EXAMINING THE IMPACTS OF REFORESTATION AND BIOREMEDIATION PROJECTS ON HIGH SCHOOL ENVIRONMENTAL SCIENCE STUDENTS’ FEELINGS OF BIOPHILIA AND LEARNING ABOUT ENVIRONMENTAL ISSUES IN HAWAI‘I

by

Lorinda Forster

A professional paper submitted in partial fulfillment of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2019
©COPYRIGHT

by

Lorinda Forster

2019

All Rights Reserved
Mahalo nui loa to the students of Kamehameha Schools.
# TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND .................................................................1

2. CONCEPTUAL FRAMEWORK ............................................................................5

3. METHODOLOGY ...............................................................................................9

4. DATA AND ANALYSIS ......................................................................................17

5. INTERPRETATION AND CONCLUSION ..........................................................35

6. VALUE ..............................................................................................................43

REFERENCES CITED ............................................................................................46

APPENDICES .........................................................................................................50

| APPENDIX A | IRB Approval and Letter .................................................................51 |
| APPENDIX B | Attitudes Towards Nature Survey ......................................................53 |
| APPENDIX C | Attitudes Towards Nature Parent Survey ........................................63 |
| APPENDIX D | Student Journal Prompts Relection: Halema‘uma‘u and Crater Rim Trail 67 |
| APPENDIX E | Annotated Drawing: Vegetation, Soil and Water ...............................69 |
| APPENDIX F | STIP Scientific Terminology Inventory Probe ..................................73 |
| APPENDIX G | Bioremediation Reflection “Picture Tells A Thousand Words” 75 |
| APPENDIX H | Model of Ecological Succession of ‘Ōhi‘a Rainforest .........................79 |
| APPENDIX I | ‘Ōhi‘a Quiz ...............................................................................................83 |
LIST OF TABLES

1. Data Triangulation Matrix .................................................................16
LIST OF FIGURES

1. Attitudes Towards Nature Survey part 2 ...............................................................17
2. Attitudes Towards Nature Survey Pre-assessment
   Part 3 Connection to Nature ..............................................................................18
3. Attitudes Towards Nature Survey Post-assessment
   Part 3 Connection to Nature ..............................................................................18
4. Attitudes Towards Nature Survey Parts 4 and 5 Utilitarian Uses of Nature .........19
5. Attitudes Towards Nature Survey Parts 4 and 5 Nature’s Importance ...............20
6. Attitudes Towards Nature Survey Parts 4 and 5 Earth’s Limit ...........................21
7. Attitudes Towards Nature Survey Parts 4 and 5 Disconnect from Nature ..........22
8. Attitudes Towards Nature Survey
   Part 6 Consequences of Environmental Issues ..................................................23
   Connection to Nature ..........................................................................................24
10. Attitudes Towards Nature Parent Survey Home Activities .............................25
11. Attitudes Towards Nature Parent Survey Student Conversation ..................26
12. Scientific Terminology Inventory Probe
    Comparison of Pre and Post Answers ..................................................................28
13. Example 1 Annotated Drawing Vegetation, Soil and Water ...............................29
14. Example 2 Annotated Drawing Vegetation, Soil and Water ...............................30
15. Example 3 Annotated Drawing Vegetation, Soil and Water ...............................31
16. Annotated Drawing Vegetation, Soil and Water Mean, Medium,
    Mode of Drawing, Processes, Accuracy and Questions ........................................31
17. Example 1 Halemaʻumaʻu Successional Model ..................................................32
18. Example 2 Halemaʻumaʻu Successional Model ..................................................33
19. Example 3 Halemaʻumaʻu Successional Model ..................................................34
20. Mean, Median, Mode of Halemaʻumaʻu Successional Model ............................34
21. Mean Difference on Each Question for Knowing Ōhiʻa Quiz ............................35
22. Students Extracting Mud from Kumuola Fishpond ..........................................36
23. Students Propagating Plants for Bioremediation ..............................................37
24. Halemaʻumaʻu Crater Hike ................................................................................38
This action research study focused on the overall problem of how to promote biophilia in students while learning in experiential, place-based settings. Surveys, reflections, scientific terminology probes, annotated drawings, modeling and pre/post quizzes were used to access the results of the study. Results of the study indicate that some students were inspired to follow career paths in the natural sciences while others were further disconnected from nature. Some progress was made in learning vocabulary and facts about places visited. Further work is needed to promote deeper learning and feelings of biophilia for students prone to disconnecting from nature.
INTRODUCTION AND BACKGROUND

The study took place in an environmental science high school class at Kamehameha Schools, Hawai‘i Campus. The school has been operating since 1887, before the overthrow of the Hawaiian Kingdom by businessmen (KS’ Ho‘okahua Cultural Vibrancy Group, 1893). Upon death Bernice Pauahi Bishop, a member of the royal Hawaiian family, left an endowment based on income from 375,000 acres of land in Hawai‘i. Ninety eight percent of the school’s educational activities are supported by the interest from the endowment. School tuition is minimal in comparison to other private schools in Hawai‘i. The majority of students receive financial aid. Preference is given to students with Hawaiian ancestry for admittance to school (About Kamehameha Schools, 1996). All students at the Kamehameha Schools, Hawai‘i Campus have some Hawaiian heritage and, therefore, Kamehameha Schools, Hawai‘i Campus values place-based and culturally relevant pedagogy. The environmental science classroom is a great fit for implementing these pedagogical approaches.

The environmental science classes in this study are electives and are open to 9 through 12 grade students. Sometimes students are placed in the class to fill their schedules despite and not having signed up for the class. As a teacher, I feel encouraging biophilia and knowing the local environment is important for future generations so they make a positive impact on the world. It is my ultimate goal to increase student commitment to protect the environment.

Understanding and appreciating nature is particularly relevant for Hawaiian students because pre-contact Hawaiians were exceptionally close to nature being world
famous resource stewards. Cultures differed within and between islands to ensure resource conservation avoiding overexploitation in many different rainfalls and elevations. Upon contact with Europeans in 1778, it was observed that a fairly large population was supported through sustainable agriculture and fishing practices while maintaining large numbers of endemic species (Handy & Handy, 2004). Further proof of nature intimacy can be seen in the Hawaiian language itself. Durning (1992) makes the point that scientific understandings of nature that rival modern day knowledge can be seen within indigenous customs, languages and practices. Place, wind and rain names illustrate the fantastic observations that Hawaiians made during their tenure on the Hawaiian Islands (Akana, 2015).

Pre-contact Hawaiian land and water management practices ensured conservation of resources. Sections of land, normally stretching from mountains to sea, known as ahupua‘a, were managed to supply a variety of resources for people. Resources were not freely accessed at all times because management was overseen by a konohiki (chief). At times resource use was prohibited. Many words of importance are associated with water (wai). Waiwai means prosperous. Kanawai means law or privilege. Water management within the ahupua‘a was also overseen by the konohiki. Water was diverted in irrigation ditches (auwai) to taro patches and fishponds. Access to water was dependent on work done to maintain and build auwai. Re-using the water throughout the landscape ensured not only plenty of food but also good quality drinking water. Ecological wisdom is embedded in many Hawaiian words and sayings. For instance, the word for fisherman or to fish is lawai‘a. When translated, lawai‘a conveys practice of sustainable fish harvests. Lawai‘a literally means “enough fish” “lawa i’a”. The implication is that the job of the
fisherman is to catch enough fish to feed the people; therefore, excluded catching as many fish as you can is prohibited (Pukui & Elbert, 1974).

