ASSESSING THE EFFECTS OF EXPEDITIONARY FIELD SCIENCE COURSES ON STUDENT'S ENVIRONMENTAL LITERACY

by

Adam Geoffrey Bavier

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

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2020

ACKNOWLEDGEMENTS

Special thanks and gratitude to the Ecology Project International – Yellowstone administrative and field teams.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

ABSTRACT

This action research project studied how student's environmental literacy responded to an immersive field biology experience. Treatment was a 5-day expeditionary field course designed to connect students to wildlife research in Yellowstone. While on course, students participated in science education modules structured around the natural and cultural history of bison and the modern practices used to manage their population. Pre/post environmental literacy assessments were administered and a progressive Draw-an-Ecosystem model was delivered and scored. Results showed moderate content knowledge learning as well as increases in students empowerment and intention to act relative to environmental issues and their confidence with science competencies.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

Gardiner Montana is a small community of 875 year-round residents located at the northern entrance to Yellowstone National Park. The community of Gardiner are bordered to the south by the national park and to the east and west by the Custer Gallatin National Forest. The town contains a single K-12 school that serves approximately 200 students from the community, as well as students from the villages of Corwin Springs and Emigrant directly north up highway 89. Ninety-three percent of the students are Caucasian. 12.5% qualify for free or reduced cost lunch, which is far lower than Montana's average of 43.6% (Public School Review, 2018)

Ecology Project International has been partnering with the Gardiner School's science department for the last six years, working to bring environmental literacy experiences to its students. Despite living so close to so much public land, it has been communicated to us by our partners at the school that many of these students struggle in their understanding of, and personal connection to, the ecology of the Greater Yellowstone Ecosystem. This follows the broader trend in the United States, with students participating in 15% fewer outdoor recreational experiences per year in 2018 compared with 2012 (Outdoor Foundation, 2019). To address this need, the school district and National Park Service offered a single environmental education experience is all 4th grade students at the Gardiner school in the form of the National Park Service's

Expedition Yellowstone program, a 4-day residential environmental education program that operated out of the Lamar Valley Bison Ranch. While a valuable experience, a single 4th grade trip proved insufficient to build the foundation for environmentally literate students. Beyond a single teacher evaluation form, little work is done during this program to assess or quantify student's environmental literacy learning, and so program successes and challenges are difficult to identify and communicate (NPS, 2019).

Barriers to participation in outdoor activities and education experiences are myriad and may be exacerbated in rural communities like Gardiner (Scott, 2013). Given the lack of available environmental education experiences for rural students, it is little wonder then, that they would struggle with connection to the landscape. This struggle reinforces the need for quality experiential, place-based field education in this community.

As our partnership with the Gardiner school district has grown, we have engaged in several projects with the students, including both day and expeditionary programming, with our core experience being the 8th grade science trip. All the students in the grade are invited to participate in a 5-day field science excursion into the park each winter. While on course, students were trained in the protocols for an NPS wildlife study, then spent the bulk of instructional time out on the ground in Yellowstone, collecting data for the project. Students participated in science education modules, were given time for reflection and mindfulness, and were asked to examine a number of land management issues from the viewpoints of varied stakeholders. As a capstone to the experience, students design a short research project and presentation, generated a question answerable

from the NPS project data set to which they have been contributing, that was delivered on the final day of course. The experience is designed to provide students with a hands-on field experience that informs each of the three components of environmental literacy: knowledge, dispositions, and science competencies, with the hope of fostering an attachment to public lands, a net positive increase in environmental literacy, and a measurable change in behavior. Students at Gardiner School were also given the opportunity to participate in several day programs with EPI in their 9th and 10th grade year. An additional course goal for the 8th grade trip was to build a foundational connection to field science so as to encourage student's participation in our future course offerings. This 5-day field experience served as the treatment for this project.

Ecology Project International's present assessment and evaluation model is summative and utilizes a pre/post environmental literacy assessment as well as evaluative data. For this project, we introduced a progressive Draw-An-Ecosystem model for formative assessment of new ecological systems knowledge (Sanford, 2017).

I assessed a group of eighth grade participants from Gardiner School in Park County Montana in my study. The age range was consistent with typical eighth grade groups with a mixture of 13 and 14-year old students. The group had an even mixture of backgrounds between the children of park employees, traditional ranching/agriculture background and parents engaged in the service industry. As a result of the disruption caused by COVID closures across the state, only six students were included in this study.

As availability of field experiences is limited, ensuring our courses are of the highest educational quality and efficiency is paramount in satisfying our goal of improving environmental literacy in the Gardiner community.

Focus Question

The focus question for this study was, How does the environmental literacy of middle and high school students respond to a 5-day expeditionary field biology experience?

Sub-questions included the following:

1. Where do we find the greatest changes in environmental literacy sub-components pre/post treatment?
2. How do changes in environmental literacy sub-components related to knowledge compare with group generated Drawn-an-ecosystem progressive models?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Environmental Literacy

Environmental Education (EE) programs come in a variety of forms (residential, field-based, expeditionary, etc.) and seek to inform and improve student's environmental literacy (EL). EL is defined by the North American Association of Environmental Education's Framework for Assessing Environmental Literacy as:

"[S]omeone who, both individually and together with others, makes informed decisions concerning the environment; is willing to act on these decisions to improve the wellbeing of other individuals, societies, and the global environment; and participates in civic life. Those who are environmentally literate possess, to varying degrees:

- the 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
- Appropriate behavioral strategies to apply such knowledge and understanding in order to make sound and effective decisions in a range of environmental contexts (NAAEE, 2000)."

EE programs design curriculum and activities to have positive impacts on students' knowledge, dispositions, competencies, and behaviors as they relate to the

environment. Any new educational systems should be designed with this framework in mind.

EE programs facilitate that learning by connecting students to positive, constructive outdoor experiences. This work is particularly important as outdoor exploration as a habit is down across the United States, with Americans reporting one billion fewer outings per year in 2018 as compared to 2008 and 49.5% of the population reporting no engagement with outdoor outings at all (Outdoor Foundation, 2019).

Some states have responded to the need for creating a culture of quality EE programming and securing the funding necessary for that development. California has developed a blueprint for improving environmental literacy in every student in their system across all grade levels (ELTF, 2015). In a single year, Washington State Parks and Recreation Commission, through its No Child Left Inside program, secured more than $2.7 million to "empower local communities to engage students in outdoor education…" (Johnson, 2009). There are great advantages for states willing to take the lead in integrating EE programming into their curriculum (Dhanapal, 2013).

Environmental Literacy and Science Education

Environmental literacy instruction partners well with the Next Generation Science Standards 3-dimensional learning outcomes, and field investigations provide a natural structure for students to apply science and engineering practices (Mustam, 2016). Experiencing lessons in an outdoor school setting can be linked to a significant increase in student's scientific curiosity and desire to engage with science (Lin Ting, 2014). Outdoor learning experiences positively affect science achievement in students

(Rios, 2017). Students who participate in residential outdoor science programs experience an immediate increase in concern towards conservation as well as resiliency in long-term positive attitudes towards science and stewardship behavior (AIR, 2005).

Fostering stewardship in students is particularly important in the GYA where huge portions of Wyoming (55.9%), Idaho (70.4%) and Montana (37.5%) are public land under the jurisdiction of Federal land management agencies (US Bureau of the Census, 2001). The US system of federal land management is structured such that collaboration between land managers, scientists, and the public is required to direct decision making. Public comment events, town hall-style question sessions, and interagency stakeholder meetings are all integral to our system of land management. Teaching that employs natural environments as the context for learning (EIC) has been shown to increase student's interpersonal abilities. More than 90% of educators who employed EIC reported increases to student's ability to work in groups, ability to act with civility towards one another, and ability to communicate with public and private agencies (Lieberman & Hoody, 1998). Giving students local to the GYA, who will become the future commenting public, the opportunity to practice the skills and dispositions necessary to be an informed participant in the land management process is vital for that system's protection.

The explanations for a slower adoption of EL instruction in Montana than other states are myriad and poorly studied. In Japan, a lack of traditional and accepted teaching methods as perceived by community members has been identified as the cause for a similar conflict in the application of environmental education (Imamura, 2017).

Additionally, it is possible the lack of inclusion of culturally relevant materials and background could be a source for reluctance or resistance to EE programming (Manse, 2016). Changes to adopt more recognizable teaching strategies and familiar pedagogy may help environmental education organizations overcome this bias.

Assessment Strategies

A well-balanced assessment strategy is an excellent example of a modern pedagogical practice that could be easily adapted for a field-based program. Modern assessment strategies are an education best-practice. They add validity to an EE program and provide teachers and parents with post-course results more familiar with traditional academic settings. Measuring environmental education outcomes yields important understandings of the impact that can be used for future program planning, to attract support from donors, and in grant writing/reporting (Herman, 2010).

When considering a balanced assessment strategy, efforts should be made to include formative assessment embedded into curriculum and summative assessment delivered at the program's end (Russ, 2014). Studies show that formative assessment has a positive effect on student's ability to learn (Klute, 2017). Additionally, formative assessment offers opportunities for teachers to gauge student understanding in real-time, giving them a broader view of their classroom and providing valuable direction for planning tomorrow's lesson (Black, 1998). Adding formative assessment to an environmental education program's repertoire could provide useful legitimacy as well as improve educational outcomes and curriculum planning.

A discipline appropriate summative assessment delivered pre, post, and post-post (delivered four weeks after a field experience) can be useful in gauging student's understanding and retention of ecological concepts (Lisowski, 1991). While no benchmarks or standards for environmental literacy presently exist, the results of these pre/post-treatments provide recognizable, quantitative summation of student learning. This data is useful to parents and administrators as it provides concrete measurements of learning outcomes and shows students and teachers evidence of growth and areas for improvement (Walvoord, 1998).

While the need for quality, standardized assessment tools are obvious, challenges arises in designing these instruments. Existing assessments are a product of the educational theory that came before and while much of that work is sound it is important to consider new methods and pedagogy when designing assessments for the modern classroom (NRC, 2001). This is of particular importance in the nontraditional education setting, where resources and classroom philosophy can be very different than in a formal classroom. In this study, the application of two assessment methods, one formative, one summative, will be applied to students and their results compared.

CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate how a 5-day immersive field experience affected student's environmental literacy, in particular, their knowledge of ecological systems. The study population was six 8th grade students from Gardiner Montana. Data was collected from February of 2020 until April of 2020. The research methodology for this project received an exemption from Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Treatment

The treatment consisted of a 5-day expeditionary field course designed to connect students to wildlife research in Yellowstone. While on course, students participated in science education modules structured around the natural and cultural history of bison as well as learned about the modern practices used to manage bison populations. Students learned to identify stakeholders and partners involved in bison management. As an anchoring activity, students were trained in radio telemetry and protocols for the NPS Home on the Range study, and spent two days in the park collecting fecal and population dynamic data for that study. Students generated their own research question that applied to the data set for which they were contributing, then worked to answer those questions on course, presenting their findings on the final day. Specific curriculum designed for this treatment included Field Investigation: Home on the Range; Viewpoints: Bison

Conservation; Why The Greater Yellowstone Ecosystem? and Small-Group Research Work (Appendix F).

Data Collection and Analysis Strategies

A 53 question Environmental Literacy Pre-Assessment (EL Pre), structured to evaluate student's environmental literacy, was delivered on the first day of course (Appendix B). A 36 question Environmental Literacy Post-Assessment (EL Post) was delivered on the final day of course (Appendix C). It was identical in construction to the pre-assessment, but with the behavior component removed. Ecology Project International defines an environmentally literate person as someone who demonstrates the knowledge, dispositions, competencies and behavior to actively engage, individually or as a group, in addressing environmental challenges. As such, the assessment is broken in four primary components: knowledge, disposition, competencies and behaviors. Knowledge: ecological systems was assessed by multiple choice answers to questions on ecological concepts and processes. Students environmental literacy knowledge: ecological systems was plotted on a box and whisker chart, and a Wilcoxon signed rank analysis was be performed. A normalized gain was calculated.

