Huli ʻĀina Kumu Wai

(Watershed Investigation)

Field Science Curriculum for Middle and High School

THE KOHALA CENTER®

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Huli 'Āina Kumu Wai curriculum is a collaborative effort of the writing team, field testers, and editors. The Writing Team members went above and beyond what they were asked to do, meeting on Sundays one to two times a month from November 2016 to May 2017. They worked evenings and weekends outside of group meetings to complete their tasks and field-test the lessons with their students. The team inspired each other and shared their mana'o throughout the project.

The field testers provided excellent feedback on the lessons and we are grateful for them and their students. Sandy Webb is a tireless, passionate science teacher who regularly conducts field science research with her students and has provided critical input to this project. Cheryl Ka'uhane Lupenui started reviewing this document and provided valuable 'āina-based education and HĀ perspective before she officially became The Kohala Center's CEO.

Patricia Otto and the Pacific Education Institute allowed us to use content from their *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes*. The *Field Investigations* guide provided a framework for this Hawai'i-specific curriculum project and important introductory sections. Thank you to Jennifer Hoof who generously allowed us to adapt her lesson *A Watershed and an Ahupua'a*. NSTA and Page Keeley have allowed us to use the *What is a Watershed* assessment probe in the *Mapping and Describing a Watershed* lesson.

Brett Moulding and Nicole Paulson provided excellent NGSS training in Honolulu in March 2017. They shared NGSS Lessons and Templates includes in the Appendix.

INTRODUCTION

Huli ʻĀina Kumu Wai (Watershed Investigations) is a middle and high school curriculum aligned with NGSS and Common Core standards. This curriculum project came about after The Kohala Center completed a *Best Practices for Conducting Field Science Research with Middle and High School Students* guide and wanted to offer lessons and more support materials to teachers.

This curriculum was modeled after *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes* (https://publicgardens.org/resources/field-investigations-using-outdoor-environments-foster-student-learning-scientific). The writing team decided to provide lessons that teachers could use with students on campus to prepare for field trips and would still be useful if field trips were not an option. Both mauka and makai lessons are included to accommodate different natural areas that teachers can access.

Each lesson is aligned with middle school NGSS standards. The writing team decided high school teachers could build on the middle school standards and scaffold the lesson to those standards. Adding the high school standards will be an improvement for a future draft.

During the writing process, one of our team members attended the Hawaiʻi Department of Education-sponsored NGSS workshop taught by Brett Moulding and Nicole Paulson in March 2017 in Honolulu. The instructors introduced an "upside-down" approach to teaching. This method included providing students with a "phenomenon" that they then create investigations to explain. Unfortunately, all of the lessons in this document had already been written so it was too late to change the format to include this alternative approach. The next draft of these lessons will include this new approach to better align this curriculum to the NGSS way of teaching and learning about science.

Huli ʻĀina Kumu Wai is a living document that will evolve over time as improvements are made based on teacher feedback. We will continue to add new lessons and information downloadable from our website at http://kohalacenter.org/hi-meet as we integrate NGSS, HĀ, and ʻāina-based education principles and practices more thoroughly. Please email us your feedback to igrossman@kohalacenter.org.

WHY CONDUCT SCIENCE INVESTIGATIONS IN THE FIELD?

WHAT ARE FIELD INVESTIGATIONS?

From *Field Investigation Manual*

Field investigations involve the systematic collection of data for the purposes of scientific understanding. They are designed to answer a question through the collection of evidence and the communication of results; they contribute to scientific knowledge by describing natural systems, noting differences in habitats, and identifying environmental trends and issues.

Why conduct field investigations?

Field investigations help students become systems thinkers, provide opportunities to engage in science and engineering practices and understand that science does not only happen in a laboratory or classroom.

Outdoor experiences in natural settings increase students' problem solving abilities and motivation to learn in social studies, science, language arts and math. Outdoor experiences also provide students with place-based connections and engage students in relevant learning experiences. Outdoor, placed-based learning, as an instructional strategy, encompasses a range of techniques and approaches that build on students' interests and backgrounds so as to engage them more meaningfully and support them in sustained learning. These strategies have been shown to promote educational equity in learning science and engineering.

Field investigations help students become informed citizen scientists and engineers, contributing knowledge to their community's understanding of natural resources in order to make issues of concern visible and share differing points of view about the preservation and use of those resources.

PLACE-BASED EDUCATION

An enormous body of education research supports the benefits of place-based, culturally integrated, investigative education.

In a survey distributed to a sample of Hawai'i Island students, a substantial majority of students had never engaged in any scientific field research during their secondary school careers, and teachers surveyed agreed that they did not have the skills, resources, or time to sufficiently plan and execute field studies. Yet research about rural students and under-represented minorities—particularly those of Hawaiian and Pacific Island backgrounds—suggests they are best served and motivated by place-based, project-based, hands-on activities and challenging science instruction, especially when their investigations address real-world problems in culturally relevant terms.[1]

The findings are clear: place-based education fosters students' connection to place and creates vibrant partnerships between schools and communities. It boosts student achievement and improves environmental, social, and economic vitality. In short, place-based education helps students learn to take care of the world by understanding where they live and taking action in their own backyards and communities.[2]

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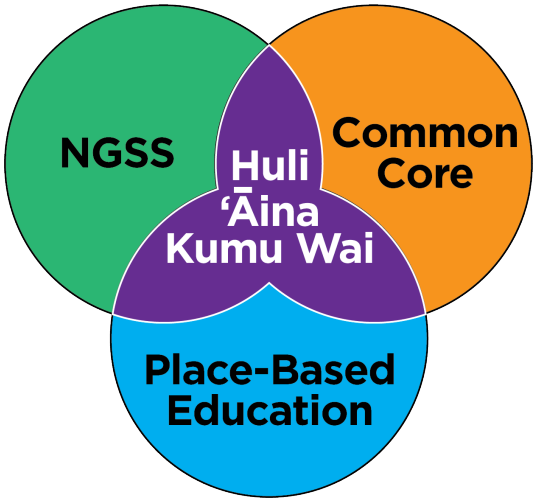
[1] Kawakami, A. J. "Issues Central to the Inclusion of Hawaiian Culture in K–12 Education," *Hūlili*, 2004, 1:111–132 Sharon Lynch, Equity and Science Education Reform (2000). Mahwah: Lawrence Erlbaum Associates; Roland Tharp & Ronald Gallimore, Rousing Minds to Life (1988). Cambridge: Cambridge University Press; Science in the Spotlight. Educational Leadership 2007, Volume 66, No. 4; Bronson, P. and Merryman, A., "The creativity crisis," Newsweek, July 19, 2010, 44–50.)

[2] *The Benefits of Place-Based Education: A Report from the Place-Based Education Evaluation Collaborative*. 2nd ed. Web. 2017. http://www.promiseofplace.org/Research_Evaluation/Display?id=105

PLANNING FOR A PLACE-BASED FIELD INVESTIGATION

"My biggest suggestion would be to seek help and make connections with nearby organizations. A teacher doesn't have to do everything independently. Once a connection is made with a nearby organizer or expert, it really becomes about facilitating an experience. Through facilitating experiences such as these the teacher will also learn to become more independent, if desired, in the future."
~ HI-MEET Teacher Participant



Teachers have several teaching and learning strategies to choose from when planning their field investigations. In a community-based field investigation, students and teachers identify and act on issues and concerns that affect their communities. A project-based field investigation uses an in-depth process over an extended period to investigate and respond to an engaging and complex question, problem, or challenge. Often students demonstrate their learning through the creation of a product that is presented or offered to people beyond the classroom. A culture-based field investigation draws on the students' and/or the community's own values, norms, knowledge, beliefs, practices, experiences, and language that are the foundation of a culture (often meaning indigenous culture) to design and employ culturally relevant frameworks to produce culturally-relevant research and knowledge rather than use one developed by outsiders. A place-based field investigation incorporates many of these methodologies as the community provides the context for learning, student work focuses on community needs and interests, and community members serve as resources and partners in the teaching and learning process. Learning is rooted in what is local—the unique history, environment, culture, and economy of a particular place.

The Kohala Center is working to build a framework for field investigations specific to Hawaiʻi and rooted in ʻāina, hence an **ʻāina-based (AB)** field investigation. This type of field investigation draws from the work in ʻāina-based learning which defines ʻāina as "the land, sea, and air—all that feeds and sustains us."[3] ʻĀina comes from a Hawaiian worldview and in this context is teacher, classroom, and a living laboratory for education.

The Kohala Center is still in its own planning and development phase of an AB field investigation framework. We offer the following for your planning, and we extend an open invitation for sharing the learning. We will continually update this manual to reflect all our learning about conducting culturally responsive, ʻāina-based field investigations.

[3] Ledward, Brandon C. 2013 ʻĀina-based learning is New Old Wisdom at Work, Hūlili Vol. 9
http://www.ksbe.edu/_assets/spi/hulili/hulili_vol_9/3_2013_Vol9_Ledward.pdf

LEARNING SCIENCE AND THE SCIENCE OF LEARNING

Teachers interested in instructional design will benefit from understanding and intentionally using the instructional model and embedded strategies supporting investigations in this guide. Supports include: 1) 5-E model, 2) science probes, and 3) place-based learning (see Planning section). A brief summary of 1) and 2) follows.

5-E model[4]

The 5-E instructional model provides a template or framework for designing instruction. The model is consistent with research on how people learn[5]. Each phase of the model serves a specific purpose. Used together, the model provides a pathway to learning important concepts, processes, and skills. As you review each investigation compare what the students are doing to the description of the phases below. In most cases, the connection will be clear. In some cases, teachers may choose to modify or adapt the specific activities to meet the needs of their students while keeping in mind the purpose of each phase.

PHASE	SUMMARY
Engagement	The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	Evaluation The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

There is an evolution in the ways to teach science, with a new model called the GRC (Gathering, Reasoning, Communicating—which has not been tested) that starts by focusing on a Phenomenon. See Appendices H and I for more details on 5E and GRC lesson templates and GRC lesson example.

The release of Next Generation Science Standards provides an opportunity to rethink science instruction and incorporate new understandings of how students learn. For example, a recent publication entitled *A Vision and Plan for Science Teaching and Learning*[6] foregrounds science and engineering practices organized around gathering,

[4] Bybee, R.W, Taylor, J.A., Gardner, A, et al. *The BSCS 5E Instructional Model: Origins and Effectiveness*. 2006. Web. 2017.
[5] Bransford, J., Pellegrino, J. W, and Donovan, S. *How People Learn: Bridging Research and Practice*. Washington, DC: National Academy Press, 1999. National Research Council. Print.
[6] Moulding, B., Bybee R., Paulson, N., Pruitt, S. (2015) A Vision and Plan for Science Teaching and Learning: An Educator's Guide to a Framework for K-12 Science Education, Next Generation Science Standards, and State Science Standards. Essential Teaching and Learning.

reasoning, and communicating (GRC) data and information. This framework emphasizes student performance expectations of phenomenon examined through the lenses of science and engineering practices, crosscutting concepts, and core ideas. While the GRC is a newer model aligned with standards, the 5E model has a long history of providing a solid scaffold for student learning and achievement. Both can be useful tools for teaching and learning.

Uncovering students' ideas in science

Have you ever wondered why, after teaching a great lesson or unit, students don't seem to get it? The science education community has been actively engaged in research and practice to better understand why this is. Terms like misconceptions, students' ideas, preconceptions and progress maps describe ways students think about science concepts and processes. This field of study helps to bridge the gap between what *teachers think and do* to what *students think and do*.

Teachers and now being asked to consider when and how they should be a *Guide on the Side* or a *Sage on the Stage* when interacting with students. Simply knowing science and engineering disciplinary ideas does not account for how students construct meaning. Increasingly, the *art of teaching* lies in how to foster learning environments in which students are intellectually engaged in a discipline. Teachers need to know and be able to ask questions that lead to deeper learning based on student thinking. If teachers are to understand how students process information and construct meaning this thinking must become visible. (Example: Where does the matter come from that makes up this wood? Answer: the air. There is a chemical reaction in which, through photosynthesis, CO_2 (a gas) + water (rain) + UV radiation (sunlight) turn into sugar, which makes up the wood.) (Example: What is the particulate nature of matter? As students master disciplinary knowledge they are also gaining facility with tools to conduct meaningful investigations.) It is expected that students will collect and have to make meaning of messy data and to learn from the experience. Hopefully this guide will provide a few guideposts to assist teachers in building and/or using these skills.

An excellent resource for teachers of science/engineering is available for gathering evidence and/or data on what students know (some of which are available through digital commons).[7] The resource is referred to as a probe. At a couple of points in this field guide you will notice reference to a probe. Each probe connects to a big idea in science. If you look closely, you will notice a probe deals with specific concepts in science like "what is a watershed,"[8] while another looks at the skill of connecting a claim with evidence and reasoning.[9] Probes are sometimes used at the beginning of lessons, but often they are a starting point for a unit or big idea that might last an entire unit or year. Teachers can use probes as a way to kick-start a new area of study or as evidence of student learning over time. Scores of science probes are now available through the National Science Teachers Association (NSTA). See references for more information.

[7] http://www.nsta.org/publications/press/uncovering.aspx

[8] Keeley, P., Tucker, L. (2016) Uncovering Student Ideas in Earth and Environmental Science: 32 New Formative Assessment Probes. NSTA Press. Retrieved from http://www.nsta.org/store/product_detail.aspx?id=10.2505/9781936137176

[9] https://teachscience4all.org/2012/11/21/claim-evidence-reasoning-tools-to-introduce-cer-in-pd-and-instruction

PROBE	DESCRIPTION	REFERENCE
What is a watershed?	The purpose of this assessment probe is to elicit students' ideas about watersheds. The probe is designed to find out what students think a watershed is.	Uncovering Student Ideas in Earth and Environmental Science: 32 New Formative Assessment Probes (see Appendix Q).
Is it a Claim?	A probe for uncovering student ideas about what constitutes a claim (also available for evidence and scientific explanations)	http://www.teachscience4all.org Based on Keeley Formative Assessment Probes

Evidence Probe
https://teachscience4all.files.wordpress.com/2012/11/is-it-evidence-fa-probe1.pdf

Claim Probe
https://teachscience4all.files.wordpress.com/2012/11/is-it-a-claim_-fa-probe.pdf

Is It an Explanation Probe
https://teachscience4all.files.wordpress.com/2012/11/is-it-a-science-explanation-fa-probe.pdf

NGSS AND FIELD INVESTIGATIONS

From Field Investigation Manual

The Three Dimensions of the Next Generation Science Standards (NGSS) (Next Generation Science Standards: For States, By States, 2013).

The Framework for K-12 Science Education and the Next Generation Science Standards are built on three integrated dimensions:

- Science and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas

Field investigations can provide opportunities for students to engage in all three of the dimensions of the Next Generation Science Standards. The specific components of each of the three dimensions are outlined in the table below.

SCIENCE AND ENGINEERING PRACTICES	CROSSCUTTING CONCEPTS	DISCIPLINARY CORE IDEAS
1. Ask questions (for science) and define problems (for engineering) 2. Develop and use models 3. Plan and carry out investigations 4. Analyze and interpret data 5. Use mathematics and computational thinking 6. Construct explanations (for science) and design solutions (for engineering) 7. Engage in argument from evidence 8. Obtain, evaluate, and communicate information	1. Patterns 2. Cause and effect 3. Scale, proportion, and quantity 4. Systems and system models 5. Energy and matter 6. Structure and function 7. Stability and change	**Physical sciences** • Matter • Force and Motion • Energy • Waves **Life sciences** • Structure and Processes • Ecosystems • Heredity • Evolution **Earth and space sciences** • Earth in the Universe • Earth Systems • Earth and Human Activity **Engineering, technology and applications of science**

Science and engineering practices

The Next Generation Science Standards encourage instruction that focuses students on solving problems and explaining phenomena – activities that characterize the pursuits of scientists and engineers. In field investigations students pose a question then plan and conduct an investigation to answer that question. Students use evidence to support explanations and build models, as well as to pose new questions about the environment. Students learn that the scientific method is not a simple linear process and, most importantly, experience the difficulty of answering essential questions such as:

- What defines my environment?
- What are all the parts and interrelationships in this ecosystem?
- What is a healthy environment?
- What is humans' relationship to the environment?
- How has human behavior influenced our environment?
- How can our community sustain our environment?
- What is my role in the use and preservation of environmental resources?

Crosscutting concepts
When planning and conducting field investigations, students and scientists grapple with the difficulties of working in a natural system while at the same time developing an understanding of its complexities and subsystems. In order to understand the system, students need to utilize the Crosscutting Concepts in concert with the associated Disciplinary Core Ideas.

The questions below provide some examples of how students and teachers might use the Crosscutting Concepts to make sense of their outdoor learning experiences.

- Patterns: What patterns do we notice in the system? What patterns do we notice in our data?
- Cause and Effect: What might be causing _____ to happen?
- Scale, Proportion, and Quantity: How many _____ are in this area? Are some organisms larger in one area than another? What parts of the system might be very small or unseen?
- Systems and Systems Models: What are the important parts of the system? How do the parts work together?
- Energy and Matter: Where are energy and matter flowing through this system?
- Structure and Function: How does the structure of _____ relate to its function?
- Stability and Change: What parts of the system are changing over time? What parts seem to stay the same?

FIELD INVESTIGATIONS VS. CONTROLLED LABORATORY EXPERIMENTS

CONTROLLED LAB EXPERIMENTS	FIELD INVESTIGATIONS
Variables are actively manipulated and controlled	Investigate descriptive, comparative or correlative trends in events
Hypothesis tested	Gather baseline data*
Variables can be more easily controlled	Take measurements in various locations
	Environment is difficult to control

** The lack of baseline data is a challenge in field ecology—try to find data sets related to your sites if possible:*

Hawai'i Watershed Atlas
http://hawaiiwatershedatlas.com

USGS data
https://www.usgs.gov/science/regions/pacific/hawaii?qt-states_l2_landing_page_tabs=2 - qt-states_l2_landing_page_tabs

THREE TYPES OF FIELD INVESTIGATIONS

From Field Investigation Manual

Are all field investigations the same?
No. For conceptual clarity, we have identified three types of field investigations: descriptive, comparative, and correlative.

DESCRIPTIVE FIELD INVESTIGATIONS	COMPARATIVE FIELD INVESTIGATIONS	CORRELATIVE FIELD INVESTIGATIONS
Involve describing and/ or quantifying parts of a natural system.	Involve collecting data on different populations/organisms, or under different conditions (e.g. times of year, locations), to make a comparison.	Involve measuring or observing two variables and searching for a relationship.

Each type of field investigation is guided by different types of investigative questions. Descriptive studies can lead to comparative studies, which can lead to correlative studies. The three types of field investigations are often used in combination to study the natural world.

A model for field investigation
The table below outlines the differences and similarities between the three types of field investigations and relates these to the essential features of inquiry.

Essential questions:
What defines my environment?
What is a healthy environment?
What is humans' relationship to the environment?
How can our community sustain/restore our environment?
What is my role in the preservation and use of environmental resources?

	DESCRIPTIVE	COMPARATIVE	CORRELATIVE
Formulate investigative question	• How many? • How frequently? • When did it happen?	• Is there a difference between groups, conditions, times, or locations? • Make a prediction or hypothesis about differences.	• Is there a relationship between two variables? • Make a hypothesis about the relationship.
Identify setting within a system	• Identify geographic scale of investigation (e.g., riparian corridor or Cedar River Watershed) • Identify time frame of the investigation (e.g., season, hour, day, month, year)		

<table>
<tr><td>Identify variables of interest</td><td>Choose measurable or observable variables</td><td>Choose a measured variable in at least two different (manipulated variable) locations, times, organisms, or populations</td><td>Choose two variables to be measured together and tested for a relationship</td></tr>
<tr><td rowspan="2">Carry out investigations</td><td colspan="3">• Multiple measurements over time or location in order to improve system representation (model)
• Individual measurement is repeated if necessary to improve data accuracy
• Record and organize data into table(s) or other forms</td></tr>
<tr><td colspan="3">Describe how sampling, measurement, observations were consistent of the two of more locations, times or organisms (controlled variables) and was random and representative of the site.</td></tr>
<tr><td rowspan="2">Analyze and interpret data</td><td colspan="3">• Means, medians, ranges, percentages, estimations calculated when appropriate.
• Organize results in graphic and/or written forms and maps using statistics where appropriate
• What patterns do we notice in the data?
• Might there be any cause and effect relationships here?</td></tr>
<tr><td colspan="2">Typical representations of the data to build descriptive and comparative models
• Charts
• Line Plots
• Bar Graphs
• Maps</td><td>Typical representations of the data to demonstrate correlations upon which models are developed
• Scatter plots
• r-values</td></tr>
<tr><td>Construct an evidence-based explanation or argument</td><td colspan="3">Makes a claim that answers the investigative question.
Use evidence from observations collected to support the claim.
• Does the claim answer the question?
• Does the evidence support the claim?
• Does the reasoning connect the evidence to the claim?
• Does the reasoning contain a science principle?</td></tr>
<tr><td>Discussion</td><td colspan="3">• What questions do I have about the data we collected?
• What questions do I have about the way we gathered the data?
• What other data or information might we need to collect or find?
• How does this data help us to understand the entire system?
• Did we identify any problems that might need to be solved?</td></tr>
</table>

PLANNING AND PROTOCOLS

PREPARING FOR LEARNING FROM ʻĀINA

"How do you behave at church, at a temple, at your Grandma's house?"

Posed to me while on a huakaʻi as an ʻōpio, I've often mulled over and even repeated this question as a relatable way to introduce behavioral protocol in the field to my students. Behavioral protocol is determined by place, our relationship to place, and our function in place. How do we engage safely and respectfully with the places of Hawaiʻi?

We can turn to the first people who walked this land for thousands of years, developing a behavioral protocol born of intimate interaction with this place, gifting us with their wisdom and understanding in mele, mele oli, moʻolelo, and hula."

Working closely in partnership with organizations who are defined as ʻāina-based is one way to start your own AB field investigation. Here is a short list to help you prepare well:

1. Clearly define why an AB investigation is important to you, your students, families, school, and community.
2. Identify ʻāina-based education organizations in your community who are ready to host and guide you in learning from the ʻāina they are taking care of (i.e. have kuleana for). Some examples for Hawaiʻi Island include (see Resources List in Appendix M for contact information):
    a. Cheyenne Perry, Mauna Kea Watershed Alliance
    b. Melanie Dudley, Puʻu Waʻawaʻa
    c. Lehua Alapai, Kaʻūpūlehu Dryland Forest
    d. Bryce Masuda, ʻAlalā Bird Sanctuary (Keauhou Bird Conservation Center Discovery Forest)
    e. Franny Brewer, Big Island Invasive Species Advisory Committee
    f. Kathleen Clark, Kahaluʻu Bay Education Center
    g. Rebecca Most, The Nature Conservancy, Kīholo Bay
    h. Lea Kaʻahaʻāina, ʻImi Pono no ka ʻĀina, Three Mountain Alliance
3. Invite potential AB sites to meet with you and identify shared purposes for engaging with ʻāina.
4. Secure a site and co-design an AB field investigation plan that connects and creates a meaningful relationship between school, ʻāina, and AB organization.
5. Visit each other's "classrooms" to get to know each other better.
6. Clarify proper protocols and other preparations specific to this site in advance of the visit (e.g. safety, behavioral, invitation, orientation, opening and closing, and gifting).
7. Prepare yourself and students for being good guests.
8. Strengthen the learning by sharing your stories with others who can benefit from your experiences.

ASSESSING FOR LEARNING FROM ʻĀINA

The Hawaiʻi Board of Education Policy E-3: Nā Hopena Aʻo (HĀ) sets the intention of our educational system on strengthening six outcomes: Belonging, Responsibility, Excellence, Aloha, Total Well-being, and Hawaiʻi (BREATH). These outcomes grounded in the values, language, culture and history of Hawaiʻi offer a relevant model for the development of an AB field investigation framework (see Appendix K).

The HĀ outcomes provide a culturally specific driver for creating optimal learning conditions for all students. Currently the Office of Hawaiian Education is developing a HĀ Assessment Framework that holds indicators of both successful learning contexts and successful content learning. In this way, Hawaiʻi can be a model for other communities to consider their own cultural contexts as places of strength for creating more than one educational pathway of learning.

For *Huli ʻĀina Kumu Wai*, ʻāina is the learning context for designing AB field investigations to strengthen HĀ outcomes. In this way, AB field investigations become transformative experiences for all participants including the ʻāina.

The HĀ Assessment Framework development process is still underway. Once completed, The Kohala Center will work with the Office of Hawaiian Education and design to a set of HĀ conditions for creating optimal learning environments. In this way, *Huli ʻĀina Kumu Wai* can become an AB field investigation practice that advances both content and context learning. See Appendix K to access more resources on HĀ.

ʻĀina-based (AB) investigations in Hawaiʻi require comprehensive planning and the establishment of appropriate protocols in order to engage respectfully and safely with the ʻāina. The following table is meant to be a quick guide to planning ʻāina-based investigations with secondary students.

PLANNING FOR CONDUCTING FIELD INVESTIGATIONS WITH SECONDARY STUDENTS IN HAWAIʻI

Before conducting the field investigation

PLANNING STEPS/PROTOCOLS	THINGS TO CONSIDER
Brainstorm and establish your big picture idea for the AB investigation	1. Who will be conducting the AB investigation? 2. What is the purpose of the AB investigation? Field science research can be controversial. Make sure that your investigation is alignment with community values and needs. 3. Where is it appropriate to conduct the AB investigation? Consider having field experiences on or near campus to keep things simple (i.e., school garden, school yard, neighboring land). Are there field trip sites you can walk to? Choose a site within your ahupuaʻa/watershed if you are able to get off campus. 4. When will you conduct the AB investigation? 5. Why is the AB investigation important to your community? 6. How do you need to prepare yourself and others to carry out the AB investigation?
Seek out school support	1. Do you have support from your school's administration? If not, how will you secure support? 2. Who else can you involve? *Enlist volunteers such as parents, other teachers, and specialists in your research field of interest.* a. It's a great idea to have a teacher partner at school with you. b. Work with an organization as a partner that can assist you to coordinate the field experience and provide technical knowledge.
Seek out community partnerships (See Appendix M – Field Investigation Resource Contacts for Field Trips and Presenters)	1. Investigate your area for environmental/cultural organizations, nonprofits, etc. that can assist you with your investigation. 2. Get to know the opportunities available in your area: network, connect with new organizations to partner with in the future, know where to go that people can assist you. 3. Find organizations that have their own programs they can bring into the classroom and on a field trip so it's less work for you. You should also help with planning to make sure the project fits into your curriculum/standards. 4. Find educators who come into the classroom to prepare students for field trips and provide background information. 5. Sign up for programs that can assist you with access to local resources and support. 6. Create a list of resource people and places to go that are a good fit for your school. These relationships can then be developed for future years of working together on research projects. 7. Go to places where there is an expert who can meet you and teach the students. 8. Seek out opportunities for citizen science participation so students can participate in authentic, real world learning experiences. 9. There are so many resources out there: do some research. If you don't find curriculum and lesson plans, there are always people out there who can help. If you don't know what you're doing initially, not a problem! (See Resources list)

	10. It can be a valuable experience to go to a far-away place, but staying in your school neighborhood is equally and even more valuable to connect students to their place. 11. Make sure you and your students are prepared and that parents know what they have to bring. Make sure students understand that they won't be allowed on field trips without proper clothes. Help students obtain supplies that they need – not all students have hiking shoes or tabis, nor can their families afford them – this can include sack lunches and backpacks. 12. Service learning: consider finding projects that incorporate service learning to provide students with other types of experiences that contribute to community well-being (e.g., not just the same weeding work you've been doing). 13. Go on field trips with other classes to share from each other's experiences and skills. For example, one teacher doesn't have experience with ocean studies, so would partner with someone who could provide that education to her students.
Safety protocol (See Appendix N – Field Trip Safety for more details)	1. Visit the site first to be sure it is accessible and safe for a student group visit. 2. Create a Safety Plan for each trip that includes pre-excursion orientation and activities, on-site orientation and activities, post-excursion documentation and activities, safety assessments of sites and activities, emergency readiness and accessibility, potential hazards and areas of caution, staff and student packing lists, and tools to be used and their purposes. 3. Create an Emergency Operations Procedure that includes site location and directions, primary points of contact, order of incident notifications, contact names and phone numbers, site map(s), potential environmental hazards, potential risks to participants, driving/terrain requirements, emergency assistance contacts and locations, phone reception, safety protocols and procedures, required documents, process for handling injuries, nearest emergency room, and guidelines for evacuation. 4. Consider having a Safety and First Aid workshop for students so everyone is prepared for fieldwork. Clarify what this would entail. 5. Have emergency contact information ready. 6. Bring a first aid kit. 7. Have a bad weather backup plan and meeting site designated. 8. Bring cell phones and make sure all staff/chaperones have each other's cell phone numbers. Make sure cell phones work at site: reception varies especially in forest locations 9. Make sure everyone can get to a safe place in case of an emergency. • Know flash flood dangers in streams • Know where the nearest ER services are (e.g., fire department) • Have a plan for injury with chaperones – bring at least one walking stick in case someone turns their ankle and make sure first aid kit is adequate – often lacking ice packs, etc. • Have a plan in place in case an adult gets injured • Require that students with bee sting allergies bring EpiPen and know how to administer and that students with asthma bring meds and inform teacher.

Behavioral protocol "How do you behave at church, at a temple, at your Grandma's house?"	*Hawaiian Cultural Values for Engaging with 'Āina* • **Aloha 'āina** – "I am this land and this land is me." In just a handful of words, Aunty Pua Kanahele captures the depth of this value. • **Kuleana** – Responsibility. As users of our natural resources, we have a responsibility to care for our natural resources. • **Mālama** – "Mālama ke kanaka i ka 'āina, mālama ka 'āina i ke kanaka." Man takes care of the land, and the land takes care of man. Reciprocation. What does this look like? • **Maka'ala** – "Eh, pay-tention!" Deep awareness of 'āina is achieved through simply paying attention using all of our senses. Deep awareness has a practical application too: safety! • **Mahalo** – Gratitude. These are just a handful of examples of easily accessible behavioral protocols available to us today. Schools already have behavioral protocols, often emphasized in the form of signs and posters posted throughout the school displaying values and expectations. You may want to consider the following questions while developing a protocol suitable for your class or group: • Are the behavioral protocols in your school space transferable to the field? Are they complete? • It is important to work on developing behavioral expectations for students to ensure safe and respectful engagement with 'āina. • Practice these and have a set signal for quiet/attention…huddle up…also don't talk too long outside – that's not why you bring kids to a site! • Another one: "watcheachudda" – for watch out for each other

Entry protocol There are many ancient and modern chants that we can draw from to use as a part of our entry protocols to natural spaces. If you feel comfortable, teach your students an appropriate entry chant. If you don't feel comfortable, invite someone in your community to teach your students an appropriate entry chant. If neither works for you, come up with a protocol that does work for you. Is it two minutes of silence? Guided meditation? Reading of a poem? What protocol will get you and your class ready to respectfully and safely interact with place?	1. Acknowledge that you are entering into someone else's home. Ask for 'ike—deep experiential knowledge from place 2. Greet the "people" of the place 3. Ask permission to enter 4. Prepare oneself mentally, physically, and spiritually to enter natural space. • Examples: a. *Noho Ana Ke Akua i Ka Nāhelehele* https://www.youtube.com/watch?v=kIhYrozzHRY b. *E Ho Mai* https://www.youtube.com/watch?v=32vcntOp0i4 c. Two minutes of silence
Reciprocation protocol "Mālama ke kanaka i ka 'āina, mālama ka 'āina i ke kanaka." Man takes care of the land, and the land takes care of man. Reciprocation. What does this look like?	• Reciprocation should be constant. Maintaining appropriate behavior in place is a form of reciprocation. • Mahalo place and even organizations you visit through a mele oli mahalo during or at the end of the day. – *Example:* Mele Oli Mahalo • "Huli ka lima i lalo." Turn the hands down. Consider giving back to your place of research and learning through service learning.
Logistics	1. *Transportation:* Ideally your school has its own buses or vans that can be used to make field trips easier to plan. Rentals need to be budgeted for and scheduled at least two weeks in advance. 2. Be clear about behavior on the bus and introduce your bus driver. 3. *Permission Slips, Consent, and Emergency Forms:* Permission slips need to be created and handed out at least two weeks prior to the field trip to ensure they are returned on time. 4. *Attire:* Reminders to students about proper attire and what to bring: lunch, water, sunscreen, rain gear, sneakers, hat, and bug repellent. You may suggest that students wear a red or school shirt (for example) so they can be seen easily on the field trip. 5. *Group Sizes, Rotations, and Scheduling:* The smaller the groups the better, and the more adult leaders (coworkers, school partners, parents, etc.) you can recruit to assist will help the students get the most out of the experience. A maximum of ten students per leader is ideal if you can garner teaching helpers. One teacher had former students come back to help with the end-of-the-year overnight field trip. Smaller groups can incur less damage to the environment while certain locations may limit visitors to small groups. 6. Train adults in advance with a checklist of do's and don'ts and a meeting 30 minutes early to review—adults can be a problem vs. a help—be clear about adult expectations! 7. Get students in groups before a field trip—even if it's for a five-minute ice-breaker activity a. *Groups:* Pre-assign student groups and van groups to assure the best working teams.

	b. *Rotations:* 30–45 minutes at least for each activity depending on the age group and subject matter. Allow 5–10 minutes for travel and gear set up between each rotation. For snorkeling, 75 minutes per snorkel group is ideal so they can complete data sheets, compile, and analyze data in the field. c. *Schedule:* Create a schedule for the field trip so each leader knows when to rotate and how much time for each session but be flexible and have a Plan B if things go longer or faster than anticipated.
Program evaluation	• Consider adding affective student reflections and pair share activities • Student focus groups or interviews • Post-field trip meeting with participating teachers and adults (what went well, what can we do better next time)
Standards alignment	See *"Worksheet to Align Standards with Lessons"*
Student reflection ideas	1. Circle up and everyone share one word describing their experience 2. Nā Hopena Aʻo – B.R.E.A.T.H – Have students reflect on which aspect they connected to the most after a field experience • **B**elonging – how am I connected to this place? • **R**esponsibility – what is my kuleana today? To this place? • **E**xcellence – how did I do my best today? – data collection, measurement, behavior, etc. • **A**loha – How can I show aloha to the people working with me today? To this place/these plants and animals? • **T**otal Well-being – How did I feel about being outside in this place today? • Sense of **H**awaiʻi – how is this place special? What moʻolelo did I learn about this place today?

Field trip checklists may be helpful for your planning: see Appendix O for an example.

ALIGNING FIELD STUDIES TO STANDARDS WORKSHEET

Teacher Worksheet for Unit Planning

Please use this document and links to align your field science unit with the NGSS, Common Core, HCPS standards, Hawaiian cultural standards, your learning targets, and assessment strategies.

UNIT COMPONENT (resource)	MY PLAN
Hawai'i Content and Performance Standards http://standardstoolkit.k12.hi.us/common-core	
Next Generation Science Standards http://www.nextgenscience.org/	
Common Core literacy skills 6–8: http://www.corestandards.org/ELA-Literacy/RST/6-8/ 9–10: http://www.corestandards.org/ELA-Literacy/RST/9-10/ 11–12: http://www.corestandards.org/ELA-Literacy/RST/11-12/ Common Core Standards are already cross-referenced in NGSS	
Common Core writing skills 6–8: http://www.corestandards.org/ELA-Literacy/WHST/6-8/ 9–10: http://www.corestandards.org/ELA-Literacy/WHST/9-10/ 11–12: http://www.corestandards.org/ELA-Literacy/WHST/11-12/	
Common Core math standards http://www.corestandards.org/MathHigh School Statistics and Probability: http://www.corestandards.org/Math/Content/HSS/ID	
Nā Hopena A'o (HĀ) **Hawaiian Cultural Framework** ***Statements:*** http://www.hawaiipublicschools.org/TeachingAndLearning/StudentLearning/HawaiianEducation/Pages/HA.aspx	
Examples of research questions See "What Types of Questions Can We Investigate?" lesson	
Student learning objectives Start with your essential question and "what do I want students to know and be able to do" and "I can" statements for middle school.	
Student learning outcomes **(Performance expectation)**	
Essential vocabulary	

Reading material Use these tools to determine the reading level of the material you are presenting to your students. https://readability-score.com/text https://lexile.com/educators/tools-to-support-reading-at-school/tools-to-determine-a-books-complexity/the-lexile-analyzer/ https://www.choosito.com/search/web Use this search engine to level readings and weed out junk: https://readable.io	
Formative assessments ***Prior knowledge:*** Uncovering Student Ideas in Science https://www.nsta.org/store/product_detail.aspx?id=10.2505/9781938946479 ***Ongoing assessment:*** MS NGSS Evidence Statements http://www.nextgenscience.org/evidence-statements HS NGSS Evidence Statements http://www.nextgenscience.org/evidence-statements	
Summative assessments/products Final Project or Report or Presentation: NGSS Sample Assessment Tasks http://www.nextgenscience.org/classroom-sample-assessment-tasks	
Field work notes	
Rubrics Field Investigation Evaluation Rubric: https://docs.google.com/document/d/1zsnrr1LLGRVCOmYF3jB0FY7Ky7b0opqYhDeOwOM0hR8/edit	

Another option is to use the Wiggins and McTighe planning model:
http://www.ascd.org/ASCD/pdf/siteASCD/publications/UbD_WhitePaper0312.pdf

Start with your essential question then "what do I want students to know and be able to do" and "I can" statements for middle school.

SAMPLE WORKSHEET TO ALIGN FIELD STUDIES TO STANDARDS

Teacher Worksheet for Unit Planning
Example from Tina Benson

Please use this document and links to align your field science unit with the NGSS, Common Core, HCPS standards, Hawaiian cultural standards, your learning targets, and assessment strategies.

