ENERGY FLOW IN AN ALASKA WETLAND

(MODIFIED FOR ADEED)

Overview:

Students play a board game illustrating energy flow.

Objectives:

The student will:

- constructing wetland food webs; and
- trace energy flow through the system.

Targeted Alaska Grade Level Expectations:

Science

[7-8] SC3.2 The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by classifying organisms within a food web as producers, consumers, or decomposers.

[6] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

Vocabulary:

carnivores – animals that eats other animals

consumers – a living thing that can only survive by consuming other plants, animals, or organisms

decomposers – a living thing that survives by breaking down dead organisms and returning the nutrients in their body to the ecological cycle

detritivores – organisms that eat dead or decaying material

energy – the force that drives the ecological cycle and makes life on Earth possible, made possible by the ability of plants to harness the energy of the sun through photosynthesis

food chain – a community of organisms where each member is eaten in turn by another member

food web – the energy circulatory system of an ecosystem

herbivores – organisms that eat plants

photosynthesis – the ability of plants to turn sunlight, carbon dioxide, and water into energy

producers – a plant or organism that produces energy from non-living things, such as sunlight

Materials:

- One die (per group)
- Markers
- Scratch paper or calculator (one per group)
- TEMPLATE: “Energy Flow in an Alaska Wetland Board Game” rules, and Energy Use Charts
- TEMPLATE: “Energy Flow in an Alaska Wetland Board Game Rules”
- TEMPLATE: “Energy Flow in an Alaska Wetland Energy Use Charts”
- STUDENT INFORMATION SHEET: “Alaska Wetland Ecology Ecology Cards”

Activity Procedure:

1. Post the TEMPLATE: “Energy Flow in an Alaska Wetland Board Game” where the students can see it as you introduce the game.
2. Discuss the concepts of producers, consumers, and decomposers. Have the students identify which of the plants and animals on the poster fit into each category.

3. Discuss with the students how organisms at each stage of the wetland food chain are able to store only 10% of the energy available. *Animals are generally not efficient at eating all the food available to them. If they were, plants would soon be scarce, and animals more scarce! Animals must use energy when they move, sense and respond to the environment, grow, and reproduce. Also, not all of the food consumed can be digested and stored; some is excreted as waste products.*
4. Discuss with the students how even though the energy is not used, it is not wasted. *The energy that is not captured by plants remains in the form of light and heat, but is mostly lost to the living system. Some of the energy lost as waste products in each link of the chain can be used by detritivores and plants. Many plants and animals die without being eaten, but this stored energy is also recycled by the decomposers. Wetland food webs often have much more energy flowing through the detrital food chains and webs than through the webs composed of producers and consumers. Still, the energy stored in the living system constantly decreases and much cannot be recaptured.*
5. Discuss how these energy facts at each link of the food chain limit the number of living things that can exist. *Carnivores are less numerous than herbivores, etc.*
6. Divide the class into four groups and distribute the Ecology Cards, as follows:

   Group #1: Freshwater marsh: bacteria, green algae, water smartweed, water flea, mosquito, dragonfly, wood frog, sandhill crane, grayling, arctic fox, human.

   Group #2: Bog: bacteria, sedge, black spruce, sphagnum moss, muskrat, mosquito, bladderwort, little brown bat, human.

   Group #3: Riparian wetland: black fly larvae, willows, moose, horsetails, Eskimo potato, springtails, shrews, wolverine, wolf, brown bear, human.

   Group #4: Coastal wetland: amphipod, bacteria, eelgrass, arrowgrasses, black brant, Canada goose, bald eagle, pink salmon, brown bear, human.
7. Have students in each group take turns reading aloud the portions of their card "Food" and "Eaten by." The group will then work together to diagram the food chain connections among the organisms. Post these diagrams next to the posted board game.
8. Play the "Energy Flow in an Alaska Wetland" game. For large classes, small groups can each represent one player and be responsible for making the calculations for each move.

Extension Ideas:

1. Students write a short story from the viewpoint of a unit of energy moving through a wetland food web.
2. Students research ecology books to determine if other types of ecosystems (for example, forests, grasslands, savannahs, oceans) do a "better job" than wetlands of capturing and storing the sun's energy. (Consider this: can producers capture more than 3% and consumers store more than 10%?) They can also research comparisons between colder areas nearer the poles and warmer areas nearer the equator.

Evaluation:

After playing the game, discuss the following:

1. In your own words, tell what a food web is.
2. What happens to most of the sun's energy that reaches a wetland?
3. Tell why or why not you agree or disagree with the statement: "A wetland is not a productive area because so much energy is wasted in the food web."
4. How can you explain the fact that organisms at the end of the food chain get the least amount of energy? Doesn't that mean that they are all going to starve to death?

This lesson adapted with permission from Alaska Department of Fish and Wildlife's *Alaska's Wetlands and Wildlife* curriculum. (2007).

ENERGY FLOW IN AN ALASKA WETLAND BOARD GAME RULES

TEMPLATE

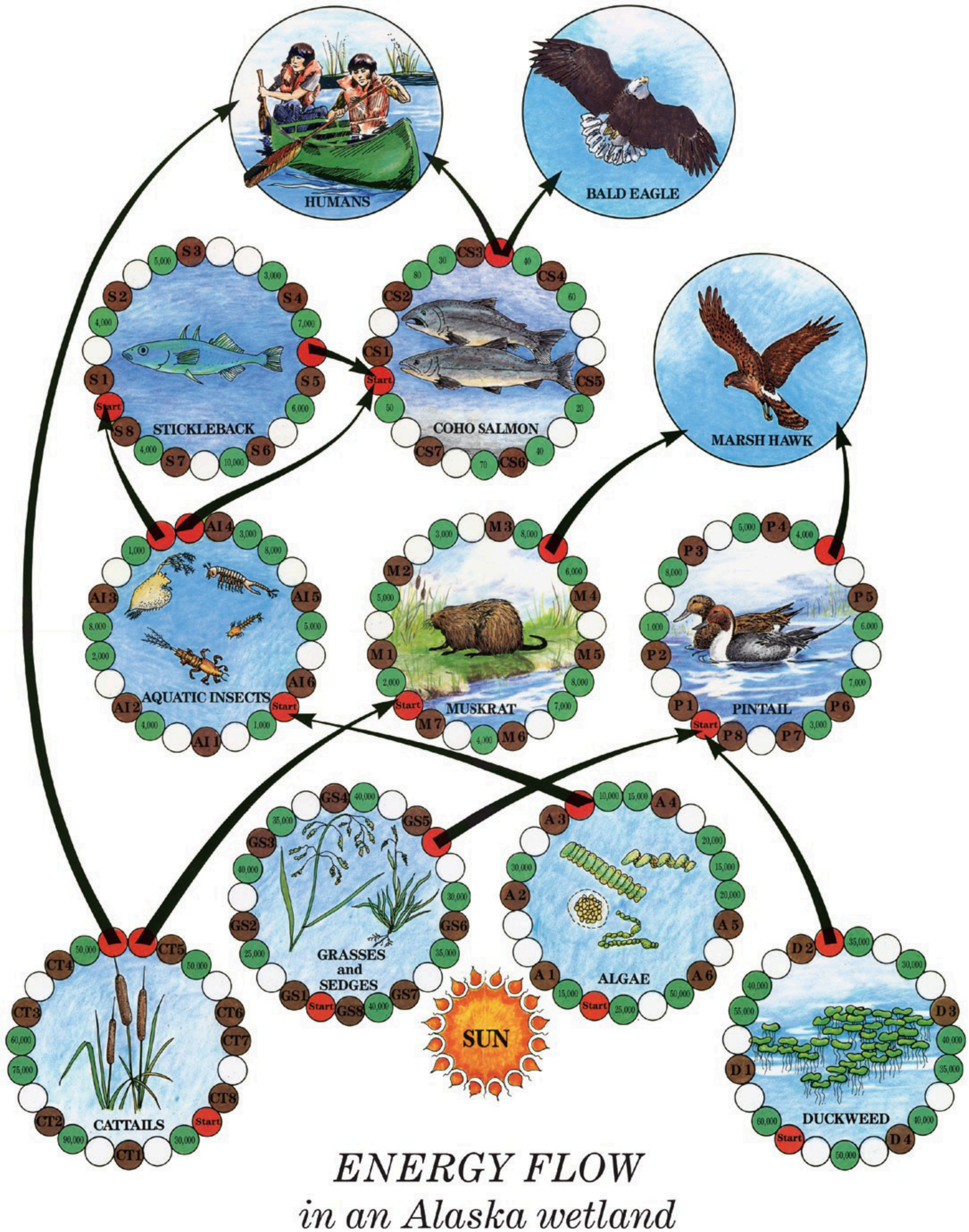
The winner of this game is the one who gets to the top of the food chain (where he or she is eaten by the marsh hawk, bald eagle, or human being) with the greatest number of calories left. A player can quickly exhaust the calories allotted as he or she meets calorie-consuming situations and events in the lives of organisms on the food chain. Merely staying alive uses up energy (in the form of respiration).