Dispositions and competencies were self-reported on a Likert scale. Behaviors were self-reported as a frequency ranking based on specific actions (i.e. I have recycled this many times in the last month). Likert questions were displayed on diverging stacked bar charts by sub-component and investigated for trends.

During treatment, students were introduced to a progressive Draw-An-Ecosystem model. The first day of course, the group was asked to construct a graphical

representation of Yellowstone as they understand it, labeling biotic and abiotic components as well as natural processes and ecological concepts. Students then returned to the model each evening to add new learning. Photos were taken each day to document the model as it progressed in complexity. Post course, the student's ecosystem model was scored qualitatively using a designed rubric (Appendix D).

Additional qualitative data was collected in the form of student interviews, instructor interviews and by examining course notes. Student and instructor interviews were conducted post course (Appendix E).

Scores assigned to ecosystem models were compared to scores from the knowledge component of student's EL Pre/EL Post to determine the utility of the Draw-An-Ecosystem activity in assessing group knowledge of ecological systems (Table 1).

Table 1. Environmental Literacy Triangulation Research Matrix.

	Data Collection Methods		
Research Questions	Source 1	Source 2	Source 3
How does the environmental literacy of middle and high school students respond to a 5-day expeditionary field biology experience?	Environmental Literacy Knowledge Pre/Post assessment	Environmental Literacy Dispositions Pre/Post assessment	Environmental Literacy Competencies Pre/Post assessment
Where do we find the greatest changes in environmental literacy sub-components?	Environmental Literacy Pre/Post assessment	Progressive Model Scores	Student interviews
How do changes in environmental literacy sub-components related to knowledge compare with group generated Drawn-an-Ecosystem progressive models?	Progressive model scores	Environmental Literacy Pre/Post assessment	Instructor Interviews/course notes

CHAPTER FOUR

DATA AND ANALYSIS

Pre/Post Results

Knowledge: Ecological Systems

The results of the Pre and Post Environmental Literacy Knowledge: Ecological Systems Subcomponent indicated a difference in means score pre to post from 48% to 70% (Figure 1). This indicated a mean increase of 22% which is confirmed as statistically significant through a Paired T-test with a p-value <.05, (p=0.00085).

A normalized gain analysis was completed and indicated G =.42. This value suggests that students learned 42% of what was possible for them to learn, a medium gain (Hake, 1998). When asked to summarize their course experience, one student said, “It was an opportunity to learn more about the ecosystem right outside our back doors.” Another agreed, “I learned a lot about the collared animals, and snow.” No single concept was highlighted on course and student interviews agree that many science topics were covered, with comments indicating students learned about “climate change and how it can effect Yellowstone,” “…how bison move around the park," “how wolves can take away from elk [populations],” and “…lots about snow.” Student comments support the normalized gain analysis that ecological systems learning occurred on course.

A Wilcoxon signed rank analysis was attempted with *N*=6 and an alpha value of 0.05. The null hypothesis was rejected for the ecological systems knowledge pre/post data indicating significant difference between pre and posttest means.

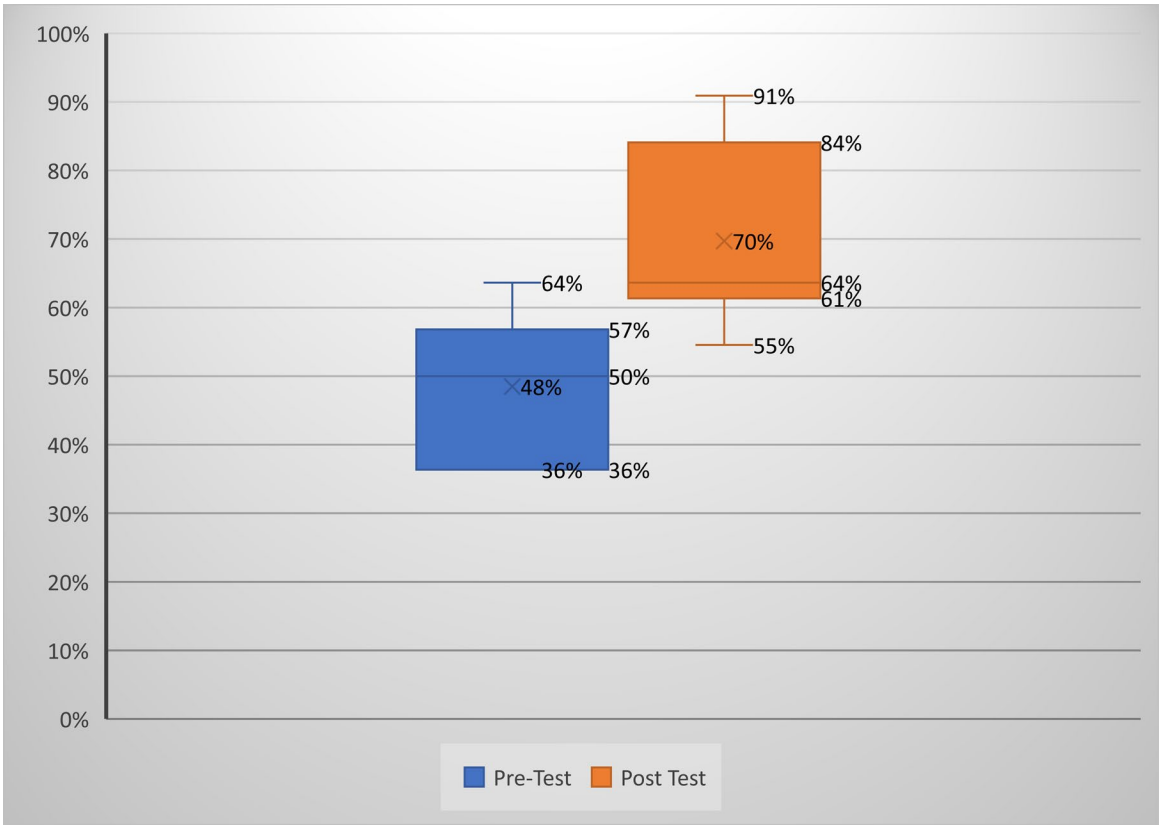


Figure 1. Box and Whisker plots showing Ecological Systems test percentages from pre-treatment and post-treatment, (N=6).

Knowledge: Action Strategies

The results of the Pre and Post Environmental Literacy Knowledge: Action Strategies Subcomponent were investigated to determine the effect of the treatment on student's understanding and awareness of how to use resources to advocate and effect positive change in their communities, relative to conservation.

The number of students indicating they were informed or very informed with "how to use different resources (time, money, materials) to support conservation" rose from 51% in the pretest to 100% in the post. The number of students indicating they were informed or very informed with "actions you can take in your community to support conservation" rose from 34% in the pretest to 100% in the post. The number of students

indicating they were informed or very informed with direct actions you can take to support the conservation of the Greater Yellowstone Ecosystem" rose from 34% in the pretest to 100% in the post. There was a net positive improvement in all subcomponents of student's knowledge of action strategies post course, with the exception of question five "how to use legal action to support conservation and protect your community" which showed one student shifting up from uniformed, and one student shifting down from very informed (Figure 2).

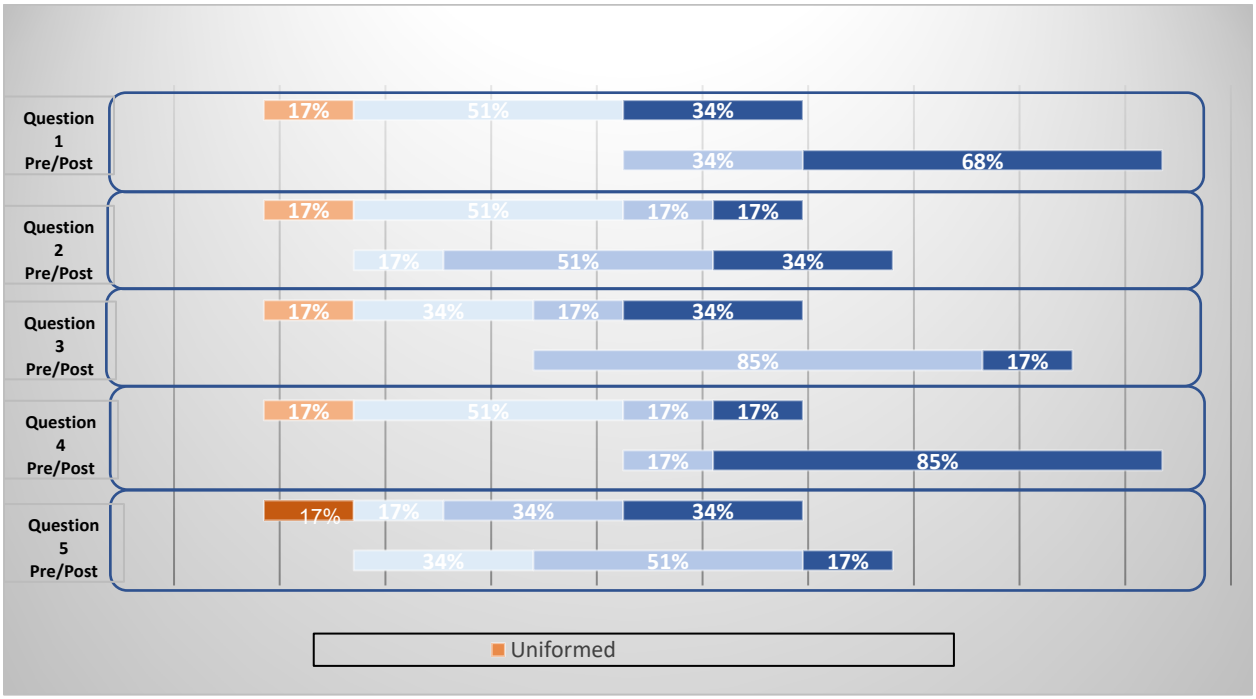


Figure 2. Student responses to how informed they are of advocacy resources in their home communities pre/post field experience, (*N*=6).

Dispositions: Environmental Views

The results of the Pre and Post Environmental Literacy Dispositions: Environmental Views Subcomponent were investigated to determine the effect of the

treatment on student's environmental sensitivity and attitudes/concerns towards to the environment.

The number of students indicating they agree or strongly agree with "changing my actions changes my community" rose from 83% in the pretest to 100% in the posttest. The exception came in question 16, where the number of students indicating they strongly agree with "I value the time I spend outside in nature" rose from 17% in the pretest to 68% in the posttest (Figure 3).

Post-course interview data tracks with the sentiment that students enjoyed connecting with the natural world through their course experience with comments like "it was excellent. I loved it. I only wish it were longer." and "I loved how we got outside a lot…," but that environmental dispositions remain largely unchanged. The quantitative data would agree with the student who described that they "…learned a lot, but my perspective stayed mostly the same," when considering their attitude towards the environment.

