of the variance and indicated the most important variables as the frequency of previous outdoor experiences, age, the presence of a positive adult role model that cares for the environment and percentage of time EE programs spent outdoors. Five hundred trees were generated and error rates leveled out near the 100th tree at 0.75 error. The most significant predictors for locus of control (Res. Mean Sq. 0.445, variation explained: 12.0%) were age, percentage of time the environmental education spent outdoors and the frequency of students' previous outdoor experiences. The most significant predictors for environmentally responsible behavior (Res. Mean Sq. 0.547, variation explained: 12.8%) were the frequency of students' previous outdoor experiences, age, the percentage of time EE programs spent outdoors and the presence of a positive adult who cares for the environment. There were no significant predictors for environmental worldview. The most significant predictors for environmental sensitivity and awareness (Res. Mean Sq. 0.732, variation explained: 22.4%) were the frequency of students' previous outdoor experiences, age and the presence of a positive adult who cares for the environment. Results for the four random forests are listed in Table 2.5 which indicates the decrease in node impurity for each possible predictor. Higher node impurity values indicate higher

degree of variable importance.

Table 2.5 Variable Importance Table shows results from four random forests each with nine predictor variables for four collapsed variables that emerged from principal component analysis. Relative importance of predictor variables and percent of variance explained is indicated. * indicates a significant predictor.

Collapsed Variable * indicates a significant predictor			
Locus of Control	Environmentally Responsible Behavior	Environmental Worldview	Environmental Sensitivity and Awareness
Res Mean Sq.: 0.445 Var explained: 12.0 %	Res Mean Sq.: 0.547 Var explained: 12.8 %	Res Mean Sq.: 0.404 Var explained: 0.03 %	Res Mean Sq.: 0.732 Var explained: 22.4 %
Age (20.820)*	frequency of previous outdoor experiences (30.607)*	frequency of previous outdoor experiences (19.377)	frequency of previous outdoor experiences (85.520)*
% of time outdoors (20.250)*	Age (25.254)*	Age (17.044)	Age (30.883)*
frequency of previous outdoor experiences (19.652)*	% of time outdoors (21.992)*	% of time in ES-L (12.301)	Env+ Adult Role Model (32.326)*
% of time in ES-L (16.599)	Env+ Adult Role Model (20.519)*	% of time outdoors (7.521)	% of time in ES-L (24.238)
Env+ Adult Role Model (12.706)	% of time in ES-L (16.552)	Previous EE (6.782)	% of time outdoors (21.582)
Previous EE (8.729)	Previous EE (14.226)	Gender (6.324)	Witness to Env Harm (17.557)
Gender (7.997)	Gender (10.117)	Witness to Env Harm (6.142)	Gender (15.183)
Witness to Env Harm (6.723)	Witness to Env Harm (9.566)	Env+ Adult Role Model (6.081)	Previous EE (12.874)
Credit (3.153)	Credit (3.429)	Credit (2.529)	Credit (5.106)

Research Question 2.1B: How are programmatic features, percentage of time spent engaged in environmental service-learning and percentage of time spent outdoors, associated with participants' environmental literacy?

Associational analyses revealed that the percentage of time an environmental

education programs spend outdoors is more strongly correlated to environmental literacy gains than the percentage of time environmental education programs engage in environmental service-learning. Stronger and more significant associations existed with the percentage of time programs spent outdoors than the percentage of time programs spent engaged in environmental service-learning.

When considering the experimental unit at the student level, positive associations occurred between percentage of time programs spent engaged with environmental service-learning and seven test questions. Two examples: “I engage in environmental restoration as part of school” ($\rho: .181, p: .000, n=386$) and “By myself, I can make a positive impact on the environment.” ($\rho: .176, p: 0.001, n=376$). One of the seven positive associations was reverse coded and represents a decrease in environmental literacy: “People are supposed to rule over nature.” ($\rho: .152, p: 0.003, n=380$). There were two negative associations: “I would like to collect environmental data for local government, so they can monitor the environmental health of our watershed.” ($\rho: -.175, p: 0.001, n=373$) and one which was reverse coded and represents an increase in environmental literacy: “Nature is strong enough to handle the bad effects of our modern lifestyles ($\rho: -.149, p: 0.003, n=389$). There were no significant associations between “percentage of time programs spent engaged with environmental service-learning and the four collapsed variables. The eight questions with significant associations to the percentage of time programs spent engaged with environmental service-learning are listed in Table 2.6. Scatterplots were constructed for the eight significant associations listed.²¹

21 See Figs. 2.4a-d Associations to Environmental Service-Learning on pages 200 - 203

Table 2.6 Associations to Environment Service-Learning Table lists questions from the environmental literacy survey with significant associations to the percentage of time EE programs spent engaged in environmental service-learning. The rightmost column lists the domain and, when applicable, sub-construct of environmental literacy (Hollweg et. al 2011) for the assessment question. Pearson's r test statistic and significance are also listed for collapsed variables from the PCA which occurred on an interval level.

Question	Relationship	Environmental Literacy Domain And Construct
I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building)	$\rho: .181, p: 0.000$ n = 386	Environmentally Responsible Behavior
There are too many (or almost too many) people on earth.	$\rho: .229, p: 0.000$ n = 388	Disposition: Environmental Worldview
Nature is strong enough to handle the bad effects of our modern lifestyles.	$\rho: -.149, p: 0.003$ n = 389	Disposition: Environmental Worldview
People are supposed to rule over the rest of nature.	$\rho: .152, p: 0.003$ n = 380	Disposition: Environmental Worldview
I have skills necessary to make a positive impact on the environment.	$\rho: .176, p: 0.001$ n = 376	Disposition: Locus Of Control
I think the restoration work that I do in natural areas is useful.	$\rho: .235, p: 0.000$ n = 375	Disposition: Efficacy
I would like to collect environmental data for local government, so they can monitor the health of our watershed.	$\rho: -.175, p: 0.001$ n = 373	Disposition: Behavioral Intention
INS: The Inclusion of Nature in Self Scale	$\rho: -.129, p: 0.014$ n = 364	Disposition: Environmental Sensitivity and Awareness

When considering significant associations at the program level, three significant associations occurred with the percentage of time programs spent engaged in environmental service-learning. There were less significant associations which occurred at the program level (n=11) than the student level (n=393). The associations which were significant were stronger than the significant associations at the student level, resulting from the lack of variability. One question was reverse coded and represents a negative association with environmental literacy: “People are supposed to rule over the rest of

nature.” (ρ : .746 p : 0.013, n =11). The other two significant associations represent a positive association with environmental literacy: “There are too many people on earth” (ρ : .676 p : 0.022, n =11) and “I plan to volunteer in a natural area.” (ρ : .634 p : 0.049, n =10). The three questions with significant associations to the “percentage of time spent engaged with environmental service-learning” at the program level (n =11) are listed in Table 2.6a.

Table 2.6a Associations to Environment Service-Learning: Table lists questions from the environmental literacy survey with significant associations to the percentage of time EE programs spend engaged in environmental service-learning. The rightmost column lists the domain and, when applicable, sub-construct of environmental literacy (Hollweg et. al 2011) for the assessment question. Pearson's r test statistic and significance are also listed for collapsed variables from the PCA which occurred on an interval level.

Question	Relationship	Environmental Literacy Domain And Construct
There are too many (or almost too many) people on earth.	ρ : .676, p : 0.022 n = 11	Disposition: Environmental Worldview
People are supposed to rule over the rest of nature.	ρ : .746, p : 0.013 n = 11	Disposition: Environmental Worldview
I plan to volunteer in a natural area (tree planting, invasive species removal).	ρ : .634, p : 0.049 n = 10	Disposition: Behavioral Intention

Positive associations occurred between the percentage of time environmental education programs spent outdoors and 14 test questions and three of the four collapsed variables: locus of control (ρ : .305, p : 0.000, n =384), environmentally responsible behaviors (ρ : .272, p : 0.000, n =393) and environmental sensitivity and awareness (ρ : .132, p : 0.009, n =384).²² There was one negative association which was reverse coded between the percentage of time environmental education programs spent outdoors and “people are supposed to rule over nature” (ρ : -.147, p : 0.004, n =380). The fourteen

²² See Figs 2.5a-i Associations to Outdoor Environmental Education on pages 204 - 212

questions with significant associations to the percentage of time environmental education programs spent outdoors are listed in Table 2.7.

Table 2.7 Associations to Outdoor Environmental Education Table lists questions from the environmental literacy survey with significant associations to the percentage of time EE programs spent outdoors. The rightmost column lists the domain and, when applicable, sub-construct of environmental literacy (Hollweg et. al 2011) for the assessment question. Pearson's r test statistic and significance are also listed for collapsed variables from the PCA which occurred on an interval level.

Question	Relationship	Environmental Literacy Domain And Construct
I recycle.	ρ : .104, p: 0.040 n = 392	Environmentally Responsible Behavior
I pick up trash.	ρ : .225, p: 0.000 n = 393	Environmentally Responsible Behavior
I talk to others (parents, friends, etc.) about environmental issues.	ρ : .247, p: 0.000 n = 388	Environmentally Responsible Behavior
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building).	P: .222, p: 0.000 n = 387	Environmentally Responsible Behavior
People are supposed to rule over the rest of nature.	ρ : -.147, p: 0.004 n = 380	Disposition: Environmental Worldview
If I had enough time or money, I would devote it to working for the environment.	ρ : .189, p: 0.000 n = 379	Disposition: Behavioral Intention
I am interested in a career working to make a positive impact on the environment.	ρ : .244, p: 0.000 n = 379	Disposition: Behavioral Intention
I have skills necessary to make a positive impact on the environment.	ρ : .193, p: 0.000 n = 377	Disposition: Locus of Control
<i>With other people</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	ρ : .276, p: 0.000 n = 375	Disposition: Locus of Control
<i>By myself</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	ρ : .144, p: 0.005 n = 375	Disposition: Locus of Control
I would be upset if the natural area where I have worked was destroyed/polluted.	ρ : .130, p: 0.012 n = 372	Disposition: Environmental Sensitivity and Awareness
I think the field monitoring I do in natural areas is useful.	ρ : .116, p: 0.025 n = 375	Disposition: Efficacy
I plan to volunteer in a natural area	ρ : .257, p: 0.000	Disposition: Behavioral Intention

(tree planting, invasive species removal).	n = 374	
I would like to collect environmental data for local government, so they can monitor the health of our watershed.	ρ : .184, p: 0.000 n = 373	Disposition: Behavioral Intention
INS: The Inclusion of Nature in Self Scale	ρ : .132, p: 0.012 n = 364	Disposition: Environmental Sensitivity and Awareness
Locus of Control (Collapsed Variable)	ρ : .305, p: 0.000 n = 384 r: .289, p: 0.000 n = 384	Disposition: Locus of Control
Environmentally Responsible Behavior (Collapsed Variable)	ρ : .272, p: 0.000 n = 393 r: .262, p: 0.000 n = 393	Environmentally Responsible Behavior
Environmental Sensitivity and Awareness (Collapsed Variable)	ρ : .132, p: 0.009 n = 384 r: .147, p: 0.004 n = 384	Disposition: Environmental Sensitivity and Awareness

When considering significant associations at the program level, four significant associations occurred with the percentage of time programs spent outdoors. There were less significant associations which occurred at the program level (n=11) than the student level (n=393). The associations which were significant were stronger than the significant associations at the student level, resulting from the lack of variability. No significant associations occurred with reverse coded questions. One negative correlation occurred which represents a negative association with environmental literacy: “I engage in environmental restoration as part of school” (ρ : -.605 p: 0.049, n=11). The three positive correlations: “If I had enough money, I would devote it to working for the environment” (ρ : .680 p: 0.021, n=11) and “I plan to volunteer in a natural area.” (ρ : .646 p: 0.044, n=10). The four questions with significant associations to the percentage of time programs spent outdoors at the program level (n=11) are listed in Table 2.7a.

Table 2.7a Associations to Outdoor Environmental Education: Table lists questions from the environmental literacy survey with significant associations to the percentage of time EE programs spend engaged outdoors. The rightmost column lists the domain and, when applicable, sub-construct of environmental literacy (Hollweg et. al 2011) for the assessment question. Pearson's r test statistic and significance are also listed for collapsed variables from the PCA which occurred on an interval level.

Question	Relationship	Environmental Literacy Domain And Construct
I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building).	P: -.605, p: 0.049, n = 11	Environmentally Responsible Behavior
If I had enough time or money, I would devote it to working for the environment.	ρ : .680, p: 0.021, n = 11	Disposition: Behavioral Intention
I plan to volunteer in a natural area (tree planting, invasive species removal).	ρ : .646, p: 0.044, n = 10	Disposition: Behavioral Intention
Locus of Control (Collapsed Variable)	ρ : .698, p: 0.017, n = 11 r: .708, p: 0.015, n = 11	Disposition: Locus of Control

Positive associations occurred between the length of the environmental education program and 18 test questions and two of the four collapsed variables: locus of control (ρ : .295, p: 0.000, n=384) and environmentally responsible behaviors (ρ : .244, p: 0.00, n=393). There were no significant negative or reverse coded associations. The eighteen questions with significant associations to the length of environmental education programs are listed in Table 2.8.

Table 2.8 Associations to Length of EE Programs Table lists questions from the environmental literacy survey with significant associations to the percentage of time EE programs spend engaged outdoors. The rightmost column lists the domain and, when applicable, sub-construct of environmental literacy (Hollweg et. al 2011) for the assessment question. Pearson's r test statistic and significance are also listed for collapsed variables from the PCA which occurred on an interval level.

Question	Relationship	Association with Environmental Literacy (direction of association w/ construct)
I pick up litter/trash	ρ : .175, p: 0.000, n = 393	Environmentally Responsible Behavior

I talk to others (parents, friends, etc.) about environmental issues	$p: .246, p: 0.000, n = 388$	Environmentally Responsible Behavior
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building)	$p: .239, p: 0.000, n = 387$	Environmentally Responsible Behavior
I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building)	$p: .166, p: 0.001, n = 386$	Environmentally Responsible Behavior
There are too many (or almost too many) people on earth.	$p: .111, p: 0.028, n = 388$	Disposition: Environmental Worldview
If I had enough time or money, I would devote it to working for the environment.	$p: .133, p: 0.010, n = 379$	Disposition: Behavioral Intention
I am interested in a career working to make a positive impact on the environment.	$p: .264, p: 0.000, n = 379$	Disposition: Behavioral Intention
I have skills necessary to make a positive impact on the environment.	$p: .205, p: 0.000, n = 377$	Disposition: Locus of Control
I enjoy spending time in natural settings (woods, mountains, desert, lakes, ocean).	$p: .111, p: 0.030, n = 382$	Disposition: Environmental Sensitivity and Awareness
<i>With other people</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	$p: .212, p: 0.000, n = 375$	Disposition: Locus of Control
<i>By myself</i> , I can work to make a positive impact on the environment (i.e. Improve or protect the environment).	$p: .187, p: 0.000, n = 376$	Disposition: Locus of Control
I pay special attention to things outdoors (plants, animals, woods, rivers, weather).	$p: .151, p: 0.003, n = 378$	Disposition: Environmental Sensitivity and Awareness
I would be upset if the natural area where I have worked was destroyed/polluted.	$p: .177, p: 0.001, n = 372$	Disposition: Environmental Sensitivity and Awareness
I think the restoration work that I do in natural areas is useful.	$p: .168, p: 0.001, n = 375$	Disposition: Efficacy
I think the field monitoring I do in natural areas is useful.	$p: .201, p: 0.000, n = 375$	Disposition: Efficacy
I plan to volunteer in a natural area (tree planting, invasive species removal).	$p: .238, p: 0.000, n = 374$	Disposition: Behavioral Intention
I would like to collect environmental data for local government, so they can	$p: .149, p: 0.004, n = 373$	Disposition: Behavioral Intention

monitor the health of our watershed.		
Locus of Control (Collapsed Variable)	ρ : .295, p : 0.000, n = 384 r : .124, p : 0.015, n = 384	Disposition: Locus of Control
Environmentally Responsible Behavior (Collapsed Variable)	ρ : .244, p : 0.000, n = 393 r : .040, p : 0.427, n = 393	Environmentally Responsible Behavior

When considering significant associations at the program level, one significant association occurred with the total length of the environmental education program. This was far less than the 18 significant associations which occurred at the student level ($n=393$). The significant association: “I think the field monitoring I do in natural areas is useful” (p : 0.001, $n=10$).

There were significant associations that occurred in multiple instances during the correlational analyses described above. Questions regarding locus of control, behavioral intention and efficacy, all of which are significant predictors of responsible environmental behavior (Marcinkowski 2001), included: “I plan to volunteer in a natural area.” “I have the skills necessary to make a positive impact on the environment.” “I think the restoration work I do in natural areas is useful.” There were significant associations with questions regarding actual environmentally responsible behaviors: “I recycle.” “I pick up trash.” “I talk to others about environmental issues.” and “I engage in environmental restoration outside of school.”

Research Question 2.3 What are the impacts of environmental education programs in the Portland metropolitan region in terms of environmental literacy?

Environmental literacy was higher for youth in the treatment group rather than the control group. Mann-Whitney-U tests performed on attitudinal and behavioral variables indicated significant differences between students from the control group (n = 62) and students in the participating environmental education organizations (n = 393). The seven questions without homogeneity were not considered and thus only twenty three of the original questions were used. Significant differences occurred between the two groups in 15 of the included questions. In all cases with significant differences, mean rank was higher for students enrolled in environmental education programs (treatment group) rather than the students in the control group. There were significant differences in two of the four included questions about environmentally responsible behavior: “I pick up litter/trash” (U = 9834.00, p = 0.009) and “I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building)” (U = 7478.00, p = 0.000). There were no significant differences in the included questions about environmental worldview. There were significant differences with all of the included questions related to environmental sensitivity and awareness, locus of control, efficacy and behavioral intention which are listed in Table 2.9.

Table 2.9 Comparison of Environmental Education Programs with a Control Group Table shows results of Mann-Whitney-U tests where significant differences occurred between all environmental education programs considered collectively (treatment group) and 8th grade students from two classes in Hillsboro, OR (control group).

Question	Mann Whitney- U	AsympSig
Have you received any other environmental education? (ex. Outdoor School, invasive removal, Audubon, Clean Rivers Ed, primitive skills)	10567.000	0.038
I pick up litter/trash	9834.000	0.009

I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building)	7478.500	0.000
If I had enough time or money, I would devote it to working for the environment.	9850.500	0.034
I am interested in a career working to make a positive impact on the environment.	8676.000	0.001
I have skills necessary to make a positive impact on the environment.	8738.000	0.001
I enjoy spending time in natural settings (woods, mountains, desert, lakes, ocean).	9387.000	0.005
With other people, I can work to make a positive impact on the environment (i.e. improve or protect the environment).	8253.000	0.000
By myself, I can work to make a positive impact on the environment (i.e. Improve or protect the environment).	9484.500	0.000
I pay special attention to things outdoors (plants, animals, woods, rivers, weather).	8646.500	0.002
I would be upset if the natural area where I have worked was destroyed/polluted.	9157.500	0.009
I think the restoration work that I do in natural areas is useful.	8359.500	0.000
I think the field monitoring I do in natural areas is useful.	7886.500	0.000
I plan to volunteer in a natural area (tree planting, invasive species removal).	8772.000	0.000
I would like to collect environmental data for local government, so they can monitor the health of our watershed.	8242.500	0.000

Research Question 2.3A: In what ways do students with previous environmental education experiences differ from those without?

Youth who indicated having previous environmental education experiences and were enrolled in a participating environmental education organization (treatment group) had higher environmental literacy than youth who indicated they did not receive

previous environmental education. First, it was observed that 308 of the 391 students that took the survey at the end of their environmental education program (treatment group) indicated previous environmental education experiences, ~79%. There were 55 of the 61 students that took the survey but were not enrolled in an environmental education course (control group) who indicated previous environmental education experiences, ~90%. Seven of the four-hundred and fifty-five students who took the assessment (treatment and control groups) indicated they had never received environmental education (control group with no previous environmental education). Eighty-five of the four-hundred and fifty-five students who took the assessment (treatment and control groups) indicated they had only one environmental education experience (treatment group without previous environmental education). Fifty-five of the four-hundred and fifty-five students who took the assessment (treatment and control groups) indicated they had at least one environmental education experience (control group with previous environmental education). Three-hundred and eight students who took the assessment (treatment and control groups) indicated they had at least two environmental education experiences (treatment-group with previous environmental education).

Mann Whitney-U tests were used to determine if any significant differences with attitudinal or behavioral questions existed between students at the end of their environmental education program (treatment group) who indicated no previous environmental education and students that took the survey but were not enrolled in an environmental education course (control group) with previous environmental education. Three significant differences occurred where students in the treatment group without

previous environmental education had significantly higher mean rank than students in the control group with previous environmental education. The three questions were:

- “I engage in environmental restoration as part of school.” ($U = 1753.500$, $p = 0.041$);
- “I think the restoration work that I do in natural areas is useful.” ($U = 1682.500$, $p = 0.020$); and
- “I think the field monitoring I do in natural areas is useful.” ($U = 1585.000$, $p = 0.006$).

Kruskal Wallis and subsequent post-hoc tests were performed comparing student responses to attitudinal and behavior questions for the four groups which were:

- Students that took the survey at the end of their environmental education program and indicated previous environmental education (treatment group with previous EE, $n = 308$).
- Students that took the survey at the end of their environmental education program and indicated no previous environmental education (treatment group no previous EE, $n = 85$).
- Students that took the survey but were not enrolled in an environmental education course and indicated previous environmental education (control group with previous EE, ($n = 55$).
- Students that took the survey but were not enrolled in an environmental education course and indicated no previous environmental education (control group with no previous EE, $n = 7$).

Significant differences existed between these four groups in sixteen behavioral and attitudinal questions. Three of the four included behavioral questions revealed significant differences (e.g., “I pick up trash/litter” (chi = 16.538, $p = 0.001$). Post-hoc tests indicated that all three of these behavioral questions had significant pairwise differences (e.g. “I pick up trash/litter” (Tx w/ PrevEE vs. Tx w/ no PrevEE, $p = 0.020$; Tx w/ PrevEE vs Con w/ PrevEE, $p = 0.006$)). There was a significant difference in only one of the ten questions which measured environmental worldview, but there were no significant pairwise differences: “When people mess with nature it has bad results.” (chi = 7.828, $p = 0.050$) In all of the 26 pairwise differences, students from the group that took the survey at the end of their environmental education program (treatment group) and indicated previous environmental education had significantly higher mean rank than either of the other groups. Initial Kruskal Wallis test results and subsequent post-hoc test results are displayed in Table 2.10. The table and clustered bar charts²³ show that youth indicating previous environmental education in the treatment group had higher environmental literacy than the three other groups in several instances.

Table 2.10 Effects of Previous Environmental Education Among Experimental Groups Table displays results from Kruskal Wallis tests to determine significant differences among four groups. Results from subsequent post hoc analyses and relative mean rank for each significant pairwise difference is displayed in two rightmost columns.

Question	Test Statistic (Chi Square)	Df	Asymp Sig.	n	Sig. Pairwise Differences	Asymp Sig.
I pick up trash/litter	16.538	3	0.001	455	↑ Tx w/ PrevEE ↓ Tx w/ no PrevEE	0.020
					↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.006
I talk to others (parents, friends, etc.)	26.330	3	0.000	449	↑ Tx w/ PrevEE	0.000

23 See Figures 2.6a-f Previous Environmental Education and Frequency Distributions on pgs 213 - 220

about environmental issues					↓ Tx w/ no PrevEE	
					↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.007
I engage in environmental restoration as part of school.	28.048	3	0.000	446	↑ Tx w/ PrevEE ↓ Tx w/ no PrevEE	0.000
					↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.041
When people mess with nature it has bad results.	7.828	3	0.050	451	n/a	N/a
If I had enough time or money, I would devote it to working for the environment.	12.827	3	0.005	441	↑ Tx w/ PrevEE ↓ Tx w/ no PrevEE	0.025
I am interested in a career working to make a positive impact on the environment.	15.964	3	0.001	440	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.001
I have skills necessary to make a positive impact on the environment.	16.235	3	0.001	439	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.002
I enjoy spending time in natural settings.	14.598	3	0.002	444	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.027
<i>With other</i> people, I can work to make a positive impact on the environment.	27.415	3	0.000	437	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.016
					↑ Tx w/ PrevEE ↓ Tx w/ no PrevEE	0.011
					↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.001
<i>By myself</i> , I can work to make a positive impact on the environment.	12.557	3	0.006	438	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.032
I pay special attention to things outdoors (plants, animals, woods rivers, weather).	14.330	3	0.002	438	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.004
I would be upset if the natural area where I have worked was destroyed/polluted.	10.536	3	0.015	433	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.035
I think the restoration work that I do in natural areas is useful.	15.798	3	0.001	436	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.001
I think the field monitoring I do in natural areas is useful.	20.898	3	0.000	436	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.000
I plan to volunteer in a natural area (tree planting, invasive species removal).	11.705	3	0.008	435	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.009
I would like to collect data for for local government so they can monitor the health of our watershed	25.502	3	0.000	435	↑ Tx w/ PrevEE ↓ Con w/ PrevEE	0.000
					↑ Tx w/ PrevEE ↓ Tx w/ no PrevEE	0.005

Chapter 2 – Discussion:

This study considers some of the educational and ecological impacts of a sample of the environmental education programs in the Portland metropolitan region. Results are first discussed in terms of the biophysical impacts of the participating environmental education programs serving the region. Second, The biophysical impacts of environmental service-learning as an environmental education pedagogy are considered. Third, environmental educational impacts (environmental literacy) of environmental service-learning and spending time outside are discussed. Fourth, the discussion considers the collective impacts of environmental education on environmental literacy. Finally, the discussion concludes with consideration of bias, generalizability and validity.

Some Biophysical Impacts of Participating Environmental Education in the Portland Metropolitan Region

Environmental education organizations that involve students in direct ecomanagement in the Portland metropolitan region have an impact on the local ecology. These activities include invasive species removal, native plantings, litter cleanups, soil modifications, trail maintenance and organic agriculture. More than 85% of the organizations surveyed stated that they engaged in some sort of environmental service-learning with their students. Slightly less (~75%) of the organizations indicated they engaged in direct eco-management as their form of environmental service-learning.

Assuming that the 22 programs surveyed were indicative of the 149 environmental education organizations in the Portland metropolitan region, collective biophysical impacts of the Portland metropolitan region's environmental education programs could be extrapolated algebraically. Significant room for error would exist if values were extrapolated, increasing values by a magnitude of ~6.5. Seven of the twenty-two organizations from research phase one provided biophysical data on their programs' impact. Based on data provided from these seven programs, at least 3,100 lbs of trash was gathered by environmental education programs in 2014. At least 61,091 sq.ft. of invasive species were removed by environmental education programs in 2014. At least 16,754 native plants were installed by environmental education programs in 2014. The reported impact of these seven programs is similar to the impact of Portland Parks and Recreation's 2014 No Ivy Day which coordinated 302 volunteers over 19 sites and removed 65,000 square foot of ivy (Portland Parks and Recreation 2015). Likewise, the No Ivy League as removed over 4,500,000 sq feet of ivy since 1994, roughly 225,000 annually (Portland Parks and Recreation 2015). The Friends of Trees indicated in their 2013 annual report that they coordinated 4,466 volunteers to plant 43,809 trees and shrubs in 85 green-spaces and neighborhoods throughout two states. It is clear that even the reported impacts, taken from the seven programs who provided data, demonstrate an impact of environmental education in the region which is relatively commensurate with leading conservation organizations in the region. These values demonstrate the direct and immediate impacts of environmental education in the Portland metropolitan region.