The game has been designed to illustrate the complexity of a wetland ecosystem, the interdependence of living things, and the importance of the sun's energy in making the ecosystem work. The calorie counts for a given situation are estimates and have been calculated to make events in the game as realistic as possible. However, they should not be considered complete and accurate measures of all energy consumed.

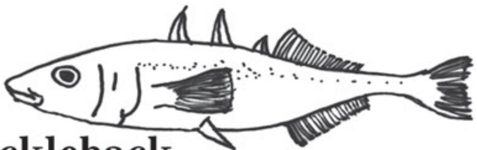
The materials you will need for this game are:
1. The Energy Flow in an Alaska Wetland Poster Game
2. The Energy Use Charts
3. A die

Rules:

1. Two to six can play at once.
2. Each player places a marker on the sun and starts the game with solar energy equal to 10,000,000 calories.
3. Players move in turn on the throw of a die. Each player follows a sunbeam to a plant (orange start circle).
4. When moving from the sun to a plant, players lose 97 percent of their energy, so they must subtract 9,700,000 calories from the 10,000,000 with which they started the game. Players are thus left with 300,000 calories, or 3 percent of their initial energy.
5. Players advance through the food web with each roll of the die, moving as many spaces as the die indicates.
6. Players landing on green spaces must pay the respiration tax indicated on the circle. For example, if a player with 150,000 calories lands on a green space marked 15,000, the player must give up 15,000 calories. The player would then have 135,000 calories remaining.
7. When a player lands on a tan space, he or she must check the Energy Use Chart to find out what energy-consuming event has occurred and how many calories it has used. For example, CT 1 (meaning cattail space #1 on the chart) reads "fungus infection on leaves, use 100,000 calories". This means that the organism has contracted a fungus infection, and any player landing on CT 1 must subtract 100,000 calories from his or her supply.
8. When a player lands on a white space, no calories are lost.
9. When a player lands on an orange space, which allows him or her to move from one organism to another, the player becomes food for the new organism. Whenever that happens, 90% of the player's remaining calories must be surrendered. (A player keep 10%). Percentages can be figured on the scratch paper or with a calculator.
10. Players enter a new organism on its start orange circle. A player must stop on the circle; give up the 90% described in Rule 9, and wait until the next turn before advancing through the organisms.
11. A player who uses all of his or her calories before reaching the top of the food chain (the marsh hawk, bald eagle, or human being) has burned out and is no longer in the game.
12. The player reaching the marsh hawk, bald eagle, or the human being with the most calories remaining is the winner. If every player burns out, there is no winner.


HUMANS
BALD EAGLE
STICKLEBACK
COHO SALMON
MARSH HAWK
AQUATIC INSECTS
MUSKRAT
PINTAIL
GRASSES and SEDGES
ALGAE
CATTAILS
DUCKWEED
SUN
ENERGY FLOW
in an Alaska wetland

Energy Use Chart



Stickleback

S 1 Courtship ceremony.
Use 800 calories.

S 2 Migrate by stream to lake.
Use 600 calories.

S 3 Develop infection of scales.
Use 500 calories.

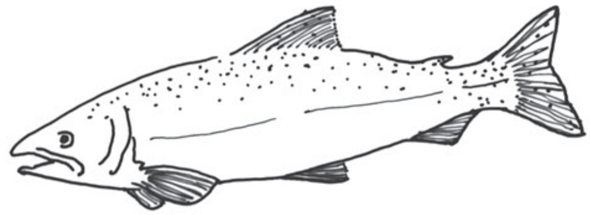
S 4 Produce eggs.
Use 350 calories.

S 5 Population explosion. Heavy competition for food.
Use 500 calories.

S 6 Fin torn. Repair tissue.
Use 600 calories.

S 7 Hot spell increases water temperature. Metabolism increases.
Use 400 calories.

S 8 Narrowly escapes attack by coho salmon by swimming rapidly.
Use 300 calories.



Coho Salmon

CS 1 Gill disease.
Use 85 calories.

CS 2 Chase other males from territory.
Use 60 calories.

CS 3 Migrate upstream.
Use 100 calories.

CS 4 Hooked by fisherman but broke his line.
Use 10 calories.

CS 5 Swim up wrong tributary stream, must return.
Use 50 calories.

CS 6 Chased by brown bear.
Use 40 calories.

CS 7 Stressed by crowding during migration.
Use 40 calories.

Aquatic Insects

AI 1 Grow new exoskeleton.
Use 5,000 calories.

AI 2 Bacterial disease.
Use 3,000 calories.

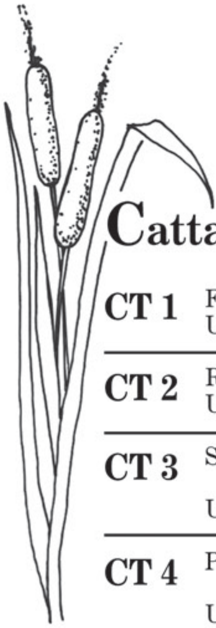
AI 3 Change into adult insect.
Use 2,500 calories.

AI 4 Repair wounds to body.
Use 2,000 calories.

AI 5 Chased by stickleback.
Use 1,500 calories.

AI 6 Time to lay eggs.
Use 3,500 calories.

Energy Use Chart



Cattail

CT 1 Fungus infection on leaves.
Use 100,000 calories.

CT 2 Replace tissues eaten by moose.
Use 60,000 calories.

CT 3 Seawater floods marsh destroying much tissue.
Use 60,000 calories.

CT 4 Produce new plants by underground buds.
Use 50,000 calories.

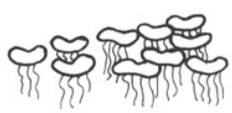
CT 5 Humans gather underground stems for food, throwing away leaves and flowers.
Use 40,000 calories.

CT 6 Chemicals seep into marsh causing abnormal growth.
Use 25,000 calories.

CT 7 Spring fire damages new growth.
Use 10,000 calories.

CT 8 Burrowing mammal destroy roots.
Use 50,000 calories.

Duckweed



D 1 Fertilizers seep into marsh causing abnormal growth.
Use 50,000 calories.

D 2 Shaded by shrub.
Use 30,000 calories.

D 3 Attacked by fungus.
Use 25,000 calories.