UNIT COMPONENT (resource)	MY PLAN
Hawaii Content and Performance Standards http://standardstoolkit.k12.hi.us/common-core/	None
Next Generation Science Standards http://www.nextgenscience.org	MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. LS2.A**:** Interdependent Relationships in Ecosystems • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • http://www.nap.edu/openbook.php?record_id=13165&page=150 • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.
Common Core literacy skills 6–8: http://www.corestandards.org/ELA-Literacy/RST/6-8/ 9–10: http://www.corestandards.org/ELA-Literacy/RST/9-10/ 11–12: http://www.corestandards.org/ELA-Literacy/RST/11-12/	CCSS.ELA-LITERACY.RST.6-8.10 By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently. CCSS.ELA-LITERACY.RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
Common Core math standards http://www.corestandards.org/Math/ *High School Statistics and Probability:* http://www.corestandards.org/Math/Content/HSS/ID	

Nā Hopena Aʻo (HĀ) **Hawaiian Cultural Framework** http://www.hawaiipublicschools.org/TeachingAndLearning/StudentLearning/HawaiianEducation/Pages/HA.aspx ***Statements:*** http://www.hawaiipublicschools.org/DOEForms/NaHopenaAoE3.pdf	***Example*** *Sense of Responsibility:* What can I do to help prevent the spread of mosquito-borne illnesses?
Examples of research questions	Why are mosquitoes the best-known disease vector? What vector-borne diseases are present in Hawaiʻi? How are they spread? How can they be avoided?
Student learning objectives **("I can" statements)**	• Students can identify vector-borne diseases that are present or will be present in Hawaiʻi. • Students can explain the life cycle of mosquitoes. • Students can identify species of mosquitoes by their characteristics • Students will be able to use techniques for collecting mosquitoes • Students can collect and display data on mosquito species
Essential vocabulary	• Vector • Larva/larvae (wriggler) • Pupa (tumbler) • Scientific name • Molt • Siphon • Emerge
Reading material Use these tools to determine the reading level of the material you are presenting to your students. https://readability-score.com/text https://lexile.com/educators/tools-to-support-reading-at-school/tools-to-determine-a-books-complexity/the-lexile-analyzer/ https://www.choosito.com/search/web	http://www.mosquito.org/life-cycle http://www.webmd.com/a-to-z-guides/zika-virus-symptoms-prevention http://www.hawaiiguardohana.org/resources/mosquitoflyer.pdf http://mauiinvasive.org/2016/03/18/no-mosquitoes-in-hawaii/ https://www.cdc.gov/zika/pdfs/control_mosquitoes_chikv_denv_zika.pdf
Formative assessments ***Prior knowledge:*** Uncovering Student Ideas in Science https://www.nsta.org/store/product_detail.aspx?id=10.2505/9781938946479 ***Ongoing assessment:*** MS NGSS Evidence Statements http://www.nextgenscience.org/evidence-statements HS NGSS Evidence Statements http://www.nextgenscience.org/evidence-statements	Keeley, P., Eberle, F., and Dorsey, C. "Does it Have a Life Cycle?" p. 111. *Uncovering Student Ideas in Science*, Vol. 3. NSTA Press, 2008.

Summative assessments/products Final Project or Report or Presentation NGSS Sample Assessment Tasks http://www.nextgenscience.org/classroom-sample-assessment-tasks	• Research Report • Public Service Announcement
Field work notes	Waipiʻo, Rainbow Falls, Keawewai Gulch, Botanical Gardens
Rubrics Field Investigation Evaluation Rubric	Field Investigation Evaluation Rubric https://docs.google.com/document/d/1zsnrr1LLGRVCOmYF3jB0FY7Ky7b0opqYhDeOwOM0hR8/edit Research Report Rubric https://docs.google.com/document/d/1bL9PvT7Y6tUXTgsuL9njLPL0DWW2HsI7o1ijcoqCPho/edit Public Service Announcement Rubric http://www.readwritethink.org/files/resources/lesson_images/lesson939/psa-rubric.pdf

PREPARING STUDENTS FOR FIELD RESEARCH: FIELD SCIENCE METHODS

SAMPLING TECHNIQUES

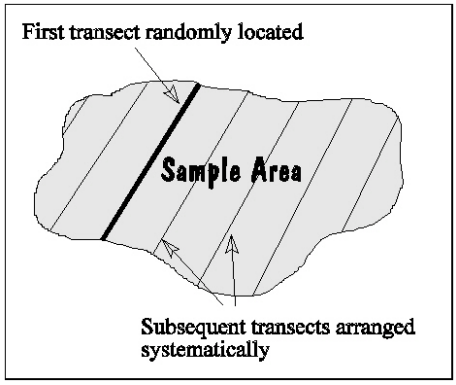
SAMPLING TECHNIQUES

How, where, and why scientists do sampling

Scientists often collect data "in the field," which could mean underwater, in a forest, in a cave, on a reef, or even the moon! Two essential methods to gather ecological information in a standardized way are: **Transect sampling** (using a single line) and **Quadrat sampling** (counted within a grid). These sampling methods provide more accurate data than random sampling or simply guessing, but they take less time than counting every specimen in a certain area. Sampling helps us estimate and compare!

A. Transect Sampling (High School)

A transect is simply a line we stretch over a study area. The line needs regular measurements marked off, like a tape measure. It is held straight and stationary.



advancedscienceresearchmethods.blogspot.com

B. Quadrat Sampling

The usual sampling unit is a quadrat. Quadrats normally consist of a square frame, the most frequently used size being one square meter. The purpose of using a quadrat is to enable comparable samples to be obtained from areas of consistent size and shape. Rectangular quadrats and even circular quadrats have been used in many surveys. It does not really matter what shape of quadrat is used, provided it is a standard sampling unit and its shape and measurements are stated in any report.

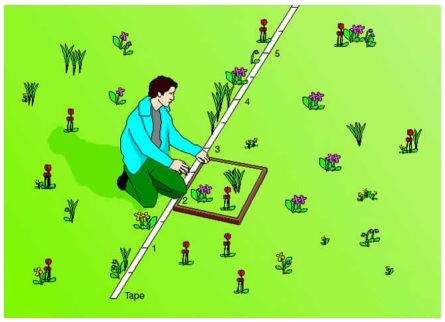
Choice of quadrat size depends to a large extent on the type of survey being conducted. For instance, it would be difficult to gain any meaningful results using a .5 m^2 quadrat study of a woodland canopy. The pattern of distribution of species should also be considered when deciding on quadrat size, because different results will be obtained using different quadrat sizes, depending on whether individuals are regularly distributed, randomly distributed, or clustered together in patches. (It may be difficult to decide if there is a pattern of distribution.)

Vocabulary

- *Transect Sampling* – counted on points of a single line
- *Quadrat Sampling* – counted on points of a grid or within the quadrat area
- *Transect Point* – measured distance on a transect line
- *Reliable* – yielding the same results in different experiments or studies
- *Intercept Point or Point Intercept* – where two lines of a quadrat cross
- *Percent Cover* – portion of a total area one species covers at a specific site
- *Error* – Statistical error is caused by random (unpredictable or unintentional) variation in making a measurement, whereas systematic error is caused by an unknown. If the cause of the systematic error can be identified, then it can usually be eliminated. Such errors can also be referred to as uncertainties.
- *Bias* – a personal preference that causes unfair judgment. In science, a sampling error caused by systematically favoring some outcomes over others.
- *Randomization* – the making of random arrangement in order to control the variable

C. Random or Systematic Sampling

Random



Random sampling is usually carried out when the area under study is very large, or there is limited time available. When using random sampling techniques, large numbers of samples/records are taken from different positions within the habitat. A quadrat frame is most often used for this type of sampling. The frame is placed on the ground (or on whatever is being investigated) and the animals and/or plants inside it counted, measured, or collected, depending on what the survey is for. This is done many times at different points within the habitat to give a large number of different samples.

In the simplest form of random sampling, the quadrat is thrown to fall at "random" within the site. However, this is usually unsatisfactory because a personal element enters into the throwing and it is rarely completely random. True randomness is an important element in ecology because statistics are widely used to process the results of sampling. Many of the common statistical techniques used are only valid on data that is truly randomly collected. It must also be noted that this technique would only be possible if quadrats of small size were being used. It would be impossible to throw anything larger than a 1 m^2 quadrat and even this might pose problems.

Systematic

Systematic sampling is when samples are taken at fixed intervals, usually along a line. This normally involves doing transects.

D. Line Transect Method

A transect line can be made using a nylon rope marked and numbered at .5 m or 1 m intervals all the way along its length. This is laid across the area you wish to study. The position the transect line is very important and depends on a multitude of factors including the boundaries of the environment you are testing, the subject you are studying, and your time frame!

A line transect is carried out by unrolling the transect line along the gradient identified. The species touching the line may be recorded along the whole length of the line (continuous sampling). Alternatively, the presence, or absence of species at each marked point is recorded (systematic sampling). If the slope, soil type, etc. along the transect line is measured as well, the results can then be inserted onto this profile.

E. Belt Transect Method

This is similar to the line transect method but gives information on abundance as well as presence or absence of species. It may be considered as a widening of the line transect to form a continuous belt or series of quadrats.

In this method, the transect line is laid out across the area to be surveyed and a quadrat is placed on the first marked point on the line. The plants and/or animals inside the quadrat are then identified and their abundance estimated. Animals can be counted (if they will sit still!) or collected, while it is usual to estimate the percentage cover of plant species. Cover is the area of the quadrat occupied by the above-ground parts of a species when viewed from above. The canopies of the plants inside the quadrat will often overlap each other, so the total percentage cover of plants in a single quadrat will frequently add up to more than 100%.

Quadrats are sampled all the way down the transect line at each marked point on the line or at some other predetermined interval (or even randomly) if time is short. It is important that the same person should do the estimations of cover in each quadrat because the estimation is likely to vary from person to person. If different people estimate percentage cover in different quadrats, then an element of personal variation is introduced that will lead to less accurate results. The height of plants in the quadrat can be recorded, and the biomass of plants can also be measured, by harvesting all the plants inside the quadrat and then weighing either fresh or dry weight in the

laboratory. This is obviously a very destructive method of sampling that could not be used too often in the same place. Sampling should always be as least destructive as possible and you should try not to trample an area too much when carrying out your survey.

Name: _____ Date: _____

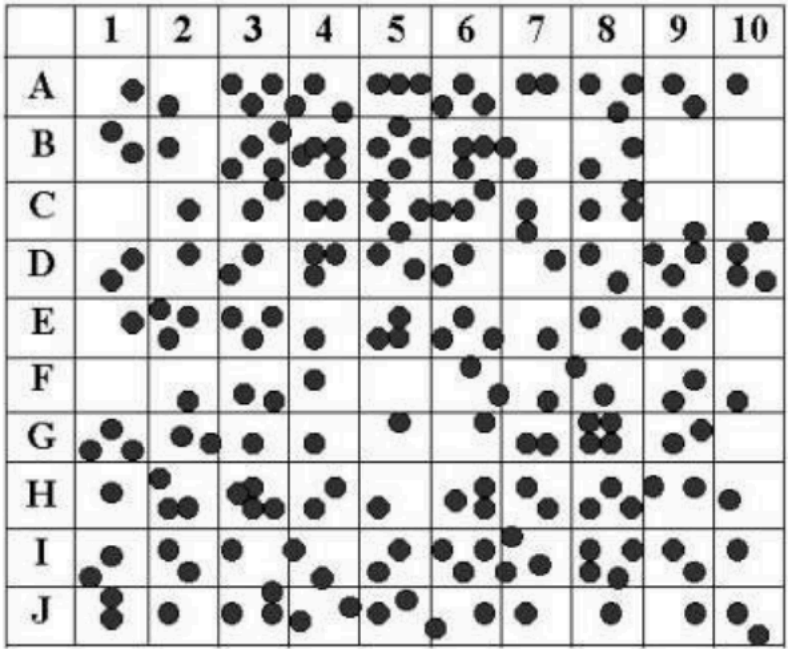
F. Quadrat Random Sampling Activity

Scientists cannot possibly count every organism in a population. One way to estimate the size of a population is to collect data by taking random samples. In this activity you will look at how data obtained from random sampling compare with data obtained by an actual count.

Procedure

1. Tear a sheet of paper into 20 slips, each approximately 4 cm x 4 cm.
2. Number 10 of the slips from 1 to 10 and put them in a small container.
3. Label the remaining 10 slips from A through J and put them in a second container.

   The grid shown below represents a field measuring 10 m on each side. Each grid segment is 1 m x 1 m. Each black circle represents one ʻilima plant.



4. Randomly remove one slip from each container. Write down the number-letter combination and find the grid segment that matches the combination. Count the number of ʻilima plants in that grid segment. Record this number on the data table. Return each slip to its appropriate container.
5. Repeat step 4 until you have data for 10 different grid segments (and the table is filled out). These 10 grid segments represent a sample. Gathering data from a randomly selected sample of a larger area is called sampling!
6. Find the total number of ʻilima plants for the 10-segment sample. This is an estimation based on a formula. Add all of the grid segment ʻilima together and divide by ten to get an average number of ʻilima plants per grid segment. Record this number in the table. Multiply the average number of ʻilima plants by 100 (this is the total number of grid segments in your sample area) to find the total number of plants in the field based on your sample. Record this number in your data table.
7. Now count all the ʻilima plants actually shown in the field. Record this number in the data table. Divide this figure by 100 to calculate the average number of ʻilima plants per each grid.

RANDOM SAMPLING DATA		ACTUAL DATA
Grid segment (number-letter)	**Number of ‘ilima**	**Total number of ‘ilima** **_____ (count by hand)** **Average number of ‘ilima (divide total by 10)** **Per grid _____**
Total number of ‘ilima		
Average per grid (divide total by 10)		
Total number of plants in field (multiply average by 100)		

Analysis

1. Compare the total number you got for ‘ilima from the sampling to the actual count. How close are they?

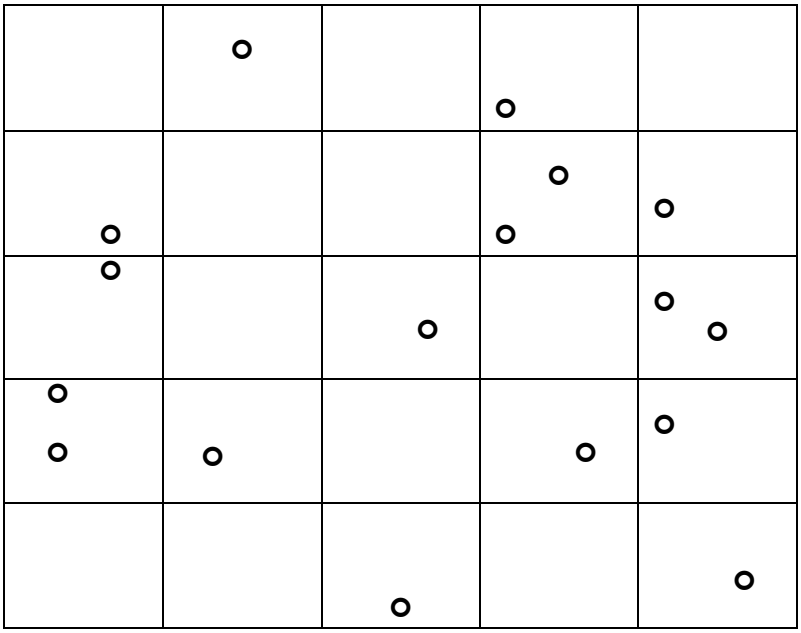
2. Why was the paper-slip method used to select the grid segments?

3. Why do biologists use sampling? Why can’t they just go into the forest and count all the ‘ilima plants?

4. Population sampling is usually more effective when the population has an even dispersion pattern. It is least effective when clumped dispersion patters are present. Explain why this would be the case.

5. Describe how you would use sampling to determine the population of dandelions in a yard.

6. In a forest that measures 5 m x 5 m, a sample was taken to count the number of ʻōlapa trees in the forest. The number of trees counted in the grid is shown below. The grids where the survey was taken were chosen randomly. Determine how many ʻōlapa trees are in this forest using the random sampling technique. Show your work! See example below.



Name: _____ Date: _____

G. Quadrat Method of Population Sampling

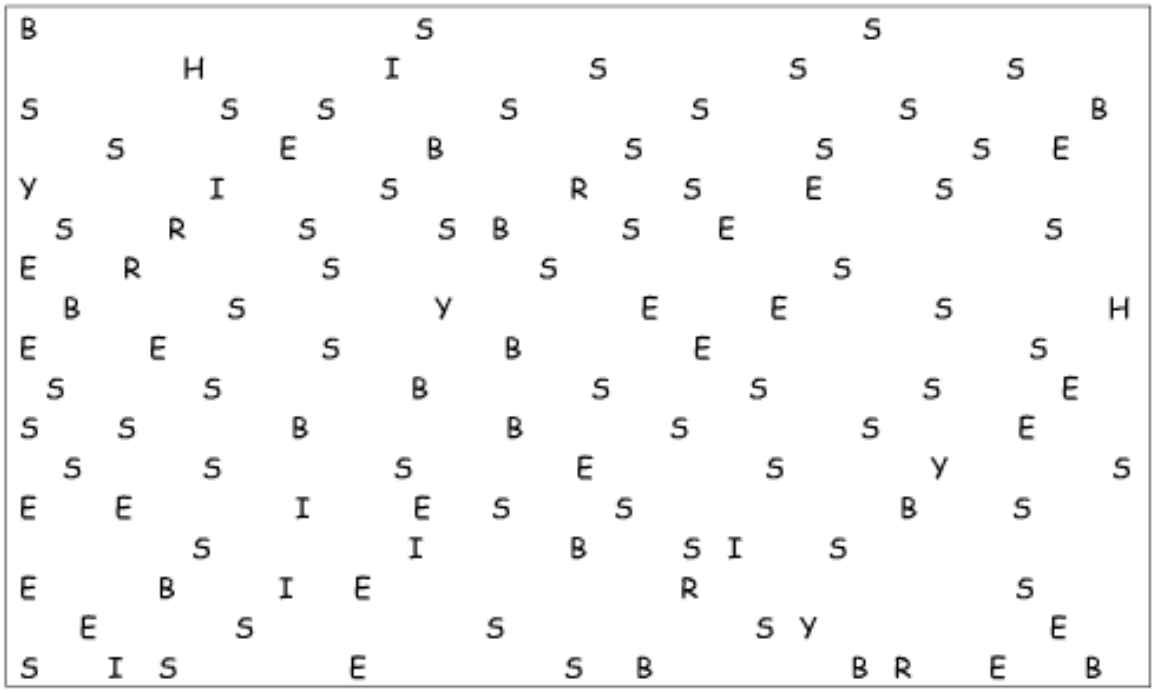
One of the most widely used of all sampling methods is the area sample. This is ordinarily a square area of predetermined size called a quadrat. In each quadrat, the number of organisms of a certain type is recorded in a data table. The estimated population of each species in a much larger area may be determined through extrapolation and random sampling.

- The population density of a species is the total number counted divided by the areas.
- The relative density is the percentage of each species out of the total number of organisms found in an area.

Procedure

1. Using the forest quadrat below, count the number of each species of tree found in the forest quadrat and record the values in the data table. **Change the key to Hawaiian forest species in your area: ʻōhiʻa lehua, koa, alaheʻe, mamaki, manono, kopiko, ʻōlapa, etc.**

0.5 acre Forest Quadrat



2. Calculate the density of each tree species per acre.
3. Determine the relative density of each species expressed as a percentage.

Table 1. Species of trees (names and symbols) located in sample area.

SPECIES OF TREE	SYMBOL	SPECIES OF TREE	SYMBOL
ʻŌhiʻa Lehua	B	Kōlea	E
Koa	H	Hāpuʻu Pulu	S
ʻŌlapa	I	Mamaki	Y
Kopiko	R		

Table 2. Total quantity, population density, and relative density of each tree species found in sample area.

	B	H	I	R	E	S	Y	TOTAL
# in .5-acre quadrat								
Population Density (trees/acre)								
Relative Density (% of total)								

Analysis

1. Create a pie graph representing the relative density of each tree species.

2. How does this sampling method indicate the plant diversity in a community?

3. If you were doing this in the real world, what are some possible sources of error?

4. If you needed to find the population density of each species of tree in a 100,000-acre forest, how would you do it? What could you do to make it more accurate?

5. Would this sampling technique work well for estimating the number of feral pigs on the Kohala Mountain? Why or why not? What other method might be used?

Name: _____ Date: _____

H. M&M's® Sampling Lesson

Problem: How can we determine the abundance of each color of M&M's in the bag?

1. Can we count all individuals of a given species at a site? Why or why not?

2. What does the term "sampling" mean to you?

3. How many "species" of M&M's are there in this bag? Create a hypothesis of how abundant each species is!

STOP: Pass out the elusive M&M's species!

4. What can you tell me about the whole bag of M&M's based on your sample? Record your totals and % in the table below.

	RED	ORANGE	YELLOW	GREEN	BLUE	BROWN	TOTAL
Total #							
%							

5. Create a bar (column) graph of the abundance (%) of each of your species found in your sample.

6. Together we will record everyone's sample on the table below and find their percentages.

	RED	ORANGE	YELLOW	GREEN	BLUE	BROWN	TOTAL
Total #							
%							

7. Create a bar (column) graph of the abundance (%) of each of your species found in the class' samples.

8. How representative was your sample of the overall percentages?

9. Could any errors have occurred in our sampling? List potential errors that could have occurred (whether they did or did not).

10. Bias can occur in science. Bias is the prejudice for or against something. Was there any bias in our experimental protocol?

11. Give an example of an experiment that could be done in a similar way using samples. Explain the question, the experiment and why sampling is best.

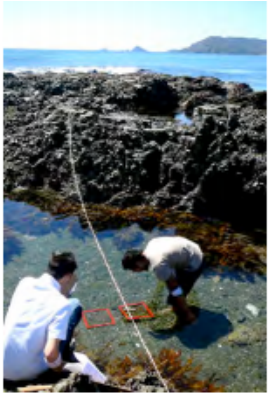
12. In a paragraph summarize what you learned from this activity and how it might be useful in the determination of species abundance in the field.

EAT YOUR M&M's!

I. Quadrat and Transect Activities (Middle School Intro and Lessons)

How, where, and why we do sampling

We often collect data "in the field," which could mean underwater, in a forest, in a cave, on a reef, or even the moon! Two essential methods to gather ecological information in a standardized way are: Transect Sampling (using a single line) and Quadrat Sampling (counted within a grid). These sampling methods provide more accurate data than random sampling or simply guessing, but they take less time than counting every specimen in a certain area. Sampling helps us estimate and compare!



What is a transect?

A transect is simply a line (could be a tangible line or not) we stretch over an area we want to study. The line must have regular measurements marked off, like a tape measure, and is held straight and stationary.

Practice with a transect

1. As a group we will determine the best place to lay our transect lines. In the interest of time we will use the following categories for this activity. The last one is a category of your choosing.

G = grass R = rock D = bare dirt

L = leaf matter O = other vegetation = your choice

Experimental question: What is the main ground cover at Ulu Lāʻau?

Procedure: Lay your transect line out 30 meters. After having laid down a transect line, count the groundcover found under the line at each meter. Do not count anything on the ground that is not situated on a meter transect point even if it's just an inch away AND there can only be one ground cover identified at each point.

METER #	1	2	3	4	5	6	7	8	9	10
Item										

METER #	11	12	13	14	15	16	17	18	19	20
Item										

METER #	21	22	23	24	25	26	27	28	29	30
Item										

Table 1. # incidents of surface over 30-meter transect line and their percentages.

	# INCIDENTS / 30 m	PERCENTAGE
Grass (G)		
Leaf matter (L)		
Rock (R)		
Other Vegetation (O)		
Bare dirt (D)		
( )		
Total	30	

Questions

1. How did the transect line help you be random in your sampling?

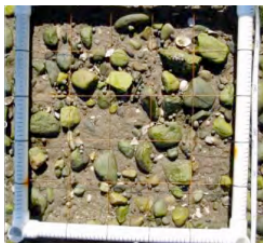
2. Do you feel that the data you collected is valid enough to truly determine the main ground cover at Ulu Lāʻau. Provide reasoning for your response.

3. How could you improve the accuracy of your data?

Practice with a quadrat

Using a quadrat

Taking samples systematically will enable you to truly define the abundance of something, its percent cover, etc.



Experimental question: What is the frequency with which dandelion, clover, grass, and other is found on the grassy area at Ulu Lāʻau?

1. *Visual estimation* – First, estimate the frequency of dandelions, clover, grass and "other" is found on the grassy area at Ulu Lāʻau. Note: Estimate means take your best guess!
2. *Quadrat estimation* – Next, use your quadrat to estimate more accurately. Place your quadrat with the top left corner at the 1m mark of your transect line. At the intersection point for each line (just stay in the inside) identify the organism. Write this down as a tally. Re-position your quadrat at 5 m, 10 m, 15 m, 20 m, 25 m and 30 m. Record your results here and you should have a total of 16 tallies for each quadrat.

Table 2. Frequency of dandelion, clover, grass and "other" at Ulu Lāʻau's grassy area using 7 m^2 quadrats.

	QUADRAT 1 1 m	QUADRAT 2 5 m	QUADRAT 3 10 m	QUADRAT 4 15 m	QUADRAT 5 20 m	QUADRAT 6 25 m	QUADRAT 7 30 m
Dandelion							
Clover							
Grass							
Other							

Table 3. Percent frequency of dandelion, clover, grass, and "other" at Ulu Lāʻau's grassy area.

	% FREQUENCY
Dandelion	
Clover	
Grass	
Other	

Final review

1. Which visual estimation method – **transect sampling** or **quadrat sampling** – do you think is better to estimate percent cover of sample populations? Think about how **reliable** the data is and whether or not there could have been **error**.

2. Was there any **bias** in any of our sampling protocols? Think about **randomization** that did or did not occur.

Vocabulary

- *Transect Sampling* – counted on points of a single line
- *Quadrat Sampling* – counted on points of a grid or within the quadrat area
- *Transect Point* – measured distance on a transect line
- *Reliable* – yielding the same results in different experiments or studies
- *Intercept Point or Point Intercept* – where two lines of a quadrat cross
- *Percent Cover* – portion of a total area one species covers at a specific site
- *Error* – Statistical error is caused by random (unpredictable or unintentional) variation in making a measurement, whereas systematic error is caused by an unknown. If the cause of the systematic error can be identified, then it can usually be eliminated. Such errors can also be referred to as uncertainties.
- *Bias* – a personal preference that causes unfair judgment. In science, a sampling error caused by systematically favoring some outcomes over others.
- *Randomization* – the making of random arrangement in order to control the variable

PREPARING STUDENTS FOR FIELD RESEARCH: INTRODUCTORY LESSONS

MAPPING AND DESCRIBING A WATERSHED

Adapted from "A Watershed and an Ahupuaʻa" by Jennifer Hoof

Student objectives

- Students will be able to describe characteristics and importance of watersheds and make connection to the ahupuaʻa system of land management
- Students will compare and contrast their local watershed and ahupuaʻa

Student performance outcome

- Students are able to make a general description of watershed
- Students will be able to make connections between watersheds and ahupuaʻa

Lesson duration: Two 60-minute class periods

Preparation time: 45 minutes (Copying of materials, gathering materials)

Materials

- Topographic map or GIS map of your area. Use Google Earth or Arc GIS (students and teachers can get free accounts!!). http://www.topozone.com/hawaii
- Ahupuaʻa map of your area http://www.ahamoku.org/index.php/maps/
- Hawaiʻi Watershed Map http://www.ctahr.hawaii.edu/wq/nps319/hawaii/hawaiiwatersheds.htm
- Atlas of Hawaiian Watershed http://www.hawaiiwatershedatlas.com/Hawaii_regions.html
- Transparency film (if maps are not laminated)
- Wet-erase pens
- Student worksheet

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	**ESS2.C: The Roles of Water in Earth's Surface Processes** Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
Crosscutting concepts	Systems and system models
Science and engineering practice	Develop a model to describe unobservable mechanisms.
Performance expectations	Explain the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical. **Relationships** In their model, students describe* the relevant relationships between components, including: 1. energy transfer from the sun warms water on Earth, which can evaporate into the atmosphere; 2. water vapor in the atmosphere forms clouds, which can cool and condense to produce precipitation that falls to the surface of Earth; 3. gravity causes water on land to move downhill (e.g., rivers and glaciers) and much of it eventually flows into oceans; 4. some liquid and solid water remains on land in the form of bodies of water and ice sheets; and

	5. some water remains in the tissues of plants and other living organisms, and this water is released when the tissues decompose.
Common Core State Standards	**Connections to Common Core State Standards**
Common Core – ELA	RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
Common Core – Math	MP4 Models with mathematics

Background

Watershed (from http://hawp.org/what-is-a-watershed)

A watershed is an area of land, such as a mountain or valley, which collects rainwater into a common outlet. In Hawaiʻi, the common outlet is ultimately the ocean. Some of the rain is absorbed by plants, some of it is absorbed underground, and the rest flows into surface rivers and streams. A critical component of a watershed's ability to collect rainwater is the existence of forests. Fog condensing on trees high up in watershed areas can increase rainfall collection and absorption by as much as 30% annually. The Hawaiian equivalent of a watershed is the ahupuaʻa. In Hawaiian cultural tradition, an ahupuaʻa is a land division with the streams and valleys serving as boundaries, varying on different islands from as little as 100 acres to more than 100,000 acres. Ahupuaʻa included the land from the mountains to the coast, and the coastal ocean extending out to and including the coral reef. Native Hawaiians also recognized the importance of forests in water production, described in this proverb: "Hahai nō ka ua i ka ulu lāʻau" – Rain always follows the forest.

Ahupuaʻa (from http://www.hawaiihistory.org/index.cfm?fuseaction=ig.page&CategoryID=299)

The concept of private property was unknown to ancient Hawaiians, but they did follow a complex system of land division. All land was controlled ultimately by the highest chief or king who held it in trust for the whole population. Who supervised these lands was designated by the king based on rank and standing. A whole island, or mokupuni, was divided in smaller parts, down to a basic unit belonging to a single family.

Each moku was divided into ahupuaʻa, narrower wedge-shaped land sections that again ran from the mountains to the sea. The size of the ahupuaʻa depended on the resources of the area with poorer agricultural regions split into larger ahupuaʻa to compensate for the relative lack of natural abundance. Each ahupuaʻa was ruled by an aliʻi or local chief and administered by a konohiki.

Within the ahupuaʻa, ʻili were smaller divisions (two or three per ahupuaʻa) that constituted the estate of the chief. Each ʻili could be formed of non-contiguous pieces called lele, or jumps. Moʻo were sections of the ʻili that were arable; usually these agricultural units did not extend to the sea. Smaller yet were the kuleana, or land tracts used by the common people for cultivation of crops. The size of kuleana, like the size of ahupuaʻa, depended on the natural fertility and abundance of the land.

The ancient ahupuaʻa, the basic self-sustaining unit, extended elements of Hawaiian spirituality into the natural landscape. Amidst a belief system that emphasized the interrelationship of elements and beings, the ahupuaʻa contained those interrelationships in the activities of daily and seasonal life.

Shaped by island geography, each ahupuaʻa was a wedge-shaped area of land running from the uplands to the sea, following the natural boundaries of the watershed. Each ahupuaʻa contained the resources the human community needed, from fish and salt, to fertile land for farming taro or sweet potato, to koa and other trees growing in upslope areas. Villagers from the coast traded fish for other foods or for wood to build canoes and houses. Specialized knowledge and resources peculiar to a small area were also shared among ahupuaʻa.

Although there was no private ownership of property, land tenure of the makaʻainana (commoners) was stable. They paid weekly labor taxes and annual taxes to the konohiki, or local overseer, who collected goods to support the chief and his court. The konohiki supervised communal labor within the ahupuaʻa and also regulated land, water and ocean use.

Stewardship of the land and its resources was formalized through the kapu system. The kapu (taboo) – administered and enforced by konohiki and kahuna, or priests – placed restrictions on fishing certain species during specific seasons, on gathering and replacing certain plants, and on many aspects of social interaction as well. In this way, the community maintained a sustainable lifestyle. Through sharing resources and constantly working within the rhythms of their natural environment, Hawaiians enjoyed abundance and a quality lifestyle with leisure time for recreation during the harvest season of the year. This lifestyle also encouraged a high level of artistic achievement. Many crafts, including Hawaiian kapa and feather work, were the finest in the Pacific. Hawaiians devoted themselves to competitive sport and martial arts as well as expression through dance and chant, creating rich traditions that continue today.

Engage

- Use "What is a Watershed?" Formative Assessment probe from *Uncovering Student Ideas in Earth and Environmental Science* by Page Keeley and Laura Tucker. NSTA Press, 2016. (see Appendix Q for document).
- Watershed video https://vimeo.com/14030972
- Ahupuaʻa video https://www.youtube.com/watch?v=JBe32eXT7RM

Explore

1. Before teaching this lesson, students should be familiarized with reading topographic maps. A simple map reading activity to locate where they are on the map, the elevation, the scale and other features like roads and bodies of water.
2. Watersheds (1–2 days)
    a. Introduction to watersheds. Take students outside to orient themselves and view the physical features of the part of the island they are located.
    b. Hand out the worksheet and discuss the meaning of watershed. Have students hypothesize what a watershed is and what the function is.
    c. Repeat the step with ahupuaʻa. Discuss what students may already know about an ahupuaʻa. Compare the definitions. Read the background information about an ahupuaʻa and a watershed in class.
    d. Hand out the laminated topo maps and wet-erase pens to groups of 2–3 students. Students will trace the boundaries of your local watershed based on their understanding of the reading, their observations, and their background knowledge.
    e. Ask students to compare their outline to other group's boundary outline.
    f. As a class, discuss how the boundaries were decided and which ones were most accurate.
    g. Then have students compare the boundaries they made with the boundaries of the local ahupuaʻa.
    h. Discuss the scientific nature of the ahupuaʻa system and if they would consider the Hawaiians who developed it "scientists."

Explain

Have students synthesize maps on attached student handout.

Elaborate (refer to Appendix L for a unit example on watersheds)

- Have students generate questions about their watershed.
- What kinds of descriptive studies could they do?
- What types of comparative studies could they do?
- What types of correlative studies could they do?
- What are some cause/effect relationships that humans have with both watersheds and ahupuaʻa?

Evaluate

Have students use CER Rubric (Appendix C) to evaluate their paragraph from question #8.

Student Handout Name: _____ Date: _____

WATERSHEDS AND AHUPUAʻA

Before the lesson

1. Look at the word "watershed" and try to break it down. What do you think it means?

2. What do you think an ahupuaʻa is?

Background

Watershed (from http://hawp.org/what-is-a-watershed)
A watershed is an area of land, such as a mountain or valley, which collects rainwater into a common outlet. In Hawaiʻi, the common outlet is ultimately the ocean. Some of the rain is absorbed by plants, some of it is absorbed underground, and the rest flows into surface rivers and streams. A critical component of a watershed's ability to collect rainwater is the existence of forests. Fog condensing on trees high up in watershed areas can increase rainfall collection and absorption by as much as 30% annually.

Ahupuaʻa (from http://www.hawaiihistory.org/index.cfm?fuseaction=ig.page&CategoryID=286)
The Hawaiian equivalent of a watershed is the ahupuaʻa. In Hawaiian cultural tradition, an ahupuaʻa is a land division with the streams and valleys serving as boundaries, varying on different islands from as little as 100 acres to more than 100,000 acres. Ahupuaʻa included the land from the mountains to the coast, and the coastal ocean extending out to and including the coral reef.

Shaped by island geography, each ahupuaʻa was a wedge-shaped area of land running from the uplands to the sea, following the natural boundaries of the watershed. Each ahupuaʻa contained the resources the human community needed, from fish and salt, to fertile land for farming taro or sweet potato, to koa and other trees growing in upslope areas. Villagers from the coast traded fish for other foods or for wood to build canoes and houses. Specialized knowledge and resources peculiar to a small area were also shared among ahupuaʻa.

Procedure

1. Find your town on the map. Recall that topographical maps are flat representations of the surface of the earth, which is not flat. The contour lines show the peaks and valleys of the earth's surface.
2. Mark the boundaries of your watershed using the overhead marker. Base the boundaries on your understanding of what a watershed does.

Questions

1. How did you decide which way the water would flow?

2. What criteria did you use to determine how large the watershed is?

3. Were there any areas that you were unsure about? How did you make a decision about these areas?

4. List two things you learned about your watershed from this activity.

5. Do activities on the land and in the stream up the mountains affect the quality of life further down? How?

6. Hypothesize about the living organisms you would find upstream compared to downstream in your watershed. Give reasons to support your hypothesis.

7. Compare the boundaries of your official watershed and your ahupuaʻa. Are they the same? Different? Explain.

8. Write a paragraph that makes a claim, provides evidence and gives reasons as to how watersheds and ahupuaʻa are alike or different. Include at least two reasons to support your claim.

9. Do you think the waters of your ahupuaʻa are "healthy"? Justify your answer by listing specific criteria you would use to assess "health."

WHAT TYPES OF QUESTIONS CAN WE INVESTIGATE?

Student objectives

- Students will be able to distinguish between three different types of investigative questions
- Suggest questions that can be asked about the natural world

Student performance outcome

I can categorize investigative questions into whether they are descriptive, comparative, or correlative questions and come up with questions about the natural world.

Materials

- Sets of investigative questions (one set per three students). Copy questions onto card-stock and cut into sentence strips; place in an envelope.
- Handout. Three types of field investigation questions.
- Question on board: Given the categories descriptive, comparative, and correlative, how would you categorize the set of questions in your envelope?

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	This is a rare lesson where there is no connection to a disciplinary core idea. This is a mini-lesson on the Science and Engineering Practice #1 Asking Questions.
Crosscutting concepts • Patterns • Cause and Effect	• Students observe patterns to classify types of questions. • Students see some questions indicate cause and effect.
Science and engineering practice • Asking questions	Students sort questions to analyze many types of questions that lead to descriptions and explanations of how the natural world works.
Common Core ELA – Anchor Standards – College and Career Readiness – Anchor Standards for Writing – 7	CCSS.ELA-LITERACY.CCRA.W.7 Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Background

This lesson provides a focus on the NGSS Science and Engineering practice of **asking questions**. Scientific questions differ from other types of questions in that they can be answered by explanation based on empirical evidence. ʻĀina-based investigations provide students with an opportunity to ask questions that differ from the traditional controlled experiments in the classroom. ʻĀina-based investigations work well to contribute information (evidence) about essential questions about the natural world such as:

Examples of essential questions *(just use one set)*

ʻĀINA	WATERSHED	AHUPUAʻA
What defines my ʻāina?	What defines my watershed?	What defines my ahupuaʻa?
What is healthy ʻāina?	What is a healthy watershed?	What is a healthy ahupuaʻa?
What is humans' relationship to our ʻāina?	What is humans' relationship to our watershed?	What is our community's relationship to our ahupuaʻa?
How can our community sustain our ʻāina?	How can our community sustain our watershed?	How can our community sustain our ahupuaʻa?
What is my role in the preservation and use of ʻāina resources?	What is my role in the preservation and use of watershed resources?	What is my role in the preservation and use of ahupuaʻa resources?

These essential questions about the relationships between humans and the natural world are complex and cannot be answered with one field investigation.

Asking a testable question is central to scientific practices. The following lesson is geared to help students think about the ways questions are asked and the types of questions field investigators research. There are three types of field investigations: **descriptive**, **comparative**, and **correlative**.

Descriptive field investigations involve **describing parts of a natural system**. Scientists might try to answer descriptive questions such as, "Where do palila (*Loxioides bailleui*) go when their habitat becomes a new highway development? Or "What areas do palila (*Loxioides bailleui*) select for nesting locations?"

In ***comparative field investigations***, data is collected on different populations, or under different conditions (e.g., times of year, locations), to **make a comparison**. A researcher might ask a comparative question such as, "Does more ʻōhiʻa lehua (*Metrosideros polymorpha*) grow in wet, mesic, or dry forest habitats?"

