beetles

Science and Teaching for Field Instructors

# Ecosystem Literacies & Exploration Guides

Students love catching small organisms like insects, other arthropods, and amphibians. But in many ecosystems (any area with a complex set of interactions between biotic and abiotic factors), they need help figuring out where and how to find and catch critters. With guidance, students also love observing and engaging in thoughtful study of organisms they've caught - but they often need some coaching to go beyond just "catch and release." One way to encourage thoughtful study is to prompt them to think about the structures and behaviors the organism has that help it survive within the conditions of the ecosystem (their adaptations). It helps students engage more deeply in thinking about the structures and behaviors of organisms if you give them some "**ecosystem literacy**" first - **framing their perspective by describing some of the significant living and nonliving conditions of the ecosystem that affect the organisms they'll be studying.**

Below you'll find ecosystem literacy conditions for five different ecosystems you might explore with students. For each ecosystem, we include short descriptions of a few significant environmental conditions and questions to ask students to get them thinking about these conditions. Also included are information, techniques, and tools for exploring each ecosystem.

We know this is far from an exhaustive list of ecosystems. To give students ecosystem literacy for an ecosystem not described here, think about the unique conditions (biotic and abiotic) that affect organisms in that ecosystem. Don't tell students everything you know about an ecosystem: instead, **share just a few significant conditions, ask students to discuss how those conditions might affect the organisms in the ecosystem they'll be exploring, and encourage them to consider these factors as they observe organisms' structures and behaviors.** See the examples below to get a sense of the level of detail to offer students.

When students are prompted to study organisms with this kind of framework in mind, they'll be equipped to make relevant, focused observations that can be used to build their understanding of ecological concepts. To see how an ecosystem literacy-based organism exploration can be part of a longer activity in which students develop conceptual understanding, see the BEETLES activities, *Discovery Swap*, and *Structures & Behaviors*.

In order for these explorations to be most successful, we recommend that **field instructors carry a few minimal tools,** including hand lenses, containers to catch and view organisms, and small aquarium nets. For some specific ecosystems, we've recommended a few other tools as well. For more information on tool suggestions and possible purchasing options, see the BEETLES website page "What's in Our Backpack?"

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# Streams & Ponds

## Particularly Useful Tools:

- Aquarium nets and/or kick nets (a wide flat net)
- Clear cups to contain organisms
- Identification key and information about stream organisms

## Explain Ecosystem Literacy:

1. **Before we explore this stream/pond, let's think about what conditions might be like for the organisms that live here.**

2. **Oxygen and breathing:**
   - *Most organisms that live underwater breathe oxygen. What are some structures or strategies organisms could use to get oxygen?*
   - [Some organisms have structures (like gills) to help them get oxygen from the water. Others might go to the surface to get oxygen. Some take air bubble "oxygen tanks" underwater.]

3. **Food sources:**
   - *What are some food sources in a stream/pond?*
   - [Some stream and pond organisms eat algae, and some eat other organisms. Others eat things that fall into the stream like dead leaves, twigs, or insects].

4. **Currents (streams only):**
   - *What are some ways organisms might deal with stream currents?*
   - [Some organisms survive by clinging to rocks. Others live where they can avoid currents, like under rocks. Others are strong swimmers].

## Explain Exploration and Observation Techniques:

- **Here are some strategies to search for organisms in this pond/stream:**
  - a. **Look under rocks**: Pick up rocks in the stream, then look for organisms on or underneath the rocks. Look carefully for motion - organisms are often camouflaged.
  - b. **Scoop with a net**: Some people look for an organism, then try to scoop it. But because most of the organisms here are so hard to see, you'll probably catch a lot more of them if you don't only aim to scoop organisms you can see. Instead, "blindly" scoop back and forth where many critters live- on underwater plants, in dead leaves, or in algae. Get some of the "muck" they live on in your net. Then carefully look through what's in your net. Look for motion - those moving things are organisms - and put them in water in a cup.