D 4 Repair damaged tissue shredded by propeller.
Use 20,000 calories.

Grasses and Sedges

GS 1 Drought dries out ground around roots.
Use 25,000 calories.

GS 2 Produce seeds.
Use 30,000 calories.

GS 3 Partially covered by road construction.
Use 35,000 calories.

GS 4 Shaded by taller growing cattails.
Use 20,000 calories.

GS 5 Storm floods marsh and covers leaves with water.
Use 25,000 calories.

GS 6 Fungus disease.
Use 30,000 calories.

GS 7 Underground stems trampled by animal trail.
Use 30,000 calories.

GS 8 Leaves used to build duck's nest.
Use 25,000 calories.

Algae

A 1 It's time to reproduce.
Use 40,000 calories.

A 2 Repair tissue damage caused by storm.
Use 30,000 calories.

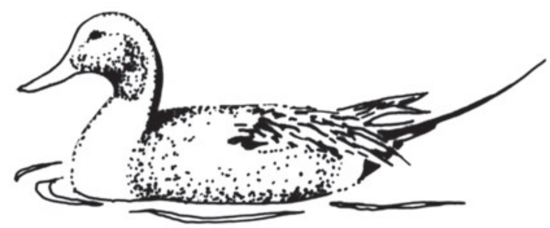
A 3 Mold grows into tissues and takes food.
Use 20,000 calories.

A 4 Sewage spill stimulates abnormal growth.
Use 10,000 calories.

A 5 Viral infection.
Use 40,000 calories.

A 6 Water becomes deep. Grow longer branches.
Use 60,000 calories.

Energy Use Chart



Muskrat

M 1. Produce and nurse two offspring.
Use 7,000 calories.

M 2 Shed winter coat.
Use 7,000 calories.

M 3 Grow winter coat.
Use 6,000 calories.

M 4 Build house on bank of stream.
Use 5,000 calories.

M 5 Attacked by marsh hawk. Dive and swim to safety.
Use 5,000 calories.

M 6 Population explosion. Battle for territory.
Use 3,000 calories.

M 7 Late summer fire destroys habitat. Move to new location.
Use 3,000 calories.

Pintail

P 1 Habitat destroyed. Migrate 100 miles.
Use 3,000 calories.

P 2 Viral infection with high fever.
Use 2,500 calories.

P 3 Replace lost feathers.
Use 2,000 calories.

P 4 Overpopulation. Heavy competition for food.
Use 7,000 calories.

P 5 Build nest.
Use 6,000 calories.

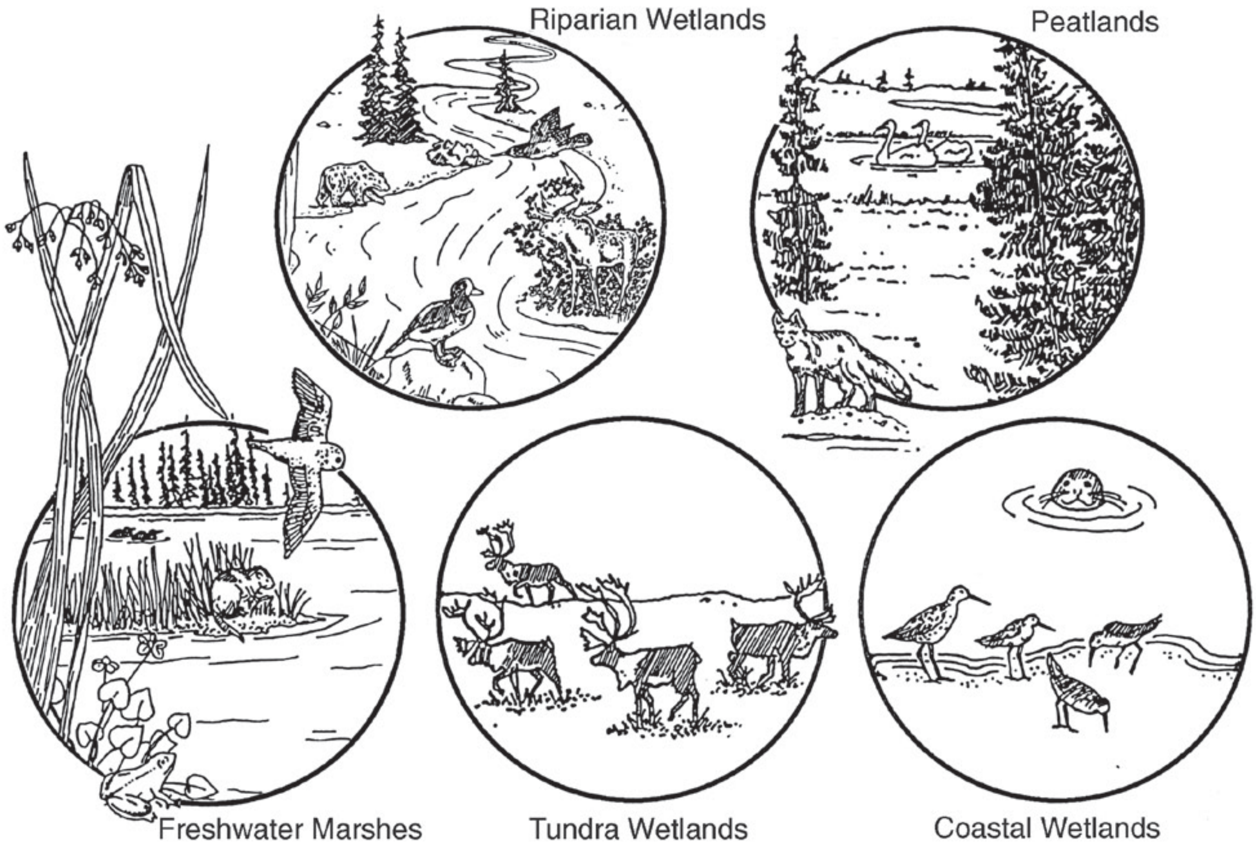
P 6 Courtship ceremony.
Use 5,500 calories.

P 7 Search for new food supply.
Use 5,000 calories.

P 8 Predator attack. Defend nest.
Use 5,500 calories.

PROFILES OF ALASKA'S WETLANDS:

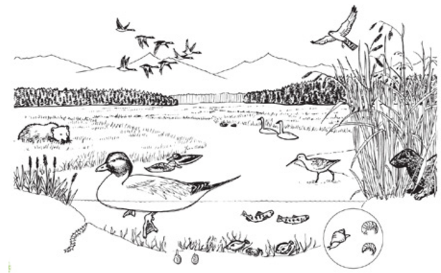
Wetlands have been classified in many different ways, as there is such a broad range of sizes and habitat types. This curriculum emphasizes five distinct types of wetlands: coastal wetlands, freshwater marshes, riparian wetlands, peatlands, and tundra. Within each of these broad classifications, there are often several different habitat types.



COASTAL WETLANDS

Key Characteristics:

1. Water is saline or brackish (a mix of both salt water and fresh water).
2. Nutrients are abundant due to tidal mixing.
3. The habitat is often very important or crucial for migratory birds and juvenile fish.
4. Vegetation is salt tolerant.
5. Habitat types include salt marshes, mudflats, and eelgrass beds; land formations include estuaries, lagoon/barrier island and lagoon/spit systems.



Extremely productive

Vegetated saltwater wetlands along Alaska's coast are extremely productive "edge" areas where nutrients from the land flow down to the sea and nutrients from the sea are brought inland by the tides. Many are important feeding, resting, and nesting habitats for astonishing numbers of migratory birds. These wetlands are also the nursery for many juvenile fish and invertebrates such as salmon fry, bottomfish, crabs, and shrimp.