Hawaiian care of landscapes is further illustrated in names of land areas. Wao kanaka and wao akua are the upper elevation areas in ahupua’a. Wao denotes wild habitat and kanaka is designated for use of people while akua is a place for the gods (Fisher, 2015). Entrance into the forest was limited for sparingly collecting feathers or plants. Hawaiians did not go into this part of the forest unless absolutely necessary and would have done so with care (Handy & Handy, 2004). Many proverbs speak of being careful in the forest and its relationship to other factors in the landscape.

Hawaiians knew that the forest was related to rainfall. “Hahai no ka ua ia ka ululāʻau.” Pukui, 1983, p. 50). This Hawaiian proverb means “rain always follows the forest.” Another translation denotes that harvest of vegetation was done sparingly since overharvest would decrease rainfall (Pukui, 1983). Even though Hawaiians gathered many plants from the forest care was taken out of respect for the gods and to ensure rainfall.

However, after contact and colonization, connections to nature declined for most Hawaiians due to loss of land and subsequent poverty. The Great Mahele, in 1848, allowed foreign land ownership and was a significant change from how Hawaiians managed land. The concept of land ownership was non-existent before 1779. By the early 1900s most private lands in Hawai‘i were owned by foreigners. After the Great Mahale, the Hawaiian people were physically and economically disadvantaged since their existence traditionally depended on agriculture and harvest from forests and the ocean. Cycles of poverty started generations ago for some Hawaiian families. Statistics show
that more Hawaiians live in poverty and are unemployed than other ethnicities currently residing in the state of Hawai‘i (Kana‘iaupuni, 2005). The impact of loss of land and poverty is substantially reducing opportunities to interact with nature; hence children’s ties to nature are not as strong as once exhibited by Hawaiians.

Further isolation from nature wisdom occurred when the Hawaiian language was banned from being spoken in government activities in 1893 and in schools in 1896. Ties to language and land were politically altered during this historical period distancing Hawaiians from nature. In 1880, 57% of schools were conducted in Hawaiian. No students were taught using the Hawaiian language by 1902 (Schutz, 1994). Few of my students speak the Hawaiian language fluently. Even fewer of their parents speak the Hawaiian language fluently.

While Hawaiians have this vast cultural heritage of nature, at times there is a disconnect in students’ connection to nature, much like other children their age who have grown up with video games, phones, TV and supervised outdoor activities. Often when working on garden type activities, students complain about the weather, mud or getting their nails dirty, or even refusing to touch soil or other organic material. I worry about these biophobic tendencies and long-term impacts. If the next generation does not know the natural world, will they want to protect it? Additionally, the class is an elective so rigor is a complex part of planning. I want to ensure that learning is occurring.

This action research study focused on the overall research question: How do place-based activities influence student attitudes to nature and learning?

This project looked at three sub-questions:
1. How does participation in place-based projects impact students’ sense of stewardship?

2. Do place-based activities improve student understanding of importance of soil and water conservation in healthy ecosystems?

3. Is student understanding of Hawai‘i island rainforest restoration and succession improved after reforestation activities and hiking?

**CONCEPTUAL FRAMEWORK**

The term biophilia was coined in 1984 and it is the innate ability to focus on life and life like processes. This connection with nature has given humans an evolutionary advantage (Wilson, 1984). The ability to learn about nature quickly was later called “naturalist intelligence” (Gardner, 1999). Biophilia is more important than ever as environmental issues threaten the health of water, air, earth and life (Wilson, 1984). Biophobia is becoming more common in children as people become urbanized, crime increases and children are increasingly amused by technology. The term nature-deficit disorder describes how lack of time outdoors leads to negative consequences in children and adults’ mental health. Nature restores the human spirit. Biophilia, therefore is beneficial to individuals as it promotes a sense of protection (Louv, 2008; Louv, 2012).

Many researchers have explored attitudes to nature. Dewey and Muir are some of the earliest pioneers in this work (Dewey, 1925; Muir, 1894). Biophilia has been measured since the 1970s by Stephen R. Kellert from Yale University. Themes in Kellert’s work include dominionism, ecologism/scientism, humanism, moralism, naturalism, negativism and utilitarianism. He refined his work for nearly two decades. In
2013 Letourneau studied the validity of Kellert’s survey methods and found that measuring biophilic attitudes is a complex endeavor. It is recommended that the Biophilic Attitudes Inventory (BAI) be used in conjunction with other instruments to assess biophilia/biophobia (Letourneau, 2013). The Two Major Environmental Value model (2-MEV) was developed to measure environmental attitudes in two categories preservation and utilization. Later, another category was added to the instrument appreciation. One way that these instruments can be used is to validate the impacts of environmental education (Bogner, 2018). This literature was used to develop the survey given to students provided in Appendix B Attitudes Towards Nature Survey.

Assessing biophilic tendencies of Hawaiian students is important for cultural reasons. The study of nature in Hawai‘i underlies the very essence of how Hawaiians are different from the Polynesians from which they descended. Hawaiian cultural practices that developed from around 400 A.D. were significantly shaped by the abiotic and biotic conditions. This explains why place-based and culturally relevant strategies have been found to improve pedagogy for indigenous students (Jegede, 1995; Jegede 1996; Kawakami & Aton, 2000; McKinley, 2004). Place based education is defined as when students are immersed in local landscapes and cultures in experiences (Place-based Education Evaluation Collaborative, 2010). Most science concepts are taught through a European lens often clashing with cultural values, making learning challenging (Aikenhead, 1996). Environmental Science is uniquely suited to create opportunities for learning that minimize the clashes of cultures (western and indigenous) providing
students with opportunities to apply science to resource use related to Hawaiian culture in a contemporary context (Edelson, 2007).

Ramiriz (2013) stated that passion in learning can be generated by curricular storylines. Passion is the key to success in instructional strategies like inquiry, project-based learning, and problem-based learning. In this research, the story is based on experiencing nature once common in the Hawaiian landscape, fishponds and forests. Both have strong ties to Hawaiian culture.

It has been emphasized that educators should motivate and educate children from a place of love of the environment rather than fear of the consequences from neglect (Orr, 2004). Appreciation of nature is a better approach to making students good stewards. Often times students are made to feel responsible for the overexploitation that has taken place. Educators should encourage appreciation of nature to promote individuals that want to protect the environment (Bogner, 2018). In this study, this means that students must learn more about the importance of *Metrosideros polymorpha*, than the threats to the species. *Metrosideros polymorpha* is known as ‘ōhi‘a lehua and is an endemic tree.

*Metrosideros polymorpha* is an important plant to the story for several reasons. First of all, *Metrosideros polymorpha* plays a unique role in succession. It is one of the first plants to colonize lava fields but it also is a climax species; sometimes living for over 1000 years. *Metrosideros polymorpha* grows on the Big Island of Hawai‘i from coastal areas to 9000 feet. *Metrosideros polymorpha* role in the ecosystem is varied as its name implies including helping to break down rock into soil, growing in cohort populations changing conditions for future ecosystems, providing nectar for many of the
endemic honeycreepers, having many different colors of flowers (red, orange, and yellow) and forms (tree, shrub, prostrate shrub) (Mueller-Dombois & Boehmer, 2013; Stone and Pratt, 1994). The polymorphism that occurs in *Metrosideros polymorpha* can be found in many endemic plants, thus *Metrosideros polymorpha* can be referred back to when explaining genetic variability of other species (Culliney, 2006).

Experiential education is a strategy used to connect student learning to nature. One benefit of experiential learning is that there is a long-term impact on responsible behavior (Caulfield & Woods, 2013). To encourage optimum learning in experiential education is it suggested that students need to take responsibility and have six C’s incorporated into activities. The six C’s include complexity (social, scientific, cultural, and environment), connection (to people, to place and to planet), consequences of actions (individual, societal, political, multinational), citizenship (rights and responsibilities), care (self, others and environment) and critical thinking. Higgins is worried that outdoor learning may have too much recreational value and stresses the need to make the activities real/relevant, involve relationships and responsibility.