Land managers often work with volunteers and environmental education

programs to manage natural areas. Many urban areas have large volunteer programs to manage their natural areas (Dresner, et al. 2014; Wolf, K. & Blahna, D. 2001). These programs provide significant education in their volunteer experiences and often recognize environmental volunteering as informal environmental education. Educational outcomes of environmental volunteering are commonly studied and include how volunteering is associated with sense of place, efficacy, social connectedness, environmental identity and environmentally responsible behaviors (Dresner, M. et al. 2014; Ryan, R. L., Kaplan, R., & Grese, R. E. 2001). There is however, no known study which quantifies the biophysical impacts of all types of environmental education programs region wide. Albeit coarse-scale and by means of extrapolation, this study points to the degree of biophysical impact of environmental education programs in the Portland metropolitan area.

Biophysical Impacts of Environmental Service-Learning

Results of this study did not clarify whether the greater amount of time environmental education programs spent engaged with environmental service-learning led to greater biophysical impacts to local ecology. Patterns among environmental education organizations according the percentage of time spent engaged with environmental service-learning emerged despite the variations in the type of biophysical impact among environmental education programs. Environmental education programs lacked common metrics in part because they had different goals (e.g., trail maintenance,

organic agriculture or invasive species). They also lacked common metrics because there were different degrees of monitoring and reporting precision. Some organizations provided very detailed information (e.g., 912 of dead plants removed among other outcomes) while other organizations provided estimations via email. Given current data collection methods used by the participating environmental education programs, it was impossible to conclude if there was a significant association between the amount of time environmental education programs spent engaged with environmental service-learning and direct biophysical impacts to local ecology. Future analysis could occur if biophysical impact of environmental service-learning was consistent among programs.

Hypothesis 2.1: Biophysical outcomes will be greater for programs that employ environmental service-learning rather than those programs with a typical environmental learning focus was rejected.

Environmental Service-Learning and Outdoor Environmental Education: Impacts on Environmental Literacy

Environmental service-learning and outdoor education positively affected environmental literacy. The positive effects of outdoor education on environmental literacy are well documented and include improving attitudes (Dillon, M. et al. 2006), influencing intended and actual behavior (Bogner 1998), is recognized as a significant life experience (Chawla 1999) and is important to children's development (White 2004).

Environmental service-learning is less thoroughly researched than outdoor education. Studies indicate that environmental service-learning improves sense of place (Curry et al. 2002), promotes ecological citizenship (Kelly & Abel 2012), has benefits to the community (Ward 1999) and increases locus of control (Tedesco, L. & Salazar, K. 2006). This research supported these findings and indicates that outdoor environmental education positively affected environmental sensitivity and awareness, environmentally responsible behavior, behavioral intention, efficacy and locus of control. The research also indicated that environmental service-learning positively affected efficacy, environmentally responsible behaviors, behavioral intention and environmental worldview.

There were significant positive associations between environmental literacy assessment questions and the time programs spent engaged in environmental service-learning and the time programs spent outdoors with survey responses. The survey responses represented gains in in participants' environmental literacy. Thus, increased time programs spent engaged in environmental service-learning and increased time programs spent outdoors was correlated with higher environmental literacy. Random forests indicated that locus of control, environmentally responsible behavior and environmental sensitivity and awareness were all predicted to some degree by the percentage of time program engaged in environmental service-learning and the percentage of time programs spent outdoors. Age and the frequency of youths' previous outdoor experiences were stronger predictors overall. Of course, environmental education programs could not affect students' age or the frequency of youths' previous

outdoor experiences. Programs did however, have influence on where their programming occurs or what pedagogies they utilize.

The percentage of time programs spent outdoors was found to have more impact on environmental literacy than the percentage of time spent engaged in environmental service-learning. Significant correlations indicated the greater the percentage of time programs engaged in either environmental service-learning or outdoor environmental education, the greater the students' environmental literacy. However, there were a larger number of significant correlations with outdoor environmental education (18 sig. correlations when pooling) than with environmental service-learning (8 sig. correlations when pooling). Moreover, the correlations were generally stronger with outdoor environmental education than with environmental service-learning. This suggested that outdoor environmental education (indicated by the percentage of time programs spent outdoors) was, at least in the short-term, a more effective strategy for improving youths' environmental literacy than environmental service-learning. Moreover, practitioners indicated that environmental service-learning occurred almost exclusively outside (relative time spent outdoors exceeded or equalled relative time spent engaged in environmental-service learning for all participating programs). Therefore, adding other outdoor environmental education activities to outdoor environmental service-learning activities may help develop environmental literacy. Previous studies have indicated that outdoor environmental education significantly affects actual and intended environmentally responsible behavior (Bogner 1998), attitude towards wildlife (Dettmann-Easler, D., & Pease, J. L. 1999) and environmental sensitivity (Woodhouse, J.

L., & Knapp, C. E. 2000). The impacts of environmental service-learning have been less thoroughly studied than outdoor environmental education.

Hypothesis 2.1: Students in programs that employ environmental service-learning will have significantly greater scores in the environmental literacy assessment than students engaged solely in environmental learning was confirmed.

Educational Impacts of Environmental Education in the Portland Metropolitan Region

A census provides meaningful information on the extent of a population. Censuses have been used to determine the extent and impact of environmental service-learning programs statewide in Florida (England, TA & Marcinkowski, T 2007), environmental education in community colleges nationwide (Vincent, S., Santos, R., Cabral, L., Sloane, L., & Bunn, S. 2014) and environmental stewardship programs citywide in Seattle, WA (Wolf, K & Blahna, D, 2011). Despite these three studies, censuses of environmental education programs are rare. This research performed a census, counting, in research phase one, environmental education organizations servicing the Portland, OR metropolitan region with extended programming (> 8 hours) for students grade 6-12.

Overall, students participating in environmental education programs indicated higher environmental literacy than students from the control group, those not engaged in

environmental education. Comparisons with a control group indicated that environmental education had significant effects on environmental sensitivity and awareness, environmentally responsible behaviors, efficacy, locus of control and behavioral intention. Environmental education had little influence on environmental worldview, as measured in this study.

Students who indicated they had multiple environmental education experiences showed higher environmental literacy than those students who indicated only one environmental education experience. Several significant pairwise differences existed between students who were enrolled in an environmental education program and indicated they had previous environmental education (treatment group w/ previous EE) and students enrolled in an environmental education program with no previous environmental education (treatment group w/ no previous EE). Likewise there were several significant pairwise differences between students who were enrolled in an environmental education program and indicated they had previous environmental education (treatment group w/ previous EE) and students not enrolled in an environmental education program with previous environmental education (control group w/ previous EE). No significant pairwise differences occurred between students who were enrolled in an environmental education program and indicated they had previous environmental education (treatment group w/ previous EE) and students not enrolled in an environmental education program with previous environmental education (control group w/ no previous EE). This was likely due to a result of the small amount of students ($n = 7$) not enrolled in an environmental education program with no previous

environmental education (control group w/ no previous EE).

Hypothesis 2.3: Students indicating previous environmental education experiences will have higher environmental literacy than students indicating they had no previous environmental education experiences was confirmed.

Students may retain some degree of environmental literacy regardless of how long ago they received environmental education (recognizing median age = 14). There were very few differences between students enrolled in an environmental education program with no previous environmental education (treatment group w/ no previous EE) and students not enrolled in an environmental education program with previous environmental education (control group w/ previous EE). The elapsed time between students' previous environmental education experiences and when they took the survey was unknown.

Only a portion of the observed variance in environmental literacy collapsed was explained by 'predictor' variables. Random forests indicated that locus of control (0.120 variance explained), environmentally responsible behavior (0.128 variance explained) and environmental sensitivity and awareness (0.224 variance explained) could be explained by 'predictor variables.' For each of these three variables (constructs within environmental literacy) there were several factors that may have further explained the variance. Demographic information relating to household income, race and parental education were not considered. However, these factors are understood as significant

predictors of educational outcomes (Hanna, G. 1995; Hines, J. M., Hungerford, H. R., & Tomera, A. N. 1987; Raudenbush, S. W., Fotiu, R. P., & Cheong, Y. F. 1998).

Furthermore, Roth (1992), based on Erickson et al. 1978, discussed the relative influences of key sectors on individuals' environmental literacy which include home, community, church, school, media and interest groups. Consideration of these broad influences did not occur.

Bias, Generalizability and Validity

The results of this study must be considered in terms of complicating factors inherent in educational research. Consider subject selection - how environmental education programs (phase one of the research) and how students (phase two of the research) were chosen for the study. Of the 149 programs that were identified, 52 were contacted to participate in the study; ultimately only 22 programs participated in the first phase of the research. There was a 42.3% return rate which is greater than the average of 35.7% for surveys of organizations found in a meta analysis of 1607 studies between 2000 and 2005 (Baruch, Y & Holtom, BC, 2008). However, only eleven organizations participated in phase two of the research, a 21.2% return rate. Response rate for students who took the survey (phase two), rather than organizations wherein an administrator was interviewed on the telephone (phase one), is unknown. The study was granted informed consent where students choose whether or not to take the survey. Effects of non-response bias is assumed nominal. There were 393 students that took the assessment and most

students responded to all survey questions. The lowest response value was $n = 364$ for one question. Most questions' response values were between $n = 380$ and $n = 390$ (Berg, N. 2005). Selection bias may have occurred considering the response rate of environmental education organizations that participated in phase two of the research (student surveys). The first phase of the research may have failed to identify all the qualifying environmental education organizations in the region. Further, selection bias was more likely to have occurred with new, small or minimally connected grassroots organizations rather than well established large programs which were easily identified.

Reporting bias may have occurred during telephone interviews with environmental education administrators (phase one). Administrators reported programatic data (e.g., percentage of time outdoors, percentage of time engaged with environmental service-learning) during a ten-minute telephone interview (Ezzati, M., Martin, H., Skjold, S., Vander Hoorn, S., & Murray, C. J. 2006). Furthermore, biophysical outcomes for each of the programs were reported in different fashions (email vs. attached report) and at different scales. These uncertainties are important to recognize, yet they do not discredit the analysis. Inclusion of a biophysical analysis adds texture, albeit coarse-scale, to this coupled socio-ecological analysis.

Language and mutual understanding of terms may have affected results. It was expected that strong associations to time spent engaged with environmental service-learning would exist. During telephone interviews (phase one) practitioners may have considered part of their activities environmental service-learning when they were not, or vice versa. Furthermore, the quality (thin vs thick) of environmental service-learning was

not considered.

The study considers students in environmental education programs between 6th and 12th grade with diverse programming in the Portland metropolitan region and can be generalized to students in the region. Results from eleven different programs were collapsed into one analysis (phase two). These programs were diverse and may not have been suitable for comparison. Levene's tests indicated that some questions did not have homogeneity of variance. While these questions were excluded from analyses, the variation among groups, revealed by the Levene test, imply important differences among participants. The age range of participants was substantial, 11-19. Younger participants may have had different levels of maturity, comprehension and survey buy-in than older participants. The cognitive and social developmental levels of older students are, on average, expected to be higher than younger students. The analysis indicated that age was an important predictor. The number of participating students in each program ranged four to sixty-seven. The total length of the programs ranged from 40 – 450 hours, though length of program was found to be a relatively unimportant predictor variable. The study considered mandatory environmental education programs (associated with formal education), optional programs, programs with rigorous application processes, credit incentivized programs and financially incentivized programs. Environmental education programming is diverse (Volk, T. L., & McBeth, W. C. 1997; Hollweg et al 2011) and significant variation among programs, as in this study, was expected.

Test questions may have been misunderstood. Students of different ages may have interpreted these questions differently – another potential bias. While the term

“environmental education” was defined in the survey with examples, it is likely that a nineteen year old respondent understood “previous environmental education differently than an eleven year old respondent. The study indicated scant influence of incentives like credit for participation on student responses. There is a broad range of previous outdoor experiences that a student may have considered when answering the question “Before this program, how frequently did you spend time outdoors?” This study indicates positive associations between environmental literacy and this questions regarding the frequency of previous outdoor experiences. However, students may have considered unfavorable experiences (e.g., shoveling snow or mowing) or favorable experiences (e.g., fishing, skiing, camping).

There may have been bias due to survey administration. The environmental literacy survey (phase two) was delivered by several different people. Survey administrators had a script, but *how* they delivered the assessment, interested or lack luster, may have affected student responses (Hildum, D. & Brown, R. 1956). The environmental literacy assessment used in this study was appropriate for the subjects, was relevant and measured established constructs of environmental literacy (Hollweg et al 2011) . Feedback was elicited from several environmental education practitioners, researchers and students. The assessment includes established measurements in the fields of conservation psychology and EE (Clayton 2003, Schultz 2001, Dunlap et al. 2000). The assessment was administered for two years in different middle schools throughout the region. Practitioner, student and researcher feedback was continuously used to refine the instrument.

The study used a posttest only experimental design which affected the inferential capacities of the research. A pre-post test design would have allowed for greater use of inferential statistics. A pre-post test design would have allowed for research to infer if significant results were a result of environmental education which occurred during a program. Using only a posttest design, it is possible that among group differences are a result of factors not considered in this research.

Chapter 2 – Conclusion:

There is a large number of environmental education organizations in the Portland Oregon metropolitan region. These organizations and their different programs have a substantial impact in raising the environmental literacy of young people and the ecological integrity of the region. This research enumerated the region's environmental education organizations and assessed aspects of their efficacy. Within the context of the participating environmental education organizations, this research shows that environmental literacy is significantly affected by age, percentage of time programs spent outdoors, percentage of time programs spent engaged with service learning, previous environmental education experiences, frequency of previous outdoors experiences and having a relationship with an adult that cares for the environment. Furthermore, when considering environmental literacy, outdoor environmental education is more effective than environmental service-learning. This research may guide environmental education practitioners, school leadership and policy makers implementing environmental

education. Furthermore, it may inform land managers, natural area volunteer coordinators and restoration practitioners working with young people.

Environmental education programs work collectively to increase the environmental literacy of students. Given the scale and complexity of the educational system it is recognized that systematic improvements and individual, student-centered successes often require the collective efforts of multiple organizations or sectors (Kania, J., & Kramer, M. 2011). This is true for environmental education, multiple environmental education organizations work together to improve the environmental literacy of the student population these organizations serve. This research illustrates the collective impacts of multiple environmental education in the Portland metropolitan region.

This research is timely as Oregon further develops its effort to improve environmental literacy statewide. The Oregon Environmental Literacy Plan (OR HB-2544) was finalized in 2010 and was the second state in the country to adopt a plan. Since then, many more states have adopted environmental literacy plans. The Oregon Environmental Literacy Plan identifies several strands which are akin to educational standards. These strands however are not explicitly tested in formal education assessments and funding is not directly tied to environmental literacy outcomes. Organizational leadership of the Oregon Environmental Literacy Plan changed in 2014, currently resting with the Oregon State University Extension in the Oregon Environmental Literacy Program Council²⁴. This research is not contracted work of the Oregon Environmental Literacy Program Council, but rather is one of several local

²⁴ Disclosure Statement: Author serves on the Oregon Environmental Literacy Program Council.

research efforts (Dresner, M. Handelsmann, C., Braun, S. & Rollwagen-Bollens, G., 2014; Saxton, E., Burns, R., Holveck, S., Kelley, S., Prince, D., Rigelman, N., & Skinner, E. 2014; Williams, D. R., Burns, H., & Kelley, S. S. 2014; Dresner, M., & Fischer, K. A. 2013) which may support a growing movement involving environmental education, environmental stewardship and E-STEM education.

Chapter 3 – A Fine-Scale Case Study of 8th Grade Students Engaged in Environmental Education and Environmental Service-Learning

This chapter evaluated the educational outcomes of three slightly different environmental education programs. The programs were compared according to time spent engaged in environmental service-learning with response variables including change in environmental literacy scores, quotes, work samples, class performance scores and anecdotal evidence. Data were quantitative and qualitative with fine-scale analysis of learning activities and educational outcomes. This chapter addressed one overarching research question: *How does the quantity and quality of time spent engaged in environmental service-learning affect participants' environmental literacy?*

Chapter 3 – Research Questions:

RQ 3: How does participation in a year-long environmental education and environmental service-learning program affect 8th grade students' environmental literacy?

- **RQ 3.1:** Using pre-post assessment measures, how does participation in the program affect students' environmental literacy?
- **RQ 3.2:** How do changes in students' environmental literacy differ between control (C1 and C2), environmental service-learning focus (T1), inquiry focus

(T2) and equal focus (T3) groups?^{25 26}

Chapter 3 – Introduction: Theoretical Background to Hypotheses Regarding Environmental Education, Environmental Service-Learning and Environmental Literacy

Environmental education improves environmental literacy (Volk, T. L., & McBeth, W. C. (1997). Therefore, youth who participated in the environmental education program (treatment group) were expected to show gains in environmental literacy.

Students participating in the environmental service-learning focus group (T1) spent more time engaged with direct ecomanagement and lessons geared towards environmental service – collectively “environmental service-learning.” While students engaged in the inquiry focus group (T2) and the equal focus group (T3) employed less time in environmental service-learning and more in inquiry. In this study, environmental service-learning included direct environmental action where students could see the validity and impact of their efforts. Witnessing their impact and receiving this positive feedback, was hypothesized to promote gains in the affective (disposition) domain of environmental literacy, particularly efficacy and locus of control. Furthermore, students

25 Description of Treatments: T1: 50% class instruction (same for all treatments); 40% environmental service-learning, 10% inquiry, T2: 50% class instruction (same for all treatments); 10% environmental service-learning, 40% inquiry, T3: 50% class instruction (same for all treatments); 25% environmental service learning, 25% inquiry, C1: posttest only, C2: pre-posttest only.

26 See Figure 3.1 Continuum of Environmental Education Programs Foci: Evergreen Middle School Environmental Service-Learning Treatment Arrangement on page 221. Note that figure combines “class instruction time” and “inquiry time” which is discussed in footnote #25 above, resulting in the following placement on scale.

in the environmental service-learning focused group spent more class time developing competencies central to environmental literacy.

Chapter 3 – Hypotheses:

Hypothesis 3.1: Students engaged in the program will have significant increases from pretest to posttest environmental literacy scores.

Hypothesis 3.2A: Students engaged in environmental service-learning focus group (T1) will have significantly greater environmental literacy posttest scores than students in inquiry focus group (T2) and the equal focus group (T3), particularly the behavior domain.

Hypothesis 3.2B: All groups will have significantly greater environmental literacy posttest scores than the two control groups (C1 or C2).

Chapter 3 – Methodology:

This mixed methods case-study utilized concurrent procedures with qualitative and quantitative measures to analyze the educational outcomes of environmental service-learning. Quantitative data included pre-post environmental literacy test scores and state

science test scores. Qualitative data included quotes, work samples, observation and anecdotal evidence.

Students enrolled in the environmental service-learning program at Evergreen Middle School (E.M.S.), in Hillsboro, OR, received different curricula or treatments²⁷. All 8th grade students at E.M.S. were split into two 'larger' experimental groups. The 1st group was sampled, while the 2nd group remained a control; they did not receive any specialized Environmental Education (EE) curriculum and worked with a different science teacher. The effects of different teachers were not controlled and were considered in the interpretation of the results. There were roughly 360 students in the population, and thus, 180 in the control and 180 engaged in one of three treatments. Class rosters were not precise; some students enrolled but did not attend while others remained in the class for a brief period of time.

There were three treatment groups within the 'larger' treatment group and two control groups within the 'larger' control group. The treatment groups, referred here as T1 (environmental service-learning focus), T2 (inquiry-focus) and T3 (equal-focus), received variations in their classroom activities. The control groups, referred here as C1 (pre-posttest) and C2 (posttest only) received no specialized instruction. A total of 192 students took the pretest and 211 took the posttest. The number of students in each experimental group is provided in Table 3.1. All students were in the 8th grade. Students indicated their age and gender in the posttest only. Students' gender is provided in Table 3.2 and ages are provided in Table 3.3. Differences in age were trivial and were not

27 See Figure 3.1: Continuum of Environmental Education Programs Foci: Evergreen Middle School Environmental Service-Learning Treatment Arrangement on page 221 and Figure 3.2 Evergreen Middle School Treatment Arrangement on page 222

considered.

Table 3.1 Number of Participants Table displays experimental groups and the number of students participating in each of the pre and posttest environmental literacy assessment. Experimental groups are organized in two manners. First, there are five individual experimental groups. Second, all treatment groups are put together and all control groups are put together.

Experimental Group Designation	Pretest	Posttest
T1: Environmental Service-Learning Focus	n = 66	n = 60
T2: Inquiry Focus	n = 67	n = 59
T3: Equal Focus	n = 27	n = 30
C1: Pre-Post Control Group	n = 32	n = 32
C2: Post Only Control Group	n/a	n = 30
Total	n = 192	n = 211
All Treatment Groups	n = 160	n = 149
All Control Groups	n = 32	n = 62
Total	192	211

Table 3.2 Number of Male and Female Participants Table displays experimental groups and the number of students indicating either male or female gender. Experimental groups are organized in two manners. First, there are five individual experimental groups. Second, all treatment groups are put together and all control groups are put together.

Experimental Group Designation	Gender	
	Male	Female
T1: Environmental Service-Learning Focus	n = 25	n = 28
T2: Inquiry Focus	n = 29	n = 24
T3: Equal Focus	n = 11	n = 18
C1: Pre-Post Control Group	n = 13	n = 16
C2: Post Only Control Group	n = 11	n = 15
Total	n = 89	n = 101
All Treatment Groups	n = 65	n = 70
All Control Groups	n = 24	n = 31
Total	n = 89	n = 101

Table 3.3 Ages of Participants Table displays experimental groups and the number of students indicating each particular age. Experimental groups are organized in two manners. First, there are five individual experimental groups. Second, all treatment groups are put together and all control groups are put together.

Experimental Group Designation	Age of Student			
	12	13	14	15

T1: Environmental Service-Learning Focus	n = 0	n = 11	n = 44	n = 0
T2: Inquiry Focus	n = 1	n = 15	n = 37	n = 3
T3: Equal Focus	n = 0	n = 7	n = 22	n = 0
C1: Pre-Post Control Group	n = 0	n = 9	n = 22	n = 0
C2: Post Only Control Group	n = 1	n = 8	n = 18	n = 0
Total	n = 1	n = 50	n = 143	n = 3
All Treatment Groups	n = 1	n = 33	n = 103	n = 3
All Control Groups	n = 0	n = 17	n = 40	n = 0
Total	n = 1	n = 50	n = 143	n = 3

Each of the three treatment groups received 40 hours of instruction, over 33 days during the 2013/2014 school year on roughly a weekly basis²⁸. This specialized instruction, which the treatment groups received, occurred in place of the typical 8th grade science curriculum, which the control groups received. Each day of instruction lasted approximately 55 minutes. Learning objectives were consistent between each treatment group for 32 of the 40 hours and involved plant ecology, soil functions, hydrology and riparian ecosystems. Lessons included inquiry activities and may all be considered scaffolding towards a summative full inquiry project. The remaining 8 hours for each of the three treatment groups varied student activities. Treatment group 1 (T1) had eight hours of eco-management and thus was considered the environmental service-learning (ES-L) focused treatment group. Treatment group 2 (T2) had three hours of eco-management and thus was considered the inquiry focused group. Treatment group 3 (T3) had six hours engaged in eco-management and thus was considered the equal focus group. The inquiry focused (T2) spent five hours engaged with medium to high level inquiry activities; the equal focus (T3) treatment group spent two. The added inquiry

²⁸ See Figure 3.3: List of Lesson Plans on page 223

activities for T2 and T3 account for differences between the treatment groups' time spent engaged with eco-management. These inquiry activities were extensions to existing curriculum, involved a research field trip and assessed the distribution of invasive species on the school campus. The environmental service-learning focused group (T1) and inquiry focused group (T2) had one replica each. The study worked with one teacher for all of the treatment groups to control the myriad possible effects of different teaching styles, behavior management, classroom layout and teacher beliefs when comparing among treatment groups. The science teacher in the study only had five classes and therefore each treatment group could not have two replicas. Therefore, the two extreme treatment groups (environmental service-learning and inquiry focused) were chosen to replicate. Designation of the treatment groups was explicit in order to address confounding factors relating to unintentional tracking of students, special education, english language acquisition, behavioral needs and teacher/student fatigue at certain times of the day. The environmental service-learning and the inquiry focused treatment groups were each assigned to a class that presented as high functioning and low functioning, while the equal focus treatment group was assigned to a class which presented moderately. The high and low group assignments were intended to average out with one another. The environmental service-learning group was assigned to a class considered low functioning because there were many behavioral issues which occurred in the class. The inquiry focused group was assigned to a class considered low functioning, where several students received special education. These two group assignments were expected to be as commensurate as possible in their classroom performance. Both the

environmental service-learning and inquiry focused classes were assigned to classes considered high functioning where little behavioral issues occurred and there was a high proportion of students in the advanced mathematics course. All five classes, the three treatment groups, took the pre and post environmental literacy assessment previously discussed²⁹. There were two different control groups. Control groups were taught by a different teacher than the students in the treatment groups. Control 1 (C1) took the pre and post environmental literacy assessment. Control 2 (C2) took the post environmental literacy assessment.

The environmental literacy assessment previously discussed³⁰ was administered on the 1st week of the program, September 2013, for each of the treatment groups and the pre-posttest control group (C1). The assessment was administered again during the last week of the program, May 2014, for all experimental groups: treatment and controls. The posttest only control group (C2) did not receive the pretest in order to evaluate any pretesting effects on posttest scores.

A principal component analysis (PCA) on student environmental literacy scores was performed to assess the coding of variables and determine if latent constructs emerged and agree with a priori theoretical model. Exploratory analysis was completed to determine if statistical dependency occurred between variables. Chi square tests were used to determine significant relationships between attitude and behavior questions and the following five questions:

- Gender (Table 3.10);

29 For Environmental Literacy Assessment see Appendix C

30 See Chapter 2 methods and Environmental Literacy Assessment in Appendix C

- Have you received any other outdoor environmental educational? (Table 3.11);
- Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment? (Table 3.12);
- Have you seen something bad happen to the environment before? (Table 3.13); and
- Before this program how frequently did you spend time in the outdoors? (Table 3.14).

The first four questions had binary responses: “male” or “female” and “yes” or “no”. The fifth question had a five-point Likert scale (never, infrequently, sometimes, frequently, very frequently). However, it was treated as binary (a requirement of the chi-square analysis) by grouping the lowest three values (never, infrequently, sometimes) and the highest two values (frequently, very frequently). The lowest three values accounted for 40% of the responses and the highest two values accounted for 60% of the responses indicating a convenient division which aligned with literature indicating that frequent outdoor experiences are significant life experiences (Chawla 1999).

