# Watersheds and Wetlands

## Watersheds

When rain falls or when snow melts, where does the water go? Where does water from your hose or sprinklers end up? Some of it soaks into the ground, but the excess water, called runoff, flows from high points to low points, eventually draining into a body of water. This drainage basin—the area through which all water flows from its highest source to a lake or ocean—is called a watershed.

### Where It All Begins

A watershed starts at mountain peaks and hilltops. Snowmelt and rainfall run into mountain streams. As tributaries connect, the streams get bigger, eventually becoming rivers. As the rivers leave the mountains and reach flatter ground, the water slows and looks for the path of least resistance across the land. This path may be along a concrete channel provided for flood control. Eventually the rivers flow into a lake or ocean.

All land is part of a watershed, and the characteristics of the land greatly affect how water flows through the watershed. On heavily vegetated, relatively flat terrain, runoff is slow, and percolation—seepage—into the ground is great. In steep, bare terrain, runoff flows rapidly. Human-made features, such as dams or large paved areas, can also affect the water flow.

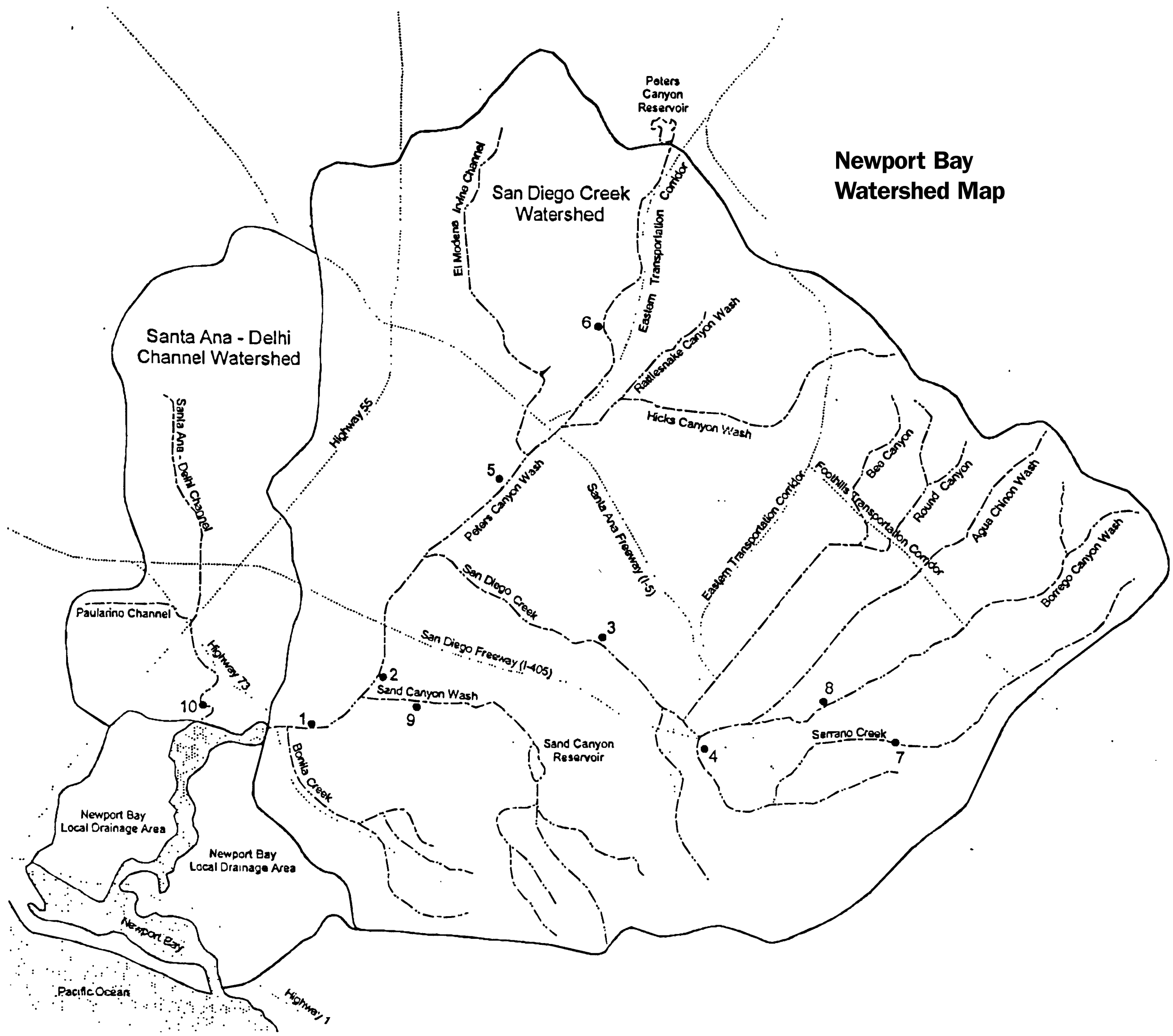
### It's Not Just Water

Water flows downstream, taking with it whatever it picks up. For example, if a creek flows through an agricultural area, it can pick up fertilizer, manure, and pesticides from farming operations. In urban and suburban areas, it might gather fertilizers that wash off lawns, untreated sewage from failing sewer pipes, illegal wastewater discharges from industrial facilities, sediment from construction sites, lawn clippings and branches from yard maintenance, and oil from roads and parking lots. These pollutants may be deposited on river floodplains, may concentrate in coastal estuaries, or may drain directly into the ocean.

All land areas—agricultural, suburban, urban, and coastal—can have an impact on our fresh and marine waters. Water quality is affected by everything that goes on within the watershed.

### Your Watershed

Orange County has 13 watersheds, all of them ending in the Pacific Ocean. In one of them, water drains into Upper Newport Bay from an area of approximately 154 square miles of land. This watershed extends from the Bay to the Santiago Hills and includes parts of Costa Mesa, Irvine, Lake Forest, Laguna Hills, Newport Beach, Orange, Santa Ana, and Tustin. Most of the water enters the Bay via San Diego Creek.




## Wetlands

Wetlands are known by many names including swamps, marshes, mudflats, sloughs, and estuaries. Most wetlands are transition ecosystems between land and water. Each is different in its own way: some are covered with water, others are quite dry; some are saltwater, others fresh water, others a mixture of both; some are full of foliage, others appear barren; some are pool-sized, others stretch across thousands of acres.

A few generalizations can be made about wetlands. All wetlands have water present at least part of the year. Some wetlands are only damp, and some are wet only below the surface. But the presence of water leads to the two other defining characteristics of wetlands: hydric (saturated) soil and hydrophytic (water tolerant) plants.

**Where In the World Are They?**

Wetlands are found everywhere—along coastlines, in land-locked areas, in rural territory, and in the middle of urban areas. Precipitation and topography play key roles in the formation of a wetland. Generally, wetlands are found:

- along rivers and lakes
- near coasts and bays
- in depressions where land is lower than the surrounding landscape
- in places where groundwater seeps out of the ground
- in broad, flat areas that receive significant rainfall.

**Estuaries**

Many coastal wetlands, including most wetlands along the southern California coast, are estuaries. Estuaries are areas where freshwater streams meet the sea along the shores of bays and river mouths. They are the drainage point for the area's watershed. Upper Newport Bay is just such a wetland.

Estuaries like Upper Newport Bay are particularly rich, productive ecosystems for several reasons:

- The freshwater sources deposit nutrient-rich sediments into the estuary.
- The ebb and flow of the tide cause a continual mixing of the water, distributing food and nutrients throughout the Bay and maintaining a relatively high level of oxygen in the water.
- The amount of sunlight in areas like southern California coupled with the shallow water in the estuary provides ideal conditions for photosynthesis by microscopic algae.

With shifting boundaries that change with the tides, estuaries contain many habitats, from submerged marshland, to thick mudflats, to dry scrub brush. Each area accommodates the needs of different species of plants and animals, many of them adapted to the exact conditions of that habitat.

## The Value of Wetlands

They used to be called swamplands and were thought to be useless. As a result, many wetlands, particularly those near population centers, were destroyed—diked, drained, and filled with soil to create buildable land. Others were converted to farmland. In California, only 9 percent of our historic wetland acreage remains. It is only recently that humans have recognized the immense value of preserving wetlands. Wetlands are now considered to be among the most productive ecosystems in the world.

Wetlands provide many benefits within a watershed, from decreasing flooding and erosion to increasing wildlife and water quality. The benefits from the wetlands in Upper Newport Bay include:

- water filtration
- habitat for animals
- recreation for people
- economic contribution.

### Water Filtration

Wetlands act as filters to improve water quality. The water that flows through the watershed into wetlands contains sediment and pollutants—fertilizers, soaps, pesticides, and lawn clippings, to name a few. As water enters a wetland, it slows, which causes sediment in the water to settle out, trapping the pollutants before they reach the ocean.

Wetlands handle the pollutants in several ways. Some are buried in layers of wetland soil. Others are absorbed by plants. Within the plants and soil, biological processes can break down and convert pollutants into less harmful substances. Without the wetland, the sediment and pollutants would drain directly into the ocean. Ocean pollution as a result of runoff from land is a major environmental problem, threatening marine wildlife and human health. In recent years, polluted runoff has been responsible for numerous beach closures in southern California and elsewhere. In Orange County, education and regulations have paid off; in 2003, there were 81 beach closures—down from 137 in 2002.

### Habitat

Acre for acre, there is more life in a healthy wetland than there is in almost any other kind of ecosystem, even matching the high productivity of rainforests and coral reefs. Wetlands support a tremendous variety of fish, birds, amphibians, mammals, reptiles, insects, and other animals—providing food and shelter for them all.

Wetland waters are nutrient-rich with phytoplankton, zooplankton, and the organic debris of decaying plants. Many species of juvenile and small fish, as well as insects and small crustaceans, feed on these nutrients. In turn, larger fish, mammals, birds, reptiles, and amphibians have a plentiful food supply. In the rich mud of a mudflat, many small animals—shrimp, crabs, snails, clams, and worms—live in a submerged city of tunnels and burrows.

Wetlands are havens for birds. They wade among the grasses, probing the mud for food. They swim in the open waters, scooping up fish. They soar overhead, searching the land and water for their next meal. It is estimated that 75 percent of all North American birds depend on wetlands. Migratory birds from around the world stop at wetlands to feed and breed.

Many animal species use wetlands as nurseries. Fish and shellfish such as halibut, croaker, white seabass, and shrimp return to wetlands annually to spawn. Larval and juvenile fish develop in the wetlands until they grow strong enough to venture out into the ocean. Many birds build their nests among marsh plants, and in the wetlands chicks learn to fly and to forage for food. The thick vegetation and shallow water found in wetlands provide good places to hide from predators, and the rich sources of food provide energy for young animals to grow.