Krajcik reiterated that meaningful real-world problems should be a focus in project-based pedagogy. There should be a shift from covering many topics superficially to a practice of science that is relevant to students. To provide students with rigorous coverage of standards educators should articulate goals as performances (with practices and content) and that learning goals, tasks and assessments should be linked (Krajcik, 2007).
METHODOLOGY

The research methodology for this project received an exemption by Montana State University’s Instructional Review Board and compliance for working with human subjects was maintained (Appendix A).

Problem

Often students are interested in helping the environment but are not enthusiastic about stewardship activities. At first, students seem really concerned about the environment. Over time, some students have a waning in interest. Elective science classes can provide an experiential education for students. This study investigates stewardship effects on feelings of biophilia and learning in an elective class.

Purpose

It is hoped that by investigating student feelings towards stewardship and learning during experiential education that improvements can be made to pedagogical practice so I can positively influence students in the long-term to care for and know about the environment. This research is important for students to make the elective class more meaningful and the effects of learning more long lasting. Other elective teachers may find this helpful in balancing class enjoyment with meaningful learning.

Research Questions

The overall research question is “How do place-based activities influence student attitudes to nature and learning?” The three sub-questions seek to answer this overall question. Sub-question one, is “How does participation in a reforestation project and a
hike impact students’ sense of nature stewardship?” Sub-question two is, “Do place based activities improve student understanding of importance of soil and water conservation in healthy ecosystems?” Sub-question three is, “Is student understanding of Hawai‘i island rainforest restoration and succession improved after reforestation activities and hiking?”

Description of Study Sample

The 28 students participating in this study took Environmental Science during the Spring 2019 semester at Kamehameha Schools, Hawai‘i Campus located in Kea’au on the Big Island of Hawai‘i. The school admittance policy preferences students with Hawaiian heritage. However, over 30 ethnicities are represented at the school. It is not uncommon for students to have five or more ethnicities (K. Rose, personal communication, January 9, 2019). Socioeconomic status of students varies at the school. Even though the school is a private school, financial aid is received by many students, sometimes paying for their entire tuition. From school year 2015-16 to school year 2017-18, students receiving financial aid has increased from 80.4 to 83%. Students receiving full scholarships has grown from 65.6% to 80.8% in this time period (K. Rose, personal communication, January 9, 2019). According to the Attitudes Towards Nature Survey approximately 70% are certain that they signed up for the class, while 11% did not and the remaining ones are unsure. Females compose 43% of the students and males compose 57%. This population of students consists of 29% seniors, 36% juniors, 4% sophomores and 32% freshman. About 70% of the students have over a 3.0 GPA (Attitudes Towards Nature Survey). The Attitudes Towards Nature Survey is described further in the next section.
I have 11 years of teaching experience at the school and have taught on all the Kamehameha campuses (Kapālama, Maui and Hawaiʻi). During this time, I have taught biology, chemistry, geometry, medical problem solving and environmental science. This is the fourth year of teaching the elective environmental science semester class. I have tried several different approaches to the class and have found that a project-based approach is the most promising in making a science elective that incorporates experiential learning. I feel that experiential learning is a major deficiency in the required science classes. Many of our students come from rural areas and experiential learning is more suited to their background.

Description of Treatment

Students participated in a one-day field trip setting up a bioremediation experiment, at Kumuola, a traditional Hawaiian fishpond. The environmental issue that students explored was copper contamination due to paint from a radio tower once housed on the shore of the pond. Students went on a field trip to the pond where they set up ongoing research about using common plants in the surrounding area to bioremediate the sediments containing copper. As each class visits the pond, they expand on research done by previous semesters. Two weeks prior to the fish pond field trip students studied pollution in the water cycle, soil fertility, fertilizer use and heavy metals in the environment. The one-day fish pond field trip focused on the use of indigenous plants to absorb copper from sediments in the fishpond. Students extracted soil from the pond, collected seeds in the area and set up the experiment.

Students also hiked the Volcano National Park Halemaʻumaʻu hike through lava fields and endemic ʻōhiʻa lehua, *Metrosideros polymorpha*, forests. *Metrosideros*
polymorpha plays a unique role in succession. It is one of the first plants to colonize lava fields but it also is a climax species; sometimes living for over 1000 years. Succession and impacts of invasive species were explored on the Halemaʻumaʻu hike which has various stages of succession and plant communities. While on the hike students made sketches of various areas, including the Halemaʻumaʻu crater floor (that stopped erupting last year), the crater rim trail (last eruption about 130 years ago) and a couple of sites in between the two that are a bit older. Sketches focused on plant species, abiotic factors, layers of the forest and any birds observed.

Last, students participated in a reforestation project located on the campus grounds centered mainly around Metrosideros polymorpha. The polymorphism that occurs in Metrosideros polymorpha can be found in many endemic plants, thus Metrosideros polymorpha can be referred back to when explaining genetic variability of other species (Culliney, 2006). Lectures and readings were centered around restoration techniques including microorganisms that boost soil fertility, sheet mulching, and foster ecosystems. Science connected to Meterosoides polymorpha was emphasized including soil morphology effects in ecological succession, role as keystone species, propagation from seed to outplanting, and learning the characteristics and the seven Hawaiian rain names associated with Meterosoides polymorpha blossoms in the school’s district.

Instrument Description and Analysis

Students completed an Attitudes Towards Nature Survey (ATNS) (Appendix B). Most questions were Likert scale and the survey was given at the beginning of the semester and again at the semester’s end. Analysis was done by grouping questions
together for themes and trends in student beliefs. There were six parts to the survey. Each part is described here. Part one was analyzed for demographic information. Part two was analyzed to assess the average previous experiences that students had annually from 6-18 years old. Part three was analyzed for feelings of biophilia. Parts four and five were analyzed for student’s relationship to nature in the following ways utilitarian uses of nature, nature’s importance, earth’s limits, and disconnects from nature. Part six was analyzed for students’ concern for various parts of nature. Pre and post results were analyzed to see if there was a difference in feelings of biophilia during the semester. This survey was given to all Environmental Science students and pre-post results were analyzed for change in mean for each question in parts three through six.

Parents completed an Attitudes Towards Nature Parent Survey (ATNPS) near the class’s end to answer question one (Appendix C). The survey’s purpose was to collect information about parent values of nature, record any changes parent observed in student attitude during the course of the semester as observed by parents and ask parents for parent input. The survey was analyzed using mean of most questions and a qualitative review of open-ended questions.

Students completed the Volcano National Park Halema’uma’u Hike Reflection (VNPHHR) (Appendix D). The prompt for the reflection was “What issues are impacting ‘ōhi’a forests today? How important is the role of humans to ‘ōhi’a forests today? Why? Do you want to share anything else about how this day impacted your awareness of “ōhi’a forests?” Reflections were analyzed qualitatively for themes and also referenced to themes in student survey.
The Scientific Terminology Inventory Probe (STIP) was used to assess student familiarity with concepts relating to projects (Appendix F). This STIP was given before instruction and after projects had been concluded. This same instrument was given for the sub-question number 3. Student’s familiarity, ability to define and apply vocabulary to what was learned in class were analyzed. Terms related to soil and water conservation included erosion, cover cropping, bioremediation, and soil fertility. Comparison of pre-post answers was done to access learning.

The Annotated Drawing Vegetation, Soil and Water (ADVSW) was analyzed for students’ understanding the importance of vegetation to conserving soil and water (Appendix E). Students were asked to draw two landscape scenes, one with vegetation and one without. On each drawing students indicated quality and quantity of water resources as influenced by the presence of absence of vegetation. The ADVSW was analyzed 30% by effort in drawing necessary areas, 40% by details of processes and 30% by accuracy. Analysis of student work using mean, median and mode details of processes and accuracy was completed and compared to rubric for this study.