  *(**Note**: warn students not to net rocks, or scrape nets on rocks, and to be careful to not make holes in the nets).*

  - c. **Use kick nets**: In this technique, 1-2 students hold the kick net in the water. 1-2 other students stand a few feet upstream, where they shuffle their feet and move rocks around to dislodge organisms that will float downstream and get caught in the net. You can also do this with a small net much closer downstream from a rock you're moving with a hand.

## Explain Safety Warnings:

a. Move slowly and be mindful of slippery edges of ponds, and slippery rocks. If you're barefoot, watch for sharp objects.

b. If the current is strong, be careful not to get in a position where you might be swept away.

c. Be respectful of organisms and put them back as close to where they were found as you can.

d. Use clear plastic cups filled with water to contain and observe organisms. Switch the water out if organisms are held for a long time.

## Before students explore, explain:

- When you find organisms, see if you can observe body structures or behaviors that might help them survive currents or help them get oxygen. Think about how the organism might get its food and avoid being eaten.

# Intertidal/Rocky Shore

## Particularly Useful Tools:

- Golf pencils
- Index cards
- Containers for organisms
- Identification key and information about intertidal organisms

## Explain Ecosystem Literacy:

1. **Organisms are a reflection of their environment.** It helps us understand the organisms we're observing if we understand the conditions they live in. So, before we explore the intertidal, we're going to think about what it might be like for organisms to live here.

2. **Wave shock:**
   - *Organisms in tidal zones are pounded by ~ 8,000 waves per day! What structures or behaviors might they have to help them survive that?*
   - [Organisms might avoid waves by running, swimming, flying away, or hiding between or under rocks. Others have structures that help them cling to rocks so they won't be swept away, some are rubbery to bend with the waves, and others have hard body parts (like shells) to protect them from waves.].

3. **Living in and out of water:**
   - *The intertidal is covered in ocean water part of the time and exposed to air part of the time. It can also be cold or hot. Tidepool organisms all get oxygen from water, not from the air. They have to be able to survive under cold water, and dried out in the hot sun during the same day. They need to get oxygen from water even when they're exposed to the air. What are some ways organisms might do that?*
   - [Some organisms can move around and follow the tide, so they're always under water. Other organisms are stuck in one place (sessile), so they have behaviors and body structures to prevent themselves from drying up. They also must be able to trap enough water to allow them to breathe.]

4. **Competition for space:**
   - *The intertidal area is not very wide, and intertidal organisms have to crowd into this limited space. How do organisms deal with the "real estate shortage?" Where do they find space to live?*
   - [Some live on top of other organisms, like on a shell. Some live higher on rocks, where it's drier, and where fewer competing organisms can survive]

5. **Eating, and avoiding being eaten:**
   - *How do these organisms get food? How might organisms that are stuck to a rock get food? What are some ways intertidal organisms might defend themselves from predators?*
   - [Some organisms that are fixed in one place have structures that help them defend against predators that try to eat them. Some have structures they put out when they're underwater to grab food, or to filter small particles of food from the water, then pull them back in when they're out of the water.]

## Explain Exploration and Observation Techniques:

- **Here are some strategies to search for organisms in this pond/stream:**
  - **a. Slow down, get down, look around**. The slower you move, the more you'll see. Crouch, sit or lie still so you can see everything up close. Look up under ledges and overhanging rocks. Put your feet as low as you can, then put your face where your feet are.
  - **b. Look under rocks**. Gently roll rocks over to see the organisms underneath. Gently roll them back the same way as you found them, to preserve their home.
  - **c. Look on and around algae.** Intertidal organisms that eat algae (seaweed) often can be found on algae. Others may hide in it. Look carefully, because they are often well-camouflaged.
  - **d. Be patient**. Many intertidal organisms can sense your presence, and may hide as soon as you arrive. Sit by one tidepool for a while and see how much you can notice. More organisms might come out if you're still and quiet.

