Wetlands Outreach Ecology

Workshops
in Eastern Washington
Methow & Chewuch River Valleys

Presented by Trust for Habitat Conservation
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Wetlands Outreach Ecology Workshops
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Federal Project Officer	Fred Weinmann, US EPA
EPA Advisory Assistance	Linda Storm, Debbie Larsen, Laurel Michael, Cecilia Contreras
University Cooperators	Helen Buttemer, Howard Hughes Summer Ecology Institute Coordinator, Ola Edwards, Co-director
Instructors	Art Partridge, Charlie Dewberry, Dana Visalli, Dave Rudholm, George Wooten
Assistants	Robert Crandall, Gina Monteverde
Program Coordinator	Mary Poss, Trust for Habitat Conservation
Guidebook Author	George Wooten
North Central Educational District Coordinator	Marilyn Crouch
Methow Valley School District Environmental Coordinator	Sandy Moody

Organizations Involved

US Environmental Protection Agency

Trust for Habitat Conservation

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US Forest Service

The author may be reached at:

George Wooten
Methow Field Institute
226 West Second Ave
Twisp, WA 98856
509-997-6010
george.wooten@gmail.com
www.okanogan1.com

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Wetlands are defined federally as *those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions*.

Wetlands are important for many reasons. Wetlands provide critical **habitat** for many species of wildlife. Wetlands improve water **quality** through filtration and assimilation of sediments and nutrients. Wetlands **store** and recharge groundwater supplies critical to late-season uses. Wetlands reduce the frequency and severity of **flooding** by acting as overflow outlets and restricting energy flows.

Our purpose in presenting these workshops is to develop an awareness and enthusiasm for wetlands. Our objectives are to:

- Target an audience of individuals with an investment in wetlands
- Provide an outdoor experience
- Learn through hands-on approaches
- Illustrate processes with tangible examples
- Use multidisciplinary integration

Section 1 An introduction to wetlands

We are studying wetlands in this workshop because of their importance and because they offer excellent opportunities to interact with natural features of the environment, in ways both stimulating and fun. The workshops begin by studying individual wetlands components and then encourages participants build upon their understanding of how the whole system works. Activities which can be copied and used in curricular activities for grades K-12 are marked as *Exercises*, and have a file symbol (🗁) at the top of the exercise.

What makes wetlands so important?

Some of the important functions of wetlands include the following:

- **Flood and erosion control.** Wetlands spread out and resist the force of high flood waters.
- **Ground water recharge.** Wetlands store water in the wet season, making it available later on.
- **Filtration of sediments and toxic materials**. Wetlands pick up material passing through, including sediment, and toxic compounds.
- **Wildlife Habitat.** Wetlands provide diverse habitats for a large number of plants and animals.
- **Food chain production.** Wetlands provide food for wildlife and humans.

What is a wetland?

Definition of a wetland - US Army Corps, 1987 Wetlands Manual:

Wetlands are defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

The **key point** is that by definition, wetlands must have wetland characteristics in all of three criteria: soils, hydrology and botany. These workshops will study wetlands through each of these fields individually, gradually building a complete system out of the parts.

One way wetlands are classified is by their environmental regime: whether they are salt or fresh water, peat-forming or not, permanent or temporary, mineral-rich or mineral poor, riparian or isolated, etc. In this workshop, we will see how different environments change the type of wetland formation.

Another way of classifying wetlands is by the structure of the plants that grow in them: aquatics, emergents, herbaceous plants, shrubs or trees. In this workshop we will explore how structure is correlated with wetland types.

Yet another way is by their formation through geological processes, whether they are glacial, sedimentary, tidal, etc. We will look at one aspect of geomorphology in this workshop - glacially formed wetlands.

Equipment used to study wetlands

The equipment used to study wetlands can be simple as simple as bringing along an open mind. Scientists record their observations in bound notebooks, and these may be accompanied by sketches of varying degrees of style and accuracy. Maps and mapping tools are recommended in order to properly locate wetlands and the way home. Rubber waders of varying depths are commonly used for keeping feet dry. Raincoats, rain hats, mosquito repellent and/or mosquito net hats can be carried to help stay more comfortable. Specialized equipment might include shovels, thermometers, a ruler, soil augurs, soil test kits, nets for insect and animal trapping, water sampling tools and bottles, and a vegetation flora.