The Bioremediation Reflection (BR) “Picture Tells a Thousand Words” was analyzed for student understanding of tasks, place in science process and connection to macroscale and qualitatively for added themes (Appendix F). Qualitative document review was done assessing understanding of the purpose and learning related to activity.

The Scientific Terminology Inventory Probe (STIP) was used to assess student familiarity with concepts relating to projects for research question three as well (Appendix E). This STIP was given before instruction and after projects had been concluded. This same instrument was given for the sub-question number 2. Analysis
knowledge of the following terms (biomass, biodiversity, matter cycles, invasive species) was also done. Comparison of pre-post answers was done to access learning.

Succession was modeled in drawing various landscapes located in Volcano National Park on the Halema‘uma‘u Crater Hike (Appendix G). The Halema‘uma‘u Succession Model (HSM) prompt was “construct a model of ʻōhiʻa rainforest succession that shows patterns of forest establishment, and the effects of invasive species”. Models were analyzed using the rubric for observations, ability to order drawings in correct succession, identification of primary and climax species, analyze the effects of invasive species on forest regeneration and to analyze the effects of vegetation on soil development. Data was reported as mean, median and mode for each part of the rubric drawings, observations and questions.

Students were given a pre-post quiz over Knowledge of ʻŌhiʻa (appendix H). Students knowledge of name and meaning of the scientific name was tested. Knowledge of range of ʻōhiʻa was assessed, role in ecosystem and status were accessed. Also students were required to match ʻōhiʻa rain names with descriptions.

**Triangulation Matrix**

Table 1 is an overview of the sub-questions and triangulation matrix.
<table>
<thead>
<tr>
<th>Questions</th>
<th>Data Collection Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>“How do place-based activities influence student attitudes to nature and student learning?”</td>
<td></td>
</tr>
<tr>
<td>Subquestion 1: How does participation in a reforestation project and a hike impact students’ sense of nature stewardship?</td>
<td>Subquestion 1: How does participation in a reforestation project and a hike impact students’ sense of nature stewardship?</td>
</tr>
<tr>
<td>Subquestion 2: Do place based activities improve student understanding of importance of soil and water conservation in healthy ecosystems?</td>
<td>Subquestion 2: Do place based activities improve student understanding of importance of soil and water conservation in healthy ecosystems?</td>
</tr>
<tr>
<td>Subquestion 3: Is student understanding of Hawai‘i island rainforest restoration and succession improved after reforestation activities and hiking?</td>
<td>Subquestion 3: Is student understanding of Hawai‘i island rainforest restoration and succession improved after reforestation activities and hiking?</td>
</tr>
</tbody>
</table>
DATA AND ANALYSIS

The Attitudes Towards Nature Survey ATNS part two prompted students to indicate how often on average they participated in the following activities on average from ages five to 11. Results indicate that about half the student population (N=28) have done all activities over three to four times a year on average per year (Figure 1). The most common nature activity amongst this student population growing up is swimming. About half of the students have done all activities over three to four times a year on average per year. Horseback riding and surfing had the largest numbers for non-participation.

![Figure 1](image)

*Figure 1. Attitudes Towards Nature Survey part 2, (N=28).*

The results of the Attitudes Towards Nature Survey ATNS pre-assessment part three connection to nature indicate that 58.9% have a positive relationship to nature while 13.1% are disconnected from nature (Figure 2). The remaining 28% of the students have neutral feelings towards nature.
Figure 2. Attitudes Towards Nature Survey pre-assessment part 3 connection to nature, \((N=28)\).

The results of the Attitudes Towards Nature Survey ATNS post assessment part three connection to nature indicate that 72% have a positive relationship to nature while 21% are disconnected from nature (Figure 3). The remaining 7% of the students have neutral feelings towards nature. Students with a positive relationship to nature increased by 13%. Students with a disconnection to nature also increased by 14%.

Figure 3. Attitudes Towards Nature Survey post-assessment part three connection to nature, \((N=28)\).
Results from the Attitudes Towards Nature Survey ATNS parts four and five utilitarian uses of nature indicate 47% of students agree that plants and animals should be used for utilitarian purposes (Figure 4). Twenty two percent of the student population does not agree that plants and animals should be used. The remaining 31% are neutral in their views of plant and animal use.

Results from the Attitudes Towards Nature Survey ATNS parts four and five nature’s importance indicate that on average 59.9% of students agree that nature and their ability to serve nature is important (Figure 5). Twenty seven percent of students were neutral in thinking that nature is important. The remaining 14.8% disagreed that nature was important. Results from the Attitudes Towards Nature Survey parts four and five nature’s importance indicate that on average 84% thought that nature and their ability to serve nature is important. Six percent were neutral in their thinking about nature. One percent disagreed that nature is important or that it is important to take care of nature.

*Figure 4. Attitudes Towards Nature Survey parts 4 and 5 utilitarian uses of nature, (N=28).*
Results from the Attitudes Towards Nature Survey ATNS parts four and five indicate that 59% of the student population believe that the earth does have a limit and that humans play a large role in pushing the limit (Figure 6). Students that were neutral about the idea of earth having a limit were 33% of the population. The remaining seven percent of the population does not think earth has a limit. Results from the post ATNS parts four and five indicate that 71% of the student population believe that the earth does have a limit and that humans play a large role in pushing the limit. Students that were neutral about the idea of earth having a limit were one percent of the population. The remaining 19% of the population does not think earth has a limit.
Results from the Attitudes Towards Nature Survey ATNS parts four and five disconnect from nature indicate that 13% of the student population do not feel that nature is needed for human survival (Figure 7). Sixty three percent feel that nature is needed for humans. The remaining 26% feel neutral about environmental issues and humans need of nature. Results from the post Attitudes Towards Nature Survey parts four and five disconnect from nature indicate that 23% of the student population do not feel that nature is needed for human survival (Figure 6). Seventy percent feel that nature is needed for
humans. The remaining seven percent feel neutral about environmental issues and humans need of nature.

Figure 7. Attitudes Towards Nature Survey parts 4 and 5 disconnect from nature, \((N=28)\).

Results from the Attitudes Towards Nature Survey ATNS parts four and five disconnect from nature indicate that 73% of feel on average that environmental problems are of supreme consequences to items listed (Figure 7). After supreme importance, average numbers were as follows, 17.9%, 9.8% and 5%. Three percent thought environmental issues were not important at all. Results from the post Attitudes Towards Nature Survey parts four and five disconnect from nature indicate that 72% of feel on average that environmental problems are of supreme consequences to items listed (Figure
After supreme importance, average numbers were as follows, 18.9%, 10%, and five percent. Four percent thought environmental issues were not very important.

Figure 8. Attitudes Towards Nature Survey part 6 consequences of environmental issues (N=28).

The results of the Attitudes Towards Nature Parent Survey Children Connection to Nature indicate that all parents surveyed agreed that it was important for their children and other people’s children to have a connection to nature (Figure 9). Nine strongly
agreed that it was important that their own child had a connection to nature while four parents agreed only. Ten strongly agreed that it was important that the next generation had a connection to nature while three parents agreed only. No parents disagree that their child or any child from the next generation should have a strong connection to nature.

Figure 9. Attitudes Towards Nature Parent Survey Children Connection to Nature, \(N=14\).