***Additional Possible Routines:***

- Prompt students to record observations in the tidepools with words and pictures. Give them index cards (small, and fit in a pocket), and golf pencils (small, float if dropped in water, and no metal eraser ends). After giving them some time to move around and explore what interests them, prompt students to spend 15 minutes observing one tidepool:
  - 5 minutes silently observing and writing 20 words that come to mind
  - 5 minutes writing detailed observations of what they are seeing, smelling, hearing, touching
  - 5 minutes drawing a diagram of one small thing they observe, with written labels of structures or descriptions of behaviors.
- For a guided exploration that works well in tidepool settings, see the BEETLES Exploration Routine, *Interview an Organism*.

## Explain Safety Warnings:

- **a.** Stay within the designated area.
- **b.** Never turn your back on the ocean! Always keep an eye out for waves.
- **c.** Explore with a buddy.
- **d.** Move slowly, don't run or jump, and be mindful of slippery rocks and seaweed.
- **e.** Look where you put your feet- you often cannot avoid stepping on organisms, so step gently!
- **f.** Pick up creatures carefully and hold and observe them low to the ground so they won't be harmed if you accidentally drop them. Try to put organisms back exactly where and how you found them.
- **g.** Try to keep your hands free (carry things in pockets not in your hands), so if you slip and fall you can catch yourself.

## Before students explore, explain:

- When you find organisms, see if you can observe body structures or behaviors that might help them survive wave shock, and with living both in and out of water. Think about how the organism might get its food, and avoid being eaten.

# Under Logs & Rocks

## Explain Ecosystem Literacy:

1. **Before we look for critters under rocks/logs, let's think about what it might be like to live there.**
2. **Protection:**
   - *What might a rock/log protect creatures from?*
   - [Living under a rock/log can protect organisms from dryness, heat, rain etc. - conditions under a rock/log are pretty consistent compared to outside of it. Some organisms might also be seeking protection from predators too big to fit under a rock/log. When you roll rocks/logs, pay attention to how the organisms behave - do they immediately move towards cover? Dig down into the ground? Do they sit still? Do you see tunnels they might use to safely move away from under the rock/log?]
3. **Food sources:**
   - *What are some food sources available under rocks/logs? Do you think all the "under rock/log" organisms find their food there? What are other places these organisms might get food?*
   - [Many under rock/log organisms eat leaf detritus, fungi, or other organisms found under logs. Others might have to leave the protection of the rock/log to find food. Look for possible food sources under the log you're checking out.]

## Explain Exploration and Observation Techniques:

**a.** Car**efully move rocks/logs, and look underneath**. Look under rocks/logs. Many organisms may move right when you uncover them- be ready to catch them in small cups or bug boxes.

**b.** **Look beyond the obvious**. At first you might see many organisms move as the rock/log is removed- but there's probably more there, possibly camouflaged. Look carefully and see what you can find.

## Explain Safety Warnings:

**a.** Advise students of any harmful snakes, scorpions, spiders etc. in your area, and how to avoid being bitten or stung by them.

**b.** Roll rocks/logs towards you, so in the (unlikely) case of startling a snake, it will strike away from you. Don't put your hands where you can't see, to avoid accidentally touching an animal that might bite or sting. Don't kick rocks/logs over with your feet.

**c.** Don't step in the space underneath the rock/log, and do put the rock/log back as you found it. Put it back slowly and gently to avoid crushing organisms. If a larger organism, like a salamander, has moved since you rolled the rock/log, it might be crushed when you replace it. Try putting a stick next to it to act as a pillar, or pick up the organism, roll the rock/log back, then put the organism in position to crawl back under the log.

**d.** Warn students about potentially hazardous plants like Poison Oak, Poison Ivy, and Stinging Nettle See A Note on Poison Oak/Ivy in the Buggy Bushes, Shrubs & Grasslands section (page XX).

## Before students explore, explain:

- When you find organisms, see if you can observe body structures or behaviors that might help them survive here. Think about what the organism might use the rock/log to protect it from. Think about how the organism might get its food, and how it avoids being eaten. Think about if, when, and how it might sometimes come out from under the log/rock.