A small portion is vegetation

Although Alaska has approximately 2.1 million acres of coastal wetlands, only about 17% of those are vegetated. Much of Alaska's share of vegetated coastal wetlands is mud flats; a small percentage are salt marshes. Salt marshes are the only type of coastal wetland to be considered a true wetland according to the Clear Water Act Guidelines.

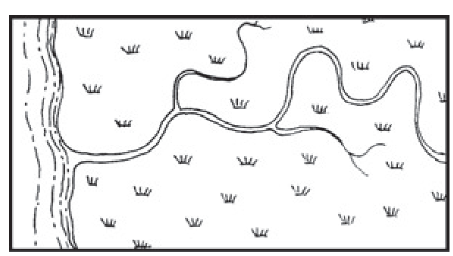
COASTAL WETLAND HABITAT TYPES

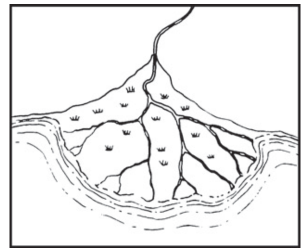
Salt marshes are in areas where protection from harsh wave action allows **halophytic** (prefers or tolerant of salt water) vegetation to grow. The soil is typically fine clay mixed with **humus** (decayed organic matter). Extensive stands of sea grasses and salt-tolerant sedges provide staging areas for migrating swans, geese, and other waterbirds. Salt marshes also help to protect ocean shores from erosion. Nearly half of Alaska's salt marsh habitat is along the coastline of western Alaska.

Mud flats are not well known as important habitat, as most of the fauna that live there are not visible, but reside below the surface of the flats. However, a rich diversity of invertebrates including many types of clams and worms provides critical food for shorebirds, diving and dabbling ducks, flatfish, juvenile salmon, and marine invertebrate predators. Vegetation is limited in mudflat wetlands, however microscopic phytoplankton live on and between the grains of sand and mud, and larger algae like sea lettuce grow on the surface.

Eelgrass beds grow completely submerged in shallow protected coastal areas. Alaska's Izembek Lagoon shelters one of the largest eelgrass beds in the world. Eelgrass is a flowering plant that provides essential food and shelter for a vast array of invertebrates, fish and other wildlife. Eelgrass survival is dependent upon adequate light availability, therefore it is easily impacted by human activities that stir up the water and increase water **turbidity** (cloudiness).

Estuaries are areas where streams and rivers meet the sea, fresh and salt water mingle, and nutrients dissolved in the shallow water column are shunted back and forth by tidal action. The constant flows of fresh and seawater circulate nutrients several times daily, making estuaries some of the most biologically rich areas in the state.



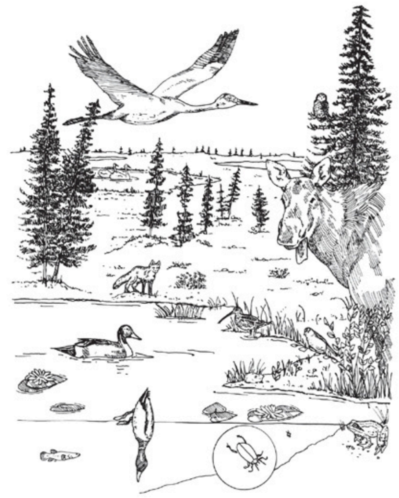


Deltas are a type of estuary where flat coastal topography allows the river to slow down so much that sediment drops out into a characteristic deposit, often dividing the river channel into a maze of multiple channels. More than 20 million shorebirds, including the entire world population of western sandpipers and most of the red knots and dunlin in North America, stop to rest and feed in the Copper River Delta. The Yukon-Kuskokwim Delta is the nesting grounds for nearly 2 million waterfowl and an estimated 100 million shorebirds.

Shallow lagoons are wetland areas hidden behind spits or barrier islands that blunt the force of icy winds, rough seas, or in the north – harsh scouring action of pack ice. Because they are protected, lagoons often permit the development of salt marshes. In summer, lagoons are relatively warm and brackish and support dense concentrations of fish close to the shore.

Nearly all of the Pacific Coast population of black brant stop to rest and feed at Izembek Lagoon before making a nonstop flight across the Gulf of Alaska and Pacific Ocean to the West Coast and Mexico. Nearly the entire world population of Steller's eiders and emperor geese in Alaska Peninsula lagoons during fall; many of these birds remain in Alaska throughout the winter.

PEATLANDS



Key Characteristics:

1. Two major types are bogs and fens.
2. Decomposition is slow and incomplete, resulting in a buildup of dead and partially decayed plants called peat.
3. Drainage is slow or lacking.
4. Water and soils are usually cold; in bogs they are acidic, and nutrient deficient.
5. In bogs, sphagnum moss is a dominant plant, often growing very thick. Other plants are adapted to growth in acidic, nutrient deficient and waterlogged conditions.

Mucky wetlands

If you've spent time in the boreal forest, you've probably visited a peatland before, but perhaps did not realize you were in wetland, at least not in time to prevent your boots and socks from becoming soaked in black muck. Those mucky open space, surrounded by thick brown moss, a few shrubs and perhaps a "drunken" tree or two, are peatlands.

Peatlands are commonly called muskeg, an old Algonquian term referring to a soggy bog. However, the term can be confusing, as it has been used for many different types of habitats. Alaska has about 127 million acres of peatlands, roughly 75% of all Alaska's inland wetlands.

Two types

Two major types of peatlands are **bogs** and **fens**. Bogs are distinguished by a lush growth of moss (usually sphagnum) and thick, organic, acidic soils. The water source in bogs is mainly precipitation. **Fens** are complexes of groundwater-influenced linked channels that usually receive some drainage.

Not much drainage

Peatlands form in places where drainage is slow or scarcely existent and soil and water temperatures are low. They often form when ponds and lakes are covered by floating plants and eventually become filled in by accumulating dead plant materials.

Peat buildup

Unlike other wetlands, where decomposition and export of dead plants is rapid, cold, acidic and nutrient poor conditions in bogs and fens result in the slow build-up of **peat**. In Interior and northern Alaska, cool temperature are the main factor that slows decomposition and results in peat buildup, whereas in southeastern Alaska, a wet climate that waterlogs soils and restricts oxygen is the primary factor for peatland formation. Thick layers of peat and surface mosses insulate the soil, causing further cooling, and preventing thawing of permafrost.

Mosses rule

Mosses found in bogs influence what else can or cannot grow there. Certain peat mosses facilitate waterlogged conditions due to their ability to hold 200 times their weight in water – similar to a sponge. Leaf-like projections on the small moss stems contain gas-filled cells that fill with water. If they are not already saturated, mosses can also wick up groundwater. Peat mosses also release acids, creating conditions intolerable to decomposing bacteria and many plants.

Tough plants

Plants that can tolerate these difficult conditions include health plants like the pungent Labrador tea (*Ledum palustre)*, bog blueberry *(Vaccinium uliginosum*), bog rosemary *(Andromeda polifolia)*, and Tamarack *(Larix laricina)* (also called Larch). Insectivorous plants, such as the Sundew (*Drosera rotundifolia)* thrive in the low-nutrient soils because they are able to gain nutrients from insects. Black spruce trees *(Picea mariana*) are the dominant tree, but lodgepole pines sometimes inhabit peatlands in southeastern Alaska.