In order to answer *Research Question 3: How does participation in a year-long environmental education and environmental service-learning program affect 8th grade students' environmental literacy?* multiple statistical analyses were employed for each of the sub questions. *Research Question 3.1: Using pre-post assessment measures, how does participation in the program affect students' environmental literacy?* was investigated by measuring differences within experimental groups. Statistical tests included Wilcoxon Signed Rank test for pre-post differences for each of the experimental

groups and Paired Sample T-Tests were run on collapsed scores which emerged from the principal component analysis. *Research Questions 3.2: How do changes in students' environmental literacy differ between control (C1 and C2), environmental service-learning focus (T1), inquiry focus (T2) and equal focus (T3) groups?* was investigated by measuring differences among experimental groups at different levels of analysis. Kruskal Wallis H with mean ranks and Mann Whitney-U tests were used to determine among group, pre and post, differences for each of the five experimental groups. Results were inconclusive when looking at each experimental group individually and therefore, all three treatment groups were combined and both control groups were combined. Kruskal Wallis H with mean ranks and Mann Whitney-U tests were used again to determine among group, pre and post, differences for the combined treatment and control groups. Further analysis of among group (treatment vs control) differences occurred by comparing students with positive or negative responses to four of the five questions considered in the Chi-square analysis. The four questions were:

- Have you received any other outdoor environmental educational?;
- Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?;
- Have you seen something bad happen to the environment before?; and
- Before this program how frequently did you spend time in the outdoors?.

Student responses to these four questions (e.g., yes/no) and treatment group assignment (treatment vs. control) yielded a 2 x 2 level of analysis. All student responses to behavioral and attitudinal questions were considered in one of four possible groups. This

analysis occurred to determine the impact of these four covariants and student responses to behavioral and attitudinal questions. Mann-Whitney U statistical tests were used and frequency distributions for each of the four possible groups were constructed.

Student standardized science test scores, Oregon Assessment of Knowledge and Skills (OAKS), were analyzed to assess gains in scientific knowledge. Scores were arranged in terms of percentage of students that exceeded, met or were below proficiency. Test score values were calculated for control groups using Evergreen Middle School's 2013/2014 scorecard (ODE 2014), assuming half of the student population was in the treatment group.

OAKS tests measure Physical, Life and Earth Sciences. In many cases knowledge of these fields is an essential element of environmental education (e.g, Core Standard 6.2 Interaction and Change: The related parts within a system interact and change.). However, there are differences among the content standards where the applicability to environmental education ranges from explicit (e.g., Explain how individual organisms and populations in an ecosystem interact and how changes in populations are related to resources.) to tangential (e.g., Describe the relationships and interactions between and among cells, tissues, organs, and organ systems.). OAKS test scores show general scientific knowledge. Sufficient detail to isolate student scores for select content areas was not available.

Qualitative data were analyzed according to an a priori theoretical framework, the domain of environmental literacy (Hollweg et. al 2011). The analysis did not consider qualitative results among treatment groups and assumed no commensurate analog for the

control groups. Other than anecdotal evidence, qualitative results were not gathered for the control groups. Qualitative results were included to provide texture and further understanding of the effects of environmental education and environmental service-learning on the students in the three treatment groups. The results considered the three treatment groups collectively. Qualitative results include student journals, student work samples, student research posters, observation, pictures, open ended survey responses, essays, learning activities, in class assessments, discussion with students and discussion with teachers. Data from these sources were gathered and organized according to the a priori framework in order to determine how each of the four domains were addressed. Each of the four domains of environmental literacy has sub-constructs, except behaviors³¹. The sub-constructs were listed for each of the larger domains (dispositions, knowledge, competencies and environmentally responsible behaviors) when data were available.

Chapter 3 – Results:

Quantitative results of this mixed methods case-study include pre-post environmental literacy test scores and 8th grade science state standard scores. Qualitative data included quotes, work samples, observation and anecdotal evidence.

Quantitative Results

Frequency distributions for all environmental literacy assessment questions are

31 See Fig 1.1 Domain of Environmental Literacy on Page 188

displayed for pre and posttest scores. These distributions are organized in two manners. First, they are organized according to each of the five individual experimental groups and second, all the treatment groups are put together and all of the control groups are put together³². These data were examined statistically for normal distribution using the Shapiro-Wilk test and homogeneity of variance using Levene's statistic based on medians. Student responses were not normally distributed for pre or posttest scores for either organization of experimental groups: five individual experimental groups or treatment groups combined and control groups combined. Nearly all Levene's test statistics were insignificant. Student responses showed homogeneity of variance in nearly all cases. The three exceptions where student responses' variances were not homogenous were:

- Posttest scores for the Inclusion of Nature In Self scale between all five experimental groups (Levene statistic: 3.179, p: 0.015).
- Posttest scores for the Inclusion of Nature In Self scale between treatment groups combined and control groups combined (Levene statistic: 11.337, p: 0.001).
- Posttest scores for “There are too many (or almost) too many people on earth” between all five experimental groups (Levene statistic: 2.585, p: 0.039)

A principal component analysis (PCA) was run to determine if multiple questions measured the same underlying latent factor. Preliminary analysis created a correlation matrix determinant to check for multicollinearity ($2.49 \times 10^{-5} > .000001$). No correlations were too high (> 0.90) and it was determined that multicollinearity was not a problem for

³² See Figs 3.4a-3.4ac Environmental Literacy Frequency Distribution Boxplots on pages 227 - 241

these data. Sampling adequacy was met (KMO: 0.914) and Bartlett's test of sphericity (Chi 3213.193, Sig: 0.00) confirmed that the correlation matrix was not an identity matrix. Questions not included in pretest and three outliers were excluded; the principal component analysis assumes no outliers. Variamax rotation was used and four factors emerged which explained 52% of the total variance. Cronbach's alpha was computed to measure internal consistency. All questions for each of the four factors had alpha coefficients greater than 0.70 and therefore supported collapsing the four variables. The four collapsed variables were locus of control (cronbach's α : .778), environmental sensitivity and awareness (cronbach's α : .814), environmental worldview (cronbach's α : .716) and environmentally responsible behavior (cronbach's α : .766). The four variables confirmed a priori coding and align with the domains of environmental literacy (Hollweg et al. 2011). The collapsed variables or underlying latent factors and corresponding test questions are listed below in Table 3.4. Factor scores were then used for further analysis.

Table 3.4 Latent Factors Table shows four latent factors resulting from PCA, corresponding questions with weights. Cronbach's α displays the level of internal consistency for questions in each factor.

Factor (Cronbach's α)	Assessment Questions (weight)
Locus of Control (.778)	<ul style="list-style-type: none"> - By myself, I can make a positive impact on the environment. (0.746) - With others, I can make a positive impact on the environment. (0.732) - I have the skills necessary to make a positive impact on the environment. (0.637) - I think the restoration work that I do in natural areas is useful. (0.609)
Environmental Sensitivity and Awareness (.814)	<ul style="list-style-type: none"> - I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time. (0.772) - I enjoy spending time in natural settings. (0.712) - I pay special attention to things outdoors. (0.697) - Inclusion of Nature In Self. (0.618) - I would be upset if the natural area where I work was destroyed. (0.595)
Environmental Worldview (.716)	<ul style="list-style-type: none"> - When people mess with nature it has bad results. (0.733) - People must obey the laws of nature. (0.661) - Plants and animals have as much right as people to live. (0.600) - If things don't change we will have a big disaster soon. (0.594) - There are too many (or almost) too many people on earth. (0.594)

ERB: Environmental ly Responsible Behavior (.766)	<ul style="list-style-type: none"> - I engage in restoration outside of school. (0.700) - I engage in restoration in school. (0.686) - I talk to others about environmental issues. (0.681) - I pick up trash. (0.633)
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Research Question 3.1: Using pre-post assessment measures, how does participation in the program affect students environmental literacy?

Overall, results indicated a decrease in environmental literacy for all treatment groups when comparing pretest to posttest results. This was addressed with a Wilcoxon Signed Rank test for each question on the environmental literacy assessment to find significant differences. For each of the experimental groups with significant differences the questions, appropriate test statistic, significance level, measure of central tendency and variance are listed below in Table 3.5. There were significant differences in at least two questions between pretest and posttest scores for all three treatment groups and the pre-post control group. There was a significant increase from pretest to posttest in only one instance, the environmental service-learning focused group: “I think the restoration work that I do in natural areas is useful.” ($z = 2.100$, $p = 0.036$). Five significant differences occurred when analyzing the pre-posttest scores for all the treatment groups condensed into one group only. There was a significant increase from pretest to posttest in only one of these five instances: “I think the restoration work that I do in natural areas is useful.” ($z = 1.986$, $p = 0.047$). The Wilcoxon Signed Rank test assumes homogeneity of variance, which occurred for all questions except the Inclusion of Nature in Self scale.

The decrease in environmental literacy scores occurred when analyzing collapsed

variables that emerged from the principal component analysis. Paired sample t-tests indicated two significant pre-post differences for the four experimental groups with pretests showed. In both instances students' scores were significantly lower from pretest to posttest scores: environmental sensitivity and awareness ($t = 2.248$, $p = 0.027$) and environmentally responsible behavior ($t = 2.111$, $p = 0.042$).

Table 3.5 Significant Pre-Post Differences Table shows significant scores (Test Statistic) and level of significance (p-value) of Wilcoxon Signed Rank Test for each of the four experimental groups with both pre and posttesting and all the treatment groups combined. Measures of central tendency (median) and variability (interquartile range) are given.

Experimental Group	Question	(Z) Test Stat	Sig. p-value	Pre median (IQR)	Post median (IQR)
Environmental Service Learning Focus	People are clever enough to keep from ruining earth.	-2.014	0.044	3(2)	4(1)
	People are supposed to rule over the rest of nature.	-2.526	0.012	2(2)	3(1)
	I think the restoration work that I do in natural areas is useful.	2.100	0.036	3(1)	4(1)
Inquiry Focus	If I had enough time or money, I would devote it to working for the environment.	-2.096	0.036	3(1)	3(1)
	<i>With other people</i> , I can work to make a positive impact on the environment.	-2.487	0.013	4(3)	3(1)
Equal Focus	I recycle.	-2.537	0.011	5(1)	4(2)
	If I had enough time or money, I would devote it to working for the environment.	-2.032	0.042	4(1)	3(1)
Pre-Post Control	I engage in environmental restoration as part of school.	-2.123	0.034	2(1)	1(2)
	Inclusion of Nature in Self scale	-2.036	0.042	4(3)	3(2)
All Treatment Groups Combined	I recycle.	-3.234	0.001	4(1)	4(2)
	I think the restoration work that I do in natural areas is useful.	1.986	0.047	3(1)	4(1)
	If I had enough time or money, I would devote it to working for the environment.	-3.077	0.002	3(1)	3(1)
	People are clever enough to keep from ruining earth.	2.296	0.022	3(2)	3(2)
	People are supposed to rule over the rest of nature.	2.852	0.004	2(2)	2(1)

Research Question 3.2: How do changes in students' environmental literacy differ between control (C1 and C2), environmental service-learning focus (T1), inquiry/monitoring focus (T2) and equal focus (T3) groups?

Among group differences for both the pre and posttest scores showed inconclusive results when comparing among the five experimental groups when considered individually. However, when comparing the three treatment groups collectively and the two control groups collectively results indicated higher environmental literacy for the combined treatment group than the combined control group. Among group differences were addressed using Kruskal Wallis H with mean ranks on both pre and posttest scores with a subsequent pairwise analysis. The Kruskal Wallis H with mean ranks does not assume normal distribution or similarly shaped distributions. Results for each of the experimental five groups individually are listed in the Appendix and indicate each question with a significant difference, appropriate test statistic and significance level.

Comparing the three treatment groups collectively with the two control groups collectively indicated significantly higher environmental literacy for the treatment group as measured in the posttest. Among-group pretest differences were analyzed with a Kruskal Wallis H with mean ranks comparing all treatment group responses together (T1, T2, T3) with all control group responses together (C1, C2). There were no significant differences among pretest scores indicating that students came from the same population.

Therefore, differences in posttest scores could be attributed to experiences occurring during the study. A similar analysis was performed with posttest results, combining all treatment groups (T1, T2, T3) and comparing them with all control groups (C1, C2). The treatment groups combined had higher mean ranks than the control groups combined in all of the eight of thirty questions with significant differences. For each of the larger combined groups, all treatment or all control, with significant differences, the questions, appropriate test statistic, significance level and relative mean rank are listed below in Table 3.5. The Mann Whitney U test was used to compare mean ranks were for this analysis. Mann Whitney U with mean ranks does not assume normal distribution or similarly shaped distributions. Results of Kruskal Wallis H with mean ranks and Mann Whitney U test with mean ranks were consistent and Mann Whitney U scores. Frequency distributions are displayed graphically in Figures 3.5a-l, 3.6a-l, 3.7a-g, 3.8a-j³³ and indicate that a larger percentage of students in the treatment groups responded favorably to test questions (higher environmental literacy) than students in the control group.

Table 3.5 Significant Among Group Posttest Differences, Treatment Vs Control Table shows significant scores (Test Statistic Chi Square) and level of significance (Asymptotic Significance) of Kruskal Wallis Test H with mean ranks for all treatment groups compared with all control groups.

Question	Test Statistic (Chi Square)	Df	Asymp Sig.	n	Relative Difference
I engage in restoration as part of school	14.682	1	0.000	208	Treatment Groups ↑ Control Groups ↓
Plants and animals have as much of a right as people do to live	3.910	1	0.048	211	Treatment Groups ↑ Control Groups ↓
Someday people will know enough to control nature	4.171	1	0.041	203	Treatment Groups ↑ Control Groups ↓

33 Figs 3.5a - Figs 3.8j Frequency Distribution Histograms on pages 242 - 282

I feel a part of me would be missing if I could not get out and enjoy nature from time to time	5.031	1	0.025	207	Treatment Groups ↑ Control Groups ↓
I think the restoration work that I do in natural areas is useful.	6.773	1	0.009	208	Treatment Groups ↑ Control Groups ↓
I think the field monitoring that I do in natural areas is useful.	6.829	1	0.009	208	Treatment Groups ↑ Control Groups ↓
I would like to collect environmental data for local government, so they can monitor the environmental health of our watershed.	4.254	1	0.039	208	Treatment Groups ↑ Control Groups ↓
Inclusion of Nature in Self Scale	5.876	1	0.015	200	Treatment Groups ↑ Control Groups ↓

Statistical dependency occurred in several instances with five questions considered in a chi-square analysis as potential covariants (significant life experiences) with behavioral and attitudinal responses. The covariants and number of statistical dependencies were:

- gender: 4;
- previous environmental education: 7;
- an environmental positive role model: 6;
- witness to environmental harm: 11; and
- frequency of previous outdoor experiences: 16.

Gender had the least number of occurrences (only four) and therefore was dropped from further analysis. Previous environmental education had seven occurrences of statistical dependency: three questions were behavioral, three about worldview and one regarding locus of control. Students with a positive adult role model caring about the environment had six occurrences of statistical dependency: five questions were behavioral and one regarding worldview. Students that witnessed something bad happen to the environment

had eleven occurrences of statistical dependency: two questions were behavioral, one question related to intention, two about locus of control, three related to environmental sensitivity and one regarding efficacy. All of the test questions with statistical dependencies for each of the five independent variables are listed below in Table 3.6. Furthermore, the chi-square test statistic, p-value and measures of central tendency are also listed for each of these significant associations between the covariants and attitudinal and behavioral test questions in the Appendix³⁴.

Frequent previous outdoor experiences and witness to environmental harm had the most impact on behavioral and attitudinal responses. Students indicating they had previous environmental education, had an adult role model who cares for the environment, had witnessed environmental harm or had frequent previous outdoor experiences had higher environmental literacy scores than those students that did not for all of the significant associations listed in Table 3.6.

Table 3.6 Statistical Dependencies with Life Experiences Table displays presence or absence of statistical dependencies between independent variables, rightmost five columns, and attitudinal and behavioral questions, left most column. Dependencies were found with chi-square analyses for each question combining all experimental groups. Frequency of outdoor experiences were dichotomized by grouping the lowest three values (never, infrequently, sometimes) and the highest two values (frequently, very frequently).

Attitude and Behavioral Questions with Significant Relationships to Life Experience	Gender	Previous EE	Positive Env Role Model	Witness to Env Harm	Freq of Outdoor Exp*
I recycle		X			X
I pick up litter/trash			X		X
I talk to others (parents, friends, etc.) about environmental issues.		X	X	X	X
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building).		X	X		X

³⁴ See Appendices J-O

I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building).			X		X
Plants and animals have as much right as people to live	X				
People must obey the laws of nature.		X	X		
Nature is strong enough to handle the bad effects of our modern lifestyles		X			
There are too many (or almost too many) people on earth.	X				
People are treating nature badly.		X			
People will someday know enough about how nature works to control it.	X				
Before this program how frequently did you spend time in the outdoors?			X	X	
If I had enough time or money I would devote it to working for the environment.				X	X
I have skills necessary to make a positive impact on the environment.					X
I enjoy spending time in natural settings (woods, mountains, desert, lakes, oceans).				X	X
<i>With other people</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).		X		X	X
<i>By myself</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).				X	X
I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.				X	X
I pay special attention to things outdoors (plants, animals, woods, rivers, weather).				X	X
I would be upset if the natural area where I have worked was destroyed/polluted.				X	X
I think the restoration work that I do in natural areas is useful.				X	X
I plan to volunteer in a natural area (tree planting, invasive species removal).	X				X
Inclusion of Nature in Self (INS) Scale: Ranges from 1-7 and measures cognitive representation of self. See assessment on page 127 for picture of scale.				X	X
Total	4	7	6	11	16

Recognizing statistical dependency between particular variables, further among-group differences were analyzed for subsets of interest, considered significant life experiences (Chawla 1999). Posttest scores for all three treatment groups combined (T1, T2, T3) were compared to the two control groups combined (C1, C2) for the following subsets:

- 1.) Have you received any other outdoor environmental education?³⁵
- 2.) Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?³⁶
- 3.) Have you seen something bad happen to the environment before?³⁷
- 4.) Before this program how frequently did you spend time in the outdoors?³⁸

Research Question 3.2: How do changes in students' environmental literacy differ between control (C1 and C2), environmental service-learning focus (T1), inquiry/monitoring focus (T2) and equal focus (T3) groups?

Students with the four measured significant life experiences were more likely to positively respond to the studied environmental education program than students without these significant life experiences. Mann Whitney U tests were performed on attitudinal and behavioral responses to determine if significant differences occurred for each of the sample subsets. Comparing posttest scores of students in the treatment groups indicating

35 See Figs 3.5a-l Frequency Distribution Histograms on pgs: 242 - 253

36 See Figs 3.6a-l Frequency Distribution Histograms on pgs 254 - 265

37 See Figs 3.7a-g Frequency Distribution Histograms on pgs 266 - 272

38 See Figs 3.8a-j Frequency Distribution Histograms on pgs 273 - 282

that they had previous environmental education showed significant differences compared to students in the control groups indicating they had previous environmental education in 12 of the 29 attitudinal or behavioral questions. Similar posttest comparisons (treatment vs control) for students indicating they had a positive adult role model who cares for the environment were significant for 12 of 29 questions. Likewise, there were 7 of 29 possible significant differences for each subgroup of students: those having witnessed environmental harm and those with frequent outdoor experiences. There was variation in which questions were significant among the subgroups. The number of significant differences for each group/subgroup were:

- treatment vs control: 8;
- students with previous EE, treatment vs control: 12;
- students with a environmental positive role model, treatment vs control: 12;
- students that had witnessed environmental harm, treatment vs control: 7; and
- students with “frequent” or “very frequent” outdoor experiences, treatment vs control: 7.

The differences among the groups and subgroups are listed in Table 3.7. While there is some consistency for questions like: “I engage in restoration as a part of school” and “I would like to collect data for local government so they can monitor the health of our watershed,” other questions like “I enjoy spending time in natural settings” were significantly different between the treatment and control groups only for those students with a positive adult role model that cares for the environment. There were significant differences for the three questions which measure locus of control between the treatment

and control groups only for those students with a positive adult role model, those students with previous environmental education or those that had witnessed something bad happen to the environment. None of these three subgroups showed significant differences for all three of the questions which measure locus of control. The two questions regarding efficacy were consistent, showing significant differences, excepting those students with frequent previous outdoor experiences.

Table 3.7 Groups/Subgroups with Significant Posttest Differences Table shows environmental literacy assessment questions with significant among groups differences for all treatment groups combined with all control groups combined. Includes four subgroups: respondents indicating “yes” to three questions: “Have you received any other environmental education?”, “Besides instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”, “Have you seen something bad happen to the environment before?” and respondents indicating “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time in the outdoors?”. For each question the environmental literacy domain (Hollweg et. al 2011) and the corresponding latent construct (PCA analysis or a priori coding, efficacy) are listed in the second column. Two questions indicated with a * have reverse wording and were excluded from the PCA analysis as outliers.

Environmental Literacy Assessment Question	Domain & (construct)	Groups/Subgroups with Significant Among -Group Posttest Differences				
		All Tx v Con	Prev EE Tx v Con	Env+ Adult Tx v Con	Seen Env Harm Tx v Con	Freq Out Tx v Con
I engage in restoration as part of school.	Behavior (ERB)	X	X	X	X	X
Plants and animals have as much of a right to live as people do.	Disposition (Environmental Worldview)	X	X	X	X	X
People are clever enough to keep from ruining the earth.*	Disposition		X			
People must obey the laws of nature.	Disposition (Environmental Worldview)			X		X
When people mess with nature it has bad results.	Disposition (Environmental Worldview)		X			
Someday people will know enough to control nature.*	Disposition	X		X		
I have skills necessary to make a positive impact on the environment.	Disposition (Locus of Control)		X		X	

I enjoy spending time in natural settings.	Disposition (Environmental Sensitivity and Awareness)			X		
<i>With other people</i> , I can work to make a positive impact on the environment.	Disposition (Locus of Control)		X	X		
<i>By myself</i> , I can work to make a positive impact on the environment.	Disposition (Locus of Control)			X		
I feel a part of me would be missing if I could not get out and enjoy nature from time to time.	Disposition (Environmental Sensitivity and Awareness)	X	X		X	X
I pay special attention to things outdoors.	Disposition (Environmental Sensitivity and Awareness)		X	X		X
I think the restoration work that I do in natural areas is useful.	Disposition (Efficacy)	X	X	X	X	
I think the field monitoring that I do in natural areas is useful.	Disposition (Efficacy)	X	X	X	X	
I would like to collect environmental data for local government, so they can monitor the health of our watershed.	Disposition (Behavioral Intention)	X	X	X	X	X
Inclusion of Nature in Self scale. Ranges from 1-7 and measures cognitive representation of self. See assessment on page 127 for picture of scale.	Disposition (Environmental Sensitivity and Awareness)	X	X	X		X
Total		8	12	12	7	7

Results for each significant attitudinal and behavioral question are displayed with frequency distributions, Mann Whitney U and chi square values in Figures 3.5a-l, Figures 3.6a-l, Figures 3.7a-g and Figures 3.8a-h. Frequency distributions are given for all responses for each of the two groups in the analysis: all treatment groups combined (T1, T2, T3) and all control groups combined (C1, C2). Mann Whitney U test scores are listed to compare these two groups: treatment vs control. For each of the two groups,

frequency distributions of subsets are displayed: students answering “yes” vs students answering “no.” Mann Whitney U scores are listed to compare these two groups for each subset (e.g., treatment group responses for students answering “yes” to “Have you received any other outdoor environmental education?” compared to control group responses for students answering “no” to “Have you received any other outdoor environmental education?”). Significant chi-square values are listed to compare the two subsets within the two groups (e.g., treatment group responses for students answering “yes” to “Have you received any other outdoor environmental education?” compared to treatment group responses for students answering “no” to “Have you received any other outdoor environmental education?”). Frequency distributions indicate multiple instances where no significant differences occurred when comparing only the treatment and control group, yet when carving away one of the four subgroups significant differences did occur.

Student responses to each of the four questions (previous environmental education, adult role model who cares for the environment, witness to environmental harm and previous outdoor experiences) were considered collectively and tallied. Students were grouped according to the number of responses of “yes” and “frequently/very frequently” to each of the four questions (previous environmental education, adult role model who cares for the environment, witness to environmental harm and previous outdoor experiences). The number of significant differences in attitudinal and behavioral responses between the experimental groups combined are listed in Table 3.8. Students with minimal environmental experiences (those indicating “yes”

and “frequently/very frequently” to none or only one of the four select questions) showed no significant difference between treatment and control groups in their posttest attitudinal and behavioral responses. Students with moderate environmental experiences (those indicating “yes” and “frequently/very frequently” to two of the four select questions) showed significant differences between the treatment and control groups in two of their posttest attitudinal and behavioral responses. Students with substantial environmental experiences (those indicating “yes” and “frequently/very frequently” to three or four of the four select questions) showed significant differences between the treatment and control groups in five of their posttest attitudinal and behavioral responses.

Table 3.8 Collective Impacts Table organizes students according to the the number of “yes” or “frequently/very frequently” to select questions (previous EE, adult role model, witness to env. harm and previous outdoor experiences) in left column. For each group (0-4), provides the number of significant differences occurred when comparing the treatment and control groups.

Number of “yes” or “frequently/very frequently” responses student indicated (previous EE, adult role model, witness to env. harm and previous outdoor experiences)	Number of significant differences between treatment groups combined and control groups combined.	n
0	0	10
1	0	20
2	2	40
3	5	64
4	5	77

Student standardized science test scores, Oregon Assessment of Knowledge and Skills (OAKS), were analyzed to assess gains in scientific knowledge and are listed in Table 3.9. In the environmental service-learning focus group 20.3% students exceeded proficiency, while only 6.3% of the students in the equal focus group exceeded proficiency. When considering all of the treatment groups collectively, the percentage of

students exceeding proficiency was 12.9%, yet only 6.3% for all other students at the school. While the percentage of students meeting proficiency was commensurate among the two groups, the percentage below proficiency was markedly lower for the students in the treatment group – nearly 7% lower.

Table 3.9 Oaks Testing 8th Grade Science Scores Table shows the percentage of student that exceeded, met and were below science performance expectations for 8th grade. Groups are arranged to display the three treatment groups in the study, all treatment groups together, all students not in treatment groups, all of Evergreen Middle School, Like-School Average and Oregon. Control groups used in the study were not displayed because the data was not available. However, all students not in the treatment groups is listed for comparison purposes. The percentages listed assume an equal number of students in both the “all treatment groups” and “all students not in treatment groups” categories and was computed algebraically with the percentages for all of Evergreen Middle School.

OAKS Testing 8th Grade Science Scores			
Group	Percent Exceeded	Percent Met	Percent Below
Environmental Service Learning Focus	20.3	43.5	36.2
Inquiry Focus	8.7	49.3	42.0
Equal Focus	6.3	46.9	46.9
All Treatment Groups	12.9	46.5	40.6
All Students NOT in Treatment Groups*	6.3	46.3	47.4
Evergreen Middle School	9.6	46.4	44.0
Like-School Average	10.5	55.0	34.6
Oregon	12.0	54.8	33.1

Qualitative Results

Qualitative results were considered for all treatment groups collectively. Within treatment group differences were not considered. Moreover, while the control groups did not engage in any parallel activities it was assumed that the outcomes evident for the

treatment groups were unique and that the control groups did not have similar outcomes. This assumption was supported by discussion with the science teacher for the control group classes. This teacher indicated that no parallel environmental education activities occurred throughout the school year. This claim was corroborated by other teachers. No qualitative data were available for students in the control group.

Research Question 3.2: How do changes in students' environmental literacy differ between control (C1 and C2), environmental service-learning focus (T1), inquiry/monitoring focus (T2) and equal focus (T3) groups?