The results of the Attitudes Towards Nature Parent Survey Home Activities indicate that keeping a pet is the most popular “nature activity” with 86% of participants reporting keeping a pet in the past and 79% of participants reporting currently having a pet (Figure 10). Growing food plants was second most popular with 57% currently growing food and 71% growing food sometime in the past. Hunting was a reported activity for past and present by 36%. Animal husbandry was currently practiced by 14%
and in the past by 36%. Growing useful plants was reported by 14% currently and 29% in the past. Seven percent of participants reported growing plants for aesthetic reasons.

Figure 10. Attitudes Towards Nature Parent Survey Home Activities, (N=14).

Results from the Attitudes Towards Nature Parent Survey Student Conversation indicate that 8 students were reported to have spoken to their parents about excursions in the class (Figure 11). Six students did not mention excursion at home. Seven students asked for additional nature activities at home during the semester. Seven students did not request additional activities relating to nature during the semester.
Results from Attitudes Towards Nature Parent Survey indicate that students that did mentioned working in the garden the most (an activity that was not a focus of this study). Fishponds and the value of sustainable agriculture were also mentioned. Students that showed more interest in nature, were reported by their parents, to be interested in new hikes, interested in a home cacao production of 1000 trees, and have been researching colleges with agriculture and forestry programs.

Results from the Volcano National Park Halema’uma’u Hike Reflection indicated that most students answered using previous knowledge rather than what was discussed on the hike. Rapid ‘ōhi’a death, ROD, was mentioned by 85% of participants on the hike as an impact to the forest while only 20% mentioned the impacts of invasive species. Importance of ‘ōhi’a was indicated with some correct answers including: pioneer species,
protection of watershed, keystone species and creator of soil. One student said, “Ohia is important because it is used as food, shade and also cleans and protects our watershed. This impacts us because we need clean water to survive”. Many students neglected to answer the human importance to preserving ‘ōhi‘a. Prevention of spreading the disease was mentioned by 35%. Planting ‘ōhi‘a seedlings, removing/preventing invasive species, and enhancing the indigenous companion fern ‘uluhe was mentioned by seven percent. One student said, “The issues that are impacting the ohia are invasive species, rod, and humans. We are important because we can help the ohia grow without problems and we can protect it from invasive species”. Another student mentions the fern, “Humans may help restore by finding companion plants who can help the ohia such as uluhe”. Many students made vague statements about protecting the environment or simply neglected to answer these questions. One student answered “we need to watch what we do to the environment”.

Results from the Scientific Terminology Inventory Probe comparison of pre and post answers indicate that students make improvements in understanding all nine terms (Figure 12). The most growth was observed in understanding erosion, cover cropping, invasive species and restoration. Little growth was observed with succession, biomass, bioremediation, soil fertility and foster ecosystems.
Figure 12. Scientific Terminology Inventory Probe comparison of pre and post answers, \((N=28)\).

Results from group one Bioremediation Reflection indicated that students were able to identify variables in the experiment, the purpose of sanding seeds, and some identified that the main purpose of sanding the seeds was to bio-remediate copper from the pond. Results from group two Bioremediation Reflection indicate that students understood that copper impacts the base of the food chain on the algae. Further by taking the mud out of the pond, students were removing the copper in hopes of bio-remediating soil using plants. Results from group three Bioremediation Reflection indicated that students could identify variables in the experimental set-up, could identify that mud is smelly when it lacks oxygen and that copper can be taken out of soil by some plants.

The results of the Annotated Drawing Vegetation, Soil and Water show mean percent values of 100%, 95%, 90% and 70% for drawing, processes, accuracy and
questions, respectively; median percent values of 100%, 100%, 88% and 75% for drawing, processes, accuracy and questions respectively and mode percent values of 100%, 100%, 100% and 75% for drawing, processes, accuracy and questions respectively (Figure 13, 14 and 15).

*Figure 13. Example 1 Annotated drawing vegetation, soil and water.*
Figure 14. Example 2 Annotated drawing vegetation, soil and water.
Figure 15. Example 3 Annotated drawing vegetation, soil and water

Figure 16. Annotated drawing vegetation, soil and water mean, medium, mode of drawing, processes, accuracy and questions, (N=28).
The results of the Halemaʻumaʻu Successional Model show mean percent values of 86%, 70% and 70% for drawings, observations and questions respectively; median percent values are 88%, 75% and 75% for drawings, observations and questions respectively and mode percent values are 100%, 50% and 50% for drawings, observations and questions respectively (Figure 17, 18, 19, 20).

Figure 17. Example 1 Halemaʻumaʻu successional model.
Figure 18. Example 2 Halema‘uma‘u successional model.
Figure 19. Example 2 Halemaʻumaʻu successional model.

Figure 20. Mean, median, mode of Halemaʻumaʻu successional model, \((N=28)\).
Results from the Knowing ʻŌhiʻa Quiz indicate that improvements were made on all questions except four and 10 (Figure 15). The largest growth was seen in question five with a 54% increase in correct answers. Questions 1 and 2 had a 21% increase. Questions seven, eight, 11 and 14 had over 10% increase.

**Figure 21.** Mean difference on each question for Knowing ʻŌhiʻa Quiz, \((N=28)\).

**INTERPRETATION AND CONCLUSION**

This study indicates that by participating in the three place-based activities student feelings polarized relating to biophilia. In parts two through five increases in biophilia were seen as well as increases in biophobia. I did request that students not pick neutral on the survey unless they could not go slightly agree or disagree on the post survey. On reflection, most of the activities required a lot of student physical stamina. Much of the weather on these activities was hot. The fishpond field trip required extracting smelly mud from the bottom of the pond (Figure 16 and 17).
Figure 22. Students extracting mud from Kumuola Fishpond.
Figure 23. Students propagating plants for bioremediation.

The Halema’uma’u hike was on a warm day even though we were at 4000 feet elevation (Figures 18 and 19).
Figure 24. Halemaʻumaʻu Crater hike.

Figure 25. Halemaʻumaʻu Crater on day of hike.
The reforestation days were often warm and work laden, lacking firm links to the educational components (Figures 20, 21, and 22). For students who tend to like being in nature, these activities strengthened their bond and learning seemed to click in place. For students who were not sure about nature at the beginning of the semester, these activities seemed to distance them further.

*Figure 26. Students working at reforestation site.*
Figure 27. Reforestation site at end of semester.
The parent population that answered the survey indicate that family values towards nature are positive. Some have really strong biophilic values. Effects of enhanced biophilia were indicated by some parents saying their children requested more hikes, talked about excursions and are planning to pursue agriculture or forestry in college.

This study supports the idea that participation in place-based activities (fishpond field trip, fertilizer experiment, hiking, and restoration project) helped students understand importance of soil and water conservation. Improvements in student understanding were seen in vocabulary (erosion, cover cropping, bioremediation and soil fertility), associated with soil and water conservation in the scientific terminology inventory probe. Students were able to generally describe how phytoremediation works at the fishpond. Throughout the semester students participated in hands-on place-based exercises to reinforce this learning. This experiential education had many of the six C’s
that Caulfield and Woods mention: complexity, connection, consequences of actions, citizenship, care and critical thinking.

Results from the Annotated Drawing Vegetation, Soil and Water indicate that further improvements could be made to instruction to ensure better understanding of soil and water conservation. Although over 80% of students were able to accurately draw processes important to soil and water conservation, ability to apply knowledge to questions was lacking for 20% of the class. More time and perhaps discussion was needed to extend the concepts.

The Scientific Terminology Inventory Probe indicate that gains were made with invasive species and restoration with at least \( \frac{1}{3} \) of students being able to define them at the end. Further work is needed to improve instruction about biomass and foster ecosystems as indicated by scientific terminology inventory probe. No students could define biomass or foster ecosystems. The last two concepts were part of the restoration project. Discussions and exit tickets could improve student understanding of these concepts. Although restoration activities had what Krajcik described as a real problem, I think the activities alone lacked some of the C’s described by Caulfield and Woods. Although the problem of restoration itself has plenty of complexity and a need for critical thinking, I think students needed more scaffolding to understand how to apply more complex thinking. Additionally, the shortness of the class makes the consequences of their methods difficult to see.