Wildlife vary

Bogs are generally areas of low productivity; meaning food for wildlife is not as abundant as in other wetland areas. The acidic water that slows decomposition and cycling of nutrients also inhibits growth of algae and bacteria, which are essentially the bottom of the food chain. However, peatlands are important for different wildlife species during all seasons. Insectivorous birds like songbirds, raptors like the harrier, and grazing birds like swans all use peatlands as feeding areas. Wood frogs use bogs and fens for breeding and depositing their eggs. Aquatic or semi-aquatic mammals such as beavers, mink, and otter often find their preferred foods in these wetlands. Moose browse on willows, as well as on the mineral-rich submerged vegetation.

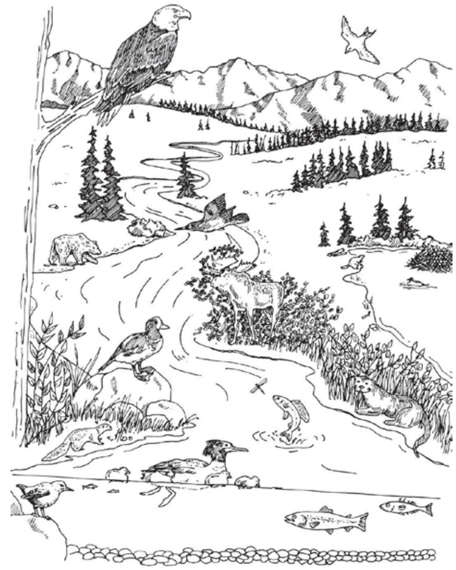
Important open areas

Fens serve as important open areas in forests beacuse they are either treeless or support only scattered, stunted trees. Open areas are valuable for different wildlife species during different seasons. In fall, deer and moose use these wetlands for courting. During sring and summer, the open areas provide room for birds to engage in aerial displays. Hawks and owls find good vantage points along the edges of such areas, where they can be ready to dive toward lemmings and voles that may venture out of mossy nests.

RIPARIAN WETLANDS

Key Characteristics:

1. Rivers of streams are the major influence.
2. Nutrients are moved downstream by way of channeled flows.
3. Water levels change in response to precipitation, freeze-up and break-up.
4. Plant and animals are distributed in zones relative to the distance from main channels.
5. Fish and wildlife use them as important movement corridors.



River Connection

The **riparian zone** refers to the ecosystem bordering streams and rivers. Riparian wetlands include ponds, abandon stream channels called oxbow lakes, and gravel bars with tall willow stands. Riparian wetlands are created by seasonal flooding of the adjacent river, or a shallow groundwater or other hydrological connection to the main channel.

Nutritious floods

Ice formation, ice cover, break-up, and alternating storms and dry periods bring periods of flooding to the riparian zone. Such flooding nourishes riparian wetlands when the rich load of organic debris and nutrients overflows stream banks. In fact, the frequency with which riparian wetlands are connected to stream or river systems in one of the key factors determining the amount of food available for fish and birds. When the river is not flooding, riparian wetlands may drain back into streams, returning nutrients that are eventually carried into estuaries.

A Good Home

Shrubby riparian wetlands with stands of willows, birches, and alders are important to Alaska's wildlife. Many types of songbirds nest or feed in floodplain willow stands during the summer. Willows are also a primary food for moose during both summer and winter. Silt deposited during flooding is a rich substrate for showy flowering plants such as River Beauty (*Chamerion latifolium*), and favorite bear foods like Eskimo Potato *(Hedysarum alpinum)* and Soapberry *(Shepherdia canadensis)*

Food for Fish

Many types of fish rely indirectly on riparian areas for food because decomposing leaves from shrubs and plants is an important energy source for the aquatic invertibrates that fish eat. Decaying salmon carcasses in turn provide valuable marine-derived nutrients to the riparian area.

FRESHWATER MARSHES

Key Characteristics:

1. Shallow waters
2. Soft-stemmed vegetation emerges (stems, leaves and/or flowers stick out) from the water (emergent vegetation).
3. The soil bottom is made up of a high concentration of organic materials and is rich in materials.

Shallow Basins

Freshwater marshes exist where water collects in shallow depressions, created as a result of a variety of geological processes. For example, glaciers gouge holes as they flow over bedrock, and when glaciers recede, these holes are exposed. Freezing and thawing in permafrost soils creates basics when ice formed polygons subside. Where soil conditions allow, these holes and basins collect and hold water either from precipitation, groundwater, or nearby lakes and streams. The movement of rivers over time also leaves behind abandoned channels called oxbow lakes, which develop into marshes as they fill in.

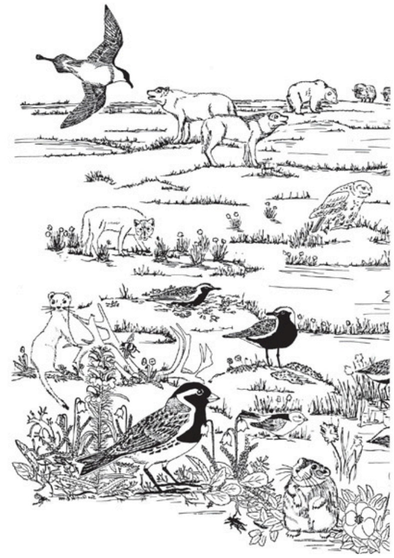
Vegetation Emerges!

A major characteristic of freshwater marshes is emergent vegetation such as cattails (*Typha* spp), Yellow pond lily (*Nuphar polysepalum*), Five-fingered cinquefoil (*Potentilla palustris*), horsetails (*Equisetum* sp) and sedges. Many of the plants have adaptations to life in shallow water including floating leaves and flowers; entire plants that float; "emergent" growth forms that allow the plant to live with roots submerged and stems partially covered by water; and abilities to carry on photosynthesis while being totally submerged.

Wildlife uses

Freshwater marshes support a wide array of plants, invertebrates, and wildlife. Emergent vegetation provides food and cover for invertebrates and fish such as grayling and sticklebacks. Larger fish forage on aquatic invertebrates and terrestrial insects that drop from plants into the water. Many species of loons, diving ducks, and other waterbirds nest in or near lakes, ponds, and marshes, using the plants for nesting materials and for cover at the first hint of trouble.

TUNDRA WETLANDS



Key Characteristics:

1. Short and challenging growing season, due to a severe cold and persistent wind.
2. Trees are absent.
3. Elevation is most important factor determining where plants grow.
4. Some are extremely productive during the thaw period, providing good habitat for migratory water birds and some mammals (for example, lemmings)

Cold and flat

Tundra dominations in western and northern portions of Alaska where flat or gently sloping areas have poor drainage and are often underlain by permafrost. Large portions of these tundra areas are wetlands. Tundra is also found in alpine areas statewide, but only a small portion of alpine tundra is wet enough to be considered a wetland. Most of lowland tundra remains wet or moist throughout the short season of thaw because water cannot seep through the permafrost and instead flows slowly over flat ground. Slow decomposition also results in peat deposits in some lowland tundra.

Landform medely

Tundra is a mosaic of many different landforms and plant communities. On a micro level, elevation is an important factor determining where different plants can grow because it affects the degree of wetness of an area. Often completely different plant communities are separated by only a few inches in height. The wettest tundra areas typically have shallow standing water throughout the summer. Sedges and related plants such as cottongrass (*Eriophorum* spp.) thrive in this type of environment.

In somewhat drier patches, such as gravel bars, river banks, hummocks, and tops of ice-wedge polygons, surface waters drain by late summer. The drier conditions allow grasses and dwarf willows to become established, as well as tiny saxifrages and other flowers like mountain avens (*Dryas* spp.) and poppies. If conditions are dry enough, tussock-forming cottongrasses (e.g. *Eriophorum vaginatum*) may create their own mini-uplands. The tussocks may be only several inches higher than the surrounding tundra, but the height is enough to provide a dry roothold for dwarf and shrub birches (*Betula glandulosa/nana*), Labrador tea *(Ledum palustre*), lichens, and many berry-producing plants such as lingonberry (*Vaccinium vittis-idaea)* and cloudberry (*Rubus chamaemorus*).