Many species that depend on wetlands to survive have suffered great losses over the years as wetlands have disappeared. More than one-third of endangered and threatened species in the U.S. spend at least a portion of their lives in a wetland ecosystem.

### Recreation

Wetlands aren't beneficial just for wildlife. These areas provide wonderful recreational opportunities. People come to wetlands to:

- bird watch
- photograph wildlife
- draw or paint
- walk or bike
- kayak or canoe
- fish

Besides providing a site for such activities, wetlands are available to anyone who simply wants to enjoy the wonders of nature.

### Economics

Our nation's fishing and shellfishing industries harvest many species that depend on wetlands for their survival. This catch is valued at $15 billion a year.

Coastal wetlands are critical to human food supplies. These areas produce millions of tons of organic matter that provide the food for large commercial fish. And many fish consumed by people—for example halibut and seabass—use wetlands as nurseries for their young.

The Southern California Beach Valuation Project estimated that beaches in Orange and Los Angeles Counties accounted for more than $1 billion of revenues during summer 2000. Approximately 106,130 people visited Orange County beaches during this three-month period. Beaches are engines for coastal economies and cannot afford closures. Policies to improve water quality, such as wetland protection, could result in large economic gains through beach-tourism.

## Upper Newport Bay

Upper Newport Bay in Newport Beach is the largest remaining estuary in southern California. It provides habitat for hundreds of species of plants and animals, including humans.

### For the Birds

Upper Newport Bay is home for nearly 200 species of birds, including several rare, threatened, or endangered species, such as the Light-footed Clapper Rail, Belding's Savannah Sparrow, California Least Tern, and California Brown Pelican. The Bay is also an important stopover for migrating birds on the Pacific Flyway. During the winter months, up to 30,000 birds can be seen here on any day. It is one of the few remaining places where migrating ducks and other waterfowl can rest.

### From Fish to Furry Creatures

Roughly 80 species of fish have been identified in Upper Newport Bay. Most numerous are the small fishes, such as the silvery mullet that is frequently seen jumping out of the water. Of course these small fish provide food for predators, such as the gray smoothhound shark and round stingrays. Some fish are only seasonal, using the Bay as a nursery. Some species of fish have adapted to life in the mud. Gobies and killifish seek out small pools, waiting for the tide to come back in. The long-jawed mudsucker actually burrows into the mud, where it can survive under extreme conditions of reduced oxygen and elevated temperature.

Various invertebrates live in the wetlands—bay mussels, snails, worms, shrimp, clams, and crabs, to name a few. Several species of amphibians, reptiles, and mammals can also be found in Upper Newport Bay. Frogs, snakes, lizards, squirrels, rabbits, raccoons, coyotes—all play their part in the food chain and in the ecosystem of Upper Newport Bay.

### Life as a Plant

Plants are an extremely important part of a wetland ecosystem, providing both shelter and food for the animals that live there. Many of the plants in Upper Newport Bay, as in any estuary, have developed specialized ways of living in an environment that has changing levels of moisture and salinity. These plants, called halophytes, include cordgrass, pickleweed, and saltgrass—each with features that allow the plant to survive in this environment. For example, saltgrass has specialized glands that serve as saltshakers to get rid of extra salt.

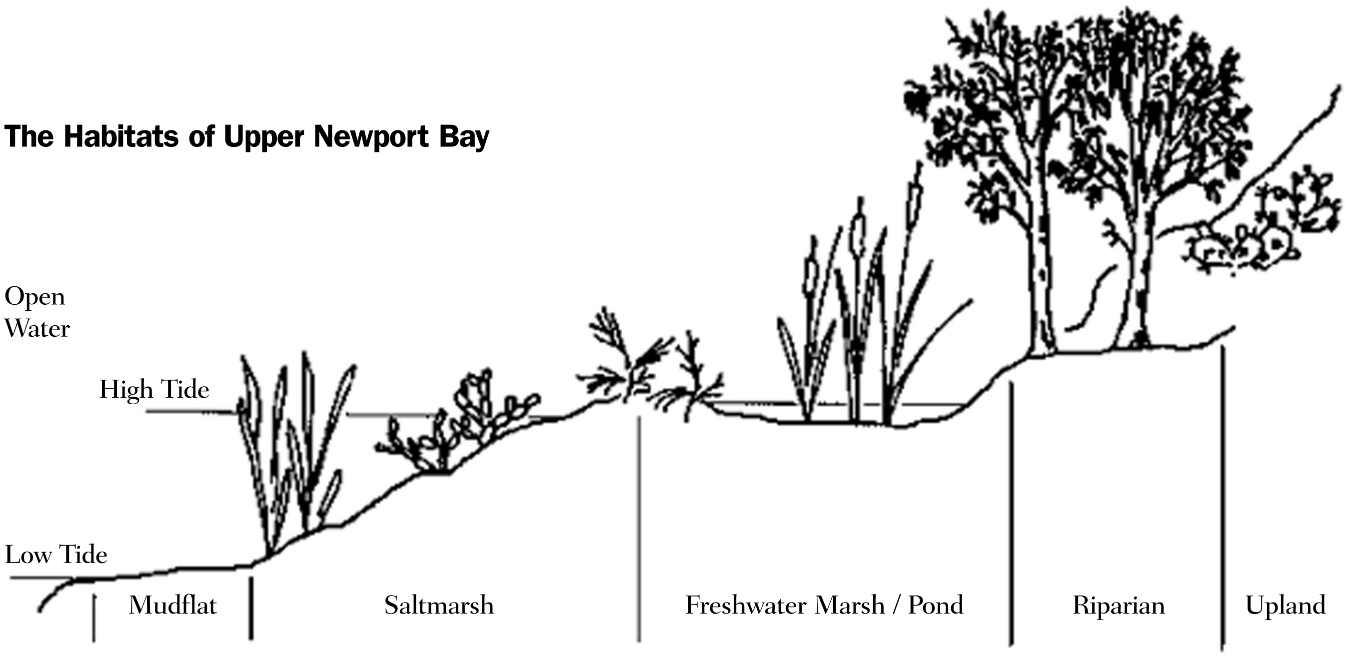
Along with the marsh plants in the Bay are rare riparian and scrub communities that include willows and sages. Upper Newport Bay is home to many native California species, which provide food and shelter for native animals. Victims of habitat loss, several of the Bay plants are protected by the Endangered Species Act.

### Where to Live?

Within Upper Newport Bay, there are several habitats—places where the combination of food, water, shelter, and space allow particular types of animals or plants to survive. Though not always distinct in their boundaries, and changing in size according to daily tide fluctuation, the habitats found at the Bay include:

- open water
- salt marsh
- mudflat
- freshwater marsh
- riparian
- coastal sage scrub

**The Habitats of Upper Newport Bay**




**Open Water** — This is the actual standing water in the bay. The water is teeming with plankton. Fish—from the tiny anchovy to the large bat ray—swim in the water while ducks swim above, and osprey and other seabirds fly overhead. Aquatic plants, such as eel grass and sea lettuce, are also present.

**Mudflat** — When the tide recedes twice a day, the exposed shoreline becomes a mudflat—muddy, flat land. Plant life is limited to algae. But marine animals are in abundance—worms, clams, snails, crabs—and even a few fish that have adapted to the muddy conditions. Many shore birds with long pointed beaks, such as the Black-necked Stilt and Long-billed Curlew, probe the mud for a meal.

**Salt Marsh** — The area from the high-tide line to the mudflat is the salt marsh. Plants living in this area, such as cordgrass and pickleweed, have adapted to being periodically submerged in water and growing in salty soils. Long-legged birds, such as herons and egrets, can be seen walking along the water's edge. The elusive Light-footed Clapper rail builds its nest among the grasses and the Belding's Savannah Sparrow gleans insects from the pickleweed.

**Freshwater Marsh** — Water-loving plants such as cattails and sedges grow in this area, near freshwater inputs such as storm drains or creeks. Introduced species, such as the African clawed frog and mosquito fish, dominate these areas now. Dragonflies, ducks, and egrets are among the species that enjoy the marsh.

**Riparian** — The land alongside the creeks and other fresh water drainage points is called riparian. (*Riparian* is derived from the Latin word "ripa" meaning "streambank.") The plants here, commonly willows and cottonwood trees, like moist soil. Songbirds can be seen and heard among the foliage.

**Coastal Sage Scrub** — The bluffs and undeveloped mesas around the Bay provide the upland habitat. The drier slopes are home to coastal sage scrub and drought-resistant succulents such as prickly pear cactus. Snakes, lizards, coyote, rabbits, squirrels, and other critters live and hunt here. Red-tailed Hawks and Turkey Vultures often soar on the currents of warm air that arise from the bluffs.

# Activity: Mapping Your Watershed

**Summary:** In this activity, students will become familiar with the geography of California as it relates to Upper Newport Bay's watershed by examining various types of maps. Students will travel around the classroom in small groups, visiting different map "stations" and working together to answer questions about each map.

**California State Content Standards**

**SCIENCE**

**Biology/Life Sciences**

- **Ecology 6b**. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

**Earth Sciences**

- **California Geology 9a.** Students know the resources of major economic importance in California and their relation to California's geology.
- **California Geology 9c.** Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

**Investigation & Experimentation**

- **1h**. Students will read and interpret topographic and geologic maps.

**Objectives:**

Students will be able to:

- Read a variety of maps and present the information they gather from the maps
- Describe the geography of California and Upper Newport Bay

**Materials:**

Some or all of the following maps:

✓ Local area road map
✓ Newport Bay/San Diego Creek Watershed Map (*from "Watershed and Wetlands" background information*)
✓ Orange County Wetlands map (*http://www.ocwatersheds.com/watersheds/intro_wetlands.asp*)
✓ Aerial maps of Newport Bay and San Diego Creek Watershed (*http://www.ocwatersheds.com/watersheds/intro_aerial.asp; 714-973-6694*
✓ *Note: San Diego Creek Watershed drains into Newport Bay Watershed)*
✓ Nautical charts of Newport Bay Area (*http://maptech.com)*
✓ Topographical map of local area (*http://mapping.usgs.gov http://maptech.com)*
✓ Orange County Green Map (*www.ocfohbp.org; 949-399-3669)*

Handout
*Map Questions*

**Preparation:**

Make a copy of the questions for each map. Place maps around the classroom; tape the appropriate list of questions next to each map. Number each map station.

**Time Required:**

Approximately 1 hour

## Procedures:

1. Divide the class into equal groups according to the number of map stations you have and instruct each group to stand by a station.

2. Explain that each group will have a few minutes at each station to use the map(s) to answer the questions posted at that station. Instruct each group to record its answers.

3. Tell students to stay at their station until you signal them to go to the next station.

4. Judge the amount of time at each station according to the number of stations and students' abilities. Continue the activity until every group has visited every map station.