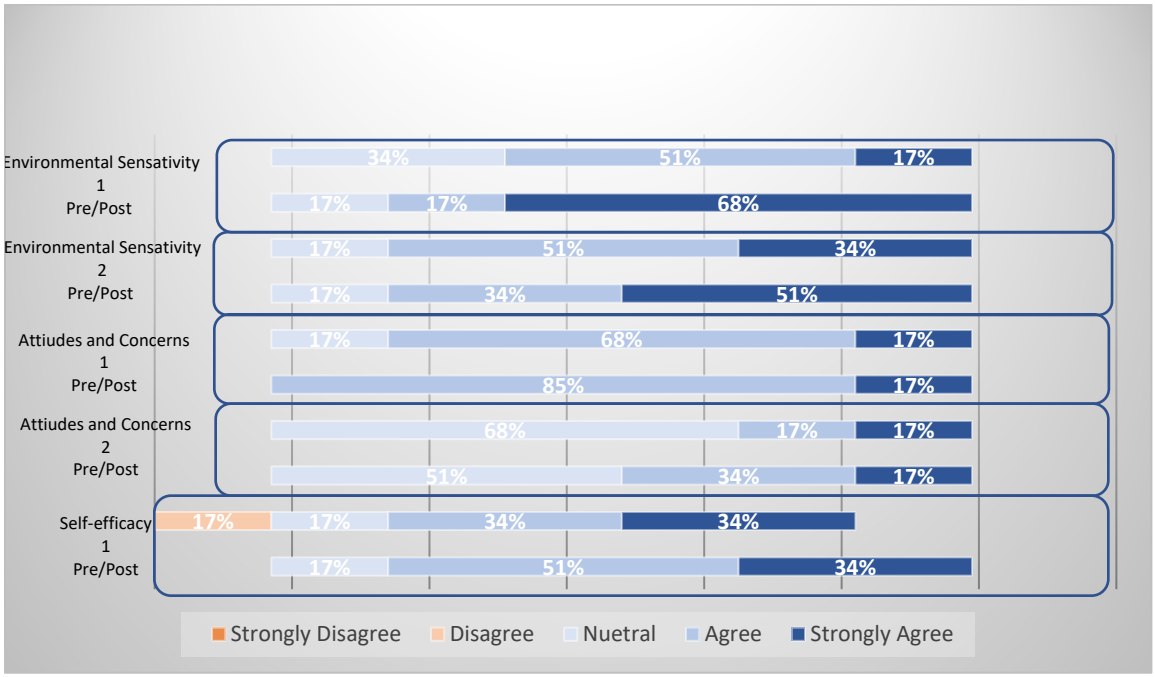


Figure 3. Students responses to their views of the environment pre/post treatment, (*N*=6).

Dispositions: Empowerment and Intention to Act

The results of the Pre and Post Environmental Literacy Dispositions: Empowerment and Intention to Act Subcomponent were investigated to determine the effect of the treatment on student's self-efficacy, locus of control, and intention to act.

The number of students indicating they strongly agree with "it is important for me to act and make decisions to support conservation and the natural world" rose from 0% in the pretest to 51% in the posttest. Pretest, 51% of students indicated they disagreed or strongly disagreed with the statement "I plan to talk to my friends and/or family about the effects of climate change." That number disappeared in the post test with 0% of students indicating the disagreed or strongly disagreed with that sentiment. Pretest, 0% of students indicated they agreed or strongly agreed with the statement "I plan to find out more about

how the meat my family and I consume is raised and help make more sustainable decisions about how we purchase meat." That number increased to 34% of students in the posttest (Figure 4).

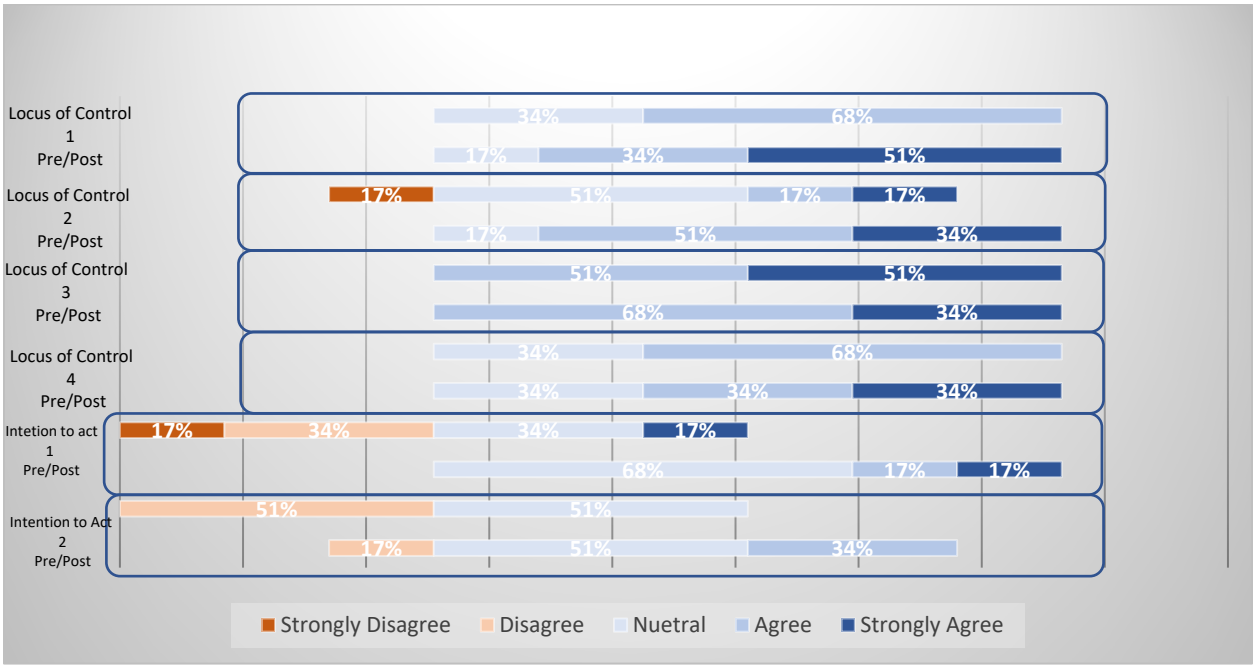


Figure 4. Student responses to their feelings of empowerment and intention to act, (*N*=6).

Competencies: Science and Engineering Practices

The results of the Pre and Post Environmental Literacy Science Competencies Subcomponent were investigated to determine the effect of the treatment on student's confidence with science and engineering practices.

Of all the components of environmental literacy assessed, confidence with science and engineering practices showed the most students landing in the strongly agree region posttreatment. The number of students indicating they strongly agree with the statement "I am able to use data I have collected to create graphs and tables that demonstrate my results" rose from 17% in the pretest to 85% in the posttest. The number of students

indicating they strongly agree with the statement “I am able to create a poster or presentation that communicates results and my conclusions” rose from 17% in the pretest to 85% in the posttest. The number of students indicating they strongly agree with the statement “I feel comfortable orally presenting my conclusions” rose from 17% in the pretest to 85% in the posttest.

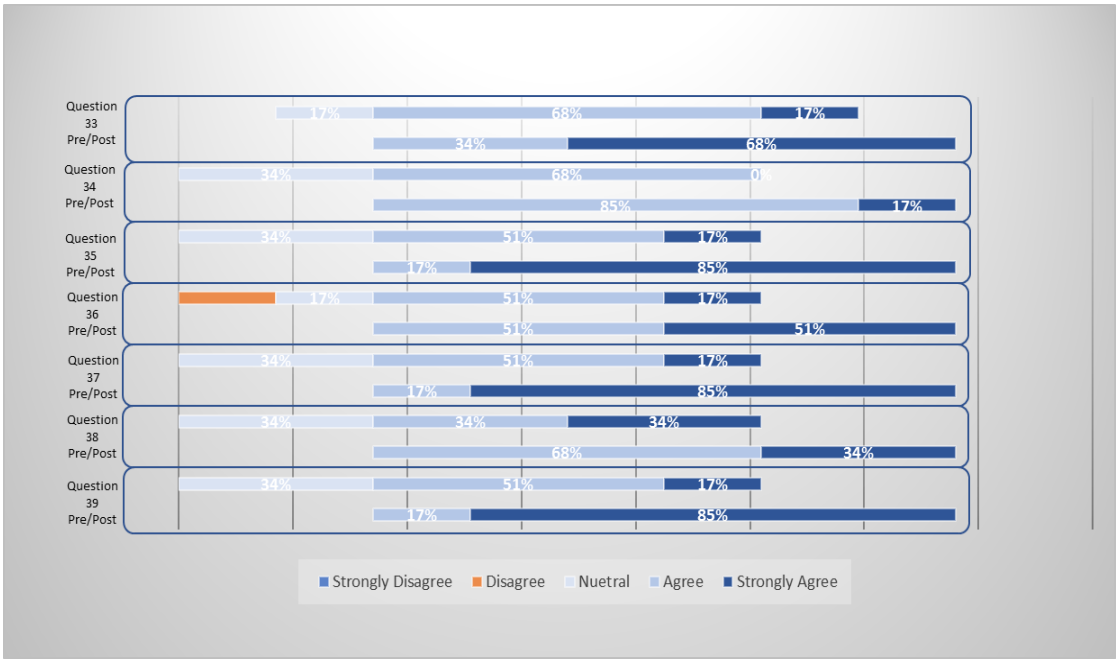


Figure 5. Students responses to their confidence with science and engineering practices pre/post treatment, (*N*=6).

Progressive Model Results

Additional knowledge: ecological systems data was taken using a progressive Draw-An-Ecosystem model. The score of the initial iteration was 8/27 or 30%. The score of the second iteration was 13/27 or 48%. The score of the final iteration was 19/27 or 70 percent. This is a percent increase of 40 from first iteration to last (Table 2).

Model Iteration	Percent Score
Day 1	30%
Day 3	48%
Day Final	70%

Table 2. Student's scores on each iteration of their progressive model.

A normalized gain analysis was completed and indicated G =.57. This value suggests that students included an addition 57% of what was possible for them to include in their model updates as compared to their first iteration.

Scored against the rubric, students' day 1 iteration received eight of a possible 27 points (Figure 6). The following parameters were displayed: Sun drawn or labeled (1 point), Rock or soil labeled or shown in cross section (1 point), Explicit mention of humans incorporated into ecosystem and anthropogenic influences identified (3 point), hydrologic cycle labeled or shown in cross section (1 point), one stated example of systems or environmental issues (1 point). Additional information was displayed, but not present on rubric to be scored.

Figure 6. Students initial model of the Greater Yellowstone Ecosystem with graded elements highlight, (*N*=6).

Scored against the rubric, students' day 3 iteration received 13 of a possible 27 points (Figure 7). The following parameters were displayed: Sun drawn or labeled (1 point), Rock or soil labeled or shown in cross section (1 point), Explicit mention of humans incorporated into ecosystem and anthropogenic influences identified (3 points), More than one example of water shown (snow, river, underground, atmosphere) (2 points), more than one illustrate example of systems or environmental issues (climate change, deforestation, habitat fragmentation) (3 points), complex interaction with the cycling of matter and energy through the atmosphere (3 points). Additional information was displayed, but not present on rubric to be scored.

Figure 7. Students updated model, mid-treatment, of the Greater Yellowstone Ecosystem with graded elements highlight (new learning represented in red), (*N*=6).

Scored against the rubric, students' final iteration received 19 of a possible 27 points (Figure 8). The following parameters were displayed: Sun drawn and energy displayed with magnitude or direction (2 points), Rock or soil labeled or shown in cross section (1 point), Explicit mention of humans incorporated into ecosystem and anthropogenic influences identified (3 points), More than one example of water shown (snow, river, underground, atmosphere) (2 points), more than one illustrate example of systems or environmental issues (climate change, deforestation, habitat fragmentation) (3 points), complex interaction with the cycling of matter and energy through the atmosphere (3 points), trophic web illustrated with more than two arrows, memberships displayed independent of feedback loops (3 points), symbiosis represented but uncategorized (1 point), nutrient cycling displayed or some mention of nutrients (1 point). Additional information was displayed, but not present on rubric to be scored.