Correlative field investigations involve measuring or observing two variables and **searching for a pattern**. These types of investigations are typically not explored until high school. Correlative questions focus on two variables to be measured together and tested for a relationship: "How does pH affect the number of species in a stream?" "Does the ʻōpaeʻula (*Halocaridina rubra*) population go down when dissolved oxygen concentrations go down?"

Lesson 1: What Questions Can I Investigate?

Engage

1. Review the essential questions. These big picture questions are why we conduct field investigations.
2. Asking questions is an important part of scientific investigations. While these essential questions are important questions, they are too big to investigate. Scientists work by investigating smaller, testable questions. Ask the students to brainstorm questions they might have about an outdoor space on campus such as their schoolyard or school garden. Or have students brainstorm everything they can **measure** about their local environment, that helps them develop testable questions and procedures.
3. Have students share their questions with a partner or make a class list of questions.

Explore

1. Give groups of students the cards with examples of questions. Advise them that there are different kinds of questions. Ask them to sort the cards without any leading directions and ask they share what categories they used to sort them and what patterns did they notice in each type of question.

2. Introduce the three categories scientists use. Distribute the handout and discuss the three types of field investigation questions. You may want to give them broad examples of each type: Descriptive – Lewis and Clark; Comparative – Darwin comparing finches; and Correlative – CO_2 levels and temperature across the globe or predator/prey relationships. If needed ask students questions to help them identify differences in the questions.
    a. What patterns do you notice in each type of question?
    b. What words are important to look for when identifying each type of question?
3. Ask the students to now sort the questions into three categories – descriptive, comparative, and correlative.

Explain

1. Give the groups time to think about each question and agree on the categories.
2. When they have their questions categorized, facilitate a discussion by asking the questions below or have the groups discuss before sharing with the class.
    a. Did you all agree to this category? Explain how you came to this decision.
    b. Can each one of you come up with a justification as to why these questions fall into the categories they do?
    c. Do you have an "uncertain pile" if so, why? What more do you need to know?
    d. What questions do you have about your categories?
    e. Think of your own examples of each type of question?
3. Using a chart identifying the different question categories, have students, from the groups place a question in the category they selected and have them say why they chose that category.

Elaborate

1. Discuss why scientists need to think about the questions they pose before working in the field.
2. Have students come up with a descriptive, comparative, and correlative question about an area of interest in Hawai'i's natural landscape. It's important that students know that scientists do exhaustive research into the related work of other scientists before conducting their own investigations. Show them peer reviewed journal articles in ecology/conservation and look at the references at the end of each article (high school teachers especially, have a small collection of sample scientific research articles preferably on Hawaiian ecosystems)
3. Discuss which of their questions, if addressed, would most help the community? Improve the health of the watershed? Restore the ahupua'a? Have students defend and debate their choices.
4. Show students examples of how these testable questions can be helpful in conservation/restoration.

Evaluate

As students categorize the questions ask them to justify how they classified each question, and ask them to identify the patterns they notice in each type of question (e.g., descriptive questions often begin with "how many," "when," or "where").

Some questions may fit more than one category; what is important is that students can justify their thinking for each category. For example, students may identify the question, "What is the air temperature at your school throughout the year?" as descriptive, because they would be documenting the temperature of a specific location. Other students may call it a comparative question, because they could use the collected temperature data to compare two different times of year.

Lesson worksheets

- Three Types of Field Investigation Questions
  https://docs.google.com/document/d/1_qXA2jw8IXTYH0ZJw0UmWKICWkBGmRbj2u3rfL-2jKc/edit
- Investigative Questions for Sorting
  https://docs.google.com/document/d/1CPYdiSObG4F1tPIPoW1lzJyoUK-cW4MNgRpA_VFGYbY/edit
- Investigative Questions Sorting Key
  https://docs.google.com/document/d/1c_EyF55JNVPaeQyT-uyZTDFz3pDykA7s5qsjwfv8oyY/edit
- Student Worksheet
  https://docs.google.com/document/d/1OuMfJvYHujFi_1LAywu6riUfrOgb9NA36-X4NXxtBps/edit

Investigative Questions for Sorting

- Do more ferns grow close to the water or away from the water?
- How many kōlea (pacific golden plover; *Pluvialis fulva*) use the school habitat during the school year?
- Which location (under bushes, open grass, or on black top) has the highest temperature at 7 a.m. at Kanu o Ka ʻĀina School?
- When do ʻopihi kōʻele (black-foot ʻopihi; *Cellana exarata*) reproduce?
- Does more ʻōhiʻa lehua (*Metrosideros polymorpha*) grow in wet, mesic, or dry forest habitats?
- Are more insects found in the schoolyard in September, October, or November?
- How many hāʻukeʻuke (helmet urchin; *Colobocentrotus atratus*) live in this tide pool?
- How does ʻōhiʻa lehua (*Metrosideros polymorpha*) blossom abundance change as elevation changes at Hakalau Wildlife Refuge?
- How many flowers does a wiliwili (*Erythrina sandwicensis*) produce from September to December in Waikoloa?
- Are soil temperatures the coolest at a depth of 5cm, 10cm, or 15cm?
- How often do coral spawn in West Hawaiʻi?
- Are mature koa (*Acacia koa*) trees taller than mature ʻōhiʻa lehua (*Metrosideros polymorpha*) trees at Puʻuwaʻawaʻa Forest Reserve?
- What is the air temperature at your school throughout the school year?
- How do mouse populations change as ʻio (Hawaiian hawk; *Buteo solitarius*) populations increase in the Mauna Kea watershed?
- Where do you find the most roly-poly bugs (pill bug; *Armadillidiidae*): under a log, under a pot, or under bushes?
- As elevations increase, how does the number of māmane (*Sophora chrysophylla*) trees per acre change in Kaʻohe Restoration Area?
- Are traffic sounds louder in front of the school or behind the school?
- What is the depth of Waipiʻo Stream at the shore in December?
- Is there a difference in the size of the range of a pueo (short-eared owl; *Asio flammeus sandwichensis*) and a barn owl (*Tyto alba*) on Hawaiʻi Island?
- Do tree species, tree density, tree diameter, or tree height differ between north and south facing slopes in _____?
- When do pueo (short-eared owl; *Asio flammeus sandwichensis*) nest in West Hawaiʻi?
- What is the relationship between number of rain events and germination of new seedlings at Koaiʻa Tree Sanctuary?

- Do birds sing more from 8:30–9 a.m. or from 3–3:30 p.m.?
- Is wind speed greater near the building or out on the playground in March?
- What is the relationship between the amount of sunshine and salinity in tide pools in the summer?
- What kinds of plants grow in _____ Forest?
- Which habitat (in the forest, in a field, or by a stream) has the greatest percentage of sand in the soil?
- What is the number and range of feral cattle (*Bos taurus*) in the Kohala Watershed?
- How does dissolved oxygen change as water temperature goes up in _____ Stream?
- Are sharks more active during the dawn or the dusk in _____?
- What types of birds use the school habitat during the school year?
- What is the range of honu (green sea turtle; *Chelonia mydas*) living at Kīholo Bay?
- How does pH affect the number of species in a stream?
- Are there more palapalai ferns (*Microplepia strigosa*) near streams or away from streams in the Wet Forest at Kalōpā Forest Reserve?
- Are there more feral pigs (*Sus scrofa*) per acre in the Kohala Forest Reserve or Kalōpā Forest Reserve?
- Do temperatures differ between forested and non-forested streams in _____?
- In December, which grass grows faster, fountain grass (*Pennisetum setaceum*) or kikuyu grass (*Pennisetum clandestinum*)?

Investigative Questions Sorting Key

DESCRIPTIVE QUESTIONS
• How many kōlea (Pacific golden plover; *Pluvialis fulva*) use the school habitat during the school year? • How many hāʻukeʻuke (helmet urchin; *Colobocentrotus atratus*) live in this tide pool? • How many flowers does a wiliwili (*Erythrina sandwicensis*) produce from September to December in Waikoloa? • How often do coral spawn in West Hawaiʻi? • What is the depth of Waipiʻo Stream at the shore in December? • What is the air temperature at your school throughout the school year? • What kinds of plants grow in _____ Forest? • What types of birds use the school habitat during the school year? • When do ʻopihi kōʻele (black-foot ʻopihi; *Cellana exarata*) reproduce? • What is the range of honu (green sea turtle; *Chelonia mydas*) living at Kīholo Bay? • What is the number and range of feral cattle (*Bos taurus*) in the Kohala Watershed?

COMPARATIVE QUESTIONS
• Are more insects found in the schoolyard in September, October, or November? • Is wind speed greater near the building or out on the playground in March? • Where do you find the most roly-poly bugs (pill bug; *Armadillidiidae*): under a log, under a pot, or under bushes? • Which habitat (in the forest, in a field, or by a stream) has the greatest percentage of sand in the soil? • Are soil temperatures the coolest at a depth of 5 cm, 10 cm, or 15 cm? • Are traffic sounds louder in front of the school or behind the school? • Which location (under bushes, open grass, or on black top) has the highest temperature at 7:00 a.m. at Kanu o Ka ʻĀina School? • Are sharks more active during the dawn or the dusk in _____? • Do more ferns grow close to the water or away from the water? • Do temperatures differ between forested and non-forested streams in _____? • Do birds sing more from 8:30–9 a.m. or from 3–3:30 p.m.? • In December, which grass grows faster, fountain grass (*Pennisetum setaceum*) or kikuyu grass (*Pennisetum clandestinum*)?

CORRELATIVE QUESTIONS
• How does ʻōhiʻa lehua (*Metrosideros polymorpha*) blossom abundance change as elevation changes at Hakalau Wildlife Refuge? • How does dissolved oxygen change as water temperature goes up in _____ Stream? • How do mouse populations change as ʻio (Hawaiian hawk; *Buteo solitarius*) populations increase in the Mauna Kea watershed? • As elevations increase, how does the number of māmane (*Sophora chrysophylla*) trees per acre change in Kaʻohe Restoration Area? • How does pH affect the number of species in a stream? • What is the relationship between number of rain events and germination of new seedlings at Koʻaia Tree Sanctuary? • What is the relationship between the amount of sunshine and salinity in tide pools in the summer?

** Some questions could fall into a different category depending on how the investigation is set up.*

Name_____

Student Worksheet: Asking Testable Questions

When scientists are looking for answers in the natural world, they first have to develop questions.

Scientists have to use certain methods in order for their findings to be taken seriously.

The first step in this process is **developing a testable question**.

The types of testable questions that scientists develop are separated into three categories: **descriptive, comparative,** and **correlative**.

For a description and examples of each, see **back** of this worksheet.

For this lesson, you will be given a baggie with questions written on slips of paper. You and your partner need to sort out the questions into the three categories. Once you are done have the teacher check your work.

After the class discussion, fill in the following chart with descriptive, comparative and correlative questions that you could ask about _____.

DESCRIPTIVE	1. 2. 3.
COMPARATIVE	1. 2. 3.
CORRELATIVE	1. 2. 3.

DESCRIPTIVE QUESTIONS

Descriptive field investigations involve describing parts of a natural system. Descriptive questions focus on measurable or observable variables that can be represented spatially in maps or as written descriptions, estimations, averages, medians, or ranges.

- How many _____ are there in a given area?
- How frequently does _____ happen in a given period?
- What is the [temperature, speed, height, mass, density, force, distance, pH, dissolved oxygen, light density, depth, etc.] of _____?
- When does _____ happen during the year? (flowering, pollination)
- Where does _____ travel over time? (What is an animal's range?)

COMPARATIVE QUESTIONS

In comparative field investigations data is collected on different groups to make a comparison. Comparative questions focus on one measured variable (Dependent variable) in at least two different (Independent variable) locations, times, organisms, or populations.

- Is there a difference in _____ between group (or condition) A and group B?
- Is there a difference in _____ between (or among) different locations?
- Is there a difference in _____ between two different times?

CORRELATIVE QUESTIONS

Correlative field investigations involve measuring or observing two variables and searching for a pattern. Correlative questions focus on two variables to be measured and tested for a relationship.

- What is the relationship between variable #1 and variable #2?
- Does _____ go up when _____ goes down?
- How does _____ change as _____ changes?

WHAT MAKES A HYPOTHESIS TESTABLE?

Introductory Activity

Hook: Ask the students which of the following hypotheses are testable?

1. Caffeine use does not affect typing speed. https://www.thoughtco.com/caffeine-and-typing-speed-project-609021
2. Caffeine does not affect concentration.
3. Caffeine makes you smarter.

What made you know that the hypothesis was testable? Data could be collected to answer #1 #2 and #3 could not easily be tested.

Engage

Watch video on Scientific Method and Developing Hypotheses.
https://www.brainpop.com/science/scientificinquiry/scientificmethod/

Explore

Directions: For each of the problems and observations below, develop a hypothesis to explain what is happening. Then, develop a simple experiment to test the hypothesis.

PROBLEM	OBSERVATION	HYPOTHESIS	EXPERIMENT
A stream in your backyard is usually very clear but it is not today.	There are pig footprints.		
Your surf spot is closed and you can't go surfing today.	The water is very muddy at your surfing spot.		

Problem #1: Students could hypothesize that the activity of pigs contributed to the debris in the stream.

- Independent variable – activity of pigs
- Dependent variable – debris in the stream
- Controlled variables – Stream temperature, stream size, weather conditions

Problem #2: Students could hypothesize that rain washed dirt into the ocean.

- Independent variable – amount of rainfall
- Dependent variable – dirt in the ocean
- Controlled variables – how water turbidity (visibility) is measured

Discuss some students' examples. Each of the simple experiments should have an independent variable and a dependent variable. All other variables should be controlled. Allow students to develop their own problem, observation, hypothesis and experiment.

References

- https://educators.brainpop.com/lesson-plan/scientific-method-lesson-plan-developing-hypotheses/
- ***Testing Ideas.*** Understand Science website. UC-Berkeley https://undsci.berkeley.edu/article/howscienceworks_06

DESCRIPTIVE FIELD INVESTIGATION: SCHOOLYARD BIODIVERSITY

Essential question: In this lesson, students begin to answer the question: What biotic and abiotic factors influence biodiversity on a schoolyard?

The Schoolyard Biodiversity investigation and its companion descriptive lessons Biodiversity Mauka and Biodiversity Makai use the same biodiversity index.

Student objective(s)

- Practice a sampling method to collect data in the schoolyard
- Accurately record abiotic and biotic factors including species **richness** and **evenness** within a sampling site
- Use a simple biodiversity index to determine individual and whole class biodiversity of sample(s)
- Construct an evidence based explanation (claim, evidence and reasoning) to argue degree of biodiversity of individual sites and/or data across sites

Student performance expectation

Schoolyard Biodiversity addresses NGSS Middle School disciplinary core idea LS2: Interactions, Energy, and Dynamics Relationships in Ecosystems. This investigation helps students answer the question, **"How does a system of living and non-living things operate to meet the needs of the organisms in an ecosystem**?" Additionally, the activities prepare students to meet performance expectation MS-LS2-5: **Evaluate competing design solutions for maintaining biodiversity and ecosystem services.** The schoolyard biodiversity investigation alone will not provide sufficient experiences to fully meet the performance expectation. Instead, it provides foundational experiences across the 3-D framework necessary for further investigation. High school standards are also applicable.

Lesson duration: Three 60-minute class periods

Preparation time: 30 minutes (Copying of materials, gathering materials)

Materials

Per student

- Clipboard
- Ruler
- Hand lens
- Paper or Observation Form

Per team

- Hula hoop or quadrat
- Colored pencils
- Thermometer
- BioKIDS App (optional)

Per class

- Field guides
- Access to Internet
- Soil moisture meter

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea Ecosystems: Interactions, Energy, and Dynamics MS-LS2	A. Ecosystem dynamics, functioning and resilience B. Biodiversity and humans
Crosscutting concepts Connections to the Nature of Science	• Patterns • Cause and effect • Science addresses questions about the natural and material world
Science and engineering practices Connections to the Nature of Science	• Analyze and interpret data • Construct explanations and design solutions • Engage in argument from evidence • Scientific knowledge is based on empirical evidence (ecological sampling)

Common Core – ELA	RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. RI.8.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced WHST.6-8.1 Write arguments focused on *discipline-specific content*. WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
Common Core – Math	MP4 Models with mathematics 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems 6.EE.C.9 Represent and analyze quantitative relationships between dependent and independent variables. 6.SP.B.5 Summarize numerical data sets in relation to their context

Background for teachers
http://sciencenetlinks.com/lessons/introducing-biodiversity/
http://www.teacherstryscience.org/ngsslp/backyard-biodiversity-ngss
http://www.nwf.org/Eco-Schools-USA.aspx

Biodiversity

What is it?
Biodiversity can be defined on a variety of levels. Ecosystem biodiversity refers to the variety of habitats within a particular area or region. Species biodiversity describes the different kinds of plants and animals located within a particular habitat. On a more complex level, genetic biodiversity looks at the variety of characteristics within a particular species. The opposite of species diversity is monoculture. The term monoculture refers to a situation in which only one species occupies a particular area or region. Examples of man-made monocultures include lawns and farms (such as pineapple fields and papaya farms).

The Schoolyard Biodiversity Investigation focuses on species biodiversity. Researchers use the terms **evenness** and **richness** to describes species biodiversity. **Species richness** describes the number of **different** species in a given area (animals, plants, insects, etc.), whereas **species evenness is the total number** of all individuals within each

species in that same area. The ratio of richness to evenness can be used to calculate a biodiversity index number helps researchers compare differences across study sites, habitats, and locations. See https://socratic.org/questions/whats-the-difference-between-species-richness-and-species-evenness for species richness and evenness information and graph examples.

Why is biodiversity important?
Habitats having a greater variety of different species of plants and animals have a greater biodiversity. These habitats are also healthier and more stable. One reason diverse communities have greater levels of health is that organisms of the same species tend to be more spread out. This reduces the ability of a disease to spread throughout a habitat. Additionally, if a certain type of species of tree or plant does become infected, the other species will remain and continue to provide the habitat components for the organisms in that area.

In an area consisting of monoculture, an area with only one type of plant species growing, the plants are more susceptible to disease and other stresses because they are all the same and less spread out (no other types of plants between them). As a result, [the entire habitat can be dramatically altered when impacted by disease or other stresses]. Human-made monocultures (crops, etc.) are created to make harvesting easier. However, they typically require larger amounts of pesticides and herbicides (to prevent diseases and/or "weeds") and larger amounts of energy and labor to maintain before harvesting.

Procedure with students
Pre-assessment
Use the Cognitive Content Dictionary in Appendix 1 to gather student ideas on key terms like biotic, abiotic, biodiversity, richness, evenness, sample, and species. Ask students if they have heard of each word, what comes to mind when they hear the word, and if they can put the word in a sentence. This GLAD Strategy can be used throughout the lesson to support moving from student language to scientific language.

Alternative
If this lesson is used at the start of the year, you might want to use this free NGSS assessment probe to determine students' ideas about claims, evidence and reasoning. Go to http://schd.ws/hosted_files/mtc2014/bd/Keeley-Harmon_CERFramework.pdf

Engage

Video
Show one of the following (or other) video on biodiversity. Ask students to look for words and ideas that define biodiversity.

- Why is biodiversity so important? – TED Ed
  http://thekidshouldseethis.com/post/why-is-biodiversity-so-important-ted-ed
- Learning to protect biodiversity
  https://www.youtube.com/watch?v=kHhspf5IfdE
- Cool /short video on biodiversity
  https://www.youtube.com/watch?v=4WOflTif7T8
- Bill Nye is good for middle school
  https://www.youtube.com/watch?v=-Sybgof-X2k

Think-Pair-Share
Think: Ask students to think about how to answer the question: **What biotic and abiotic factors influence biodiversity on a schoolyard?** Student can write or draw their answer (worksheet, journal, or scratch paper). Ask them to consider both biotic (living) and abiotic (non-living) factors. Ideas might include temperature, soil moisture, invasive species, human impact, nutrients, etc.

Pair: Have students discuss their ideas with a partner. If appropriate, answers should include a claim, evidence (data based on their initial ideas about where plants and animals are found in the schoolyard), and a reason (connected to prior knowledge, information from the video, or other).

Share: Invite students to share their ideas in groups or whole class.

Teachers use data from individual groups or from the whole class as assessment information to provide formative information about students' overall understanding of biodiversity.

Explore

However, Richness and Evenness are critical concepts to be mastered in biodiversity studies. Revisit these terms frequently as the investigation unfolds.

Description: Within each of the sampling sites (using quadrates or hula hoops), students collect data on the number of **different** species (richness) and total of **all** individuals within each species (evenness). A data collection form is located at the end of the investigation.

Ahead of time

1. Identify study sites in the schoolyard for investigation. Place a quadrat or hula hoop on the ground to define the study area.
2. Establish teams (student or teacher selected).
3. Assign each team a study area.
4. Make copy of data collection forms or load the BioKIDS application on iPod/iPad (see Appendix)
5. Review protocols for respectfully entering a site.

Preparation with students

1. Intro and review of protocols. Remind students to stay calm and observe from a distance before approaching their sampling site.
2. Review data collection forms
    a. Tell each team to spend 20–30 minutes **observing** and **recording**
        i. Take a photo or make a drawing of the species you find
        ii. Describe what you see, hear, smell and feel (abiotic and biotic)
    b. Note abiotic factors within the circle such as direct/indirect light from sun, location, time of day, moisture (arid, irrigated, temperature, etc.)
    c. Collect data on all of the animal species in their study site. Note living things from the ground to the sky within your circle.
        i. Try to identify the type of animal species (bird, reptile, worm, snail, insect with six legs, arachnid with eight legs, crustacean with 10–14 legs, myriapod with 20+ legs, or other)
        ii. Note signs or tracks of animals, be sure to photograph or draw identifying marks. Try to determine what animal group it is in.

Back in the classroom elicit students' ideas about collecting data in the schoolyard. Students can work alone or in small groups to consider one or more of the following questions.

- What questions do I have about the way we gathered the data?
- What questions do I have about the data we collected?
- What other data or information might we need to collect or find?

Combine or upload data (BioKid or other) into a spreadsheet that contains all of the students' data. Use information collected on-site to determine the animal names (species).

Example of Combined Data from All Sites

ANIMAL NAME	SITE 1	SITE 2	SITE 3	MICROHABITAT	TOTAL
Earthworm	0	1	1	In dirt	2
Ant	6	2	0	On ground	8
Beetle 1	0	1	0	On ground	1
Beetle 2	0	0	1	On leaf	3
Nēnē	0	0	1	On grass	1
Sparrow	0	0	1	In the sky	1
Kōlea	1	0	0	On grass	1
Butterfly	0	1	1	In the sky	2
Human	0	0	1	On dirt	1
Other	1	0	1	On dirt	3
# Kinds of animals (richness)	3	4	7		14
# Animal total (evenness)	8	5	7		20

Teachers use data from individual groups or from the whole class as assessment information to provide formative information about students' abilities to collect and record data for use in the other tasks.

Explain

Part 1: Create bar graphs that illustrate patterns in evenness and richness data from each of the schoolyard zones. This task assesses students' ability to construct and interpret graphs of the data they have collected (an important element of the NGSS practice "analyzing and interpreting data").

Students may need to review the difference between evenness and richness before beginning.

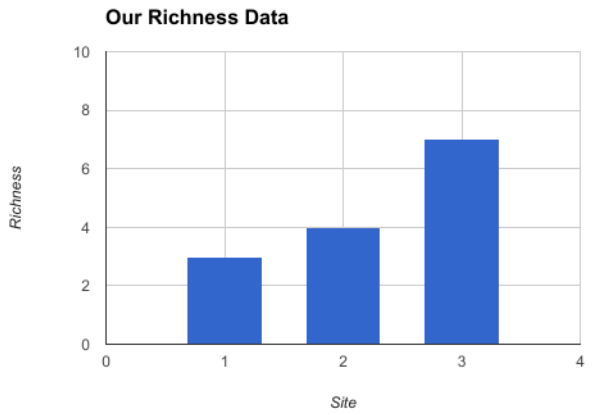
Example of Student Graphs for Evenness and Richness

Instructions

1. Use your site summary to make a bar chart of the evenness data. Please remember to label your axes.

Result: According to the bar chart above, Site 1 has the highest evenness.

2. Use your site summary to make a bar chart of your richness data. Please remember to label your axes.



Result: According to the bar chart about, Site C has the greatest richness.

Teachers use graphs students create for formative purposes, for making decisions about further instruction students may need. For example,

- If students are weak on the practices (creating and interpreting graphs), the teacher may decide to help them with drawing accurate bars or the appropriate labeling of axes.
- If the students are weak on understanding of the core idea, the teacher might review the concepts of species evenness or species richness.

Elaborate

Construct an explanation to support your answer to the question: What biotic and abiotic factors influence biodiversity on a schoolyard?

Part 1

1. Explain how researchers use data on richness and evenness to calculate a biodiversity index. The Simplified Diversity Index is a decimal number between 0 and 1. The closer the diversity index is to 1 then the more the habitat is diverse and healthy (WDNR, 2005).
    - Diversity Index value of 0 indicates no diversity
    - Diversity Index value of 1 indicates high diversity
    - Diversity Index value of 0.5 indicates area is relatively diverse

A simple biodiversity index is calculated as follows:

RICHNESS: Number of different species in a given area (numerator = a)	EVENNESS: Total number of individuals in the same area (denominator =b)	RATIO (a/b): The biodiversity index is expressed as a decimal convert ratio to a decimal
Taro patch has one type of plant	There are 60 taro plants in the taro patch	Biodiversity of taro patch = 1/60 or .02
A 4 x 4 meter square area of a dryland forest has 1 ʻōhiʻa tree, 1 wiliwili tree, 1 koaiʻa tree, 1 hala pepe tree, and 1 maʻo hau hele (hibiscus shrub)	Total number of different species is 5	Biodiversity of 4 x 4 meter square dryland forest = 5/5 or 1

2. Ask students to discuss how they could describe the two examples above.
    a. The taro patch has (no, high, or relative diversity) because…
    b. The dryland forest example has (no, high, or relative diversity) because…
3. Revisit biodiversity definitions highlighting the importance of evenness and richness. An area is considered biodiverse if it has both a high animal evenness and high species richness.

Part 2

1. Ask students to review their answer to the question.
2. Remind students of the three key parts of an explanation: a claim, more than one piece of evidence, and reasoning.
3. Ask students to construct an explanation to support your answer to the question: Which zone of the schoolyard has the greatest biodiversity?

Example of Student Explanation for Which Zone of the Schoolyard Has the Greatest Biodiversity

Instructions: Using what you have learned about biodiversity, the information from your class summary sheet, your bar charts for evenness and richness, and the biodiversity index, construct an explanation to answer the following scientific question.

Scientific Question: What biotic and abiotic factors influence biodiversity on a schoolyard?

Make a CLAIM: Write a complete sentence that answers the scientific question.

Site C has the greatest biodiversity

Give your REASONING: Write the scientific concept or definition that you thought about to make your claim. Think about how biodiversity is related to evenness and richness, and how the simple biodiversity index represents this ratio.

An area is considered biodiverse if it has both a high animal evenness and high species richness.

Give your EVIDENCE: Look at your data and find two pieces of evidence that help answer the scientific question. Think about which site has the highest evenness and richness.

Site C has more richness and evenness together as calculated by the biodiversity index.

Evaluate

This task serves as a summative assessment, as an end-of-investigation check. Students construct an explanation to support an answer to the question: Which zone of the schoolyard has the greatest biodiversity?

What impacts biodiversity on the school campus? Do you think abiotic factors influenced biodiversity. Use your data as evidence to support your argument.

Schoolyard Animal Data

ANIMAL NAME	SITE 1	SITE 2	SITE 3	TOTAL
Pillbugs	2	1	0	3
Ants	8	6	4	18
Kōlea	1	0	0	1
Spiders	1	1	0	2
Sparrows	1	0	3	4
# Kinds of animals (richness)	5	3	2	9
# Animal total (evenness)	13	8	7	28

Task
Write a scientific argument to support your answer for the following question.

Scientific Question: Which zone has the highest biodiversity?

Coding Rubric for Task

	4	3	2	1
Scientific explanation	Contains all parts of explanation (correct claim, two pieces of evidence, reasoning)	Contains correct claim and two pieces of evidence but incorrect or no reasoning	Contains correct claim + one piece correct evidence OR two pieces correct evidence and one piece incorrect evidence	Contains correct claim, but no evidence or incorrect evidence and incorrect or no reasoning

Correct responses
Claim
Correct: Site A has the highest biodiversity.

Evidence
1. Site 1 has the highest animal richness.
2. Site 1 has high animal evenness.

Reasoning
Explicit written statement that ties evidence to claim with a reasoning statement: that is, Site A has the highest biodiversity because it has the highest animal richness and high animal evenness. Biodiversity is a combination of both richness and evenness, not just one or the other.

Extend
Have students work in groups to create a scientific poster describing their investigation. Students can present their partners and practice speaking and listening skills.

How can you increase biodiversity on the school campus? Have students research potential projects like schoolyard habitats https://www.fws.gov/cno/conservation/schoolyard.html http://www.nwf.org/Garden-For-Wildlife/Create/Schoolyards.aspx

How are different places identifying biodiversity issues? Example: Hakalau NWR planting more trees and endangered shrubs to provide more food sources and habitat to support diverse bird species.

Ask students to sample biodiversity near their homes and compare. They can use paces and look at ground cover/canopy cover in a 5 x 5 paced area.

References

- "4 Classroom Assessment." National Research Council. 2014. Developing Assessments for the Next Generation Science Standards. Washington, DC: The National Academies Press. doi: 10.17226/18409. https://www.nap.edu/catalog/18409/developing-assessments-for-the-next-generation-science-standards – research. Web.
- https://publicgardens.org/resources/field-investigations-using-outdoor-environments-foster-student-learning-scientific

Student Worksheet 1 Name: _____ Period: _____ Date: _____

Schoolyard Biodiversity Investigation

Background

What is biodiversity?

_____

_____

Draw an example of an environment that demonstrates biodiversity and one that does not.

BIODIVERSE	NOT BIODIVERSE

Biodiversity depends on two different species measurements: evenness and richness.

Evenness is _____

Richness is _____

Draw a picture that demonstrates species evenness versus species richness.

SPECIES EVENNESS	SPECIES RICHNESS

Experimental question: Which zone in the schoolyard has the greatest biodiversity?

Zone 1: _____

Zone 2: _____

Zone 3: _____

Prediction: _____

_____

_____

Abiotic data
Non-living Factors Found in the Sample Area

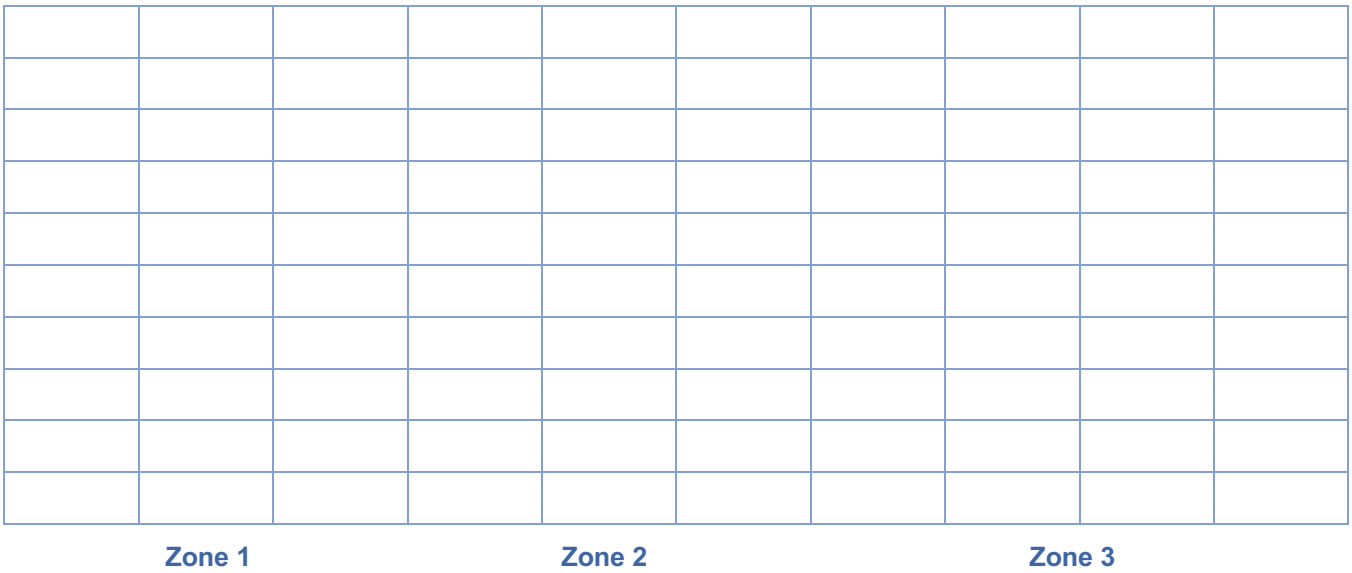
	ZONE 1	ZONE 2	ZONE 3
Time			
Temperature			
Location			
Human Impact			
Soil Moisture			

Biotic data
Amount of Each Organism Found in the Sample Area (use tally marks)

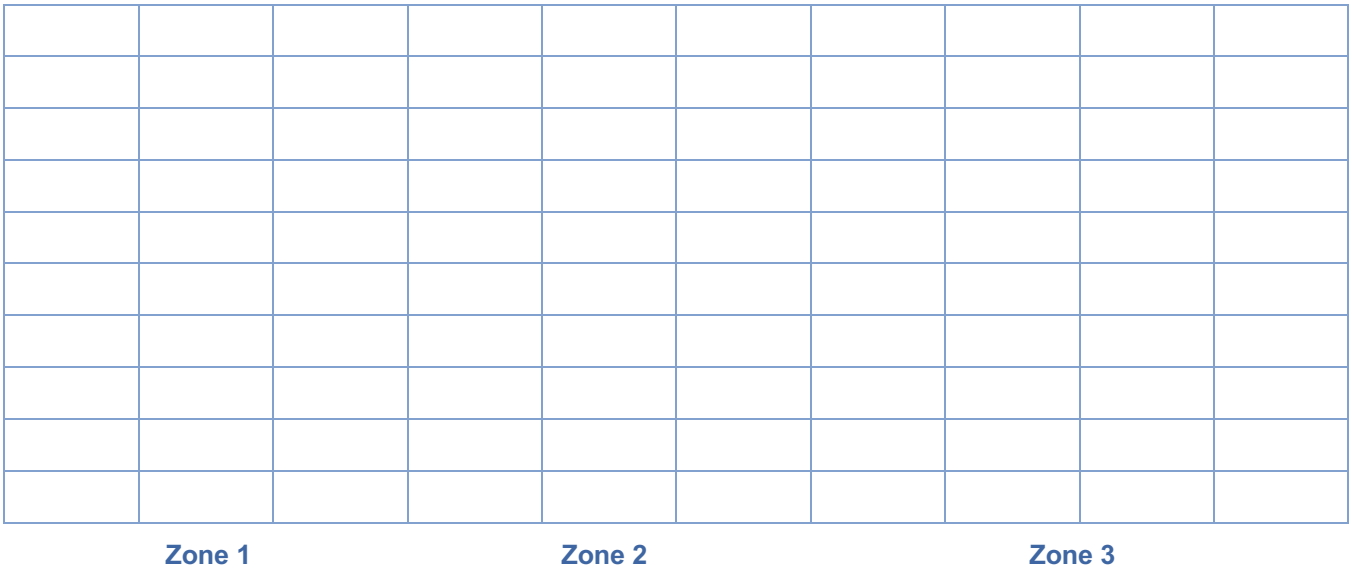
ORGANISM NAME	ZONE 1	ZONE 2	ZONE 3	TOTAL
Total amount of organisms found (evenness)				
Amount of different species observed (richness)				

Analysis: Graph the evenness and richness for each of the three zones

Evenness Comparison in Three Zones



Species Richness Comparison in Three Zones



Further analysis: Scientists use a formula called a biodiversity index to describe the amount of species in a given area. A simple biodiversity index is calculated as follows:

$$\frac{\text{the number of species in an area (richness)}}{\text{the total number of individuals in the area (evenness)}} = \text{Biodiversity Index}$$

Calculate the biodiversity for each environment below. Show your work in the specified box.

Zone 1	***Zone 2***
Zone 3	***Total***

Understanding the results

- The simplified biodiversity index is a decimal number between 0 and 1. The closer the diversity index is to 1, the more the habitat is diverse and healthy.
- Biodiversity Index value of 0 indicates no diversity.
- Biodiversity Index value of 1 indicates high diversity.
- Biodiversity Index value of 0.5 indicates area is relatively diverse.
- Biodiversity Index of a healthy forest would typically range around 0.7 – 0.8. Diversity Index of an agricultural field would typically range from 0.02 or less.

Conclusion

Use the following format to write your conclusion:

- ***Claim:*** Answers the experimental question
- ***Hypothesis:*** Was it supported or not?
- ***Evidence:*** Cite your data
- ***Reasoning:*** Discuss the analysis of the biodiversity index
- ***Errors/Limitations:*** Improvements

Alternative Data Collection Sheet

Sample 1: Biodiversity Data Collection Chart

DIFFERENT KINDS OF SPECIES	TOTAL NUMBER OF SPECIES	
Number of different kinds of animal species	Total number of animals	Ratio (a/b)
Tally marks	Tally marks	
Number of different kinds of insect species (numerator = a)	Total number of insects (denominator =b)	Ratio (a/b)
Tally marks	Tally marks	
Total number of different kinds of all species	Total number of all individual organisms	Ratio (a/b)
Total =	**Total =**	

Sample 2: Biodiversity Data Collection Form

GROUP DATA SUMMARY
Area surveyed: _____
Number of different kinds of animals: _____ Total number of animals: _____
Number of kinds of insects: _____ Total number of insects: _____
Total number of kinds of organisms (animals and insects combined): _____
Total number of organisms: _____

CLASS DATA SUMMARY
Area surveyed: _____
Number of kinds of animals: _____ Total number of animals: _____
Number of kinds of insects: _____ Total number of insects: _____
Total number of kinds of organisms (animals and insects combined):_____
Total number of organisms: _____

COMPARATIVE FIELD INVESTIGATION: SURFACE TEMPERATURES IN THE SCHOOLYARD

Essential question: How do human activities affect the surface temperature on campus?

Student learning objectives:

- Students will observe an outdoor environment and ask an experimental question.
- Students will conduct an experiment that answers their experimental question.
- Students will make conclusions about the effect of human activities on temperature (on the schoolyard and globally).

Student performance outcome: Students examine evidence for patterns in data that connect natural processes and human activities to changes in temperature.