5. Have each group present one of the maps and discuss their findings. Compare their answers with those of the rest of the class.

## Alternative Procedure *(generally for more advanced students):*

1. Instead of placing questions next to each map, select questions from the Map Questions handout and make your own list of questions for each student or group.

2. Explain that students are to answer each of the questions by finding the appropriate map. Review the types of maps displayed.

3. Allow students time to circulate around the room and write answers to their questions.

4. When all students have finished, read through all the map questions, having students share their answers.

## Follow-up:

Use the following questions to ask students what they learned from the maps.

1. What area constitutes the watershed for Upper Newport Bay?
   *(The entire San Diego Creek Watershed drains into Upper Newport Bay.)*

2. Is the watershed primarily "green" areas or "developed" areas? What makes up each of these areas?
   *(The watershed is primarily developed, including houses, businesses, schools, streets and highways.)*

3. How does water flowing through the watershed create problems in the Bay?
   *(All of the water that runs off into San Diego Creek, and all of the pollutants that the runoff collects, end up in Upper Newport Bay. That includes all kinds of litter and debris, fertilizer, animal wastes, pesticides, oil, detergent, paint, and anything else that finds its way into the runoff. These pollutants disturb the food web and ecosystem balance in the Bay.)*

4. What can you do to help improve the Upper Newport Bay watershed?
   *(For example:*
   *Keep cars well maintained and free of leaks.*
   *Recycle used motor oil.*
   *Do not pour chemicals on the ground or down storm drains.*
   *Properly dispose of trash in garbage cans.*
   *Pick up pet waste.*
   *Don't dispose of leaves or grass clippings in the storm drain; try composting yard waste.*
   *Landscape yards with native, drought-tolerant plants that do not require fertilizer .*
   *Prevent runoff by not over-watering.*
   *Avoid allowing even clean water to run off into gutters.*
   *Try "natural" [non-toxic] pest control.)*

**Extensions:**

1. Demonstrate the sources of pollution in a watershed using an interactive, tabletop model. See *http://www.ocwatersheds.com/PublicEducation/EnviroScape.asp* or call the Orange County Stormwater Program at (714) 567-363 to learn more about the EnviroScape Model.

2. Have students view a PowerPoint slide show on Watershed Science at *http://www.ocwatersheds.com/PublicEducation/pe_other_materials.asp*.

Adapted from "Mapping Your Watershed" from *Save San Francisco Bay Watershed Education Program*, www.saveSFbay.org

# Map Questions

## Local Area Road Map

1. Locate your school on the map. What is the shortest route to Upper Newport Bay on roads and highways?

2. How many miles would you need to travel along roads from your school to the Bay? How many miles would it be if you could go straight "as the crow flies"?

3. Locate parks, wildlife refuges, and preserves on the map. Which ones have you visited? About what percentage of the map contains these "green" areas? What percentage is "developed," that is, with houses, business, schools, streets, highways?

4. Locate the Orange County Airport on the map. Why do you think the airport is built on an historic wetland site? What effects do you think the airport has on the Bay?

## Orange County Topographical Map

1. What do the contour lines on the map represent? Where are the highest and lowest points on the map?

2. Locate the creeks and channels that flow into Upper Newport Bay.

3. What is the length of San Diego Creek?

4. A creek's "watershed" is the area of land that sheds water to the creek. The watershed for a creek is defined by the ridge lines (highest points) that separate it from another creek's watershed. What areas drain into San Diego Creek?

5. Can you find any roads on the map? How are these different from and similar to the creeks?

6. Where would pollutants running off your school parking lot flow?

## Newport Bay/San Diego Creek Watershed Map

1. What cities' runoff drains into Newport Bay?

2. Is your home located in the Newport Bay/San Diego Creek watershed?

3. Where might pollutants that drain into the Bay, including sediment, originate?

## Nautical Chart of Newport Bay

1. Maps can be made to highlight different features. For example, some maps highlight landforms while others highlight roads and highways. What does this map highlight? Why would you need a Nautical Chart?

2. What do the small black numbers on this map represent? Why do you think these numbers might change? How frequently, and in what locations, do you think these numbers vary?

3. Locate the Pacific Coast Highway Bridge, Shellmaker Island, Big Canyon, the Salt Dike, Least Tern Island, and the San Diego Creek drainage point.

4. What is the average depth of Upper Newport Bay? Where are the maximum and minimum depths?

5. How do you think the depth has changed over time?

6. How might global climate change affect the habitat distribution at Upper Newport Bay?

## Orange County Wetlands Map

1. How many wetlands are there in Orange County?

2. What percentage of wetlands are estuaries—where the land meets the ocean?

3. Which wetlands are largest?

4. Which estuaries drain the largest watershed?

## Aerial Map of Newport Bay Area
## or
## Detailed Road Maps

1. Where does fresh water enter Newport Bay?

2. What might be picked up by water on its way into the Bay? What problems might this runoff cause?

3. Where does salt water come into Newport Bay?

4. What kind of water would you expect to find in the Bay?

## Orange County Green Map

1. Find the following waterways:
   - Aliso Creek
   - Carbon Creek
   - Coyote Creek
   - San Gabriel River
   - San Juan Creek
   - Santa Ana River
   - Santiago Creek
   - Trabuco Creek

   Where does each creek or river eventually lead?

2. Locate the San Diego Creek Watershed. Where is San Diego Creek (Peter's Canyon Corridor) in the watershed?

3. Are the areas that drain into San Diego Creek mainly "green" or "developed"?

4. Where does San Diego Creek flow into?

5. If a watershed is compared to a bathtub, what part of the bathtub is the Bay?

# Activity: Wetland Habitats

**Summary:** This activity uses a flow chart and habitat cards to introduce and classify common types of wetlands.

**California State Content Standards**

**SCIENCE**

**Biology/Life Sciences**
- **Ecology 6e**. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

**Investigation & Experimentation**
- **1g**. Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.

**Objectives:**
Students will:
- Classify wetlands based on their characteristics.

**Materials:**
- *UNB Inhabitant Cards* (Appendix A)
- Map of the United States
- *(optional)* Pictures of wetlands (from books, magazines, internet)
- Handouts
  - *Wetland Habitats Flow Chart*
  - *Habitat Cards*

**Preparation:**
- If necessary, review the use of a flow chart, practicing as a group with one of the pictures.
- Make a copy of the *Wetland Habitats Flow Chart* for each student or group

**Option 1 – see Procedures**
- Make a copy the *Habitat Cards* for each group.

**Option 2 – see Procedures**
- Make one copy of the *Habitat Cards*, cut them apart, and place them at various stations around the room, perhaps with photos of that wetland habitat.

**Time Required:**
- Approximately 45 minutes

Adapted from “Wetland Habitats” from *WOW! The Wonders of Wetlands*, co-published by International Project WET and Environmental Concern

## Procedures:

1. Discuss wetlands with students. Explain that wetlands are classified, in part, by the type of water, frequency and degree of inundation, and types of vegetation most prevalent there.

2. Tell students that they are going to use a flow chart to identify ten wetland types by the habitats they provide.

3. Divide the class into groups and distribute to each group a copy of the *Wetland Habitats Flow Chart*.

4. Proceed with Option 1 or 2 below:

### Option 1

Distribute a copy of the *Habitat Cards* to each group. Have each group use the *Wetland Habitats Flow Chart* to identify the ten wetlands described on the *Habitat Cards*.

### Option 2

Tell students that around the room are descriptions and pictures of various types of wetlands. Explain that they are to move from station to station and use the flow chart to identify each type of wetland.

## Follow-up:

1. Have students share their answers, discussing any discrepancies.
   *(See Answer Key.)*

2. Have students use the *UNB Inhabitant Cards* and the flow chart to classify the wetlands in Upper Newport Bay.

3. Using a map of the United States, have students discuss where the different wetland types might appear.

4. From what they have read on the *Habitat Cards*, have student identify the value of wetlands.

**Answer Key:**

1. sandy beach
2. shrub swamp
3. aquatic plant bed
4. wet meadow
5. mud flat
6. tidal freshwater marsh
7. forested wetland
8. seagrass bed
9. bog
10. salt marsh

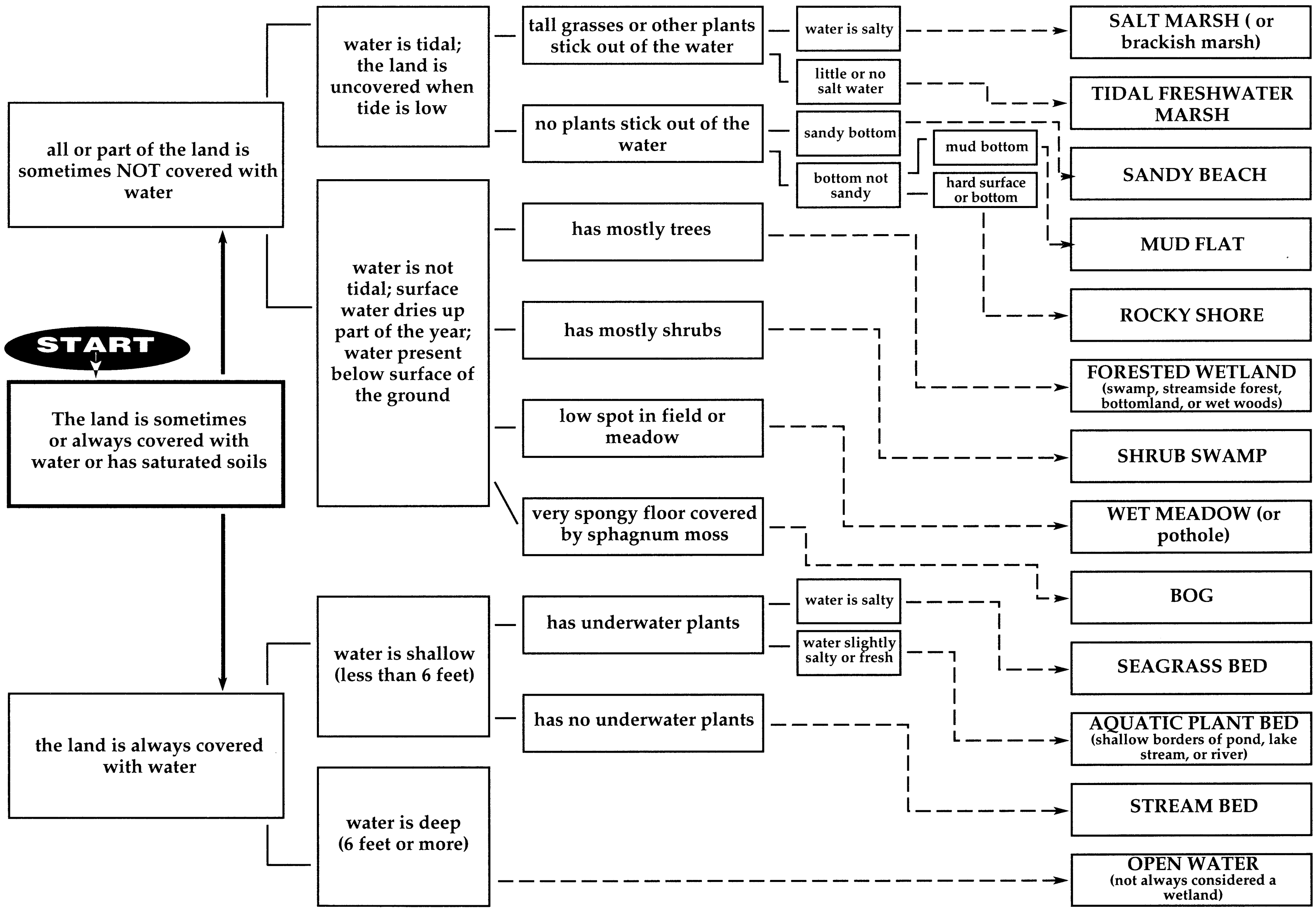
## Extensions:

Make a list of several organisms that live in the various habitats. Randomly assign organisms to student groups and have them determine the likely habitat for each organism and explain why.