# Buggy Bushes, Shrubs & Grasslands

## Particularly Useful Tools:

- White sheet
- Sweep net (cone-shaped canvas net specifically designed for catching insects)
- Shake boxes
- Poofers (see BEETLES website page "What's in Our Backpack?" for instructions on making shake boxes and poofers)
- Clear cups and bug boxes to contain organisms
- Identification key and information about insects and plants

## Explain Ecosystem Literacy

1. **Before we look for critters in the bushes/shrubs/grass, let's think about what it might be like to live there.**

2. **Small world:**
   - *Relating to the world would be different if you were the size of an insect. Moving around on one tiny blade of grass could take a long time! Other creatures like birds or humans would seem huge. How might this landscape be different if you were very small? What would it be like to move around in it? What kind of food might be available? Where might you hide?*
   - [Insects' small size means that the top of the grass and the base of the grass might be very different places for them to live. Think about what tiny changes in the environment, like a human footstep, might be like for something small. Small organisms have structures for eating, moving, and protection- but they might look very different from those of larger animals.]

3. **Seasonality:**
   - *This ecosystem might be very different in another season. What are some conditions that may be different throughout the day? Throughout the year? How might the organisms survive those changes? What are the main food sources in this area? Are those food sources available all year?*
   - [Temperature, food availability, moisture, and weather may change with seasons, and what may seem like insignificant changes to us may be huge changes for a small critter. Some organisms might be dormant (not moving or fully functioning) during cold times of year when there's less food available.]

## Explain Exploration And Observation Techniques:

a. **Sheet shake**: Put a white or lightly colored bedsheet on the ground below a bush. Shake the bush vigorously; insects on the leaves or branches will fall onto the sheet. Use cups or bug boxes to collect the insects and other arthropods. [Note: a sheet of white paper will work in place of a bedsheet).

b. **Sweep netting**: Hold a large canvas net in front of you at ankle height. Walk through the grass and sweep the net from side to side through the grass; your wrist should make small figure-eight movements, keeping the open end in front catching stuff as you sweep the net. Insects that you probably don't see perched on blades of grass will get caught in the net. After walking a few feet, carefully turn the net inside out and place any insects into cups or bug boxes for easy viewing.

c. **Shake boxes**: . Shake branches of bushes over the box, then shake the contents of the box into the bag for viewing, with the bag held up against the white box, to make invertebrates easier to see. Keep the bags out of prolonged direct sunlight, or the critters will fry.

d. **Poofer technique**. Use a poofer to catch small, quick-moving organisms: Find a critter on the ground, then put the window-screened end of the poofer down near the insect or spider; put your mouth on the other end and suck in air to create a "vacuum" that will bring the creature up against the screen. Maintain suction on the tube as you lift it from the ground to keep the critter inside the tube. Close your hand against the window screened end of the tube to make sure the critter doesn't fall out. Transfer the critter to a cup or bug box, then check it out! This technique works best with two people - one to use the poofer, and the other to hold the cup or bug box.

- Note: For more information on making Shake Boxes and Poofers, see the blog post, *What's in our Backpacks? (http://beetlesproject.org/whats-in-our-backpack/)*

## Explain Safety Warnings:

a. Warn students about any potentially harmful organisms, like ticks.

a. Handle organisms carefully, and do your best to not squish insects as you put them in a cup.

b. Put the organisms back as close to where you found them as possible. If you found an insect in a bush, don't return it to the ground.

## Before students explore, explain:

- When you find organisms, see if you can observe body structures or behaviors that might help them survive the conditions in this ecosystem, including seasonal changes. Think about how a tiny organism might perceive this world. Think about what they might eat, what eats them, how they move around, and how they might defend themselves. See if you find any evidence that things are eating the plant they're on or near.

### A Note on Poison Oak/Ivy

**If in an area with poison oak/ivy, your students might get an itchy rash when they return home, which may make them unenthusiastic about nature.** If we move students through a poison oak/ivy area without being thoughtful, we might miss the suffering students go through from rashes that flare up back home. If you don't get poison oak/ivy rashes, talk to people who do get it to learn how miserable it can be.