Section 1 Exercise - Classifying wetlands

Using a dichotomous key to classify a wetland

This exercise uses a dichotomous key to classify a wetland. Carefully read each of the following pairs of descriptions, and pick the one that best fits the wetland you are in. Follow the key to the next lead listed until the name for the type of wetland is reached.

1a. The land is saturated with water for 3 weeks of the growing season - **2**.
1b. The area is **an upland**, not a wetland.
2a. The water is salty, brackish or tidal - **Saltwater or Tidal wetland**.
2b. The water is always fresh, and isolated from tides - **3.**
3a. The soil is ALWAYS inundated by water - **4.**
3b. The soil is sometimes NOT inundated with water; it may be continually moist or dry, but the top layer of the soil is sometimes partly exposed at the surface - **6.**
4a. The water is 6 feet or more deep. **Open water** (not always considered a wetland).
4b. The water is less than 6 feet deep - **5.**
5a. The water is moving, and plants don't grow on the bottom - **Stream bed**.
5b. The water is still or sluggish, and plants are growing on the bottom - **Aquatic or emergent plant bed** (shallow ponds, lakes, and streams).
6a. Area has mostly trees - **Forested wetland.**
6b. Area not dominated by trees - **7.**
7a. Area dominated by shrubs - **Shrub swamp or Carr.**
7b. Area not dominated by shrubs - **8.**
8a. Soil is primarily peat - **Mire or Peatland - 9.**
9a. Area recharged by mineral water - **Fen.**
9b. Area fed only by rain water and generally acidic and dominated by sphagnum moss. - **Bog.**
8b. Soil not primarily peat - **10.**
10a. Area dominated by herbaceous plants (including graminoids), and without standing water most of the year - **Wet meadow or Pothole.**
10b. Area herbaceous, muddy, bare or with decomposed litter, with fluctuating water levels over the year - **Marsh.**

Section 2 Overview of wetland genesis - geomorphology

Wetland formation is governed by many geologic and topographic factors, collectively referred to as geomorphology, or the science of landforms. Broad features of the landscape affect the location and amount of various soil types and water regimes which in combination can lead to conditions for wetland formation. Landscape-sized features may be too large to appreciate from the ground, so it is helpful to view these features from a distance or map that allows patterns to be discerned. Much can be learned about the natural history of an area using topographic maps, aerial photography and other specialized maps such as geologic maps.

Soil chemistry and texture

The Eightmile Fault (also called the Chewuch-Pasayten Fault, or Pasayten Fault) that crosses the Chewuch River area following Eightmile Creek is one of the Pacific Northwest's major structural landforms. It is the boundary between crystalline granitic rocks of the Okanogan to the east, and a 10-mile wedge of marine sedimentary and volcanic rocks called the *Tyaughton Trough* or "*Methow Graben*", which extends north from Twisp, Washington about 200 miles.

There is a big difference between sedimentary and granitic (often called crystalline, or acidic) rocks, in the way chemical and physical properties affect ground water and wetland formation.

Granitic rocks weather to quartz sand which has large pores for water retention. Deep deposits of glacial drift composed of granitic parent materials have enormous water holding capacity, however these sandy soils also dry more rapidly. Granite bedrock is brittle crystalline, and breaks internally to form cracks that act as water sinks and springs.

Sedimentary and volcanic rocks (collectively, deposited rocks) have finer grain textures and thus hold less water in the pore spaces, but finer pores also retain water longer during drought. Deposited rocks tend to weather to clay soils, for instance during glacial pulverization. Glacial processes can layer soils, and if they are composed of clays, then they form an impervious seal, called hardpan, capable of holding water in a perched aquifer, which may also become a wetland.