Lesson duration: Three 60-minute class periods

Preparation time: 30 minutes (copying of materials, gathering materials)

Materials

- Thermometers
- Clipboards
- Pencil
- Computer for analysis

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	ESS3.D: Global Climate Change
Crosscutting concepts	Stability and Change: Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
Science and engineering practice Asking questions and defining problems	Students sort questions to analyze many types of questions that lead to descriptions and explanations of how the natural world works.
Performance expectations	MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
Common Core – ELA	**Connections to Common Core State Standards** CCSS.ELA-LITERACY.WHST.6-8.1.A Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
Common Core – Math	CCSS.MATH.CONTENT.7.SP.B.3 Informally assess the degree of visual overlap of two numerical data distributions with similar variability, measuring the difference between the centers by expressing it as a multiple of a measure of variability.

Background

Vocabulary

- *Global warming* – an increase in the Earth's average atmospheric temperature that causes corresponding changes in climate and that may result from the greenhouse effect
- *Climate change* – a long-term change in the Earth's climate, especially a change due to an increase in the average atmospheric temperature
- *Independent variable* – (in an experiment) a variable that is intentionally changed to observe its effect on the dependent variable
- *Dependent variable* – (in an experiment) the event studied and expected to change when the independent variable is changed
- *Controlled variable* – experimental variables that are held constant and unchanged throughout the investigation
- *Central tendency* – the tendency of samples of a given measurement to cluster around some central value
- *Mean* – average value
- *Median* – the middle value
- *Mode* – the most common value

Engage

1. Formative Probes (Page Keeley): What affects the temperature of Earth?
2. Students think about the question, "Is the temperature outside in the schoolyard the same in every place?" Students share their ideas and continue with the class discussion by answering, "How can humans change the temperature of an environment?"
3. Students plan and carry out an investigation to determine how human activities affect the surface temperature on campus.
4. Teach students that good experimental questions describe what will be manipulated (the independent variable) and what will be measured (the dependent variable). Students turn to their group and decide what the variables are in the experiment. Students should conclude that the independent variable is the surface and the dependent variable is temperature.

Explore

1. Take students outside to walk and observe the campus. Students look for human altered surfaces and natural surfaces that they might compare in their experiment and record their observations on a clipboard with their group.
2. Upon returning to the classroom, create a class list of the two different types of surfaces observed (human altered versus natural). Students make a prediction about how the surface temperatures on these surfaces would compare to each other. This prediction and will become more specific in their hypothesis.
3. Students select two different locations to compare (a natural surfaces and a human influenced surfaces) to answer their experimental question. Groups decide on their locations.
4. Students write their hypothesis and complete the data table headings with their chosen locations on the data collection sheet.
5. Explain the importance of recording the date, time, weather, and describing the study site. When the data is analyzed and compared to others, it will be important to understand additional variables that may have affected the results. When conducting field investigations, we work in the environment that is available and cannot change or eliminate weather.
6. Review the importance of multiple trials and explain that every team will measure the temperature for 15 trials at each location.
7. Ask students, "When we go outside and take the surface temperature, what do we need to do the same each time (controlled variables) to provide for a fair test?" Provide time for groups to discuss and share their ideas. Controlled variables should be listed on their board and may include: Shade the thermometer to eliminate the influence of direct sunlight, leave it in place for the same amount of time, provide time for the thermometer to return to its normal temperature between trials

8. Students carry out the surface temperature investigation following the procedure. The procedure can either be written by the teacher (with student input), written by the class, or written by each group. However, the basic procedures include:
    - Record date, time, and place where investigation takes place.
    - Describe the weather and site of the investigation. Record air temperature.
    - Leave thermometer flat on the ground for 1 minute, shading the thermometer from direct sunlight, and recording the temperature 15 times at each of the 2 locations

Explain

1. Once the data is collected, students calculate averages (mean, median, or modes) for each location. Students use chart linked (https://docs.google.com/document/d/1zOmV9AhBYtCRG_1Q1Wt5FPrGrnzL5DCXM1HXwGFA1xM/edit, Appendix E) to determine what type of central tendency is best for their data and circle that data on their table.
2. Students discuss the appropriate type of graph (https://docs.google.com/document/d/1H55W0dmVILSKIPGY1Q-vTk-f6dki0xxceC8_Vn6b_v8/edit, Appendix D) and create a graph using excel or sheets. Use the checklist linked (https://docs.google.com/document/d/1JS000T20P3uUhk2Q9ZvcH58tzWrDXalYmLa5ZNSXlr0/edit, Appendix F) as the graph is developed.
3. Students review the procedure and make any changes to include what they actually did in the field.
4. In groups students discuss:
    - Patterns in their data
    - The procedure (what worked, what didn't)
    - Any factors that may have influenced their data
    - Any inconsistent data
5. Students share their discussion notes with the class.
6. Ask students, "Do we have evidence to answer our question? How do man-made surfaces affect the surface temperature on campus?" Have students share their group's answer to the class.
7. If the answer is "Yes", students start constructing their argument/explanation using data as evidence to answer the investigation question. They use the Claim, Evidence, Reasoning template and rubric to guide their writing. If the answer is "No", student groups must determine why not and either collect more data or revise their procedure.

Claim Evidence Reasoning (CER) rubric
https://docs.google.com/document/d/1OJglgR1EgiFhzggwNxmCAQZPyld8cjVdk-WiP4pq4II/edit?usp=sharing

Elaborate

1. Ask students to apply their experimental results to the larger picture of temperature change on Earth, what is the impact of human's resurfacing the land? How could these human caused changes affect atmospheric temperatures? What would be the implications for other species?
2. Students may have to do additional research and reading on the topic of global warming and climate change (https://www3.epa.gov/climatechange/kids/) to answer these questions. Teachers may have groups do jigsaw research on the following topics and how these land use issues affect global temperature: Urban heat island index (https://www.youtube.com/watch?v=UUQAX-aPbbE), deforestation, farmland and pastures, coastal development.
3. Students may also explore the website https://www3.epa.gov/climatechange/kids/scientists/clues.html to uncover the evidence for climate change. They can observe carbon dioxide data https://www3.epa.gov/climatechange/kids/scientists/pieces.html
4. Teachers may also have all students read (or jigsaw specific sections) http://www.earthday.org/campaigns/education/story-climate-change/ or http://www.ck12.org/biology/Global-Climate-Change/lesson/Global-Climate-Change-BIO/?referrer=featured_content
5. Students add additional evidence to their conclusion based on global warming and climate change research.

6. Groups present their experiment to their peers.
7. Important to relate this to overall watershed health—groundcover and runoff/turbidity/nutrients; canopy cover/temperature/DO.
8. Another easy thing to measure is the permeability of surfaces around the schoolyard. Have students bring water outside in containers and pour equal amounts on different surfaces around campus. Time the absorption and observe run off. You can also compare water evaporation to various surfaces and temperatures too.

Evaluate

1. Science Investigation Rubric: See Appendix B
   https://docs.google.com/a/waikoloa.k12.hi.us/document/d/1SoUAziksBM5oGlvkJCsnBVV5JsSDttEQYL06HgXAgFE/edit?usp=sharing
2. Documenting Field Investigations Checklist: See Appendix P
   https://docs.google.com/document/d/1odN8lAaSAhWCjZN9rQyiNzcU39Uw23hNrmBmmhqv4Zg/edit?usp=sharing

Surface Temperature in the Schoolyard Data Sheet

Experimental question: How do human activities affect the surface temperature on campus?

Procedure

1. Choose two different locations for the experiment: Human-influenced and Natural Surface
2. Complete the location column in the data table for each location prior to collecting the data. Record the data, study site description, and weather for each location.
3. At each location, collect data on the temperature of surface. Shield the temperature probe from direct sunlight and record the temperature in the data table in Celsius. Record the temperature 15 times at each location.
4. Once all 15 trials are recorded, analyze the data for central tendency (mean, median, and mode).

Location 1: Human-Influenced

Date: _____ Time: _____ Place: _____

Study site description: _____

Weather: _____

Location 2: Natural

Date: _____ Time: _____ Place: _____

Study site description: _____

Weather: _____

Surface Temperature (°C)

	HUMAN-INFLUENCED SURFACES	NATURAL SURFACES
Air Temperature °C		
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Trial 6		
Trial 7		
Trial 8		
Trial 9		
Trial 10		
Trial 11		
Trial 12		
Trial 13		
Trial 14		
Trial 15		
Mean		
Median		
Mode		

Conclusion

Claim
Evidence
Reasoning

CORRELATIVE FIELD INVESTIGATION: SOIL TEMPERATURE AND TIME OF DAY

Essential question: How do abiotic factors affect an ecosystem?

Experimental question: How does the temperature of soil change with time of day?

Student objectives
Students will:

- Be able to collect field data.
- Be able to create a scatter plot graph with the line of best fit.
- Be able to find the correlation coefficient between the two variables.

Estimate preparation time: 15 minutes

Estimated lesson time: 45 minutes

Materials
Thermometers (5–15)
Meter stick or metric tape measure

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	LS2.C Ecosystem Dynamics, Functioning, and Resilience
Crosscutting concepts	• Patterns, Cause and Effect • Stability and Change
Science and engineering practice	• Practice 4 – Analyzing and Interpreting Data • Practice 6 – Constructing Explanations and Designing Solutions
Performance expectations	LS2-4 Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.
Student performance outcome	Students will be able to measure the temperature of the soil. Students will be able to generate a graph with the best fit line.
Common Core – ELA	CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. CCSS.ELA-LITERACY.WHST.6-8.2.F Provide a concluding statement or section that follows from and supports the information or explanation presented. CCSS.ELA-LITERACY.WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.
Common Core – Math	CCSS.MATH.CONTENT.HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

Background
Temperature is the average kinetic energy of the particles in an object. A thermometer is used to indirectly measure temperature using a gas tube filled with red colored alcohol. The alcohol expands upon heating, going up with the temperature and goes down upon cooling. This video (http://study.com/academy/lesson/what-is-temperature-definition-lesson-quiz.html) explains temperature in greater detail. Soil refers to "the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants."

A soil profile is a section of the soil that shows all of the different soil horizons. Look at http://www.ctahr.hawaii.edu/mauisoil/a_profile.aspx to learn more about soil profiles.

A correlation coefficient is a number between -1 and 1 that explains the linear dependence of two variables. To learn more about this concept you can watch this YouTube video (https://www.youtube.com/watch?v=ugd4k3dC_8Y). A high school correlation coefficient lesson plan can be found at http://www.cpalms.org/Public/PreviewResourceLesson/Preview/53889.

Engage

1. What does a thermometer measure?
2. Is this a direct or indirect measurement? A direct measurement directly measures what you are looking at (the mass of an object, distance of an object). An indirect measurement uses something else to measure (the liquid in thermometers expand and rises up, when the outside temperature is warm).
3. How does soil temperature change at different times of day? Why do you think this? Write this as your hypothesis.

Explore

1. Students should get in pairs.
2. Choose campus locations and different times of day to measure temperature. Leave thermometer for 5–10 minutes in each location (depending on type of thermometer), record the temperatures and time in the data table.
3. Repeat steps 2–4 with two other locations.
4. Calculate the average temperature of the soil at the different times of day.
5. Draw a graph of the average temperature of the soil over time labeling the axes. Add the line of best fit. Refer to the data analysis checklist in Appendix F for more specifics on this.
6. To calculate the slope, measure the change in y values and divide by the change in x values.
7. Create a scatter plot graph in Google Sheets with the time of day in the first column and the temperature in the second column. Insert the line of best fit with the equation of the line. The slope is the correlation coefficient if it is between -1 and 1. If the slope is positive, there is a positive correlation between time of day and temperature. If the slope is negative, there is a negative correlation between time of day and temperature. The steeper the slope, the greater the correlation.

Explain

1. Students analyze the data by creating a scatter plot graph with the line of best fit.
2. Explain the correlation between the temperature of the soil and the time of day.
3. What is the correlation coefficient?
4. How could this data affect the organisms that live in the ecosystem observed?

Elaborate

1. Put your data on the overall class spreadsheet.
2. Compare your results with other student data. How do these results compare?
3. Find the class average of the different locations.
4. Do you think that there is a relationship between the soil temperature and the organisms that live there? How might you investigate this relationship?

5. Research soil organisms at lifeunderyourfeet.org and write a paragraph on how abiotic factors affect organisms in the soil.

Evaluate

Teachers can evaluate students based on the Field Investigation Evaluation Rubric in Appendix B.

Resources

- https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280
- http://www.ctahr.hawaii.edu/mauisoil/a_profile.aspx
- http://www.lifeunderyourfeet.org

Time of Day and Temperature Observation Form

Location: _____

Date: _____ Time: _____

Description of site: _____

TIME OF DAY	TEMPERATURE OF SOIL (°C) IN LOCATION A	TEMPERATURE OF SOIL (°C) IN LOCATION B	TEMPERATURE OF SOIL (°C) IN LOCATION C	AVERAGE TEMPERATURE (°C)

FIELD SCIENCE INVESTIGATION LESSONS (UKA, KAI, WATERSHED)

DESCRIPTIVE FIELD INVESTIGATION: MAUKA BIODIVERSITY

Essential question: In this lesson, students answer the question: What biotic and abiotic factors influence biodiversity in dry or wet mauka areas?

The Biodiversity Mauka Investigation is a companion to the Schoolyard Biodiversity and Biodiversity Makai Investigation. Each uses the same biodiversity index.

Experimental question: What is the biodiversity of the mauka study area?

Student objective(s)

- Practice a sampling method to collect data in dryland or wetland mauka areas.
- Accurately record abiotic and biotic factors including species richness and evenness within a sampling site
- Use a simple biodiversity index to determine individual and whole class biodiversity of sample(s)
- Construct an evidence based explanation (claim, evidence and reasoning) to argue degree of biodiversity of individual sites and/or data across sites

Student performance expectation

Biodiversity Mauka addresses NGSS Middle School disciplinary core idea LS2: Interactions, Energy, and Dynamics Relationships in Ecosystems and/or High School disciplinary core idea LS2: Interdependent Relationships in Ecosystems. This investigation helps students answer the question, ***"How does a system of living and non-living things operate to meet the needs of the organisms in an ecosystem?"*** Additionally, the activities prepare students to meet performance expectation MS-LS2-5: ***Evaluate competing design solutions for maintaining biodiversity and ecosystem services*** and HS LS2-7 ***Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** The Biodiversity Mauka Investigation alone will not provide sufficient experiences to fully meet performance expectations. Instead, it provides foundational experiences across the 3-D framework necessary for further investigation.

Lesson duration: Three 60-minute class periods

Preparation time: 30 minutes (copying of materials, gathering materials)

Materials

Per student

- Clipboard
- Ruler
- Hand lens
- Paper or Observation Form

Per team

- Hula hoop or quadrat
- Thermometer
- BioKid App (optional)

Per class

- Field guides
- Access to Internet
- Soil moisture meter
- Measuring tape, string

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea MS – Ecosystems: Interactions, Energy, and Dynamics MS-LS2 HS – Interdependent Relationships in Ecosystems	A. Interdependent relationships in ecosystems B. Ecosystem dynamics, functioning and resilience C. Biodiversity and humans
Crosscutting concepts Connections to the Nature of Science	• Patterns • Cause and effect • Stability and change • Science addresses questions about the natural and material world
Science and engineering practices Connections to the Nature of Science	• Analyze and interpret data • Construct explanations and design solutions • Engage in argument from evidence • Scientific knowledge is based on empirical evidence (ecological sampling)
Common Core – ELA	RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. RI.8.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced. WHST.6-8.1 Write arguments focused on *discipline-specific content*. WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Common Core – Math	MP4 Models with mathematics 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. 6.EE.C.9 Represent and analyze quantitative relationships between dependent and independent variables. 6.SP.B.5 Summarize numerical data sets in relation to their context.

Background for teachers
Biodiversity can be defined on a variety of levels. Ecosystem biodiversity refers to the variety of habitats within a particular area or region. Species biodiversity describes the different kinds of plants and animals located within a particular habitat. On a more complex level, genetic biodiversity looks at the variety of characteristics within a particular species. The opposite of species diversity is monoculture. The term monoculture refers to a situation in which only one species occupies a particular area or region. Examples of man-made monocultures include lawns and farms (such as pineapple fields and papaya farms).

The Mauka Biodiversity Investigation focuses on species biodiversity. Researchers use the terms evenness and richness to describes species biodiversity. ***Species richness describes the number of different kinds of species*** (animals, plants, insects, etc.) in a given area, whereas ***species evenness is the number of individuals within each species in that same area***. The ratio of richness to evenness can be used to calculate a biodiversity index number helps researchers compare differences across study sites, habitats, and locations. See https://socratic.org/questions/whats-the-difference-between-species-richness-and-species-evenness for species richness and evenness information and graph examples.

Background on Hawai'i's dry forests
A Hawaiian dry forest consists of small trees, shrubs, and grasses and receives less than 127 cm (50 in) of rain per year. In Hawai'i, 90% of the plant species are native plants, and nearly 25% of them are found in the dry forest. On the island of Hawai`i, dry forests are found on the leeward side of the island. There are protected areas and natural reserves set up at different locations as attempts to save this highly endangered forest.

Hawaiian dry forests are one of the most critically endangered habitats in the world. The forest is highly degraded and its range has been reduced by 90%. The biggest problems for dry forests are fires and invasive grass. One grass that native Hawaiian plants cannot compete with after fires is fountain grass. Fountain grass is fire adapted and easily regenerates after wildfires, which native plants did not historically experience. Fountain grass also competes with native plants for light and water, and crowds out native seedlings. It provides a lot of fuel for wildfires because of the large clumps and bunches that form at the base of the grass. The most common way of controlling fountain grass is the use of herbicide as well as pulling it out of the ground, roots and all.

There are many threatened and endangered plants found in Hawaiian dry forests. Uhiuhi, a medium-sized tree up to 10 m (35 ft) tall, has dark, rough bark. Hawaiians used the wood from uhiuhi to make fishing supplies that sink rather than float because the wood is so dense. There are about 100 wild Uhiuhi left in the Hawaiian Islands. Lama is a small, slow growing tree that grows up to 35 feet tall and 10 feet wide. It grows on all of the Hawaiian Islands, mostly in dry forests, up to elevations of 4,000 ft. Traditionally, lama was used for medicine as well as for its wood, known as the Hawaiian ebony. Kokia is a small tree that is 4–10 m (13–35 ft) tall. It has showy flowers and star-shaped leaves, and is commonly used as a garden or ornamental plant. Traditionally, the sap of this tree was used to dye fishing nets red. There are only three wild kokia left, all in the North Kona district, and they are not naturally reproducing. Wiliwili grows 35–45 ft tall and has about the same width. The trunk and branches have a few short spines growing on them. It is one of Hawai'i's few deciduous trees, shedding its leaves in the summer in order to conserve water. Wiliwili blooms in the summer after it sheds its leaves and can flower through November. It has large, showy flowers that are curved and claw-shaped. They grow 2–5 cm (1–2 in) long and are usually orange, but can be different colors like red, peach, salmon, green, yellow, or white. Wiliwili wood was traditionally used for buoys for fishing and for the 'ama of a canoe. The seeds can also be used in lei. (From PRISM, 2007 https://hilo.hawaii.edu/affiliates/prism/documents/Dry_Forest_Lesson_1.pdf)

Background on Hawaiʻi's wet forests (montane/mesic forests)
Wet forests are tropical moist broadleaf ecoregions. Ecoregions are areas with similar climates, soil, and biodiversity. Tropical wet forests in Hawaiʻi are comprised of mixed mesic forests, rain forests, windward lowland and montane areas, as well as wet shrublands. They receive 3,000 to 11,250 mm (118 to 443 in) of rain per year. Common canopy vegetation found in wet forests are Koa and ʻōhiʻa lehua. Loulu fan palms often rise above the forest canopy while understory plants including apeʻape, ʻoha wai, hāhā, kāmakahala, kanawao, ʻākala, māmaki, and olonā lie low and cover the ground. Mosses and vines hang from trees in wet forests. Wet forests also harbor epiphytic flowering plants, meaning they grow on other plants. Early Hawaiians used the plants for food sources or medicinal purposes. Flowers were fed to children to cure constipation and pāʻaoʻao (illness causing physical weakness).

Wet forests can include wetlands such as swamps, ponds, marshes, and intertidal forest wetlands. They are located from 300 to 1,700 m above sea level. Kohala Mountain, on Hawaiʻi Island, possesses imperiled wet forest habitats on its windward side. One is the tropical montane bog, which is home to centuries-old trees and endangered species. Less than 100 acres remain of the montane bogs in the world. Another is the tropical montane cloud forest, which is laden with moss and slow-growing forest species. These forests collect up to 30% of their moisture from cloud drip. The tropical lowland wet forest has been altered by human disturbance and invasion of alien plants, so protecting these habitats are essential for the survival of many native species.

Coastal mesic forests are found 300 m above sea level and are home to kukui, hala, hau, ʻōhiʻa lehua, lama, and milo. Polynesian-introduced species including noni, pia, and ki are also found here. Mixed mesic forests are found at 750 to 1,250 m above sea level and include swamps, stream sides and bogs.

Wet forests do not have any native mammals, but are important to bird species like owls and waterfowl. The most popular bird species, most of which are endangered, are the Hawaiian goose (nēnē), Laysan duck, Koloa duck, moorhen, and Hawaiian coot.

Streams in wetland forests are also common breeding grounds for insects like the dragonfly and damselfly. The streams often house fish species, crustaceans, and mollusks.

Wet forests are important in naturally filtering water to trap sediment and nutrients. They not only prevent erosion and floods by retaining ground and surface water flow, but also provide water to the watershed through fog drip. The most common threats to Hawaiian wet forests are degradation and erosion due to feral animals. Diverting streamflow, recreational activities, and the introducing invasive species also pose threats to the survival of the ecosystem.

Sources
- https://www.worldwildlife.org/ecoregions/oc0106
- http://nativeplants.hawaii.edu/plant/view/Clermontia_arborescens_waihiae

Resources
- Last Stand: The Vanishing Hawaiian Forest (The Nature Conservancy)
  https://www.nature.org/media/hawaii/the-last-stand-hawaiian-forest.pdf
- Hawaiʻi Forest Institute
  https://www.hawaiiforestinstitute.org/

Procedure with Students

Engage

Video and reading
Show the video on Hawaiʻi Island ecosystems from Kumukahi (http://www.kumukahi.org/units/ka_honua/paeaina/hawaii). This six-minute video describes the districts of Hawaiʻi Island. Accompanying informational text provides additional information (readability is ~Grade 9). Teachers may need to modify the reading based on student ability.

Explain that an ecosystem is the set of all components, biotic (living) and abiotic (non-living), along with environmental factors that make up a living system. There are many relationships that happen in ecosystems that can affect types of species found in an area and population size. In this task, students investigate an undisturbed (as possible) ʻāina-based natural study area near the school. Typically undisturbed sites are more biodiverse than those modified by humans.

Divide students into three groups. Have each group use the video/reading to research the information about each district. A data collection sheet is provided in Appendix 1.

Class discussion

1. Choose two districts highlighted in the Kumukahi video. Use abiotic and biotic factors to describe similarities and/or differences in locations. Provide an example (e.g., description of Kohala abiotic and biotic factors… and Hilo abiotic and biotic factors has…) and then give students think time before eliciting student responses.
2. What makes the Hāmākua district unique? Use abiotic and biotic factors to describe a relationship (e.g., high cliffs provide nesting sites for koaʻe bird).
3. What abiotic and biotic factors influence how humans interact in different districts? As a class, provide one example from each of the six districts.

Show a map of Hawaiʻi Island. Explain to students they will be conducting a small-scale study in one of the districts of the island. Point out the district your sampling area is located in and ask students what abiotic and biotic features they might expect to see in this area. Ideas on human interaction might be discussed as well.

Explore

Students collect data on the total number of all species (evenness) and the number of different species (richness) in specified field study site. Students explore the question: **what is the biodiversity of the specified upland (mauka) field study site?**

1. In the classroom: review strategies for observing.
   Use four of the five senses (sight, hearing, touch, smell) to record observations (draw, use numbers, label diagrams, write a description). Model this with an object (e.g. leaf, twig, rock). Ask students to describe its physical properties and characteristics. To prompt student thinking model drawing and/or writing observations.
   - What does it look like? (e.g., size, shape, color)
   - What does it feel like? (e.g., texture, temperature)
   - What does it smell like?
   - What does it sound like?

   Don’t worry about making drawings beautiful; make them informative using as much detail and explanation as possible. Keep in mind that field guides compare types of organisms, not individuals. Drawings should highlight key features that distinguish species of grasses or insects (e.g. grass types or insect types), not individuals within the same species (individual grasses).

2. Practice making observations within transects and/or quadrat.
   A transect line is any line, marked at regular intervals, that is easy to use in the field. Transect lines can be purchased commercially, made from measuring tape or rope marked off at regular intervals. A quadrat is a

framed area. A frame can be made using PVC pipes, hula-hoops, wooden dowels or even cardboard. Use monofilament or string to section off the quadrat into a set number of squares, circles or intercepts. For an explanation of creating simple transects and/or quadrats go to: http://www.hawaii.edu/gk-12/opihi/classroom/measuring.pdf

3. Conduct field study
    a. Identify undisturbed field study site and set up sites (study areas) along transect/quadrat.
    b. Establish teams (student or teacher selected).
    c. Assign each team a study area.
    d. Review Field Study Observation Form or field notebooks (paper) to collect data.
    e. Review planning and protocols for entering a site. Ask students to stay calm and observe from a distance before approaching.
    f. Note abiotic factors within the site such as direct/indirect light from sun, location, time of day, moisture (arid, irrigated, temperature, etc.). Abiotic factors often contribute to explanations of the research question at hand.
    g. Have students identify and count the different number of species along the transect at prescribed intervals (e.g., one-meter intervals). Instruct each team to spend approximately 20 minutes observing and recording all of the animals and signs of animals in their study site during that time.
    h. Take a photo or make a drawing of the species (types of living things) you find.

Explain

1. Create a team summary of field study data
   Back in the classroom ask students to explain their ideas about collecting data from the field study site. Students can work alone or in small groups to consider one or more of the following questions.
    - What questions do I have about the data we collected?
    - What questions do I have about the way we gathered the data?
    - What other data or information might we need to collect or find?

Field Study Biodiversity Data Collection Form Team Summary

SUMMARY OF TEAM DATA	
Area surveyed: _____	
Number of different kinds of animals: _____	Total number of animals: _____
Number of kinds of plants: _____	Total number of plants: _____
Number of kinds of insects: _____	Total number of insects: _____
Total number of kinds of organisms: _____	Total number of organisms: _____

Option: Use field guides or electronic resources to research plants and animals.

Questions for their research might include:
- What is the name of this insect?
- What is the normal range of this animal?
- What are the habitat needs of a nēnē goose?

Resources
- Hawaiian Ethnobotany Online Database
  http://data.bishopmuseum.org/ethnobotanydb/ethnobotany.php?b=d&ID=ilima

- Organisms of Hawai‘i
  http://www.hear.org/images/organisms/hawaii/index.html
- Hawaiian Plants and Tropical Flowers
  http://wildlifeofhawaii.com/flowers/wildflower-and-plant-sites

2. Ask students to create bar graphs
   Each team creates their own graph to illustrate patterns in evenness and richness data from each of the field study site. Refer to the **Descriptive Field Investigation: Schoolyard Biodiversity** for an example of how to graph data. Students may need to review the difference between evenness and richness before beginning. Use this task to assess students' ability to construct and interpret graphs of the data they have collected (an important element of the NGSS practice "analyzing and interpreting data").

3. Collect and summarize class field study data
   Consolidate class data as a whole, noting discrepancies and fuller explanations to develop explanations and arguments later. Teacher can set up a template in Google Sheets and add student data as groups finish. Teams finishing early can work on identification.

SUMMARIZE THE CLASS DATA BELOW	
Number of different kinds of animals: _____	Total number of animals: _____
Number of kinds of plants: _____	Total number of plants: _____
Number of kinds of insects: _____	Total number of insects: _____
Total number of kinds of organisms: _____	Total number of organisms: _____

Discussion: Review the procedural issues of sampling. Gather ideas on how this "snapshot" of a sampling area supports descriptive analysis. Discuss how individual field site observation data and whole class data work together to create a fuller description of a "site."

Elaborate

Construct an explanation to support the question: **What is the biodiversity of the specified upland (mauka) field study site?** The explanation should include:

Claim: Directly responds to the question "What is the biodiversity of the specified upland (mauka) field study site?"

Evidence: Measurements and/or observations are relevant to the claim (uses summary class data)

Reasoning: Describes why there is enough evidence to support the claims
- Compare Mauka Biodiversity to Schoolyard Biodiversity or Makai Biodiversity sites, which is higher?
- Use scientific knowledge of the biodiversity index value to situate the sampling site within

Review how researchers use data on richness and evenness to calculate a biodiversity index. The Simplified Biodiversity Index is a decimal number between 0 and 1. The biodiversity index is calculated by dividing the species richness by the total amount of organisms. The closer the biodiversity index is to 1, the more the habitat is diverse and healthy (WDNR, 2005).
- Biodiversity Index value of 0 indicates no biodiversity
- Biodiversity Index value of 1 indicates high biodiversity
- Biodiversity Index value of 0.5 indicates area is relatively diverse

Refer to https://publicgardens.org/resources/field-investigations-using-outdoor-environments-foster-student-learning-scientific, pp. 13–14 for a full explanation of the procedure.

Evaluate

Individually construct an explanation based on team and/or whole class data.

- Write, draw or dictate an explanation. (Claim, Evidence, Reasoning – CER) (see Appendix C)
- Peer review explanations.
- Complete a final revision of the explanation.

Discussion

- What is the impact of abiotic factors on biodiversity. Verbally use the format of claim, evidence and reasoning to argue your case.
- How can you increase biodiversity?
- What impacts biodiversity?

Extension

Have students work in groups to create a scientific poster describing their investigation. Students can present their partners and practice speaking and listening skills.

Data Collection Sheet

Hawai‘i Island Ecosystem Regions
Abiotic and Biotic Factors Introduction

Essential question: How are the abiotic and biotic factors of our island districts similar and different?

Prediction: _____

_____

Important vocabulary
Ecosystem: _____

Abiotic: _____

Biotic: _____

DISTRICT	GROUP 1 ABIOTIC (non-living) CHARACTERISTICS	GROUP 2 BIOTIC (living) CHARACTERISTICS	GROUP 3 HOW HUMANS INTERACT WITH THE ECOSYSTEM
Hilo			
Puna			
Ka‘ū			
Kona			
Kohala			
Hāmākua			

Additional resource: https://www.hawaii-guide.com/big_island_of_hawaii/regions

Answer the essential question based on your new observations. Use new vocabulary in your paragraph:

_____

_____

_____

_____

Experimental question: What is the biodiversity of the mauka study area?

Prediction:

_____

_____

_____

_____

Wide-angle Observation (drawing and notes)

Field Study Observation Form

Location: _____

Abiotic data
Non-living Factors Found in the Sample Area

	ZONE 1	ZONE 2	ZONE 3
Time			
Temperature			
Location			
Human Impact			
Soil Moisture			

Biotic data

KIND (type) OF PLANTS OR ANIMALS OBSERVED	NAME, DESCRIPTION OR PICTURE (also see below for extra space)	HOW MANY	COMMENTS

SUMMARIZE THE CLASS DATA BELOW	
Number of kinds of animals: _____	Total number of animals: _____
Number of kinds of plants: _____	Total number of plants: _____
Number of kinds of insects: _____	Total number of insects: _____
Total number of kinds of organisms: _____	Total number of organisms: _____

Calculate the Biodiversity Index

The Simplified Biodiversity Index is a decimal number between 0 and 1. The biodiversity index is calculated by dividing the species richness by the total amount of organisms. The closer the biodiversity index is to 1, the more the habitat is diverse and healthy (WDNR, 2005).

- Biodiversity Index value of 0 indicates no biodiversity
- Biodiversity Index value of 1 indicates high biodiversity
- Biodiversity Index value of 0.5 indicates area is relatively diverse

Show your work below:

DESCRIPTIVE FIELD INVESTIGATION: TIDE POOL BIODIVERSITY

Essential question: How does biodiversity change dependent on living and nonliving variables in a tide pool.

Experimental question: What is the biodiversity of a tide pool study site?

Student objectives
Students will be able to observe and document tide pool biodiversity, and recognize distinguishing features among species.

Student performance outcome
Students complete a descriptive field investigation in a tide pool (observe and record), construct an evidence based explanation, calculate biodiversity of the tide pool, and use argumentation skills to defend a conclusion.

Suggested time required
Preparation: 40 minutes
Lesson: Three class periods (30 min. introduction and data collection methods; 30 min. for data collection; 45 min. for data analysis)

Materials

Per student
- Clipboard
- Ruler
- Paper (data sheet or write in the rain paper)
- Hand lenses (optional)

Per pair of students
- Transect tape (or meter stick, tape measure, marked rope, ruler.)
- Ruler
- Hula hoop or quadrat
- Colored pencils (optional)

Per class
- Field (ID) guides
- Internet access (optional)

Next Generation Science Standards

CONNECTIONS TO THE 3 DIMENSIONS OF NGSS	
Disciplinary core idea	Interdependent Relationships in Ecosystems: Resilience • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)
Crosscutting concepts	Systems and system models, Patterns
Science and engineering practice	Use models, construct evidence-based explanations, and use argumentation from evidence.
Performance expectations	Students articulate a statement that relates the given phenomenon to a scientific idea. Students use evidence and reasoning to construct an explanation for the given phenomenon.
Common Core State Standards	

Common Core – ELA	RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. RI.8.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced WHST.6-8.1 Write arguments focused on *discipline-specific content.* WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
Common Core – Math	MP4 Models with mathematics 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems 6.EE.C.9 Represent and analyze quantitative relationships between dependent and independent variables. 6.SP.B.5 Summarize numerical data sets in relation to their context

Background for teachers

- http://sciencenetlinks.com/lessons/introducing-biodiversity/
- http://www.teacherstryscience.org/ngsslp/backyard-biodiversity-ngss

Biodiversity

What is it?

Biodiversity can be defined on a variety of levels. Ecosystem biodiversity refers to the variety of habitats within a particular area or region. Species biodiversity describes the different kinds of plants and animals located within a particular habitat. On a more complex level, genetic biodiversity looks at the variety of characteristics within a particular species. The opposite of species diversity is monoculture. The term monoculture refers to a situation in which only one species occupies a particular area or region. Examples of man-made monocultures include lawns and farms (such as pineapple fields and papaya farms).

The Tide Pool Biodiversity Investigation focuses on species biodiversity. Researchers measure species richness and evenness to measure biodiversity. Species richness describes the number of different kinds of organisms present in a particular area (animals, plants, insects, etc.) or the total number of different species. Whereas species evenness is the relative abundance of the different species making up the richness of an area. Evenness compares the similarity of the population size of each of the species present. The ratio of richness to evenness gives the biodiversity index number. The Biodiversity Index number helps researchers compare differences across study sites, habitats, and locations. As species richness and evenness increase, so diversity increases

Why is biodiversity important?
Habitats that have a greater variety of different species of plants and animals have a greater biodiversity. These habitats are also healthier and more stable. One reason diverse communities have greater levels of health is that organisms of the same species tend to be more spread out. This reduces the ability of a disease to spread throughout a habitat. Additionally, if a certain type of species of tree or plant does become infected, the other species will remain and continue to provide the habitat components for the organisms in that area.

In an area consisting of monoculture, an area with only one type of plant species growing, the plants are more susceptible to disease and other stresses because they are all the same and less spread out (no other types of plants between them). As a result, the entire habitat can be dramatically altered when impacted by disease or other stresses. Human-made monocultures (crops, etc.) are created to make harvesting easier. However, they typically require larger amounts of pesticides and herbicides (to prevent diseases and/or "weeds") and larger amounts of energy and labor to maintain before harvesting.

Background for students
Video
Show one of the following (or other) video on biodiversity. Ask students to look for words and ideas that define biodiversity.

- Why is biodiversity so important? – TED Ed
  http://thekidshouldseethis.com/post/why-is-biodiversity-so-important-ted-ed
- Learning to protect biodiversity
  https://www.youtube.com/watch?v=kHhspf5IfdE

Vocabulary

- *Tide Pool* – a pool of water remaining on a reef, shore platform, or beach after the tide has receded
- *Intertidal Zone* – of or relating to the littoral region that is above the low-water mark and below the high-water mark
- *Biodiversity* – diversity among and within plant and animal species in an environment
- *Adaptation* – The adjustment or changes in behavior, physiology, and structure of an organism to become more suited to an environment.
- *Salinity* – the concentration of dissolved salts in water etc., usually expressed in parts per thousand by weight.
- *pH* – pH is a measure of hydrogen ion concentration; a measure of the acidity or alkalinity of a solution. Aqueous solutions at 25°C with a pH less than seven are acidic, while those with a pH greater than seven are basic or alkaline.
- *Abundance* – the quantity or amount of something, e.g., a chemical element or an animal or plant species, present in a particular area, volume, sample, etc.
- Scientific classification
  - *Phylum Echinodermata* – A phylum of marine invertebrates which includes starfishes, sea urchins, brittlestars, crinoids, and sea cucumbers. They have radial symmetry, a calcareous skeleton, and tube feet operated by fluid pressure.
  - *Phylum Arthropoda:* Arthropods are the largest and most diverse group in the animal kingdom. Included in this group are crustaceans (shrimp, lobsters, crabs and barnacles). Bilaterally symmetrical, arthropod bodies are divided into sections, with numerous jointed appendages such as walking legs, claws, antennae or mouthparts.
  - *Phylum Mollusca* – Snails, Clams, Mussels, Octopus. Soft, legless, bilaterally symmetrical animals that usually secrete calcium carbonate shells. Largest group of animals in the sea. Have a muscular foot

for locomotion and a radula.
  - *Invertebrate* – an animal lacking a backbone, such as an arthropod, mollusk, annelid, etc.
  - *Vertebrate* – an animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.
  - *Algae* – a simple nonflowering plant of a large group that includes the seaweeds and many single-celled forms. Algae contain chlorophyll but lack true stems, roots, leaves, and vascular tissue.
- *Correlate* – have a mutual relationship or connection, in which one thing affects or depends on another.