Adapted from "Wetland Habitats" from *WOW! The Wonders of Wetlands,*
co-published by International Project WET and Environmental Concern

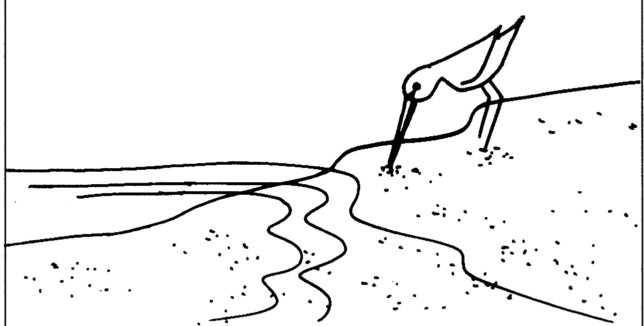
# Wetland Habitats Flow Chart

Carefully read each of the habitat cards, then use this flow chart to identify each habitat. Start at the left side of the page at the first box. There are two boxes connected to that box—choose the one that matches the description on the card. Then move on to the next set of boxes, following the lines, and make another choice. Continue until you reach the name of the habitat described on the card. Can you identify all ten habitats?



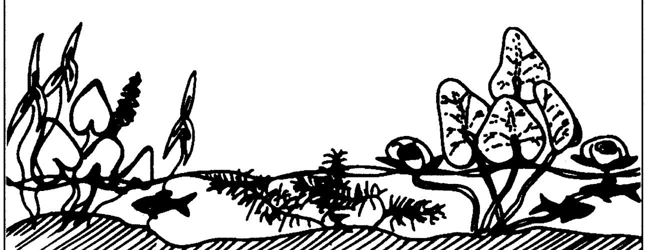
# Habitat Cards

1. During storms, the waves push grains of sand into ever-changing patterns. During low tide the animals that live among the sand grains feel the summer heat or the winter cold. Shore birds search along the water's edge for these animals and for bits of food that wash in from the water. No plants grow here.

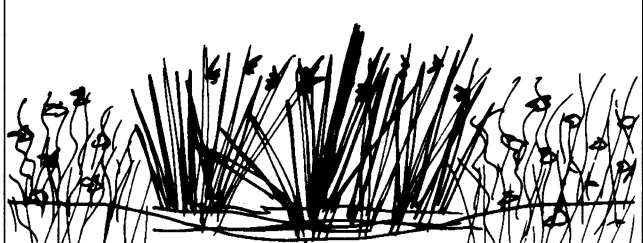


2. Scrubby, low-growing thickets of shrubs grow here, in places that may have started out as wet meadows. You might find these places near the coast, or where lakes, streams, rivers, marshes, and forested swamps overflow. They are not always covered with water. This type of wetland offers good habitat for fish, reptiles, amphibians, and many other animals.

3. In the shallow borders of ponds, lakes, rivers, and streams, where there is good light and the water has little salt, underwater plants and plants with floating leaves grow. Some of these plants are valuable food for many kinds of waterfowl including ducks, geese, and swans. All make places for little fish and other animals to live and feed. These plants slow water movement and protect the soil on shores and banks from erosion.

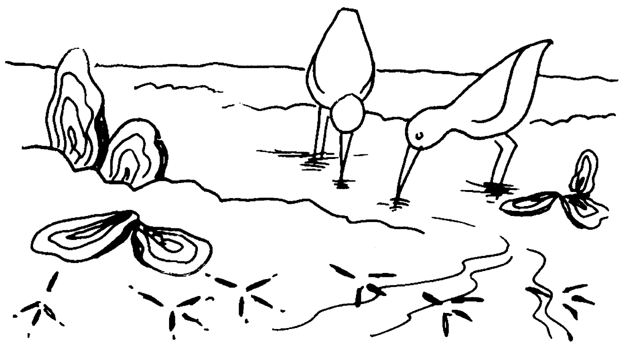


4. Depressions in the ground may fill with rain and ground water and stay wet for several days or weeks. Landowners often mow or plow around these spots to avoid getting tractor wheels stuck in the soft ground. On spring evenings, these puddles seem alive with the high-pitched calls of spring peepers (tiny frogs) looking for mates among the rushes and sedges that grow here. In the heat of the summer, these places usually dry up.

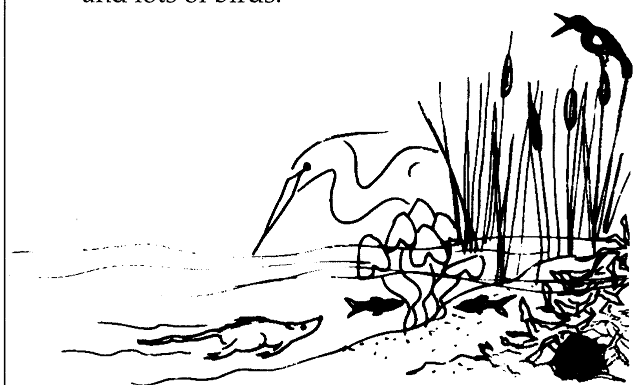


# Habitat Cards

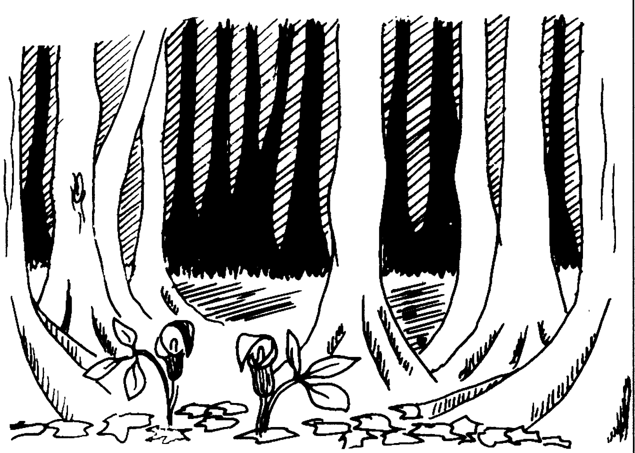
5. Fine particles of dirt make mud when they settle out of the water. Where the water is very shallow, the muddy bottom is uncovered at low tide. While this area may not look like home to many animals, and few or no plants grow here, lots of creatures live down in the mud. Watch for hungry shore birds searching for them in the mud.



6. Tall grasses and other kinds of plants grow up out of the water. The water contains little or no salt, but the push of incoming tides is strong enough to raise the water level in the river. The ground is sometimes flooded and sometimes dry or exposed. The plants provide food and places to hide for many kinds of animals including fish, invertebrates, muskrats, and lots of birds.



7. Where trees grow in low-lying areas, the ground may hold water for part of the year. In the spring, many beautiful wildflowers grow here, and frogs and salamanders find wet places to lay their eggs.



8. In salty bays or at the ocean's edge, two kinds of plants may grow under the shallow water. They can only live where it is shallow because they are rooted on the bottom and need light to make food. The plants are eaten by many animals, and many of them find safe places to live among the plants. These plants protect the shore and reduce the muddiness of the water by slowing the waves.

# Habitat Cards

9. Old lakebeds and other low areas that fill with rainwater sometimes accumulate layers of partially decayed plants called peat. At first glance these places might look dry, but their moss-covered floors actually hold a good deal of fresh water just below the surface. The ground here feels very spongy. Some shrubs and evergreen trees also grow above the sphagnum moss. In these unusual conditions, many unique, beautiful, and rare plants and animals can be found.

10. Along the shore where the water is salty, tall grasses grow up out of the water. Tides move in and out, but some places are flooded only during storms and very high tides. When the tough plants here die, they break down in the water to form little particles called detritus. Many animals eat detritus by filtering it out of the water.

# Activity: Explore a Wetland

*(Field Study)*

**Summary:** Students explore a local wetland, learning about different characteristics of the wetland and the plants and wildlife it supports.

**California State Content Standards**

**SCIENCE**

**Biology/Life Sciences**
- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.

**Investigation & Experimentation**
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

**Objectives:**

Students will be able to:
- Identify the habitats of the wetland
- Describe different organisms that live in the wetland

**Materials:**
- Field guides
- Clipboards
- Collecting dishes and jars
- Hand lenses and/or magnifying glasses
- Binoculars
- Digital camera
- *UNB Inhabitant Cards* (Appendix A)
- Handout
  - *- Field Notes Worksheet*

**Preparations:**
- Make a copy for each student or group of the *Field Notes Worksheet.*
- Contact the wetland you plan to visit (see list in Appendix D) to obtain permission for access and to find out what specific areas students can focus on, what equipment and materials may be borrowed, and what activities are available at the site.
- Use this field trip to the wetland to prepare for or in conjunction with other activities. See:
  - Wetland Soil
  - Measuring Decomposition
  - Water Quality
  - Space for Species
  - Seed Experiments
  - Plant Monitoring
  - Stewardship

**Time Required:**
- The amount of time required will vary between a minimum of one hour to a full day, in addition to follow-up after the field trip.

**<u>Procedures</u>:**

### BEFORE THE FIELD TRIP:

1. Inform students that they will be taking a field trip to a wetland and that they will be acting as field biologists for the trip, exploring the ecology of the wetland.

2. Review each of the items on the *Field Notes Worksheet.*

3. Encourage students to study the *UNB Inhabitant Cards*.

### AT THE WETLAND SITE:

1. Remind students that wetlands are fragile and rare ecosystems that are easily damaged. Review some behavior rules:
   - Do not feed the wildlife.
   - Do not disturb any form of plant or animal life.
   - Do not collect specimens unless you have permission.
   - Do not walk on the mudflats.