Glacial geomorphology

The Methow and Chewuch River watersheds are excellent areas to study glacial processes. In addition to the alpine cirques and valley glaciers of the North Cascades, areas to the north also experienced *ice-sheet* or *continental* glaciation. This area is the southern terminus of the *Cordilleran Ice Sheet*, which stretched from Chelan north to Alaska in a nearly unbroken sheet of mile-plus deep ice, during the *Pleistocene Ice Age*, 16,000 years to 10,000 years ago.

There are three main types of glaciers found in the Methow and Chewuch watersheds: alpine, valley, and ice sheet (continental).

The Cordilleran ice sheet covered all but the highest peaks, which protruded from the ice sheet as isolated islands of rock, called *nunataks*. The Mountains of Isabella Ridge at the head of Eightmile Creek were nunataks. Their tops are jagged from the action of smaller alpine glaciers, in contrast to the mountains at the head of Falls Creek, which have had all their prior features rounded off by the action of the ice sheet.

In addition to scraping the tops of mountains, the continental glacier pushed all this scraped-off material, called *glacial drift*, or *glacial till*, into the valleys, much like stucco. The bedrock bottom of the valleys is actually many hundreds of feet below this layer of drift. Underground obstructions can impound ground water behind them, forming wetlands where the water table breaks the ground's surface.

Alpine glaciers and their moraines are much smaller, and the transported materials are coarser, having traveled shorter distances, Alpine glaciation tends to form localized basins in the bedrock (cirques), leading preferentially to lake and tarn formation rather than wetlands. These lakes may eventually fill in from their edges, however, leading to wetlands formation over time. It is thought that there were phases of alpine glacial advance several thousand years prior to the arrival of the ice sheet, and again during the last several thousand years.

Valley glaciers were formed in larger watersheds such as the Chewuch River, Eightmile Creek and Falls Creek, during both alpine and continental glaciation phases. They are intermediate in size between the two, and result in classical glacial features of straight, broad, U-shaped valleys, with steep walls. The bottoms of the valley glaciers have been covered over by subsequent drift deposited by the continental glacier, and it is in these bottomlands that many wetlands are found, associated with riparian features.

Exercise: Mapping wetlands with aerial photography and topographic maps

Materials: Maps and aerial photographs of the workshop area, compass.

Aerial photographs and topographic maps can be useful in determining the geologic history of an area. Using some of these maps, try and find the following features:

Geologic fault (hint: look for long straight features that cut across valleys and mountains, or separate mountains from basins).

Glacial valley (hint: look for straight, broad, U-shaped valleys, with steep sides and flat bottoms).

Alpine cirque (hint: look for circular bowl-shaped areas near the tops of mountains).

Which of the above features appear to be likely places to find wetlands? (hint: look for large flat areas, with water or swamp symbols marked on the map).

Section 3 Wetland soil properties

Soil taxonomy

Soil taxonomy is a system of soil classification for interpreting soil surveys. Based on both field characters and properties inferred from field data, soil scientists have classified soils into 9 orders of mineral soils and one order of organic soils. All wetland soils are termed ***hydric soils.***

A soil is classified as an **organic soil** (***histosol***) if more than half of the upper 80 cm (31.5 inches) of soil is organic or if organic soil material of any thickness rests on rock or on fragmented material having interstices filled with organic material (a *histic epipedon*). Organic materials are the undecomposed remains of vegetation. This means that if a purely organic soil layer (also called a *horizon*) such as peat or muck is 16 inches deep, then the soil is a histosol. The lack of decomposition in histosols is due to a lack of oxygen, thus most histosols are also hydric soils. Histosols are further subdivided into *folists* (leafy), *fibrists* (peat, undecomposed organic), *hemists* (half-decomposed), and *saprists* (completely decomposed).

If a soil isn't a histosol, then by definition, it is a **mineral soil**. Mineral soils have a more involved taxonomy, but fortunately for wetland scientists, many hydric mineral soils can be readily classified by the presence of characteristic soil colors caused by the oxygen-poor environment of wetlands. Clays are a very important constituent of soils that may develop into an impervious layer within a soil type. The microscopic structure of clays causes the soil mass to swell when wetted, thus imparting its waterproof characteristic.