Resources

- TKC Tide Pool and Invert Phylum Intro https://docs.google.com/document/d/1jPNNwfEHZkzR5BDv5Z_e_qUI9cr8OWnm3w3d9EZSuKA/edit
- DLNR Tide Pool ID https://dlnr.hawaii.gov/dar/files/2014/04/tidepool.pdf
- Background content and videos on the intertidal zone http://www.untamedscience.com/biology/biomes/intertidal-zone-aquatic-biome/
- Additional background lessons on the intertidal zone (place-based for Hawaiʻi) http://www.hoikecurriculum.org/unit/on-the-edge-living-in-the-intertidal-zone/

Data analysis

- *Biodiversity Index used in this lesson called:* Descriptive Field Investigation: Schoolyard Biodiversity https://publicgardens.org/resources/field-investigations-using-outdoor-environments-foster-student-learning-scientific

Engage (indoors)

Share the Intro to Tide Pools handouts linked above and below:

- TKC Tide Pool and Invert Phylum Intro https://docs.google.com/document/d/1jPNNwfEHZkzR5BDv5Z_e_qUI9cr8OWnm3w3d9EZSuKA/edit
- DLNR Tide Pool ID https://dlnr.hawaii.gov/dar/files/2014/04/tidepool.pdf

1. Begin by asking, "What is the intertidal zone?" show students "The Intertidal": https://www.youtube.com/watch?v=DR1gP5S6Bsk
2. What challenges do animals living in this zone have to face? (water loss, higher temperature, increased or decreased salinity, wave action).
3. How might tide pool species be adapted to living in these environments?
   a. ***Water loss:*** dry up or "desiccate": either run and hide (crabs, snails), tide pools are great places to hide, or they "clam up" close a shell to retain water, some just allow themselves to dry out, some seaweeds/chitons can withstand 75% water loss.
   b. ***Temperature/salinity:*** sea temp relatively constant and mild, air temps are much more extreme, most intertidal inverts can tolerate more extreme variations. Move to moist damp places, ridges help snails lose extra heat, More fresh water from rain etc.: many just close shells.
   c. ***Feeding restriction:*** not a lot of sediment can accumulate so not many deposit feeders, instead most are filter feeders- need to be underwater to filter so many grow more slowly than if they were elsewhere. Mobile animals are usually grazers that scrape algae, bacteria and other food.
   d. ***Waves:*** impact varies along shoreline, not as much impact in a bay, organisms exposed to waves anchor themselves to rocks, seaweeds/algae use holdfasts or encrust, mussels hold on with their byssal threads, thicker shells, low profiles.
4. Share how different species thrive in different parts of the intertidal zone.
5. How diverse are Hawaiian tide pools?
6. How can we determine the biodiversity of a tide pool?

Safety talk

1. Need to be extra careful in tide pools. Wear reef shoes if you have them or can borrow.
2. Make sure no high surf warnings and that it will be low tide. Always keep an eye out for large waves.
3. Train students how to flip rocks carefully and slowly to minimize disturbing the animals and always flip rocks back over exactly where you found them. Most tide pool invertebrates are nocturnal and hide under rocks during the day.
4. Train students how to handle animals carefully and keep them in the water as much as possible. Do not squeeze animals, hold them gently and with support so they won't fall and get injured.
5. Show students pictures of poisonous DO NOT TOUCH animals like fireworms and cone snails (see DLNR ID sheet)

Explore (outdoors)

Write the investigative question on the board: "How biodiverse are Hawaiian tide pools in our study area?"

Collect data on the number of different animals or species (richness) and the number of individuals of each species (richness) in specified tide pools.

1. Divide the class into pairs and give each pair a transect tape and a quadrat.
2. Students (with teacher assistance) select a tide pool that contains animals and place the transect tape across the tide pool (parallel to the shoreline). Have students identify and count the different number of species and number of individuals of each species along the transect. If there is time, have students use ID resources to identify species, if not, have students come up with names of different species along the transect, such as: "pink rocky stuff" or "black and white wana" or "skinny starfish". As they ID or name the different species, have them count the number of each individual they find along the transect. Model this set up in the classroom before going outside.
3. Students record observations using written words/phrases, drawings, labeled diagrams, and numbers to describe the area along the transect line on the Tide Pool Study Observation Form.
4. Use field guides or electronic resources to research plants and animals. (can be done in the classroom)
    - Tide Pool Identification sheet (print on waterproof paper or laminate) https://dlnr.hawaii.gov/dar/files/2014/04/tidepool.pdf
    - Waikīkī Aquarium ID website http://www.waikikiaquarium.org/experience/animal-guide/
    - Photographs by Keoki and Yuko Stender http://www.marinelifephotography.com/marine/marine.htm
    - Black and white drawings of Hawaiʻi intertidal species http://tammyyee.com/origami-n-stuff4kids/coloring/hawaiiintertidal144.jpg

Questions for their research might include:

- What is the name of this invertebrate?
- What is the normal range of this animal?
- What is this tide pool species habitat needs?
- Where could we find a more biodiverse tide pool?

Formative assessment

Wrap up targeted field investigation by asking students to refer back to the investigative question and revise their explanation by adding more evidence, or examples from researching their species. The teacher should review the explanations, select one or two that are approaching expectation, and invite the class to discuss how the explanation could be improved (consider using a science journal or data log book). An example follows:

- Claim: The tide pool we studied *is or is not* (choose one) biodiverse.
- Evidence: During field study we found evidence of…
- Reasoning: Scientifically speaking, an area is considered biodiverse if… and our study area met this definition in the following way (extended reasoning).

Explain

1. Elicit students' ideas about collecting tide pool data. Students can work alone or in small groups to consider one or more of the following questions.
    a. What questions do I have about the data we collected?
    b. What questions do I have about the way we gathered the data?
    c. What other data or information might we need to collect or find?
    d. What patterns did I notice between the tide pools we studied? What similarities and differences did I notice?
    e. How does this data help me to understand the entire system?
    f. Did I identify any problems that might need to be solved?
    g. What land uses mauka of this site might impacts this ecosystem?
2. Introduce and explain what a biodiversity index is and how it is used. Also referred to and taught in another lesson in this guide called *Descriptive Field Investigation: Schoolyard Biodiversity.* Detailed background information can be found above and here: https://publicgardens.org/resources/field-investigations-using-outdoor-environments-foster-student-learning-scientific
    a. Introduce the term Biodiversity Index to the students. Discuss the purpose of placing a numerical value on the biodiversity of an area (to compare with other areas, to determine changes over time, to determine how to manage a site, etc.) Discuss that species richness and species evenness are used to measure biodiversity. If desired, also discuss random sampling and how scientists frequently cannot count every plant or animal in an area. Explain that instead they use various techniques to take samples of data (counting in a certain area) and then average those samples.
    b. Pass out copies or have the students set up a chart like the one below. Create the same table on the board.

Sample Biodiversity Data Collection Chart Habitat

TALLY OF DIFFERENT SPECIES	TALLY OF EACH SPECIES FOUND (species richness)	SPECIES #:TALLY (of individuals for each species) (species evenness)	TOTAL NUMBER OF ALL INDIVIDUALS FOUND	DIVERSITY INDEX # OF SPECIES/ TOTAL NUMBER OF INDIVIDUALS
Example	I I I I (4 different species counted)	Species 1: I I I (3) Species 2: I I I I (4) Species 3: I (1) Species 4: I I I (3)	11	4/11 = .3636
Tide Pool A				

3. Calculate biodiversity of the tide pool using the Biodiversity Index. The Simplified Biodiversity Index is a decimal number between 0 and 1. The closer the biodiversity index is to 1, the more the habitat is diverse and healthy (WDNR, 2005).
    - Biodiversity Index value of 0 indicates no biodiversity
    - Biodiversity Index value of 1 indicates high biodiversity
    - Biodiversity Index value of 0.5 indicates area is relatively diverse
    - Biodiversity Index of a healthy forest would typically range around 0.7–0.8. Biodiversity Index of an agricultural field would typically range from 0.02 or less.

Elaborate

Ask students to refer back to the investigative question and revise their explanation by adding more evidence, or examples from researching their species. The teacher should review the explanations, select one or two that are approaching expectation, and invite the class to discuss how the explanation could be improved. An example follows:

- Claim: This tide pool *is or is not* (choose one) biodiverse.
- Evidence: During field study we found evidence of…
- Reasoning: Scientifically speaking, an area is considered biodiverse if… and our study area met this definition in the following way (extended reasoning).

Evaluate

Invite students to do a final revision on their question. Repeat the Think-Pair-Share activity from the Engage part of the lesson.

Think-Pair-Share

- ***Think:*** Ask students to choose one of the following responses and think about how to answer the question "Is this tide pool biodiverse?" Students can write or draw their answers (worksheet, journal, or scratch paper).
  - The tide pool IS diverse because (provide evidence)
  - The tide pool IS NOT diverse because (provide evidence)
- ***Pair:*** Have students discuss their ideas with a partner. Answers should include a claim (is or is not), evidence (data based on their initial ideas about what species are found in the tide pool), and reasoning (connected to something they learned from the video).
- ***Share:*** Take a census of class. Is = ?? Is not = ??

Summative assessment

Have students present the diversity of one tide pool they studied to the class. Students can take pictures to show peers where the data came from and use science journals or data log books to take notes. Students can compare the biodiversity between their tide pools.

Extension

Have students work in groups to create a scientific poster describing their investigation. Students can present to their partners and practice speaking and listening skills.

What impacts biodiversity in tide pools?

- What are the tide pool species habitat needs?
- Where could we find a more biodiverse tide pool?

How are different places identifying biodiversity issues? Example: Hakalau NWR planting more trees and endangered shrubs to provide more food sources and habitat to support diverse bird species.

Observation form background

Have students use transects to measure tide pools and record GPS of where they started and compass direction

Moon phase information

http://www.kamehamehapublishing.org/_assets/publishing/multimedia/apps/mooncalendar/index.html

Tide Pool Study Observation Form

Take a lot of photos to help document the site. Modify data sheets for your student and site needs

Location: _____

Date: _____ Time: _____

Low Tide Time: _____

Teacher Name: _____

Student Name: _____

Weather conditions

Temperature: _____ Average Wave Height (ft): _____

Wind speed (Beaufort scale, mph, average): _____

0–1 (calm); 1–3 (light air); 4–7 (light breeze, wind felt on face, leaves rustle); 8–12 (gentle breeze, leaves in constant motion); 13–18 (moderate breeze, raises dust and loose paper, small branches move); 19–24 (fresh breeze, small trees sway); 25–31 (strong breeze, large branches move, hard to use umbrella); 32–38 (near gale, whole trees move); 39–46 (gale, wind impedes walking)

Cloud Cover: _____ (estimate percent): _____

Other Observations (seasonal, evidence of stressful events): _____

_____

Moon phase: _____

Tide Pool Surveyed (location details): _____

Describe Tide Pool Physical Characteristics (e.g., size; bottom is sandy, rocky, lava): _____

_____

Other Observations (seasonal, evidence of stressful events): _____

_____

After you have collected data on the transect, fill in the two charts below with all of the species you found and the number of each. For instance, you may have found 3 ʻaʻama or rock crabs.

SPECIES	TALLY OF NUMBER OF TIMES FOUND ALONG TRANSECT	TOTAL NUMBER OF TIMES FOUND ALONG TRANSECT
Total species along transect		**Total number of all organisms found (species abundance)**
Biodiversity index = # of species/ total organisms	**BI =**	

Biodiversity Index

Tally up all of the species you found.

TALLY OF DIFFERENT SPECIES	TALLY OF EACH SPECIES FOUND (species richness)	SPECIES #: TALLY (of individuals for each species) (species evenness)	TOTAL NUMBER OF ALL SPECIES FOUND	BIODIVERSITY INDEX # OF SPECIES/ TOTAL NUMBER OF INDIVIDUALS
Example	I I I I (4 different species counted)	Species 1: I I I (3) Species 2: I I I I (4) Species 3: I (1) Species 4: I I I (3)	11	4/11 = .3636
Tide pool A				
Tide pool B				
Tide pool C				

Adapt this diagram as needed. On the following diagram, write the names of the species found along your transect, and where you found them. Orient the transect line parallel to the shoreline. Observe species along each meter (or every 2 meters if a large tide pool) and a meter to the left and right of the transect line. This diagram is an exact model of the transect line. Please mark the location and name of each species you find with a circle or dot. Feel free to use abbreviations or made up names. The object is to know how many DIFFERENT SPECIES you find along the transect. If there are a large number of individuals, estimate the total number and circle the area on the diagram and label.

1 METER TO LEFT		1 METER TO RIGHT
Meter 1	**transect line**	
Meter 2		
Meter 3		
Meter 4		
Meter 5		

On back: Draw picture of site, including transect location(s) and habitat observations at each transect point

Hawai‘i Island Ecosystem Regions Abiotic and Biotic Factors Introduction

Essential question: How are the abiotic and biotic factors of our island districts similar and different?

Prediction: _____

_____

Important vocabulary

Ecosystem: _____

Abiotic: _____

Biotic: _____

DISTRICT	GROUP 1 ABIOTIC (non-living) CHARACTERISTICS	GROUP 2 BIOTIC (living) CHARACTERISTICS	GROUP 3 HOW HUMANS INTERACT WITH THE ECOSYSTEM
Hilo			
Puna			
Ka‘ū			
Kona			
Kohala			
Hāmākua			

Additional resource: https://www.hawaii-guide.com/big_island_of_hawaii/regions

Answer the essential question based on your new observations. Use new vocabulary in your paragraph: _____

_____

_____

Experimental question: What is the biodiversity of the mauka study area?

Prediction: _____

_____

_____

Wide-angle Observation (drawing and notes)

Abiotic/Biotic Field Study Observation Form

Location: _____

KIND (type) OF PLANTS OR ANIMALS OBSERVED	NAME, DESCRIPTION OR PICTURE (also see below for extra space)	HOW MANY	COMMENTS

SUMMARIZE THE CLASS DATA BELOW	
Number of kinds of animals: _____	Total number of animals: _____
Number of kinds of plants: _____	Total number of plants: _____
Number of kinds of insects: _____	Total number of insects: _____
Total number of kinds of organisms: _____	Total number of organisms: _____

Calculate the Biodiversity Index

The Simplified Biodiversity Index is a decimal number between 0 and 1. The biodiversity index is calculated by dividing the species richness by the total amount of organisms. The closer the biodiversity index is to 1, the more the habitat is diverse and healthy (WDNR, 2005).

- Biodiversity Index value of 0 indicates no biodiversity
- Biodiversity Index value of 1 indicates high biodiversity
- Biodiversity Index value of 0.5 indicates area is relatively diverse

Show your work below:

Introduction to Tide Pools

The intertidal zone is the shoreline between the high- and low-tide marks. It is the only part of the marine world that faces regular exposure to air (emersion).

Rocky shores generally occur on steep geologically young coasts—they are often geographically isolated and have lots of endemic species.

Most rocky intertidal organisms live right on the rock's surface. Living on the rock's surface subjects them to great physical stress.

Air is much harsher than the water.

The higher organisms live in the intertidal zone, the more time they spend out of water.

Water loss: dry up or "desiccate": either run and hide (crabs, snails), tide pools are great places to hide, or they "clam up" close a shell to retain water, some just allow themselves to dry out, some seaweeds/chitons can withstand 75% water loss.

Temperature/salinity: sea temp relatively constant and mild, air temps are much more extreme, most intertidal inverts can tolerate more extreme variations

- Move to moist damp places, ridges help snails lose extra heat,
- More fresh water from rain, etc.: many just close shells

Feeding restriction: not a lot of sediment can accumulate so not many deposit feeders, instead most are filter feeders: need to be underwater to filter so many grow more slowly than if they were elsewhere

- Mobile animals are usually grazers that scrape algae, bacteria and other food

Waves: impact varies along shoreline, not as much impact in a bay, organisms exposed to waves anchor themselves to rocks, seaweeds/algae use holdfasts or encrust, mussels hold on with their byssal threads, thicker shells, low profiles

For those that have adapted to physical extremes, the rocky intertidal can be good to live. Lots of light and nutrients for photosynthesis. Intertidal populations usually limited by space, not food and nutrients.

Introduction to Invertebrates

Animals without a backbone, 95% of all species on earth, enormous variety especially in the sea, 20% of Hawaiian marine invertebrates are endemic.

Classify animals into broad categories called phyla on the basis of overall body plan:
1. ***Radially:*** wheel shaped symmetry
2. ***Bilaterally symmetric:*** left and right, top and bottom, front and back

There are 30–33 named phyla of multi-celled animals, all except Chordata consist entirely of invertebrates. Marine invertebrates generally are most active at night.

Phylum Porifera: Sponges
Very primitive animals, have no true tissue or organs and live glued to rocks. Most sponges are marine. A sponge is covered with tiny pores and usually has a large hole on the top. Water enters the body through the pores and exits through the large hole. The oxygen needed for respiration is supplied by this continual current of water. Tiny structures called spicules are scattered in the body to give sponges rigidity. They can be upright and branching or attached and encrusting. Most are bright colors: blue, orange yellow etc.

Phylum Cnidaria: Corals, Sea Anemones, Jellyfish
Simple multi-celled animals, Cnidarians body is basic with a mouth and stomach but no anus at all. Most are carnivores and many secrete an external skeleton to protect their soft body. Members of the phylum Cnidaria, are radially symmetrical with tentacles in multiples of 4 or 6 around a central mouth and stinging tentacles. Lack true organs but have specialized tissues to carry out life functions. Cnidarians capture food with tiny stinging capsules, called cnidae or nematocysts, within specialized cells, called cnidocytes, on the tentacles. Food captured by tentacles that ring the mouth enters the stomach cavity, and when the food is finally digested the remnants are expelled through the mouth. Their life cycle alternates between two adult body forms, the polyp and the medusa. Polyps are fixed in place while medusae are free swimming. Corals have lost medusa stage and exist as polyps only. The current name of the phylum "Cnidaria" emphasizes the importance of the stinging cells for the biology of this entire group of animals, and this name has replaced the more familiar phylum name Coelenterata.

Phylum Platyhelminthes: Flatworms
Simplest worms, bilaterally symmetrical, hermaphroditic. Most are nocturnal or cryptic. Many are symbiotic or parasitic. They are soft bodied, breathe through their body surface, have no body cavity and have rudimentary nervous and digestive systems. They are often brightly colored. Swim by undulating sides, crawl using hairs on undersurface.

Phylum Mollusca: Snails, Clams, Mussels, Octopi
Soft, legless, bilaterally symmetrical animals that usually secrete calcium carbonate shells. 85,000–110,000 species, largest group of animals in the sea, 20% of Hawaiian mollusks are endemic. Unique, well defined organs and complex sensory, circulatory, digestive and reproductive systems. Have a muscular foot for locomotion and a radula, a tongue-like chitonous feeding apparatus studded with tiny teeth. Gills are housed in the mantle cavity, a fleshy fold of the body wall that encompasses the body and secretes the shell.

Phylum Annelida: Segmented Worms
Elongate worms with bodies divided by segments. Have unique body plans. Bilaterally symmetrical, move by using hydraulic pressure. Muscles are located in the tube-like body wall. When these muscles contract they increase the hydraulic pressure of the body fluids inside the worm's body, extending the front end of the worm and permitting it to squeeze through holes between rocks and to burrow in the soil. Often buried in hard substrates or sediment with only tentacular plumes visible.

Phylum Arthropoda: Crabs, Shrimp, Lobster, Barnacles
Arthropods are the largest and most diverse group in the animal kingdom. Included in this group are crustaceans (shrimp, lobsters, crabs and barnacles). Crustaceans have well-developed organ systems. Bilaterally symmetrical, arthropod bodies are divided into sections. Bodies can be short or elongate, with numerous jointed appendages such as walking legs, claws, antennae or mouthparts. Bodies are generally divided into three regions (head, thorax, and

abdomen or tail). Arthropods have external skeletons made of an animal plastic called chitin. In order for the animal to grow, this exoskeleton is periodically shed in the process of molting.

Phylum Echinodermata: Sea Stars, Urchins, Brittlestars, Cucumbers
Echinoderm bodies exhibit radial symmetry (wheel-shaped pattern) divided into five parts or having five lines radiating from a central point. They have a 'water vascular system' a complex of water-filled reservoirs and canals ending in multitudes of hollow tube feet, used for locomotion, feeding and sometimes respiration. The skeletons of echinoderms are internal structures of carbonate. Sea urchins have rigid skeletons, with the mouth opening on the lower surface, called the "oral side", next to the surface of the sea floor, and with the anus upward, on the top of the body, called the "aboral" side. Sea cucumbers have tiny skeletal elements and a flexible body wall, but they are oriented differently, moving across the sea floor like huge worms, with the mouth, or oral end, at the front and the aboral end, with the anus, at the rear.

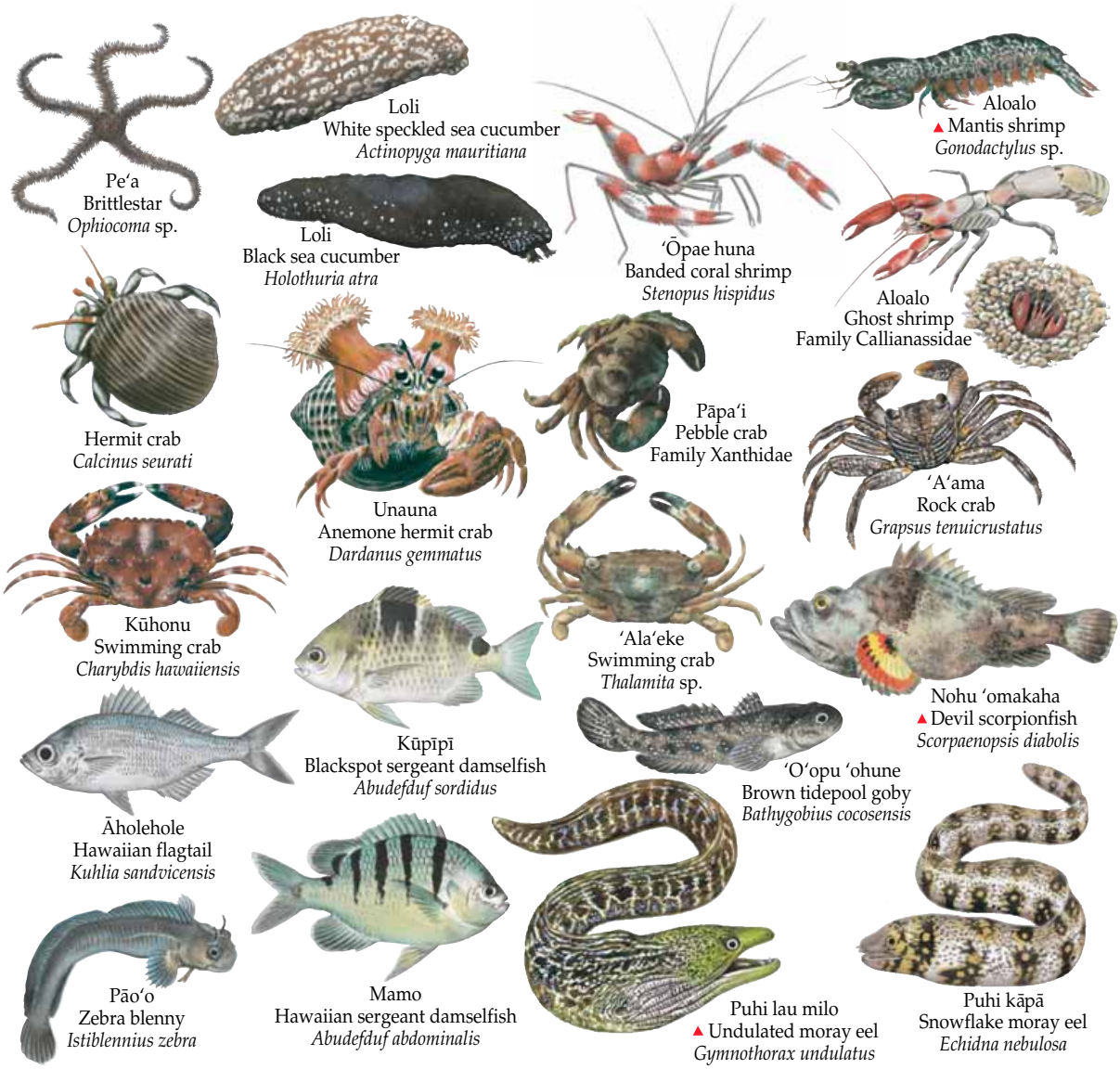
Phylum Chordata: Tunicates
Tunicates are filter-feeding animals that as adults either attach permanently to hard substrates or drift in open ocean. They may be solitary or colonial. Tunicate bodies are complicated and evolutionarily advanced. Most have larvae that resemble tiny tadpoles, complete with gill slits, muscular tail and "backbone" consisting of a stiff rod and a nerve cord. As adults, most lose these vertebrate like characteristics. The body of an adult tunicate is quite simple, being essentially a sack with two siphons through which water enters and exits. Water is filtered inside the sack-shaped body. Their bodies are pierced by numerous pores and the body wall feels smooth to the touch. There are four classes of tunicates.

Invertebrate Phyla

Hawai'i Coral Reef Network: ***http://www.coralreefnetwork.com/marlife/inverts/inverts.htm***

	**Phylum Porifera – sponges** Simple encrusting or vase-shaped bodies perforated with numerous pores; colors often bright reds, yellows, and oranges.
	**Phylum Cnidaria – corals and anemones** Radially symmetric cup-like polyps or medusae; ring of tentacles surround mouth; often with calcareous exoskeleton.
	**Phylum Platyhelminthes – flatworms** Dorso-ventrally flattened worms; lacking dorsal or lateral gills; often brightly colored.
	**Phylum Mollusca – snails, clams, octopus** Shelled animals, often crawling on a muscular foot; gills housed in a mantle cavity; radula feeding apparatus; also includes non-shelled octopus and squids.
	**Phylum Annelida – segmented worms** Elongate worms with bodies divided by segments; worms often buried in hard substrates or sediment with only tentacular plumes visible.
	**Phylum Arthropoda – crabs, shrimp, lobsters** Jointed appendages encased in carapace; body short or elongated, often with numerous jointed appendages such as walking legs, claws , antennae or mouthparts.
	**Phylum Echinodermata – seastars, urchins, brittlestars, cucumbers** Radially symmetric with internal skeletons; body often covered with spines and tube feet.
	**Phylum Chordata – non-vertebrate sea squirts** Usually encrusting, sponge-like filter feeders; body pierced by numerous pores; body wall feels smooth to the touch.

Hawaiian Tidepool and Shallow Reef Identification



Safety First!

- Check water conditions - watch out for strong surf and currents.
- Wear proper footgear with grip on soles - fishermen's tabis are best; old sneakers, reef shoes and diving booties are okay. DO NOT wear rubber slippers or sandals.
- Beware of sharp or slippery rocks.
- Walk slowly and watch for holes, crevices and drop-offs on the reef.
- Don't put your hands or feet in holes or under ledges where you can't see.
- ▲ Be careful of dangerous marine life, particularly those shown on this card.
- If you don't know what something is, don't touch it.
- Protect yourself from the sun.

Be a Good Reef Visitor!

- Walk carefully and watch your step - use your lookbox; many sea creatures are fragile and you could crush them.
- Move slowly so you see more.
- Look more than you touch - try not to disturb creatures or their living places.
- If you touch, do it gently - use just one finger, and always keep animals in the water.
- Return rocks to their original positions.
- Leave animals where you found them, and please don't collect unnecessarily.
- If you pick seaweeds, pinch, don't pull.
- Collect trash - leave the area cleaner than when you arrived.

Produced by the Education Program
Division of Aquatic Resources
Department of Land and Natural Resources
in association with the Waikīkī Aquarium

Funded in part by the Federal Aid in Sport Fish Restoration Program through your purchase of fishing equipment and motor boat fuels.

Designed & illustrated by Les Hata

COMPARATIVE[10] FIELD INVESTIGATION: WATER QUALITY STUDY (MAUKA)

Essential question: How do human activities in our watershed affect water quality?

Student objectives
Students will:

- Plan and carry out an investigation on water quality in their watershed;
- Analyze and interpret their data;
- Write an argument/explanation using data as evidence.

Student outcomes
I can work collaboratively to plan and carry out an investigation on water quality in my watershed. I can analyze the water quality data from streams in my watershed to provide evidence in constructing an argument/explanation for why or why not differences occur.

Lesson duration: Three class periods; one field day

Preparation time: Varies with experience

Materials

- Clipboards
- Kilo Kahawai Worksheets
- Water Quality Properties Worksheets
- Sampling containers
- Waste container
- Writing utensils
- Graph paper
- Water Quality Monitoring Kit http://www.lamotte.com/en/education/water-monitoring/3-5886.html
- Water Quality Sampling Procedures http://betterlesson.com/lesson/resource/3253702/testing-directions-and-data-table?from=resource_title

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea *ESS3.C: Human Impacts on Earth Systems* Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	Students compare water quality of streams of varying stream order to investigate how human activities are changing environments and impacting other living things. This is a foundational activity for understanding in this DCI and can connect to the following NGSS Performance Expectations: MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
Crosscutting concepts • Patterns • Cause and Effect • Systems and system models • Stability and Change	• Students look for patterns in their data and consider reasons for results including human impacts on a natural system. • Students collect field data to see how increasing stream order affects water quality. • Students learn about community impacts on their watershed and other living things.

[10] Note: If limited to one site, this investigation can be modified into a descriptive field investigation; if number of sites/samples is increased, this investigation can be modified into a correlative field investigation.

Science and engineering practice • Planning and carrying out investigations • Analyzing and interpreting data • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	• Students plan and carry out an investigation to answer the question, "Is there a difference in water quality among streams of varying stream order?" • Students analyze and interpret their data. • Students use the Claim, Evidence, Reasoning framework to construct an evidence-based argument/explanation to answer their research question. • Students use their evaluation to communicate their findings to others.
Common Core State Standards	**Connections to Common Core State Standards (CCSS)**
Common Core – ELA http://www.corestandards.org/wp-content/uploads/ELA_Standards1.pdf	This lesson can connect to standards within the following anchor standards for writing: • Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence. • Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
Common Core – Math http://www.corestandards.org/wp-content/uploads/Math_Standards1.pdf	If the number of sample sites/samples is increased, this lesson can be easily modified to connect to Grade 6 – 8 math standards related to Statistics and Probability.

Engage (classroom)

Mini-Lesson 1: Background (one class period)

1. Ask students to independently write what they already know about the following questions on three large post-its each:
    - What is in the water that we drink?
    - How do we know that it is safe for drinking?
    - What does water quality really mean?
2. Have students place their post-it answers on three post-it posters arranged around the room.
3. Share and briefly discuss student answers with the class by reading several answers for each question. Which student answers does the class agree with the most and why?
4. Introduce the scientific concepts this investigation involves (PowerPoint, https://docs.google.com/presentation/d/1kVquUq50gtil-ZsHc62ZJTXvdQD-y1yx8i7sPMxicOo/edit -slide=id.g1eb0166594_0_12):
    - Watershed
    - Stream order
    - Water quality
    - Water quality properties
    - Point and non-point pollution
5. *Optional:* Give students the opportunity to explore local point and non-point pollution further through this independent web research activity (Roehm, 2016).

Mini Lesson 2: Field Investigation Overview (one class period)

1. Introduce the field investigation and question: How does water quality change as stream order increases?
2. Review remainder of the Water Quality Investigation worksheet in preparation for conducting the field investigation.
    a. Tell students that good investigation questions describe what we will manipulate (independent variable). Have students underline the manipulated (independent) variable in the question (stream order).

    b. Good comparative questions also describe what to measure (dependent variable). Have students double-underline the responding (dependent) variable in the question (water quality).
    c. Controlled variables are also critical to a successful investigation. Have students circle the controlled (kept the same) variables in the procedure.
3. Ask students to write a prediction of how water quality changes with increasing stream order.

Explore (one field day)

1. Take students off-campus to carry out the investigation at designated sites (2–3 sites).
2. Students carry out the investigation following procedures as described on teacher-provided student handouts (x2).
3. Students record data on the provided worksheets (x2).

Explain (one class period)

1. Students determine rank; record on data sheet *(can also be completed in the field)*.
2. Students discuss calculated ranks in groups *(can also be completed in the field)*:
    a. Does this rank indicate a healthy stream environment?
    b. How will this rank affect the biodiversity of the river?
3. Students display data in graphic form.
    a. *Optional:* Students discuss which graphic representation is best and why.
4. Students review the procedure and make any changes to include what they actually did in the field.
5. Argumentation – in groups students discuss:
    a. patterns in the data
    b. the procedure
    c. any factors that may have influenced their data
    d. any inconsistent data
6. Students share in a whole class discussion and record.
7. Ask students, "Do we have evidence to answer our question, 'How does water quality change as stream order increases?'" Have students discuss in groups.
8. Students construct an argument/explanation using data as evidence to answer the investigation question. Use the Claim, Evidence, Reasoning template.

Elaborate (classroom)

Here are some ideas for elaboration:

1. Have students discuss using some of these questions:
    a. How do human activities in our watershed affect water quality?
    b. What are possible reasons water quality was or was not different for different sites?
    c. What inputs to the system might cause water quality to be lower in one location than another?
    d. How do you think water quality might be different if you measured them at different times of the day? Different times of the year?
    e. How might this information inform actions/decisions in our community?
2. Have students continue their research and/or investigations to add to their argument/explanations, such as:
    a. Design a solution using technology to monitor and minimize water quality issues in your watershed (MS-ESS3-3)
        i. What are the criteria for a solution? What constraints are there?
        ii. Evaluate your solution:
            1. How well does your solution meet criteria and constraints?
            2. What are the limitations of your solution?

Evaluate (classroom)

1. Documenting Field Investigations Checklist
   https://docs.google.com/document/d/1odN8lAaSAhWCjZN9rQyiNzcU39Uw23hNrmBmmhqv4Zg/edit?usp=sharing
2. CER Rubric – Appendix C
   https://docs.google.com/document/d/1OJglgR1EgiFhzggwNxmCAQZPyld8cjVdk-WiP4pq4II/edit?usp=sharing

Additional resources

1. Whatzzzzup Stream? Water goes with the flow
   https://www.epa.gov/sites/production/files/2016-01/documents/whatzzzzzup_article.pdf
2. Stream Order
   http://www.cotf.edu/ete/modules/waterq3/WQassess4b.html

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- "USGS Water Science School." USGS Water Science School, U.S. Geological Survey (USGS), 2016. http://water.usgs.gov/edu/. Web. 26 Feb 2017.

Student Handout Name: _____ Date: _____

Water Quality Study

Essential question: How do human activities in our watershed affect water quality?

Investigation question: How does water quality change as stream order increases?

Make a prediction (initial claim): Predict the relationship between water quality and stream order. Provide reasoning for your prediction.

Materials

- Clipboard
- Kilo Kahawai Worksheet
- Water Quality Properties Worksheet
- Sampling containers
- Waste container
- Writing utensil
- Graph paper
- Water Quality Monitoring Kit http://www.lamotte.com/en/education/water-monitoring/3-5886.html
- Water Quality Sampling Procedures http://betterlesson.com/lesson/resource/3253702/testing-directions-and-data-table?from=resource_title

Plan the field investigation

1. Identify variables under study
    a. Independent (manipulated) variable:
    b. Dependent (responding) variable:
    c. Controlled variables:
2. Site selection
    a. Review two to three sampling sites (chosen by teacher) of different stream order within the same watershed (e.g., https://drive.google.com/file/d/0B31aOjveM5KUSUVaTHR3cnNKNXM/view)
    b. Using the map identify the stream order of the sampling sites

Carry out the investigation (collect the data)

1. Visit sites (preferably on same day or under similar conditions) to do sampling
2. Split into data collection groups as directed by teacher
3. Collect qualitative data through general stream observations
    a. Spend 20 minutes exploring and observing the stream
    b. Record data on Kilo Kahawai: Stream Observations Worksheet
4. Collect quantitative data on stream water quality properties (each group is assigned one)
    a. Follow procedures detailed in water quality sampling procedures handout
    b. Record data on Water Quality Properties Worksheet
5. Make sure to record data correctly
6. Determine rank for the water quality parameter investigated, ensure accuracy
7. Share with class

Analyze and interpret data

1. ***Organize data:*** You will now analyze your assigned water quality property further.
    a. Using graph paper, create a graph representing water quality property rank for each location. Make sure to include the following:
        i. Data recorded and accurate ranks
        ii. Title and columns and/or axes labeled correctly
        iii. Correct units
        iv. An appropriate graph

2. ***Identify relationships:*** Describe patterns and trends in data in the space below.
    - *See Kilo Kahawai:* Stream Observations Student Worksheet https://docs.google.com/document/d/1OBojHk4Ha8sdwRKcjFHhAKzz8mrP7c62tVMm1-J9M1c/edit
    - Water Quality Data Analysis Information Booklet
    - https://drive.google.com/drive/folders/0B31aOjveM5KUX3JYNDNNVXZLYnc

Kilo Kahawai (Stream Observations)

Time		*Pō Mahina*		*Mahina/Season*	
Stream location	*Stream name* *Branch of stream* *Site location* *Length of survey area*		**Weather**		
Stream shape	*Straight* *Meandering (curvy)*		**Stream color**	_____ Green _____ Orange-Red _____ Milky/White _____ Red _____ Black	_____ Foam _____ Muddy/Cloudy _____ Multicolor _____ Brown _____ Other
Stream speed	*Fast* *Medium* *Slow*		**Smells around the stream**	_____ Chlorine _____ Musky/Sewage _____ Fish _____ Grassy	_____ Rotten egg _____ Flowery _____ Other
Bottom of the stream	_____ Rocky _____ Boulders _____ Logs/limbs _____ Gravel	_____ Sand _____ Clay _____ Muddy _____ Other	**Observation field notes** _____ _____ _____ _____ _____ _____		
Edges *(banks) of the stream*	_____ areas where earth has been worn away _____ bare soil at the sides of the Stream _____ cement at the sides of the Stream _____ rocks at the side of the Stream				

3. ***Interpret data:*** Identify the relationship (if any) between water quality and stream order. Use this to provide evidence for your claim. What are possible reasons water quality was or was not different for different sites?

Water Quality Properties

	SITE 1	RANK (1–4)	HEALTHY STREAM ENVIRONMENT? (Y/N)	EFFECT ON BIODIVERSITY? (+/-)	SITE 2	RANK (1–4)	HEALTHY STREAM ENVIRONMENT? (Y/N)	EFFECT ON BIODIVERSITY? (+/-)
Temperature								
Dissolved oxygen								
Phosphates								
Nitrates								
pH								
Turbidity								
Fecal coliform								
Rank	*Average rank*				*Average rank*			

Construct an argument/explanation

- Claim Evidence and Reasoning Worksheet (https://docs.google.com/document/d/1vJ20iIiebCCc6njLJxaDAqNs4EED-lNS6QOWrJZ5HHQ/edit)

Extend the investigation

Discuss the following questions in your group then record your own answer below.

1. How might this information inform actions/decisions in our community?
2. Recommend future actions and explain why.

Argument/Explanation Student Page

Group name: _____ Date: _____

Location/stream order: _____

Name: _____ Date: _____

Investigation question: ***How does water quality change as stream order increases?***

CLAIM
Did I clearly answer the question? Did I limit the claim to the date, time, and place of the field study?

EVIDENCE
Did I use the right data? Did I give enough data?

REASONING
Did I tell why there is enough evidence to support the claim? OR Did I use a science concept to explain why my evidence supports the claim?