Abundant food

Some tundra wetland areas are very productive during the brief arctic summer. Migrations of millions of shorebirds, waterfowl, and other water birds return to the tundra to nest from wintering grounds as far south as Antarctica and South America. In general, densities of nesting water birds are higher closer to the coast. Other wildlife like caribou also find abundant food near tundra wetlands. Lemmings graze green growth and stockpile "haystacks" for the coming winter. Grizzly bears, arctic foxes, jaegers, and snowy owls roam the tundra searching for small mammals, or bird eggs and nestlings to eat.

In winter some move on

After the brief summer ends, many fish and birds migrate to more southern areas, while polar bears and arctic foxes head north with the ice pack. Brown bears dig dens, and arctic ground squirrels dig burrows and then sleep away the long winter. Insect larvae go dormant and fish find deep, spring-fed holes in rivers. Still, some wildlife are adapted to the harsh winter conditions. Lemmings and voles, muskoxen, ptarmigan, ravens, and caribou remain active year-round.

WATERBIRDS

Waterbirds are those species found around fresh water or salt water. These birds get their food from the water and can be found in Alaska wetlands. Examples of waterbirds include waterfowl, shorebirds, loons, grebes, gulls, terns, cranes, and herons.

Waterfowl. Ducks, geese, and swans together are called waterfowl. The world's 145 waterfowl species are all web-footed swimming birds, and along the edges of their broad bills, they all have a row of tooth-like serrations that they use to tear vegetation, grasp small fishes, or strain edible plants from pond water. All have downy young that unlike the naked, helpless young of most other birds, are able to see, walk, eat, and run within hours of hatching.

Divisions. Waterfowl can be divided into two groups: ducks, and geese and swans. The duck group can be further sub-divided into diving ducks or "divers" and puddle ducks or "dabblers".

Some differences:

Geese and swans mate for life; they molt (replace their feathers) only once a year; and the male guards the nest and helps the female care for the young. They are adapted for walking on land and for grazing on vegetation. Ducks on the other hand mate only for a single season, each year going through elaborate courtship rituals. The male leaves the female once she begins to sit on the eggs and thereafter has nothing to do with her or her young.

Diving ducks dive for clams, insects, crustaceans, fish, and deep plants. Most nest at or over water, preferring large marshes and lakes. Some divers can go down to 150 feet. When they take off from the water, their short pointed wings require that they build up speed in a long pattering run along the water surface (loons and grebes also take off this way). Diving ducks that nest in Alaska include the bay ducks, also known as inland divers (canvasback, redhead, ring-necked duck, and scaup), and sea ducks (eiders, scoters, long-tailed ducks, harlequin ducks, goldeneyes, bufflehead, and mergansers).

Dabbling ducks feed on insects and crustaceans on the surface of the water by walking through the water. They also feed on bottom-dwelling animals and plants by "tipping up" so that only their bottom and wagging tail can be seen in areas of shallow water. Because their broad wings allow them to fly quickly off the water when taking off, they can nest and feed on small ponds (hence the nickname "puddle ducks"). Mallards, pintails, green-winged teal, American wigeon, gadwalls, and northern shovelers are dabbling ducks that migrate through and breed in Alaska (the mallard is the most common duck in North America).

Loons are striking birds with black and white spots and stripes. They sit low in the water and often sink straight down like a submarine. Young loons are carried right on their mothers' backs. In flight, loons hold their heads lower than their body. Webbed feet and sharply pointed bills are other characteristics of this excellent diver that feeds on fish or aquatic invertebrates. All five species of loons found in North America use Alaska's wetlands and coastal waters for nesting, brood-rearing, and wintering. Breeding is most likely to occur on waters that are relatively free of human disturbance.

Grebes have long, skinny necks and are smaller than loons. Instead of having webbed toes, grebes' toes are lobed. Like loons, grebes carry their young on their backs. Unlike loons, grebes dive forward, rather than sinking. Both red-necked grebes and horned grebes can be seen swimming and diving in Alaska's freshwater lakes, ponds, and slow-moving rivers. Western and pied-billed grebes can be found in southeast Alaska during autumn and winter.

Shorebirds and waders. Shorebirds, in general, have long legs for wading, short tails, and sharp, pointed wings such as falcons and other fast flyers. Dowitchers, godwits, plovers, turnstones, sandpipers, curlews, snipe, phalaropes, and yellowlegs are among the many whirling flocks that migrate through Alaska. They stage in areas like the Copper River Delta by the millions.

Some shorebirds are upland birds in the sense that they feed and nest in drier areas away from wetlands; but as a group these birds are among the most abundant users of Alaska wetlands, where they find food, stage along their migration route, or nest. Some shorebird species, such as the bristle-thighed curlew, the black turnstone, and the western sandpiper, nest only in Alaska wetlands.

Seabirds. A wide variety of birds fit into the category of "seabird", which include gulls, terns, and cormorants. In general seabirds have webbed feet, and their bills are sharp for snatching up fish and invertebrates. Several seabirds spend the summer in inland wetlands, although a larger variety of seabirds nest on the coast or on islands. Many seabirds spend most of the year (September through April) along the coast or at sea.

Natural fluctuations. Populations of waterbirds naturally fluctuate in response to climatic conditions, ecological factors (habitat conditions and predators), and the effects of human actions. Many waterbird species that occur in Alaska are still abundant, but some populations have shown downward trends recently and others over the long term.

Who's stable? Examples of populations of species that appear to be healthy in most areas are gulls, swans, snow geese, dabbling ducks, and sandhill cranes. Examples of species that have experienced some decline in the past but have since increased include cackling and white-fronted geese in western Alaska, and the Aleutian goose. (The Aleutian Canada goose population was as low as 800 birds in 1967 but now is over 80,000 birds and has been removed from the endangered species list). Examples of species that appear to be diminished or declining are the emperor goose, the dusky Canada goose, most sea duck species (eiders, scoters, long-tailed ducks), and most shorebirds. Among the species that are officially listed as **threatened or endangered** are the Eskimo curlew, spectacled eider, and Steller's eiders that breed in Alaska

Waterbird Migration

Migration is a mysterious topic. How do birds, fish, mammals, and insects travel such immense distances with such exactness?

Some migratory animals travel at night, some during the day, some in the skies, some on land, and others deep within the sea. Unerringly, migrating animals locate their necessary habitats. Scientists have proposed that migrating animals use the stars, the sun, and even the Earth's magnetic field for guidance. Some animals such as salmon, use their sense of smell to guide them. Most migrating species probably use a combination of means to guide their journeys.

Geese migrate along flyways. Geese migrate in a Vee or cluster formation at about 50 mph. Their movement is steady and unhurried and closely follows the movements of the seasons. Geese migrate along four different flyways (Pacific, Central, Mississippi, and Atlantic), which are generalized migration pathways. Geese make their spring migration (south to north) from February to April. Fall migrations (north to south) occur from September to December. Some birds use only the Pacific Flyway while others cross or use all four North American Flyways. Although species' actual migrations do not strictly conform to these flyways, they are a useful way of generalizing migration routes.

Many migrate. There are a variety of remarkable migrating waterbirds in Alaska, including ducks, geese, swans, cranes, herons, gulls, terns, and shorebirds. Arctic terns make the longest journey, traveling all the way from Antarctica to Alaska to breed. Wetlands are important to all for both breeding and wintering. Additionally, wetlands are important stopover sites for food and rest during the long migrations.