Even if a soil can't be positively classified, there are a number of easily recognized indicators of hydric soils to try and observe. Most of these indicators are due to prolonged saturation of the soil leading to ***anaerobic*** (without air) conditions within the soil:

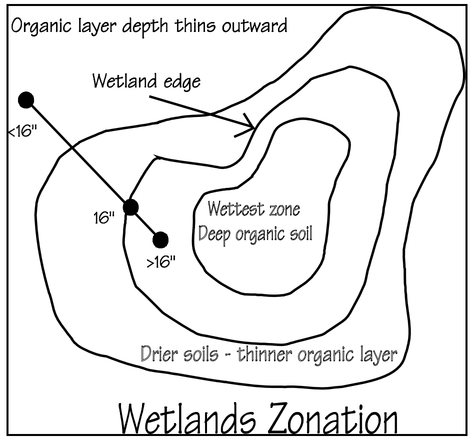
- "Rotten egg" or sulfidic odor. This odor indicates hydrogen sulfide, which only forms under reducing (anaerobic, or without air) conditions.
- Iron or manganese concretions. These are BB-sized dark particles within 3 inches of the surface indicating prolonged saturation and anaerobic conditions in the soil.
- Peat soils derived from sphagnum moss are likely wetlands.
- In sandy soils, a dark organic layer near the surface, or streaking of dark material in subsurface layers of sandy soils. The dark layers indicate organic material that is not being oxidized.

Wetland zonation

Many wetlands, when viewed from above, exhibit concentric patterns of zonation from the wettest soils to the driest, going from the center to the perimeter of the wetland. A similar zonation can be seen along riparian area bordered by wetlands, where the zones run parallel to the stream course. These patterns are usually observable by the presence of linear zones of plants with different tolerances or preferences to soil wetness. In histosols, these characters may be reflected underground by a tapering-off of the upper organic horizon as the soil gets drier further from the wet areas.

Section 3 Wetland soil sampling

Exercise: Sample the depth of the organic soil horizons (layers)



Materials: A shovel a 100-foot tape measure and a ruler. This is an exercise for a wetland with organic soils (histosols). This exercise may be prepared ahead of time for younger age groups who may not be comfortable or safe wielding a shovel. Be safe with the tools, keeping the sharp end pointed downwards. Make sure that it is allright to dig these test pits before beginning. Fill in all dug holes when done. Soil samples from this exercise can be used as filters in the next exercise on soil-water interactions.

Walk to an area about 50 feet past the edge of the wetland that you are fairly sure is an upland. Using the shovel to cut cleanly through the soil and any roots, dig a straight-sided hole until you reach mineral soil. Clean up the sides of the hole so that the soil layers are clearly visible. Measure the depths of the layers and record them in the notebook. If the organic layer is deeper than 16 inches, then you are within a wetland (surprise!). Try digging a hole another 50 or 100 feet further away. You can continue moving further from the wetland until you find an organic layer less than 16 inches deep, or you run out of space or time. Plan ahead.

Repeat this hole-digging procedure in an area about 50 feet within the area you think is a wetland, and measure the depth of the organic layer. If the organic layer is deeper than 16 inches, that is a good indication you are in a wetland.

Dig some holes on a line in between the other two, until you find one where the organic soil layer is close to 16 inches deep. This is the point defined as the edge of the wetland. This line of sample points crossing the wetland boundary is called a transect. Professionals wanting to mark the entire boundary of a wetland might repeat this procedure until they have gone around the entire wetland area (whew!).

Answer the following questions from the data:

Where are the deepest organic soils? The shallowest?

What type of organic soil is present (undecomposed peat, decomposed muck, or intermediate?

Does the wetland edge seem to thin evenly or abruptly?

Older students can make a graph with the X-axis the distance from the wetland edge, and the Y-axis the depth of the organic layer.

After several of these transects are made, one finds that certain plants indicate the edge much easier than digging holes. Can you now follow the edge clear around the wetland?