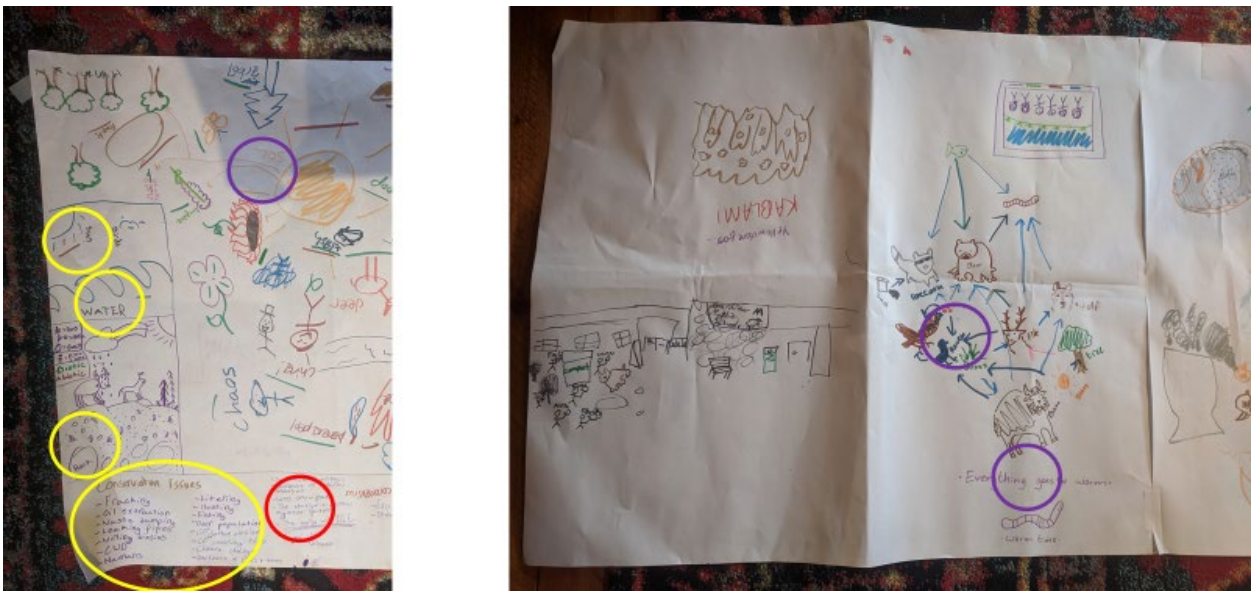


Figure 8. Students final model of the Greater Yellowstone Ecosystem with graded elements highlighted (new learning represented in purple). Page one is shown on the left of the image, page three is shown to the right, (*N*=6).

In posttreatment evaluative interviews, students provided some insight into which course activities were most impactful. Of students interviewed, 100% described the ungulate research, wolf observation and snow science lessons as good or excellent. Indeed, bison and wolf ecology present themselves as a highlight in testimonials, with one student commenting "I also learned a lot about wolves and bison, how they are hunted, and how to identify the male and females," and another indicating a potential improvement in environmental disposition, "my views have changed a bit on bison and wolves, and I learned to see both sides better, including tourists and those who guide tours, and hunters and ranchers who are more against the wolves because they impact their livelihood."

There is some disparity in assessment numbers and student impressions surrounding the independent research projects. This activity provides students the

opportunity to use their science and engineering practices to generate a research project based on the data collected in the field for the ungulate study. It should most closely correlate with student's confidence with science competencies. While we saw a substantial increase in Likert scores for this subcomponent, only four out of six or 66% of students described that element of the experience as good or excellent.

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Claims of the Study

With only data from a single course to be compared, it is challenging to find adequate evidence to make articulate claims relative to the study's focus questions. Respective to the Gardiner students, significant learning was measured in knowledge: ecological systems across two assessments. Significant improvement in self-reported confidence with science competencies was displayed, in particular, student's ability to use data to create graphs and display results, student's ability to create a poster and communicate conclusions, and students comfort orally presenting findings. There was little change in Gardiner students' dispositions: views of the environment, but a large number of student's posttreatment indicated a strong confidence in dispositions: empowerment and intention to act.

With a G score of .42 on the pre/post assessment and a G score of .57 on the Draw-an-Ecosystem model, science knowledge learning was high (Hake, 1998). This came as a surprise, as the treatment was not designed to provide much science content learning. Lessons were structured to improve student's views of the environment as well as an opportunity to practice their science competencies (Appendix F) but such a large increase in ecological systems knowledge suggests science content learning must be happening elsewhere on course. It is also possible that as students became more familiar with the Draw-an-Ecosystem model over the course experience, they were better able to

manipulate it and it became easier for them to display learning. While the Draw-an-Ecosystem model is a more open form of assessment, it is still bound by the scoring rubric. By probing instructors or reflecting on previous classroom ecological knowledge evaluations it is possible students grew in understanding of what was being assessed and were better able to include those elements.

Student quotes indicate a highly diverse learning experience, with snow, bison, wolves, conservation, population dynamics, and geothermals all being mentioned as learning topics. This thematic diversity was reflected in the student's progressive model as well, the first iteration received points from five of nine possible categories, and the final iteration received points from nine of nine possible categories.

Connection to conservation of the natural world grew significantly among students from this treatment. There was a 66% increase in students indicating they were informed or very informed about direct actions they could take to support conservation in the GYE pre/post, and a full half of students strongly agreed that it was "…important to act and make decisions to support conservation and the natural world" post treatment. Strong agreement with the statement "I value the time I spend in nature" leapt from 17% to 68% post treatment. There can be no doubt that the course experience strengthened student's knowledge of conservation action strategies, how students rank the importance of conservation, and how students value their connecting to the natural world.

The treatment had a strong positive effect on student's confidence with science competencies, in particular, those most hands-on skills. Graph making, presentation design and science communication all saw large increases pre/post treatment. The

confidence that comes from performing the same science and engineering practices students learn in the classroom, to a real-world scientific study with serious and knowable consequences, is evident and significant.

Value of the Study and Considerations for Future Research

As a pilot of the pre/post environmental literacy assessment, this study was a success. Students were able to take the assessment first and last day of course without it feeling like an interruption. Data was easily input and analyzed without issue. The subcomponents were clearly demarcated and provided insight and nuance to the results.

Changes to the content of the assessment are challenging to recommend. At 53 questions, the preassessment is robust, however environmental literacy is a broad concept. EL leaning encompassing a large spectrum of topics and skills and so it would be hard to pare down the number of questions asked. Indeed, while I would be cautious to increase the size of the assessment, additional data on each subcomponent would be helpful. Including more non-traditional forms of assessment embedded into the course experience, like the Draw-an-Ecosystem model, would provide more data on individual courses without having to increase the size of for pre/posttests. Identifying new non-traditional assessment techniques for dispositions, science competencies and behaviors would be valuable and I would like to include those methods in future studies.

The Draw-an-Ecosystem model itself proved a fun tool to implement and provided interesting information on student's experience. There are concepts included in the second and third iteration of the model that I am confident students did not learn on course. The role carbon dioxide plays in global climate change is not material we instruct

on. Why then, did that not appear in the first iteration of the model, if students already possessed that knowledge? Perhaps it is a failing of implementation, not enough time given or not enough incentive for students to engage, but the possibility that that concept existed in the group, was dormant, and then became activated during the course by some experience the students related to it, is deeply intriguing. Was a new connection made by students, between carbon emissions, climate change and the GYE? If so, why? From where did that connection arise, how significant is it and what can we do on future courses to structure experiences to build the same associations. Rather than acquiring new learning, activating prior knowledge to learn new connections on a field experience is a curious topic and one I would like to commit to when designing assessments for future study.

No benchmarks exist for environmental literacy learning, and it would be possible through pre/post assessment data to create those tiers. Grade level expectations for environmental literacy would help lend legitimacy and accountability to EL programming. Generating benchmarks would be an enormous collaborative effort, but it could be done and I would be interested in learning what the environmental dispositions of a 3rd grader should be compared to an 8th grader.

Impact of Action Research on the Author

This was an important experience for me. A large difference between my style of instruction and that of a formal educator is the lack of grading, standards, or requirements. Too often in environmental literacy education we lean on the idea that connection to nature or love of the outdoors can't be effectively measured. That the

metaphorical seeds we plant through our instruction are hidden and cannot be known, and while I agree that its challenging to effectively quantify concepts like connection or love that does not mean we shouldn't try. Only through experimentation, revision and failure will we improve out methods of assessment, and it was empowering to be involved in that work for this project. I am excited to continue to design and deliver assessments in my work.

The process of paper writing has been challenging. So much of generating this final paper was formatting work and I wonder at the usefulness of having so many great instructional minds hacking away for hours at Microsoft word. I did learn many new skills for manipulating graphs and formatting documents, and I respect that papers need be uniform for submission to the university archive, but I would be lying if I said I was not discouraged more than once in this process by the amount of tinkering in Word required. Perhaps that is intentional, perhaps this is just a taste of academia and I should count myself lucky that my hours spent formatting were not, instead, days, but I do think about the opportunity costs.

Action research as a tool for improving instruction and planning is clear. I would never have the same confidence with project creation, data collection, analysis, and reflection on results without this experience. It has made me a more informed educator, a more skilled project manager, and has changed my mental model for assessment strategies. I speak with greater confidence about evaluation and the connection between lesson objective, experience, and assessment data has been made firm. The application of

the same science and engineering practices I teach and encourage in my students to my own instruction was enlightening.

Action research has also revealed itself as a useful development and reporting tool. As a career non-profit employee, grant writing and reporting is a vital skill. Being able to provide funders with quantifiable learning, supported by quotes and images of student work, makes grant applications and funding requests much more solid.

REFERENCES CITED

American Institutes for Research. (2005). Effects of outdoor education programs for children in California. The California Department of Education. Retrieved from http://www.seer.org/pages/research/AIROutdoorSchool2005.pdf

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Educational Assessment: Principles, Policy and Practice. 5*(1), 7–74.

Dhanapal, S. (2013). A comparative study of the impacts and students' perceptions of indoor and outdoor learning in the science classroom. *Asia-Pacific forum on science learning and teaching*. Retrieved from https://www.eduhk.hk/apfslt/v14_issue2/dhanapal/index.htm

ELTF (2015) A blueprint for environmental literacy. Redwood City, CA: Californians Dedicated to Education Foundation. Retrieved from https://www.cde.ca.gov/pd/ca/sc/documents/environliteracyblueprint.pdf

Imamura, M. (2017, March) Beyond the limitations of environmental education in Japan. *Educational Studies in Japan: International Yearbook,* (3-14). Retrieved from https://files.eric.ed.gov/fulltext/EJ1147528.pdf

Hake, R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64-74.

Johnson, T., LeBlanc, M., Fortin, M., et. al. (2009). No Child Left Inside outdoor Education and Recreation Grant Program Final Report. Submitted to Washington OSPI. Retrieved from https://parks.state.wa.us/DocumentCenter/View/6008/NCLI-Final-Report-2009-10-02?bidId=

Klute, M., Apthorp, H., Harlacher, J., & Reale, M. (2017). Formative assessment and elementary school student academic achievement: A review of the evidence. *Regional Education Laboratory Central.* Article 259. U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/edlabs.

Lieberman, G. A., and Hoody, L. L. (1998). Closing the achievement gap: using the environment as an integrating context for learning. (Executive summary). San Diego, CA: State Education and Environment Roundtable (SEER)

Lin Ting, K. (2014). Effects of outdoor school ground lessons on students' science process skills and scientific curiosity. *Journal of education and learning*, Vol. 4, No. 4. Retrieved from https://files.eric.ed.gov/fulltext/EJ1075796.pdf

Lisowski, M., Disinger, J. (1991) The Effect of Field-Based Instruction on Student Understandings of Ecological Concepts. *The Journal of Environmental Education*, 23:1, 19-23. Retrieved from 10.1080/00958964.1991.9943065

Mustam, B (2016). Informal and formal environmental education infusion: Actions of Malaysian teacher and parents among students in a polluted area. *Malaysian online journal of educational science,* Volume 9-20. Retrieved from *https://files.eric.ed.gov/fulltext/EJ1088640.pdf*

North American Association for Environmental Education (2011) *Developing a Framework for Assessing Environmental Literacy.* (professional paper) Washington, DC, 20036, Retrieved from http://www.naaee.net/framework

National Research Council. (2001*). Knowing what students know: The science and design of educational assessment.* (professional paper) Washington, DC: National Academy of Sciences. Retrieved from https://doi.org/10.17226/10019.

Rios, J., Brewer J., (2014) *Outdoor Education and Science Achievement*, Applied Environmental Education & Communication, 13:4, 234-240. Retrieved from https://doi.org/10.1080/1533015X.2015.975084

Russ, A., Byron, M., Colodner, D., (2014). *Measuring Environmental Education Outcomes.* (professional paper) NAAEE and Cornell University Civic Ecology Lab. Retrieved from https://naaee.org/eepro/resources/measuring-environmental-education-outcomes

Sanford, R., Staples, J., Snowman, S. (2017) *The Draw-an-Ecosystem Task as an Assessment Tool in Environmental Science Education*. (professional paper) Science Education and Civic Engagement. Retrieved from: http://new.seceij.net/articletype/projectreport/the-draw-an-ecosystem-task-as-an-assessment-tool-in-environmental-science-education/

US Bureau of the Census. (2001). *Statistical Abstract of the United States: 2001 (12th ed.)* (n.d.) Washington, DC, Retrieved from https://www.census.gov/library/publications/2002/compendia/statab/121ed.html

Walvoord, B., Anderson, V., (1998). *Effective Grading: A Tool for Learning and Assessment*. San Francisco: Jossey-Bass.