A qualitative analysis indicated that students in the treatment group demonstrated various degrees of environmental literacy for each of the four domains. Knowledge has five sub-constructs, disposition has five sub-constructs and competencies has seven sub-constructs. Students did not demonstrate knowledge, disposition or competencies for all of the sub-constructs. Students in the treatment group demonstrated three of the five sub-constructs in the knowledge domain with an understanding of: physical and ecological systems (aquatic, soils, plants), environmental issues and action strategies. Students in the treatment group demonstrated four of the five sub-constructs in the disposition (attitudes) domain: sensitivity, awareness and concern, assumption of personal responsibility and locus of control. Students in the treatment group demonstrated five of the seven sub-constructs in the competencies domain: identifying environmental issues, asking relevant questions, analyzing environmental issues, investigating environmental

issues and creating plans to resolve environmental issues. Environmental behaviors were demonstrated through learning activities, teacher quotes and student quotes. Qualitative results were summarized and organized according to the domain of environmental literacy and listed in Table 3.10. The table indicates that many of the sub-constructs within each of the four domains of environmental literacy were demonstrated to some degree by students in the treatments group.

Table 3.10 Qualitative Results Table shows qualitative results for treatment group subjects. Results are organized according to the domain of environmental literacy (Hollweg et. al. 2011). The four domains are in the left column with corresponding details for that domain in the middle column. The rightmost column displays results where students demonstrated the component of environmental literacy within the corresponding row.

Desired Environmental Literacy Outcomes		
Environmental Literacy Strand	Detail	
Knowledge What did the students learn and know about: Sources - journals - work samples - posters	Physical and Ecological Systems:	<u>Aquatic Physical and Ecological Systems:</u> <i>Excerpts from work samples, journals, poster presentations and assessments:</i> - “dissolved oxygen will be higher here because it is colder” - “the site has higher turbidity because there is less bank stability which means higher erosion” - “sinuosity is how twisty the river is” - “canopy in the riparian area provides shading to water and makes it colder” - “turbidity is how murky the water is” - “quagga mussels cover all the surface so plants can't grow” - “[macroinvertebrate] richness is important because some macroinvertebrates are intolerant to pollution” <i>Learning activities:</i> - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects <u>Soil Physical and Ecological Systems:</u> <i>Excerpts from work samples, journals, poster presentations and assessments:</i> - “infiltration is affected by how porous the soil is” - “compost has more nutrients than mulch” - “water infiltrated the slowest at the control site because it was the most compact”

		<p>- “The soil was full of water so the infiltration rate was slower than if it had not rained the day before”</p> <p>- “Soils moderate water flow and storage; support life; store and recycle nutrients”</p> <p>- “infiltration rate is slower in riparian area than upland area”</p> <p><i>Learning activities:</i></p> <p>- soil type and infiltration rate sampling, analysis and research projects</p> <p>- soil compaction and infiltration rate sampling, analysis and research projects</p> <p><u>Plant Physical and Ecological Systems:</u></p> <p><i>Excerpts from work samples, journals, poster presentations and assessments:</i></p> <p>- “recruitment is higher in compost plots cause more nutrients and water are available for baby plants”</p> <p>- “competition for sunlight is important...canopy blocks sunlight and herbs can't grow as abundantly”</p> <p>- “composted plots: ↑ seeds in seed bank; mulched plots: ↓ seeds in seed bank; control plots: ? seeds in seed bank”</p> <p><i>Learning activities:</i></p> <p>- structural plant diversity sampling, analysis and research projects</p> <p>- invasive species distribution sampling, analysis and research projects</p> <p>- plant recruitment rates of different soil types sampling, analysis and research projects</p>
	Environmental Issues:	<p><i>Excerpts from work samples, journals, poster presentations and assessments:</i></p> <p>- “water quality can be described by water's pH and turbidity”</p> <p>- “[macroinvertebrate] richness is important because some macroinvertebrates are intolerant to pollution”</p> <p>- “land use is important because the more urban an area [aquatic system] the greater the negative impact on...richness of macroinvertebrate species”</p> <p>- “invasive species traits: fast growth, rapid reproduction, seeds spread easily, change according to environment”</p> <p><i>Learning activities:</i></p> <p>- environmental restoration: invasive removal, soil amending and native planting</p> <p>- invasive species distribution sampling, analysis and research projects</p> <p>- macroinvertebrates as bioindicators sampling, analysis and research projects</p> <p>- water quality sampling, analysis and research projects</p>
	Citizen Participation and Action Strategies:	<p><i>Excerpts from work samples, journals, poster presentations and assessments:</i></p> <p>- “we restored this area putting in native plants and adding different soil amendments”</p>

		<p><i>Learning activities:</i></p> <ul style="list-style-type: none"> - environmental restoration: invasive removal, soil amending and native planting
<p>Dispositions How did students respond to environmental issues:</p> <p>Sources:</p> <ul style="list-style-type: none"> - journals - pictures - survey 	Sensitivity:	<p><i>Observation:</i></p> <ul style="list-style-type: none"> - keen student awareness of natural phenomena on field trips <p><i>Student quotes:</i></p> <ul style="list-style-type: none"> - “made me more aware about the nature and makes me want to help and I would but I don't have time” - “helped us a lot with the understanding of nature and I hope other kids get this opportunity” - “it makes me sad when companies ruin open land” - “this was so amazing! Loved the field trips” - “I like spending a lot of time outside” <p><i>Teacher Quotes:</i></p> <ul style="list-style-type: none"> - “(They) made many comments on the environment around them.” - “Students were careful with their outdoor research lab and the school ground in general when they were aware of the impact and effort that were involved with the lab.”
	Attitudes and Concern Toward the Environment:	<p><i>Observation:</i></p> <ul style="list-style-type: none"> - students upset that seedling at restoration site was pulled <p><i>Student quotes with pro-environmental attitudes:</i></p> <ul style="list-style-type: none"> - “invasive species are bad” - “I ♥ science” - “English Ivy is a problem because it covers EVERYTHING” - “Earth Matters” - “plants and animals are important” - “I am a christian and I believe man is supposed to rule over nature and take care of it, NOT abuse it.” - “I am sad that nature is being destroyed because it is beautiful, but I don't like working outside” - “nature is an amazing thing that humans are abusing. We can fix this problem but we are too greedy” <p><i>Teacher Quotes:</i></p> <ul style="list-style-type: none"> - “My students certainly LOVED being outside and having the opportunity to go on field trips. Many students mentioned that it was their first field trip in many years.” <p><i>Student quotes with negative environmental attitudes:</i></p> <ul style="list-style-type: none"> - “I don't care about nature and I really don't care about the people who do care about nature. I don't believe in nature, nor the animals. I didn't like learning about nature and I never will.” - “I don't care if they pollute unless it effects the things I love or where I live” - “I can care less about nature”
	Assumption of Personal Responsibility:	<p><i>Student quotes:</i></p> <ul style="list-style-type: none"> - “we must do something to help nature. Are you green?” - “how can we restore forests?”

		<ul style="list-style-type: none"> - “don't stop helping the environment” - “our world may be destroyed by ourselves” - “the environment is a huge mess we won't clean up but should”
	Locus of Control/Self Efficacy:	<i>Student quotes:</i> <ul style="list-style-type: none"> - “I live on a farm and I clean up anything lying around to keep the environment healthy.”
Competencies Skills and abilities that students demonstrated they knew how and when to apply Sources: - journals - essays - class activities	Identify environmental issues	<i>Excerpts from work samples, journals, poster presentations and assessments:</i> <ul style="list-style-type: none"> - “land use is important because the more urban an area [aquatic system] the greater the negative impact on...richness of macroinvertebrate species” - “[macroinvertebrate] richness is important because some macroinvertebrates are intolerant to pollution” - “quagga mussels cover all the surface so plants can't grow” - “English Ivy is a problem because it covers EVERYTHING” - “invasive species traits: fast growth, rapid reproduction, seeds spread easily, change according to environment”
	Ask relevant questions about environmental conditions and issues	<i>Excerpts from work samples, journals, poster presentations and assessments:</i> <ul style="list-style-type: none"> - “[in our restoration plots] which soil amendment will allow water to infiltrate the soil the fastest?” - “which of the [research] field trip sites will have a more diverse plant population?” - “[in our restoration site] will recruitment be higher in composted plots because the soil contains more nutrients and moisture for the seeds?” - “how does land use affect the number of macroinvertebrates in the stream?” - “how can we restore forests?” <i>Learning activities:</i> <ul style="list-style-type: none"> - structural plant diversity sampling, analysis and research projects - invasive species distribution sampling, analysis and research projects - plant recruitment rates of different soil types sampling, analysis and research projects - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects
	Analyze environmental issues	<i>Learning activities:</i> <ul style="list-style-type: none"> - structural plant diversity sampling, analysis and research projects - invasive species distribution sampling, analysis and research projects - plant recruitment rates of different soil types sampling, analysis and research projects - water quality sampling, analysis and research projects

		<ul style="list-style-type: none"> - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects <p><i>Teacher Quotes:</i></p> <ul style="list-style-type: none"> - “students ability to apply concepts and ideas from the activities in class greatly enhanced their ability to both recognize and talk about environmental issues. Their discussions with each other, with our resident science fellow and myself were much deeper and used much more domain specific vocabulary than they had access to previously.”
	Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)	<p><i>Learning activities:</i></p> <ul style="list-style-type: none"> - structural plant diversity sampling, analysis and research projects - invasive species distribution sampling, analysis and research projects - plant recruitment rates of different soil types sampling, analysis and research projects - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects - water quality sampling, analysis and research projects - stream morphology assessment, analysis and research projects - macroinvertebrates as bioindicators sampling, analysis and research projects <p><i>Teacher Quotes:</i></p> <ul style="list-style-type: none"> - “The students definitely were better able to identify variables within an experiment, analyze results especially variability in data through doing box and whisker plots and analyzing outliers, and manipulate variables within experiments. Their ability to discuss results using advanced ideas and advanced language was greatly increased.”
	Create and evaluate plans at various scales to resolve environmental issues	<p><i>Learning activities:</i></p> <ul style="list-style-type: none"> - schoolyard restoration and creation of outdoor learning laboratory - analysis of different restoration treatments within learning laboratory in terms of hydrology and plant community response. <p><i>Teacher Quotes</i></p> <ul style="list-style-type: none"> - “the students were able to discuss with greater clarity the impact of humans on the natural world.”
Environmentally Responsible Behaviors	n/a	<p><i>Learning activities:</i></p> <ul style="list-style-type: none"> - schoolyard restoration and creation of outdoor learning laboratory - invasive species removal at local restoration site - litter removal at local restoration site <p><i>Teacher Quotes</i></p>

		<p>- “(the students) were more interested in engaging with restoration projects when they were able to understand the results they were causing.”</p> <p>- “the students were careful with their outdoor research lab and the school ground in general when they were aware of the impact and effort that were involved with the lab.”</p> <p><i>Student Quotes</i></p> <p>- “I live on a farm and I clean up anything lying around to keep the environment healthy.”</p>
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Chapter 3 – Discussion:

Results of this study inform multiple research areas within environmental education. Results are discussed and consider the most notable findings first and continue with progressively less notable findings. The findings (from most to least notable) are in relation to:

- significant life experiences
- the value of environmental education
- comparing environmental education pedagogies
- change in environmental literacy

Discussion concludes with consideration of bias, generalizability and validity.

Significant Life Experiences

Students receiving environmental education in any of the treatment groups who also had significant environmental experiences showed the greatest increases in

environmental literacy. It is unclear if either of the four significant environmental experiences (prior environmental education, a positive adult role who cares for the environment, having witnessed environmental harm or previous frequent outdoor experiences) was more significant to these students. The associational analysis indicated more significant associations with having witnessed environmental harm and previous frequent outdoor experiences with survey test questions than the other two variables. Conversely, students with prior environmental education or a positive adult role who cares for the environment model were more likely to positively respond to environmental education program described here (treatment) than students with those same experiences in the control group.

Students in the treatment group who indicated they had prior environmental education or a positive adult role model showed greater environmental literacy (largest amount of differences) when compared to students in the control group who also indicated they had prior environmental education or a positive adult role model. Students receiving environmental education in any of the treatment groups without these significant experiences did not show increases in environmental literacy. This suggests that the significant life experience of having an adult role model that cares for the environment may be a necessary precursor to positively responding to environmental education.

The Value of Environmental Education Programs, Inquiry and Environmental Service Learning vs Traditional Classrooms

Posttest scores which combined treatment groups and control groups were analyzed for differences because there was evidence that students came from the same population. Changes in posttest scores were attributed to the treatment because there were no significant pretest differences in students' responses for the 33-question environmental literacy assessment among groups, all treatment groups compared with all control groups. There were significant differences in posttest scores with eight of the thirty-three questions. Thus students' environmental literacy was significantly affected in terms of the following domains and indicated by the following questions. The domains and associated questions were:

- Environmentally Responsible Behaviors;
 - I engage in restoration as part of school (environmentally responsible behavior);
- Dispositions;
 - Plants and animals have as much of a right to live as people do (environmental worldview);
 - Someday people will know enough to control nature (environmental worldview);
 - I feel a part of me would be missing if I could not get out and enjoy nature from time to time (environmental sensitivity and awareness);
 - I think the restoration work that I do in natural areas is useful (efficacy);
 - I think the field monitoring that I do in natural areas is useful (efficacy);

- I would like to collect environmental data for local government, so they can monitor the environmental health of our watershed (behavioral intention); and
- Inclusion of Nature in Self Scale (environmental sensitivity and awareness).

The significant differences in student responses did, at this scale, show that students in the treatment group had greater environmental literacy than students in the control group. The areas (sub-constructs) with greater environmental literacy were environmentally responsible behavior, environmental worldview, environmental sensitivity and awareness, efficacy and behavioral intention.

Hypothesis 3.2b: All treatment groups will have significantly greater environmental literacy posttest scores than control groups (C1 or C2). was confirmed at this scale.

Standardized science test scores, OAKS, showed that students in the treatment groups demonstrated greater scientific knowledge than students in the control group. Differences were evident at either scale of analysis: treatment vs control and among all treatment groups. The differences among treatment groups were substantial. In the environmental service-learning focus group 20.3% students exceeded proficiency, while only 6.3% of the students in the equal focus group exceeded proficiency. However, the differences among these three treatment groups was likely not a function of a slight variation in learning activities. OAKS tests measure Physical, Life and Earth Sciences.

While all three fields of science were instructed, much of the OAKS test includes content not considered in this study. Content standards were the same throughout the environmental education program for all treatment groups and only learning activities were varied. However, there were several differences in terms of the content standards instructed between the treatment groups and the control groups. Comparing all treatment groups combined with all of Evergreen Middle School or the 'acting' control group which was labeled as “all students not in treatment groups” in Table 3.9 Oaks Testing 8th Grade Science Scores was the most valid comparison of OAKS test scores to determine the effect of this environmental education program on students' overall science knowledge. The percentage of students exceeding proficiency was 12.9% for all treatment groups yet only 6.3% for all other students at the school. While the percentage of students meeting proficiency was commensurate among the two groups, the percentage below proficiency was markedly lower for the students in the treatment group – nearly 7% lower.

Environmental education is often authentic. Authentic pedagogy requires 1.) students construct meaning and produce knowledge, 2.) students use disciplined inquiry to construct meaning and 3.) students aim their work toward the production of discourse, products and performances that have meaning beyond school (Newmann and Wehlage, 1993). Authentic pedagogy is grounded in constructivist theory and requires that educators facilitate the clarification, expansion and development of student knowledge. Environmental education which employs data collection, data analysis, field trips, testing questions, restoring a natural area and testing the efficacy of restoration strategies requires students to construct their own meaning, yet it is grounded in empiricism.

Environmental education such as this is not education informed by the banking deficiency model (Friere 1970). Extended environmental education programming (40+ hours over a school year) with an environmental scientist and environmental educator provides opportunities for substantive conversation where students learn from, interact, discuss and debate with one another, experts and individuals with differing experiences and viewpoints. Contrast this programming to non-authentic environmental education where one or two pages on invasive species are included in an Earth Science textbook. Authentic pedagogy yields products and performances that have value or meaning beyond school. Environmental service-learning and scientific inquiry instructional practices do not yield products associated with typically formal education environments such as tests, essays and final assignments. Outcomes of this study's environmental education program were a 100+ sq meter schoolyard restoration site and poster presentations of research results at a professional conference. The educational theory of situated learning (Roelofs and Terwel 1999) posits that knowledge is bound to the environment. This research shows how the impact of authentic environmental projects which have larger meaning and applicability than typical classroom projects which students may see as isolated and irrelevant.

Comparing Environmental Education Pedagogies: Inquiry vs Environmental Service-Learning

Some conclusions may be drawn to support the idea that a slight variation in the

amount of time students spent engaged in environmental service-learning affected students' environmental literacy when assuming that all students came from the same initial population. Considering only significant posttest results among treatment groups (pairwise analysis) where no significant differences occurred in the pretest, it was clear that the inquiry focused treatment group had higher environmental literacy than the environmental service-learning focused treatment group. There were five questions measuring dispositions which were:

- “People must obey the laws of nature.”;
- “ I enjoy spending time in natural settings.”;
- “I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time.”;
- “ I would be upset if the natural area where I have worked was destroyed/polluted.”; and
- “Inclusion of Nature in Self Scale (Shultz 2001)”.

Furthermore, the equal focused treatment group scored significantly higher than the environmental service-learning focused treatment group in two of these instances which were:

- “ I enjoy spending time in natural settings.”; and
- “I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time.”

These five questions, on which the environmental service-learning focused treatment group scored relatively lower than the other treatment groups, all measured dispositions.

Most of these questions (4/5) measured the environmental sensitivity and awareness latent construct revealed in the Principal Component Analysis. None of these five questions showed significant within group (pre-post) differences. There were neither increases in the inquiry or equal focused groups nor decreases for the environmental service-learning focused treatment group. However, there were significant within-group differences with composite scores generated in the Principal Component Analysis. A paired sample t-test ($t = 2.248$, $p = 0.027$) showed that the environmental service-learning focused treatment group's environmental sensitivity and awareness decreased significantly throughout the study.

The number of significant pairwise differences markedly changed from the pretest to the posttest. Pretest results suggest that, in terms of environmental literacy, students began the program with some significant differences. Roughly 8% of the possible among-group differences (pairwise analysis) were significant; 69% of those differences were among treatment groups, ~ 5% of total. These differences are important and may suggest that students in the different treatment groups came from different populations. However, posttest differences among all experimental, treatment and control, groups showed change in significant differences. Roughly 10% of the possible among-group differences (pairwise analysis) were significant; 17% of those differences were among treatment groups, 1.5% total. The change in significant among-treatment group differences suggests that while students may have originated with slightly different levels of environmental literacy they collectively gravitated towards a level with similar distributions regardless of their treatment group.

Results indicated that slight variation in the amount of time spent engaged in environmental service-learning and inquiry did not affect environmental literacy. Evidence pointed toward inquiry-focused instruction promoting environmental literacy, but results were inconclusive considering significant pretest pairwise differences among treatment groups. Furthermore, the significant pairwise differences in student responses showed that students in each of the treatment groups had greater environmental literacy than students in the control groups.

Hypothesis 3.2a: Students engaged in T1 (environmental service-learning focus) will have significantly greater environmental literacy posttest scores than students in T2 (inquiry focus) and T3 (equal focus); particularly the behavior domain was rejected.

Hypothesis 3.2b: All groups will have significantly greater environmental literacy posttest scores than the control groups (C1 or C2). was confirmed with this analysis.

It is important to consider 'how' in education and not just 'what.' Content standards across disciplines are incorporating skills sets (how) in addition to facts (what). Consider the 8th grade Next Generation Science Standards (NGSSs). A disciplinary core idea is the “roles of water in earth's surface processes,” students are expected to know that “water continually cycles among land, ocean, and atmosphere via transportation, evaporation, condensation and crystallization and precipitation, as well as downhill flows on land.” Further, students who demonstrate an understanding, a performance

expectation, can “construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes” (how). Both inquiry activities and environmental service-learning lent themselves to the 'how' and 'what' expected in the NGSSs. The performance expectations in the NGSSs may lend themselves more or less to scientific inquiry or environmental service-learning, but also depend on the learner. Student inquiry projects assessed water infiltration rate and available soil moisture in different soil types while environmental service-learning projects designed restoration plots with different soil types to maximize water infiltration and available soil moisture. The essential question: “what is the most effective strategy for maximizing learning in terms of cognitive, affective and behavioral capacities?”

Science inquiry requires students make precise observations, ask testable questions, design testable experiments, analyze their results and communicate their findings (National Research Council 1996). Environmental service-learning requires students understand the system they are serving or working in and make meaningful contributions to the environment, while scientific inquiry does not require meaningful contributions. Full scientific inquiry requires dissemination of findings. In this regard, environmental service-learning may be more authentic (Newmann & Wehlage, 1993). Both pedagogies are informed by “constructivism” where misconceptions are challenged and students produce conditionalized knowledge (Kolb, D. & Fry, R. 1974; Phillips, D. 1995). Findings of this study suggest that environmental service-learning is not as effective as scientific inquiry in increasing environmental literacy.

Environmental service-learning and scientific inquiry are overlapping pedagogies. Both require scaffolding and require significant amounts of time be dedicated to this process. Environmental service-learning can not be considered to occur only when students are engaged in meaningful activities which benefit the environment – direct ecomanagement in this study. Nor can scientific inquiry be considered to occur only when students are testing hypotheses. Students build conditional knowledge which may be framed by the intended outcome, final project, stated objective of the course or learning activity. Therefore, the exact same scaffolding activity, in this study's case learning physical properties of soil (texture, hydraulic conductivity, porosity), could be seen as inquiry or environmental service-learning. Knowing the properties of soil was necessary to test infiltration rates of soil types (high level inquiry activity) or to choose which soil amendment to use in the restoration project (environmental service-learning). The results of this study suggest that the distinction between the two pedagogies may not always be clear to students.

Change in Students' Environmental Literacy Throughout the School Year

Overall, within group, pre-post differences were inconclusive. Significant differences occurred with all four experimental groups and showed both gains and losses. For example, significant differences within the environmental service-learning focused group included a decrease in environmental sensitivity collapsed score which emerged from the Principal Component Analysis factor score. Conversely, there was an increase

in response to “I think the restoration work that I do in natural areas is useful.”

Significant gains and losses also occurred when considering the treatment groups collectively. There were more significant decreases in environmental literacy than increases. Considered in isolation, results showed that students' environmental literacy may have actually decreased. There were more significant decreases from pretest to posttest scores than increases. Students with significant life experiences could not be analyzed for significant pre-post differences. The four questions about significant life experiences were not included in the pretest.

Hypothesis 3.1: Students engaged in the program will have significant increases from pretest to posttest environmental literacy scores was rejected.

Qualitative Support for Change in Environmental Literacy

Qualitative results corroborated effects of the program on students' environmental literacy. These results could not, however, be used for comparison, either among treatment groups or comparing treatment groups to control groups. No qualitative results were gathered for the control group students and analysis did not consider different treatment groups. Moreover, it was assumed that students' demonstrated knowledge is a function of the environmental education received in this program. Anecdotal evidence, observation and the classroom teacher supported the conclusion that students had previously not known much of the environmental science instructed throughout the year.

The teacher remarked: “[students] used much more domain specific vocabulary than they had access to previously.” Indeed, students demonstrated knowledge which included domain specific vocabulary ranging from low order thinking such as recall (“sinuosity is how twisty the river is”) to higher order thinking such as synthesis (“recruitment is higher in composted plots because more nutrients and water are available for baby plants”). The different types of knowledge and thinking, ranged from low to high order (Bloom, B. 1956; Krathwohl, D. 2002) and are considered in the NGSSs.

Treatment-group students' dispositions towards the environment were made clear with statements like: “Nature is an amazing thing that humans are abusing. We can fix this problem but we are too greedy” or on the other hand: “I don't care about nature and I really don't care about the people who do care about nature. I don't believe in nature, nor the animals. I didn't like learning about nature and I never will.” While most student quotes displayed a positive disposition towards the environment, some student quotes showed the opposite. Quotes from the teacher directly addressed these differences. When asked “Did you see any change in the students' interest/concern (disposition) for the natural world that was likely related to our work?” the teacher responded: “For most students, yes. There will always be a subset of students that do not show interest in science.” The teacher went on to say about the general student population: “They definitely enjoyed science more and were more interested ... when there are hands-on real-world activities and observable results.”

Students in the treatment groups displayed some environmental competencies which the control students were assumed not to have. Several students in the treatment

groups, about 50, attended a professional conference, the Joint Aquatic Sciences Meeting (JASM), and presented results from their research to professional scientists in poster format. The control group did not participate in the conference. While students in the control group may have participated in a science fair outside of school, the rigor of questions and authenticity of presenting at JASM is higher than that of a science fair. Further, the control group did not participate in any outdoor environmental science research projects or any restoration activities through the school. The teacher noted: “the students were able to discuss with greater clarity the impact of humans on the natural world and were more interested in engaging with restoration projects when they were able to understand the results they were causing.” and “the students responded extremely positively to the hands on activities done in class, the relationship formed with a ‘real scientist’, the opportunity to present their research alongside graduate students at the conference, and the increased amount of interaction with a real data site and being able to compare sites.”

Qualitative results provided little meaningful information to support change in environmentally responsible behaviors resulting from participation in the environmental education program. There were some obvious behaviors which occurred throughout the program relating to direct ecomanagement: participation in schoolyard restoration and litter removal. Students also participated in indirect service (research) by conducting and disseminating environmental science. However, these activities occurred as part of the curriculum; essentially, they were required of the students in the treatment groups. Qualitative evidence of environmentally responsible behaviors which occurred outside

school requirements were nominal. The science teacher noted: “the students were careful with their outdoor research lab and the school ground in general when they were aware of the impact and effort that were involved with the lab.” A student noted: “I live on a farm and I clean up anything lying around to keep the environment healthy.” Additionally, one student was observed very upset because someone had uprooted a vine maple sapling planted in the outdoor science laboratory restoration site.

Hypothesis 3.2b: All groups will have significantly greater environmental literacy posttest scores than the control groups (C1 or C2). was confirmed with this analysis.

Bias, Generalizability and Validity

The results of this study must be considered in terms of complicating factors inherent in educational research. Consider subject selection - how students were assigned to experimental groups and particularly treatment groups. The researcher had no input in how control groups were assigned; random assignment was assumed. More importantly, students in the control groups received instruction from a different teacher than those students in the treatment groups. Significant differences in teaching style, behavior management or values around environmental issues may have existed which may have impacted students' responses. The school did not engage in intentional tracking where students with high performance scores are grouped in one class, while those with low scores are grouped in another. However, unintentional tracking does exist and may have

influenced how students were assigned to groups. Students learning English as a Second Language (ESL) were in the same class with an instructional aid and students in the high level mathematics class were in only two of the five treatment groups. Several students receiving special education were in one class. Results may be biased despite intentionally assigning classes to treatment groups to balance subject performances in the first month of school (Ary, D., Jacobs L., Sorensen C., & Walker, D. 2013). Further, the environmental literacy assessment was delivered by two different people. The cooperating teacher for the program delivered the assessment to the treatment group students and the control group teacher who had little exposure to the program delivered the assessment to the control group students. Both teachers had a script, but *how* they delivered the assessment, interested or lack luster, may have affected student responses (Hildum, D. & Brown, R. 1956). Additionally, when the posttest was delivered to students in the treatment groups, those students in the leadership program were absent on a field trip. Anecdotal evidence suggested these students, roughly 30, would have scored relatively high on the environmental literacy assessment; they were unevenly distributed through the treatment groups. Effects of non-response bias was assumed moderate to nominal. The greatest difference, for any experimental group, between number of subjects taking the pre and post (posttest n/pretest n or vice versa) was 12%. The lowest difference was 0% (Berg, N. 2005).