Section 3 Soil-water interactions

Exercise: Nature's sponge

Materials: A gallon jug, sealable plastic storage bags, a waterproof marker, seven quart Mason jars with volume markings on the side, seven large funnels (these can be made from quart-sized plastic juice bottles or small coffee-cans, with the bottoms well perforated with a nail so that water can easily run out), a piece of log end that can be used as a tamping tool that will fit within the funnels, and some soil samples of peat, loam, gravel, humus, clay, and sand, which can be stored moist in the plastic bags. Advanced students will need a watch with a second-hand.

Place the specimens of different soil types so that they are all 1 inch deep in the bottoms of the funnels. Make one funnel up with no soil as a control. Premix a slurry of about a cup of sandy mud into the gallon jug. The mixture should be nearly opaque when stirred.

Holding the mason jars under the funnels, pour a half-quart of the well-stirred slurry into the funnels, and collect what runs off in the Mason jars, which have been marked to match the type of soil in the funnels. When all the water has gone through, arrange the jars in order of the clearest to the darkest. Advanced students can measure the time it takes between the when the first drops to come through steadily until the water is just at the surface of the soil, then make a second time measurement of how long it takes for the water to stop draining. Record all observations in notebooks.

What type of soil filters the most sediment out of the slurry? The least? Which soil type takes the longest to filter? The shortest? Which takes the longest to drain dry? The shortest?

When all these measurements are done, empty the Mason jars, and replace the funnels over them. Press out the remaining water in the soil filters and measure the amount in each Mason jar. Which soil type released the most water when squeezed? The least?

Everybody should discuss the significance of these results.

Section 4 Hydrology - sampling macroinvertebrates

Exercise: Sampling macroinvertebrates for water quality

Materials: Ruler, thermometer, pH paper, a ping-pong ball for measuring water flow speed, magnifying glasses, a microscope, if available, sketch pads, field guides, a shovel (best kept with the instructor), capped vials for sampling water and invertebrates, miscellaneous pans for holding or catching live specimens. Nets can be made from the following materials: nylon netting sewn over hoops and fastened to a broom handle; strainers taped securely to a broom handle; plastic wrap tightly sealed around one end of a coffee can which has had both ends opened, for use as an underwater viewing window; and minnow traps made of old plastic gallon pop containers which have been joined with silicone cement. Cut both ends off of one bottle to make it into a large diameter clear tube, and cut the tops off of two others. Glue these together with the tube in the middle and the two narrow lid ends pointing inward. Cut windows in the sides and cover these with plastic sealed with a rubber band. Use small amounts of food bait as in a regular minnow trap, and remove the animals through the windows, being careful to do it in a pan of water so they don't dry out.

This exercise will visit different habitats to determine where different types of small animals live. Different functions and needs of each animal make it fit for different habitats. Before embarking, note that wetlands are not as dangerous as some not-so-nice fairy stories would have us believe, but a they *do* have their own unusual animal species. Just as we take care to watch where we walk or step on a crowded city street, we should be careful to watch where we step and not poke fingers into holes or soil without first looking. Some insects can bite, and the group might find a tick, some mosquitoes or a leech, but they can be avoided. Younger students will be reminded that cruelty or undue stress to animals won't be tolerated and that all the animals sampled will be returned unharmed to where they came from when done.

Using the attached *Key to Macroinvertebrate Functional Groups*, by T.C. Dewberry, or a similar guide, explore several habitats, collecting specimens. Take some samples from several small holes dug underground, replacing the soil in the hole after digging. Have some people sketch what they find, and have others describe the habitats in their notebooks. Share information. Take data on water and soil temperature, water depth, water flow speed, pH, and for advanced students, record the amount of shade, type and amount of adjacent vegetation, bank characteristics, etc. Collect samples of the water from the environment in a clear, capped vial.

Discuss adaptations of each of the collected species to their different habitats. How many different habitats were there? What animals have generalist adaptations (able to function in another environment)? What adaptations make an animal a specialist (adapted to only one or a few special environments)?