DIRECTIONS: **Explore local point and non-point pollution sources online. Complete the following research guide as you conduct your search.**						
Water Quality Research Guide (Roehm, 2016) Pollutants	Where did the pollution come from? Or, what caused the pollution?	Point or non-point	Characteristics impacted (DO, phosphates, nitrates, etc.)	Effect on wildlife/ biodiversity	Resource title (who published it?)	Website link

COMPARISON FIELD INVESTIGATION: URCHIN POPULATION AT TWO TIDE POOLS

Essential question: How do human regulations impact the population of marine organisms?

Experimental question: How does the population of urchins compare between two different tide pools?

Student objectives
Students will:

- Learn the five different types of urchins in Hawaiʻi.
- Learn skills to survey tide pool organisms.
- Be able to collect field data and generate a graph comparing the two urchin populations.
- Answer essential question with data collected.

Student performance outcome: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions may result in a new ecosystem.

Lesson duration: Four days – Two 60-minute class periods and two two-hour field trips (this could vary based on distance to tide pools)

Preparation time: 30 minutes (copying of materials, Printing and laminating data sheets, gathering materials)

Materials

- Transect line
- Thermometer
- 7 counters (optional)
- Laminated data sheets
- Grease pencils
- Beaufort Wind Scale
- Tabbies
- Tide Chart
- Hawaiian Lunar Cycle chart http://www.instanthawaii.com/cgi-bin/hi?Weather.moon

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	LS2.C Ecosystem Dynamics, Functioning and Resilience
Crosscutting concepts	Stability and Change
Science and engineering practice	• Engaging in Argument from Evidence • Scientific Argument is open to revision in light of new evidence
Performance expectations	LS2-6 Evaluate the claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions may result in a new ecosystem.
Student performance outcome	• Students will be able to differentiate between the five types of urchins. • Students will be able to survey urchins in a tide pool. • Students will be able to generate a graph comparing the two urchin populations. • Students will be able to explain why the difference in urchin population was observed.

Common Core – ELA	CCSS.ELA-LITERACY.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. CCSS.ELA-LITERACY.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. CCSS.ELA-LITERACY.WHST.6-8.2.F Provide a concluding statement or section that follows from and supports the information or explanation presented. CCSS.ELA-LITERACY.WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.
Common Core – Math	CCSS.MATH.CONTENT.HSA.CED.A.2 Graph equations on coordinate axes with labels and scales.

Background

Urchins are sea organisms that have round bodies, live in rocky areas, and belong to the Animalia kingdom. Sea urchins belong to the family of Echinoderms, meaning spiny skin, along with sea stars. All echinoderms have radial symmetry, a water vascular system for nutrient transportation and tube feet for locomotion and/or collecting food.

Sea urchins play a vital role in marine ecosystems by consuming algae and other dead organisms like fish and mussels. They are also an important food source to other creatures. Urchins use their spines, hard outer body, and venom when threatened. Their spikes are also useful for catching food. And, although they can defend themselves, move around, and capture food, urchins do not have brains.

Five out of thousands of species of urchins are commonly found in Hawaiʻi. These are the hāʻukeʻuke ʻulaʻula (pencil urchin), wana, hāwaʻe maoli (collector urchin), hāʻukeʻuke kaupali (helmet urchin), and ʻina (rock-boring urchin). Hāʻukeʻuke ʻulaʻula have red, thick, flattened spines. Hāwaʻe maoli are native to Hawaiian waters and have short, slender spines. Hāʻukeʻuke kaupali have thick, flattened, stubby spines and cling to cliffs. Wana have long, slender spines and are the most common long-spine urchin in Hawaiʻi. ʻIna are the most common urchin in Hawaiʻi and the Indo-Pacific and have medium-length spines.

Engage

Day 1

1. What urchins are you familiar with?
2. What are the five types of urchins that you see in Hawaiʻi? Collector, helmet, pencil, rock-boring, and wana (What are the Hawaiian names and scientific names)? Refer to the species identification chart below.
3. What are the differences between the five types of urchins?
4. What similarities do all urchins share?
5. What role do urchins have in the marine ecosystem?
6. What is random sampling vs. transect sampling? Researchers use sampling to acquire a section of the population to perform an experiment or observational study. Basic random sampling techniques are where a select a group of subjects (a sample) for study is selected from a larger group (a population). Transect sampling uses a single line to provide more accurate data than random sampling. Refer to Appendix High School: Sampling Techniques for more detail on sampling techniques.
7. Students should develop a hypothesis for the field testing and write on the data sheet. Refer to the Introduction Activity on hypotheses for more detail on this.

Explore

Follow procedure below to answer the following questions:

Essential question*:* How do human regulations impact the population of marine organisms?

Experimental question: How does the population of urchins compare between two different tide pools?

Procedure

Day 2 (Two-plus hours depending on travel time to tide pool)

1. Record temperature of ocean using thermometer.
2. Record strength of wind using Beaufort wind scale. (See resources below).
3. Record time of low tide, high tide, and lunar phase.
4. Have students work in pairs to identify the five types of urchins according to the species identification chart above. Teacher will ensure that students accurately identify organisms.
5. After students have successfully identified the urchins, put a seven-meter transect line at the back of the tide pool.
6. Measure the distance from the transect line to shore. Record distance on data sheet.
7. A pair of students should walk from transect line to shore surveying the urchins in a 1 m zone.
8. Surveying entails one student using a counter to survey the rock boring urchins while the other team member can tally the urchins on the laminated data sheet.
9. Each pair of students will share the data from their zone so that the entire class has the data from zones 1–7.

Procedure for second tide pool: Day 3

1. Record temperature of ocean using thermometer.
2. Record strength of wind using Beaufort wind scale. (See resources below).
3. Record time of low tide, high tide, and lunar phase.
4. Put a seven-meter transect line at the back of the tide pool.
5. Measure the distance from the transect line to shore. Record data on data sheet.
6. A pair of students should walk from transect line to shore counting the urchins in a 1 m zone.
7. One student can use a counter to survey the rock-boring urchins while the other team member can tally the urchins on the laminated data sheet with a grease pencil.
8. Each pair of students will share the data from their zone so that the entire class has the data from zones 1–7.

Data analysis

Day 4

1. Once data has been collected at two tide pools, discuss what type of graph should be used to address problem statement.
2. Refer to Appendix on Data Analysis for types of graphs.
3. Create a hand draw graph comparing the total number of urchins at the two tide pools. Put the number of urchins, the dependent variable, on the y-axis and the tide pool, the independent variable, on the x-axis.
4. Continue to explain and elaborate sections below. Complete a written lab report for assessment.

Explain

1. Find the total urchin population at the two sites. Compare the totals between the two tide pools and answer the problem statement.
2. Why do you think there was/was not a difference in the urchin population at the two sites?

Elaborate

1. What were some data errors from the experiment? When were the controlled variables (variables that should stay the same) not in fact controlled? What errors outside of your control did you observe while collecting data in the field?
2. How could this experiment be improved?
3. Do you think similar numbers would be found in other tide pools?

4. Why is it important to have healthy urchin populations in tide pools?

Evaluate

1. Teachers can evaluate students based on the Field Investigation Evaluation Rubric in Appendix 3.

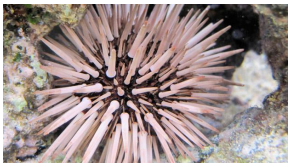
Resources for background information

- Dunlap, Heather and Monaghan, Tara. "Sea Urchin." Tree of Life Web Project. Web. 15 Aug 2016. http://tolweb.org/treehouses/?treehouse_id=4881
- The Nature Conservancy. "Hawai'i Marine: Sea Urchins to the Rescue." Web. 18 Oct 2016.
- Niesen, Thomas. "Echinoderm Diversity: Echinoids and Sea Cucumbers." New York, NY: Harper Resource, 2000.
- Poppe, Jessica. "The Perils of Reduced pH on Sea Urchin Development." Tufts University, 2008. Web. 13 Jan 2017.
- University of Hawai'i. "Rock-boring Urchin". Waikīkī Aquarium. Web. 23 Aug 2016. http://www.waikikiaquarium.org/experience/animal-guide/invertebrates/echinoderms/rock-boring-urchin/

Resources for Data Collection

- Beaufort Wind Scale http://www.spc.noaa.gov/faq/tornado/beaufort.html
- Hawaiian Moon Names http://www.instanthawaii.com/cgi-bin/hi?Weather.moon
- Hawaiian Urchins http://www.botany.hawaii.edu/basch/uhnpscesu/htms/kahoinvr/family/echinomet.htm
- Lunar Cycles https://stardate.org/nightsky/moon

Urchin Species Identification Chart

TYPE OF URCHIN	HAWAIIAN NAME	SCIENTIFIC NAME	PICTURE OF URCHIN
Collector	Hāwaʻe maoli	***Tripneustes gratilla***	
Helmet	Hāʻukeʻuke kaupali	***Colobocentrotus atratus***	
Long Spine	Wana	***Echinothrix diadema***	
Pencil	Hāʻukeʻuke ʻulaʻula	***Heterocentrotus mammillatus***	
Rock-Boring	ʻIna	***Echinometra mathaei***	

Urchin Data Sheet

Problem Statement: How does the urchin population compare between two tide pools?

Hypothesis: _____

_____

_____

Location: _____

Date: _____ Time: _____

Description of site: _____

Distance from transect line to shore: _____

Conditions: _____

_____

_____

Temperature of water: _____ Time of low tide: _____ Time of high tide: _____

Lunar cycle: _____ Hawaiian lunar cycle: _____

Beaufort wind scale: _____

TYPE OF URCHIN	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	TOTAL
Collect								
Helmet								
Pencil								
Rock								
Wana								

CORRELATIVE FIELD INVESTIGATION: TIDE POOL DIVERSITY COMPARISONS

Essential question: How do habitat characteristics affect the diversity of species that are found there?

Experimental question: Does tide pool proximity to shoreline affect tide pool diversity?

Student objectives
Students will:

- Be able to collect field data and create a graph.
- Be able to find the correlation coefficient between the two variables.
- Develop their understanding of the correlation between species diversity and habitat characteristics.

Student performance outcome
Students can construct an argument supported by empirical evidence/data, that depending on the physical habitat, the biological populations are affected. Students can design an experiment and write a scientific research paper.

Lesson duration
15 minutes introduction; 50 minutes collecting data; 30 minutes analyzing data. Three to four 45-minute sessions.

- ***Session 1:*** Introduce concepts with vocabulary, videos, questions, discussion, and procedures that will be followed in the field
- ***Session 2:*** Review procedures and safety concerns, collect data
- ***Session 3:*** Data analysis, discussion and designing of experiment
- ***Session 4:*** Online research
- ***Session 5:*** In the field to collect on individualized experiment related to tide pool or specific organism
- ***Session 6:*** Work on research paper
- ***Session 7:*** Present findings to the rest of the class

Materials

- Transect or measuring tape
- Quadrats
- Clipboards
- Data collection sheets
- Laminated paper and grease pencils
- Laminated Tide Pool ID sheet

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	LS2.C: Ecosystem Dynamics, Functioning, and Resilience Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
Crosscutting concepts • Patterns • Cause and effect • Stability and change • Connections to nature of science • Scientific knowledge assumes an order and consistency in natural systems	• Patterns can be used to identify cause and effect relationships. • Cause and effect relationships may be used to predict phenomena in natural or designed systems. Small changes in one part of a system might cause large changes in another part. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Science and engineering practices • Analyzing and interpreting data • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	• Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1) Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2) • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
Performance expectations	MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]
Common Core – ELA	**Connections to Common Core State Standards** CCSS.ELA-LITERACY.WHST.6-8.1. Write arguments to support claims with clear reasons and relevant evidence. RST.6-8.1, RST.6-8.7, RST.6-8.8, RI.8.8 WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. WHST.6-8.9 ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. CCSS.ELA-LITERACY.SL.6-8.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation. CCSS.ELA-LITERACY.SL.6-8.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
Common Core – Math	MP4, 6.RP.A.3, 6.EE.C.9, 6.SP.B.5 CCSS.MATH.CONTENT.6.SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots. CCSS.MATH.CONTENT.6.SP.B.5 Summarize numerical data sets in relation to their context CCSS.MATH.CONTENT.8.SP.A.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

Background

Vocabulary

- *Tide Pool* – a pool of water remaining on a reef, shore platform, or beach after the tide has receded
- *Intertidal Zone* – of or relating to the littoral region that is above the low-water mark and below the high-water mark
- *Biodiversity* – diversity among and within plant and animal species in an environment
- *Salinity* – the concentration of dissolved salts in water etc., usually expressed in parts per thousand by weight.
- *pH* – pH is a measure of hydrogen ion concentration; a measure of the acidity or alkalinity of a solution. Aqueous solutions at 25° C with a pH less than seven are acidic, while those with a pH greater than seven are basic or alkaline.
- *Abundance* – the quantity or amount of something, e.g., a chemical element or an animal or plant species, present in a particular area, volume, sample, etc.
- Scientific classification
  - *Phylum Echinodermata* – A phylum of marine invertebrates which includes starfishes, sea urchins, brittlestars, crinoids, and sea cucumbers. They have radial symmetry, a calcareous skeleton, and tube feet operated by fluid pressure.
  - *Phylum Arthropoda:* Arthropods are the largest and most diverse group in the animal kingdom. Included in this group are crustaceans (shrimp, lobsters, crabs and barnacles). Bilaterally symmetrical, arthropod bodies are divided into sections, with numerous jointed appendages such as walking legs, claws, antennae or mouthparts.
  - *Phylum Mollusca* – Snails, Clams, Mussels, Octopus. Soft, legless, bilaterally symmetrical animals that usually secrete calcium carbonate shells. Largest group of animals in the sea. Have a muscular foot for locomotion and a radula.
  - *Invertebrate* – an animal lacking a backbone, such as an arthropod, mollusk, annelid, etc.
  - *Vertebrate* – an animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.
  - *Algae* – a simple nonflowering plant of a large group that includes the seaweeds and many single-celled forms. Algae contain chlorophyll but lack true stems, roots, leaves, and vascular tissue.
- *Correlate* – have a mutual relationship or connection, in which one thing affects or depends on another.

Research related to the topic

Meager et al. "Both abundance and species richness increased with pool size and decreased with distance up the intertidal zone. The distribution patterns of fish in these soft-substrata tide pools were similar to patterns noted for fish in rocky tide pools."

Resources

- TKC Tide Pool and Invert Phylum Intro
  https://docs.google.com/document/d/1jPNNwfEHZkzR5BDv5Z_e_qUI9cr8OWnm3w3d9EZSuKA/edit
- DLNR Tide Pool ID
  https://dlnr.hawaii.gov/dar/files/2014/04/tidepool.pdf
- Background content and videos on the intertidal zone
  http://www.untamedscience.com/biology/biomes/intertidal-zone-aquatic-biome/
- Additional background lessons on the intertidal zone (place-based for Hawai'i)
  http://www.hoikecurriculum.org/unit/on-the-edge-living-in-the-intertidal-zone/

Data analysis – correlation coefficient

The correlation coefficient is a number between -1 and 1 that explains the linear dependence of two variables. To learn more about this concept you can watch this you tube Video. A high school correlation coefficient lesson plan can be found at http://www.cpalms.org/Public/PreviewResourceLesson/Preview/53889

Engage

1. Elicit student understanding by asking, "What is the intertidal zone?" Have students do a think-pair-share and share back ideas to the class. Break about the word parts "Inter = between" and "tidal = tides", hence the intertidal is the area between the low and high tides.
2. Pose this second question to students to think-pair-share, "What challenges do animals living in this zone have to face?" Record their ideas on the board. Ideas may include, but are not limited to: water loss, higher temperature, increased or decreased salinity, wave action

Explore

Classroom

1. Provide students with DLNR Tide Pool ID (see pages 120–122 and https://dlnr.hawaii.gov/dar/files/2014/04/tidepool.pdf) to observe Hawai'i's most common intertidal species. Based on their observations, have students discuss how tide pool species are adapted to living in these environments? Add student ideas to the board. Possible ideas from students are listed below:
    a. WATER LOSS: dry up or "desiccate" – either run and hide (crabs, snails), tide pools are great places to hide, or they "clam up" close a shell to retain water, some just allow themselves to dry out, some seaweeds/chitons can withstand 75% water loss
    b. TEMPERATURE/SALINITY: sea temp relatively constant and mild, air temps are much more extreme, most intertidal inverts can tolerate more extreme variations. Move to moist damp places, ridges help snails lose extra heat, more fresh water from rain etc.: many just close shells
    c. FEEDING RESTRICTION: not a lot of sediment can accumulate so not many deposit feeders, instead most are filter feeders- need to be underwater to filter so many grow more slowly than if they were elsewhere. Mobile animals are usually grazers that scrape algae, bacteria and other food
    d. WAVES: impact varies along shoreline, not as much impact in a bay, organisms exposed to waves anchor themselves to rocks, seaweeds/algae use holdfasts or encrust, mussels hold on with their byssal threads, thicker shells, low profiles
2. Explain to students that these challenges have led to many different adaptations in the intertidal zone. There are many different species that live in this environment; this is called biodiversity. Abundance refers to the amount of that species.
3. Ask students to discuss the following questions in their team, "What characteristics of a tide pool might affect biodiversity and abundance within that pool?" An example might be the size (area and depth), salinity, temperature, closeness to shore. Student groups share back their ideas.
4. Ask students to then discuss and record their hypothesis to the following experimental question, "Does tide pool proximity to the ocean impact species diversity?" Students must explain their reasoning. Explain that they will be testing their hypothesis through a field investigation.

Formative assessment

Have students show understanding of correlation. Present a relationship and state whether it has positive, negative, or no correlation. Examples: Number of cars in parking lot for beach and temperature. Number of cars in parking lot for beach and amount of rainfall.

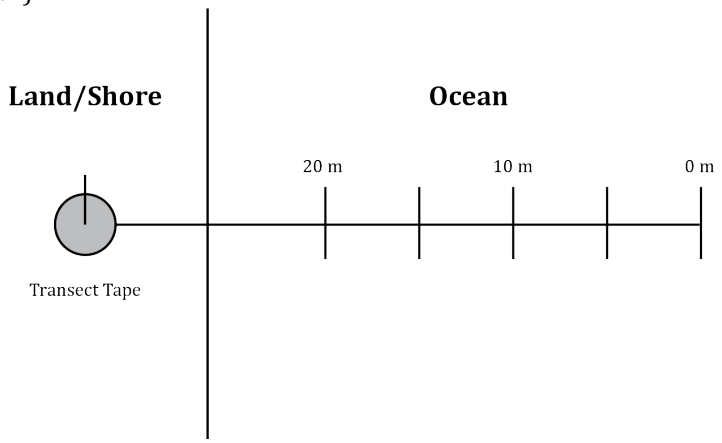
Field

1. Take students to tide pools at low tide when conditions are safe to carry out the investigation at designated sites.
2. Students carry out the investigation following procedures below.
3. Students record data on the provided worksheet.

Field procedure

1. Review safety precautions for tide pool research (waves/winter swells, sun, slippery rocks). Students must be extremely careful when in the tide pools.
2. Students should wear reef shoes if possible. Only take data at low tide and not during winter swells.
3. Students will probably need to look under rocks as most tide pool species are nocturnal. Be sure to show students how to carefully flip rocks, hold rocks on their sides, and make sure to replace the rocks exactly as they were found. Tide pool invertebrates are very fragile!

4. Record weather conditions on *Field Observations* sheet below. Take careful observation notes of the environment (season, surf, water quality, plants blooming, recent rainfall and runoff?, species presence (crabs, whale season?, dolphins observed), air quality, fishermen, divers, snorkelers, boats, etc.).
5. Students will lay a transect perpendicular to the shoreline going as far out as the tide allows them to. The largest transect number will be the closest to shore (transect tape will be on shore and 0 mark is farthest distance that students can safely reach).



6. Students need to complete the first two columns of their data table before collecting data on organisms. At each meter point, students will place a quadrat (for their sample area). Within each quadrat they are to record the number of different species in their data table.
7. Create a graph on paper or in Google Sheets with two columns (close to shore tide pools and close to waves tide pools) each with two columns number of species in the first column and the amount of each species in the second column. Insert the line of best fit with the equation of the line. The slope is the correlation coefficient.

Explain (field/classroom)

1. Use your data and graph to explain the correlation between the tide pool proximity to the shoreline and number and diversity of species.
2. Develop explanations for the phenomenon they have experienced
    a. Students discuss in groups:
        i. Does tide pool proximity to shore impact species diversity?
        ii. What factors might be influencing the differences in species diversity?
    b. Students display data in graphic form.
        i. *Optional:* students discuss which graphic representation is best and why.
    c. Students review the procedure and make any changes to include what they actually did in the field.
    d. Argumentation – in groups students discuss:
        i. patterns in the data
        ii. the procedure
        iii. any factors that may have influenced their data
        iv. any inconsistent data
    e. Students share in a whole class discussion and record.
    f. Ask students, "Do we have evidence to answer our question, '"Does proximity to ocean (vs. proximity to beach) impact species diversity in the intertidal?" Have students discuss in groups.
    g. Students construct an argument/explanation using data as evidence to answer the investigation question. Use the Claim, Evidence, Reasoning Template.

Elaborate

1. Compare data with other tide pool sites that have different physical characteristics. What other biotic and abiotic factors may impact tide pool biodiverstiy.

2. Have students continue their research on a specific species that they observed in this biodiversity experiment and design their own experiment for that species. Students develop their experimental question, hypothesis, procedures, and data table for the experiment.
    a. *Example:* Students may have noticed that the Hawaiian Mussel is most abundant close to shore and want to investigate its abundance throughout the intertidal. These students would research that species and create methods to accurately count (sample) that species in the intertidal zone.
3. Additionally, students may choose to investigate some of these experimental questions:
    a. What do tide pool species need to prosper? Does the size of the tide pool, where it's located, water temperature, salinity, or pH have an impact on the species that live there?
    b. How might climate change impact tide pool diversity? How might temperature and ocean acidification impact tide pool species diversity?
    c. Does time of year impact species diversity?
    d. Does lunar cycle affect species diversity?
    e. How do human activities in our watershed affect water quality and tide pool species?
4. Have students complete a scientific research paper based on their research and literature review.

Evaluate (classroom)

Teachers can evaluate students based on the Field Investigation Evaluation Rubric in Appendix 3.

1. Documenting Field Investigations Checklist (https://docs.google.com/document/d/1odN8lAaSAhWCjZN9rQyiNzcU39Uw23hNrmBmmhqv4Zg/edit?usp=sharing, Appendix P)
2. CER Rubric (https://docs.google.com/document/d/1OJglgR1EgiFhzggwNxmCAQZPyld8cjVdk-WiP4pq4II/edit?usp=sharing, Appendix C)

Resources

- Meager, Justin James et. al. *Factors affecting the distribution, abundance and diversity of fishes of small, soft-substrata tidal pools within Moreton Bay, Australia.* https://www.researchgate.net/publication/234169601_Factors_affecting_the_distribution_abundance_and_diversity_of_fishes_of_small_soft-substrata_tidal_pools_within_Moreton_Bay_Australia. Web. 2005.
- Hawai'i Tide Pool and Shallow Reef Identification. DLNR-DAR. https://dlnr.hawaii.gov/dar/files/2014/04/tide pool.pdf.
- *Oregon Tidal Zones.* Oregon State Parks. Tide Pool Zones described. http://oregontide pools.org/tidalzones
- Laguna Ocean Foundation. http://www.lagunaoceanfoundation.org/tidepools/.
- Metaxas, Anna and Robert E. Scheibling. *Community Structure and Organization of Tide Pools.* Marine Ecology Progress Series, 1993. Vol. 98, 187–198. Print.
- http://www.int-res.com/articles/meps/98/m098p187.pdf
- Allen, Jessica et al. *Effects of Physical Dimensions on Tide Pool Diversity.* PowerPoint slide show. http://studylib.net/doc/5314114/effects-of-physical-dimensions-on-tide-pool-diversity.

Tide Pool Study Observation Form

Name: _____ Date: _____ Time: _____ Tide: _____

Weather conditions (temp, wind, cloud cover):

_____

Observations:

_____

Amount of Different Species: ***Do not count the same species more than once (that is abundance, NOT diversity)***

DISTANCE FROM SHORE (m)*	TRANSECT POINT (m)	ECHINODERMS (urchins, sea cucumbers, brittle stars, sea stars)	MOLLUSKS (nerites, periwinkles, limpets, other snails)	ARTHROPODS (crabs, hermit crabs)	OTHER INVERTEBRATES	VERTEBRATES (fish)	ALGAE	TOTAL NUMBER	NOTES

** Only if transect tape is set up with 0 at the farthest point out that students can safely reach*

DISTANCE FROM SHORE (m)*	TRANSECT POINT (m)	ECHINODERMS (urchins, sea cucumbers, brittle stars, sea stars)	MOLLUSKS (nerites, periwinkles, limpets, other snails)	ARTHROPODS (crabs, hermit crabs)	OTHER INVERTEBRATES	VERTEBRATES (fish)	ALGAE	TOTAL NUMBER	NOTES

CORRELATIVE FIELD INVESTIGATION: NATIVE PLANTS AND ROAD PROXIMITY

Essential question: Is the abundance of native plants affected by a road?

Student objectives
Students will:

- Observe their outdoor environment and the native plants present.
- Become familiar with the native and non-native plants in their environment.
- Analyze and compare the data for the abundance of native species in the environment

Student performance outcome: Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.

Lesson duration: Three 60-minute class periods

Preparation time: 30 minutes (Copying of materials, Printing ID cards in color, gathering materials)

Materials

- Transect
- Clipboard
- Native Plant ID Guide with Pictures: https://docs.google.com/document/d/1XTLHtQCYzyycgbqfhmRg7cEC2nE-yp3ZC2GeQ8MT_bs/edit?usp=sharing
- Students need to wear covered shoes

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	LS2.C Ecosystem Dynamics, Functioning, and Resilience Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. http://www.nap.edu/openbook.php?record_id=13165&page=154
Crosscutting concepts	**Stability and Change** Small changes in one part of a system might cause large changes in another part. http://www.nap.edu/openbook.php?record_id=13165&page=98
Science and engineering practice	Engaging in Argument from Evidence
Performance expectations	MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Common Core State Standards	**Connections to Common Core State Standards**

Common Core – ELA	WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. • http://www.corestandards.org/ELA-Literacy/WHST/6-8/ • Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Common Core – Math	CCSS.MATH.CONTENT.6.SP.B.5 • http://www.corestandards.org/Math/Content/6/SP/B/5/ • Summarize numerical data sets in relation to their context

Background

Vocabulary

- *Native (Indigenous)* – organisms that live in their place of origin because they evolved there over time or migrated into the environment naturally (without human influence
- *Non-native (alien, exotic, introduced)* – organisms that do not naturally occur in a specific location; introduced to the new environment either intentionally or accidentally through human actions
- *Endemic* – native organisms that not naturally found anywhere else in the world; usually confined to a small geographic region
- *Invasive* – introduced species that causes environmental, economic, or human harm (http://ed.ted.com/lessons/the-threat-of-invasive-species-jennifer-klos)
- *Bias* – prejudice in favor of or against one thing

Resources

- Slide show https://docs.google.com/presentation/d/1Mb3A06udnlsxVKndQPjE13eFfuU2WWEh7Wd93D-Hzvo/edit#slide=id.g21902bae01_0_15
- Last Stand: The Vanishing Hawaiian Forest http://www.nature.org/media/hawaii/last_stand_web_lo.pdf
- Hawai'i Invasive Species Website http://dlnr.hawaii.gov/hisc/info/
- Video: Strange Days on Planet Earth – Invaders https://www.youtube.com/watch?v=a_HWqlmvX1k

Engage

1. Pre-assess students' understanding of the concepts of native and non-native species.
2. Show them two different trees – Koa and albizia. Ask students, what makes these plants similar and different?
3. Ask students to discuss, "Is there such a thing as a bad plant or animal?" Explain using Koa and Albizia as an example.
4. Clarify the definitions for: native, non-native, introduced, indigenous, endemic, and invasive using the presentation referenced in resources.

Explore

1. Take students on a nature walk to conduct a general survey of the non-developed land next to campus. Look at the different trees and shrubs, identifying them using the plant ID guide. Students come back with a list of species that they observed.
2. Ask students, how do you think the amount of native plants will change as we go further from the road? Why? Record student group ideas. Their ideas will eventually lead to their experimental hypothesis.
3. How could we answer this question? Could we count every species from the road inland? (No. Scientists use sampling methods to gather data in large ecosystems.)
4. Introduce students to a transect and how to use it to as a means to standardize sampling methods. Students practice with the transect in an open area outside the classroom, collecting data at each meter point. Students share back what their data tells them about the environment.
5. Check for understanding by asking, "How can we use this method to answer our question about native plant abundance?"

6. Students make a prediction for the experimental question and record it in their data table.
7. As a class, develop procedures for the investigation. It may be similar to:
    a. Assigning each team a transect line that they set-up perpendicular to the road.
    b. Students set-up their transect line and record field information on their data sheet.
    c. Students must stay with their team at all times. Assign roles: 1) write down the data 2) keep track of location on transect 3) identifying organism with the ID card
    d. Teams record the type of species under each meter of their transect line.
    e. Once their data is recorded, they total the number of native and non-native species.

Explain

1. Once the data is collected by each team, students share their data to the class. The class records all group data. To enhance the experiment, students can collect data on more than one transect. "Group" columns would just need to be added to the data table.
2. Students discuss the appropriate type of graph (https://docs.google.com/document/d/1H55W0dmVILSKIPGY1Q-vTk-f6dki0xxceC8_Vn6b_v8/edit?usp=sharing) and create a graph on their paper or using excel or sheets. Use the checklist (https://docs.google.com/document/d/1JS000T20P3uUhk2Q9ZvcH58tzWrDXalYmLa5ZNSXlr0/edit?usp=sharing) as the graph is developed.
3. Students review the procedure and make any changes to include what they actually did in the field.
4. In groups students discuss:
    a. Patterns in their data
    b. The procedure (what worked, what didn't)
    c. Any factors that may have influenced their data
    d. Any inconsistent data
5. Students share their discussion notes with the class.
6. Ask students, "Do we have evidence to answer our question? Is the abundance of native plants affected by a road?" Have students share their group's answer to the class.
7. If the answer is "Yes", students start constructing their argument/explanation using data as evidence to answer the investigation question. They use the Claim, Evidence, Reasoning template and rubric to guide their writing. If the answer is "No", student groups must determine why not and either collect more data or revise their procedure.

CER rubric

- https://docs.google.com/document/d/1OJglgR1EgiFhzggwNxmCAQZPyld8cjVdk-WiP4pq4II/edit?usp=sharing

Elaborate

1. How could the information gained from this experiment be important for our community? How can we use this information to help preserve our native watersheds?
2. How could invasive species affect our ecosystem and native plants? Use the following resources to help students connect to other world issues:
    a. http://ed.ted.com/lessons/the-threat-of-invasive-species-jennifer-klos/
    b. https://www.youtube.com/watch?v=a_HWqlmvX1k (Strange Days on Planet Earth: Invaders)
3. Students add their additional learning from the reading to their conclusion.

Evaluate (rubric)

1. Field Investigation Reporting Rubric
   https://docs.google.com/a/waikoloa.k12.hi.us/document/d/1SoUAziksBM5oGlvkJCsnBVV5JsSDttEQYL06HgXAgFE/edit?usp=sharing – Appendix B
2. Documenting Field Investigations Checklist
   https://docs.google.com/document/d/1odN8lAaSAhWCjZN9rQyiNzcU39Uw23hNrmBmmhqv4Zg/edit?usp=sharing – Appendix P

Schoolyard Native Plant Investigation

Example Student Worksheet

Name: _____ Date: _____ Period: _____

Experimental question: Is the abundance of native plants affected by the road?

Hypothesis: _____

_____

Materials

- Clipboard
- Data sheet
- Transect
- Waikoloa Plant ID Guide

Procedure

1. Set up a transect line with zero starting at the road.
2. Record environmental conditions.
3. Walk along the line and record the type of plant that you are observing under each meter point and whether it is native or introduced.
4. Class data will be recorded.

Date: _____ Time: _____ Place: _____

Study site description: _____

_____

Weather: _____

_____

Group Data Sheet: Native Plant Investigation

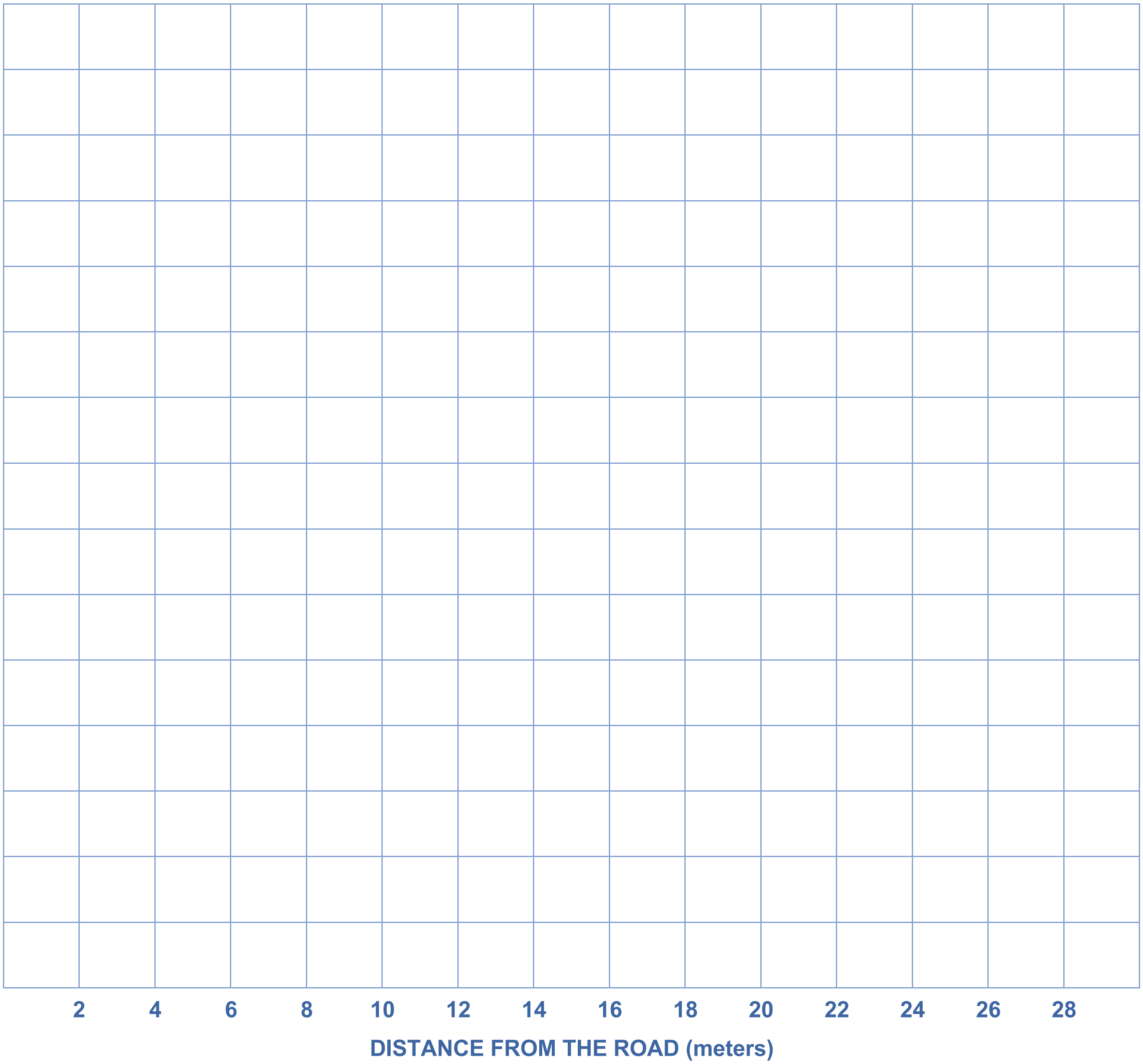
DISTANCE FROM ROAD (meters)	SPECIES NAME	NATIVE OR INTRODUCED
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

Class Data Sheet

DISTANCE FROM ROAD (meters)	GRP 1	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6	GRP 7	TOTAL NATIVE	TOTAL INTRODUCED
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									

Analysis for Native Species

Title: ____



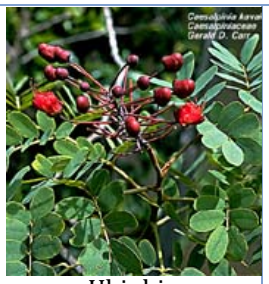
Conclusion

Use the following format to write your conclusion:

- ***Claim:*** Answers the experimental question
- ***Hypothesis:*** Was it supported or not?
- ***Evidence:*** Cite your data
- ***Reasoning:*** Using knowledge of native and introduced (invasive) species, explain your results
- ***Errors/limitations:*** Improvements

Common Species in Waikoloa

Most Common Natives

 Wiliwili *Erythrina sandwicensis*	 Uhiuhi *Mezonueron kavaiensis*	 ‘A‘ali‘i *Dodonaea viscosa*	 Ma‘o hau hele *Hibiscus brackenridgei*	 ‘Ohai *Sesbania tomentosa*
 ‘Ilima *Sida fallax*	 ‘Uhaloa *Waltheria indica*	 Kolomona *Senna gaudichaudii*	 Koali ‘awa *Ipomoea indica*	 ‘Āweoweo *Chenopodium oahuense*

Most Common Weeds

 Fountain grass *Cenchrus setatceus*	 Buffle grass *Cenchrus ciliaris*	 Kiawe *Prosopis pallida*
 Indigo Bush *Indigofera suffruticosa*	 Ēkoa (Haole Koa) *Leucaena leucocephala*	 Brome fescue *Vulpia bromoides*

CORRELATIVE FIELD INVESTIGATION: FOUNTAIN GRASS IMPACTS ON THE GROWTH OF ʻĀWEOWEO

Essential question: How do plants cause changes in other species' populations?

Experimental question: How does the growth of the fountain grass impact the abundance of the native shrub ʻāweoweo?

Student objectives
Students will:
- Be able to collect field data and create a graph.
- Be able to find the correlation coefficient between the two variables.
- Develop their understanding of the correlation of the two plants

Student performance outcomes
Students will:
- Be able to use a transect line to survey plants.
- Utilize data to generate a graph with a best fit line and a correlation coefficient.
- Draw conclusions from graph.