**Spend time helping students learn to recognize it.** Just pointing it out to students, or saying things like, "leaves of 3, let it be," isn't very effective. Instead, ask students to describe poison oak/ivy (stalks and leaves, especially leaf shape and edges) out loud, and then to describe what it reminds them of, e.g., the wavy edge of a cartoon cloud, their knuckles. Then, do the same with a plant students often confuse with poison oak/ivy, like blackberries. Then point out key things they may have overlooked (like "leaves of three, let it be"). Repeat the language and examples they come up with to help them recognize it on their own. Coach your group to point it out to each other while hiking. If you're moving through an area where you've got to step and move your body carefully to avoid touching these plants, realize that your students will often unknowingly walk right into it.

**Finally, consider going through student areas in advance and clipping poison oak/ivy in your path (clean the clippers well afterwards!).** And carry a small container of Tecnu, so students can immediately clean oils off skin. Telling them to wash it off later with cold water and soap is less effective. Scrubbing a lot is an important part of getting it off, so coach them well, and consider carrying a washcloth for this purpose.

# Plants

## Explain Ecosystem Literacy:

1. **Before we check out these plants, let's think about what it might be like to live here as a plant.**
2. **Survival:**
   - *Ask students what plants need to survive.*
   - [Access to air, water, minerals, and sunlight, a place to grow, and they must be able to survive hungry herbivores and parasites. Plants also exist within a huge range of conditions. Variation in temperature, solar exposure, water availability, and soil content all affect what plant life can survive in an ecosystem.]
3. **Environmental conditions:**
   - *Ask students to observe the area and look for signs of extreme environmental conditions. Prompt them by asking if they see signs of drought, fire, flood, high winds, landslides, human impact, sunlight availability, etc. How might these conditions impact how plants grow in this area?*
4. **Additional questions might include:**
   - *There's not a lot of sunlight available on this forest floor. How do plants on the forest floor get enough sunlight to survive?*
   - *It's very dry in this ecosystem. How do plants here survive with very little water?*
   - *The plants growing on this cliffside get hit with extreme wind. What are some of the possible effects of wind on a plant? How might the structure and shape of these plants be related to living in a windy environment?*
   - *How might winter affect plants' ability to get the resources they need to survive?*

## Explain Exploration And Observation Techniques:

a. **Field Journaling**. In journals, students might capture observations of a single plant, compare multiple plants, map out plant growth patterns, and many other techniques. See the BEETLES Model Field Journal page (http://beetlesproject.org/resources/field-journal-pages/) and the free journaling curriculum by John Muir Laws, Emilie Lygren, Emily Brueunig, and Celeste Lopez (http://www.johnmuirlaws.com/cnps-curriculum) for more ideas and techniques in field journaling.

b. **Look beyond the obvious**. Some plants are small and rarely seen, and some grow in unexpected places. Encourage students to change their perspective to find overlooked plants, and to notice interesting details on plants.

## Explain Safety Warnings:

a. Warn students about potentially hazardous plants like Poison Oak, Poison Ivy, and Stinging Nettle. See A Note on Poison Oak/Ivy in the Buggy Bushes, Shrubs & Grasslands section (page 8).

b. Advise students to be careful with edible plants in accordance with your programs' policies.

## Before students explore, explain:

- When you find plants, see if you can observe structures that might help them survive. Try to explain how the structures you observe (like serrated leaf edges, fuzz, waxy leaves, etc.) might help the plant survive. Think about how this place changes in the seasons, and if the plant you're observing might change as well with the seasons. Think about the everyday conditions that might affect how this plant survive, and also the extreme environmental conditions it experiences.

## ABOUT BEETLES™

**BEETLES™** (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

*www.beetlesproject.org*

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*California*: YMCA Camp Campbell, Rancho El Chorro Outdoor School, Blue Sky Meadow of Los Angeles County Outdoor Science School, YMCA Point Bonita, Walker Creek Ranch, Santa Cruz County Outdoor Science School, Foothill Horizons Outdoor School, Exploring New Horizons Outdoor Schools, Sierra Nevada Journey's School, San Joaquin Outdoor Education, YMCA Camp Arroyo, Shady Creek Outdoor School, San Mateo Outdoor Education, Walden West Outdoor School, Westminster Woods.
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