APPENDICES

APPENDIX A

IRB APPROVAL

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

2155 Analysis Drive
c/o Microbiology & Immunology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-4706
FAX: 406-994-4303
E-mail: cherylj@montana.edu

Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-4706
cherylj@montana.edu

MEMORANDUM

TO: Adam Bavier and John Graves

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

DATE: November 25, 2019

RE: *"Assessing the Effects of Expeditionary Science Courses on Student's Environmental Literacy" [AB112519-EX]*

The above research, described in your submission of November 19, 2019, 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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

____ (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

ENVIRONMENTAL LITERACY PRE-TEST

ECOLOGY PROJECT

Student Survey Yellowstone | **YEL - 2020 Local & Visit** | **PRE**

This survey aims to assess the learning of students on course. This survey is anonymous, however the information collected will be used for technical evaluation, marketing, promotion and program improvements.

Time needed to complete this evaluation: 20 minutes

Instructions: Please read each question carefully and mark in the ANSWER SHEET the answer that is most appropriate. It's important that you answer this survey individually and that you complete all questions.

SECTION 1. PERSONAL INFORMATION

In the section labeled 'Identifier' please put your two digit birth month and day with your favorite animal following. For example, if your birthday is March 5 and your favorite animal is a snail you would write – *0305snail*.

1	Age	A: 14 or less	B: 15 years	C: 16 years	D: 17 years	E: 18 years or more
2	Grade	A: Middle school	B: 9th grade	C: 10th grade	D: 11th grade	E: 12th grade | F: College
3	Gender	A: Male	B: Female	C: Non-binary/third gender	D: Prefer to self-describe	E: Prefer not to say
4	School Type	A: Public	B: Private			

SECTION 2. WHAT DO YOU KNOW ABOUT THE ENVIRONMENT?

5 **Why are predator population dynamics important for Yellowstone wildlife biologists to study?**

- **A** Predators numbers need to kept as low as possible to maximize elk populations
- **B** Yellowstone predator populations increase genetic diversity of predator populations throughout the Greater Yellowstone Ecosystem
- **C** Predators transmit dangerous diseases, such as brucellosis, to livestock outside of Yellowstone National Park
- **D** Wildlife biologists need to understand how predators influence prey populations
- **E** Options B and D

---

6 **The amount of snow that accumulates annually in the Greater Yellowstone Ecosystem has begun to decrease and will continue decreasing as a result of climate change. Which of the following is TRUE about the ecological impacts of reduced annual snowpack?**

- **A** Earlier snowmelt will make it harder for animals to travel to higher elevations in the spring
- **B** Native grasses, wildflowers, and shrubs will benefit from less available water throughout the year
- **C** River levels will drop earlier in the summer than the historical average, resulting in less overall flow and increased in-stream water temperatures
- **D** Snowpack doesn't affect forest fire frequency and severity, so the rate and intensity of fires won't change
- **E** Reduced snowpack only affects people who like to ski, snowboard, and snowshoe, so there will be no ecological impacts

---

7 **Habitat is a term that refers to a place that has the proper conditions for organisms and communities of animals and plants to live. For many organisms that live in seasonal environments, during part of the year their habitat does not have the proper conditions for their survival. How might organisms and communities of animals adapt to unfavorable winter changes in their habitat conditions?**

- **A** Migrate to an area where conditions are more favorable
- **B** Producers shift to become consumers and consumers become producers
- **C** They don't change their behavior, they go on with activity as normal
- **D** They become more active to stay warm
- **E** Consume less food

---

8 **What are examples of ways climate change will affect ungulates, such as bison and elk, in the Greater Yellowstone Ecosystem?**

- **A** Hotter and drier summers will likely lead to drought conditions, reducing the availability of grasses and other plants for ungulates to eat
- **B** Bison's historic high population across a wide range of habitats across North America shows that they will likely thrive despite rapid climate change in the Greater Yellowstone Ecosystem
- **C** Changing season lengths and overall climatic metrics like annual precipitation, daily temperatures, etc., will likely affect ungulate migration patterns and timing
- **D** Predators will likely be affected by climate change first, causing a huge population explosion of ungulates
- **E** Options A and C

---

9 **In order to contribute to ecosystem health, what is something you could do on your next snowshoe?**

- **A** Be courteous to others on the trail
- **B** If snow has melted from areas where you travel, stay on areas where snow and ice remain to minimize your impact
- **C** Avoid traveling through terrain where it is obvious that an avalanche has been triggered recently
- **D** Only leave microtrash behind
- **E** Pick up animal scat along the way and pack it out to remove negative impacts of decomposing feces

---

10 **Wolves play an important role as apex predators in their ecological communities. When wolves were reintroduced, what happened to other organisms in Yellowstone?**

- **A** Wolves have decimated small mammal populations like squirrel and rabbit
- **B** The elk and other prey populations plummeted resulting in an explosion of all kinds of invasive plant species
- **C** Wolves haven't gained enough of a foothold in Yellowstone to have an impact on the ecosystem
- **D** Wolves have introduced a natural population control on prey species like elk
- **E** Grizzly bear and cougar populations have increased because the introduced wolves don't know to avoid the predators and are therefore easy prey

ECOLOGY PROJECT

Student Survey
Yellowstone

YEL - 2020
Local & Visit

PRE

How informed are you about...?		A	B	C	D	E
11	Direct actions you can take to support the conservation of the Greater Yellowstone Ecosystem	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
12	Strategies you can use to convince others to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
13	How to use different resources (time, money, materials) to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
14	Actions that you can take in your community to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
15	How to use legal action to support conservation and protect your community	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED

SECTION 3. YOUR VIEW OF THE ENVIRONMENT

		A	B	C	D	E
16	I value the time I spend outside in nature	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
17	I appreciate the interdependence and equal importance of all life forms	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
18	Recycling should be required in my community	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
19	I am worried about the effects of land management issues and their effects on wildlife	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
20	Changing my actions can change my community	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
21	It is important for me to act and make decisions to support conservation and the natural world	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
22	It is important for me to explain to others how climate change will negatively impact snowpack and water availability in the Greater Yellowstone Ecosystem	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
23	No matter where I live, it is important to make sure my actions do not have a negative impact on ecosystems	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
24	I do not expect others to change their habits if I do not change my own in regards to conscientious consumption and waste	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
25	I plan to talk to my friends and/or family about the effects of climate change	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
26	I plan to find out more about how the meat my family and I consume is raised and help make more sustainable decisions about how we purchase meat	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

SECTION 4. YOUR SKILLS TO STUDY NATURE

		A	B	C	D	E
27	I can ask questions that can be answered through field research and the collection of data	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
28	I am able to design a methodology to collect data that allows me to answer a question I have created	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
29	I am able to use data I have collected to create graphs and tables that demonstrate my results	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
30	I am able to construct conclusions and explanations using graphics, charts, and tables	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
31	I am able to create a poster or presentation that communicates results and my conclusions	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
32	I am able to defend my arguments and findings to others	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
33	I feel comfortable orally presenting my conclusions	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

34	I have seen a wolf in the wild before this course	A. NO	B. YES
35	I have visited a national park before this course	A. NO	B. YES
36	I have visited Yellowstone National Park before this course	A. NO	B. YES
37	I have cross-country skied or snowshoed before this course	A. NO	B. YES

APPENDIX C

ENVIRONMENTAL LITERACY POST-TEST

ECOLOGY PROJECT INTERNATIONAL

Student Survey Yellowstone | YEL - 2020 Local & Visit | POST

This survey aims to assess the learning of students on course. This survey is anonymous, however the information collected will be used for technical evaluation, marketing, promotion and program improvements.

Time needed to complete this evaluation: 15 minutes

Instructions: Please read each question carefully and mark in the ANSWER SHEET the answer that is most appropriate. It's important that you answer this survey individually and that you complete all questions.

SECTION 1. PERSONAL INFORMATION

In the section labeled 'Identifier' please put your two digit birth month and day with your favorite animal following. For example, if your birthday is March 5 and your favorite animal is a snail you would write – *0305snail*.

1	Age	A: 14 or less	B: 15 years	C: 16 years	D: 17 years	E: 18 years or more
2	Grade	A: Middle school	B: 9th grade	C: 10th grade	D: 11th grade	E: 12th grade / F: College
3	Gender	A: Male	B: Female	C: Non-binary/third gender	D: Prefer to self-describe	E: Prefer not to say
4	School Type	A: Public	B: Private			

SECTION 2. WHAT DO YOU KNOW ABOUT THE ENVIRONMENT?

5 **Why are predator population dynamics important for Yellowstone wildlife biologists to study?**

- A Predators numbers need to kept as low as possible to maximize elk populations
- B Yellowstone predator populations increase genetic diversity of predator populations throughout the Greater Yellowstone Ecosystem
- C Predators transmit dangerous diseases, such as brucellosis, to livestock outside of Yellowstone National Park
- D Wildlife biologists need to understand how predators influence prey populations
- E Options B and D

---

6 **The amount of snow that accumulates annually in the Greater Yellowstone Ecosystem has begun to decrease and will continue decreasing as a result of climate change. Which of the following is TRUE about the ecological impacts of reduced annual snowpack?**

- A Earlier snowmelt will make it harder for animals to travel to higher elevations in the spring
- B Native grasses, wildflowers, and shrubs will benefit from less available water throughout the year
- C River levels will drop earlier in the summer than the historical average, resulting in less overall flow and increased in-stream water temperatures
- D Snowpack doesn't affect forest fire frequency and severity, so the rate and intensity of fires won't change
- E Reduced snowpack only affects people who like to ski, snowboard, and snowshoe, so there will be no ecological impacts

---

7 **Habitat is a term that refers to a place that has the proper conditions for organisms and communities of animals and plants to live. For many organisms that live in seasonal environments, during part of the year their habitat does not have the proper conditions for their survival. How might organisms and communities of animals adapt to unfavorable winter changes in their habitat conditions?**

- A Migrate to an area where conditions are more favorable
- B Producers shift to become consumers and consumers become producers
- C They don't change their behavior, they go on with activity as normal
- D They become more active to stay warm
- E Consume less food

---

8 **What are examples of ways climate change will affect ungulates, such as bison and elk, in the Greater Yellowstone Ecosystem?**

- A Hotter and drier summers will likely lead to drought conditions, reducing the availability of grasses and other plants for ungulates to eat
- B Bison's historic high population across a wide range of habitats across North America shows that they will likely thrive despite rapid climate change in the Greater Yellowstone Ecosystem
- C Changing season lengths and overall climatic metrics like annual precipitation, daily temperatures, etc., will likely affect ungulate migration patterns and timing
- D Predators will likely be affected by climate change first, causing a huge population explosion of ungulates
- E Options A and C

---

9 **In order to contribute to ecosystem health, what is something you could do on your next snowshoe?**

- A Be courteous to others on the trail
- B If snow has melted from areas where you travel, stay on areas where snow and ice remain to minimize your impact
- C Avoid traveling through terrain where it is obvious that an avalanche has been triggered recently
- D Only leave microtrash behind
- E Pick up animal scat along the way and pack it out to remove negative impacts of decomposing feces

---

10 **Wolves play an important role as apex predators in their ecological communities. When wolves were reintroduced, what happened to other organisms in Yellowstone?**

- A Wolves have decimated small mammal populations like squirrel and rabbit
- B The elk and other prey populations plummeted resulting in an explosion of all kinds of invasive plant species
- C Wolves haven't gained enough of a foothold in Yellowstone to have an impact on the ecosystem
- D Wolves have introduced a natural population control on prey species like elk
- E Grizzly bear and cougar populations have increased because the introduced wolves don't know to avoid the predators and are therefore easy prey

ECOLOGY PROJECT INTERNATIONAL

Student Survey Yellowstone | YEL - 2020 Local & Visit | POST

How informed are you about...?