Materials
- Clipboard
- Data Table
- Tape Measure
- Field with fountain grass and ʻāweoweo

Next Generation Science Standards

DIMENSION FROM THE FRAMEWORK	CONNECTIONS TO THE 3 DIMENSIONS OF NGSS
Disciplinary core idea	LS2.C Ecosystem Dynamics, Functioning and Resilience
Crosscutting concepts	• Patterns, Cause and Effect • Stability and Change
Science and engineering practice	Using Mathematics and Computational Thinking
Performance expectations	LS2-4 Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.
Common Core – ELA	CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. CCSS.ELA-LITERACY.WHST.6-8.2.F Provide a concluding statement or section that follows from and supports the information or explanation presented. CCSS.ELA-LITERACY.WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.
Common Core – Math	F.LE.5 Interpret the parameters in a linear, quadratic, or exponential function in terms of a context.* S.ID.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data

	S.ID.8 Compute (using technology) and interpret the correlation coefficient of a linear fit

Background
Fountain Grass (*Pennisetum setaceum*), an invasive plant in Hawaiʻi, is prevalent in the Koaiʻa Tree Sanctuary and has taken over most of the leeward side of Hawaiʻi Island. It poses many threats to Hawaiʻi Island's native ecosystems. It invades dry forests, growing rapidly, changing structure of the forest and outcompeting indigenous plants for resources. It is a major fire threat and invades bare lava flows, disrupting native primary succession (Tunison). It has even been hypothesized to be allelopathic (toxic) to nearby native species (Melora Purell, pers comm).

A correlation coefficient is a number between -1 and 1 that explains the linear dependence of two variables. To learn more about this concept you can watch this YouTube video: https://www.youtube.com/watch?v=ugd4k3dC_8Y

An ecosystem is the set of all components, biotic (living) and abiotic (non-living), along with environmental factors that make up a living system. There are many relationships that happen in ecosystems that can affect population size. Competitive interaction is the relationship in which two organisms compete for the same set of resources.

Engage

Think, Pair, Share: How might plants cause changes in other species' populations?

- Do you think that the growth of one plant can affect the growth of another plant? How so? Talk with your group, share back to the class.
- Generate a hypothesis for the relationship between the growth of fountain grass and the growth of ʻāweoweo.

Explore

1. Use a tape measure as a transect line in an outdoor setting with fountain grass and ʻāweoweo. Plots along the transect line are 60 m wide and 6 m long (360 square meters).
2. Create six transect lines and record the number of ʻāweoweo and fountain grass plants in each plot using the student data sheet.
3. Total the number of each type of
4. Create a graph in Google Sheets with the number of fountain grass plants in the first column and the number or ʻāweoweo plants in the second column. Insert the line of best fit with the equation of the line. The slope is the correlation coefficient if it is between -1 and 1.

Explain

1. How did the number of ʻāweoweo plants compare to the number of fountain grass plants?
2. Use your data to explain the correlation between the growth of fountain grass and ʻāweoweo. Is there a positive or negative correlation? Is there a direct or indirect relationship?
3. What is the correlation coefficient?
4. Does this support your hypothesis?
5. Why do you think this relationship exists?
6. Discuss the answers from #1–4 with the group.
7. Were the two plants able or unable to coexist? What resources were both plants needing? What type of relationship within the ecosystem might these plants have? Discuss as a class.
8. What does your data suggest about the competition of the plants?
9. How might the eradication of fountain grass affect the population of ʻāweoweo? How else might the eradication of fountain grass affect the ecosystem?

Elaborate

1. Research the phytochemicals in fountain grass that may inhibit or promote the growth of ʻāweoweo. What are the potential impacts of fountain grass on native plants based on this data?

2. What evidence would you present at a council meeting about the importance of the eradication of fountain grass?

Evaluate

- Compare your results with those of Parker School students: http://www.kohalacenter.org/docs/resources/hi-meet/HIMEET_2016_ParkerSchool_GrassAweoweo.pdf. Are the results the same? Why or why not?
- Teacher can evaluate students based on the rubric in Appendix B.

Resources

- "Fountain Grass." Hawai'i Invasive Species Council Fountain Grass Comments. February 21, 2013. Web.
- Tunison, Timothy J. "Fountain Grass (Pennisetum Setaceum) Info Excerpt." April 18, 2016. Web.
- Jensen, Chelsea. "Restoring Kohala." West Hawaii Today, October 28, 2012. Web.
- Duvachelle, D. "'Aweoweo Chenopodium oahuense (Meyen) Aellen." Plant Fact Sheet. NCRS. November 2009. Web.
- http://www.kohalacenter.org/docs/resources/hi-meet/HIMEET_2016_ParkerSchool_GrassAweoweo.pdf
- http://dlnr.hawaii.gov/hisc/info/invasive-species-profiles/fountain-grass/
- http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/ecosystem/ecosystem.html/

Fountain Grass and ʻĀweoweo Observation Form

Location: _____

Date: _____ Time: _____

Description of Site: _____

PLOT #	FOUNTAIN GRASS PLANTS	ʻĀWEOWEO PLANTS
1		
2		
3		
4		
5		
6		

APPENDICES

Unit and Lesson Ideas

- Watershed Introduction (PowerPoint)
  https://drive.google.com/drive/folders/0Bxu-JdvuLJz1R3I3X21aZFhoZzQ
- Ahupuaʻa Introduction (PowerPoint)
  https://drive.google.com/drive/folders/0Bxu-JdvuLJz1R3I3X21aZFhoZzQ
- Introduction to Field Investigations (PowerPoint)
  https://drive.google.com/drive/folders/0Bxu-JdvuLJz1R3I3X21aZFhoZzQ
- Native Plant Lesson Introduction slide show (PowerPoint)
  https://docs.google.com/presentation/d/1Mb3A06udnlsxVKndQPjE13eFfuU2WWEh7Wd93D-Hzvo/edit#slide=id.g21902bafba_0_0

APPENDIX A: LETTER TO ADMINISTRATOR

See/print following page.

P.O. Box 437462 | Kamuela, Hawai'i 96743 | +1 808 887-6411 | Fax +1 808 885-6707 | kohalacenter.org

THE KOHALA CENTER®

Dear School Administrator,

I am writing in support of your teacher taking students on field science trips. Outdoor experiences in natural settings increase students' problem solving abilities and motivation to learn in social studies, science, language arts, and math. Outdoor experiences also provide students with place-based connections and engage students in relevant learning experiences. Outdoor, placed-based learning, as an instructional strategy, encompasses a range of techniques and approaches that build on students' interests and backgrounds so as to engage them more meaningfully and support them in sustained learning. These strategies have been shown to promote educational equity in learning science and engineering.

Field investigations help students become systems thinkers, provide opportunities to engage in science and engineering practices and understand that science does not only happen in a laboratory or classroom. Field investigations of the environment involve the systematic collection of data for the purposes of scientific understanding. They are designed to answer a question through the collection of evidence and the communication of results; they contribute to scientific knowledge by describing natural systems, noting differences in habitats, and identifying environmental trends and issues.[1]

Research about rural students and underrepresented minorities—particularly those of Hawaiian and Pacific Islander descent—suggests their interest in science increases through place-based, project-based, hands-on activities and science instruction, especially when field investigations address real-world problems in culturally relevant terms.[2, 3]

We hope you will support your teachers and students in pursuing outdoor learning experiences both on the school grounds and off-site. We would like to assist in any way we can to encourage students' outdoor learning opportunities. Feel free to contact me if you have any questions, 808-785-2355 or igrossman@kohalacenter.org. Thank you for your time and consideration.

Ilene Grossman

Ilene Grossman
Environmental Education Coordinator

[1] Association of Fish and Wildlife Agencies. *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Practices.* 2015. Print.
[2] Kawakami, A. J. 2004. "Issues Central to the Inclusion of Hawaiian Culture in K–12 Education." *Hūlili: Multidisciplinary Research on Hawaiian Well-Being* 1:111–132. 2004. Print.
[3] Lynch, Sharon. *Equity and Science Education Reform*. 2000. Print.

APPENDIX B: FIELD INVESTIGATION REPORTING RUBRIC

	NEEDS WORK	ALMOST THERE	YOU GOT IT!
Question/ purpose			Asks a question that can be answered through experimentation
Prediction/ hypothesis	Hypothesis is not related to the experimental question	Hypothesis is not connected to a science concept or something known OR does not explain how the independent variable will influence the dependent variable	Hypothesis is based on a science concept or something known AND explains how the independent variable will influence the dependent variable
Materials	No materials listed	Incomplete list of materials	Complete list of materials with amounts of each
Procedures	Procedures do not relate to the hypothesis or purpose of the experiment	Procedures are not complete, easily repeatable or does not identify all variables	Procedural steps are: • written clearly and can be repeated • clearly related to the hypothesis and identify independent, dependent, and controlled variables • complete with all measurements that will be taken
Data and observations	Data is collected, but not connected to the experimental question or hypothesis OR is so unorganized that it cannot be understood	Data is appropriate for the experiment, but either not accurate or not organized	Data is presented in an organized table (with clear headings, subheadings, and units) and includes environmental observations (location, day, time, weather)
Analysis	Graphs and mathematical calculations are not connected to the experimental question or hypothesis OR are so unorganized that they cannot be understood	Graphs and mathematical calculations are appropriate, but are not accurate or not organized	Graphical display of data and required mathematical calculations are accurate and presented clearly (Title, axis labeled, captions)
Conclusion/ explanation			See Claim, Evidence, Reasoning (CER) rubric https://docs.google.com/document/d/1OJglgR1EgiFhzggwNxmCAQZPyld8cjVdk-WiP4pq4II/edit?usp=sharing
Conclusions are analyzed	Understandings and connections are not related to the conclusion of the experiment	New questions and connections are related to the conclusion, but are not analyzed completely and clearly	Conclusion is used to ask new questions, make new hypothesis based on those questions, and relate the outcome of the experiment to the real world

APPENDIX C: CER CONCLUSION WRITING RUBRIC FOR STUDENTS AND TEACHERS

	NEEDS WORK	ALMOST THERE	YOU GOT IT!
Claim	Makes an inaccurate claim	• Makes an accurate, but incomplete claim • Does not limit the claim to the place, date, and time of study	• Makes an accurate and complete claim • Directly and clearly responds to the question • Limits claim to place, date, and time of study
Evidence	Provides inappropriate evidence. The evidence does not support the claim.	Provides appropriate, but insufficient evidence to support the claim.	• Provides appropriate and sufficient evidence to support the claim. • Appropriate: Measurements and observations are relevant with averages and/or totals of what was measured given • Sufficient: enough data is given to share the trends and the range of data from the different conditions
Reasoning	Provides inappropriate reasoning.	Provides appropriate, but incomplete reasoning (not all evidence is accounted for)	• Provides reasoning that connects the evidence to the claim. • Does not repeat claim or evidence. • Describing why there is enough evidence to support the claim. • Describes how the investigation method with controlled variables and/or multiple trials helps to validate the data. • Includes clear, appropriate, and sufficient scientific concept to explain why the evidence supports the claim.

APPENDIX D: ANALYZING DATA

Taken from *Bowen, Michael and Anthony Bartley. "The Basics of Data Literacy: Helping Your Students (and You!) Make Sense of Data". Arlington, VA: NSTA, National Science Teachers Association, 2014. Print.*

Types of Independent Variables

TYPE	DESCRIPTION	EXAMPLE	GRAPH (typical, but not limited to)	INTERPRETING/ ANALYZING	LIMITATIONS
Nominal	Category data; unrelated variables; difference between two categories; cannot predict what would happen with third	Types of birds Native and non-native	Bar graph	Use the mean to compare the categories from the baseline, "there is or isn't a difference"; address the amount of data variation with adding individual data to look at overlap	Use to describe similarities and differences, but cannot be used to predict outcome in future events
Ordinal	Ordered category; relative ordered relationship; allows for simple prediction but not a lot of precision	Size of tide pools Type of tree (by size)	Line graph	Compare the level of the raw data to each other; include the relationship to each other (positive or negative)	Allows for future predictions if a pattern is obtained; limited accuracy unless the variable is isolated
Interval-ratio	Measures or counts with a (potential) zero; involves unit; best opportunity to make predictions	Elevation Distance from stream	Scatterplot graph Line of best fit or trend bar	Interpolation (predicting between two distinct points) and extrapolation (predicting beyond measured points) using a line of best fit	May create the misconception that there is one value in the prediction; use of a "trend bar" will provide student a range for their prediction

APPENDIX E: WHEN TO USE MEAN, MEDIAN, OR MODE

Source: ***https://statistics.laerd.com/statistical-guides/measures-central-tendency-mean-mode-median.php***

	HOW TO CALCULATE	ADVANTAGES	LIMITATIONS
Mean	Average: add the numbers and divide by how many there are	Includes every data point	• Susceptible to outliers or when the data is skewed • Very large and very small numbers can distort the answer
Median	The number in the middle: put the values in order from lowest to highest, then find the number that is exactly in the middle	Very big and very small values don't affect it	Takes a long time to calculate for a very large set of data
Mode	The value that occurs most often: put the values in order from lowest to highest, find the number that occurs most often	Only type of central tendency that can be used for non-numerical data	• There may be more than one mode • There may be no mode at all • It may not accurately represent the range of data

APPENDIX F: DATA ANALYSIS CHECKLIST

Source: ***http://www.sciencebuddies.org/science-fair-projects/project_data_analysis.shtml***

1. Before graphing, ask yourself these questions:
    a. Is it complete, or did you miss something?
    b. Do you need to collect more data?
    c. Did you make any mistakes?
2. Determine which type of central tendency is most appropriate for your data. Calculate the mean, median, or mode.
3. Make sure that your data table title, columns, and rows are all clearly labeled (including units).
4. Place the independent variable on the x-axis of your graph and your dependent variable on the y-axis.
5. Check your data table by asking yourself the following questions:
    a. Is there sufficient data to know that your hypothesis is supported or not?
    b. Is your data accurate?
    c. Have you summarized your data with mean, median, mode as appropriate?
    d. Does your table specific units of measurement for all data?
6. Check your graph by asking yourself the following questions:
    a. Have you selected the appropriate graph type for the data you are displaying?
    b. Does your graph have a title?
    c. Have you placed the independent variable on the x-axis and the dependent variable on the y-axis?
    d. Have you labeled the axes correctly and specified the units of measurements?
    e. Does your graph have the proper scale (the appropriate high and low values on the axes)?
    f. Is your data plotted correctly and clearly?

APPENDIX G: NGSS – 5E MODEL – LESSON PLANNING TEMPLATE

From NGSS Workshop – Brett Moulding and Nicole Paulson

Grade/grade band:	**Topic:**	**Lesson # ____ in a series of ____ lessons**
Brief lesson description:		
Performance expectation(s):		
Specific learning outcomes:		
NARRATIVE/BACKGROUND INFORMATION		
Prior student knowledge:		
Science and engineering practices:	**Disciplinary core ideas:**	**Crosscutting concepts:**
Possible preconceptions/misconceptions:		
LESSON PLAN – 5-E Model		
ENGAGE: Opening activity – Access prior learning / stimulate interest / generate questions: http://www.youtube.com/watch?v=PUB1GU_tvpI&safe=active		
EXPLORE: Lesson description – Materials needed / probing or clarifying questions:		
EXPLAIN: Concepts explained and vocabulary defined: **Vocabulary:**		
ELABORATE: Applications and extensions:		
EVALUATE: **Formative monitoring (questioning / discussion):** **Summative assessment (quiz / project / report):**		
Elaborate further / reflect: enrichment:		

Materials Required for This Lesson/Activity

QUANTITY	DESCRIPTION	POTENTIAL SUPPLIER (item #)	ESTIMATED PRICE

APPENDIX H: LESSON IDEA TEMPLATE – GRC MODEL INSTRUCTIONAL ALIGNMENT TO THREE DIMENSIONS

From NGSS Workshop – Brett Moulding and Nicole Paulson

Student Science Performance

Grade:	**Title:**
Topic:	
Performance expectations (standard) from State standards or NGSS:	
Lesson performance expectations:	
Student science performance	
Phenomenon: ***Gathering*** ***Reasoning*** ***Communicating***	
Assessment of student learning *Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations.* *This may be a rubric, narrative, or other set of descriptors that are useful for distinguishing proficient from non-proficient performances.*	
SEP, CCC, DCI Featured in Lesson	**Science essentials** *(Student Performance Expectations From Appendix C, D, E)*
Science practices	
Crosscutting concepts	
Disciplinary core ideas	

APPENDIX I: GRC MODEL LESSON EXAMPLE INSTRUCTIONAL ALIGNMENT TO THREE DIMENSIONS

From NGSS Workshop – Brett Moulding and Nicole Paulson

Student Science Performance

Grade 7	**Title:** ***Gassy plants***
Topic: Photosynthesis	

Performance expectations (standard) from State standards or NGSS:
MS LS1–6
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Lesson performance expectations:

- Carry out an investigation to gather evidence to identify the cycle of matter in photosynthesis.
- Construct explanations for the cycling of matter in photosynthesis.
- Use models to communicate the cycle of matter in photosynthesis
- Develop an argument for the role photosynthesis plays in the cycling of carbon and oxygen, including the structures within the cell that allows photosynthesis to happen.

Student science performance

Phenomenon: When a plant is in the light, it gives off more gas than in the dark.

Gathering
Students carry out an investigation to gather evidence for how light affects the cycling of matter (i.e., carbon dioxide, water, and oxygen) through photosynthesis [production of glucose].

Students use a table (model) to collect the data and observations from the investigation of changes caused by the plant being in the light or not in the light.

Students obtain information by reading the "xxxxxxx" about inputs and outputs (cycling) of matter and energy during photosynthesis.
(Teacher hint: Students work with elodea in flasks, water doped with baking soda, and pipettes to collect the gas that is produced as they shine a light on the plant. Students record observations in a notebook. Then, they will do a reading on photosynthesis to gather information the "outputs and inputs of photosynthesis.)

Students engage in a brief discussion to develop additional questions to develop the second investigation

Students develop an investigation, using CO_2 and O_2 sensors, to quantitatively observe the patterns present in photosynthesis.

Reasoning
Students construct an explanation for the process of photosynthesis and the role chlorophyll and chloroplasts play. They will support their explanations with the information they gathered from the investigations, and draw upon prior knowledge from lessons on cells. [They can use a drawing to help guide their thinking].

Students participate in a group discussion to identify patterns present in the cycling of matter through photosynthesis.

Questions:

1. How did removing light from the system affect the amount of gas produced/used?
2. Do you notice a pattern that developed in the system?
3. Where did the gas that was produced come from?
4. Would this system have behaved the same without water?
5. Would this system have behaved the same without CO_2?
6. Could this process occur in a different organism?
7. Where did the energy that drives photosynthesis come from and, where did the energy "go"?

Students revise/edit their explanations based on the whole group discussion.

Communicating
Students individually develop models to communicate their explanation of the cycling of matter through photosynthesis. The model can be a sentence "carbon dioxide and water in the presence of light and chlorophyll will combine to form sugar and oxygen gas", or a drawing. They need to include evidence from their investigations in their explanation.

Assessment of student learning
Student models should show the relationships between carbon dioxide, water, oxygen, and glucose.
Models should show the flow of energy from the sun as it is stored in the plant as glucose. Students should include the structures inside a plant that allow photosynthesis to occur.

SEP, CCC, DCI Featured in Lesson	**Science essentials** *(Student Performance Expectations From Appendix C, D, E)*
Science practices	
Crosscutting concepts	
Disciplinary core ideas	

APPENDIX J: NGSS SCIENCE AND ENGINEERING PRACTICES (SEPS) 1–8

Practice 1: Asking questions and defining problems – middle school only
Ask questions that:
1. Arise from observations and phenomena
2. Clarify evidence
3. Determine relationships between independent and dependent variables
4. Clarify or refine a model
5. Require evidence or data collection to answer
6. That can be investigated in the outdoor environment
7. That can be answered through the development of a process or system

Activity Ideas:
1. Guided observations outdoors
    a. Using all your senses, spend two minutes observing your surroundings
    b. What do you hear close by?
    c. What do you hear far away?
    d. What do you see around you?
    e. What time of year is it and how can you tell by looking around you?
    f. Can you tell if this landscape has been impacted by humans?
2. Share observations
3. What questions do you have about this place based on your observations?
4. What makes a "testable question"?
5. Is it a "testable question"?

Design Problem Ideas (need to provide background info or have students do research?):
1. Erosion Control
2. Invasive species control
3. Native vs. Invasive species dominance
4. Soil chemistry and impact on species found

Lesson: Developing a Testable Question – see "What Types of Questions Can We Investigate?" introductory lesson

Practice 2: Developing and using models – *NOT PART OF "STEPS"; middle school only
Developing, using, and revising models to describe, test and predict:
1. Evaluate limits of model
2. Develop or change model according to variables
3. Use a model of a system with less predictable factors
4. Develop a model to show relationships among variables
5. Develop a model to predict or describe
6. Develop a model to generate data

How do kids think about modeling their world? Help teach about models. WHEA has a Modeling our World class I and II. *Model Ideas:*
1. Carbon Cycle and Climate Change Impacts – leading to climate change testing (water temperature, air temperature, CO_2 levels in air and water)
2. Photosynthesis
3. Erosion model – using different erosion control materials, test which method works best for soil type, slope, and climate
4. Watershed Model
5. Ahupuaʻa model
6. Scale model of an ecosystem or garden as a system
7. Sampling as a model for the environment – e.g., M&M's sampling activity
8. Project WILD games – "Oh Deer" game

Practice 3: Planning and carrying out investigations – middle school only

1. Planning and carrying out investigations that use multiple variables: Plan an investigation. In the design identify dependent and independent variables, controls, materials, how measurements will be taken and recorded, and how much data will be collected.
2. Conduct an investigation, evaluate, and/or design revise the experimental design to produce data to serve as the basis for evidence of the goals of the investigation.
3. Evaluate the accuracy of various methods of collecting data.
4. Collect data to produce data to serve as evidence to answer scientific questions.
5. Collect data about the performance of a proposed object, tool, process, or system.

Practice 4: Analyzing and interpreting data

1. (Visual) representation that will allow data to be communicated.
2. Tabulating, graphing or statistical analysis – brings out meaning of data and its relevance.
3. Engineers – create a model that allows for predictions.

Grades 6–8

- Create graphical displays of data to identify relationships
- Apply mean, median, mode and variability to analyze and characterize data

Grades 9–12

- Compare data sets for consistency
- Use models to generate and analyze data
- Identify patterns in data – correlations for linear models
- What are the limitations of data analysis? (sample size or selection)
- Compare and contrast various types of data sets (self-generated or archived)
- Consistency of measurements and observations. Are there outliers? Data error (precision vs. accuracy, limitations of tools)
- Statistical analysis – t-test (compares two variables), ANOVA (analysis of variance- for more than two variables, can be depicted with box and whisker plots)
- Analyze data to identify design features –

Practice 5: Using mathematics and computational thinking

1. Mathematics and computational thinking are applied in science and engineering differently, however, they also bring together these two fields i.e. engineers apply mathematical form of scientific theories; scientists use technologies designed by engineers
2. Students are expected to use mathematics to
    a. Represent physical variables and their relationships
    b. Make quantitative predictions
    c. Logic, geometry, calculus
3. Computers/digital tools
    a. Enhance power of mathematics by automating calculations
    b. Approximating solutions that cannot be calculated precisely
    c. Analyzing large data sets to identify meaningful patterns
    d. Laboratory tools connected to computers: observing, measuring, recording, and processing data
4. Computational thinking
    a. Strategies for organizing and searching data
    b. Creating sequences of steps called algorithms
    c. Using and developing new simulations of natural and designed systems
5. ***Mathematics is a critical tool that is key to understanding science***

Grades 6–8

- Identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Examples:
  - Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends
  - Use mathematical representations to describe and/or support scientific conclusions and design solutions

Grades 9–12

- Using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Example:
  - Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Practice 6: Constructing explanations and designing solutions

1. Goal of science is to construct explanations for causes of phenomena.
2. Explanation can be based on theory (background research) and student understanding
3. Explains how variables relate to one another
4. Engineering involves defining the problem, generating, testing and improving solutions.
5. Science – construct an explanation
6. Engineering – construct a model and test prototypes

Grade 6–8

- Construct explanations that shows relationships between qualitative or quantitative variables
- Construct a scientific explanation based on student experiments, theory and law
- Apply scientific reasoning to show why data is adequate for the explanation or conclusion
- Design, construct and/or test an object, process or system
- Optimize performance of design by testing, revising and retesting.

Grades 9–12

- Make claim about quantitative and/or qualitative variables
- Construct and REVISE scientific explanation based on student experiments, theory and law
- Link evidence to claims
- Design, evaluate or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria and tradeoff considerations.

Practice 7: Engaging in argument from evidence

1. Practice comparing and evaluating argument or design solutions
2. Peer critique (maybe include a sheet for students that they could use when they critique another's work) and comparison of experimental procedures and data (poster sessions and presentations)
3. Construct, use, and/or present an argument [claims, evidence and reasoning protocol – Joseph S. Krajcik (5–8)]
4. Examples of CER for students using graphs and data that could be used prior to looking at their own experimental data
5. Understand the processes scientist/engineers use to reach agreement

Practice 8: Obtaining, evaluating, and communicating information

Obtaining information is the background knowledge and beginning stages of the process.

1. Read, interpret and produce science/engineering and technical text
   a. Critically read scientific texts to describe patterns in or evidence about the natural world (Close reading strategies, AVID strategies, graphic organizers, thinking maps)
      i. Gather, read, evaluate (high school only), synthesize information from multiple sources (background information)
2. Integrate qualitative/quantitative data in written text (lab write-up that incorporates data table, graphs, models, photographs, diagrams from the experiment)

3. Use tables, diagrams, graphs, models, interactive displays, and equations to communicate orally, in writing, or in discussion
4. Communicate scientific information in writing and through oral presentations (citizen science websites, write-ups, and symposium/poster session)

Assessment (NGSS rubrics – Appendix F)

1. Prefer the condensed version at the end of the document
2. Formative assessments recommended for each section (field journal)
3. Summative assessment (Symposium presentations)

Additional resource

- NGSS Evidence Statement Examples
  https://www.nextgenscience.org/evidence-statements

NĀ HOPENA A‘O (HĀ) STATEMENTS – HAWAIIAN CULTURAL EDUCATION FRAMEWORK

November 2015
Source: http://www.hawaiipublicscools.org/DOE%20Forms/NaHopenaAoE3.pdf

B.R.E.A.T.H.

1. Strengthened Sense of **B**elonging:
   I stand firm in my space with a strong foundation of relationships. A sense of Belonging is demonstrated through an understanding of lineage and place and a connection to past, present, and future. I am able to interact respectfully for the betterment of self and others.
   a. Know who I am and where I am from
   b. Know about the place I live and go to school
   c. Build relationships with many diverse people
   d. Care about my relationships with others
   e. Am open to new ideas and different ways of doing things
   f. Communicate with clarity and confidence
   g. Understand how actions affect others
   h. Actively participate in school and communities

2. Strengthened Sense of **R**esponsibility:
   I willingly carry my responsibility for self, family, community and the larger society. A sense of Responsibility is demonstrated by a commitment and concern for others. I am mindful of the values, needs and welfare of others.
   a. Come to school regularly, on-time and ready to learn
   b. See self and others as active participants in the learning process
   c. Question ideas and listens generously
   d. Ask for help and feedback when appropriate
   e. Make good decisions with moral courage and integrity in every action.
   f. Set goals and complete tasks fully
   g. Reflect on the quality and relevancy of the learning
   h. Honor and make family, school, and communities proud

3. Strengthened Sense of **E**xcellence:
   I believe I can succeed in school and life and am inspired to care about the quality of my work. A sense of Excellence is demonstrated by a love of learning and the pursuit of skills, knowledge and behaviors to reach my potential. I am able to take intellectual risks and strive beyond what is expected.
   a. Define success in a meaningful way
   b. Know and apply unique gifts and abilities to a purpose
   c. Prioritize and manage time and energy well
   d. Take initiative without being asked
   e. Explore many areas of interests and initiate new ideas
   f. Utilize creativity and imagination to problem-solve and innovate
   g. See failure as an opportunity to learn well
   h. Assess and make improvements to produce quality work

4. Strengthened Sense of **A**loha:
   I show care and respect for myself, families, and communities. A sense of Aloha is demonstrated through empathy and appreciation for the symbiotic relationship between all. I am able to build trust and lead for the good of the whole.
   a. Give generously of time and knowledge
   b. Appreciate the gifts and abilities of others
   c. Make others feel comfortable and welcome
   d. Communicate effectively to diverse audiences
   e. Respond mindfully to what is needed
   f. Give joyfully without expectation of reward

g. Share the responsibility for collective work
h. Spread happiness

5. Strengthened Sense of **T**otal Well-being:
I learn about and practice a healthy lifestyle. A sense of Total Well-being is demonstrated by making choices that improve the mind, body, heart and spirit. I am able to meet the demands of school and life while contributing to the wellbeing of family, ʻāina, community and world.
    a. Feel safe physically and emotionally
    b. Develop self-discipline to make good choices
    c. Manage stress and frustration levels appropriately
    d. Have goals and plans that support healthy habits, fitness and behaviors
    e. Utilize the resources available for wellness in everything and everywhere
    f. Have enough energy to get things done daily
    g. Engage in positive, social interactions and has supportive relationships
    h. Promote wellness in others

6. Strengthened Sense of **H**awaiʻi:
I am enriched by the uniqueness of this prized place. A sense of Hawaiʻi is demonstrated through an appreciation for its rich history, diversity and indigenous language and culture. I am able to navigate effectively across cultures and communities and be a steward of the homeland.
    a. Pronounce and understand Hawaiian everyday conversational words
    b. Use Hawaiian words appropriate to their task
    c. Learn the names, stories, special characteristics, and the importance of places in Hawaiʻi
    d. Learn and apply Hawaiian traditional worldview and knowledge in contemporary settings
    e. Share the histories, stories, cultures, and languages of Hawaiʻi
    f. Compare and contrast different points of views, cultures, and their contributions
    g. Treat Hawaiʻi with pride and respect
    h. Call Hawaiʻi home

ʻĀina-based investigations provide teachers and students opportunities to engage with HĀ (BREATH) in a unique way.

1. Strengthened Sense of **B**elonging:
I stand firm in my space with a strong foundation of relationships. A sense of Belonging is demonstrated through an understanding of lineage and place and a connection to past, present, and future. I am able to interact respectfully for the betterment of self and other.

    Through conducting ʻĀina -based investigations students can strengthen their Sense of Belonging through deepening their understanding of their relationship to their watershed and its natural resources.
    a. Know who I am and where I am from
        i. *Students will deepen their understanding of their watershed and their place in it.*
    b. Know about the place I live and go to school
        i. *Students will connect to natural resources in their watershed.*
            1. Watershed issues
            2. Stewardship action projects
    c. Build relationships with many diverse people

2. Strengthened Sense of **R**esponsibility
3. Strengthened Sense of **E**xcellence
4. Strengthened Sense of **A**loha
5. Strengthened Sense of **T**otal Well-being
6. Strengthened Sense of **H**awaiʻi

Additional resource

- Hawaiian Cultural Education Framework
  http://www.olelo.hawaii.edu/olelo/nhmo.php

APPENDIX L: MIDDLE SCHOOL STUDENT FIELD RESEARCH PACKET EXAMPLE

Laura Jim's 7th grade Biology class – Hawai'i Preparatory Academy

Purpose of program: Through this program we will be able to conduct relevant outdoor research experiences and field research activities that are aligned with Common Core and Next Generation Science Standards. We will also develop an understanding of watersheds (including their value), the water cycle, invasive and endemic species, and field research techniques.

Schedule

	PD. A 17 PAX	PD. B 11 PAX	PD. E 15 PAX
Step 1a: First class	Tuesday, Jan.26 12:40–1:50	Tuesday, Jan.26 2:00–3:10	Wednesday, Jan.27 9:30–10:40
Step 1b: Second class	Thursday, Jan.28 10:50–12:00	Thursday, Jan.28 8:10–9:20	Friday, Jan.29 8:10–9:20
Step 2: Senses and observations skills @ Nature Park	Monday, Feb.1 8:10–9:20	Monday, Feb.1 9:30–10:40	Tuesday, Feb.2 8:10–9:20
Step 3: Introduction to field work @ Nature Park	Tuesday, Feb.2 12:40–1:50	Tuesday, Feb.2 2:00–3:10	Wednesday, Feb.3 9:30–10:40
Step 4: Day of research @ Kalōpā State Park	Tuesday, Feb.16 8:10–3:10	Monday, February 15 8:10–3:10	Wednesday, Feb.17 8:10–3:10

Presentation topics

First class

1. Review of watershed through interactive activity and review
2. How does water move around the earth?
3. What is special about Hawai'i's watersheds? How do they differ from elsewhere?
4. Why are there so many endemic organisms in Hawai'i? (Hawai'i's isolation)

Second class (content not included below)

1. Hawai'i's most common endemic organisms
2. Other visitors to our forests
3. Biodiversity: What is it? Is it important?

Field trip 1: Opening our senses
Field trip 2: Quadrat and transect activities
Field trip 3: Conduct field investigations

First class

Today's goals

1. Review information about watersheds.
2. Learn about the water cycle
3. Determine the uniqueness of Hawai'i's watersheds and their importance.

BEFORE YOU BEGIN THIS, PLEASE RECORD THE DATES NOTED ABOVE IN YOUR PLANNER! Also, just FYI: If you go to Ha'ikū on this assignment, you will find the links to all the websites listed here!
Record what you remember from the presentation Ms. Didi gave about watersheds. Do NOT go back to your notes. This is intended merely as a check-in to see what you remember!

How does water move around the Earth? Using an image draw where (you think) water goes on this Earth. Label as much as you can.

STEP 1: Go to the following website: http://water.usgs.gov/edu/watershed.html

Define a watershed.

What is the size of a watershed?

Explain briefly the statement: "A watershed is a precipitation calculator"

STEP 2: Go to the following website: http://oceanexplorer.noaa.gov/edu/learning/player/lesson07.html

Click on the water cycle video. Record notes below but do NOT draw the water cycle. You will do that next.

STEP 3: Go to the following website http://water.usgs.gov/edu/watercycle.html

1. Draw and label the water cycle as shown. Color it too but leave room next to the terms so that you can add information (next task)! You can turn the paper sideways if you prefer!

2. Visit the interactive website https://www3.epa.gov/safewater/kids/flash/flash_watercycle.html AND record information about the various terms offered on the drawing above. You will obviously need to simplify things and not everything will have content. Please add "fog drip" into your cycle as well.

Fog drip is water dripping to the ground during fog (https://en.wikipedia.org/wiki/Fog). It occurs when water droplets from the fog adhere to the needles or leaves of trees or other objects, coalesce into larger drops, and then drop to the ground (http://glossary.ametsoc.org/wiki/Fog_drip). Fog drip can be an important source of moisture in areas of low rainfall, or in areas that are seasonally dry.

Water Cycle for Schools

Water cycle for kids (ages 5-95) and schools - in many languages. Available as:

Diagram | **Interactive Web site**

3. Looking at the water cycle, how do you think Hawai'i's water cycle is different than this "typical" water cycle? List some ways in which they are different.

4. Talk to another student about your ideas. Collect his/her signature below documenting you had a conversation.

STEP 4: Go to the following website: http://hawp.org/forested-watersheds-and-cultural-resources/

1. Read the following information and explain why trees are necessary for the hydrologic cycle.

> Disturbed Water Cycle – trees are an important part of maintaining the Earth's water resources. By drawing up groundwater through their roots and then releasing it into the atmosphere through their foliage, they play a significant role in the hydrologic cycle. In addition, their roots also help to create large conduits in the soil, which helps water to infiltrate through the ground area; their trunks and stems help to stop surface runoff, which contributes to erosion, and a large proportion of precipitation is intercepted by their leaf canopies and then re-evaporated back into the atmosphere.
>
> Furthermore, the leaf litter and other organic residue from trees help to provide a ground covering and increase the soil's capacity to store water.Trees literally control the amount of water available in the atmosphere, the soil or even in the ground water. Thus, areas that have been cleared of trees cannot retain as much moisture in the ground and atmosphere and this very often leads to a drier climate and eventual desertification.
>
> For example, instead of intercepting precipitation and allowing the rain water to gradually percolate down to the soil to eventually join the groundwater systems, the bare, tree-less areas promote surface water run-off – which might convert into dangerous flash floods. Also, this water – instead of being reabsorbed by tress and re-released back into the atmosphere, is lost in the run-off and ultimately to the oceans.

2. What does Hahai nō ka ua i ka ulu lā'au mean? Using the above information and the translation in the reading, try to truly explain this proverb.

3. Read down to the Hawaiian proverbs that demonstrate the importance of forests on the Hawaiian culture. Choose your favorite proverb and rewrite it in Hawaiian and English here.

STEP 5: Go to the following website: http://hawp.org/why-watersheds-matter/

1. What is the value of watersheds? Make some guesses here!

2. Watch the video titled "Why Watersheds Matter" and record notes below. Choose, in your opinion, the top 6.

IMPORTANCE	EXPLANATION

Field Trip 1: Opening Our Senses

You will spread away from your friends and lie quietly.

1. Take 5 minutes to observe the environment around you using all your senses. You will here a "ding" to start and end this time.

2. Take 5 minutes to record the to write five statements. You will hear a double ding to start and end this time. These must start with one of the following:
    - I felt…
    - I saw…
    - I heard…
    - I touched…
    - I smelled…

3. Come back together (without talking) and we will share one comment from each person. Choose wisely and star the one you recorded up above.

4. After sharing your one observation, extend it by adding a wonder statement. Record this here:

   I wonder….
    - Is this "wonder statement" a testable question? Why or why not?

   If you said no, go to question 5. If you said yes, go to question 6.

5. Please alter your wonder statement to make it be a testable question.

6. Give a VERY BRIEF explanation of an experiment you could perform to test your wonder statement.

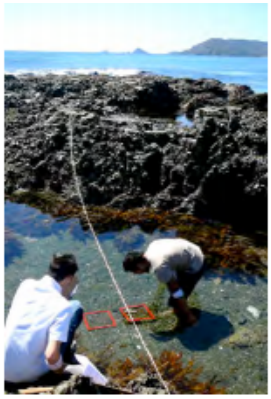
Introduction to Sampling

M&M's Lesson – see in Sampling Methods section above

Field Trip 2: Quadrat and Transect Activities

How, where, and why we do sampling

We often collect data "in the field," which could mean underwater, in a forest, in a cave, on a reef, or even the moon! Two essential methods to gather ecological information in a standardized way are: Transect Sampling (using a single line) and Quadrat Sampling (counted within a grid). These sampling methods provide more accurate data than random sampling or simply guessing, but they take less time than counting every specimen in a certain area. Sampling helps us estimate and compare!



What is a transect?

A transect is simply a line (could be a tangible line or not) we stretch over an area we want to study. The line must have regular measurements marked off, like a tape measure, and is held straight and stationary.

Practice with a transect

1. As a group we will determine the best place to lay our transect lines. In the interest of time, we will use the following categories for this activity. The last one is a category of your choosing.

G = grass	R = rock	D = Bare dirt
L = leaf matter	O = other vegetation	=

Experimental question: What is the main ground cover at Ulu Lāʻau?

Procedure: Lay your transect line out 30 meters. After having laid down a transect line, count the groundcover found under the line at each meter. Do not count anything on the ground that is not situated on a meter transect point even if it's just an inch away AND there can only be one ground cover identified at each point.