Examine the water samples from each of the environments, first for visible differences, then with a magnifying glass and a microscope. Describe what you see, and then discuss the differences in water quality between different habitats.

Section 4 Wetland Hydrology

A model ecosystem - beaver ponds

Beaver are rodents, as evidenced by their long, curved front upper teeth. The teeth are kept trimmed by constant gnawing on wood. These teeth suit them well for constructing their "lodges", which are half-submerged piles of logs and sticks. In order to protect them from marauding carnivores, lodges are heavily armored and may be over ten feet thick. Beaver will cut down trees as large as two feet in diameter if trees that size are within reach of their wetland home, and smaller trees are not available. The green tops of trees are used for food, and the larger branches are used as structural materials. Branches are stuck into the mud at the bottom of the lodges for use in winter when the surface ice is frozen.

Smaller branches and twigs are placed as dams in response to the sound of running water. Holes in the branch dam are filled with mud clods from the roots of submerged wetland plants. Eventually the dam restricts water flows enough to create a ponded area behind it, and these ponds that beaver create can cover large acreages. That is why beaver are called nature's engineers.

Physical adaptations that benefit beaver are obvious. A beaver has webbed feet for paddling in the water. Its thick, flat tail is used as a paddle and rudder. The tail is used as a danger signal by slapping the water when threatened, and if pursued, a beaver can actually throw a large bucketful of water into the face of an attacker as it swims away. Its fur is waterproofed with oil that it applies from special sebaceous glands used for this purpose. It also has musk glands that it uses to scent-mark its territory. A beaver's ears, nose and eyes all have membranous flaps that keep out water during dives, and it can hold its breath for a quarter of an hour.

Exercise: Visit to a beaver pond

Preparation: For this exercise, visit a beaver dam or lodge. An increment borer or pruning hand saw for measuring tree age is useful. If occupied, the lodge won't be available for close inspection, however, it can be viewed with binoculars. Beaver themselves are a rare sight, however, if approached quietly, one might get a quick view, or at least a loud slap! of the tail. Beaver can also be found in riparian areas, where they may attempt to create new ponds. These areas with new dams are a good place to see the different types of wood that they use, and how their dams are constructed. Abandoned beaver ponds offer a good place to view both old dams as well lodges.

Discuss the types of wood that make up the dam. What are the largest trees they have cut down? Are there some species preferences? What other plant species are used in dam construction? What other wildlife are using the area?

How much does the water table fluctuate? Do you see signs such as floating sticks in the branches, indicating the water is rising, or is the water around the bases of shrubs at the pond margin, indicating a rising water table?

Construct a timeline of how and when the beaver pond began. Are there old snags still standing in the pond? How old were they when they died? Are there new wetland shrubs growing around the margin that grew when the dam was created? How old are they? What do you think the area looked like before the beaver pond was made? Ten years ago? A hundred years ago? What would happen next year if the beaver left the area? In ten years? One hundred?

How many different species can be recognized that seem to be restricted to the pond area? Now visit the area below the dam and see how many of the same species grow there. How many species can be found which only grow in the pond area, and how many are only found in the riparian area below the dam? Which species can increase their numbers due to available habitat, and which ones are losing habitat?

A model ecosystem - moose

Moose are the world's largest member of the deer family. Like beaver, they are found in boreal (northern ecosystems) areas of the world. The limiting factor for their survival appears to be availability of forage when the land is covered with winter snow packs. Because of their large size, moose are not adapted to warm climates where they would overheat during the warm season, but its greater height allows it to reach shrubs that are unavailable to shorter animals such as deer.

In winter, moose will seek out fallen trees and shrubby areas, and strip them of their buds and cambium layers to meet their nutritional requirements. Because protein-rich grasses are often unavailable during winter, moose must gain the most amount of energy from summer feeding while expending the least amount of time and energy which could be used for reproduction, caring for young, and other moose behaviors. To do this, a moose's diet is varied to take maximum advantage of seasonally available protein and carbohydrate sources. Such a diet is termed *browsing*, and by using a wide variety of shrubs and seasonally available forbs, a moose can meet its high energy requirements.