		A	B	C	D	E
11	Direct actions you can take to support the conservation of the Greater Yellowstone Ecosystem	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
12	Strategies you can use to convince others to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
13	How to use different resources (time, money, materials) to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
14	Actions that you can take in your community to support conservation	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED
15	How to use legal action to support conservation and protect your community	UNINFORMED	SOMEWHAT UNINFORMED	NEUTRAL	INFORMED	VERY INFORMED

SECTION 3. YOUR VIEW OF THE ENVIRONMENT

		A	B	C	D	E
16	I value the time I spend outside in nature	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
17	I appreciate the interdependence and equal importance of all life forms	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
18	Recycling should be required in my community	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
19	I am worried about the effects of land management issues and their effects on wildlife	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
20	Changing my actions can change my community	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
21	It is important for me to act and make decisions to support conservation and the natural world	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
22	It is important for me to explain to others how climate change will negatively impact snowpack and water availability in the Greater Yellowstone Ecosystem	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
23	No matter where I live, it is important to make sure my actions do not have a negative impact on ecosystems	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
24	I do not expect others to change their habits if I do not change my own in regards to conscientious consumption and waste	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
25	I plan to talk to my friends and/or family about the effects of climate change	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
26	I plan to find out more about how the meat my family and I consume is raised and help make more sustainable decisions about how we purchase meat	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

SECTION 4. YOUR SKILLS TO STUDY NATURE

		A	B	C	D	E
27	I can ask questions that can be answered through field research and the collection of data	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
28	I am able to design a methodology to collect data that allows me to answer a question I have created	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
29	I am able to use data I have collected to create graphs and tables that demonstrate my results	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
30	I am able to construct conclusions and explanations using graphics, charts, and tables	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
31	I am able to create a poster or presentation that communicates results and my conclusions	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
32	I am able to defend my arguments and findings to others	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
33	I feel comfortable orally presenting my conclusions	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

34	I saw a wolf in the wild during this course	A. NO	B. YES

Thank you for participating in this survey!

APPENDIX D

DRAW-AN-ECOSYSTEM RUBRIC

Rubric for Scoring Draw-an-Ecosystem Activity

Category and Score	3	2	1	0
Nutrient Cycling	Positive and negative deefback arrows that also suggest magnitude	Positive and negative feedback arrows	A positive or negative feedback arrow, or mention of	none
External energy input	Quantitative/qualitative aspect to labeling energy (source/sink). Magnitude and direction of energy transfer	Sun and labeled energy. Magnitude or direction	Sun drawing or label	none
Geosphere	Complex interaction with cycling of matter and energy	Cycling of matter or energy	Rock or soil; labeled or shown in cross section	no soils/rock layers
Trophic Levels	More than two; arrows linking food web members (independent of feedback loops)	Consumer's and producers labeled	Predator/Prey relationship illustrated	none
Organism interrelationships	More than one example of symbiosis provided, catagorized and labeled. Competition illustrated	More than one example of symbiosis provided, catagorized and	Symbiosis represented; uncatagorized	none
Human Activities	Explicit mention of humans incorporated into ecosystem, anthropogenic influences	Evidence of more than one type of human activity/visitor use	Evidence of one human activity	no indication the humans are involved in the ecosystem
Hydrologic Cycle	Evidence of transformation of water forms, storage residence time	More then one example of water shown (snow, river, underground, atmospheric	labeled or shown in cross section	no water present in figure
Atmosphere	Complex interaction with cycling of matter and energy	Multiple nutrients cycling	water and oxygen cycling	no labeling
Systems and Environmental Issue	Illustrated example (climate change, deforestation, habitate fragmentation)	Stated example	Implied/infered	none

APPENDIX E

STUDENT QUOTES AND TESTIMONIALS

Student Quotes from Interviews

Course Name	Name of Participant	Testimonial & Quote
3/4/20 - Gardiner School	Anonymous	I enjoyed it a lot! The instructors were cool and I learned so much. I learned more about bison and wolves.
3/4/20 - Gardiner School	Anonymous	This course was a great experience for me. I loved how we got outside a lot and seeing the wolves was amazing and I would recommend this to others. This experience made me open my eyes and realize that there is always something to do outside.
3/4/20 - Gardiner School	Anonymous	I see conservation work in a better light due to the information I learned on this course.
3/4/20 - Gardiner School	Anonymous	It was an opportunity to learn more about the ecosystem right outside our back doors. It was very eye opening. I learned a lot, but my perspective mostly stayed the same.
3/4/20 - Gardiner School	Anonymous	It was excellent. I loved it. I only wish it was longer. I learned a lot about the collared animals, and snow.
3/4/20 - Gardiner School	Anonymous	It was a lot of fun. It would definitely be something I would go do again if prices were lowered.
3/4/20 - Gardiner School	Anonymous	All of my expectations were met. This has consistently been an academically robust program that blends fun and learning. This is a great, high quality program and I have no suggestions. Students learned/exhibited the ability to listen and consider multiple viewpoints in complex wildlife management situations.

APPENDIX F

LESSONS DESIGNED FOR TREATMENT

FIELD INVESTIGATION: HOME ON THE RANGE

Summary
This lesson will provide students with a basic working understanding of the "Home on the Range" study, including the rationale behind it, research question, and data collection protocols. Students will explore the role bison play in historical and modern terms, and what that role means for other ungulates living on the same landscape. Students will have the opportunity to learn and practice each step of the research protocol as well as work through the decision-making process necessary to select which animal the group will seek out on their field days.

Background information
A historically large bison population has caused concern about whether there is enough "home on the range" for the animals that make up one of the most diverse and abundant mammal communities in North America. In addition to bison, significant populations of elk, mule deer, bighorn sheep, and pronghorn call Yellowstone's northern range home. All of these ungulates must cope with changing plant conditions, grazing effects, and a warming climate while facing predation risk from a rich community of wolves, cougars, and bears.

Why do we care so much about bison? From Chris Geremia, our research partner: Before Euro-American hide-hunters, settlers, and the military almost eradicated bison in the 19th Century, 25-30 mission bison roamed North America. At the turn of the 19th/20th Century, only 75-100 bison remained on private ranches from Texas to Montana.

Bison are uniquely constrained to live almost exclusively within Yellowstone, with their abundance artificially controlled by management agreements that require the culling of animals when they leave the park. Bison numbers in northern Yellowstone increased by 700% since 2000 due in part to emigration from other areas of the park and potentially due to a precipitous decline in the elk population during the 2000s. While elk remain more abundant in the park than bison, the northern range has shifted from being elk-dominated to being bison-dominated in terms of grazing pressure. Transition to a bison-dominated system likely has cascading behavioral and numerical effects on the many ungulates and predators that make up this multi-prey, multi-predator system. While there is public concern that increased grazing pressure might have negative effects on "range quality," i.e., the ability of the range to produce forage sufficient for the animal communities that depend on it, preliminary studies suggest that the northern range grasslands have demonstrated resilience to the increased grazing pressure (Frank et al. 2016). Additionally, scientists do not yet know how the five most prominent ungulate species share and/or compete for resources across the landscape, and what the increased bison population might be doing to shift behavior within each species. Perceived conflict between bison and other ungulates such as elk and cows for resources can increase antagonism from members of the public toward bison, especially if folks understand the relationship to be zero sum. If, for example, bison don't directly compete for food or other resources sought by more popular animals (or they actually grow the food resource), that information could be used to change the public perception regarding bison. Climate change will also add additional stress to a complex system through

increased forest fires, droughts that could reduce forage availability, heat stress in both the winter and summer, or increased pest/parasitic loads. A geographically or genetically constrained bison population would be less resilient to those impacts than a more robust population. Thus, it is critical understand how ungulate and plant communities are responding to the recent change in bison population, not only for public perception but also so that wildlife managers can set bison up for success in an uncertain future.

In short, the research question is, "To evaluate numerical and behavioral responses of bison, elk, mule deer, bighorn sheep, and pronghorn populations to historically high numbers of bison."

Learning objectives

- Students will be able to synthesize the guiding research questions for the Home on the Range study and describe how those questions relate to the research protocols, as well as the conservation "why" behind the study
- Students will gain experience manipulating a .kmz file and reading satellite imagery
- Students will develop a baseline understanding of how to conduct each component of the research protocol
- Students will gain ownership over the course strategy for data collection

Lesson progression:

Engage

Deliver the history of bison in a story or timeline format. You can find all the materials you need in the Bison Binder including a year by year timeline, photos to interpret from, and plenty of background material. This story or timeline should aim to provide students with an understanding of the population that is currently in the park, the reintroduction process and the cultural concerns associated with returning a species that has been absent from the landscape for decades.

Explore

Refresh students' memories by writing the three questions our research study aims to answer on a white board. Those questions are:

1. Identify spatial overlap of bison, elk, mule deer, pronghorn, and bighorn sheep. How and where do these species niche's overlap? *(Where are the animals in the moment?)*
2. Compare differences in seasonal home range size, migration distance, migration route architecture, and movement cues among the different ungulate guilds in Yellowstone. (*Where are they heading over time, and why are they moving?*)
3. How does the movement of bison affect the distribution of the different grazing members of Yellowstone's ungulate guilds? (*How does the presence or absence of bison affect other ungulates behavior/preferences?*)

Walk the students through the three questions and include the simplifications in italics. It is okay to simplify research quality questions when you are working to design a study, it helps you think more clearly about data needs. If students want to challenge the assumptions that those simplifications are made based on, that's great! Ask for evidence for their challenge and let

them design a new simplification. Ultimately we are hoping to provide some clarity as we begin to brainstorm a method. Looking at the three questions and their addendums, *why* do you think scientists in the park care so much about answering these questions? Solicit ideas, thoughts, "I wonder" statements, etc., and make sure that both the public perception of bison conflicting with other species (esp. cows and elk) for space and climate change/the ability to be resilient as a population come up in the conversation. Come back to this theme throughout the course.

Now move on to methods: how might we design a study to get us relevant and useful data? Allow students to propose ideas and focus on materials. No idea is a bad idea when brainstorming, but students need to back up their methodologies with a list of materials they would need to execute that method. If a procedure requires 8 helicopters and 25 field technicians, it is too complex and needs to be streamlined. Have students voice their ideas and take note of what materials and methods they are already familiar with. Challenge and clarify misconceptions as they arise.

Explain

These are all great ideas and some probably have parity for what we will be doing in the field. The next section will be station work where we will introduce students to the actual method we will be using. Explain that you will break participants into three groups and that each group will travel to a different station where they will spend 15 minutes learning about some portion of the method. Students will need their journal and something to write with and be prepared to interact and ask good questions at each station. There will be a performance evaluation at the end of the lesson….students are going to have to execute on these protocols out in the park! Now is the time to be curious, to make mistakes and learn as much as they can before heading out into inclement weather to collect data for the national park service. The 3 stations set up as:

1) ***Selecting an Individual*** **-** Set up the laptop with the most recent points downloaded to it. Show students how to use the tools (especially the time slider). Discuss with students what they should consider when choosing an animal to track (accessibility, safety, time, significance of data). Have students come up with at least two animals they would recommend the group pursues based on these criteria.
2) ***Tracking and Data Sheet*** - One instructor should demonstrate to students how telemetry works. Show students how to use the frequency list to find an animal, and how to find that frequency on the receiver. Show students how to adjust the gain and volume to help find a signal. Explain to students the basic premise of how radio telemetry work and some of the environmental factors that can affect its reliability. Walk students through the data sheet, highlighting anything that might seem confusing (aspect, age class, etc.). Allow ample time for students to get hands on with equipment and to ask questions about the data sheet.
3) ***Snow Corer and Site Setup*** - Introduce student to the protocols for taking an accurate snow corer. Things to reinforce with students: *Using gloved hands to handle the core, what qualifies as a proper soil cookie, and ensuring all pieces of the snow core make it back into the case*. This component of the research protocol can seem a little abstract to students, so be sure to emphasize why it is important we do this and what the bison team can do with this information. Show a sketch of a fecal collection site. Note the site setup, the use of flagging, approximate distances and number of samples taken. Students will need to be able to set up a plot like this in the field.