2. Determine how you want students to explore and make observations: all groups in all areas or each group in a separate area; on foot or in canoes/kayaks or both.

3. Tell students that field guides and the *UNB Inhabitant Cards*, along with collecting jars and hand lenses, are available to help them identify organisms they find.

4. Remind students to spend time quietly observing—listening, watching, smelling, touching.

5. Hand out a copy of the *Field Notes Worksheet* to each student or group.

### AFTER THE FIELD TRIP:

Have students compare and discuss their *Field Notes Worksheets.* Use the following questions to help generate discussions.

a. Did the weather and the tide have any effect on what you saw at the wetland?
b. How might the wetland change with the seasons?
c. Did you discover any plants or animals that you didn't expect to find? Any that you haven't been able to identify?
d. Which habitat had the highest biodiversity among animal and plant species?
e. What food chains exist among the organisms you saw in the wetland?
f. How do humans use and affect the wetland?
g. How would the information you gathered be useful to biologists?
h. Were there differences among students' *Field Notes Worksheets*? Why?

**Extensions:**

1. Have students create a virtual wetlands PowerPoint lesson for lower grades.
2. Tour other wetlands and compare their ecology. (See Appendix D.)
3. Visit the Peter and Mary Muth Interpretive Center. Call 949- 923-2290 for information.

# Field Notes Worksheet

**Wetland Name/Location:** ____________________

**Date**:____________________ **Time**: ____________________

**General Observations:**
Spend 5 minutes quietly observing. What do you see, smell, hear, and feel?

**Weather**

Temperature: ____________________ Cloud Cover: ____________________

Wind: ____________________ Other: ____________________

**Tide**

High or low: ____________________ Coming in or going out: ____________________

**Geology**

What signs of tectonic shifting can you identify?

**Habitats, Animals, Plants**

| **Habitat**<br>Include brief description. | **Animals**<br>List animals seen in each category in each habitat, including how many and what they were doing. Be sure to include humans under mammals. | **Evidence of Animals**<br>(tracks, burrows, droppings, nests, etc.) | **Plants**<br>List plant species.<br>Indicate **S**carce or **A**bundant<br>**N**ative or **I**nvasive<br>Describe adaptations for that habitat. |
|---|---|---|---|
| | mammals<br>birds<br>fish<br>invertebrates<br>reptiles | | |

| **Habitat**<br>Include brief description. | **Animals**<br>List animals seen in each category in each habitat, including how many and what they were doing. Be sure to include humans under mammals. | **Evidence of Animals**<br>(tracks, burrows, droppings, nests, etc.) | **Plants**<br>List plant species.<br>Indicate **S**carce or **A**bundant<br>**N**ative or **I**nvasive<br>Describe adaptations for that habitat. |
|---|---|---|---|
| | birds<br>fish<br>invertebrates<br>reptiles | | |
| | mammals<br>birds<br>fish<br>invertebrates<br>reptiles | | |
| | mammals<br>birds<br>fish<br>invertebrates<br>reptiles | | |

### Water

Describe and sketch any organisms you see in a sample of the water. How do the organisms move? Do the organisms interact?

### Threats

What evidence do you see of threats to the habitats?

# Activity: Wetland Webs

**Summary:** Students learn about the inhabitants in wetlands and construct a typical wetland food web to discover the interconnectedness of the ecosystem.

## California State Content Standards

### SCIENCE

**Biology/Life Sciences**

- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.
- **Ecology 6f.** Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.

### ENGLISH-LANGUAGE ARTS

**Grades 9-10**

**Reading Comprehension**

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

**Speaking Applications**

- **Deliver Expository Presentations 2.2**
  **b.** Convey information and ideas from primary and secondary sources accurately and coherently.
  **e.** Anticipate and address the listener's potential misunderstandings, biases, and expectations.
- **Apply Appropriate Interviewing Techniques 2.3**
  **a.** Prepare and ask relevant questions.
  **b.** Make notes of responses.
  **d.** Respond correctly and effectively to questions.
  **e.** Demonstrate knowledge of the subject or organization.
  **f.** Compile and report responses.
- **Deliver Descriptive Presentations 2.6**
  **a.** Establish clearly the speaker's point of view on the subject of the presentation.
  **b.** Establish clearly the speaker's relationship with that subject (e.g., dispassionate observation, personal involvement).
  **c.** Use effective, factual descriptions of appearance, concrete images, shifting perspectives and vantage points, and sensory details.

**Grades 11-12**

**Listening and Speaking Strategies**

- **Organization and Delivery of Oral Communication 1.8.** Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.

## Objectives:

Students will be able to:

- Identify wetland inhabitants
- Identify the various roles within in a food web
- Explain the concept of interconnectedness

## Materials:

- *UNB Inhabitant Cards* (Appendix A)
- Notepads and pencils
- Chart paper or butcher paper

## Preparations:

- Have several sheets of chart paper or lengths of butcher paper available for each large group of students.

## Time Required:

- Approximately 50 minutes for each of the two activities; additional time for research

**Procedures:**

Conduct the following activities with the *UNB Inhabitant Cards* to help students learn about the plants and animals that inhabit Upper Newport Bay and discover the relation of one species to another in a wetland food web.

**Each One Teach One:**

1. Hand out one or more of the *UNB Inhabitant Cards* to each student. Give students time not only to learn the information on their cards but also to conduct outside research to learn other facts about the inhabitants on their cards.
2. Explain to students that they are to interview other students about the inhabitants of Upper Newport Bay and that, in turn, they will be interviewed about their species. Ask students to keep a list of the inhabitants within each of the following categories: plants, birds, land animals, fish, other marine animals. Have students determine how they might categorize the species in each list, for example by habitat or by trophic level.

**Build a Food Pyramid, Food Chains, Food Webs:**

1. Discuss the various roles within a food web:

   - primary producers (autotrophs—which covert energy from the sun)
   - primary consumers (herbivores—which consume primary producers)
   - secondary consumers (carnivores—which consume primary consumers and other secondary consumers)
   - detritivores (micro- and macroorganisms that decompose dead plant and animal matter)

   Point out that organisms within a community interact with each other and with the abiotic, non-living, environment—that is, sun, soil, water, inorganic nutrients, etc. Explain that the passage of energy from one organism to another takes place along a particular food chain—that is, a sequence of organisms related to one another as prey and predator. Ask students to give examples of simple food chains. For example:

   Shore birds eat clams.
   Clams eat plankton.
   Zooplankton eat phytoplankton.
   Phytoplankton are dependent upon nutrients in the water and the sun for energy to make their own food through photosynthesis.
2. Tell students that in most ecosystems, food chains are linked together in complex food webs, with many interconnections. Explain that webs may involve more than 100 different species, with predators taking more than one type of prey, and each type of prey being exploited by several different species of predator. Emphasize that the connection between species in a food web can make or break the function of the ecosystem.
3. Hand out one or more *UNB Inhabitant Cards* to each student. Have students use the information on the cards to build a "food pyramid" from the primary producers up. Ask students how the number of species in the bottom levels compares to the number of species at the top level. Ask why they think the pyramid is shaped this way. Point out that a large body often requires a more abundant food source and a larger habitat.

4. Next, divide the students into large groups and have them lay out their cards on the chart or butcher paper to create food **chains**. Ask them to write the name of their species on the paper and to draw arrows pointing to what is consumed.
5. Combine groups and have them compare their food chains and now create food **webs** showing how the chains are interconnected.
6. Demonstrate ecosystem stability by adding or removing food web connections.

**Follow-up:**

After the activities, ask students to share and explain their food webs. Ask the following questions to generate a discussion:

1. How does the size of the organism generally relate to its position in the food web?

   *(In general, the larger the animal, the higher it is on the food web.)*
2. Did you note any exceptions to this generalization?
3. What other connections, besides predator-prey, hold an ecosystem in balance? *(Mutualism is common in nature, and species depend on one another for more than just a meal. Pollinators and animals provide dispersal mechanisms; microbes and roots provide soil aeration; plants provide protection, shelter, and nesting refuge; etc.)*
4. What could happen to the food web if a hazard, such as an oil spill, occurred?

   *(Food webs are fragile, and the removal of even one link in the chain may ultimately result in the collapse of the entire food web. For example, an oil spill may block out the sun and disrupt photosynthesis in phytoplankton, decreasing the amount of plankton in the water. Clams then cannot find enough to eat and their numbers will decrease. And ultimately, the shore birds that eat the clams will have to find some other food item, move to another habitat, perhaps forgo reproduction that year, or maybe even starve.)*
5. Why would the disruption and possible destruction of a marine food web matter to us?

**Extensions:**

1. Make more *UNB Inhabitant Cards*. The *UNB Inhabitant Cards* represent only a small portion of the organisms in Upper Newport Bay. There are, for example, more than 200 species of birds. Have students research other species at the Bay within each category and make cards to match the existing *UNB Inhabitant Cards*. (See the list of *Species Common to Upper Newport Bay* in Appendix B.)
2. Build a food chain for each of the foods in a meal, e.g. a student's lunch. Think about the energy transfer required to produce one pound of beef versus one pound of rice, or a spiny lobster versus a bluefin tuna.

# Activity: Wetland Soil

**Summary:** Students learn about the properties of wetland soils and about the organisms that live in wetland soil.

## California State Content Standards

### SCIENCE

#### Biology/Life Sciences

- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

#### Investigation & Experimentation

- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1i.** Students will analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

### ENGLISH-LANGUAGE ARTS

#### Grades 9-10

#### Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.

## Objectives:

Students will be able to:

- Classify soil according to color
- Describe conditions that create the color characteristics of wetland soils
- Describe organisms that live in the soil and their interrelationships

## Materials:

- 3 or more soil samples from various areas and depths in a wetland
  *(Likely locations for wetlands include the edges of ponds and streams, low lying topography that is often wet and muddy, drainage ditches that are frequently full of water, or sites with obvious wetland vegetation—e.g., cattails and reeds. See Appendix D for southern California wetlands.)*
- Several packs of 64 Crayola® crayons
- Poster board or manila folders
- Handouts
  - *Wetland Soils*
  - *Wetland Soils Color Chart*
  - *Field-Based Soil Sample Data Chart*
  - *Analyzing Soil Samples Worksheet*

**Note:** The activity "Measuring Decomposition" also requires soil samples. Consider collecting samples for both activities concurrently.

Adapted from "Wetland Soils in Living Color" from *Project WET Curriculum and Activity Guide*, © International Project WET

**Preparations:**

- Collect soil samples from 3 different locations at the wetland—mudflat, water's edge, and upland area. (**Note**: A soil probe will extract a deep narrow sample with minimal disruption of the landscape, but it does not work well in dry soil. A garden trowel may be used, but obtaining a continuous sample will be difficult.)
  - Call the site to verify that you can take soil samples and to inquire about what tools and assistance are available for collection.
  - At each location, remove a scoop of soil about the size of a Ping Pong ball at two-inch intervals to a depth of eighteen inches.
  - Place each sample in a specimen jar or zip-top bag and label with the location and depth of the sample.
  - Refill the hole.