Results from Halema‘uma‘u succession model indicate that 80% of students were able to draw their surroundings on the hike. Fifty percent was the mode for observations made while mean and median were higher showing some level of better observations.
This could be improved by going on a “mini-hike” on campus so students understand how to record their observations better. Students were not able to extend their thinking well with mean and median being just over 60%. The mode was 50%. The term succession was primarily covered on the hike which lacks many of the C’s in experiential education, namely citizenship. Follow-up questions were done after the hike when students were tired and should have been further discussed in class to expand on the complexity, connection, consequences of actions, care and critical thinking that students could have experienced on the hike. The need for improvement in instruction is fully illustrated by the results of the scientific technology inventory probe. Only a couple of students could define succession one month after the hike.

The Knowing ‘Ōhi‘a Quiz indicates improvements in student understanding; however, many were under 20%. One rain name showed no increase while another one showed a decrease. To increase student knowledge of rain, I plan to make a rain card that we can refer to throughout the semester to identify the rain as it is occurring. A decrease was also seen in question four, understanding the ‘ōhi‘a life cycle. Seed collecting was done on one day. A couple of students were absent. A hand-out would be a good addition to the exercise as well as completing the exercise on a couple of occasions. An improvement to this lesson would be to require a practical where students have to find seeds of the correct maturity.

VALUE

The value of this study for students was that they participated in experiential learning related to local and cultural issues, namely bioremediation of pond sediments and forest restoration. Both of these issues have an empowering element for indigenous
Hawaiians who were some of the only Polynesians to keep fishponds on such a large scale. Additionally, forests were revered and used for timber, medicine and feathers. These students were the first class that has tried to revive local rain names associated with ʻōhiʻa lehua.

The value of this study for my school was that authentic learning opportunities, place-based learning and culturally relevant content were cultivated. The school fishpond was utilized for an on-going bioremediation project. The restoration project progressed with further propagation of nearly 1000 threatened Metrosideros polymorpha as well as other species. Rain names associated with the plant were explored and incorporated into one curriculum progressing culturally relevant education goals. Indicators of student biophobia were revealed and could be further studied.

This study’s value made me reflect on conceptual learning, how to evaluate and extend learning to outdoor environments and on how to encourage biophilia. The conceptual learning needed more work. The students were close to understanding the concepts; however, I think learning units needed better links to strategies to reinforce learning. I also think that discussion could play a much larger role in facilitating the learning. I found that towards the end of the semester some students had become more passionate and opinionated. More discussion may have increased biophilia for other students. Although I incorporated readings and presentations, I did not require the exercises which would have linked the outdoor learning with the reading. Lastly, I think I did not emphasize environmental issues enough while in the classroom. Even though Orr and Bogner suggest motivating students from a place of loving nature, I felt that high school should go into greater depth of issues. Perhaps students felt that working to restore
nature was not necessary or worth the hard work. On another note, I felt like the activities required too much work and did not allow students enough time to enjoy and observe nature. More observational activities were needed.

This study is relevant to any educator that aims to promote biophilia, stewardship and learning through experiential education. The need to conserve water, soil and forests requires human care at this time in history. Many current practices reduce the health of the environment. Hawai‘i ecosystems are particularly impacted by invasive species. Many endemic species, will not survive into the future without the help of humans. This study looks at activities where students interact with, restore and study nature.

This study’s value for the teaching profession is important to those trying to incorporate project-based curricula rather than traditional approaches. Planning curricular approaches is more important as each experience should be a learning experience. However, in this study, even “outstanding” students did not always remember or learn material presented. This indicates a need for further improvement in training students to learn using experiential learning.
REFERENCES CITED


APPENDIX A

IRB APPROVAL AND LETTER
MEMORANDUM

TO: Lorinda Forster and Marcie Reuer

FROM: Mark Quinn, Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 18, 2018

RE: "Examining the Impact of Reforestation and Bioremediation Projects on High School Environmental Science Students’ Feelings of Biophilia and Learning about Environmental Issues in Hawaii" [LF101818-EX]

The above research, described in your submission of October 17, 2018, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects’ responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects’ financial standing, employability, or reputation.

(b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

(b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.
APPENDIX B

ATTITUDES TOWARDS NATURE SURVEY
Attitudes Towards Nature Survey

The purpose of this survey is to collect information regarding feelings about nature and to analyze any changes in student attitude during the course of the semester. Results will be reported in Mrs. Forster’s thesis. All information will be coded and no personal information will be shared. Participation in this research is voluntary and participation or non-participation will not affect grades or class standing in any way. If you do not wish to participate, results will not be included in research or alternative assignments will be given when appropriate.

Part 1: What grade are you in?

- Freshman
- Sophomore
- Junior
- Senior

Part 1: What is your sex?

- Female
- Male

Part 1: Did you sign up for this class?

- Yes
- No
- Maybe

Part 1: If yes, please provide a short answer why you chose to take the class.
What is your cumulative grade point average?

- above 4.0
- 3.5-4
- 3.0-3.4
- 2.5-2.9
- 2.0-2.4
- below 2.0
- don't know
- Other:
Part 2: Please check the box that corresponds to the number times per year (on average) that you between ages 6 and 18 participated in each of the following activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>0 times</th>
<th>1 to 2 times</th>
<th>3 to 4 times</th>
<th>5 to 6 times</th>
<th>7 to 8 times</th>
<th>9 to 10 times</th>
<th>11 or more times</th>
</tr>
</thead>
<tbody>
<tr>
<td>went camping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>went fishing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>went for a walk or hike in nature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>worked in a garden or cared for plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>swam in a river, lake, sea or ocean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>watched or listened to birds, insects or other animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>collected objects in nature such as rocks, leaves, fruit, insects or seashells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gazed at stars or watched clouds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rode in a canoe, kayak, sailboat or other non-motorized watercraft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rode a horse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>went surfing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 3: Please indicate how much you agree or disagree with each of the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>strongly disagree</th>
<th>slightly disagree</th>
<th>neutral</th>
<th>slightly agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like to observe animals like insects and birds.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>I don't like getting dirty when I go outside.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>I like the sounds of wind and rain.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>It's usually too hot or too rainy to enjoy being outdoors.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>I like learning the names of plants and animals.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>We should get rid of insects as much as we can.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>I like the smell of plants and animals in the wild.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td>The thought of being deep in the woods, away from civilization, is frightening.</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
</tbody>
</table>
### Part 4: Please indicate how much you agree or disagree with each of the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Slightly disagree</th>
<th>Neutral</th>
<th>Slightly agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbes are important to nature.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The best plants and animals are those that people can eat or make into other things.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It's okay to hunt animals for food.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All plants and animals are important in nature.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature is valuable for its own sake.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants and animals are around for people to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I need time in nature to be happy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not feel that humans are dependent on nature to survive.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes when I am unhappy I find comfort in nature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The most important reason for conservation is human survival.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>He ali‘i ka ʻāina; he kauwā ke kanaka. The land is the chief, man is its servant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not care about environmental</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 5: For each statement, please indicate whether you strongly agree, mildly agree, unsure, mildly disagree or strongly disagree.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Mildly Agree</th>
<th>Neutral</th>
<th>Mildly Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans were meant to rule over the rest of nature.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The earth is like a spaceship with very limited room and resources.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Humans are severely abusing the environment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Human ingenuity will insure that we do NOT make the earth unlivable.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am a servant of the land.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>We are approaching the limit of the number of people the earth can support.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Despite our special abilities, humans are still subject to the laws of nature.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Environmental threats such as deforestation, global climate change and invasive species have been exaggerated.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>He aliʻi ka ʻāina; he kauwā ke kanaka. The land is the chief; man is its servant.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Part 6: I am concerned about environmental problems because of the consequences for

<table>
<thead>
<tr>
<th></th>
<th>supreme</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>not important</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>marine life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>birds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>my future</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>my lifestyle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>my health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>all people</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>people in my community</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>my grandchildren</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What kinds of activities do you think would help you or other students appreciate nature more?