Research bias, where the researcher communicates expectations to the subjects, may have occurred and is evident in student responses on the environmental literacy survey. Student responses in the treatment groups included statements indicated they

enjoyed working with the researcher: “it was a great experience to have with Steve” and “Steve is awesome,” while there was no mention of the researcher in any of the control group responses. Results from students with positive statements about the researcher may be affected by social desirability bias. Conversely, some results may have been negatively inflated. One open ended response in a treatment group indicated: “I did not like learning about anything Steve taught us and I thought it was extremely boring, a waste of time. Instead of boring us all year long with stuff we don't care about, let us study something we are interested in.” Furthermore, 25% of the treatment group subjects responded to the open ended question, while only 15% of the control group subjects responded to the open ended question.

The generalizability of this study may be considered across scales, for multiple populations. Given that subject assignment to either of the two science teachers (i.e. grade level blocks) was entirely random, results could be generalized for children in the 8th grade living in the Evergreen Middle School service area. Generalizing these results to students in the larger Portland metropolitan region or further, to the statewide population was not possible because Evergreen Middle School's demographics. There were larger numbers of english learners at Evergreen Middle School (24%) than in the nearby Portland School District (17%). When compared to all school's statewide for the 2013/2014 school year, Evergreen Middle School's overall proficiency rating was level three (15-44% performance) while the statewide average was level four (44-90%) (ODE 2014). Further, when compared to middle schools with similar student demographics, Evergreen Middle School was below average and fell in the the bottom third of

“comparison schools” (ODE 2014).

There was some evidence that a testing effect may have occurred. Twenty of the thirty-five pairwise differences among experimental groups occurred between treatment groups and the post-test only control group. Yet only 4 of the 35 pairwise differences among experimental groups occurred between treatment groups and the pre-posttest control group. The disparity between the number of these differences suggested a possible testing effect or that the two control groups came from different populations. In fact, there were significant among group differences between the two control groups with four of the questions. In all instances the pre-posttest control group had higher mean rank than the posttest only control group.

The environmental literacy assessment used in this study was reliable and valid. Feedback was elicited from several environmental education practitioners, researchers and students. The assessment included established measurements in the fields of conservation psychology and environmental education (Dunlap et al. 2000; Schultz 2001; Clayton 2003). The assessment was administered for two years in different middle schools throughout the region. Practitioner, student and researcher feedback was used to refine the instrument.

Chapter 3 – Conclusion:

Environmental education which includes science inquiry, environmental service-learning, outdoor experiences, E-STEM and environmental monitoring improves

environmental literacy. One component of environmental literacy, dispositions towards the environment, includes efficacy, concern and awareness of the environment, locus of control, environmental sensitivity and intention to act. These dispositions, some behaviors, competencies and knowledge were all positively affected by environmental education in this study. Furthermore, students in treatment groups gravitated to common levels of environmental literacy for each domain, suggesting an environmental literacy developmental capacity both influenced and akin to stages of predominate developmental theories (Piaget 1964; Kohlberg 1969; Maslow, A., Frager, R. & Cox R. 1970; Kohlberg, 1971; Fischer, K. 1980).

The role of the instructor, how they teach, their interest and passion, their communication style and their connection to students are some of the factors which affect student outcomes. Indeed several students referenced the study's instructor saying things like: "I ♥ Steve" and "you are the bomb.com." Who the instructor is, how they teach and what their beliefs are makes a significant difference on students' environmental literacy outcomes (Cronin-Jones 1991). Furthermore, youth with a positive adult role model, in this case the instructor, who cares for the environment facilitate environmental literacy develop; this is evident in research on significant life experiences (Chawla, L. 1999) and empirically demonstrated in this study.

Demographics and previous experiences significantly impact students' response to environmental education. Research on significant life experiences often shows that adults with high environmental literacy, dubbed 'empowered' by Roth (1992), consider formative time spent in natural settings as the most significant life experience in

developing their environmental literacy (Chawla, L. 1999). Indeed previous time in nature exerted strong influence on several behavioral and attitudinal (disposition) questions regardless of students' participation in this study's environmental education program. Further significant life experiences include a positive adult role model that cares for the environment, awareness of environmental harm and environmental education (Chawla, L. 1999). This research corroborates the understanding of the significant life experiences literature and adds detail. Students who receive environmental education and have these significant life experiences (positive adult role model who cares for the environment, frequent time outdoors, witness to environmental harm or previous environmental education) respond more positively to environmental education than those who do not. This is particularly evident for students with a positive adult role model that cares for the environment and those having previous environmental education. The synergistic influence of these significant life experiences are less clear for students having frequent previous time spent outdoors and those students having witnessed environmental harm. Considered entirely, this suggests that while significant life experiences are no doubt very important in developing a more environmentally literate population, these experiences are not in and of themselves creating more environmentally literate students. Rather, these significant life experiences are a developmental milestone which must first occur for students to respond positively to environmental education and progress toward high stages of environmental literacy.

Environmental service-learning and scientific inquiry are increasingly common in public schools. Only recently has the impact of environmental-service learning on

environmental literacy been studied (England & Marcinkowski 2007; Leege, L. & Cawthorn, M. 2008; Schneller, A. 2008). Studies on service-learning have built a body of evidence showing that meaningful service reinforces classroom learning (Honnet & Poulsen 1989; Furco 1996; Astin 2000). Studies on scientific inquiry and human learning indicate that students create new conditionalized knowledge by asking and answering questions (Welch, W., Klopfer, L., Aikenhead, G, & Robinson, J. 1981; Bybee & Goodrum 1999; Anderson 2002). How environmental literacy is impacted and, more specifically, the relative effectiveness of one strategy over the other is important and timely research. Environmental education practitioners in public schools often have a limited amount of class time to implement environmental education in the classroom, often needing to follow curricular pacing guides and prepare for standardized testing. Knowing the most effective strategies for improving environmental literacy will support environmental education practitioners implementing similar programs in their classrooms. This research informs the current topics of Environmental-Science Technology Engineering and Mathematics (E-STEM), Science and Environmental Education.

Both successes and limitations in this study point to further research. First, comparing the pedagogical techniques of environmental service-learning and science inquiry could be done with larger amounts of time differing among groups, while maintaining the content and standards static as in this study. Differences among treatment groups were nominal, possibly from relatively small variation in activities. Longitudinal analysis of this program on students' environmental literacy may reveal new

and interesting findings which were not evident immediately after the study. Consistent with educational research, replicating the study for different demographics or taught by different instructors would be helpful.

Chapter 4 – Creation of a Schoolyard Outdoor Environmental Science Learning Laboratory and its Ecological Outcomes

This chapter evaluated the biophysical outcomes of the student-led environmental service-learning program described previously in chapter three and describes program implementation. The actual ecological research project, outlined in both chapter three and described in detail in this chapter, was oriented toward assessing the environmental literacy of the participants, not to rigorously test ecological outcomes of restoration. The change in biophysical conditions resulting from environmental service-learning activities the participants in the study were compared with conditions at reference sites.

Biophysical data were quantitative and included to provide context and additional results as to some of the biophysical effects of environmental service-learning. Students participating in the environmental service-learning project engaged in similar ecological research (evaluating biophysical success of restoration) as described in this chapter. A description of student inquiry activities appears in the Green Teacher's *Teaching About Invasive Species* (Braun 2014). Program implementation was characterized with qualitative data providing insight for potential replicability for similar programs. This chapter addressed one overarching research question: *How does the quantity and quality of time associated with environmental service-learning programs affect the ecology of the areas where the program occurs?* A single case study was used to determine if an ecological effect was evident at one restoration site which resulted from environmental service-learning activities.

Chapter 4 – Research Questions:

RQ 4: Will ecological conditions at the schoolyard restoration site, restored by 8th grade students creating an outdoor environmental science learning lab, change when compared to control and reference sites given?

- **RQ 4.1:** Will plant richness, abundance and diversity at the schoolyard restoration site change when compared to reference sites?
- **RQ 4.2:** Will soil resistance at the schoolyard restoration site change when compared to reference sites?
- **RQ 4.3:** Will available soil moisture at the schoolyard restoration site change when compared to reference sites?
- **RQ 4.4:** Will soil chemistry (Nitrogen and Phosphorus) at the schoolyard restoration site change when compared to reference sites?
- **RQ 4.5:** Will Soil bulk density at the schoolyard restoration site change when compared to reference sites?

Chapter 4 – Introduction: Theoretical Background to Hypotheses Regarding Plant Community and Soil Response to Restoration

While the experiment follows an appropriate scientific layout with randomization, replicates, control and reference sites, its primary function was to facilitate student

learning about the scientific process involved in evaluating restoration projects.

Determination of success of restoration or significant relationships between restoration strategies and environmental response was beyond the scope of this project. The trajectory of the change was understood to be inconclusive given the short time period and lack of replicates in this study. Given this scope, hypotheses related to environmental response were stated with an understanding that results would ultimately be inconclusive and lack generalizability. These were included to support findings of educational response (change in students' environmental literacy) resulting from environmental service-learning discussed in chapter three of this document.

The plant community was not diverse at the beginning of the project. It was completely dominated by *Hedera helix* (english ivy), with nearly 100% cover in the site. Therefore, it was expected that as *Hedera helix* was removed and replaced with native species, abundance would decrease while richness and diversity would increase.

Restoration activities included the the addition of mulch and compost. Mulch and compost were expected to increase soil porosity and decrease evaporation which is soil water retention (Gallardo-Lara and Nogales 1987; Billeaud and Zajicek 1989; Debosz et al. 2002; Doring et al. 2005). Soil porosity is inversely related to bulk density (Gallardo-Lara and Nogales 1987; Billeaud and Zajicek 1989; Debosz et al. 2002; Doring et al. 2005). Added mulch has a high C:N ratio and may immobilize available nitrogen while existing soil fauna decompose organic material in the short term. This immobilized nitrogen will be mineralized in the long-term. Available Phosphorus is present in compost and Cation Exchange Capacity (CEC) will increase from mulch and compost

additions.

Chapter 4 – Hypotheses:

Hypothesis 4: Ecological conditions will change at the schoolyard experimental restoration site.

Hypothesis 4.1a: Plant species diversity and richness will increase at the schoolyard experimental restoration site.

Hypothesis 4.1b: Plant species abundance, measured by percent cover, will decrease at the schoolyard experimental restoration site.

Hypothesis 4.2: Soil will have less resistance (less compacted) at the schoolyard experimental restoration site.

Hypothesis 4.3: Available soil moisture will increase at the schoolyard experimental restoration site.

Hypothesis 4.4a: Available soil nitrogen will decrease at the schoolyard experimental restoration site.

Hypothesis 4.4b: Available soil phosphorus will increase at the schoolyard experimental restoration site.

Hypothesis 4.5: Soil bulk density will decrease at the schoolyard experimental restoration site.

Chapter 4 – Methodology:

Three sites were used for this study. The Society for Restoration Ecology (2004) states that two reference sites should be considered when measuring efficacy of restoration activities (third site). The first was an experimental restoration site on a schoolyard. Restoration activities (soil amendments, native plantings, invasive removal) were performed primarily by 8th grade students as part of an environmental education experience focused on environmental service-learning. Some restoration was performed by school district facilities management. The site began covered entirely by *Hedera helix*; subsequently, school district personnel removed ivy and root wads mechanically, using a back hoe in September 2013. Students spread mulch and compost, planted native species, added informational signs and set up walking paths in March and April 2014. The majority of restoration activities ended before the third sampling period (Spring 2014). However, the project was designed to encourage continued use and upkeep of the restoration site. At time of manuscript submission students had continued to upkeep the site (i.e. weeding and litter removal). The second site, a reference, was on the same

schoolyard, but was not restored by students. This site was representative of typical school landscaping, comprised mainly of ornamental shrubs with little structural diversity and requiring little maintenance. The site had similar dimensions and aspect (lengthwise north-south) as the schoolyard experimental restoration site and was 2.5 meters by 80 meters. However, a portion of the site (15 meters) ran east-west and created a right angle to the remainder of the site. The site was characterized as an example of mitigation (Society for Ecological Restoration International Science and Policy Group, 2004) and used for reference. The third site was on nearby Portland State University's campus where initial restoration began in 2001. There were follow up plantings in 2004 or 2005 and 2009 or 2010. This site was dominated by *Hedera helix* with root wads as deep as 0.5 meters throughout the site. College students from the university removed the ivy, planted native species, deposited a 10m nurse-log and added informational signage. The site was the first on campus to convert typical landscaping (ornamentals and invasives) to native species and led to the conversion of several more on-campus sites. The site had similar dimensions and aspect (lengthwise north-south) as the schoolyard experimental restoration site and was 2.5 meters by 80 meters. However, there were small sections of pavement (sidewalks) which bisected the planting strip. Therefore, there were multiple 2.5 meter wide strips of different lengths separated by small sidewalks. The site was characterized as an example of restoration (Society for Ecological Restoration International Science and Policy Group, 2004) and used for reference. The three sites used in the study are hereafter named: schoolyard experimental restoration site, schoolyard mitigation reference site and university restoration reference site.

The schoolyard experimental restoration site, where the outdoor environmental science lab was created, is a long narrow parking strip on the west side of Evergreen Middle schoolyard³⁹. It was approximately 2 x 60 meters and ran lengthwise north/south. Immediately west of the site were private residences with tall wooden fences. There was a parking lot to the east. The restoration established an outdoor environmental science field laboratory used by the science department at Evergreen Middle School (Braun 2014). As an outdoor field laboratory, different restoration treatments were employed for students to study biotic and abiotic response⁴⁰. Consideration of these different treatments was not included in this analysis, rather all treatments were seen as one restoration treatment. Variation among these different treatments were accounted for as a range or combination of restoration strategies.

A fourth site, a control site adjacent to the schoolyard experimental restoration site which would receive no restoration, was proposed but was not used. The school district applied herbicide on the proposed site during the study period and this was not communicated to the researcher. It was determined both unsafe and confounding. Further, it was unclear if chemical management (herbicide) of the proposed area began as a result of this project. No management had occurred until this project began.

Restoration of the schoolyard experimental restoration site employed biotic and abiotic modifications. Restoration activities began in September 2013 after baseline data were recorded. One-hundred and eight 8th grade students, the Principal Investigator,

39 See Fig 4.3 Overview of Evergreen Middle School Restoration and Reference Site Locations on page 284

40 See Fig 4.1 Evergreen Middle School Outdoor Learning Laboratory Layout and Fig 4.2 Evergreen Middle School Outdoor Learning Laboratory Treatment Designations on page 283 Figures are provided for background and most pertinent to learning activities to be discussed Chapter #3 Results and Analysis.

school district facilities personnel and the 8th grade science teacher employed restoration modifications. These modifications included:

- The mechanical removal of invasive species with a backhoe, originally 100% *Hedera helix*.
- The hand removal of invasive species throughout the study period (weeding).
- Increasing surface roughness of existing soil (tilling from 5 - 25 cm).
- Adding soil amendments with 14 yards of topsoil, 4 yards of compost and 4 yards of pine fir mulch (16.82 cubic meters) spread over 120 sq meters.
- Planting 60 native species (perennial herbs, shrubs and small trees).
- Watering plantings, using watering cans directly on plantings, twice per week during periods of no rainfall.

Restoration strategies took place during the 2013/2014 school year. Students did not participate in designing the experiment or restoration layout. Native plant species were dependent on available donations. It was proposed by the principal investigator that only native plant species which occurred on either of the two reference sites would be planted at the schoolyard experimental restoration. However, financial considerations drove native plant species decisions. Selection of soil amendments were also determined by cost and availability of donations.

Environmental data were recorded at the three sites by the principal investigator in order to evaluate restoration success (Passell 2000; Purcell et al. 2002; SER 2004 as cited in Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005). These data were used for the analysis discussed here. These same data were gathered by the students involved in this project,

yet those data were not used in the analysis which follows. Student data were used for in-class scientific inquiry and student presentation at the Joint Aquatic Sciences Meeting in Portland, Oregon in May 2014. Student data may be used at a later time for citizen science research by the principal investigator. Multiple variables were measured and considered good practice when assessing restoration success (SER 2004; Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005). The data used in this analysis (data collection by principal investigator) included:

- Plant cover, visual estimation;
- Soil moisture, taken with Vernier Soil Moisture Probe;
- Soil resistance (compaction) values, taken with a handheld Lang Penetrometer;
- Soil chemistry, analyzed at A & L Western Laboratories Incorporated; and
- Soil bulk density, analyzed at A & L Western Laboratories Incorporated.

The soil and plant community parameters were chosen by the researcher because they were tangible (e.g., students could feel change in compaction or see change in plant community composition) or, in the case of soil chemistry, had been shown to exert significant influence on plant community structure (Huenneke, L. F., Hamburg, S. P., Koide, R., Mooney, H. A., & Vitousek, P. M. 1990). These data were gathered over a two year time span (2013-2014) in order to determine a response to restoration treatment. Data were collected prior to restoration in spring 2013 (5/2013), during restoration in fall 2013 (10/2013), after most restoration activities occurred in spring 2014 (5/2014) and in fall 2014 (10/2014). Data were collected in spring and fall in order to capture seasonal variation (Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005). The short period of time to

determine response may be seen as a shortcoming of this study, yet was representative of many restoration managers' time scale (Mitsch, W. J., & Wilson, R. F. 1996), typical for a schoolyard project and was inherent in PhD research. It is recognized however, that long-term monitoring is ideal and labeling a project as successful may not be accurate without long-term monitoring of a site (SER 2004; Palmer et al. 2005). Moreover, as stated previously, discussed in detail in chapter three, the primary purpose of this project was to determine educational response (change in environmental literacy) resulting from environmental service-learning (restoring a schoolyard to create an outdoor environmental science laboratory). The project was designed to be suited for student learning: comparing before and after effects among different sites (Braun 2014). Of course, another purpose of this research, to consider the ecological 'success' of this restoration project, followed the same design: comparing before and after effects among different sites.

Each of the three sites were sampled no more than four times over the course of one year and a half. The schoolyard experimental restoration site was sampled four times: spring 2013, fall 2013, spring 2014 and fall 2014. The schoolyard mitigation reference site was sampled three times: fall 2013, spring 2014 and fall 2014. The university restoration reference site was sampled two times: spring 2014 and fall 2014. Conditions at reference sites were assumed identical for each season from year to year. For example, conditions at the university restoration reference site were sampled in spring of 2014 but were not sampled during spring 2013. However, data from spring 2014 were used to represent conditions during 2013. In both instances (university

restoration reference site and schoolyard mitigation site) where conditions were assumed, initial management, restoration or landscaping activities occurred more than ten years ago and communities are relatively stable (Mooney, H. A., Hamburg, S. P., & Drake, J. A. 1986) where significant interannual change is unlikely. Table 4.1 shows when each of the sites were sampled and when values were assumed.

Table 4.1 Site Sampling Schematic Table shows when each of the three sites were sampled and when values were assumed.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site	Sampling Occurred	Sampling Occurred	Sampling Occurred	Sampling Occurred
Schoolyard Mitigation Reference Site	Data Assumed	Sampling Occurred	Sampling Occurred	Sampling Occurred
University Restoration Reference Site	Data Assumed	Data Assumed	Sampling Occurred	Sampling Occurred

Fitting a model to observed changes in the environmental data taken during these points in time may have provided inaccurate predictions. Therefore, statistical analysis compared measures of central tendency and variation among groups (Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005). Long term data may be collected and further analyzed, but was beyond the scope of this study. Longitudinal data would support student learning and provides a more accurate account of the ecological impacts of restoration activities.

In order to address *Research Question 4.1: Will plant richness, abundance and diversity at the schoolyard restoration site change when compared to reference sites?* plant communities were measured at each of the four sites by visually estimating percent

cover using randomly placed square meter quadrats. Twenty randomly placed replicas were used to accurately capture the community composition. At the restoration site, the sample was approximately 1/6 of the population: 20 square meters sampled of the 120 square meters of the total area. Adequate sample size was confirmed by plotting percent cover of each species against sample size (Barbour et al. 1997) for all four sites after each four points in time.

Each of the three sites' plant communities were characterized for each of the four sampling periods according to species richness, percent of total area covered by plants, percent of area with as bare ground, Simpsons diversity and Shannon-Wiener diversity. Beta diversity was calculated and is listed below using both Simpsons and Shannon-Wiener indices, however, further mention discussions of beta diversity is restricted to Shannon-Wiener index, expect where listed in Table 4.2 for reference. The Shannon-Wiener index is less affected by multiple relatively rare species and more suitable for a community dominated by a very few abundant species (Boyle, T. P., Smillie, G. M., Anderson, J. C., & Beeson, D. R. 1990). The Percent Similarity index (Czenkowski) was calculated to compare among sites through the four points in time (Thom et al. 2002; Steen et al. 2013). Weighted and unweighted indices were used. The weighted index accounted for percent of species cover, while the unweighted index considered only species richness. The change between points over time were used to evaluate possible change towards or away from reference sites (Zedler & Callaway 1999; Steen et al. 2013).

Soils were considered in several ways. All measurements were taken on the same

day early in the morning to limit the influence of evapotranspiration from plant uptake and incident radiation. In order to address *Research Question 4.2: Will soil resistance at the schoolyard restoration site change when compared to reference sites?* soil resistance or compaction values, taken at field capacity (except fall 2014 which was especially dry), were measured using a handheld Lang penetrometer (Arshad et al. 1996, Doran & Jones 1996). Five randomly placed replicates were taken at each location to capture within site variation (Dick et al. 1996). In order to address *Research Question 4.3: Will available soil moisture at the schoolyard restoration site change when compared to reference sites?* soil moisture at field capacity (except fall 2014 which was especially dry) was measured using a Vernier Soil Moisture Probe (Arshad et al. 1996, Doran & Jones 1996). The probe had a level of precision to 0.1%, measured a range of 0 – 45% volumetric water content with $\pm 4\%$ accurate readings. Five randomly placed replicates were taken at each location to capture within site variation (Dick et al. 1996). The United States Geological Survey rain gage and Portland HYDRA networks⁴¹ were used to determine precipitation values at each site for 24 hours, 72 hours and 168 hours prior to sampling.

In order to address *Research Question 4.4: Will available soil chemistry at the schoolyard restoration site change when compared to reference sites?* and *Research Question 4.5: Will soil bulk density at the schoolyard restoration site change when compared to reference sites?* composite soil samples were analyzed at A & L Western Laboratories Incorporated. Composite samples were taken using five randomly placed replicates at each location to capture within site variation (Dick et al. 1996). For each

41 USGS station ID 452657122481700 used for schoolyard experimental restoration site and schoolyard mitigation reference site. Nearby Portland HYDRA network gage at 2033 NW Glisan St. was used for university restoration reference site.

replica, organic material was removed and one small shovel of soil taken from the A-horizon was mixed into a bucket. Soil from each replica was thoroughly mixed to produce the composite sample which comprised of 50% of the total soil. A & L Western Laboratories Incorporated also analyzed the soil texture of the composite samples. It was intended that these data (chemistry, bulk density and texture) would be gathered for three points in time: fall 10/2013 (T=1), spring 2014 (T=2) and fall 2014 (T=3). This was due to seasonal variation in nitrogen availability and cost of lab work. There were however, communication issues with the laboratory and bulk density was not measured for the university restoration reference site in fall 2013, nor was bulk density measured for any of the three sites during fall 2014. Considering this shortcoming some data were arranged without statistical analysis. For all other soil parameters, variance among the groups were statistically analyzed using ANOVA and Tukey's HSD test to determine significant differences among sites over time (Zedler & Callaway 1999; Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005).

Measuring infiltration rates was proposed but abandoned. Infiltration rates were especially slow and would have been functionally irrelevant. During the fall 2013 sampling period, infiltration rates at the schoolyard experimental restoration site and the schoolyard experimental restoration site slowed to less than 1 cm/hour. All three sites were in urban settings, adjacent to large impervious areas (pavement) and enclosed by cement curbs. There was significant variation among sites in how close the top of the soil was to the cement curb. In some instances the soil level was higher than the curb, while in other instances the soil was below the curb. Further, there was a range of soil to

curb levels within each site. Whether water flowed overland to impervious areas or infiltrated the soil would, during high intensity rain events, be a function of curb engineering if any ponding occurred. Given the infiltration rates obtained during the fall 2013 sampling period, ponding and overland flows were likely to occur during rain events.

Chapter 4 – Results:

Research Question 4.1: Will plant richness, abundance and diversity at the schoolyard restoration site change when compared to reference sites?

The plant community changed at the schoolyard experimental restoration site, but it is not clear which of the two reference sites was more similar. Species richness of the schoolyard experimental restoration site began with only one species present, *Hedera helix* (english ivy), and had at least twenty-two species in spring 2014. The schoolyard mitigation reference site had less species (richness range: 14-15) than the university restoration reference site (richness range: 43-44). The total area covered by plants at the schoolyard experimental site began as 100%, prior to any restoration activities (spring 2013). After ivy was removed (fall 2013), 2% of the site was covered with plants. After soil amendments (mulch and compost) were added and native plantings occurred (spring 2014 & fall 2014), between 10% and 14% of the site was covered with plants. The total area covered by plants at the schoolyard mitigation reference site ranged between 64%

and 73%. The total area covered by plants at the university restoration reference site ranged between 82% and 92%. Beta diversity increased at the schoolyard experimental restoration site. It began with a Shannon-Wiener value of 0 (spring 2013); at the end of the sampling period the Shannon-Wiener value was 2.3. Beta diversity was higher at the university restoration reference site (Shannon-Wiener range: 2.9 – 3.1) than at the schoolyard mitigation reference site (Shannon-Wiener range: 1.6 – 1.8). Table 4.2 characterizes the plant communities and lists each of these measures for each site during each sampling time; scatterplots show total cover, species richness and beta diversity.⁴²

Table 4.2 Characterization of Plant Communities Table lists plant community measures: species richness, total area covered, area of bare ground, Shannon-Wiener diversity index and Simpsons diversity index. * indicates that area of bare ground is not inverse of total area covered because cover estimations may exceed 100%. Cover was estimated from breast height, ~1.5 meters, to the ground.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site	Richness: 1 Total Cover: 100% Bare Ground: 0% Shannon-Wiener: 0 Simpsons: 0	Richness: 6 species Total Cover: 2 % Bare Ground: 98 % Shannon-Wiener: 1.1 Simpsons: 0.52	Richness: 22 species Total Cover: 14 % Bare Ground: 88* % Shannon-Wiener: 2.4 Simpsons: 0.87	Richness: 20 species Total Cover: 10 % Bare Ground: 95* % Shannon-Wiener: 2.3 Simpsons: 0.86
Schoolyard Mitigation Reference Site	Not sampled	Richness: 14 species Total Cover: 64 % Bare Ground: 41* % Shannon-Wiener: 1.8 Simpsons: 0.79	Richness: 15 species Total Cover: 70 % Bare Ground: 37* % Shannon-Wiener: 1.6 Simpsons: 0.74	Richness: 15 species Total Cover: 73 % Bare Ground: 55* % Shannon-Wiener: 1.8 Simpsons: 0.79
University Restoration Reference Site	Not sampled	Not sampled	Richness: 43 species Total Cover: 82* % Bare Ground: 25* % Shannon-Wiener: 3.1 Simpsons: 0.94	Richness: 44 species Total Cover: 92* % Bare Ground: 49* % Shannon-Wiener: 2.9 Simpsons: 0.92

The Proportional Similarity Index (PSI) (Czekanowski) was used to estimate similarity in species composition and species cover among sites for each sampling period

⁴² See Figs 4.5a-c on pages 286-287

(Bray & Curtis 1957 as cited by Thom et al. 2002). The unweighted Proportional Similarity Index estimates similarity in species composition, while the weighted Proportional Similarity Index estimates similarity in terms of percent cover. Proportional Similarity Index (weighted and unweighted) estimates for each reference site and the schoolyard experimental restoration site are listed in Table 4.3. The weighted Proportional Similarity Index value of the schoolyard experimental restoration site and the schoolyard mitigation reference site for spring 2013 exceeded 100%. Calculated values can exceed 100% in communities with 100% cover of only one species if that species occurs in both communities. However, two communities can not be more than 100% similar and this value was omitted from further analysis. The schoolyard experimental restoration site began (spring 2013) more similar to the schoolyard mitigation site (PSI unweighted: 12.5%) than to the university restoration reference site (PSI unweighted: 0%). The schoolyard experimental restoration site ended (fall 2014) more similar to the university restoration reference site (PSI unweighted: 31.3% & PSI weighted 48.7%) than to the schoolyard mitigation site (PSI unweighted: 28.6% & PSI weighted 14.9%).