Expand

After each group has had ample time at each station, bring the students back together. Ask for groups to share which animals they have selected and require they provide evidence for that animal's suitability. The instructors not facilitating the conversation should be meeting to develop a plan for which animals will be sampled and the logistic for organizing the field teams.

In order to help guide groups in the field, EUREKA! groups have a strategy for winter Home on the Range data collection. You can think of it as a hierarchy or pyramid, and drawing this pyramid out for students can be very helpful for them to create a mental model of the structure of their field experience. We have three basic "classes" of data collection: Opportunistic Classification, Targeted Classification, and Targeted Fecal Collection. They increase in difficulty and in usefulness to our research partners. They work out as follows:

- **Targeted Fecal Collection:** The top of the pyramid. The crown jewel! This is when we have selected an animal of high priority, located it in the park, tracked it with telemetry, traveled to a location of use, confirmed its presence, classified its herd, and collected its fecal. The most challenging and time consuming of all our data collection strategies, this provides the motherlode of data that our partners are hungriest for!
- **Targeted Classification:** The middle of the pack. This is when we are able to identify a collared individual by alpha numeric or radio frequency and classify the age, sex, and number of the herd it is in, but are unable to take fecal or snow samples. This happens most often in passing, as we see an animal from the road, but some impediment prevents us from sampling its fecal (physical limitation, environmental barriers, time/energy, etc.) This is still very useful data and is worth collecting.
- **Opportunistic Classification:** The bottom of the pyramid, least useful but most in demand, our partners need data on herd dynamics across the park. How many individuals are in groups together, where are those groups, and what is the approximate age/sex of those individuals? Any opportunity we have to get out on the group, take a GPS point and confidently classify a herd of ungulates provides simple, useful data for our park partners as they are thinking about niche partitioning.

As we head out into the park today be keEUREKA!ng these different strategies in mind. Driving out to or back from our targeted fecal sites we may have a chance to sample opportunistically! We may pass a collared individual in her herd right next to the road and can grab a quick and accurate targeted classification. All this data is useful and we should maximize our efficiency while we are in the field.

Evaluate

Allow students the chance to voice questions leftover from the lesson. Listen to concerns and consider which aspects of the project might be most challenging or least challenging. This is a good chance to check in with a self-confidence survey (thumb-o-meter) to see where students rate themselves with confidence in executing research protocols.

VIEWPOINTS: WOLF CONSERVATION

Summary

Expose students to the realities of an important conservation issue in this ecosystem, wolf conservation, and begin to explore the importance of collaboration, respect, and listening in real world issue resolution.

Learning objectives

Students will:
Visualize changes in an environmental issue overtime.
Describe the GYE wolf conservation issue and stakeholders.
Evaluate the issue.
Develop opinions on both sides of the issue, and discuss the issue as a group.

Key concept

Grey wolf, predators, wolf pack, endangered, restoration, relocation, livestock, buffer addendum, regulation, management, stakeholder.

Lesson progression:

Engage

Gather the students and do a group brainstorm of some of the most important conservation issues facing the Greater Yellowstone Ecosystem. If the group exhausts their ideas and haven't brought up wolf conservation lead them to come up with that issue by asking questions about the activities they have done on course and how they relate to conservation issues. Explain that they are going to create a historical time line together of the grey wolf in Yellowstone National Park.

Yellowstone grey wolf timeline:

1872 Wolves present when park is established.
Late 1800s-early 1900s Predators, including wolves, are routinely killed in Yellowstone.
1926 Last wolf pack in Yellowstone killed.
1960 NPS management policy changed to allow populations manage themselves.
1974 Grey wolf listed as endangered; recovery is mandated under Endangered Species Act.
1975 The long process to restore wolves in Yellowstone begins.
1995-1996 31 gray wolves from western Canada relocated to Yellowstone.
1997 10 wolves from northwestern Montana relocated to Yellowstone National Park; U.S. District Court judge orders the removal of the reintroduced wolves in Yellowstone, but stays in order pending appeal. (Decision reversed in 2000.)
1995-2003 Wolves prey on livestock outside Yellowstone less than expected: 256 sheep, 41 cattle.
2005 Wolf management transfers from federal government to ID and MT government.
2008 Wolf population in MT, ID, WY removed from Endangered Species list, then returned.

2009	First fair chase wolf hunt begins in Montana.
2011	400-500 wolves live in Greater Yellowstone Ecosystem.
2012	Wolf delisted in WY, hunting begins there.
2014	District judge rejects WY management plan and relists wolves there.

Additional timeline for discussion:

Wolves in Wyoming
Aug. 31, 2012: The U.S. Fish and Wildlife Service announces it will delist wolves in Wyoming, establishing hunting areas in the northwest corner of the state and allowing wolves to be shot on sight everywhere else.
Sept. 30, 2012: The delisting becomes formal.
Oct. 1, 2012: Wolf hunting season opens in Wyoming, setting a quota of 52 and selling about 4,500 wolf licenses.
Nov. 13, 2012: Four conservation groups file a lawsuit to place wolves back on the endangered species list in Wyoming.
Jan. 1, 2013: Game and Fish reports 42 wolves were killed in the trophy area, and 25 were killed in 2012 in the rest of the state.
Jan. 1, 2014: Game and Fish reports 24 wolves were killed in the trophy zone from a quota of 26 and 39 wolves were killed in the rest of the state.
Sept. 23, 2014: U.S. District Judge Amy Berman Jackson, ruling from a federal court in Washington, D.C., rejects a Wyoming wolf-management plan that had declared wolves unprotected predators that could be shot on sight in most of the state.
Sept. 24, 2014: Wyoming Governor Matt Mead sings an emergency rule that changes the population buffer addendum (minimum 150 wolves and 15 breeding pairs outside Yellowstone National Park) and turns it into a regulation.
Sept. 30, 2014: Judge Jackson continues suspension of wolf hunting in the state and continues her previous ruling to relist wolves under the protection of the Endangered Species Act in Wyoming.

Explore

Depending on how many students you have, give them one or more fact cards. Have students work together to figure out where each fact card belongs on timeline. If you have a good place to hang a rope and use clothes pins that works well for visualization, if not using a table or the ground works.

Once students feel good about the entire timeline, you can have one student read off each time and fact from beginning to end. Make sure to stop along the way to see that the whole group agrees with placement, and if not, why? Certain facts cards can also be used as teachable moments that connect to the bigger picture of the GYE (gauge your group and act accordingly).

Middle school adaptations

This activity can make for a very good Quest for Knowledge. I would suggest pulling 8 of the fact cards that are the most significant and creating a more concise timeline. We want to drive

success in this activity, so pull fact cards with high importance and information that can be matched correctly without a lot of background knowledge of wolf management.

While the dinner crew is preparing food, for example, have the Quest for Knowledge group of students work on building this timeline to share with the other students post-meal. Work with the group of students as you all talk through each fact card to correctly build the timeline. Engage the student's discussion as you piece the timeline together. Visuals and smaller group work are a great help for younger students!

Stakeholder activity

Explain to the group that they are going to take sides in the controversy surrounding wolf reintroduction and conservation.

Option 1: Put rope, water bottle, student journal and marker in the middle of the students (or whatever objects you see fit for this introduction). Let the students know that they have just arrived to an island and only get to choose one of the resources to survive. Pose the question: Which resource will you choose and why? Once students have all given their answer and reasoning explain that each person chose their resource because of their opinion, interest and perspective, and that every person's perspective, interest and opinion should be valued.

Option 2: Split group in half and have them on opposite sides of each other. Put any sort of object that is different on either side in the middle of the two groups. Have them draw the object from their side. And after a couple minutes have them share their findings. What's different about all the drawings? The group should come to the conclusion that there are different perspectives or different viewpoints.

One team will represent elk hunters from Idaho, one team will represent ranchers from Wyoming, one team will represent the National Park Service, and one team will represent conservationists and 'Rick McIntyre's wolf groupies'. Questions: What concerns do you think these respective groups might have? What priorities? What federal agencies might be involved in the issue, and where might they stand?

Explore

Set up a town hall meeting. Setting:

Split students into groups randomly. Provide each group with a whiteboard (or have them just write in their journals) and have each group come up with a list of the different people and groups that have an interest in wolf reintroduction and management. Once students have generated their list, ask if they know of a general term for referring to the various interest groups with the goal of identifying the word 'stakeholder'. Ask if any student can provide a definition of a stakeholder. If that is provided, but students still look a little confused, go over a few examples.

Let the students know that there are many stakeholders with various interests and opinions, and that we will now explore this further by taking it to a public community meeting in the town of (make up a town in MT preferably). Another option would be to have the groups imagine they are presenting arguments to the Supreme Court or participating in a public debate. Split the

students into their respective stakeholder groups and tell the groups that from the different interest groups we shared we will be focusing on a few specifically. Distribute one stakeholder role card to each student group. Have each stakeholder group read the first line on who they are off their identification card.

Here are the stakeholder role cards:

Defenders of Wildlife

Who: A national conservation organization that is dedicated to the protection of native species in their natural communities to create a diverse, secure, and thriving network of healthy lands and waters.

Viewpoint: They see the state regulated hunting as a threat to wolf populations that may decrease wolves likelihood to survive in the long run. They would like to see more non-lethal measures (such as dog proof fencing and electric fences) taken to help people live with the wolves.

Supporting Facts:

- In 2012, 124 wolves were killed, 89 of which were part of the hunting season in Wyoming. Wolves had a

National Park Service

Who: The federal agency in charge of national parks in the United States, including Yellowstone National Park. They "care for special places saved by the American people so that all may experience our heritage."

Viewpoint: Their goal is to safeguard places in the United States for the enjoyment of future generations. Therefore their best interest is in preserving Yellowstone as the beautiful wild land that it is which includes wolves. NPS generally wants to protect the wolves.

Supporting Facts:

- While there is no hunting in the park, wolves that venture out of Yellowstone are occasionally killed due to

Montana Fish, Wildlife, & Parks

Who: The MT state agency that works to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the people who reside in the state.

Viewpoint: The MT FWP uses science and research to make management decisions, while keeping in mind stakeholder stances, especially the viewpoints of their primary funders, hunters and fishermen. Since the recent delisting of wolves from the Endangered Species List they are also in charge of managing hunting quotas and wolf populations based on science and public opinion.

FWP obtained full authority to manage wolves in Montana upon the federal delisting of the Rocky Mountain gray wolf in May 2011. FWP is committed to using its authority to responsibly manage Montana's wolf population while addressing conflicts with livestock and other wildlife populations. FWP is further committed to allowing hunters, who are showing a real interest in pursuing wolves, to become even more involved in Montana's approach to wolf management. The focus will be on ensuring that Montana's conservation and management program keeps the wolf off the federal endangered species list while pursuing a wolf population level below current numbers to manage impacts on game populations and livestock.

Yellowstone Wolf Guides

Who: An organization that takes clients on tours in Yellowstone and surrounding areas to view wild wolves.

Viewpoint: These tourist agencies like the wolf populations because they draw in more clients and increase profits. The more people who see wolves, the more people come to find them (and the more they are willing to pay).

Supporting Facts:

- Increased profits due to tourism for wolf watching have been estimated at $5,000,000, up to $761 per person.

Ranching Family

Who: A fourth generation family that depends on free range cattle to make a living. Their cattle are kept on the family's 1000 acre ranch in Wyoming that is fenced by mostly barbed wire. They have lost cattle to wolf attacks.

Viewpoint: They see the wolves as a threat to their livelihood because the wolves kill their cattle which impacts the amount of money they will be able to make in selling them for meat. They think the wolf population should be controlled and lowered in order to protect their livelihood.

Supporting Facts:

- Wolves have been reported killing livestock like cattle and sheep.

U.S. Fish and Wildlife Service

Who: The federal agency that works to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people.