☐ bird watching

☐ species surveys

☐ work opportunities for growing useful plants

☐ snorkeling

☐ fish and coral surveys

☐ nature walks

☐ processing useful materials

☐ Other:
What kinds of activities do you think would help you or other students appreciate nature more?

☐ bird watching

☐ species surveys

☐ work opportunities for growing useful plants

☐ snorkeling

☐ fish and coral surveys

☐ nature walks

☐ processing useful materials

☐ Other:
APPENDIX C

ATTITUDES TOWARDS NATURE PARENT SURVEY
Parent Survey

The purpose of this survey is to collect information about students prior experiences in nature, record parent values of nature and to analyze any changes in student attitude during the course of the semester as observed by parents. Results will be reported in Mrs. Forster's thesis. All information will be coded and no personal information will be shared. Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. If you do not wish to participate, results will not be included in research or alternative assignments will be given when appropriate.

Part 1: How much do you agree with this statement? It is important that my child has a connection to nature.

☐ Strongly Agree

☐ Agree

☐ Neutral

☐ Disagree

☐ Strongly Disagree
Part 2: Which of the following activities are practiced at your household currently?

- Keeping a pet
- Hunting
- Raising animals for food
- Growing plants for food
- Growing plants for other needs such as timber, fiber, medicine....
- Beekeeping
- Other:

Part 3: Has your son or daughter mentioned reforestation or bioremediation work done at school at home?

- Yes
- No

If yes, please describe.

Your answer
Has your son or daughter shown more interest in nature or activities involving nature this semester?

- Yes
- No

If you answered yes, please explain.

Your answer

Part 4: How much do you agree with the following statement? "It is important for the next generation to have a connection to nature".

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Please share tips on engaging teens to connect with nature in meaningful and long-lasting ways.

Your answer
APPENDIX D

STUDENT JOURNAL PROMPTS

REFLECTION: HALEMAʻUMAʻU AND CRATER RIM TRAIL
Halemaʻumaʻu and Crater Rim Trail Hike Reflection

“Explain how invasive species impact a growing and mature ʻōhiʻa forest. How do invasive species impact your actions in restoring ʻōhiʻa forests? How important is the role of humans to ʻōhiʻa? Why? Do you want to share anything else about how this day impacted your awareness of ʻōhiʻa forests?”
APPENDIX E

ANNOTATED DRAWING: VEGETATION, SOIL AND WATER
Annotated Drawing: Vegetation, Soil and Water

Directions:
- Sketch two mountain scenes:
  - a forest with stream, ocean and aquifer and
  - area without a forest/vegetation but similarly has a stream, ocean and aquifer
- Add details about the health and movement of water and soil surrounding both areas.
- Be sure to include these details
  - Evaporation
  - Infiltration
  - Transpiration
  - Rainfall (indicate velocity to ground and source)
  - Run-off (indicate velocity)
  - Erosion
  - Soil microbes
  - Soil structure
  - Relative temperature
  - Relative soil moisture

<table>
<thead>
<tr>
<th>Trait(s)</th>
<th>Beginning</th>
<th>Developing</th>
<th>Proficient</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>Drawings made lack detail needed for most of the following.</td>
<td>Drawings lack enough detail or are not labeled enough to represent some of the following:</td>
<td>Drawings display area accurately in terms of features</td>
<td>Drawings display area accurately in terms of features</td>
</tr>
<tr>
<td>30%</td>
<td>Mountains</td>
<td>Mountains</td>
<td>Mountains</td>
<td>Mountains</td>
</tr>
<tr>
<td></td>
<td>Stream</td>
<td>Stream</td>
<td>Stream</td>
<td>Stream</td>
</tr>
<tr>
<td></td>
<td>Ocean</td>
<td>Ocean</td>
<td>Ocean</td>
<td>Ocean</td>
</tr>
<tr>
<td></td>
<td>Aquifer</td>
<td>Aquifer</td>
<td>Aquifer</td>
<td>Aquifer</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>Forest</td>
<td>Forest</td>
<td>Forest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Extra features are added to give model more detail. Some areas are 'magnified' when needed.</td>
<td>Extra features are added to give model more detail. Some areas are 'magnified' when needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Color is added in areas to emphasize certain processes.</td>
<td>Color is added in areas to emphasize certain processes.</td>
</tr>
</tbody>
</table>
| Details of processes 40% | Less than half of the processes from prompt are labeled, highlighted or expanded when necessary.  
OR  
Added details need the following: arrows and velocity. | About ½ of the processes from prompt are labeled, highlighted or expanded when necessary.  
OR  
Added details need more of the following: arrows and velocity. | Most processes from prompt are labeled, highlighted or expanded when necessary.  
Arrows are used when appropriate.  
Velocity of rain/water is noted or depicted.  
Consequences of processes is included when appropriate. | All processes from prompt are labeled, highlighted or expanded when necessary.  
Arrows are used when appropriate.  
Velocity of rain/water is noted or depicted.  
Consequences of processes is included when appropriate. |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy 30%</td>
<td>Less than half of the drawing is accurate.</td>
<td>About ½ of the drawing is accurate.</td>
<td>Most of the drawing is accurate.</td>
</tr>
</tbody>
</table>
APPENDIX F

STIP (SCIENTIFIC TERMINOLOGY INVENTORY PROBE)
<table>
<thead>
<tr>
<th>Succession</th>
<th>Erosion</th>
<th>Cover cropping</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
</tr>
<tr>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
</tr>
<tr>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
</tr>
<tr>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Bioremediation</th>
<th>Soil fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
</tr>
<tr>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
</tr>
<tr>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
</tr>
<tr>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Invasive species</th>
<th>Foster ecosystems</th>
<th>Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
<td>❑ I have never heard of this.</td>
</tr>
<tr>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
<td>❑ I have heard of this but I’m not sure what it means.</td>
</tr>
<tr>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
<td>❑ I have some idea what it means.</td>
</tr>
<tr>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
<td>❑ I clearly know what it means and can describe it.</td>
</tr>
</tbody>
</table>

Please describe any of the terms that you know about below.
APPENDIX G

BIOREMEDIATION REFLECTION (BR) “PICTURE TELLS A THOUSAND WORDS”
A Picture Tells A Thousand Words: Group 1

Directions: Below the photo describe what you were doing and learning in this photo.

What were you doing in this photo? Explain how this activity relates to seed structure and how it will influence germination.

Explain why this was important to setting up the experiment.

Which experimental variable does this contribute to? (independent, dependent or controlled)

What did you learn?

How did this activity reduce the impact of human activities on the fishpond?
A Picture Tells A Thousand Words: Group 2

Directions: Below the photo describe what you were doing and learning in this photo.

What were you doing in this photo? Describe any observations of the soil here (texture, smell, color...)

Explain why this was important to setting up the experiment. Describe the previous pathway of copper in the area. How did the copper end up in sediments.

Describe the pathway of copper in the fishpond in the sediments remaining. Be sure to include algae, small fish, and large fish.

Describe the possible pathway of copper in the sediments used in the experiment.