METER #	1	2	3	4	5	6	7	8	9	10
Item										

METER #	11	12	13	14	15	16	17	18	19	20
Item										

METER #	21	22	23	24	25	26	27	28	29	30
Item										

Table 1. # incidents of surface over 30-meter transect line and their percentages.

	# INCIDENTS / 30 m	PERCENTAGE
Grass (G)		
Leaf matter (L)		
Rock (R)		
Other Vegetation (O)		
Bare dirt (D)		
( )		
Total	30	

Questions:

1. How did the transect line help you be random in your sampling?

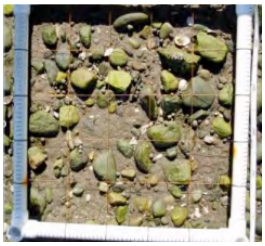
2. Do you feel that the data you collected is valid enough to truly determine the main ground cover at Ulu Lāʻau. Provide reasoning for your response.

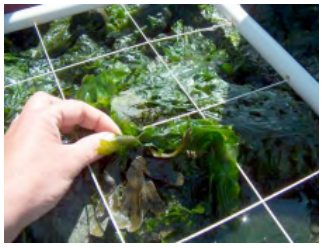
3. How could you improve the accuracy of your data?

Practice with a quadrat

Using a quadrat

Taking samples systematically will enable you to truly define the abundance of something, its percent cover, etc.





Experimental question: What is the frequency with which dandelion, clover, grass, and other is found on the grassy area at Ulu Lāʻau?

1. *Visual estimation:* First, estimate the frequency of dandelions, clover, grass and "other" is found on the grassy area at Ulu Lāʻau. Note: Estimate means take your best guess!
2. *Quadrat estimation*: Next, use your quadrat to estimate more accurately. Place your quadrat with the top left corner at the 1m mark of your transect line. At the intersection point for each line (just stay in the inside) identify the organism. Write this down as a tally. Re-position your quadrat at 5 m, 10 m, 15 m, 20 m, 25 m and 30 m. Record your results here and you should have a total of 16 tallies for each quadrat.

Table 2. Frequency of dandelion, clover, grass and "other" at Ulu Lāʻau's grassy area using 7 m^2 quadrats.

	QUADRAT 1 1 m	QUADRAT 2 5 m	QUADRAT 3 10 m	QUADRAT 4 15 m	QUADRAT 5 20 m	QUADRAT 6 25 m	QUADRAT 7 30 m
Dandelion							
Clover							
Grass							
Other							

Table 3. Percent frequency of dandelion, clover, grass, and "other" at Ulu Lāʻau's grassy area.

	% FREQUENCY
Dandelion	
Clover	
Grass	
Other	

Final review

1. Which visual estimation method – **transect sampling** or **quadrat sampling** – do you think is better to estimate percent cover of sample populations? Think about how **reliable** the data is and whether or not there could have been **error**.

2. Was there any **bias** in any of our sampling protocols? Think about **randomization** that did or did not occur.

Vocabulary

- *Transect Sampling* – counted on points of a single line
- *Quadrat Sampling* – counted on points of a grid
- *Transect Point* – measured distance on a transect line
- *Reliable* – yielding the same results in different experiments or studies
- *Intercept Point or Point Intercept* – where two lines of a quadrat cross
- *Percent Cover* – portion of a total area one species covers at a specific site
- *Error* – Statistical error is caused by random (unpredictable or unintentional) variation in making a measurement, whereas systematic error is caused by an unknown. If the cause of the systematic error can be identified, then it can usually be eliminated. Such errors can also be referred to as uncertainties
- *Bias* – a personal preference that causes unfair judgment. In science, a sampling error caused by systematically favoring some outcomes over others.
- *Randomization* – the making of random arrangement in order to control the variables in an experiment

Field Trip 3: Conduct Field Investigations

HI-MEET field trip and "products" overall plan

Introduction

I am very excited to spend some time at Kalōpā with you. As part of your work at Kalōpā you will be completing two items. The first is a field research project (of your choosing). While at Kalōpā you and a partner will be developing and executing a project of your choosing. You will have about 4 hours to do this in. The second part is an "other" product you will work on independently. You will see options below of what you can choose from but know that you will be collecting some items while at Kalōpā. For example, if you are choosing to make a short video you would need a video camera. I will be bringing all the media items I have.

Calendar of Various Items

	PDS. A & B		PD. E	
Think about plan for "other" product	Thur., Feb. 4		Fri., Feb. 5	Video, Photo ID key, My Hawai'i story contest, other?
Trip to Kalōpā	Tue., Feb. 16	Mon., Feb. 15	Wed., Feb. 17	At Kalōpā you will be developing an experiment, and completing your research. You will also be given time to work on your "other" project by writing, collecting images, etc.
"Other" product due	Thur., Feb. 25		Fri., Feb. 26	Complete your "other" product using media or knowledge you collected on the trip. You will have class time and homework time to work on this.
Scientific paper due	Thur., March 3		Fri., March 4	Complete a scientific paper of your findings. See the rubric included. You will have class time and homework time to work on this.

Items to bring

You MUST be prepared on our day to Kalōpā.

Please take time to write this into your planner now:

- raingear
- backpack
- filled water bottle (at least one)
- lunch (no pre-paid available)
- warm clothes
- long pants and long shirt (mosquito prevention)
- closed-toe walking shoes
- sun protection
- science notebook
- writing implements (pen, pencil, et.)
- technology (optional)

TENTATIVE TIMING FOR THE DAY	AVAILABLE MATERIALS
8:10 Meet at bus and prepare to depart 8:15–8:45 Drive to Kalōpā 8:45–9 Acquaint to area and students share "other" project plan with needs 9–9:30 Walk the nature trail and open senses 9:30–10:15 Develop project ideas, establish groups, create "pre-experimentation" papers 10:15–11:30 Run Data Collection 11:30–12 Eat lunch and share initial findings 12–2 Finish data collection 2:15 Pack into van and head home! 3:00 Clean van and return materials	Field guides Transect tapes Quadrats Rope Tape Binoculars Thermometer Soil test kit Magnifying glass Bug cube Sheet Cameras and iPod

"OTHER" PRODUCT	SCIENTIFIC FIELD RESEARCH AND SCIENTIFIC PAPER
Option 1: Video of Kalōpā Create a video of Kalōpā. You will need to introduce the area, discuss points of interest, and share the history of Kalōpā. Images should be the driving force of your video. **Option 2: Video of research** Create a video of your research completed at Kalōpā. With the help of your partner(s) share your experimental question, your research methods, and your findings. **Option 3: Photo ID book** Create a photo ID key that includes at least 15 native plants of Kalōpā. You will then create a book that provides, for each organism, at least one photo, an explanation on its size, coloration, location, etc., and its various names (scientific, common, Hawaiian, etc.). **Option 4: My Hawai'i story contest** Create a poem or story (1,000 words or less) that addresses the theme "Planet at the Crossroads." This can not be an acrostic poem and you need to think about the following: • Your written piece must connect to the theme and to Hawai'i's unique environment. • You express your ideas clearly. • Your written piece is creative and original. We need to hear YOU in it!	**Steps to our field work:** 1. Open our senses to Kalōpā's flora (plants) and fauna (animals) – plus any other living or nonliving items of interest! 2. Develop an experimental question that you would like to research. 3. Locate a partner with shared interest. 4. Develop one "pre-experimental lab report" as a team. 5. Share your lab write-up with Mrs. Jim or Auntie Ilene and make adjustments as needed. 6. Complete your field research, recording results into your completed data tables. 7. Store your data for safe-keeping.

"Other" product

What is your "other" product? _____

What do you need to get today?

Field Research Ideas

"Pre-experimentation" lab write-up
Below is a template that you can complete your lab write-up into. Between you and your partner you both have two of these templates. Use one of yours for a draft and the second one as the final.

Is this your team's draft or final? _____

EXPERIMENTAL QUESTION

HYPOTHESIS

MATERIALS

PROCEDURE

Variables

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	CONSTANTS

Results
Create data table(s) here!

Lab Report: HI-MEET Final Lab Report Rubric

Group members: _____

_____

+ /64 = _____ %

CATEGORY	4	3	2	1
Purpose	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	The purpose of the lab or the question to be answered during the lab is identified, but is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is partially identified, and is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is erroneous or irrelevant.
Experimental hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted results is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
Variables	All variables (independent, dependent, and controlled) are clearly described with all relevant details.	All variables are clearly described with most relevant details.	Most variables are clearly described with most relevant details.	Variables are not described OR the majority lack sufficient detail.
Materials	All materials used in the experiment are clearly and accurately described.	Almost all materials used in the experiment are clearly and accurately described.	Most of the materials used in the experiment are accurately described.	Many materials are described inaccurately OR are not described at all.
Experimental design	Experimental design is a well-constructed test of the stated hypothesis.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is not relevant to the hypothesis.
Replicability	Procedures appear to be replicable. Steps are outlined sequentially and are adequately detailed.	Procedures appear to be replicable. Steps are outlined and are adequately detailed.	All steps are outlined, but there is not enough detail to replicate procedures.	Several steps are not outlined AND there is not enough detail to replicate procedures.

Results	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled with all units.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in written form, but no graphs or tables are presented.	Data are not shown OR are inaccurate.
Graphs	Clear, accurate graphs are included and make the experiment easier to understand. They are labeled neatly, titles and accurately created.	Graphs are included and are labeled neatly and accurately.	Graphs are included and are labeled but not titled.	Needed graphs are missing OR are missing important labels.
Discussion	Discussion includes whether the findings supported the hypothesis, an answer to the question, possible sources of error, and what was learned from the experiment.	Discussion includes whether the findings supported the hypothesis, an answer to your question is provide, and what was learned from the experiment.	Discussion includes what was learned from the experiment.	No Discussion was included in the report OR shows little effort and reflection.
Conclusion	You clearly and concisely critique the experience at Kalōpā as well as your experiment itself.	You critique the experience at Kalōpā as well as your experiment itself.	You minimally critique the experience at Kalōpā as well as your experiment itself.	You do not clearly and concisely critique the experience at Kalōpā as well as your experiment itself.
Scientific concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab. All aspects of the report demonstrate a clear grasp of sampling, your topic, etc.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.

Conclusion	You clearly and concisely critique the experience at Kalōpā as well as your experiment itself.	You critique the experience at Kalōpā as well as your experiment itself.	You minimally critique the experience at Kalōpā as well as your experiment itself.	You do not clearly and concisely critique the experience at Kalōpā as well as your experiment itself.
Scientific concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab. All aspects of the report demonstrate a clear grasp of sampling, your topic, etc.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.
Spelling, punctuation, and grammar	One or fewer errors in spelling, punctuation and grammar in the report.	Two or three errors in spelling, punctuation and grammar in the report.	Four errors in spelling, punctuation and grammar in the report.	More than 4 errors in spelling, punctuation and grammar in the report.
Appearance/ organization	Lab report is typed and uses headings and subheadings to visually organize the material.	Lab report is neatly handwritten and uses headings and subheadings to visually organize the material.	Lab report is neatly written or typed, but formatting does not help visually organize the material.	Lab report is handwritten and looks sloppy with cross-outs, multiple erasures and/or tears and creases.

APPENDIX M: FIELD INVESTIGATION RESOURCE CONTACTS FOR FIELD TRIPS AND PRESENTERS

Some organizations have funding to support school programs and some may charge a fee per student.

Other curricula

- Hōʻike o Haleakala http://www.hoikecurriculum.org/
- ʻŌhiʻa Project http://www.mgf-hawaii.org/HTML/School/ohia.htm
- Kai Eʻe Mounting Seas: Pacific Tsunami and Climate Change Curriculum http://ulukau.org/gsdl2.81/cgi-bin/cbkaiee?l=haw
- Project WILD http://www.projectwild.org/
- Project WET http://www.projectwet.org/
- Project Learning Tree (PLT) https://www.plt.org/

Hawaiʻi Island Resource List

This is the beginning of a field science resources list for field sites and classroom presenters. We will continue to update this list online.

PROGRAM/ ORGANIZATION	ORGANIZATION/ ACTIVITIES	CONTACT/PHONE	EMAIL/WEBSITE
Kahaluʻu Bay Education Center	The Kohala Center, ReefTeach volunteers	Kathleen Clark	kclark@kohalacenter.org
Puakō ReefTeach	ReefTeach volunteers	Laura Grote 808-333-6939	lauragrote@gmail.com
Kīholo Bay	The Nature Conservancy, Fish pond restoration Volunteer Work Days	Rebecca Most, 808-741-4584	rmost@tnc.org nature.org/hawaii
Puʻu Waʻa Waʻa	DOFAW – DLNR, Plant endangered trees	Melanie Dudley, 808-854-2608 Tabetha Block (permit officer for federal permit office. Need a permit to visit site and do research or planting there	napuuconservation@gmail.com tabethaablock@fs.fed.us
Kaʻūpūlehu Ahupuaʻa, Visitor Center and Dryland Forest	Kaʻūpūlehu Cultural Center Daily classes and exhibits. Open M-F only Forest site visits and restoration projects	Lehua Alapai, 808-781-4421	http://www.fourseasons.com/hualalai/services_and_amenities/hawaiian-culture/ka_upulehu_cultural_center/ lehuaalapai@gmail.com
Mauna Kea Watershed Alliance	Field trips Classroom lessons	Cheyenne Hiapo Perry, Coordinator mobile:	chperry@hawaii.edu

		808-937-5170, office: 808-933-0622, fax: 808-974-4255	
Three Mountain Alliance **ʻImi Pono no ka ʻĀina**	Volcanoes National Park and other sites in Three Mountain Alliance	Lance Tominaga, Natural Res. Mgmt. Specialist 808-985-6093 (office) Lea Kaʻahaʻāina	mrltominaga@gmail.com leakaahaaina@gmail.com
Ulu Mau Puanui	Students learn about the Kohala dry land agricultural field system cultivated by Hawaiians for centuries	808-936-1612	http://www.ulumaupuanui.org
Kona Coast National Parks **Kaloko Honokōhau National Park** **Puʻuhonua o Hōnaunau National Historical Park** **Puʻukoholā Heiau National Historic Park**	Field trip sites		https://www.nps.gov/kaho/index.htm https://www.lovebigisland.com/national-parks-on-the-big-island/#honaunau http://www.nps.gov/puho/planyourvisit/the-puuhonua.htm https://www.lovebigisland.com/national-parks-on-the-big-island/#Puukohala
Kohala Watershed volunteer work and forest visits	Kohala Watershed Partnership	Cody Dwight, Coordinator, 808-443-2761 fax 808-885-6707	http://www.kohalacenter.org http://facebook.com/TheKohalaCenter cdwight@kohalacenter.org
ʻAlalā Bird Sanctuary	Keauhou Bird Conservation Center Discovery Forest – San Diego Zoo Global	Bryce Masuda, Conservation Program Manager Hawaiʻi Endangered Bird Conservation Program	bmasuda@sandiegozoo.org
Aloha Kuamoʻo ʻĀina (S. Kona coast)	Archaeological and coastal trail Service learning projects	Monika Frazier	monikameilanifrazier@gmail.com
Big Island Invasive Species	Classroom presentations,	Franny Kinslow Brewer,	fbrewer@hawaii.edu

Committee	lessons Service learning	Communications Director 808-933-3340 Cell 808-987-0620	biisc@hawaii.edu www.biisc.org
Nā Ala Hele	Restoration and Trails work	Jackson Bauer, Hawai'i Island Nā Ala Hele Trails and Access Specialist 808-217-7732	jackson.m.bauer@hawaii.gov
Stream water quality testing and native plant restoration	UH Sea Grant College Program	Wai'ula'ula Watershed Project	http://seagrant.soest.hawaii.edu/
Kalōpā State Park Lapakahi State Park **Hāpuna Beach State Recreation Area**	DLNR – State Parks Field Trips and classroom presentations	Dena Sedar Interpretive Program Specialist 808-209-0977	dena.m.sedar@hawaii.gov
Mokupāpapa Discovery Center	Papahānaumokuāke a Marine National Monument (NOAA) exhibits; classroom presentations	Justin Umholtz, Discovery Center Program Coordinator 808-933-8184	Justin.umholtz@noaa.gov
Fisheries Management; Fishing education	DLNR – DAR	John Kahiapo	john.n.kahiapo@hawaii.gov
Barbless Hook and Fishing Education Program		Susannah Welch Outreach and Education Associate Marine Wildlife Program 808-464-3473 Fax: 808-961-9599	sbwelch@hawaii.edu
Eyes of the Reef Network	Division of Aquatic Resources (DAR)	Lindsey Kramer, Hawai'i Island Coordinator- Eyes of the Reef Network; Fish and Habitat Monitoring Tech	http://eorhawaii.org/ kramerkl@hawaii.edu
Coral Reef Alliance (CORAL)	Water Quality data collection volunteers needed – Puakō	Erica Perez	http://coral.org/ eperez@coral.org
The Kohala Center's Demonstration Farm	Sowing seeds, harvesting, removing weeds	Dave Sansone	dsansone@kohalacenter.org

Coconut Chris' Tropical Permaculture Garden	Tour, garden work	Christopher Carter	https://www.facebook.com/Cooking-life-with-Coconut-Chris-144875438908453/
USGS Pacific Islands Water Science Center	Take water and soil samples	808-967-7328	
Friends of Natural Energy Laboratory of Hawaii Authority	Ocean Matters (Mondays, 10 a.m.) Ocean Conservation Tour (Tuesdays and Thursdays, 10 a.m.) Sustainable Aquaculture Tour (Wednesdays and Fridays, 10 a.m.)	Candee L. Ellsworth Executive Director, Friends of NELHA	*Book online at* http://friendsofnelha.org/tours/
Kampachi Farms	Tour	808-331-1188	info@kampachifarm.com
Blue Ocean Mariculture	Tour	808-331-8222	
Surfrider Foundation	Beach cleanup type events		https://www.surfrider.org/support-surfrider

Oʻahu Resource List

PROGRAM/ ORGANIZATION	ORGANIZATION/ ACTIVITIES	CONTACT/PHONE	EMAIL/WEBSITE
Hawaiʻi Institute of Marine Biology	University of Hawaiʻi at Mānoa	808-956-8111	*Tour Inquiries:* himbcep@hawaii.edu http://www.himb.hawaii.edu/
Hawaii 4-H	Programs in ag., healthy living, citizenship	Honolulu County Office: 808-622-4185	
Koʻolau Mountains Watershed Partnership	Invasive species control, bio surveys	808-426-8071	koolaupartnership@gmail.com
ʻAhahui Mālama i ka Lōkahi	Native plant restoration	Richard Kaʻimi Scudder 808-263-8008	fieldops@ahahui.net http://www.ahahui.net
Hawaiʻi Nature Center	For grades K-6	808-955-0100	
Holoholo Farm	Grades: K-12 Seeding, equipment demos, experiments	808-445-0109	holoholofarm@gmail.com
Mānoa Cliff Trail Restoration Project	Volunteer: Sundays at 9 AM		manoacliffnatives@gmail.com
Olomana Gardens	Tour, workshops	808-259-0223	olomanagardens@hawaii.rr.com
Naked Cow Dairy Farm and Creamery	Grade Pre-K – Grade 8 Farm education		tours@nakedcowdairyhawaii.com

More Oʻahu field trip locations from Kōkua Hawaiʻi Foundation field trip web page:
https://www.kokuahawaiifoundation.org/fieldtrips/island/oahu

- Art Explorium
- Bishop Museum
- Camp Erdman
- Hawaiʻi Nature Center
- Hawaiian Earth Products
- Hoʼomaluhia Botanic Garden
- Hoa ʻĀina O Mākaha
- Holoholo Farm
- Hui Kū Maoli Ola
- Kaʻala Farm
- Kākoʻo ʻŌiwi
- Kahuku Farms
- Kahumana Organic Farm
- Kawainui Marsh State Wildlife Sanctuary
- Kualoa Ranch
- Kuʼu Home Kulaiwi (Aunty Nonaʼs Kalo Farm)
- Loko Ea Fishpond
- Lyon Arboretum
- MAʻO Organic Farms
- Mariʼs Garden
- Naked Cow Dairy Farm and Creamery
- ʻNalo Farms
- Olomana Gardens
- Paepae o Heʻeia
- Papahana Kuaola
- The Green House
- Tin Roof Ranch
- Waiāhole Nursery and Garden Center
- Waikalua Loko Iʻa
- Waimea Valley

Maui Resource List

PROGRAM/ ORGANIZATION	ORGANIZATION/ ACTIVITIES	CONTACT/PHONE	EMAIL/WEBSITE
Waiheʻe Coastal Dunes and Wetlands Refuge	Beach cleanup	808-244-5263	
Hawaiʻi Nature Center – ʻIao Valley	Hands-on activities	808-244-6500	
Maui Forest Bird Recovery Project (MFBRP)		808-573-0280	
East Maui Watershed Partnership	Field work	808-573-6472	miscpr@hawaii.edu
Project S.E.A.-Link	Citizenship work		info@projectsealink.org
Haleakalā National Park	Trail Stewardship, volunteer	808-572-4400	
Maui Nui Seabird Recovery Project	Seabird restoration, research opportunities		http://www.mauinuiseabirds.org/

More field trip opportunities at these websites
Kōkua Hawaiʻi Foundation field trip web page:
https://www.kokuahawaiifoundation.org/fieldtrips/island/maui

Volunteer/service learning opportunities
https://preservehawaii.org/volunteer/

APPENDIX N: FIELD TRIP SAFETY

By the NSTA Safety Advisory Board 12 March 2015 http://static.nsta.org/pdfs/FieldTripSafety.pdf

I. Purpose

The purpose of this NSTA Safety Advisory Board paper is to provide fundamental considerations for safer field trips and is not meant to address all of the hazards to specific sites or science disciplines. A field trip is defined as any activity outside of the science classroom whether it occurs on or off the school campus. NSTA provides details in its series of science safety books: Exploring Safely, Inquiring Safely, Investigation Safely and Science Safety in Community College, as well as a number of publications such as the three e-books of NSTA Ready-Reference Guides to Safer Science.

To ensure that field trips provide a safer learning experience for all students, the NSTA Safety Advisory Board recommends the following:

II. Preparation for students

- The teacher must identify clear learning outcomes for the site and the strategies for accomplishing them as a result of the field trip. (Scribner-MacLean and Kennedy, 2007). Students are less likely to engage in unsafe off-task behavior if they are engaged in learning. Establish clear behavior expectations with students. These expectations should include consequences for non-compliance and a definition of who will be supervising students at all levels. Consequences, such as immediately contacting the parent to come and take the student home for serious violations, must be established and clearly communicated in writing to parents, students and chaperones. Follow-through is critical for the reputation of the teacher, the ability to take future field trips, and the safety of the students. It also helps to protect the teacher and school district relative to legal liability issues based on duty or standard of care expectations in case of a field trip accident.
- The teacher needs to determine the optimum size of the group for the best and safest learning experience to accomplish the learning goals for the field trip site. (Stephenson, West and Westerlund, 2003; West and Kennedy, 2013). Multiple trips with smaller groups may be safer and a better learning experience than a single trip with a large number of students.
- Before the field trip takes place, the destination site should be visited by the teacher to determine if there are any safety and/or health hazards and how to address them. If the site is private property, make sure there is written permission for use and that it is in concert with the board of education's field trip policies. Review all policies and procedures of the field trip destination. Ensure that students are aware of these policies and establish consequences for non-compliance. An inventory of all needed field equipment, such as binoculars, sampling equipment, cameras, trash bags, etc., should be created as the teacher views the destination site and reviews the learning outcomes.
- The teacher should create a written plan of detailed safety procedures to distribute to parents and students. The discussion with students should include emergency procedures, preparation for weather conditions, staying with a group and a partner, procedures for meals, and other relevant issues.
- Students with special needs (physical, mental, or emotional) may need accommodations to participate fully in the field trip experience (NSTA, 2004). In preparing for the field trip experience, teachers and administrators are recommended to confer with specialists familiar with the students' special needs, with the students' parent or guardian, and when appropriate, with the student. The Individualized Education Plan (IEP), 504 Accommodation Plan, or other intervention plan should provide guidance for determining safe and appropriate accommodations for students on field trips (IDEA, 1997).
- At least one adult on the trip should be First Aid trained. A fully stocked First Aid kit should be on each bus.

III. Permission

- All school and district policies and procedures must be followed when planning a field trip. A parent and/or guardian must provide written permission for students to participate in any educational experience off school grounds. The school's administration should approve the list of students to ensure no students with unacceptable disciplinary records are allowed to attend.
- For science-related field trips, parents and guardians may require additional information about safety concerns. This may include appropriate attire, risks involved with native plants and animals, or other

relevant information. Be aware, however, that written permission for a child to participate is not a waiver of liability for student safety.

- Permission slips must include contact information for the responsible parent or guardian during the time frame of the field trip. In addition, the permission slips must include relevant medical information, including allergies, about the child. Parents and guardians will also need to give written permission for teachers to be able to give necessary medication to students as needed. Emergency contact information for chaperones is also needed. One copy of the contact and relevant medical information must accompany the teacher and the second copy must remain with the school administration.
- The teacher in charge of the field trip should review the list of students attending the trip with the school nurse so that the teacher is aware of any medical conditions that the students may have
- Emergency medical treatment permission slips for everyone, including chaperones, must also accompany the teacher.
- Teachers should not transport students in their own vehicles, even if parents or guardians have given written permission to do so. Instead, they should use transportation services according to local policy to transport students to and from the field trip location.
- If school busses are used, then the teacher must have the administration's procedures and contact information in case of vehicular problems.

IV. Supervision

- Student field trips should include adult chaperones to supervise small groups. The ratio of chaperones to students is determined by school/district policy, policies established by the destination being visited, and by the nature of the experience.
- Teachers who are sponsoring the field trip should meet with chaperones in advance to explain the expectations of the students, the expectations of the chaperone, and important emergency information.
- Teachers and chaperones should identify the method of communication and exchange contact information with one another so that in the event of unforeseen events, such as separation from the main group, injury or illness, all participants may assist with services.
- At least one adult per busload of students should be responsible for student medications and keeping a first aid kit, which may include bandages, disinfectant, and other similar items. This adult should be provided with instructions on which students receive medications, times for the medications, and specific details about medication administration. This adult should also be trained on the use of emergency medications as needed, such as rescue inhalers and epinephrine injection systems. Children with more involved medical needs should be accompanied by a parent or a person who has specific medical training and who does not supervise other students.
- The teacher should identify the school procedures for vehicle emergencies.

V. Outdoor field experiences

- Before the field trip, field trip supervisors should create a checklist of needs that may occur outdoors. These include, but are not limited to, parking, availability of drinking water, washing and lavatory facilities, trash disposal or recycling, and other needs. These needs can best be determined by a visit to the site prior to the field trip.
- Before the field trip, field trip supervisors should determine the ability to use a mobile telephone or another device such as walkie-talkies, the presence of unexpected harmful substances in the site (flooding, broken glass, fallen trees), and the local flora and fauna that are present. In particular, the presence of poisonous plants, stinging insects, and pests should be assessed.
- Adults should be placed at the head and end of the group, even for older students.
- In some outdoor experiences, acoustics can be a problem. Supervising adults and instructors may wish to bring a voice amplification device, especially in locales where there is interfering background noise, such as machinery or running water. Hand signals may also be needed in these circumstances.
- Accounting for all students regularly in outdoor experiences is crucial. Separate groups should establish rendezvous procedures and locations, and should plan to meet as a whole group regularly and take role.
- Field trip supervisors need to account for weather and other outdoor conditions. In particular, students may need to be protected to excessive sun exposure, water, and environmental hazards by wearing appropriate attire and using appropriate safeguards (e.g. broad-brimmed hats, sunscreen, sunglasses, insect repellent).

- Field trip participants should avoid taking any artifacts from a natural environment back to the classroom. Removing artifacts may disturb the local ecosystem and the items removed may pose a hazard to others. Likewise, all belongings, including trash, must be removed from the local site according to established policies.

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- West, S. and Kennedy, L. *Safety in Texas Secondary Science Classrooms*. San Antonio, TX: School Science and Mathematics Association, 2013. Print.

APPENDIX O: FIELD TRIP CHECKLIST EXAMPLE

From West Virginia Department of Education:
https://wvde.state.wv.us/prinperspective/docs/Field_Trip_Checklist.doc

Planning

- Obtain permission/trip approval from principal/principals
- Call field trip locations for pre-visit information, prices, refund info.
- Obtain written confirmation of date and arrival/departure time, bill of sale
- Ask about Bus drop/Off and Parking, and check-in procedures
- Begin fundraiser planning or set up payment plans/refund notice
- Plan a pre-visit to trip locations to check out facilities, area attractions, possible road construction, toll roads, etc.
- Call to arrange transportation, and to obtain prices and availability of dates.
- Obtain written confirmation of travel date.
- Let the bus driver know if you will need to load and unload luggage from bus
- Give the bus driver a map, directions, drop off/pick up instructions, and copy of itinerary. Let him/her know if they must remain with the group.
- Give field trip information, requirements, fee, and refund policy to students, teachers, chaperones, and administration 4–6 weeks prior to trip date
- Give students Emergency Information Forms 4–6 weeks prior to the trip date.
- Make a chaperone list and submit to board office for approval
- Check on special medications for students (EpiPens for bee stings, inhaler for asthma, etc.)
- Confirm number of students attending no later than one month in advance

Suggested student-to-chaperone ratio is 10:1. No refunds given 14 days prior to trip date.

Travel packet for parents, chaperones, and administrators should include:

- Trip Itinerary
- Group/Chaperone List
- Bus List (for student head count during the day)
- Map/Maps
- Location of First-Aid Kit
- Emergency Contact Information

One week prior to trip

- Call bus company and trip destinations to confirm dates, check on any changes
- Make arrangements for payment (get checks to bring or receipt of payment)
- Let cafeteria know about trip/# students going on trip
- Obtain first-aid needs, student medication
- Obtain permission to use school cameras, walkie-talkies, etc.
- Send out reminders to students
- Make a list of students who are not attending the trip
- Finalize arrangements for class coverage, arrange for a substitute, if needed

After the trip

- Check all areas for lost items
- Thank the hosts, chaperones, and bus driver
- Dole out appropriate tips
- Get student feedback (survey, post trip activities)

APPENDIX P: DOCUMENTING FIELD INVESTIGATION CHECKLIST RUBRIC (40 POINTS)

***Altered from pp. 7–8 of* Field Investigations Curriculum**

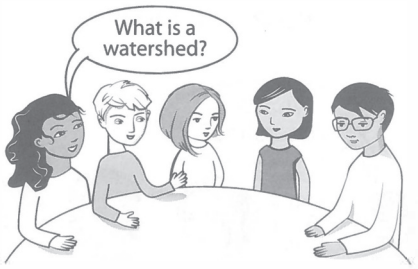
Identifies the Phenomenon to be Investigated • Includes an essential question • Includes investigation question that can be answered with quantitative measurements **(2 points)**	
Make a prediction • Generate hypothesis along with an explanation **(2 points)**	
Materials **(2 points)**	
Plan the Field Investigation • Logical steps written clearly so someone else could follow the procedure **(2 points)** • Identifies independent, dependent and controlled variables **(5 points)** • Explains how measurements will be taken **(2 points)**	
Data Collection • Systematic data collection with location, date, time of day and description of site **(7 points)**	
Analyze and Interpret Data **(6 points)** • Organize data • Identify Relationships • Interpret Data	
Construct an Argument/Explanation **(6 points)** • A claim is made based on evidence along with justification	
Extend the Investigation • Explain how the investigation could be improved or include future investigations **(6 points)**	

APPENDIX Q: "WHAT IS A WATERSHED?" FORMATIVE ASSESSMENT PROBE

Source: Keeley, Page and Tucker, Laura. "What is a Watershed?" pp. 155–159.

Uncovering Student Ideas in Earth and Environmental Science*. Arlington, VA: NSTA Press, 2016.* http://www.nsta.org/publications/press/uncovering.aspx*. Used with permission.*

What Is a Watershed?



Five friends were talking about watersheds. They each had different ideas about what a watershed is. This is what they said:

Haru: I think a watershed is an undeveloped area of branching creeks, brooks, and streams that flow down a mountain or mountain range.

Penny: I think a watershed is a group of buildings and human-made structures that water drains off of and then collects in a certain area.

Ariana: I think a watershed is a tower or some type of building that stores water for human use.

Beau: I think a watershed is an area of land where all of the water that is under it or drains off of it goes into the same place.

Coco: I think a watershed is an underground area of soil or sand that holds water when it drains into the ground.

Which friend do you agree with the most? _____ Explain your thinking.

_____

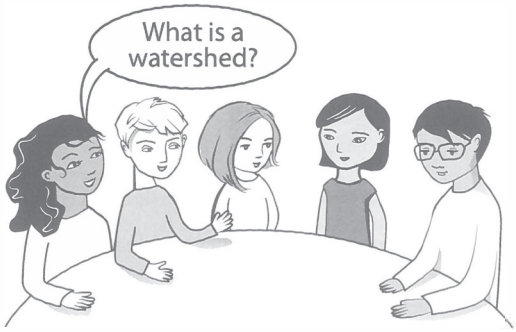
_____

_____

_____

What Is a Watershed?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about watersheds. The probe is designed to find out what students think a watershed is.

Type of Probe
Friendly talk

Related Concepts
Watershed

Explanation
The best answer is Beau's: "I think a watershed is an area of land where all of the water that is under it or drains off of it goes into the same place." This answer choice is the same definition the Environmental Protection Agency (EPA) uses to define a watershed. Furthermore, scientist and geographer John Wesley Powell described a watershed as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community" (EPA 2013).

Watersheds come in all shapes and sizes. They include both developed and undeveloped land areas. They cross county and state boundaries. In the continental United States, there are 2,110 watersheds.

Understanding the watershed concept is important for managing water resources and understanding issues about water quality, point and nonpoint source pollution, land use and rapid urban development, groundwater contamination, and the impact of personal actions and behavior on water quality.

Administering the Probe
This probe is best used with grades 5–12. The probe can be extended by using the annotated drawing formative assessment classroom technique, which is described on pages 4–5.

Related Core Ideas in *Benchmarks for Science Literacy* (AAAS 2009)

6–8 The Earth

- Fresh water, limited in supply, is essential for some organisms and industrial processes. Water in rivers, lakes, and underground can be depleted or polluted, making it unavailable or unsuitable for life.

Related Core Ideas in *A Framework for K–12 Science Education* (NRC 2012)

3–5 ESS3.C: Human Impacts on Earth Systems

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

6–8 ESS2.C: The Roles of Water in Earth's Surface Processes

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

6–8 ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

9–12 ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Related Research

- To elicit students' ideas about watersheds, a study was conducted that asked students to draw a picture of a watershed and explain their drawing. Results of the study showed students understand a watershed from a very limited scientific perspective. Several sixth- and seventh-grade students described and drew a watershed as a water storage facility or a facility that supplies water. Eighth- and ninth-grade students in the study focused on a mountainous stream. Older students also incorporated the water cycle, but they rarely represented links between land and watercourses. For all students in the study, humans did not appear to be a part of a watershed; they were regarded as separate from it (Shepardson, Harbor, and Wee 2005).
- A study by Patterson and Harbor (2005) investigated the effect of a watershed curriculum on students' geoscience learning. They found that some students thought of watersheds as water towers or well houses. They concurred that because of our everyday language, containing the word *shed* seems to imply some kind of structure with a roof that holds water.
- Studies on watersheds suggest that children associate a watershed with a mountainous, rustic area, rather than a more developed region (Shepardson et al. 2007).
- Middle school students' ideas about watersheds are not much different than those of adults. Studies suggest that science education is contributing little to the development of a citizenship knowledgeable about watersheds. Most citizens are not knowledgeable about the watershed concept, nor do they fully understand the hydrologic connection (Schueler 2000).
- A sample study showed that only 41% of the adults surveyed had any idea about what a watershed is and only 22% knew

that storm water runoff was a major cause of stream pollution (NEETF 1998).

Suggestions for Instruction and Assessment

- Have students make annotated drawings of a watershed. Drawings give students who have difficulty constructing verbal or written explanations an opportunity to reveal and explain their ideas through visual means (Keeley 2008). Having students explain their drawing reveals additional ideas they have about watersheds.
- Findings from Shepardson, Harbor, and Wee's study (2005, pp. 384–385) suggest that the following concepts need to be developed to improve students' understandings of watersheds and to enhance students' geoscience learning:
  1. A watershed is a land area that provides runoff that feeds rivers and streams.
  2. Every place on land is a part of a watershed, including the places where we live, work, and play.
  3. Smaller streams flow into larger rivers forming a river system, which is a network of tributaries that flow into a major river.
  4. Watersheds consist of a river system, which drains water from the land within the watershed.
  5. Watershed boundaries are defined based on elevation. The elevation or divide determines the direction water flows or into which basin precipitation flows.
  6. Earth's surface consists of numerous nested and joining watersheds that drain into lakes or the ocean.
  7. Sediment and other substances and contaminants on land are transported into the stream through runoff and then transported by the river system through the watershed into joining watersheds, lakes, or oceans. The contaminants transported off the land area and through the river system are often referred to as *nonpoint source pollution*. Fertilizer and pesticide runoff, for example, are nonpoint source pollutants.
- Use topographic maps or maps with elevations to have students discover that not all watersheds include mountains or mountain ranges with high elevations.
- Students can gain an intuitive understanding of the physical aspects of watersheds by creating their own watershed models out of a crumpled piece of paper. Conclude by having them use a map to trace the watershed that supplies their drinking water. More activity information is available at *www.omsi.edu/sites/all/FTP/files/expeditionnw/4.E.1.Crumple.pdf*. This activity supports the scientific practice of developing and using models to explain ideas. Be sure to discuss aspects of the model that represent a real watershed and those that do not represent a real watershed.
- Take students on a field trip to a local watershed and identify land use practices that affect the water quality in the watershed area.

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APPENDIX R: DOCUMENTING FIELD INVESTIGATIONS: CHECKLIST

Modified from **Guide to Field Investigations**

Identifies the phenomenon to be investigated	• Includes an essential question • Includes investigation question
Make a prediction (initial claim)	• Generate hypothesis along with an explanation
Materials	• Materials needed listed
Plan the field investigation	• Identifies variables – *Independent:* States what is changed – *Dependent:* States what is measured – *Controlled:* States ways measuring and sampling are kept the same • Logical steps written clearly so someone else could follow the procedure – Explains how observations/ measurements will be taken and repeated – Systematic or consistent sampling/measurement method – Sampling is random and representative of the site
Data collection	• Systematic data collection with location, date, time of day, and description of site
Analyze and interpret data	• Organize data – Data tables, charts, graphs, maps, appropriate calculations – Identify relationships ▪ Patterns and trends in data described – Interpret data ▪ Relationships are identified in data ▪ Patterns identified in data provide evidence for claim
Construct an argument/ explanation	• A claim is made based on evidence along with justification
Extend the investigation	• Explain how the investigation could be improved or include future investigations