**Alternatively**, have students collect and label samples on a field trip to the wetland.

- Make a copy for each student of the *Wetland Soils* handout.
- If taking students on a field trip to the wetland, make a copy for each group of the *Soil Sample Data Chart.*
- Make a copy for each group of the *Wetland Soils Color Chart.*
- Make copies of the *Analyzing Soil Samples Worksheet* for each group (one copy for each soil sample to be analyzed).
- Set up three stations in the room, each with a microscope and the soil samples from each area.

**Time Required:**

- Approximately 60 minutes for lesson plus time to collect soil samples or take optional field trip.

**Procedures:**

1. Read the following description of a land area to students and ask if they would classify it as a wetland.

   "The land contains some long-leafed plants that look like grasses. Most of the year the land is dry; however, almost every spring the area is flooded."

2. Tell students that wetlands have three characteristics that make them unique habitats: there must be **water** present for a sufficient period of time to establish **hydrophytic plant species** and to influence the development of **hydric soils**. Point out that because of regular flooding in the example above, one would assume that the plants are hydrophytes; however, a soil test could confirm whether the area deserves wetland classification.

3. Tell students that soils are often used to determine whether or not an area is a wetland. Show students three soil samples of varying colors. Ask students how they would classify them or distinguish one from the other.

4. Tell students that color provides important clues used by scientists when classifying soils. Explain that wetland scientists use a complex set of color charts—a Munsell soil color book—to classify soils into different types based on color, lightness and darkness, and the degree of mixture of colors. Tell students that because wetland habitats are rare, there are laws protecting wetlands from development or other disturbances; therefore, soil classification is an important tool used by scientists to determine whether a site can be defined as a "wetland," deserving stricter regulations and protected status.

5. Hand out a copy of *Wetland Soils* to each student. Read and discuss the information about how organic debris, moisture content, and mineral composition influence the color of soils. Be sure that students understand these are general guidelines and that there is variance in classifying soils. Ask students to predict whether deeper soils are gleyed or mottled? Ask how they might detect whether the location of a sample was historically used as a sediment-dump site?

6. Divide students into groups. Distribute copies of the *Wetland Soil Color Chart* to each group and review the directions at the top of the page. Explain that this is a simplified version of a chart used by wetland scientists. Have students complete the *Wetland Soils Color Chart* in their groups.

7. **If taking a field trip to the wetland**, have student groups collect the soil samples and compare them against the *Wetland Soils Color Chart.* Tell students to break open the samples to check for the truest color. While in the field, have students complete the *Field Based Soil Sample Data Chart.* Have students share and combine their data to create and label a vertical diagram of the soil colors.

8. In the classroom, point out to students the various stations set up with soil samples. Hand out copies of the *Analyzing Soil Samples Worksheet* to each student group. Explain that at each station, they are to fill out a worksheet for each soil sample.

9. Have groups move from station to station until all groups have visited each station.

**Follow-up:**

Discuss the results of students' worksheets. Point out the following:

- In addition to color, a soil's texture and degree of wetness, along with other qualities like smell and the presence or absence of living matter (biotic or abiotic), provide clues to its classification.

- A rotten-egg smell indicates the presence of hydrogen sulfide, a product of anaerobic bacteria.

- Various layers of soil from the same hole may exhibit striking differences in color, texture, and smell, caused by the presence of water, the parent soil material, aerobic or anaerobic conditions, and so on. Vertical soil samples (cores) may provide insight to historical disturbance and climatic conditions.

**Extensions:**

Create a soil log to compare changes over time:

1. Use crayons to color a strip diagram that matches the horizons of the soil sample at each depth. Record the date the soil sample was collected and where it was collected. Has there been a change in the depth of the soil horizons since the previous year? Is the soil more or less hydric?

2. Using soil test kits, record the pH and nutrients present in the soil.
   Determine the acidity of each two-inch section of the soil sample. Soils with high organic matter tend to be more acidic, but fewer plants are adapted to acidic soil conditions. Does the pH change from the surface to the bottom section?
   Determine the nutrients available to wetland plants by testing for nitrogen, phosphorous, and potassium across depth and location. What might be the source of excess nutrients?

3. Our understanding of wetlands is evolving based on knowledge gained from data over time. Compare soil sample data from previous years at the same location to determine if changes have occurred.

Adapted from "Wetland Soils in Living Color" from
*Project WET Curriculum and Activity Guide*,

# Wetland Soils

Wetland soils might be:

- saturated by permanent flooding,
- seasonally flooded, or
- intermittently covered to a shallow depth with water.

Wetland soil remains wet long enough that the upper soil layers are deprived of oxygen (anaerobic). Over time, this lack of oxygen produces chemical reactions that change the soil's color, as well as other characteristics, such as texture and organic content.

Even when water is not present, the color of soil can be used to identify an area as a wetland. By reading soils, scientists can derive information about the duration and frequency of wet conditions.

Wetland soils are divided into two major types:

1. organic
2. mineral.

**Organic** soils look like black muck or dark brown or black peat. Decomposing plants and animals contribute to the color of organic soils. In water-logged environments, which are anaerobic, organic materials tend to accumulate rather than break down (as they would in aerated environments).

**Mineral** soils lack organic material and are usually found deeper under the surface. Common mineral soil components are:

- sand
- silt
- clay

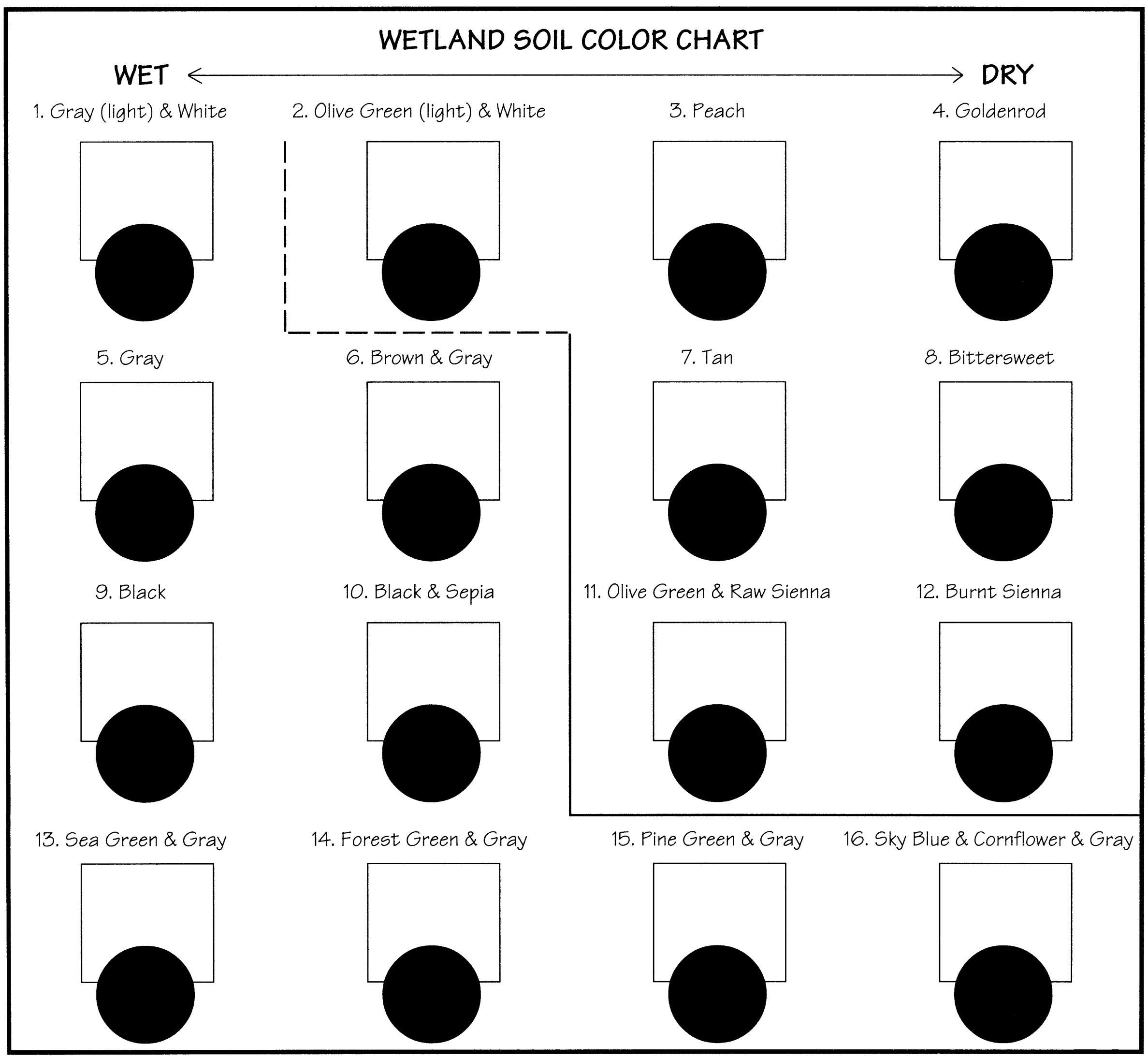
Mineral wetland soils can be gleyed (pronounced "glade") or mottled. **Gleyed** soils are created in anoxic environments where oxygen is removed from soil chemicals. The colors produced range from gray and bluish-gray to black, depending on the degree of saturation. **Mottled** soils are gray with splotches of brown, orange, red, or yellow, as a result of being alternately wet and dry. When oxygen mixes with iron, manganese, water, and other components in soil, a process similar to that which causes rust on garden tools or wrought iron occurs—oxidation—creating splotches of color. The same chemical processes are used in making pottery. When pottery is placed in a reduced (low oxygen) kiln, dark, muted colors result. When pottery is made with an oxidized firing, the finished colors are usually bright.

# Wetland Soils Color Chart

Use crayons to color the squares on the chart below. Using the correct colors is very important! Press firmly when coloring unless the name says "light." Cut out the whole chart and paste it to a piece of poster board or card stock. Carefully cut out the black circles through all thicknesses.

Use this color chart when studying soil. Wetland professionals use similar color charts to help them identify wetland soils. Hold the chart in one hand; in the other hand, hold a sample of soil behind the chart so that it is visible through one of the holes. Move the sample around until you find a color that nearly matches the **main** color of the soil. Record this classification on the worksheet.