Table 4.3 Similarities Among Sites Table lists proportional similarity index estimates for each reference site and the schoolyard experimental restoration site. Both weighted and unweighted values are listed. Theoretically, values range between 0% similar and 100% similar. However, as denoted by *, calculated values can exceed 100% in communities with 100% cover of only one species if that species occurs in both communities. Values for Schoolyard Mitigation Reference Site in Spring 5/2013 were assumed equal to values for Spring 5/2014. Values for University Restoration Reference Site in Spring 5/2013 were assumed equal to values for Spring 5/2014 and Fall 10/2013 were assumed equal for Fall 10/2014.

Sites	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site x Schoolyard	PSI unweighted (species composition): 12.5%	PSI unweighted (species composition): 10.0%	PSI unweighted (species composition): 16.2%	PSI unweighted (species composition): 28.6%

Mitigation Reference Site	PSI weighted (species cover): 120%* <i>Based on Some Assumed Reference Site Data</i>	PSI weighted (species cover): 11.4%	PSI weighted (species cover): 73.2%	PSI weighted (species cover): 14.9%
Schoolyard Experimental Restoration Site x University Restoration Reference Site	PSI unweighted (species composition): 0% PSI weighted (species cover): 0% <i>Based on Some Assumed Reference Site Data</i>	PSI unweighted (species composition): 4.00% PSI weighted (species cover): 0.638% <i>Based on Some Assumed Reference Site Data</i>	PSI unweighted (species composition): 36.9% PSI weighted (species cover): 66.5%	PSI unweighted (species composition): 31.3% PSI weighted (species cover): 48.7%

Research Question 4.2: Will soil resistance at the schoolyard restoration site change when compared to reference sites?

Examination of Soil resistance rates revealed little conclusive evidence of change at the schoolyard experimental restoration site. Normal distribution was confirmed with Shapiro-Wilk's tests for all sites at each of the three sampling periods. There was only one instance where data were not normally distributed, The schoolyard mitigation reference site in fall 2014 (W: 0.776, df: 5, Sig. 0.050). Homogeneity of variance based on means was confirmed with Levene's test statistic for all three sites during each of the three sampling periods: fall 2013, spring 2014 and fall 2014. ANOVA tests revealed no instances where significant differences occurred among sites. Further examination of among-group differences occurred with a Kruskal-Wallis test and discovered no significant differences among the three sites for each of the three sampling periods.

Descriptive statistics for soil resistance at each of the sites during the sampling period are provided in Table 4.4.

Table 4.4 Soil Resistance Table displays descriptive statistics for each of the of the three sites.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site	soil resistance not measured	Mean: 5.70 psi S.D.: 0.908	Mean: 6.70 S.D.: 3.134	Mean: 13.16 S.D.: 3.406
Schoolyard Mitigation Reference Site	soil resistance not measured	Mean: 6.88 psi S.D.: 2.958	Mean: 6.40 S.D.: 2.679	Mean: 12.50 S.D.: 1.458
University Restoration Reference Site	soil resistance not measured	soil resistance not measured	Mean: 5.50 S.D.: 1.969	Mean: 9.70 S.D.: 3.581

Research Question 4.3: Will soil moisture at the schoolyard restoration site change when compared to reference sites?

There is some indication that soil moisture at the schoolyard experimental restoration site became more similar to the university restoration reference site. Five replicas were taken at each site of the three sites during three sampling periods: fall 2013, spring 2014 and fall 2014. During the fall 2014 sampling, soils were especially dry with less than 1 cm of precipitation during the preceding 2 weeks. Soil moisture readings were not taken in spring 2013. Average values were computed and show patterns typical of the Pacific Northwest, with relatively low soil moisture in the fall at the end of the summer drought. Normal distribution was confirmed with Shapiro-Wilk's tests for all

sites at each of the three periods which were sampled. There was only one instance where data was not normally distributed, the experimental restoration site in fall 2014 (W: 0.657, df: 5, Sig. 0.003). Homogeneity of variance based on means was confirmed with Levene's test statistic for all three sites during each of the three sampling periods: fall 2013, spring 2014 and fall 2014. ANOVA tests revealed one instance where significant differences occurred among sites, fall 2014 (Mean Sq.: 34.038, F:6.140, Sig: 0.015). A subsequent Tukey's HSD test indicated one significant difference between the schoolyard experimental restoration site and the schoolyard mitigation reference site (Mean Difference: 4.980, Sig: 0.015). Given that the soil moisture data was not normally distributed for the schoolyard experimental restoration site during fall 2014, further examination of among group differences occurred. A Kruskal Wallis test confirmed a significant difference (test stat: 7.900, Adj.Sig: 0.016) between the schoolyard experimental restoration site (mean soil moisture 8.76%) and the schoolyard mitigation reference site (mean soil moisture 3.78%). Descriptive statistics for soil moisture and antecedent conditions at each of the sites during the sampling period are displayed in Table 4.5.

Table 4.5 Soil Moisture and Antecedent Conditions Table shows average soil moisture and antecedent conditions for each of the three sites and lists significant ANOVA values for soil moisture.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site	soil moisture not measured	Mean: 11.02% S.D.: 9.217 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.43 cm <i>168 hr precipitation</i> 11.15 cm	Mean: 20.48% S.D.: 0.896 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.00 cm <i>168 hr precipitation</i> 1.98 cm	Mean: 8.76% S.D.: 1.823 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.03 cm <i>168 hr precipitation</i> 0.15 cm

Schoolyard Mitigation Reference Site	soil moisture not measured	Mean: 7.32% S.D.: 1.228 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.43 cm <i>168 hr precipitation</i> 11.15 cm	Mean: 20.66% S.D.: 4.413 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.00 cm <i>168 hr precipitation</i> 1.98 cm	Mean: 3.78% S.D.: 1.101 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.03 cm <i>168 hr precipitation</i> 0.15 cm
University Restoration Reference Site	soil moisture not measured	soil moisture not measured	Mean: 22.12% S.D.: 5.393 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.00 cm <i>168 hr precipitation</i> 0.43 cm	Mean: 7.62% S.D.: 3.478 <i>24 hr precipitation</i> 0.00 cm <i>72 hr precipitation</i> 0.48 cm <i>168 hr precipitation</i> 0.61 cm
Among Group Differences (ANOVA)	n/a	Not significant	Not Significant	Mean Sq.: 34.038 F: 6.140 Sig. 0.015

Research Question 4.4: Will soil chemistry at a schoolyard restoration site change when compared to reference sites?

Simple summary statistics were gathered but provided little evidence of change at the schoolyard experimental restoration site. Table 4.6 illustrates that the soil chemistry (N&P in particular) was highest at the university restoration reference site throughout the sampling period. The soil became more alkaline at the schoolyard experimental restoration throughout the restoration (pH 5.5 in fall 2013 and pH 7.0 in fall 2014).

Table 4.6 Soil Chemistry Table shows relevant soil chemistry values for each of the three sites. Phosphorus values are reported according to Weak Bray Method unless indicated by *, in which case Olsen method was used because of pH.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental	soil chemistry not measured	Phosphorus: 63(51*)ppm	Phosphorus: 33 (159*)ppm	Phosphorus: 39 (51*)ppm

Restoration Site		Nitrogen (NO3): 56ppm pH: 5.5	Nitrogen (NO3): 6ppm pH: 7.6	Nitrogen (NO3): 4ppm pH 7.0
Schoolyard Mitigation Reference Site	soil chemistry not measured	Phosphorus: 64ppm Nitrogen (NO3): 52ppm pH 5.4	Phosphorus: 43ppm Nitrogen (NO3): 20ppm pH: 5.6	Phosphorus: 42 Nitrogen (NO3): 5 pH 5.1
University Restoration Reference Site	soil chemistry not measured	soil chemistry not measured	Phosphorus: 160ppm Nitrogen (NO3): 68ppm pH: 5.7	Phosphorus: 121ppm Nitrogen (NO3): 84ppm pH 5.1

Research Question 4.5: Will soil bulk density at the schoolyard restoration site change when compared to reference sites?

Simple summary statistics illustrated little change within each site throughout the sampling period. Table 4.7 shows that bulk density was relatively consistent among and within sites. Soil texture at the schoolyard experimental restoration site changed slightly from silt loam (fall 2013) to loam (spring 2014); soil was amended at the site between the two sampling dates. Soil texture at the university restoration reference site was consistently sandy loam.

Table 4.7 Physical Characteristics of Soil Table shows soil bulk density and soil texture for each of the three sites.

Site	Sampling Period			
	Spring 5/2013 (T=0)	Fall 10/2013 (T=1)	Spring 5/2014 (T=2)	Fall 10/2014 (T=3)
Schoolyard Experimental Restoration Site	<i>bulk density:</i> not measured <i>soil texture:</i> not measured	<i>bulk density:</i> 1.28 g/cc <i>soil texture:</i> silt loam	<i>bulk density:</i> 1.19 g/cc <i>soil texture:</i> loam	<i>bulk density:</i> not measured <i>soil texture:</i> loam
Schoolyard Mitigation	<i>bulk density:</i> not measured	<i>bulk density:</i> 1.15 g/cc	<i>bulk density:</i> 1.10 g/cc	<i>bulk density:</i> not measured

Reference Site	<i>soil texture:</i> not measured	<i>soil texture:</i> loam	<i>soil texture:</i> loam	<i>soil texture:</i> loam
University Restoration Reference Site	<i>bulk density:</i> not measured <i>soil texture:</i> not measured	<i>bulk density:</i> not measured <i>soil texture:</i> sandy loam	<i>bulk density:</i> 1.16 g/cc <i>soil texture:</i> sandy loam	<i>bulk density:</i> not measured <i>soil texture:</i> sandy loam

Chapter 4 – Discussion:

Results of this study considered biophysical outcomes of a restoration project associated with environmental service learning activities of 8th grade students. Although results are discussed within a restoration ecology framework (SER 2004), this section of study, contained within this chapter, was designed to support an analysis of educational results. Altogether, a paired study occurred which considered educational and biophysical effects of environmental service-learning across scales. The discussion within this chapter considers only the biophysical effects of environmental service-learning of one project. Results are discussed first in terms of the impacts of restoration to the plant community. Next, results are discussed in terms of the impacts of restoration to the soil. The discussion concludes with consideration of bias, generalizability and validity.

Impacts of Restoration to the Plant Community

The plant community changed significantly as a result of the restoration project. The schoolyard experimental restoration site began as an ivy desert (spring 2013).

Throughout the study richness increased significantly, twenty-two species were identified in spring 2014. Beta diversity also increased significantly at the site. Abundance of plant species decreased substantially at the site, changing from 100% cover and no bare ground to 10% covered and 95% bare ground (fall 2014).

Hypotheses 4.1: Plant species diversity and richness will increase at restoration site. and Plant species abundance, measured by percent cover, will decrease were both confirmed.

Some evidence suggests that the schoolyard experimental restoration site will follow a trajectory and become more similar to the university restoration reference site rather than the schoolyard mitigation reference site. Unweighted Proportional Similarity Index scores indicate that the schoolyard experimental restoration site became more similar to the university restoration reference site than to the schoolyard mitigation reference site. Weighted Proportional Similarity Index scores show conflicting results but must be considered in terms of total percent cover. The total percent cover of the schoolyard experimental restoration site was very low during the final 2014 sampling periods (10% - 14%) and therefore highly influenced by any species with relatively high cover. Moreover, the native plants were planted at the schoolyard restoration experimental site one month prior to sampling. Therefore, the unweighted Proportional Similarity Index scores are considered to be a superior measure because they are less responsive to percent cover (very little at schoolyard restoration experimental site) and captured the plant community's richness despite not yet being established. Beta diversity

and richness values increased significantly at the schoolyard experimental restoration, surpassing the values of the school mitigation reference site. Beta diversity and richness values may support the conclusion that schoolyard experimental site is on a trajectory towards the university restoration reference site rather than the schoolyard mitigation reference site. However, beta diversity and richness may remain stable because future intentional input of native species is not expected to occur.

Impacts of Restoration to the Soil

The soil functioning, in terms of water retention, at the schoolyard experimental restoration site may have improved throughout the study. The average soil moisture in fall 2013 was 11.02%. Soil moisture varied throughout the sampling period which was expected given seasonal fluctuations in weather patterns. There were no significant differences among the sites in the beginning of the study (fall 2013). At the end of the study however, the schoolyard experimental restoration site had significantly higher soil moisture than the schoolyard mitigation reference site. Although this suggests that water retention of the schoolyard experimental restoration site may have improved, there was no other evidence to support this conclusion.

Hypothesis 4.2: Available soil moisture and soil infiltration rates will increase at the schoolyard experimental restoration site was rejected for soil moisture.

The soil at the schoolyard experimental restoration site became more compact throughout the study. The average soil resistance value in fall 2013 was 5.70 psi with little variation among replicas (s.d. 0.908) but the mean more than doubled to 13.16 psi in fall 2014 with significant variation among replicas (s.d. 3.406). Increased compaction may be the result of students' increased use of the area for associated environmental education activities. However, no significant differences occurred among the sites within each sampling period. Therefore, increased resistance values at the schoolyard experimental restoration site may be a result of environmental factors not considered in this research. Students were observed in several instances walking in the schoolyard restoration experimental site and may have contributed towards compaction (Deluca, T. H., Patterson IV, W. A., Freimund, W. A., & Cole, D. N. 1998).

Hypothesis 4.3: Soil will become less compact at the schoolyard experimental restoration site was rejected.

Results from the analysis of soil chemistry were inconclusive. Nitrogen levels (NO₃) at the schoolyard experimental restoration site and the schoolyard mitigation site decreased throughout the study. Phosphorus levels were reported with two different methods. Given the variation of pH (5.0-7.6) two methods for determining Phosphorus levels were used, the Weak Bray and Olsen method. Interpreting phosphorus levels was further complicated by the small sample size and short time span of the study (n=3 over 1.5 years).

Hypothesis 4.4a: Available soil nitrogen will decrease at the schoolyard experimental restoration site was confirmed.

Hypothesis 4.4b: Available soil phosphorus will increase at the schoolyard experimental restoration site was rejected.

Analysis of the physical characteristics of the soil yielded inconclusive results. Soil bulk density was not determined during the final sampling period. Soil bulk density decreased slightly for both the schoolyard experimental restoration site and the schoolyard mitigation reference site, but the differences were nominal.

Hypothesis 4.5: Soil bulk density will decrease was rejected.

Ecological Impacts Within Context of Educational System

There is evidence showing that environmental service-learning improves participants' environmental attitudes (Curry et al. 2002; MacFall 2012), yet ecological outcomes to service-learning projects are infrequently considered. Likewise, restoration projects are often evaluated in terms of ecological outcomes; this is despite calls for more sociological analysis of restoration projects (Palmer et al. 2005; Ruiz and Aide 2005). The project described here, where students restored a schoolyard site to develop an

outdoor environmental learning lab, is part of a larger project which employs both a sociological and ecological analysis⁴³. The ecological analysis described in this chapter supports and provides significant texture to the educational impact of service-learning at this site. Assessing the effectiveness of environmental education in improving environmental quality is a strategic goal of the Environmental Protection Agency's Educational office (Potter, G. 2009). The observational case study outlined in this chapter may assist environmental education practitioners that need or choose to demonstrate ecological outcomes to students, community members, school administrators and land managers.

The ecological outcomes resulting from restoration at the site were, when considered in isolation, without much statistical power. These outcomes were however, audience appropriate. Students, school and community members witnessed a change in ecological conditions which were stacked with an educational function. The site included a clear scientific design with clearly labeled plots, each with different restoration treatments. These treatments involved different soil amendments and planting composition across the plots. The laboratory, associated curriculum and staff training provided students the materials, space, location and support necessary to ask and answer ecological questions related to environmental science in general, and restoration ecology in particular. Combining ecological functions with educational functions increases the likelihood that the project is self-sustainable, albeit with human inputs. Self-sustainability is an attribute for a restored system (SER 2004). Oftentimes restored areas are neglected after initial excitement wanes or if pivotal people (e.g., researcher,

⁴³ See chapter #3 for sociological (educational) analysis.

passionate teacher) moves on to other projects. Assuming the outdoor learning laboratory continues to be utilized by future classrooms, the success level of this restoration project will be by including a consideration of biophysical outcomes over time rather than being just a one-time environmental service-learning project.

Bias, Generalizability And Validity

The findings of this research are not generalizable. The efficacy of restoration treatments were not critically evaluated, nor were the methods for assessing the restoration novel. Rather, this research shows the impact of a particular environmental service-learning project. Initial results were shown to the students who participated in restoration and monitoring activities. Likewise, students displayed the findings of their research on the impact of the environmental service-learning project at the 2014 Joint Aquatic Sciences Meeting in Portland, Oregon. Similar projects could occur with similar outcomes (e.g., it is logical to presume that several 8th grade students working on a restoration site would compact soils, regardless of soil modifications). However, this project was site specific and was unique to both the restoration site and restoration practitioners. The generalizability of this research lay in the process – assessing biophysical outcomes of an environmental service-learning project may demonstrate value beyond educational outcomes if a particular environmental service-learning project is successful.

Several site-specific considerations were not considered. Legacy effects of

previous land management may have occurred. Fill dirt was present in the schoolyard restoration experimental site. Edge effects were likely to have occurred. All sites ran lengthwise north-south with a large parking lot directly east. Connectivity was not considered. The university restoration reference site was an isolated patch completely surrounded by cement, where both sites on the schoolyard were bordered by residential yards to the east.

Bias may have occurred in this analysis of the biophysical outcomes of this schoolyard restoration project. First, the project evaluation occurred on a very short timeline. Only four sampling periods occurred for each of the three sites. It was difficult to draw conclusions with data from only two years. Several years are often needed to evaluate restoration projects (Ruiz and Aide 2005). Furthermore, a control site was not used. Two reference sites provided data on where the schoolyard restoration experimental site may have trajected towards, yet data on how the site trajected away from a control would have provided meaningful information. While we can assume data on a theoretical control site's vegetation (i.e. 100% *Hedera helix*), it would be difficult to assume qualities of the soil.

The validity of this study was considered within the larger context of this research. This research is recognized as a component of social-ecological research analyzing both the educational and ecological impacts of an environmental service-learning project. Within this context, understanding some of the shortcomings (e.g., small sample size, short-timeline, lack of controls, assumed data), the research is valid. Conversely, if considered in isolation, it is clear that the research could not adequately

answer several of the research questions.

Chapter 4 – Conclusion:

Labeling a restoration project as 'successful' involves several considerations. When discussing river restoration, Palmer et al. (2005) state that the most effective restoration involves three types of success: ecological success, stakeholder success and learning success. Stakeholder success in this project involved education and aesthetics; recreation and economic benefits did not occur. The restoration activities provided educational opportunities and changed the aesthetics of the site. Learning success involved scientific contribution (this coupled study) and management experience (students, researcher and teacher); improvement of restoration methods did not occur. Ecological success, the central tenet to this chapter, involved a guiding image, ecological improvement, self-sustaining, no lasting harm done and that assessment was completed. Given these parameters, the project could be deemed an ecological success. The guiding image was for an outdoor environmental science laboratory with native plants arranged with a scientific design for future study. The change to the plant community demonstrate an aspect of improved ecological conditions, yet response of soil functioning was unclear. Assessment was completed, though recognized that long-term monitoring needs to occur.

This project may not accurately be labeled as successful when applying the nine attributes of a restored ecosystem as indicated by the Society of Ecological Restoration International (SER 2004). In their review article in *Restoration Ecology*, Ruiz- Jaen &

Aide (2005) summarize the nine attributes well: “ 1.) similar diversity and community structure in comparison with reference sites, 2.) presence of indigenous species, 3.) presence of functional groups necessary for long term stability, 4.) capacity of the physical environment to sustain reproducing populations, 5.) normal functioning, 6.) integration with the landscape, 7.) elimination of potential threats, 8.) resilience to natural disturbances, and 9.) self-sustainability.” Applying the nine attributes it is clear that we can not label the site 'restored.' At best only the first two attributes may be relevant. Of course, this research project was subject to several of the constraints detailed in Ruiz-Jaen et al.'s report (2005) relating to time and financial constraints. Long term monitoring was beyond the scope of this project. Further, this research is similar to several of the reviewed studies which assessed diversity and vegetation structure (Ruiz- Jaen, M. C., & Mitchell Aide, T. 2005).

Perhaps the most successful component of this restoration project lay in its educational capacities. The site will require consistent maintenance from students at least until there is an established plant community. With 10% - 20% plant cover currently, students pulled invasive and weedy species twice after the initial planting. It is expected that students will regularly utilize the site for scientific inquiry; the participating teacher has two well defined environmental science inquiry activities (Braun, S. 2014). The first activity pertains to plant community response (recruitment rates) to restoration strategies and the second to pertains to soil function response (infiltration rates or soil moisture) restoration strategies. Assuming that students continue to study and maintain the restoration site, students are likely to develop a sense of place, increased locus of control

and practice inquiry and land management skills (Curry et al. 2002; Schneller 2008).

This type of educational success depends on teachers in the school using the schoolyard restoration experimental site. Thus the site was designed specifically to encourage continued use as outdoor environmental science laboratory.

Considering biophysical elements, essential to restoration, may add value to future educational studies. Environmental education practitioners often rely on scant funding to achieve their objectives. Considering scientific ecological results may expand possible funding sources to include organizations interested in conservation and resource management. Comparing student results with those used here, from the scientist, could be relevant to citizen science research. Further, providing ecological results could be used in community outreach. Developing sustaining partnerships and promoting understanding is essential to environmental education. Furthermore, students benefit from understanding the value of their work. Considering the biophysical elements reinforces the authenticity of their work (Newmann & Wehlage 1993) and may help to test the value of real-world ecological work.

Chapter 5 – Dissertation Summary and Concluding Remarks:

Summary and Future Research

Several key findings emerged from this research. Youth with an adult role model who cares for the environment have higher environmental literacy than youth without an adult role model who cares for the environment. Moreover, youth with such a role model are more likely to positively respond to environmental literacy than youth without. Similar patterns occurred for youth with frequent previous outdoor experiences, having witnessed harm to the environment and having received previous environmental education and demonstrated the value of these significant formative life experiences of increasing environmental literacy.

Environmental education increases environmental literacy. Furthermore, multiple environmental education experiences collectively develop youths' environmental literacy. Youth with multiple environmental education experiences had higher environmental literacy than youth with only one environmental education experience.

The research described here, asked questions about the biophysical and educational impacts of environmental education programs in Portland, Oregon with a particular interest in environmental service-learning. The biophysical and educational analyses were essentially, a coupled (social-ecological) study which occurred across different scales. The first chapter was theoretical, placed the research into context and operationalized the term environmental service-learning.

Chapter two occurred at a coarse-scale level of analysis and considered biophysical and educational effects of twenty-two environmental education programs serving the Portland metropolitan region. Some of the biophysical effects of participating environmental education programs: 16,754 native plantings, 63,091 sq.ft of invasive species removed, 3,110 lbs of trash removed and 42,993 ft of trails maintained. Results from chapter two indicated the relative degree of importance for some significant life experiences and environmental education programmatics. The percent of time a program spent outdoors and the frequency of youths' previous outdoor experiences where significant predictors of the youths' locus of control. The frequency of youths' previous outdoor experiences and the presence of an adult role model were significant predictors of youths' environmental sensitivity and awareness. Results from chapter two indicate that outdoor environmental education may be more effective than environmental service-learning in increasing environmental literacy.

Chapter three occurred at a fine-scale level of analysis and considered the educational effects of three slightly different environmental education programs where activities were varied to involve different amounts of environmental service-learning. Results evaluating how slight variations among these groups may have affected environmental literacy were inconclusive. However, when all three programs were considered collectively and compared to a control group; the comparison indicated greater environmental literacy for students in the treatment group (all three environmental education programs). The specific areas of environmental literacy with significant differences were environmentally responsible behavior, environmental worldview,

environmental sensitivity and awareness, efficacy and behavioral intention. Furthermore, chapter three revealed that students with adults who care for the environment in their lives and those with previous environmental education experiences responded better (increased environmental literacy) to environmental education than those without.

Chapter four occurred at a fine-scale and revealed some biophysical effects of one environmental education program (same program as chapter three). Two reference sites were used to evaluate the 'success' of the schoolyard restoration. The plant community, considered in terms of Beta diversity and species richness, of the schoolyard restoration changed substantially throughout the project. The site began with only one species present with 100% cover, *Hedera helix*. At the end of the project, twenty species were identified and was more diverse (Shannon-Wiener: 2.3). The schoolyard experimental restoration site became more similar to the the university restoration reference site (PSI unweighted 31.3% & PSI weighted 48.7%) than to the schoolyard mitigation site (PSI unweighted: 28.6% & PSI weighted 14.9%).

Taken collectively, the results detailed in the preceding chapters provide valuable insight to environmental service-learning. First, what constitutes environmental service-learning is often misunderstood. In fact, my understanding (the principal investigator) of environmental service-learning changed throughout this research. Further, important elements of quality environmental service-learning were not observed during this study (including those activities designed by myself, the principal investigator) and show there may be substantial room for enhancing environmental service-learning activities. Environmental education practitioners may find it particularly relevant that outdoor

environmental education exerted stronger positive influence on youth's environmental literacy than environmental service-learning. This was an unexpected finding and should be considered when developing environmental education programs. However, these findings should not dismiss environmental service-learning and label it as inferior to outdoor environmental education. Further research on environmental service-learning which considers the relative quality, perhaps using the quality standards within environmental education or service-learning, would shed light upon the efficacy of the pedagogy. Results showing the influence of significant life experiences (adult role who cares for the environment and previous outdoor experiences) on important variables within environmental literacy (locus of control, environmental behaviors and environmental sensitivity) are important. These results add to the body of literature particular to significant life experiences. Further, they show environmental education practitioners the substantial impact of activities and adults outside their program. While this understanding may seem common knowledge, it points to interesting and potentially effective environmental education instructional techniques. The techniques are to:

- Promote students' connections with positive adults who care for the environment and will take them outside.
- Support parent/guardian's environmental literacy which may matriculate to youth.
- Provide outdoor experiences for adults who bring youth.