How did this activity reduce the impact of human activities on the fishpond? What did you learn?
A Picture Tells A Thousand Words: Group 3

What were you doing in this photo? Explain how this activity relates to how copper cycles in ecosystems.

Describe the independent, dependent, and controlled variables of the set-up

What is the control group in the experiment?

What did you learn?

How did this activity reduce the impact of human activities on the fishpond?
APPENDIX H

MODEL OF ECOLOGICAL SUCCESSION OF ‘ŌHI‘A RAINFOREST
Successional Drawing/ Reforestation Design

Fill out the table. Draw/symbolically represent at least 3 different plants (ID) with appropriate size, number of layers in the forest, details about forest floor (rocks, leaf litter, plants.....), and abiotic factors. Label % of area covered by endemic, indigenous and introduced. At the end of the hike, you will be arranging drawings in order of succession so try to access how old/mature the forest is.

<table>
<thead>
<tr>
<th>Abiotic observations</th>
<th>Biotic observations</th>
<th>Percent endemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (circle)</td>
<td>hot cool warm</td>
<td>10 20 30 40 50 60 70 80 90</td>
</tr>
<tr>
<td>Light conditions</td>
<td>shady moderate shade sun</td>
<td>10 20 30 40 50 60 70 80 90</td>
</tr>
<tr>
<td>Scent</td>
<td></td>
<td>10 20 30 40 50 60 70 80 90</td>
</tr>
<tr>
<td>Sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other interesting features</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Layers of the Rainforest

![Layers of the Rainforest Diagram](https://via.placeholder.com/150)
<table>
<thead>
<tr>
<th>Trait(s)</th>
<th>Beginning</th>
<th>Developing</th>
<th>Proficient</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawings 50%</td>
<td>Drawings made lack detail needed for most of the following: Type of plants, Forest floor, Stories, General abiotic characteristics</td>
<td>Drawings misrepresent some of the following: Type of plants, Forest floor, Stories, General abiotic characteristics</td>
<td>Drawings display area accurately in terms of Size of plants, Forest floor, Stories, General abiotic characteristics</td>
<td>Drawings display area accurately in terms of Size of plants, Forest floor, Stories, General abiotic characteristics, Extra features are added to give model more detail</td>
</tr>
<tr>
<td>Observations 20%</td>
<td>Observations are incomplete.</td>
<td>Observations are complete but some are inaccurate.</td>
<td>Observations are complete and accurate.</td>
<td>Observations are complete, accurate and show keen observation skills of key species. Observations show connections between species.</td>
</tr>
<tr>
<td>Questions 30%</td>
<td>Half of the answers are correct. Improvement in using models is needed.</td>
<td>Answers to questions are 70% correct or reference to models is not made. Improvement in using models is needed.</td>
<td>Answers to questions are 90% correct.</td>
<td>Answers to questions are 100% correct and added insights are included.</td>
</tr>
</tbody>
</table>
At the end of this hike you will need to answer the following. Reference area numbers in answers when possible. For example, Area 1 had rocks for the forest floor while area 3 was covered in leaf litter.

The following questions should be answered on a separate piece of paper.

1. Arrange your drawings into order from youngest to oldest. Write down the numbers here. ___________________________

2. Describe the difference in the forest floor, light conditions, temperature, and number of stories between the youngest and oldest.

3. Pioneers plants are those that first colonize a new site. In which area did you see pioneers? What plants pioneered the area?

4. Think about the growth of pioneers and explain how they help change rocks into soil. You need two characteristics to support your answer.

5. Normally a totally different list of species is present as pioneers versus climax species. However Hawaiian forests are unique having one plant which grows throughout. Which plant do you find as a pioneer, throughout each age and as a canopy in the mature forest?

6. Pioneer plants are referred to a R-selected while climax species are K-selected. R-selected species normally reproduce fast, make lots of babies, and grow quickly. K-selected species are slow growing, make few babies, and grow slowly. Using observations from the hike, explain if you think the plant identified in question 5 is r-selected or k-selected.

7. Reflect on how slow ʻōhiʻa grows. Most invasive plants are r-selected in all characteristics and out compete ʻōhiʻa seedlings. In which area could ʻōhiʻa seedlings establish themselves without the help of humans?
APPENDIX I

KNOWING ‘ŌHI‘A QUIZ
1. ‘Ōhi‘a lehua is ___________ to Hawai‘i.
   A. Endemic
   B. Indigenous
   C. Introduced
   D. Polynesian introduced

2. What is the scientific name for ‘ōhi‘a lehua?
   A. Metrosideros polymorpha
   B. Acacia koa
   C. Diospyros sandwicensis
   D. Thespesia populnea

3. What does the scientific name for "ōhi‘a lehua mean?
   A. Hard timbered tree that has diverse growth forms.
   B. Soft timbered tree that has many flower colors.
   C. Hard timbered trees with many flower colors.
   D. A plant that keeps lovers apart.

4. What order should the pictures be in to demonstrate ‘ōhi‘a lehua lifecycle?

   Picture 1
   Picture 2
   Picture 3

   A. 2, 3, 1
   B. 1, 2, 3
   C. 3, 2, 1
   D. 3, 1, 2

5. ‘Ōhi‘a lehua is best described by which term below?
   A. It is a keystone species which means that if it is removed, the ecosystem would change drastically.
   B. It is a tertiary consumer which means that it photosynthesizes.
   C. It is a legume which means it fixes nitrogen.
   D. It is a decomposer and is essential for nutrient cycling.
6. SELECT ALL CHOICES THAT ARE APPROPRIATE

A. Why is ʻŌhiʻa lehua important?
B. It provides nectar for many birds.
C. It helps protect the watershed.
D. It provides timber often used for firewood.
E. The flowers are picked for hula, especially Merrie Monarch.

7. PICK ALL THAT ARE APPLICABLE

Which of the following describe ʻōhiʻa lehua in the forest?

A. first on lava flows
B. growing in moderately young rainforests
C. old climax species in forests at 4000 feet elevation
D. shrub in a bog
E. a tree near sea level
F. a tree at 5000 feet elevation
G. growing in the shade of albizia
H. growing in brackish water near fish ponds
I. growing on all three Kamehameha campus’
J. growing in parks in California

8. Match the rain with the correct description

<table>
<thead>
<tr>
<th>Match</th>
<th>Question Items</th>
<th>Answer Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>A. Compact rain occurring between 8-11 in the morning or 1-3 in the afternoon that showers heavily emptying lehua blossoms, followed by light rain that causes birds to make noise.</td>
<td>A. kanilehua or kanikanilehua</td>
</tr>
<tr>
<td>B.</td>
<td>B. a delicate rare rain between 10 and 12 in the morning originating from heaven near the water's edge traveling to Pana'ewa and circling to the south ending as mist in the forest</td>
<td>B. alanilehua or wailehua</td>
</tr>
<tr>
<td>C.</td>
<td>C. suppress lehua flowers by bruising rain in Pana‘ewa. This is a rain that never ends.</td>
<td>C. kinailehua</td>
</tr>
<tr>
<td>D.</td>
<td>D. wafted lehua fragrance associated with rains in Puna usually carried on a land breeze.</td>
<td>D. moanianilehua</td>
</tr>
<tr>
<td>E.</td>
<td>E. rain that pelts the lehua blossoms</td>
<td>E. kipehipualehua</td>
</tr>
<tr>
<td>F.</td>
<td>F. Rain that causes lehua to sway gently to and fro near Hōpoe Puna</td>
<td>F. kiaweilehua</td>
</tr>
<tr>
<td>G.</td>
<td>G. rain associated with Pana'ewa that scatters lehua flowers (beating relentless rain). This term can also be used for any rain.</td>
<td>G. lūlehua or lūlehuahala</td>
</tr>
</tbody>
</table>