- Numbers 1, 5, 6, 9, 10, 13, 14, 15, 16, and sometimes 2 are probably wetland soils.
- Numbers 3, 4, 7, 8, 11, and 12 are probably not wetland soil.
- Numbers 14-16 are *gleyed* wetland soils and are most likely made of clay.
- Numbers 4, 8, and 12 can be used to match *mottles* ("rust spots") that may be found in wetland soil.



# Field Based Soil Sample Data Chart

Student name(s): ______________________________ Date: ____________

Description of location: ______________________________

______________________________

Description of plants present: ______________________________

______________________________

Possible evidence of animals (burrows, insects, human artifacts—of value or trash): ______________

______________________________

______________________________

Possible sources of water: ______________________________

______________________________

______________________________

| DEPTH OF SOIL SAMPLE | SOIL SAMPLE COLOR CLASSIFICATION | DAMPNESS OF SOIL SAMPLE (Does it stick in a ball? Can water be squeezed out?) | SOIL SAMPLE TEXTURE (Is it like coarse sand, fine silt, or clay?) |
| --- | --- | --- | --- |
| | | | |
| | | | |
| | | | |
| | | | |

# Analyzing Soil Samples Worksheet

Location of sample: ____________________________

Depth of sample:______________________________

Color Classification: __________________________

Describe the texture of the soil. *(Sandy soils feel gritty; silt will be smoother; and clay soils will form a ribbon when rolled. Place a one-inch ball of soil between thumb and base of forefinger. Gently push the soil with thumb, rolling it upward into a ribbon. If the ribbon forms longer than an inch, there is a lot of clay in the soil.)*

Are any organisms present? Describe, draw, and, if possible, identify the organisms.

What does the sample smell like?

Is the soil organic or mineral? Gleyed or mottled? What evidence helped you decide?

How does the soil at this depth differ from soils at different depths from the same location? What might account for the variation?

Do results confirm this area as a wetland?

# Activity: Measuring Decomposition

**Summary:** Students will determine soil moisture content and then measure $CO_2$ production by using a titration to determine the decomposition rates in soil.

## California State Content Standards

### SCIENCE

#### Chemistry

- **Conservation of Matter and Stoichiometry 3a.** Students know how to describe chemical reactions by writing balanced equations.
- **Conservation of Matter and Stoichiometry 3e.** Students know how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.
- **Acids and Bases 5a.** Students know the observable properties of acids, bases, and salt solutions.
- **Acids and Bases 5d.** Students know how to use the pH scale to characterize acid and base solutions.
- **Solutions 6d.** Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
- **Reaction Rates 8a.** Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
- **Reaction Rates 8b.** Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
- **Reaction Rates 8c.** Students know the role a catalyst plays in increasing the reaction rate.

#### Biology/Life Sciences

- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.

#### Investigation and Experimentation

- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.

### MATHEMATICS

- **Algebra I 3.0.** Students solve equations and inequalities involving absolute values.
- **Algebra I 15.0.** Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.

**Objectives:**

Students will be able to:

- Perform a titration
- Measure decomposition rates in soil
- Explain the importance of decomposition
- Compare soil productivity by depth and habitat

**Materials:**

- Soil samples from Upper Newport Bay or other wetland (~100 g [~ 1/2-1 cup] for each titration, depending on moisture content)
- Drying oven or microwave
- Metric balance with 0.1 g accuracy
- Beakers
- Spoon or scoop for handling soil
- Distilled water
- Gloves and goggles
- *(optional)* Incubator *(You can build an incubator using a light or heating pad in a box.)*
- *(optional)* Magnetic stirring plate and bar
- Handouts
  - *Procedures for Determining Soil Moisture Content*
  - *Procedures for Measuring Decomposition Using a Titration*
  - Data Form 1: *Soil Moisture Content*
  - Data Form 2: *Measuring Decomposition Using a Titration*
  - Data Form 3: *Summary*

**For collecting samples:**

Lid to a wide-mouthed container
Knife
Garden trowel and spatula
Plastic wrap
Marker
Air-tight container

**For each soil sample:**

- 1 shallow, wide, *airtight* container (approximately 25 cm x 25 cm)
- Beaker to hold NaOH (needs to fit inside the airtight container with air space above)
- 20 mL 1M NaOH *(sodium hydroxide)*
- 10 or 20 mL pipette
- 20 mL 1M HCl *(hydrocloric acid)*
- 2 mL 1M $SrCl_2$ *(strontium chloride)*
- Phenolphthalein
- 20-50 mL buret or "Poor Man's Buret"

**Note:** For every 5 soil samples, you will need to create a "blank," which will require an additional airtight container and beaker with NaOH.

**Note:** The activity "Wetland Soil" also requires soil samples. Consider collecting samples for both activities concurrently.

**Preparations:**

- Obtain soil samples from Upper Newport Bay or other wetland location (see Appendix D). Check with wetland staff to verify that samples can be taken.

  - Take samples from various areas (mudflat, salt marsh, riparian, upland) and various depths (e.g., a shallow sample at one to three inches and a deeper sample at four to six inches). A recommended sampling might be:

| | | | |
|---|---|---|---|
| mudflat | — | shallow | 1 |
| | | deep | 1 |
| salt marsh | — | shallow | 1 |
| | | deep | 1 |
| riparian | — | shallow | 1 |
| | | deep | 1 |
| restored upland | — | shallow | 1 |
| | | deep | 1 |
| invaded upland | — | shallow | 1 |
| | | deep | 1 |
| | Total Samples | | 10 |

To take a sample:

**Important:** Keep the soil as intact as possible because microbial activity in the soil is dependent on soil structure.

1. Brush away any undecomposed litter layer.
2. Lay the lid of a wide-mouthed jar (e.g., peanut butter jar) or similar object on the soil.
3. Use a knife to cut out a "cookie" of organic soil around the lid, cutting as deep in the soil as you need, and carefully use a trowel or a spatula to lift the sample out. Alternatively, use a soil corer.
4. Wrap each sample in plastic wrap and label its location, depth, and the date it was collected.
5. Place samples in an airtight container with minimal disturbance.

- Make copies for each group of:
  - *Procedures for Determining Soil Moisture Content*
  - *Procedures for Measuring Decomposition Using a Titration*
  - Data Form 1: *Soil Moisture Content*
  - Data Form 2: *Measuring Decomposition Using a Titration*
  - Data Form 3: *Summary*

**Time Required:**

- To obtain soil samples:
  - approximately 1.5 hours

- To determine soil moisture content:
  - approximately 25 minutes
  - if soil is too wet, additional time to dry soil sample
  - if soil is too dry, an additional 15 minutes and then 24 hours to rest soil

- To perform titration:
  - approximately 15 minutes to prepare soil samples
  - 24-48 hours to incubate
  - approximately 30 minutes to titrate
  - approximately 15 minutes for follow-up

## Procedures:

1. Introduce the lesson to students by conveying the following information:

    Soil consists of both inorganic and organic material. The inorganic material comes from rocks that have broken down to smaller particles. The organic material comes from living things in the soil. For example, plants shed leaves and drop twigs onto the soil. Eventually, this litter layer decomposes and becomes part of the organic material in the soil. When plant roots die, they also become part of the organic material in the soil. Additional organic material is added when invertebrates that live in the soil, such as worms, die. Finally, many different organisms add organic matter to the soil in the form of feces and other waste products.

    When microbes and invertebrates break down organic matter in soil, they produce $CO_2$ through the process of respiration. Thus, the rate at which $CO_2$ is produced in soil is a good indicator of the rate of decomposition of organic matter in the soil.

2. Tell students that they are going to be testing soil samples from Upper Newport Bay (or other location) to determine the rate of decomposition in the soil. Explain that they will measure the $CO_2$ produced by microbes and invertebrates in a *microcosm*—a small scale laboratory model of what occurs in nature.

3. Before students perform each procedure, have them hypothesize results.

### Determine Soil Moisture Content

4. Explain that to measure decomposition in soils, they need to measure soil moisture content because:
    - it allows calculation of the dry weight of the sample, a number that is used in the formula for determining the rate of $CO_2$ production;
    - the moisture greatly affects the rate of activity of soil microbes.

5. Divide students into groups according to the number of soil samples and assign a sample to each group. (For example, if you have collected 10 soil samples and have a class of 30, divide students into 10 groups of 3 students each.)

6. Hand out to each group a copy of Data Form 1: *Soil Moisture Content* and have each group fill in the top of the form.

7. Hand out a copy of the *Procedures for Determining Soil Moisture Content* to each group. Have students follow the procedures and fill in their data forms as they work.

**Measure Decomposition Using a Titration**

8. Tell students that they will be using the reaction of $CO_2$ with sodium hydroxide (NaOH) to measure the amount of $CO_2$ released from the soil. Explain that $CO_2$ produced by the microbes and invertebrates in soil reacts with NaOH as shown in the following equation:

$$2\,NaOH + CO_2 \rightarrow 2H^+ + CO_3^{2-} + 2\,Na^+ + O^{2-}$$

9. Overview the titration procedure:

   Begin with a known quantity of NaOH in a beaker placed in your soil microcosm—in this case, an airtight container. Because the $CO_2$ respired by soil microbes reacts with NaOH to form carbonic acid ($H_2CO_3$), the beaker solution becomes more acidic over time, as it absorbs $CO_2$.

   Next, add strontium chloride ($SrCl_2$) to the solution. $SrCl_2$ reacts with $CO_3^{2-}$ to form an insoluble precipitate. This removes all $CO_3^{2-}$ from solution and prevents the equation equilibrium from moving back to the left.

   Next add phenolphthalein to the solution. Phenolphthalein is pink in basic solutions and clear in solutions that are neutral. When you first add phenolphthalein to your solution, the presence of basic NaOH will cause the solution to turn pink.

   Then you will titrate—that is, add known quantities of acidic HCl into the solution. When the solution develops a neutral pH, it will turn clear. By measuring how much acid must be added to make the solution neutral, you can find out how much $CO_2$ was absorbed through microbial action during the incubation period. Solutions requiring less HCl indicate more productive soils. You will need to use “blanks” to account for background levels of $CO_2$.

10. Hand out the *Procedures for Measuring Decomposition Using a Titration* to each group. Point out there are three parts to this activity—preparing blanks to account for background levels of $CO_2$, preparing soil samples, and titrating. Explain that one blank needs to be prepared for every five soil samples. If each group is doing fewer than five samples, determine which groups will prepare the blanks.

11. Hand out to each group Data Form 2: *Measuring Decomposition Using a Titration.* Have students follow the procedures for performing a titration and fill in their data forms as they work.

**Follow-up:**

1. When students have finished the procedure, use Data Form 3: *Summary* to compare and discuss the results.

2. Use the following questions to discuss or have students write about their experiment.

    - Describe the general results of the titration experiment. What did you learn about soil $CO_2$ production rates?

    - Were $CO_2$ production levels higher or lower than you expected? Explain.