Viewpoint: The USFWS uses science and research to make management decisions, while keeping in mind stakeholder stances. In addition to conducting research they must also give the public opportunity to express their opinions and concerns about USFWS actions.

Supporting Facts:

- Viewpoints may range from unrestricted hunting seasons (no regulations on number harvested or areas for hunting) to returning them to the endangered species list. USFWS is responsible for upholding the Endangered Species Act which required at least 150 wolves and 15 breeding pairs.

Trophy Mountain Outfitters

Who: An organization that guides tours for hunting in Wyoming. They specialize in elk, moose, mule deer, antelope and various other trophy animals that live in Wyoming ecosystems.

Viewpoint: Hunters want more freedom to hunt wolves and think the wolf population should be lowered and highly regulated. Some hunting outfitters rely on high elk populations for money during the hunting season and have had trouble finding the numbers they did before wolves were reintroduced.

Supporting Facts:

Tell the groups they are at this public comment meeting to address what their "plan" is: each group needs to give an ideal population goal, how they plan to reach that goal (have them give as much detail as they can), how would you increase a population (hunting ban, buffer zones, educational awareness, etc.), how would you decrease a population (hunting, trapping, open season or longer, etc.). If needed, have students describe as a whole group how to increase or decrease so they can grasp a more detailed plan in their individual groups. Have students explore their stakeholder role and craft their perspective, values, and argument.

You can plan to give them "fake" statistics of the ecosystem. This can be helpful to gauge populations and give better understanding in formulating their plan.

Current population:	526
Landscape carrying capacity:	550
Current breeding pairs:	16 (included in population)
Minimum population:	300
Minimum breeding pairs:	14

Once students have had 5-10 minutes to hash out their plan have each group share their results. Have students come up with questions in a respectful manner after each group presents. Review their findings by writing all the different plans on the whiteboard. Ask students if it was difficult to play a role they didn't agree with. If so, why? Ask the students in reality which plan would they follow? And, why? How does it actually work when communities come together? What plans are currently in place in this ecosystem? Are there likely to be changes in the near future? How do you think that climate change impacts in Yellowstone will affect wolf populations in the area and their interactions with other wildlife and with surrounding human communities? What management actions would you advocate for, given these potential future changes?

Explain

The issue of wolf conservation in the Greater Yellowstone Ecosystem is hugely contentious and has no easy answer: there are intelligent, informed people on both sides of the debate. If necessary, provide additional information about the various stakeholder groups, recent developments, and factors that contribute to the different stakeholder perspectives. There should not be a winner of loser in this debate, but the instructors should wrap up the discussion and rebuttal period by highlighting the complexity of this issue: scientifically, morally, ecologically, culturally, politically, etc. Was this helpful to see the other perspectives? Realistic goals? What is a wildlife manager's first priority? Public or environment? Present or future concerns? Is there a way to do both?

Elaborate/Expand

Did listening to the debate and forming a perspective (not necessarily the one that they would personally choose) help them see the issue in a different light? What larger issues tie into wolf reintroduction (e.g. public and private land use, government regulation, prey species management)?

Ask students to put themselves in a wildlife manager's shoes. Think about how you would make a philosophical decision to answer the question "Should wolves be reintroduced to the park?" Would you solicit public opinion to get an idea of how various stakeholders view the issue? How would you balance that with the biological evidence gained from scientific studies? Ask students to get into small groups to discuss their ideas. Then have them share with the larger group and follow-up on discussion from there. What are conservation issues in their communities? Who are the various stakeholder groups? How do other conservation issues compare to wolf conservation?

Evaluate

Now that participants have been exposed to many of the current conservation issues facing the Greater Yellowstone Ecosystem, participants should take some personal time to reflect in their journals on what they wish to see for the future of this ecosystem. In other words, what is their vision? With which stakeholder group do they most strongly identify and why? To which group are they most strongly opposed? They should then follow these questions by reflecting on what actions they can take as an individual and what actions could be taken societally to make their vision a reality.

Middle school adaptations

Put a piece of rope, a full water bottle, form of food (i.e. granola bar)and a lighter in the middle of the students (or whatever objects you see fit for this introduction). Let the students know that they have just arrived to an island and only get to choose one of the resources to survive. Pose the question: Which resource will you choose and why? Once students have all given their answer and reasoning, explain that each person chose their resource because of their opinion, interest and perspective, and that every person's perspective, interest and opinion should be valued. Help the students to understand the word "stakeholder". This word is general term for referring to the various interest groups. Can the students come up with a short list of stakeholders concerning wolf management?

Explain to the students that they will be divided into groups and each group will take on the role of a stakeholder. Divide them up, and hand each small group a stakeholder card. Give them 5 minutes to review their card. Set up a boundary between two objects- identify that on one end, everyone is pro-wolf, or happy to have them reintroduced to YNP, etc. and on the other end, everyone is against the reintroduction of wolves, and they find wolves a pest and terror, etc. One at a time, have each group share their stakeholder view. Let the group decide where they fall on this pro and against boundary line. Have the group place their stakeholder car on the line so students can visualize the stakeholder's viewpoints. Does the rest of the group agree? Why or why not?

Ask students to put themselves in a wildlife manager's shoes. Think about how you would make a philosophical decision to answer the question "Should wolves be reintroduced to the park?" Would you solicit public opinion to get an idea of how various stakeholders view the issue? How would you balance that with the biological evidence gained from scientific studies?

Ask the students lastly to reflect. With which stakeholder group do they most strongly identify and why? Students do not need to share their thoughts and ideas aloud, but should create a symbol map of their personal value set, a letter to self, or a conservation pledge in their student journals. This is a time for personal reflection.

WHY THE GREATER YELLOWSTONE ECOSYSTEM (GYE)?

Summary
This lesson is designed to help students work on their sense of place, to establish in their minds where Yellowstone is geographical, why it is unique to other places in the world, and to set a baseline understanding of the components of the ecosystem and how they might interact. This lesson also provides opportunity for students to reflect on what their role might be as a component of this ecosystem for the duration of their field experience.

Learning objectives
Students will:

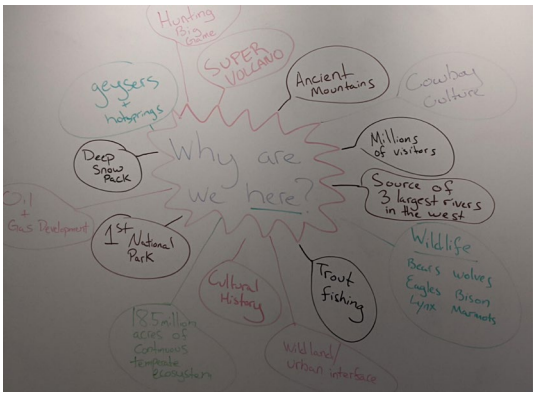
- Identify unique components of Greater Yellowstone Ecosystem including: its geographic size, major land managing interests, and diversity of flora/fauna
- As a group, construct an ecosystem model of the GYE including all prior knowledge
- Set goals for the course as a participant in the ecosystem

Lesson progression:

Engage

Invite students to consider the anchoring question for this lesson, "Why are we here?" Write the question on a white board. EUREKA! works in amazing places across the globe, with nesting sea turtles in Costa Rica, giant tortoises in the Galapagos…why are we engaging in a science expedition here in Yellowstone? What makes the Greater Yellowstone Ecosystem special?

Give students two to three minutes to write down in their journals what they know about the region they've come to visit that they find especially interesting or unique. What makes Yellowstone special?



After taking time individually, have each student share one or two things they listed and write a group list on the whiteboard. A complete list should include some or all of the following:

- Yellowstone is home of the world's first national park, encompassing 2.2 million acres and facilitating more than 4 million visitors each year
- Yellowstone holds the world's largest concentration of geysers and hot springs. Yellowstone sits atop a hot spot, and the caldera left behind by the most recent eruption is visible in the central region of the park
- The GYE is home to the youngest mountain range in the Rockies (the Tetons) and the oldest rocks in the Rockies (The Wyoming Craton ~ 3.5 billion years old) as well as the largest glaciated region in the contiguous US
- Size – it is roughly the size of the state of West Virginia. Yellowstone National Park (2.2 million acres) makes up only 12% of the GYE.

- The GYE holds the largest elk herd, bison herd, the largest number of grizzly bear and wolves anywhere in the lower 48 states
- The GYE is the source of the 3 largest rivers in the west (the Missouri, the Colorado (via the Green) and the Columbia (via the Snake)
- There is a large diversity of wildlife: Home to 67 species of mammals, 332 species of birds, 16 fish, 6 reptiles, and 4 amphibians.
- The GYE is an area of intense energy development (oil and natural gas), historic resource extraction (timber and minerals) and the new wealth model for the American west (tourism and recreation). There are areas of intense development located next to designated wilderness
- The GYE is the traditional homelands of 26 Native American tribes, making it rich in cultural as well as ecological diversity. Native peoples have lived in and traveled through the GYE since time immemorial, using these lands and waters for hunting, gathering, ceremony and all aspects of their lifeways.

The brainstorming/list-making portion is a way to gauge your group's prior knowledge of the Yellowstone area. Ideally, they will have enough background knowledge to each offer an item or two to add to the list. If they have difficulty, ask follow-up questions such as 'What can you find here that you may not see in other areas of the country (or world)?' If the student's list feels inadequate or students are struggling to grasp why Yellowstone is unique, feel free to read the introductory passage to from Jack Turner's "Travels in the Greater Yellowstone." During the reading, have them write down anything that stands out as unique, that they did not know, or that surprised them. Collect these responses on the white board.

Explore

As we continue to investigate the question "Why are we here?" we need to tap into some of our resources for developing a sense of place. We will use lots of resources on this field course including many maps and graphs. Let's take a minute to explore the land mass that is the Greater Yellowstone Ecosystem, so that we can begin to get an idea of where we are in the world and how this landscape is managed.

Open up the two laminated GYE maps and invite students to explore. Using white board markers, have students identify:

- Places they have heard of before
- Places they are curious about
- Different public and private entities with a stake in land management in Yellowstone

Once students have had the opportunity to explore the maps, give students an opportunity to share their observations and use questions to guide discussion. Consider drawing boundaries of the GYE, tracing the three major rivers/watersheds, circle the largest caldera, point out places within the park you will be visiting while on course, etc. Use the visual to help guide your discussion.

Explain/ Elaborate

As we saw, there are many organizations and entities with a say in how the rules and regulations are set here in the GYE. That was a map of the landscape, divided by man-made boundaries. We will be exploring the GYE as bio-technicians working for the National Park Service. The lens through which we investigate the GYE will be as ecologists and so we want to take time to build our own map, to refine our own mental model, of the ecology of the Greater Yellowstone Ecosystem.

Introduce the Draw-an-Ecosystem template. Onto this canvas we are going to create a map of the ecology of Yellowstone as we know it today. As you are building your model, please keep these things in mind:

- Add all biotic and abiotic components you have knowledge of.
- Highlight processes where biotic and abiotic components might interact (example: hibernation), where biotic components might interact (example: predation) or where abiotic components might interact (example: weathering)
- Consider all the different scientific disciplines that might be studies in the park: wildlife, geology, microbiology, climatology, volcanism. Include those phenomena and processes as well.

Reference the provided instructions, template and rubric for more information on the draw-an-ecosystem model.

Evaluate

We will be revisiting our ecosystem model across the course to add new learning and check in on old assumptions, but to close our lesson out we want to return to the question "Why are we here?" and flip the emphasis a bit. "What are we here?". Yellowstone, we've learned, is a deeply unique with a long and storied history. We are about to embark on a weeklong science and conservation expedition. We are about to be forever writ into the history of this landscape. There is a certain amount of responsibility in that idea and having your students investigate what decisions brought them to Yellowstone and what parts of the landscape resonate most with them is an important evaluative component in developing a sense of place. Have students take some time to pair-share on the question:

"What are we here?"

- **How did we get to Yellowstone?**
- **Why did we choose Yellowstone as a place we want to travel to?**
- **What about this ecosystem resonates most with us?**
- **What are we hoping to take home from this experience?**