Route study. Bird banding allows researchers to study the routes of migratory birds. Through recovery and sightings of bird bands, researchers can determine which flyways are being used, as well as how long migration takes. From bird band returns biologists have discovered that during spring migration birds make more stopovers as they follow improving weather northward. In fall, the birds wait and move south all at once to good weather.

Banding Lab. The U.S. Fish and Wildlife Service Bird Banding Laboratory in Laurel, Maryland, maintains a record of all bird bands in the United States. All researchers must obtain permits from the Bird Banding Laboratory in order to embark on a bird-marking project. Marked birds must have a silver colored U.S. Fish and Wildlife band with an 8 or 9 digit number. This number and all information about the bird – such as sex, age, weight, condition, date, and place of banding – are on file at the Bird Banding Laboratory.

Finding banded birds. If you find a banded bird and can read any or all of the numbers on the bands or the neck collar, you should contact the U.S. Fish and Wildlife Service and they will forward the information to the Bird Banding Laboratory. The laboratory staff will look up the numbers and contact the biologists who initiated the study. The biologists will then use the information you gave them about the circumstances in which you saw the bird in their studies. The laboratory will also let you know when and where the bird was banded.

OTHER BIRDS AND WETLANDS

Birds of Prey. These birds, called "raptors," include those species of birds that have powerful curved bills and sharp talons for capturing and eating birds, fish, mammals, amphibians, and crustaceans. Raptors include eagles, hawks, falcons, and owls. Some perch near freshwater wetlands, while others either soar high or fly low over them. Once they see or hear prey, raptors either dive down to grab it in their talons, or fly fast and capture in mid air. All birds of prey have acute vision for spotting prey over long distances. Many owls can also hear prey, even when it is beneath deep snow.

Bald eagles are common along the coast of Alaska where they feed on fish. Ospreys are also specialized to prey upon fish and nest regularly in Alaska along lakes, rivers, and coastlines south of the Brooks Range. The northern harrier is a medium-sized hawk formerly known as the marsh hawk because of its characteristic low-flying, gliding hunt over marshy areas in quest of small mammals. Buteos (soaring hawks) and many owls often perch on dead trees to spot prey. Rough-legged hawks, kestrels, snowy owls, short-eared owls, peregrine falcons, and golden eagles are raptor species commonly spotted over open marshes or tundra wetlands. Hawks hunt during the day while most owls are nocturnal hunters.

Songbirds and others. Songbirds (also called passerines) are usually perching birds, with feet designed for grasping a perch. This group includes flycatchers, swallows, jays, chickadees, thrushes, warblers, finches, sparrows, and many other birds. Many species are true forest birds; others are most common in forest openings or at the edges of forest stands where they can perch, find cover and nesting places, and keep a sharp eye out for insects over ponds, marshes, or muskegs.

Flycatchers, swallows, warblers, and sparrows are common throughout Alaska in wetlands or along wetland edges, and the dipper is a specialized year-round inhabitant of streams that stay open during winter. Shrub thickets in riparian wetlands are excellent nesting habitat for a variety of songbirds. Other birds that may be found in or near Alaska wetlands include woodpeckers, swifts, belted kingfishers, hummingbirds, ptarmigan, and red-winged blackbirds.

MAMMALS AND WETLANDS

Many different mammal species use Alaska wetlands during part or all of the year. During spring, deer, moose, and bears are attracted to lush plant growth in tidal salt marshes; interior brown bears graze the green growth on broad river floodplains; and caribou roam tundra wetlands, seeking out tender sedge roots. Bats hunt insects above ponds and bogs at dusk in mid summer and beaver, muskrat, snowshoe hares, martens, and lemmings live in Alaska's wetlands year round.

Wetland architects. Beavers create deep-water habitats by their damming activities and opening clear areas by cutting down trees. Beaver dams slow river current, decreasing the erosive power of the stream, and allowing organic materials and nutrients to settle to the bottom of the pond instead of being carried away. Beavers also enhance the growing conditions for willow, and remove the competition of larger, older trees, creating good moose habitat. Beaver activity can block the movement of fish trying to swim upstream, but new ponds also provide good spawning and rearing habitat, if the fish can get there.

Moose like riparian areas, ponds, and marshes. In summer, river floodplains provide an abundance of tender willow leaves – a favorite food of moose. In winter, the same areas provide shelter from winds and deep snows. Moose feed in ponds and marshes throughout the summer. They submerge their heads to obtain mineral-rich aquatic plants that help replace calcium lost through nursing or antler development.

Muskrats, the pond dwellers. Muskrats feed on aquatic plants such as the roots and stems of cattails, lilies, sedges, and grass and occasionally feed on mussels, shrimp, and small fish. Living below the ice in ponds during winter, they create "push-up" holes where they push up piles of the grasses collected during summer and keep an air hole open to access their cache. As shallow ponds freeze, the muskrats move to deeper ponds. Small amounts of available food and long, cold winters result in high mortality among these rodents.

Aquatic hunters – otters and mink. Land otters (also known as river otters) and mink forage on both land and in fresh or salt water. Mink prefer streams, ponds, beaches, and marshes, but will move inland to take advantage of an abundance of mice or hares. Ponds and marshes provide these animals with a variety of animal foods and plants, including small fish, crustaceans, and mollusks.

Other year-round residents. Many wetland dwellers stay year-round rather than migrating to warmer or drier regions during winter. One of the most characteristic of the year-round dwellers is the lemming, the primary food source for snowy owls. Brown, Siberian, black-footed, and northern bog lemmings are year-round tundra inhabitants in arctic Alaska. Lemmings are herbivores, storing cut plants in "hay piles" that they feed upon throughout the winter. When lemmings are particularly abundant, weasels may move to lowland tundra areas to hunt them. Other predators such as wolves, coyotes, lynx, foxes, and wolverines also include wetlands in their hunting ranges. River corridors especially, are important for travel during both summer and winter.

Don't forget the polar bear! Polar bears are officially classified as marine mammals, but wetlands and shores are important foraging grounds for polar bears in summer when seals are out of reach. The bears find bird eggs, rodents, and berries in these wetland areas.

Fishes Use of Wetlands

Alaska's wetlands are nursery areas for many fish species. Streams, rivers, and riparian wetlands produce the millions of salmon upon which Alaska's commercial, sport, and subsistence fisheries depend. Saltwater estuaries are critical to the successful transition of juvenile salmon from their freshwater birthplace to their adult life in the ocean. Estuaries are nurseries for other important commercial fish species such as halibut, sole, crab, and shrimp.

The emergent plant communities at the shallow edges of streams and rivers, in areas of slow-moving water, and in riparian wetland areas are especially important to small fish such as sculpins, young freshwater fish, and juvenile salmon. Such areas provide an abundance of invertebrate food, and protection from strong currents.

AMPHIBIANS IN ALASKA

All kinds of wetlands are ideal habitat for amphibians, as most require a life both in water and on land. Many people are surprised to discover that there are six species of amphibians native to Alaska. Most are only found in wetlands in the southeast part of the state, but one – the Wood Frog (*Rana sylvatica*), is found throughout Alaska, and has been documented as far north as on the north slope! All six species and where they are found listed below

- **Northwestern salamander** *(Ambystoma gracile)* – coastal forest wetlands in Southeast Alaska
- **Rough skin newt** (*Taricha granulosa)* – in spruce and hemlock forest wetlands in Southeast Alaska
- **Long-toed salamander** *(Ambystoma macrodactylum)* – Southeast Alaska wetlands
- **Spotted frog** *(Rana pretosia)* – wetlands and surrounding forests and grasslands from southern Yukon (Bennett Lake) all the way down to Nevada.
- **Western toad** *(Bufo boreas boreas)* – Southeast Alaska wetlands, but as far north as Montague Island in Prince William Sound.
- **Wood frog** *(Rana sylvatica)* – throughout Alaska in all kinds of habitats.