    - If you had replicates for each soil type, what was the average for each soil type? What does the average tell you about differences between soil types?

    - Did you see any variability among soil samples in the same soil type? What might be some reasons for the variability?

    - Why is the measurement of soil decomposition rates useful or important?

**Extensions:**

1. Collaborate with another school that has performed this experiment to compare results.

2. Test your backyard soils and compare results.

Adapted from *Invasion Ecology* from NSTA Press.

## Procedures for Determining Soil Moisture Content

1. Mix the entire soil sample thoroughly and remove any large chunks, such as pebbles or roots.

2. Record the weight of a small beaker.

3. Put a subsample of the soil—10-20 g—into the beaker. Weigh the soil and the beaker.

4. Subtract out the weight of the beaker to determine the weight of the subsample. (This is the *wet weight*.)

**Wet wt of soil = combined wt of beaker and soil - wt of beaker**

5. Dry the soil using either a drying oven or microwave. If using a drying oven, dry the sample for 24 hours at ~100°C. If using a microwave oven, first heat the sample on low power for 5 minutes, allow to cool, and then weigh it. (It is essential to use low power so that the soil does not reach a high enough temperature to burn or release anything other than water.) Continue heating for one additional minute and weigh the sample at each interval. Repeat this cycle until the weight change before and after heating is minimal.

6. After drying the soil, record the weight of the beaker and the soil. Subtract out the weight of the beaker to determine the weight of the soil (This is the *dry weight*.)

**Dry wt of soil = combined wt of beaker and soil after drying - wt of beaker**

7. Calculate the moisture content using the following equation:

$$\textbf{Moisture content} = \frac{\textbf{wet weight - dry weight}}{\textbf{wet weight}}$$

   This result is expressed in decimal form for use in dry weight and $CO_2$ calculations. To express as a percentage instead, simply multiply by 100.

8. **If the soil is in the 10-90% moisture range**, proceed to titrating.

9. **If the soil contains more than 90% water,** it is too wet. Spread out the total soil sample (from which your subsample came) in a thin layer and allow it to dry at room temperature out of direct sunlight until it looks moist but not wet. Repeat steps 3-7 with a new subsample after the soil has dried, to determine if the desired % moisture has been reached. If the soil is still too wet, continue the drying process until the moisture content is near 50%.

10. **If the soil contains less than 10% moisture**, follow these steps:

A. Weigh the total soil sample (from which your subsample came). This is the *total soil weight*.

B. Calculate the actual water weight in your total sample using the moisture content you previously determined using this formula:

**Actual water wt of full sample = total soil wt of full sample x moisture content of subsample**

C. Find the total dry weight of your soil sample.

**Dry wt of full sample = total wt of full sample - actual water wt of full sample**

D. For a 50% moisture sample, the *desired water weight* is equal to the dry weight of the sample. Determine how much water you need to add by using this calculation:

**Wt of water to be added = desired water wt - actual water wt**

To weigh water, first weigh a beaker and then slowly add water until you have the correct weight (correct weight = [beaker + water] - beaker).

E. Add the amount of water needed by gently sprinkling the water into the entire soil sample and mixing thoroughly. Use only distilled water.

F. Let the soil sit for 24 hours to allow microorganisms to regain activity before titrating.

## Procedures for Measuring Decomposition Using a Titration

### Part 1: Preparing Blanks

1. Create one blank for every five soil subsamples. Follow steps 3-7 of the Preparing Soil Samples procedure (Part 2) and steps 1-7 of the Titrating procedure (Part 3) **except** do not use any soil. This will allow you to compensate for any background $CO_2$ that was not contributed by the soil microbes.

2. Leave the blanks with the other containers and run titrations on all samples and blanks at the same time.

### Part 2: Preparing Soil Samples

1. Weigh the bottom of the airtight container to the nearest 0.1 g.

2. Mix soil sample thoroughly and then transfer ~25 g into the airtight container. Record the total weight of the bottom of the container and soil sample combined, to the nearest 0.1 grams.

3. Using a pipette, transfer 20 mL of 1M NaOH solution into a beaker.

4. Place the beaker containing NaOH into the airtight container with soil. The container must be tall enough to allow airspace above the NaOH beaker when the container is sealed. Be careful not to spill any NaOH.

5. Tightly seal the airtight container. Record the date, time, and temperature.

6. Store airtight containers with soil and NaOH at room temperature (20-30°C) or warmer if possible. Provide a constant warm temperature. A sunny windowsill is not appropriate because it will get hot during the day and cold at night. An incubator set at 37°C is ideal.

7. Allow the soil samples to incubate for 24-48 hours.

### Part 3: Titrating

1. Record the date and time the incubation ended.

2. Open the airtight container only when you are ready to titrate. Add 2 mL of 1M $SrCl_2$ to the NaOH solution. A white precipitate should form.

3. Add 2-3 drops of phenolphthalein indicator to the NaOH solution. The phenolphthalein should cause the solution to turn pink.

4. Fill the buret with 1M HCl and zero it. Titrate very slowly with the acid until the NaOH solution begins to become clear. Frequently swirl or use the magnetic stirrer to mix the solution while adding acid.

5. As the endpoint gets closer, add HCl one drop at a time, mixing thoroughly between drops. The endpoint has been reached when the solution turns from pink to clear. The greater the amount of $CO_2$ that has been released from the soil and has reacted with the solution, the less acid it will take to reach the titration endpoint.

6. Record the molarity of HCl used (should be 1M) and the volume of HCl required to reach the endpoint (clear solution).

7. Calculate your results using Data Form 2: *Measuring Decomposition Using a Titration*.

# Data Form 1: Soil Moisture Content

Names of group members: ______________________________

Date: ________________________________________________

Soil sample ID number: ________________________________

Soil sample location: __________________________________

Soil sample depth: ____________________________________

Date sample was collected: _____________________________

**The steps below correspond to the procedural steps on the handout "Procedures for Determining Soil Moisture Content."**

Step 1: Describe the soil sample (e.g., number and size of rocks and roots in sample; color; wet or dry to the touch):

Step 2: Weight of beaker = __________ g

Step 3: Weight of beaker and soil = __________ g

Step 4: Wet weight of soil

| __________ | - | __________ | = | __________ g |
|---|---|---|---|---|
| combined wt of beaker and soil | | weight of beaker | | Wet weight of soil |

Step 5: Drying time in drying oven: ________________________________________

OR

Time and power level in microwave: ______________________________

Step 6: Dry weight of soil

| __________ | - | __________ | = | __________ g |
|---|---|---|---|---|
| combined wt of beaker and soil after drying | | weight of beaker | | Dry weight of soil |

Step 7: Moisture content

**Moisture content =** $\frac{\textbf{wet wt - dry wt}}{\textbf{wet wt}}$ **=** $\frac{\textbf{\_\_ g - \_\_ g}}{\textbf{\_\_ g}}$ **=** __________

x 100 = __________%

Step 8: If soil is in the 10-90% moisture range, proceed to titrating.

Step 9: If soil contains more than 90% water, continue drying process until moisture content is near 50%.

Step 10: If soil contains less than 10% moisture:

A. Total soil weight = __________ g

B. Actual water weight of full sample

| __________ | x | __________ | = | __________ g |
|---|---|---|---|---|
| total soil wt<br>of full sample | | moisture content<br>of subsample | | actual water wt<br>of full sample |

C. Dry weight of full sample

| __________ | - | __________ | = | __________ g |
|---|---|---|---|---|
| total soil wt<br>of full sample | | actual water wt<br>of full sample | | dry wt<br>of full sample |

D. Weight of water to be added

| __________ | - | __________ | = | __________ g |
|---|---|---|---|---|
| desired water wt | | actual water wt | | wt of water<br>to be added |

# Data Form 2: Measuring Decomposition Using Titration

Names of group members: ______________________

Date: ______________________

Soil sample ID number: ______________________

Soil sample location: ______________________

Soil sample depth: ______________________

Date sample was collected: ______________________

**1. Calculate dry weight of soil.**

| | | |
|---|---|---|
| Weight of container (without lid) | = | __________ g |
| Weight of container with soil | = | __________ g |
| **Total Soil Weight** | **=** | **__________ g** |

Use Total Soil Weight and % soil moisture (Step 7 of Determining Soil Moisture Content) to calculate dry weight of soil. Remember to use the fraction for moisture content, not the percentage.

| | | | | |
|---|---|---|---|---|
| __________ g<br>total soil wt | - | __________<br>(moisture content<br>x total soil wt) | = | __________ g<br>dry weight |

This answer will be in grams of dry soil. For use in the final equation, you need to convert it to kilograms:

| | | | | |
|---|---|---|---|---|
| __________ g<br>dry weight | x | 0.001 kg/g | = | _________ kg dry soil |

**2. Record the amount of time you used for the incubation.**

Date and time incubation began: ______________________________________

Date and time incubation ended (should be 24-48 hours): ______________________________

**Length of incubation period = __________ days**
*(e.g., 27 hours = 1.125 days)*

### 3. Calculate the $CO_2$ produced by soil samples and the amount present in the blank(s).

Molarity of HCl used in titration ___________________
*(This should be 1. If different, ask your teacher for help in altering the final $CO_2$ respiration equation.)*

Milliliters HCl used to titrate sample ___________________

Milliliters HCl used to titrate blank ___________________
*(If you used more than one blank, determine the average.)*

$CO_2$ produced:

| | | | | | | |
|---|---|---|---|---|---|---|
| (________mL | - | ________mL) | x | 22* | = | __________ mg |
| HCl used to titrate blank | | HCl used to titrate sample | | | | **$CO_2$ produced** |

### 4. Calculate the $CO_2$ production rate.

The $CO_2$ production rate is the rate of $CO_2$ produced in milligrams $CO_2$ per day per kilogram of dry soil. Use the kg dry soil from step 1, number of days incubation from step 2, and mg $CO_2$ from step 3 above.

$$CO_2 \text{ production rate} = \frac{[(CO_2 \text{ produced in milligrams})/(\# \text{ of days incubated})]}{(\text{kilograms dry soil})}$$

$$= \text{\_\_\_\_\_\_\_\_\_\_} \ (\text{mg } CO_2/\text{day}) / \text{kg dry soil}$$

* You may wonder why there is a "22" in the equation. It is necessary to convert from milliliters HCl into milligrams $CO_2$ as shown in the following equation:

$$(HCl_{blank} - HCl_{sample}) \times 22 = (HCl_{blank} - HCl_{sample}) \times \frac{1 \text{ liter}}{1000 \text{ mL}} \times \frac{1 \text{ mol HCl}}{\text{liter}} \times \frac{44 \text{ g } CO_2}{\text{mol } CO_2} \times \frac{1 \text{ mol } CO_2}{2 \text{ mol HCl}} \times \frac{1000 \text{ mg}}{\text{g}}$$