Environmental education is of course not just for youth, which the above suggestions may seem to imply. There is a recognition that environmental education programs

directed at youth may be effective if programming occurs indirectly through adults. Programming directed at adults may, albeit indirectly, have more influence on youths' environmental literacy than direct programming to youth. Finally, results of this research indicate that environmental education is not an 'either or' situation. It is true that individual environmental education programs must make decisions about their goals and outcomes. However, as seen in this research, youth often have multiple environmental education experiences which exerts significant influence on their environmental literacy. While the Portland metropolitan region may be among the places with developed network of environmental education providers, it is among many cities and states with extensive networks. It would be helpful dig deeper into how youth are affected by participating in several different environmental education experiences. Are there differences according to number of programs, the variety of programs, the interplay between types of programs, youths' role in participation?

Concluding Remarks

A critical analysis of this research must consider both the role of science and the nature of environmental education. Environmental education was recognized by John Hug (1980) to have a “two hat” problem. The two hats are those of a “value free” educator and a value driven environmentalist. Hug states that “environmental educators have the right and duty to be environmentalists, but the dual roles must adhere to the original premise – to keep each hat on its proper head, while utilizing to the fullest the

professional skills of the environmental educators.” I must recognize that I myself wear two hats – that of an educator and that of environmentalist. Furthermore, as an environmental education researcher, I must consider my views on my role as a scientist. Roger Pielke (2007) in his book *The Honest Broker: Making Sense of Science in Policy and Politics* defines four roles: pure scientist, issue advocate, science arbiter and honest broker of policy alternative. While Pielke may have oversimplified the roles and relationships of science and policy, his classification is useful for considering the research contained here. Of course, the research here occurred within an empirical and objective framework. However, the impact or translation of this research to policy can fall into any one of Pielke's categories. I acknowledge that I am a stakeholder in the state of Oregon's environmental education. Thus, I aspire to play the role of the honest broker – providing accurate information of policy alternatives.

Supporting Figures

The Domain of Environmental Literacy

Figure 1.1 The Domain of Environmental Literacy: Outlines the organization of environmental literacy.

Taken from Hollweg et al. 2011.

Figure 1.2 Stages of Environmental Literacy: Figure shows a theoretical model of developmental trajectory of three stages of environmental literacy. Modified from Roth 1992; Hungerford and Volk 1990. double sided, dark arrows represent within stage feedbacks where knowledge, affect and behaviors all influence on another. Right facing, one-way arrows show movement through the three stages with previous components of environmental literacy building upon one another. Size of boxes represent the degree of literacy.

Figure 1.3 Environmental Service-Learning Figure provides conceptual juxtaposition of environmental service-learning within two fields: environmental education or service-learning.

Figure 2.1 Continuum of Environmental Education Programs' Foci: This describes a conceptual continuum, along which environmental education programs lay. Programs are placed upon the continuum based on the percentage of time spent engaged in environmental service learning (left value) compared to other forms of environmental education (right value), including inquiry, experiential and interpretive activities. Three examples of local programs are provided which fall along the entirety of the continuum

Figure 2.1a Biophysical Outcomes and Time Spent Engaged with Environmental Service-Learning: Arranges six programs who engage in environmental service-learning according to the relative time spent engaged with the pedagogy. Summaries for some of the biophysical outcomes reported for the year 2014 are provided.

Frequency Distributions

Student Responses (n≈390) for Questions
Specific to:
Environmentally Responsible Behaviors

never
infrequently
sometimes
frequently
very frequently

Figure 2.2a Frequency Distributions for Environmentally Responsible Behaviors: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Frequency Distributions

Student Responses (n≈390) for Questions Specific to:
Environmental Worldview

strongly disagree
disagree
no opinion/undecided
agree
strongly agree

Figure 2.2b Frequency Distributions for Environmental Worldview: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Frequency Distributions

Student Responses (n≈390) for Questions
Specific to:
Environmental Worldview

strongly disagree
disagree
no opinion/undecided
agree
strongly agree

Figure 2.2c Frequency Distributions for Environmental Worldview: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Frequency Distributions

Student Responses (n≈390) for Questions Specific to:
Environmental Sensitivity & Awareness

strongly disagree
disagree
no opinion/undecided
agree
strongly agree

Figure 2.2d Frequency Distributions for Environmental Sensitivity and Awareness: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Frequency Distributions

Student Responses (n≈390) for Questions Specific to:
Locus of Control & Efficacy

strongly disagree
disagree
no opinion/undecided
agree
strongly agree

Figure 2.2e Frequency Distributions for Locus of Control and Efficacy: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Frequency Distributions

Student Responses (n≈390) for Questions Specific to:
Behavioral Intention & Previous Environmental Experiences

strongly disagree
disagree
no opinion/undecided
agree
strongly agree

Figure 2.2f Frequency Distributions for Behavioral Intention and Previous Environmental Experiences: Shows the frequency for possible responses to environmental literacy assessment questions for all students in the study. There is a slight variation in the number of responses among questions (n = 370 – 395). Possible responses with more than 50% occurrence or are otherwise obscured are indicated with a value.

Figure 2.3 Domains of Environmental Literacy: Dispositions and Behaviors: Shows box plots of collapsed variables which emerged from PCA: Locus of Control, Environmental Worldview, ERB: Environmentally Responsible Behavior and Environmental Sensitivity and Awareness. The maximum value for each of the three collapsed variables is indicated.

Figure 2.4a Associations to Environmental Service-Learning: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent engaged with environmental service learning (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.4b Associations to Environmental Service-Learning: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent engaged with environmental service learning (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.4d Associations to Environmental Service-Learning: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent engaged with environmental service learning (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5a Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5b Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5c Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5d Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5e Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5f Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5g Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5h Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.5i Associations to Outdoor Environmental Education: Shows scatterplot of median response to indicated question for each of 11 programs (y-axis) and the percent of time the program spent outdoors (x-axis). Spearman's rho indicates the degree of the association and was calculated for all responses. Median response are shown for comprehensibility. Slight variation was further added (jitter) so that points with identical values were separated in the graph and not hidden on top of each other.

Figure 2.6a Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Figure 2.6b Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Figure 2.6c Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Figure 2.6d Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

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Figure 2.6f Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Figure 2.6g Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Figure 2.6h Previous Environmental Education and Frequency Distributions Frequency distributions for each of the four groups are provided for the indicated question. From left to right, the four groups are: a control group where youth indicated they had not received prior environmental education (n = 7), a control group where youth indicated they had received prior environmental education (n = 55), a treatment group where youth indicated they had not received prior environmental education (n = 85) and a treatment group where youth indicated they had received prior environmental education (n = 308).

Continuum of Environmental Education Programs' Foci: Evergreen Middle School Environmental Service-Learning Treatment Arrangement

Figure 3.1 Continuum of Environmental Education Programs Foci: Evergreen Middle School Environmental Service-Learning Treatment Arrangement: Details relative time spent engaged in environmental service-learning for each of three treatment groups. Differences in learning activities (e.g. inquiry, experiential, direct instruction) other than environmental service-learning are combined.

Evergreen Middle School Treatment Arrangement

Figure 3.2 Evergreen Middle School Treatment Arrangement: Details the arrangement of sample and corresponding treatment groups in relation to population. T1, T2, T3 and C1 take pre and post environmental literacy assessment. C2 takes only post environmental literacy assessment.

Lesson Title Activity	Environmental Service - Learning? Y or N	Description	In vs Out In or Out	Degree of Inquiry	Date	Participation by Treatment Groups (yes/no):		
						T1: ES-L focus P1, P2	T2: Inquiry Focus P4, P5	T3: Equal Focus P3
introduction and overview	n	overview of forthcoming year and field techniques	in	none	09/12/13	y	y	y
vegetation sampling scaffold	n	practice vegetation sampling and randomization	in	low	09/19/13	y	y	y
vegetation sampling in bioswale	n	outdoor vegetation sampling	out	low	09/26/13	y	y	y
notebook preparation	n	organize notebook and vegetation data	in	low	10/03/13	y	y	y
vegetation data analysis	n	analyze data with box and whisker plots	in	low	10/09/13	y	y	y
restoration, creating learning laboratory	y	spreading topsoil and setting plot designation	out	n/a	10/16/13	y	y	y
restoration, creating learning laboratory	y	topsoil, compost, mulch plantings	out	n/a	10/31/13	y	y	y
restoration, creating learning laboratory	y	topsoil, compost, mulch plantings	out	n/a	11/01/13	y	n	y
soil texture and infiltration	n	research on texture and effects to infiltration	out	low	11/01/13	n	y	y
soil texture	n	research on	out	low	11/07/13	y	y	y

and infiltration		texture and effects to infiltration			13			
soil infiltration experiment	n	data collection, guided inquiry	out	med	11/13/13	y	y	y
soil infiltration data analysis	n	data analysis of soil infiltration rates among treatments	in	med	11/20/13	y	y	y
soil infiltration conclusion	n	written conclusion of experiment and results	in	med	12/12/13	y	y	y
water quality	n	water quality analysis: do, turbidity, temp, ph w/ readings	in	low	01/09/14	y	y	y
water quality	n	water quality analysis: do, turbidity, temp, ph w/ readings	in	low	01/10/14	y	y	y
stream analysis	n	scaffolded analysis, stream and riparian areas	in	low	01/16/14	y	y	y
stream analysis w/ macroinvertebrates	n	scaffolded analysis, stream and riparian areas + macroinvertebrates	in	low	01/23/14	y	y	y
macroinvertebrates comparison	n	comparing macro assemblages from 2 streams	in	med	02/06/14	y	y	y
invasive	n	invasive	in/out	low	02/20/	y	y	y

plant species		plant id, invasive species mechanisms			14			
invasive plant removal	y	removal of invasive species	out	low	02/27/ 14	y	n	n
veg sampling	n	veg sampling	out	med	02/27/ 14	n	y	n
concept mapping	n	ecosystem concept mapping	in	low	03/06/ 14	y	y	y
field trip prep	n	field trip pre	in	low	03/13/ 14	y	y	y
tfc field trip	n	outdoor data collection and interpretive activities	out	med	3/14/1 4 4 hours in field	y	y	y
plant recruitment inquiry	n	inquiry- plant recruitment as a function of soil amendments	out	med-high	04/09/ 14	y	y	y
research questions prep	n	scaffolding research questions	in	med	04/16/ 14	y	y	y
thnc field trip	n	outdoor data collection and interpretive activities	out	med	04/18/ 14 4 hours in field	y	y	y
solve field trip glencoe	y	service learning glencoe woods	out	low	04/24/ 14 3 hours	y	n	y
research questions	n	research project prep	in	med	04/24/ 14	n	y	n
glencoe research field trip	n	outdoor data collection	out	med	04/25/ 14 3 hours	n	y	n
research	n	research	in	med	04/25/ 14	y	n	y

questions		project prep			14			
research project	n	research project prep	in	high	05/01/14	y	y	y
research project	n	research project prep	in	high	05/07/14	y	y	y
research project	n	research project prep	in	high	05/08/14	y	y	y
research project	n	research project prep	in	high	05/14/14	y	y	y
conference	n	research project prep	in	high	05/22/14	y	y	y
lab maintenance stewardship	y	weeding lab	out	med	05/29/14	y	n	y
research project	n	inquiry project discussion	in	high	05/29/14	n	y	n

Figure 3.3 List of Lesson Plans: Outlines and describes lesson plans for school year, designates treatment group participation and clarifies if lesson plan involved environmental service-learning.

Pre-Post Frequency Distribution Boxplots

Figure 3.4a: Frequency Distribution Boxplot: “I Recycle”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4b: Frequency Distribution Boxplot: “I pick up trash”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4c: Frequency Distribution Boxplots: “I talk to others (parents, friends, etc.) about environmental issues”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4d: Frequency Distribution Boxplots: “I engage in restoration outside of school (ex. Weed pull, tree planting, trail building)”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4e: Frequency Distribution Boxplots: “I engage in restoration as part of school (ex. Weed pull, tree planting, trail building)”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4f: Frequency Distribution Boxplots: “Plants and animals have as much right as people to live”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4g: Frequency Distribution Boxplots: “There are too many (or almost too many) people on earth”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4h: Frequency Distribution Boxplots: “People are clever enough to keep from ruining the earth”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4i: Frequency Distribution Boxplots: “People must obey the laws of nature”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4j: Frequency Distribution Boxplots: “When people mess with nature it has bad results”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4k: Frequency Distribution Boxplots: “Nature is strong enough to handle the bad effects of our lifestyles”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4l: Frequency Distribution Boxplots: “People are supposed to rule over the rest of nature”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4m: Frequency Distribution Boxplots: “People are treating nature badly”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4n: Frequency Distribution Boxplots: “People will someday know enough about how nature works to be able to control it”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4o: Frequency Distribution Boxplots: “If things don't change we will have a big disaster in the environment soon”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4p: Frequency Distribution Boxplots: “If I had enough time or money, I would devote it to working for the environment”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4q: Frequency Distribution Boxplots: “I am interested in a career working to make a positive impact on the environment”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4r: Frequency Distribution Boxplots: “I have skills necessary to make a positive impact on the environment”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4s: Frequency Distribution Boxplots: “I enjoy spending time in natural settings (woods, mountains, desert, lakes, ocean)”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4t: Frequency Distribution Boxplots: “With other people I can work to make a positive impact on the environment”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4u: Frequency Distribution Boxplots: “By myself I can work to make a positive impact on the environment”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4v: Frequency Distribution Boxplots: “I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4w: Frequency Distribution Boxplots: “I pay special attention to things outdoors (plants, animals, woods, rivers, weather)”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4x: Frequency Distribution Boxplots: “I would be upset if the natural area where I have worked was destroyed/polluted”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4y: Frequency Distribution Boxplots: “I I think the restoration work I do in natural areas is useful”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4z: Frequency Distribution Boxplots: “I I think the field monitoring I do in natural areas is useful”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4aa: Frequency Distribution Boxplots: “I plan to volunteer in a natural area (tree planting, invasive species removal)”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4ab: Frequency Distribution Boxplots: “I would like to collect environmental data for local government so they can monitor the health of our watershed”: Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately.

Pre-Post Frequency Distribution Boxplots

Figure 3.4ac: Frequency Distribution Boxplots: “Inclusion of Nature in Self Scale”:

Shows pre-post frequency distribution of student responses. Responses are organized in two manners. On the left, all treatment groups are put together and all control groups are put together. On the right, all five individual experimental groups are represented separately. The bottom half of the figure shows the possible responses, adjacent circles, with corresponding numbers. How the numbers are represented on the boxplots is displayed in the lower right of the figure.

Treatment vs Control Posttest Responses: Frequency Distributions

I engage in enviromental restoration as part of school
(ex. weed pull, tree planting, trail building).

Figure 3.5a: Frequency Distribution Histograms: “I engage in restoration as part of school” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I engage in restoration as part of school.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “never,” “infrequently,” “sometimes,” “frequently,” and “very frequently.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I engage in restoration as part of school.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

Plants and animals have as much right as people to live.

Figure 3.5b: Frequency Distribution Histograms: “Plants and animals have as much right as people to live.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “Plants and animals have as much right as people to live.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “Plants and animals have as much right as people to live.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

People are clever enough to keep from ruining the earth.

Figure 3.5c: Frequency Distribution Histograms: “People are clever enough to keep from ruining the earth.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “People are clever enough to keep from ruining the earth.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “People are clever enough to keep from ruining the earth.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

If people mess with nature there are bad results.

Figure 3.5d: Frequency Distribution Histograms: “If people mess with nature there are bad results.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “If people mess with nature there are bad results.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “If people mess with nature there are bad results.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I have skills necessary to make a positive impact on the environment.

Figure 3.5e: Frequency Distribution Histograms: “I have the skills necessary to make a positive impact on the environment.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I have the skills necessary to make a positive impact on the environment.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I have the skills necessary to make a positive impact on the environment.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

With other people I can work to make a positive impact on the environment

Figure 3.5f: Frequency Distribution Histograms: “With other people I can work to make a positive impact on the environment.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “With other people I can work to make a positive impact on the environment.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “With other people I can work to make a positive impact on the environment.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.

Figure 3.5g: Frequency Distribution Histograms: “I would feel and important part of my life was missing if I couldn't get out and enjoy nature from time to time.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I would feel and important part of my life was missing if I couldn't get out and enjoy nature from time to time.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would feel and important part of my life was missing if I couldn't get out and enjoy nature from time to time.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I pay special attention to things outdoors (plants, animals, woods, rivers, weather).

Figure 3.5h: Frequency Distribution Histograms: “I pay special attention to things outdoors (plants, animals, woods, rivers, weather).” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I would feel and important part of my life was missing if I couldn't get out and enjoy nature from time to time.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would feel and important part of my life was missing if I couldn't get out and enjoy nature from time to time.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I think the restoration work that I do in natural areas is useful.

Figure 3.5i: Frequency Distribution Histograms: “I think the restoration work that I do in natural areas is useful.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I think the restoration work that I do in natural areas is useful.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the restoration work that I do in natural areas is useful.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I think the field monitoring that I do in natural areas is useful.

Figure 3.5j: Frequency Distribution Histograms: “I think the field monitoring that I do in natural areas is useful.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I think the field monitoring that I do in natural areas is useful.”. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the field monitoring that I do in natural areas is useful.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I would like to collect environmental data for local government, so they can monitor the health of our watershed.

Figure 3.5k: Frequency Distribution Histograms: “I would like to collect environmental data for local government so they can monitor the health of our watershed.” and Previous Environmental Education: Shows post test frequency distribution of student responses for the question: “I would like to collect environmental data for local government so they can monitor the health of our watershed.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would like to collect environmental data for local government so they can monitor the health of our watershed.” and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

Figure 3.5I: Frequency Distribution Histograms: Inclusion of Nature in Self scale and Previous Environmental Education: Shows post test frequency distribution of student responses for the Inclusion of Nature in Self scale. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding each of the seven categories from 1-7. The numbers correspond to the picture of circles in lower right of the figure. The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you received environmental education before?” (With Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you received environmental education before?” (No Previous EE) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you received environmental education before?”. Test statistic and significance are reported in the bottom row, under the the corresponding two graphs. chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the Inclusion of Nature in Self scale and “Have you received environmental education before?”

Treatment vs Control Posttest Responses: Frequency Distributions

I engage in enviromental restoration as part of of school
(ex. weed pull, tree planting, trail building).

Figure 3.6a: Frequency Distribution Histograms: “I engage in environmental restoration as part of school.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I engage in restoration as part of school.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “never,” “infrequently,” “sometimes,” “frequently,” and “very frequently.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I engage in restoration as part of school.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

Plants and animals have as much right as people to live

Figure 3.6b: Frequency Distribution Histograms: “Plants and animals have as much right as people to live.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “Plants and animals have as much right as people to live.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “Plants and animals have as much right as people to live.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

People must obey the laws of nature.

Figure 3.6c: Frequency Distribution Histograms: “People must obey the laws of nature.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “People must obey the laws of nature.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “People must obey the laws of nature.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

People will someday know enough about how nature works to be able to control it.

Figure 3.6d: Frequency Distribution Histograms: “People will someday know enough about how nature works to be able to control it.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “People will someday know enough about how nature works to be able to control it.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “People will someday know enough about how nature works to be able to control it.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I enjoy spending time in natural settings.

Figure 3.6e: Frequency Distribution Histograms: “I enjoy spending time in natural settings.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I enjoy spending time in natural settings.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I enjoy spending time in natural settings.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

With other people I can work to make a positive impact on the environment.

Figure 3.6f: Frequency Distribution Histograms: “With other people I can work to make a positive impact on the environment.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “With other people I can work to make a positive impact on the environment.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “With other people I can work to make a positive impact on the environment.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

By myself, I can work to make a positive impact on the environment.

Figure 3.6g: Frequency Distribution Histograms: “By myself I can work to make a positive impact on the environment.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “By myself people I can work to make a positive impact on the environment.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “By myself people I can work to make a positive impact on the environment.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I pay special attention to things outdoors (plants, animals, woods, rivers, weather).

Figure 3.6h: Frequency Distribution Histograms: “I pay special attention to things outdoors (plants, animals, woods, rivers, weather).” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I pay special attention to things outdoors (plants, animals, woods, rivers, weather).” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I pay special attention to things outdoors (plants, animals, woods, rivers, weather).” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I think the restoration work that I do in natural areas is useful.

Figure 3.6i: Frequency Distribution Histograms: “I think the restoration work that I do in natural areas is useful.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I think the restoration work that I do in natural areas is useful.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the restoration work that I do in natural areas is useful.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I think the field monitoring that I do in natural areas is useful.

Figure 3.6j: Frequency Distribution Histograms: “I think the field monitoring that I do in natural areas is useful.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I think the field monitoring that I do in natural areas is useful.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the field monitoring that I do in natural areas is useful.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I would like to collect environmental data for local government, so they can monitor the health of our watershed.

Figure 3.6k: Frequency Distribution Histograms: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

Figure 3.6I: Frequency Distribution Histograms: Inclusion of Nature in Self scale and adult role model that cares for the environment: Shows post test frequency distribution of student responses for the the Inclusion of Nature in Self scale. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding each of the seven categories from 1-7. The numbers correspond to the picture of circles in lower right of the figure. The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (With Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?” (No Env+ Adult) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the Inclusion of Nature in Self Scale and “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I engage in environmental restoration as part of of school (ex. weed pull, tree planting, trail building).

Figure 3.7a: Frequency Distribution Histograms: “I engage in environmental restoration as part of school.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I engage in restoration as part of school.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “never,” “infrequently,” “sometimes,” “frequently,” and “very frequently.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I engage in restoration as part of school.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

Plants and animals have as much right as people to live.

Figure 3.7b: Frequency Distribution Histograms: “Plants and animals have as much right as people to live.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “Plants and animals have as much right as people to live.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “Plants and animals have as much right as people to live.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I have skills necessary to make a positive impact on the environment.

Figure 3.7c: Frequency Distribution Histograms: “I have skills necessary to make a positive impact on the environment.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I have skills necessary to make a positive impact on the environment.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I have skills necessary to make a positive impact on the environment.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.

Figure 3.7d: Frequency Distribution Histograms: “I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I think the restoration work that I do in natural areas is useful.

Figure 3.7e: Frequency Distribution Histograms: “I think the restoration work that I do in natural areas is useful.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I think the restoration work that I do in natural areas is useful.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the restoration work that I do in natural areas is useful.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I think the field monitoring that I do in natural areas is useful.

Figure 3.7f: Frequency Distribution Histograms: “I think the field monitoring that I do in natural areas is useful.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I think the field monitoring that I do in natural areas is useful.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I think the field monitoring that I do in natural areas is useful.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I would like to collect environmental data for local government,
so they can monitor the health of our watershed.

Figure 3.7g: Frequency Distribution Histograms: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and witness to environmental harm: Shows post test frequency distribution of student responses for the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “yes” to the question “Have you ever seen something bad happen to the environment before?” (SeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “no” to the question “Have you ever seen something bad happen to the environment before?” (NotSeenEnvHarm) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “yes” and those responding “no” to the question “Have you ever seen something bad happen to the environment before?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for student responses to the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and “Have you ever seen something bad happen to the environment before?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I engage in enviromental restoration as part of of school
(ex. weed pull, tree planting, trail building).

Figure 3.8a: Frequency Distribution Histograms: “I engage in environmental restoration as part of school.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “I engage in restoration as part of school.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “never,” “infrequently,” “sometimes,” “frequently,” and “very frequently.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “I engage in restoration as part of school.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

Plants and animals have as much right as people to live.

Figure 3.8b: Frequency Distribution Histograms: “Plants and animals have as much right as people to live.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “Plants and animals have as much right as people to live.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “Plants and animals have as much right as people to live.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

People are clever enough to keep from ruining the earth.

Figure 3.8c: Frequency Distribution Histograms: “People are clever enough to keep from ruining the earth” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “People are clever enough to keep from ruining the earth.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “People are clever enough to keep from ruining the earth” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

People must obey the laws of nature.

Figure 3.8d: Frequency Distribution Histograms: “People people must obey the laws of nature.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “People people must obey the laws of nature.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “People people must obey the laws of nature.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

With other people I can work to make a positive impact on the environment.

Figure 3.8e: Frequency Distribution Histograms: “With other people I can work to make a positive impact on the environment.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “With other people I can work to make a positive impact on the environment.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “With other people I can work to make a positive impact on the environment.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time.

Figure 3.8f: Frequency Distribution Histograms: “I would feel that an important part of my life was missing if I could not get out and enjoy nature from time to time.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “I would feel that an important part of my life was missing if I could not get out and enjoy nature from time to time.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “I would feel that an important part of my life was missing if I could not get out and enjoy nature from time to time.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I pay special attention to things outdoors (plants, animals, woods, rivers, weather).

Figure 3.8g: Frequency Distribution Histograms: “I pay special attention to things outdoors.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “I pay special attention to things outdoors.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “I pay special attention to things outdoors.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I would like to collect environmental data for local government, so they can monitor the health of our watershed.

Figure 3.8h: Frequency Distribution Histograms: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “I would like to collect environmental data for local government, so they can monitor the health of our watershed.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

I think the field monitoring that I do in natural areas is useful.

Figure 3.8i: Frequency Distribution Histograms: “I think the field monitoring that I do in natural areas is useful” and previous outdoor experiences: Shows post test frequency distribution of student responses for the question: “I think the field monitoring that I do in natural areas is useful.” Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding “strongly disagree,” “disagree,” “no opinion/undecided,” “agree,” and “strongly agree.” The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the question: “I think the field monitoring that I do in natural areas is useful.” and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Treatment vs Control Posttest Responses: Frequency Distributions

Figure 3.8j: Frequency Distribution Histograms: “Inclusion of Nature in Self Scale” and previous outdoor experiences: Shows post test frequency distribution of student responses for the the Inclusion of Nature in Self scale. Six graphs are shown. For all graphs, the x-axes, from left to right, show the percentage of students responding each of the seven categories from 1-7. The numbers correspond to the picture of circles in lower right of the figure. The y-axes range from 0 - 50% at increments of 10%. The first column (leftmost graphs) shows responses for all students organized by treatment groups (top-graph) and control groups (bottom-graph). The second column (middle graphs) shows responses for students who responded: “frequently” or “very frequently” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Freq Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. The third column (rightmost graphs) shows responses for students who responded: “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?” (Prev Rare Outdoor Exp) and displays the responses for the treatment groups on the top row with the control group on the bottom row. Significant test statistics are reported. Comparisons among groups, treatment vs control groups for each of the three categories: all students, those responding “frequently” or “very frequently” and those responding “never,” “infrequently,” or “sometimes” to the question “Before this program, how frequently did you spend time outdoors?”. Test statistic and significance are reported in the bottom row, under the corresponding two graphs. Chi square values are reported in the rightmost part of figure if significant relationships exist within each of the treatment and control groups for the Inclusion of Nature in Self scale and the dichotomized student responses to “Before this program, how frequently did you spend time outdoors?”.

Figure 4.1 Evergreen Middle School Outdoor Learning Laboratory Layout: Shows arrangement of treatment incorporated in outdoor learning laboratory.

Figure 4.2 Evergreen Middle School Outdoor Learning Laboratory Treatment Designations: Explains treatments used by the students in a 2 x 3 design.

Figure 4.3 Overview of Evergreen Middle School Restoration and Reference Site Locations: Shows relative locations of outdoor learning lab (schoolyard experimental restoration site), control which was abandoned because of herbicide use and and schoolyard mitigation reference site. Univeristy restoration reference site is not included as it is not in close proximity to schoolyard.