A Few Amphibian Facts

Amphibians breathe and absorb water through their skin. Their permeable skin is a very helpful feature when it comes to being efficient both in water and on land. However it also means that amphibians easily absorb pollutant and other toxins that might be in the water or in the air. This vulnerability is one of the reasons amphibians are known as "indicators" of environmental health.

All amphibians produce poisonous skin secretions to protect them from predators, keep the skin moist and prevent bacteria, molds, and diseases from entering the body. The rough-skin newt, which resides in southeast Alaska, is one of the most poisonous animals known. Ingestion is lethal to humans, and even handling the animal can be dangerous if the toxin enters the blood stream via a cut on the hand.

Frogs have amazing eyes – they can see in almost all directions at once, having the most extensive visual field among vertebrates, with exception of a few fishes. Frogs can also see colors.

Amphibians are ectotherms ("cold blooded") meaning they cannot generate their own body heat, but instead must absorb it from the environment.

Amphibians have a very unique life cycle. The word amphibian comes from the Greek word "amphibious" which means two lives. Amphibians all start out their lives in water, breathing through gills, and eventually develop lungs, which enable them to exist on land. As with insects, the process of changing from one life form into another is called **metamorphosis.** Wood frogs develop from tadpoles to adults faster than any other frog in North America. The life cycle of the wood frog is detailed on the following pages.

Wood Frog Life Cycle and Habits

Because wood frogs are distributed throughout Alaska, and have such interesting survival strategies, we've focused on this species in this curriculum. However, wetlands are critical habitat for all six species of amphibians in Alaska and if you live in Southeast Alaska, your students may enjoy learning about all six.

Wood frogs begin their lives as tadpoles hatching from eggs in spring, usually residing in the warmest and most shallow part of the wetlands. Tadpoles breathe through both gills as well as their skin and have sieve-like filter organs in their pharynx for feeding. Between their mouth and gills, they trap bacteria, protozoa, floating algae, pollen grains, and other small particles suspended in water. Tadpoles usually school up with other siblings to stir up food, increase temperature via body mass, and alert each other when predators are coming.

Mature tadpoles have legs! After a few weeks as tadpoles, metamorphosis begins. During the process the tail is absorbed back into the body, limbs grow, larval mouth parts are replaced by true jaws, teeth, and tongue; moveable eyelids form; lungs and skin glands develop; the gut assumes an adult form – including a stomach; bones harden and the intestine changes. Additionally, because the animal is most vulnerable to predators at this stage, it becomes more poisonous (less edible to predators).

Filamentous green algae are an important part of the tadpole's diet at this stage. In this manner, frogs play an important ecosystem role, helping to clean out ponds so that fish can live in them. Algae can otherwise use up all the oxygen in a wetland. Tadpoles are an important food for a variety of animals, including beetle and dragon fly larvae

By mid summer the tadpole has developed into a young froglet. Male frogs reach maturity by the end of one year, whereas females do not become **mature frogs** until 2 years following metamorphosis. Frogs may live for 5 to 10 year, but most Wood Frogs do not live longer than 4 years. They may travel away from the wetland, consuming a diet of mostly insects (like mosquitoes!) but also worms, snails, millipedes, molluscs, and other small invertebrates. They are an important food source for fresh water fish and birds.

Wood frogs freeze solid during winter! Wood frogs have an amazing strategy to survive the cold temperature of winter. In fall when temperatures start to drop, they make a nest in last year's vegetation duff. Falling leaves and snow provide additional insulation. The frog's liver is then stimulated to manufacture huge amounts of glucose (sugar), which goes into the blood. (If a human had as much sugar in her blood, she would go into a diabetic coma!)

The frog's heart rate doubles to pump all the vital organs with this new sugary blood. In the normal process of "freezing to death", water outside of an animal's cells freezes and through osmosis, all of the water is sucked out of cells and they collapse due to dehydration. Freezing to death is in fact dying of dehydration. But the concentrated glucose slush that remains in the cells of over-wintering wood frogs prevents the cells from collapsing or freezing solid, so the frog does not "freeze to death". Meanwhile, the frog's heart stops, and it doesn't even breathe! One could in fact, known the frozen frog against something and it would feel like a rock.

Frogs breed as soon as they thaw out. As soon as temperatures warm in April, wood frogs thaw out quickly. Instead of eating, the first thing on their agendas is reproduction. They are explosive breeders, which means breeding occurs in just a few days. You can hear the mating call of male wood frogs at wetlands during spring. The staccato call sounds very similar to the quacking of ducks. Males engage in competition, and even fights for the females.

In **amplexus,** the male frog clasps the female and fertilizes eggs as she lays as many as 2000 to 3000 eggs in a jelly-like mass directly into the water. Eggs hatch within 4 to 8 days depending on the water temperature.

Amphibians in Decline

Amphibians throughout the world, including Alaska, are disappearing fast. Thirty-two percent of amphibian species worldwide are threatened with extinction; 43% of species have declining populations and 122 species are believed to have become extinct since 1980. Additionally, deformities are widespread globally and reports of deformities in Alaska are on the rise. Throughout the state wood frogs have been found with partial, shrunken, deformed, or missing legs, clubfeet, and missing eyes.

Several hypotheses exist for why amphibians are in such great trouble. Hypotheses include habitat loss; elevated UV radiation; pesticides and herbicides; warmer temperatures due to climate change; introduced species including diseases and fungi; acid precipitation; and heavy metals. No doubt all of these factors are working in concert to put pressure on amphibians. Research has shown many specific cases where declines in a species can be attributed to one of the above causes.

AQUATIC INVERTEBRATES

Who are they? Aquatic invertebrates in Alaska's wetlands include a wide array of macroscopic and microscopic animals, such as the larvae of flies, mosquitoes, and beetles; mollusks; different types of worms; hydra and rotifers. They are extremely important food for fish, as well as wetland birds.

Water quality indicators. Many aquatic invertebrates can be used as an indicator of stream or wetland health, as some are very tolerant of pollution and low oxygen conditions, and some can only inhabit clear, well oxygenated waters. For flowing waters, examples of low quality indicators include the tubifex worm and leeches. Mayflies, stoneflies and caddisflies are generally indicators of good water quality.

Functional groups. Aquatic invertebrates, like other animals, can be grouped according to their ecosystem and feeding functions. Many are important in different stages of decomposition.

- Some like the dragonfly larvae and the predacious diving beetle are **predators**, consuming other invertebrates, tiny fish and even tadpoles.
- **Shredders** like some stonefly larva, break leaves and other particulates greater than 1mm in size into smaller pieces. (Much of their nutrition is actually microbes living on these surfaces "the peanut butter on the cracker").
- **Collector filterers** like blackflies, and **collector gatherers** such as some caddisflies, process materials less than 1mm into even smaller pieces.
- **Grazers** and **scrapers** may graze on algae or on microbes decomposing organic material on submerged surfaces such as leaves and rocks.
- **Filter feeders** directly remove algae and other suspended particles from the water column

Youngsters dominate. Many of the macroinvertebrates in the water are the larval form (called nymphs in some species) of terrestrial animals, and are very different looking from their adult counterparts. Some, like mayflies, are nymphs most of their lives (1-3 years), spending as little as 24 hours as mating and egg-laying adults.

Some adult forms of aquatic insects emerge during spring bird migration and nesting, and thus are a very important food sources for migratory birds!