Native Plant Species			
Species	Common Name	Species	Common Name
<i>Achillea millefolium</i>	Yarrow	<i>Dicentra formosa</i>	Pacific Bleeding Heart
<i>Trillium ovatum</i>	Trillium	<i>Gaultheria shallon</i>	Salal
<i>Aruncus diocis</i>	Goatsbeard	<i>Mahonia sp</i>	Oregon grape
<i>Camassia sp</i>	Camas	<i>Alnus sp</i>	Alder
<i>Aquilegia caerulea</i> <i>or canadensis</i>	Blue or Red Columbine	<i>Myrica californica</i>	Pacific wax myrtle
<i>Arctostaphylos uva-ursi</i>	Kinnikinnick	<i>Rosa gymnocarpa</i>	Bald-hip rose
<i>Iris tenax</i>	Oregon iris	<i>Ribes sanguineum</i>	Red flowering currant
<i>Vancouveria hexandra</i>	Inside out flower	<i>Acer circinatum</i>	Vine Maple

Figure 4.4 Native Plant Species Figure shows native plant species that may be used in the outdoor learning laboratory and only includes species present in two target reference sites.

Figure 4.5a Plant Communities' Species Richness: Shows the species richness of the three plant communities for each of the four sampling periods.

Figure 4.5b Plant Communities' Total Cover: Shows the average total cover of the three plant communities for each of the four sampling periods.

Figure 4.5c Plant Communities' Beta Diversity: Shows the beta diversity (Shannon-Weiner) index of the three plant communities for each of the four sampling periods

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Appendix A – Supporting Figures, Tables and Text for Chapter 2

Portland/Vancouver Area Environmental Education Census: Practitioner Data Collection Outline

Overview: Create an online survey to distribute to administrators or lead teachers at each of the organizations surveyed in the research. Questions 4-12 will be repeated for each program indicated in question #3. Each table will be one page of the survey. Categories listed in question #6 will be defined with examples.

Organization and Program Information		
# 1	Please indicate the name of your organization	Text, open ended
# 2	How many different EE programs does your organization facilitate that directly serve children between 6 – 12 grades	#
# 3	Please list all of the EE programs your organization facilitates and the zipcode in which the program takes place	Text, open ended. Individual fields for each program and their respective zipcodes

Activities, Pedagogy and Programmatics (for each program)		
# 4	How many hours do students/participants receive on average in this program?	#
# 5	Please indicate the percentage of time student/participants spend indoors vs outdoors. (If there is a range and it varies, choose the most representative combination equaling 100%)	Indoors (0 – 100%):
		Outdoors (0 – 100%):
# 6	Please indicate the percentage of time student/participants spend engaged in the following activities. (If there is a range and it varies, choose the most representative combination equaling 100%)	environmental service-learning: (0-100 %):
		other (please indicate): (0-100 %):

Biophysical Metrics of Success (for each program)		
# 7	Does your program utilize a measure of biophysical success (eg. # of trees planted, area of land cleared, lbs invasive species removed, length of trail repaired, garden bed planted)	Yes or no
# 8	If so, please indicate what the measure of success is and how it is measured	Text, open ended
# 9	Please indicate the biophysical outcome of an average program (ie, the results from one group of participants going through your program)	Text, open ended
#10	Please indicate the biophysical outcome for the previous year	Text, open ended

Participation in Study		
# 11	Is your organization willing to administer a 5-10 minute assessment at the conclusion of your program to student/participants in order to measure their environmental literacy?	Yes or no
# 12	If your organization is willing to administer either the assessment, will you be able to administer it via computer or will you require hard copies?	Check one: hard copies, internet or n/a

Environmental Literacy Assessment

Program Name: _____ **Date:** _____

School: _____ **Age:** _____ **Gender:** _____

Directions: Complete 5-10 min survey. There is no grade. Answer the survey completely and honestly. Answers are confidential. Do not write your name, just program name, date, school, age and gender. Reading the questions below, indicate how much you agree or disagree with the following statements. Color the bubble below which most accurately describes your belief.

Survey Questions	Response:
# 1 Have you received any other environmental education? (ex. Outdoor School, invasive removal, Audubon, Clean Rivers Ed, primitive skills)	Yes or No
# 2 Besides the instructors in this program, do you have an adult role model that enjoys the outdoors and/or cares for the environment ?	Yes or No
# 3 Have you seen something bad happen to the environment before? (ex. natural area become developed, water pollution)	Yes or No

Directions: The next 6 questions are about behaviors and have a different scale than the last 3 questions. The scale is: **Never, Infrequently, Sometimes, Frequently and Very Frequently.**

Survey Questions	Response:
#4 I recycle	Never Infrequently Sometimes Frequently Very Frequently
#5 I pick up litter/trash	Never Infrequently Sometimes Frequently Very Frequently
#6 I talk to others (parents, friends, etc.) about environmental issues	Never Infrequently Sometimes Frequently Very Frequently
#7 I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building)	Never Infrequently Sometimes Frequently Very Frequently
#8 I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building)	Never Infrequently Sometimes Frequently Very Frequently
#9 Before this program, how frequently did you spend time in the outdoors?	Never Infrequently Sometimes Frequently Very Frequently

Directions: The next 23 questions are about attitudes and values and have a different scale than the last 6 questions. The scale is: **Strongly Disagree, Disagree, No Opinion/Undecided, Agree and Strongly Agree.**

Survey Questions	Response:
#10 Plants and animals have as much right as people to live.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree
#11 There are too many (or almost too many) people on earth.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree
#12 People are clever enough to keep from ruining earth.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree
#13 People must obey the laws of nature.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree
#14 When people mess with nature it has bad results.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree
#15 Nature is strong enough to handle the bad effects of our modern lifestyles.	Strongly Disagree Disagree No Opinion/Undecided Agree Strongly Agree

#16	People are supposed to rule over the rest of nature.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#17	People are treating nature badly.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#18	People will someday know enough about how nature works to be able to control it.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#19	If things don't change, we will have a big disaster in the environment soon.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#20	If I had enough time or money, I would devote it to working for the environment.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#21	I am interested in a career working to make a positive impact on the environment.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#22	I have skills necessary to make a positive impact on the environment.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#23	I enjoy spending time in natural settings (woods, mountains, desert, lakes, ocean).	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#24	<i>With other people</i> , I can work to make a positive impact on the environment (ie. improve or protect the environment).	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#25	<i>By myself</i> , I can work to make a positive impact on the environment (ie. Improve or protect the environment).	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#26	I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#27	I pay special attention to things outdoors (plants, animals, woods, rivers, weather).	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#28	I would be upset if the natural area where I have worked was destroyed/polluted.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#29	I think the restoration work that I do in natural areas is useful.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#30	I think the field monitoring I do in natural areas is useful.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#31	I plan to volunteer in a natural area (tree planting, invasive species removal).	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree
#32	I would like to collect environmental data for local government, so they can monitor the health of our watershed.	Strongly Disagree	Disagree	No Opinion Undecided	Agree	Strongly Agree

#33) Please circle the picture below which best describes your relationship with the natural environment. How interconnected are you with nature?

Is there anything else you would like to tell us? _____

Coding for Environmental Literacy Assessment:

- I. Significant Life Experiences: 1, 2, 3, 9
- II. Components of Environmental Literacy:
 - A. Environmentally Responsible Behaviors: 4, 5, 6, 7, 8,
 - B. Dispositions:
 - i. Environmental Worldview:¹
 - a) Rights of Nature: 10, 13, 16
 - b) Eco-Crisis: 11, 14, 17, 19
 - c) Human Exemptionalism: 12, 15, 18
 - d) Cognitive representation of self in relation to nature:² 33
 - ii. Environmental sensitivity and awareness: 23, 26, 27, 28
 - iii. Locus of control/self efficacy: 22, 24, 25, 29, 30
 - iv. Motivation/intention to act: 20, 21, 24, 25

1 Questions 1-10 are taken from the New Ecological Paradigm scale

2 Question 11 is taken from the Inclusion of Nature in Self assessment

Appendix B – Supporting Figures, Tables and Text for Chapter 3

The two subsequent tables: Significant Among Group Pre test Differences and Significant Among Group Post test Differences show some results from chapter three. There were many among group differences when comparing all of the five experimental groups, yet the results were inconclusive. Out of a possible 198 pairwise pre test differences among each of the experimental groups, 16, ~8%, were significant. 11 of the 16 significant pairwise differences occurred among treatment groups, ~69% (T# x T#). Five of the 16 significant pairwise differences occurred among a treatment group and the pre-post test control group (T# x C1). Out of a possible 330 pairwise post test differences among each of the experimental groups, 35, ~10%, were significant. Six of the 35 significant differences occurred among treatment groups, ~17% (T# x T#). Twenty of the 33 significant differences occurred among treatment groups and the posttest only control group (T# x C2). Four of the 33 significant differences occurred among treatment groups and the pre-posttest control group (T# x C2). Four of the 33 significant differences occurred among the post test only control group and the pre-posttest control group (C1 x C2). In these four instances mean rank for the pre-posttest control group was higher than the posttest only control group.

Significant Among Group Pretest Differences Table shows significant scores (Test Statistic Chi Square) and level of significance (Asymptotic Significance) of Kruskal Wallis Test H with mean ranks for the four experimental groups with pre testing. The rightmost column indicates significant pairwise differences among groups and shows the relative difference in mean rank with arrows indicating which group ranked higher and which ranked lower. * indicates inconsistency between pre and post tests (i.e. not significant in post test analysis).

Question	Test Statistic (Chi Square)	Df	Asymp Sig.	n	Sig. Pairwise Differences	Asymp Sig.
I recycle.*	8.729	3	0.033	171	↑ Equal Focus ↓ Pre-Post Control	0.011*
					↑ Equal Focus ↓ ES-L Focus	0.019*
I talk to others about environmental issues*	9.835	3	0.020	169	↑ Inquiry Focus ↓ ES-L Focus	0.015*
					↑ Equal Focus ↓ ES-L Focus	0.010*
I engage in environmental restoration as part of school.	9.747	3	0.021	169	↑ Equal Focus ↓ ES-L Focus	0.007*
					↑ Equal Focus ↓ Pre-Post Control	0.018
Plants and animals have as much right as people to live.	11.747	3	0.008	191	↑ Inquiry Focus ↓ ES-L Focus	0.001
					↑ Inquiry Focus ↓ Pre-Post Control	0.030*
When people mess with nature it has bad results.	9.367	3	0.025	192	↑ Equal Focus ↓ ES-L Focus	0.013*
					↑ Inquiry Focus ↓ ES-L Focus	0.032*
					↑ Equal Focus ↓ Pre-Post Control	0.034*
If things don't change, we will have a big disaster in the environment soon.*	10.319	3	0.016	190	↑ Equal Focus ↓ ES-L Focus	0.006*
					↑ Inquiry Focus ↓ ES-L Focus	0.010*
I pay special attention to things outdoors.*	8.049	3	0.045	180	↑ Equal Focus ↓ ES-L Focus	0.006*
					↑ Equal Focus ↓ Inquiry Focus	0.011*
					↑ Equal Focus ↓ Pre-Post Control	0.041*

Significant Among Group Posttest Differences Table shows significant scores (Test Statistic Chi Square) and level of significance (Asymptotic Significance) of Kruskal Wallis Test H with mean ranks for the five experimental groups with post testing. The rightmost column indicates significant pairwise differences among groups and shows the relative difference in mean rank with arrows indicating which group ranked higher and which ranked lower. * indicates inconsistency between pre and post tests (i.e. not significant in pre test analysis).

Question	Test Statistic (Chi Square)	Df	Asymp Sig.	n	Sig. Pairwise Differences	Asymp Sig.
I engage in environmental restoration as part of school.	15.848	4	0.003	208	↑ ES-L Focus ↓ Pre-Post Control	0.001*
					↑ Inquiry Focus ↓ Pre-Post Control	0.001*
					↑ Equal Focus ↓ Pre-Post Control	0.01
					↑ Inquiry Focus ↓ Post Only Control	0.047*
Plants and animals have as much right as people to live.	19.846	4	0.001	211	↑ ES-L Focus ↓ Post Only Control	0.014*
					↑ Inquiry Focus ↓ Post Only Control	0.000*
					↑ Equal Focus ↓ Post Only Control	0.016*
					↑ Pre-Post Control ↓ Post Only Control	0.001*
					↑ Inquiry Focus ↓ ES-L Focus	0.026
People must obey the laws of nature*	16.407	4	0.003	208	↑ ES-L Focus ↓ Post Only Control	0.041*
					↑ Inquiry Focus ↓ Post Only Control	0.000*
					↑ Equal Focus ↓ Post Only Control	0.018*
					↑ Pre-Post Control ↓ Post Only Control	0.003*
					↑ Inquiry Focus ↓ ES-L Focus	0.029*
When people mess with nature it has bad results.	18.468	4	0.001	210	↑ ES-L Focus ↓ Post Only Control	0.017*
					↑ Inquiry Focus ↓ Post Only Control	0.000*
					↑ Equal Focus ↓ Post Only Control	0.002*
					↑ Pre-Post Control ↓ Post Only Control	0.000*

I enjoy spending time in natural settings*	11.757	4	0.019	210	↑ Inquiry Focus ↓ Post Only Control	0.026*
					↑ Equal Focus ↓ Post Only Control	0.009*
					↑ Inquiry Focus ↓ ES-L Focus	0.029*
					↑ Equal Focus ↓ ES-L Focus	0.010*
I would feel that an important part of my life was missing if I couldn't get out and enjoy nature from time to time.*	14.210	4	0.007	207	↑ Inquiry Focus ↓ Post Only Control	0.002*
					↑ Equal Focus ↓ Post Only Control	0.005*
					↑ Inquiry Focus ↓ ES-L Focus	0.017*
					↑ Equal Focus ↓ ES-L Focus	0.043*
I would be upset if the natural area where I have worked was destroyed/polluted.*	10.815	4	0.029	207	↑ Pre-Post Control ↓ Post Only Control	0.040*
					↑ Inquiry Focus ↓ Post Only Control	0.005*
					↑ Inquiry Focus ↓ ES-L Focus	0.019*
I think the field monitoring I do in natural areas is useful.*	9.478	4	0.050	208	↑ Inquiry Focus ↓ Post Only Control	0.044*
					↑ Equal Focus ↓ Post Only Control	0.012*
					↑ Equal Focus ↓ Pre-Post Control	0.021*
Inclusion of Nature in Self Scale*	12.518	4	0.014	200	↑ Equal Focus ↓ Post Only Control	0.011*
					↑ Inquiry Focus ↓ Post Only Control	0.001*
					↑ Inquiry Focus ↓ ES-L Focus	0.039*

Significant Relationships with Gender Table shows attitude and behavioral questions with a statistical dependency to gender. For each question with significant relationship, chi-square value, its significance and n are given. Further, the degree of association, gamma test values and its significance are given. Median on five point Likert scale (never = 1, infrequently = 2, sometimes = 3, frequently = 4, very frequently = 5) and interquartile range are given.

Attitude and Behavioral Questions with Significant Relationships to Gender	Chi Square Test Statistic, p-value; n	PRE: Degree of Association test statistic; p-value	Median (IQR)
Plants and animals have as much right as people to live	chi: 10.84 p: 0.03 n=190	gamma: 0.222 p: 0.06	Males: 4(1)
			Females: 5(1)
There are too many (or almost too many) people on earth	chi: 13.51 p: 0.01 n=188	n/a	Males: 4(2)
			Females: 3(1)
People will someday know enough about how nature works to control it	chi: 11.24 p: 0.02 n=182	n/a	Males: 3(2)
			Females: 4(2)
I plan to volunteer in a natural area (tree planting, invasive species removal)	chi: 9.72 p: 0.05 n=187	gamma: 0.263 p: 0.02	Males: 3(1)
			Females: 3(2)

Significant Relationships with Prior Environmental Education Table shows attitude and behavioral questions with a statistical dependency to question: “Have you received and other environmental education?” For each question with significant relationship, chi-square value, its significance and n are given. Further, the degree of association, gamma test values and its significance are given. Median on five point Likert scale (never = 1, infrequently = 2, sometimes = 3, frequently = 4, very frequently = 5) and interquartile range are given. Students who responded yes to “Have you received and other environmental education?” are listed as “Prior EE”, while those who responded no are listed as “No Prior” in the final column.

Attitude and Behavioral Questions with significant relationships to test question: “Have you received and other environmental education?”	Chi Square Test Statistic, p-value; n	PRE: Degree of Association test statistic; p-value	Median (IQR)
I recycle.	chi: 11.22 p: 0.02 n=209	phi: 0.232 p: 0.02	Prior EE: 4(2)
			No Prior: 3(1)
I talk to others (parents, friends, etc.) about environmental issues.	chi: 10.83 p: 0.03 n=207	phi .229 p: 0.03	Prior EE: 2(2)
			No Prior: 1(1)
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building).	chi: 16.7 p: 0 n=204	phi: .286 p: 0	Prior EE: 2(1)
			No Prior: 1(1)
People must obey the laws of nature.	chi: 10.35 p: 0.04 n=206	n/a	Prior EE: 4(2)
			No Prior: 4(2)
Nature is strong enough to handle the bad effects of our modern lifestyles	chi: 11.32 p: 0.02 n=208	gamma: .380 p: 0	Prior EE: 2(1)
			No Prior: 3(1)
People are treating nature badly	chi: 14.49 p: 0.01 n=207	gamma: -.340 p: 0.02	Prior EE: 4(1)
			No Prior: 4(1)
With other people, I can work to make a positive impact on the environment (i.e. improve or protect the environment)	chi: 13.97 p: 0.01 n=205	gamma: -.459 p: 0	Prior EE: 4(1)
			No Prior: 3(1)

Significant Relationships with Positive Environmental Role Model Table shows attitude and behavioral questions with a statistical dependency to question: “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?” For each question with significant relationship, chi-square value, its significance and n are given. Further, the degree of association, gamma test values and its significance are given. Median on five point Likert scale (never = 1, infrequently = 2, sometimes = 3, frequently = 4, very frequently = 5) and interquartile range are given. Students who responded yes to “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?” are listed as “Env+Adult”, while those who responded no are listed as “NoEnv+Adult” in the final column.

Attitude and Behavioral Questions with significant relationships to test question: “Besides the instructors in this program, do you have an adult role model that enjoys the outdoors/cares for the environment?”	Chi Square Test Statistic, p-value; n	PRE: Degree of Association test statistic; p-value	Median (IQR)
I pick up litter/trash.	chi: 14.7 p: 0.01 n=207	gamma: -.431 p: 0	Env+Adult: 3(1) NoEnv+Adult: 3(1)
I talk to others (parents, friends, etc.) about environmental issues	chi: 17.09 p: 0.00 n=206	gamma: -.425 p: 0.00	Env+Adult: 2(2) NoEnv+Adult: 1(1)
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building).	chi: 29.21 p: 0.00 n=202	gamma: -.563 p: 0	Env+Adult: 2(1) NoEnv+Adult: 1(1)
I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building).	chi: 18.41 p: 0.00 n=205	gamma: -.448 p: 0	Env+Adult: 3(2) NoEnv+Adult: 1(2)
Before this program how frequently did you spend time in the outdoors?	chi: 25.53 p: 0.00 n=205	gamma: -.504 p: 0	Env+Adult: 4(2) NoEnv+Adult: 3(1)
People must obey the laws of nature	chi: 9.71 p: 0.05 n=204	n/a	Env+Adult: 4(2) NoEnv+Adult: 4(2)

Significant Relationships with Witness to Environmental Harm Table shows attitude and behavioral questions with a statistical dependency to question: “Have you seen something bad happened to the environment before (ex. Natural area become developed, water pollution)?” For each question with significant relationship, chi-square value, its significance and n are given. Further, the degree of association, gamma test values and its significance are given. Median on five point Likert scale (never = 1, infrequently = 2, sometimes = 3, frequently = 4, very frequently = 5) and interquartile range are given, except the INS as stated in table. Students who responded yes to “Have you seen something bad happened to the environment before (ex. Natural area become developed, water pollution)?” are listed as “SeenEnvHarm”, while those who responded no are listed as “NotSeenBadEnv” in the final column.

Attitude and Behavioral Questions with significant relationships to test question: “Have you seen something bad happened to the environment before (ex. Natural area become developed, water pollution)?”	Chi Square Test Statistic, p-value; n	PRE: Degree of Association test statistic; p-value	Median (IQR)
I talk to others (parents, friends, etc.) about environmental issues.	chi: 12.17 p: 0.02 n=205	n/a	SeenEnvHarm: 2(2)
			NotSeenEnvHarm: 1.5(2)
Before this program how frequently did you spend time in the outdoors?	chi: 17.39 p: 0 n=205	gamma: -.424 p: 0	SeenEnvHarm: 4(2)
			NotSeenEnvHarm: 3(1)
If I had enough time or money I would devote it to working for the environment.	chi: 10.27 p: 0.04 n=205	n/a	SeenEnvHarm: 3(1)
			NotSeenEnvHarm: 3(2)
I enjoy spending time in natural settings (woods, mountains, desert, lakes, oceans).	chi: 15.64 p: 0 n=206	gamma: -.334 p: 0.01	SeenEnvHarm: 4(1)
			NotSeenEnvHarm: 4(2)
<i>With other people</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	chi: 9.37 p: 0.05 n=203	n/a	SeenEnvHarm: 4(1)
			NotSeenEnvHarm: 3(1)
<i>By myself</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	chi: 12.79 p: 0.01 n=204	gamma: -.236 p: 0.05	SeenEnvHarm: 3(1)
			NotSeenEnvHarm: 3(1)
I would feel an important part of my life was missing if I couldn't get out and enjoy nature from time to time.	chi: 18.31 p: 0 n=204	gamma: -.436 p: 0	SeenEnvHarm: 4(2)
			NotSeenEnvHarm: 3(2)
I pay special attention to things outdoors (plants, animals, woods, rivers, weather).	chi: 14.62 p: 0.01 n=204	gamma: -.402 p: 0	SeenEnvHarm: 4(1)
			NotSeenEnvHarm: 3(2)
I would be upset if the natural area where I have worked was destroyed/polluted.	chi: 15.28 p: 0 n=203	gamma: -.390 p: 0	SeenEnvHarm: 4(1)
			NotSeenEnvHarm: 4(1)
I think the restoration work that I do in natural areas is useful.	chi: 17.31 p: 0	gamma: -.480	SeenEnvHarm: 4(1)
			NotSeenEnvHarm:

	n=204	p: 0	3(0)
Inclusion of Nature in Self (INS) Scale: Ranges from 1-7 and measures cognitive representation of self. See Assessment on page 127 for picture of scale.	chi: 17.28 p: 0.01 n=197	gamma: -.381 p: 0	SeenEnvHarm: 4(2)
			NotSeenEnvHarm: 2(2)

Significant Relationships with Previous Outdoor Experiences Table shows attitude and behavioral questions with a statistical dependency to question: “Before this program, how frequently did you spend time outdoors?” which was considered binary in the chi-square analysis by grouping the lowest three values (never, infrequently, sometimes) and the highest two values (frequently, very frequently). For each question with significant relationship, chi-square value, its significance and n are given. Further, the degree of association, gamma test values and its significance are given. Median on five point Likert scale (never = 1, infrequently = 2, sometimes = 3, frequently = 4, very frequently = 5) and interquartile range are given, except the INS (7-point Likert) as stated in table. Students who responded with frequently = 4 or very frequently = 5 to “Before this program, how frequently did you spend time outdoors?” are listed as “FreqOutdoors”, while those who responded with never = 1, infrequently = 2, sometimes = 3 are listed as “RareOutdoors” in the final column.

Attitude and Behavioral Questions with Significant Relationships to test question: “Before this program, how frequently did you spend time outdoors?”	Chi Square Test Statistic, p-value; n	PRE: Degree of Association test statistic; p-value	Median (IQR)
I recycle	chi: 19.695 p: 0.001 n=209	gamma: -0.454 p: 0.000	FreqOutdoors: 4(1) RareOutdoors: 3(1)
I pick up litter/trash	chi: 10.302 p: 0.036 n=209	gamma: -0.267 p: 0.018	FreqOutdoors: 3(0) RareOutdoors: 3(1)
I talk to others (parents, friends, etc.) about environmental issues.	chi: 12.358 p: 0.015 n=207	gamma: -0.326 p: 0.002	FreqOutdoors: 2(2) RareOutdoors: 2(1)
I engage in environmental restoration outside of school (ex. weed pull, tree planting, trail building).	chi: 25.790 p: 0.000 n=203	gamma: -0.547 p: 0.000	FreqOutdoors: 3(1) RareOutdoors: 1.5(1)
I engage in environmental restoration as part of school (ex. weed pull, tree planting, trail building).	chi: 25.862 p: 0.000 n=206	gamma: -0.527 p: 0.000	FreqOutdoors: 3(3) RareOutdoors: 1(1)
If I had enough time or money I would devote it to working for the environment.	chi: 10.021 p: 0.040 n=207	gamma: -0.329 p: 0.000	FreqOutdoors: 3(1) RareOutdoors: 3(1)
I have skills necessary to make a positive impact on the environment	chi: 13.642 p: 0.009 n=205	gamma: -0.376 p: 0.000	FreqOutdoors: 4(1) RareOutdoors: 3(2)
I enjoy spending time in natural settings (woods, mountains, desert, lakes, oceans).	chi: 30.114 p: 0.000 n=208	gamma: -0.571 p: 0.000	FreqOutdoors: 5(1) RareOutdoors: 4(1)
<i>With other people</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	chi: 23.123 p: 0.000 n=205	gamma: -0.499 p: 0.000	FreqOutdoors: 4(1) RareOutdoors: 3(1)
<i>By myself</i> , I can work to make a positive impact on the environment (i.e. improve or protect the environment).	chi: 12.043 p: 0.017 n=206	gamma: -0.268 p: 0.011	FreqOutdoors: 4(1) RareOutdoors: 3(2)
I would feel an important part of my life was	chi: 34.177	gamma: -0.568	FreqOutdoors: 4(1)

missing if I couldn't get out and enjoy nature from time to time.	p: 0.000 n=205	p: 0.000	RareOutdoors: 3(1)
I pay special attention to things outdoors (plants, animals, woods, rivers, weather).	chi: 40.222 p: 0.000 n=205	gamma: -0.640 p: 0.000	FreqOutdoors: 4(2)
			RareOutdoors: 3(2)
I would be upset if the natural area where I have worked was destroyed/polluted.	chi: 27.367 p: 0.000 n=205	gamma: -0.390 p: 0.000	FreqOutdoors: 4(1)
			RareOutdoors: 4(1)
I think the restoration work that I do in natural areas is useful.	chi: 18.532 p: 0.001 n=206	gamma: -0.276 p: 0.014	FreqOutdoors: 4(1)
			RareOutdoors: 3(1)
I plan to volunteer in a natural area (tree planting, invasive species removal).	chi: 11.247 p: 0.024 n=205	gamma: -0.307 p: 0.004	FreqOutdoors: 3(2)
			RareOutdoors: 3(1)
Inclusion of Nature in Self (INS) Scale: Ranges from 1-7 and measures cognitive representation of self. See Assessment on page 127 for picture of scale.	chi: 29.826 p: 0.000 n=198	gamma: -0.526 p: 0.000	FreqOutdoors: 4(3)
			RareOutdoors: 3(1)