Wetlands, particularly forested wetlands, produce a diversity of high-energy, seasonal and deciduous foods, within a concentrated local area, so it is logical that moose would have physical adaptations for using those areas. The broad hooves of a moose allow it to walk in wetlands where shrubs and deciduous species with higher carbohydrate and protein levels are more abundant. Like other ruminants, a moose has four stomachs, and its digestive system is capable of processing large amounts of woody materials.

Many boreal areas have a limited amount of salt, required by mammals for survival. To get enough salt, a moose eats large quantities of wetland plants that sequester salt, such as horsetails, bladderworts and water lilies. These plants are under ice during winter, so a moose exceeds its sodium requirements during the warm months, and endures a sodium deficit during winter. To get enough sodium from these aquatic plants requires a large stomach, capable of assimilating enough bulk to extract the scant sodium present in the plant tissues. To get wetland plants, a moose's rack of antlers may be used to loosen aquatic plants from their bed, as it wades and swims through wetlands and beaver ponds.

Section 5 Wetland Botany

Facultative or obligate? - exercises in wetlands delineation

Because wetland soils are saturated during the growing season, plant growth requiring an aerobic environment is limited. Over geologic time, wetland plants have evolved physical and chemical mechanisms for living in saturated soils. Some plant species have even lost the ability to live in upland soils, in which case they are termed *obligate* wetland plants. Plants that can live on either wetland or upland soils are termed *facultative*.

Exercise: Hands around the wetland

Materials: A group of at least five people.

This is an introductory exercise for people who have just been introduced to each other, and who are visiting a wetland in the field. It requires some botany to set up. Explain to everybody that they are each going to have a "special plant friend". Assign each person their own special plant friend and introduce them to their friend. Plants chosen should be well represented on the site, and should span the range from obligate wetland to facultative to upland. Plant names should be familiar and suggestive, like *Shorty, Droopy* or *Lily.*

Now have everybody stand next to (but not on) their special plant friends. Any accidental stepping on plant friends require apologies. Then explain that since we are **all** friends, that the people need to hold hands, too, but in order not to offend their special plant friends, they need to stay next to an individual of the plant, which might mean moving to another of the same species.

This exercise teaches that plants have their own place (habitat) in nature, and plants can be common or rare. It also gets students used to looking for recognizable features in plants without a fear of learning hard names, and it gets people thinking about walking carefully.

Next, explain that some plants are extra-special, and need more encouragement. Choose three plants that are well-represented on the site, one upland, one facultative, and one a wetland obligate. Assign three or more people to each of the special plants and have each group hold hands while standing next to individual members of the same extra-special plant. For groups of three or four people, there should only be one group, which changes plants after each hand-holding.

Look at how easy or hard it was to form lines for some of the groups, and how straight or crooked they were. This illustrates how plants can be rare or common, but more importantly, it shows that there are distinct zones of plant habitat based on soil wetness. Discuss what the terms *obligate*, *facultative* and *upland* mean. Define wetland.

List of plants occurring in Falls Creek Bog

This list includes those plants within the margin of the open wetland.

Species	Common name	Wetland classification*
Agrostis scabra	rough bent grass	FAC
Agrostis variabilis	mountain bent grass	NC (FACU)
Aster modestus	great northern aster	FAC+
Calamagrostis inexpansa	narrow-spiked reedgrass	FACW
Caltha biflora var. biflora	elkslip	OBL
Carex buxbaumii	Buxbaum's sedge	OBL
Carex chordorrhiza	chord-leaved sedge	NC (OBL)
Carex diandra	lesser tussock sedge	OBL
Carex jonesii	Jones' sedge	FACW+
Carex lasiocarpa var. americana	woollyfruit sedge	OBL
Carex leptalea	bristly stalked sedge	OBL
Carex limosa	mud sedge	OBL
Carex utriculata	bottle sedge	OBL
Carex vesicaria var. vesicaria	vase sedge	OBL
Cornus canadensis	bunchberry dogwood	FAC-
Cornus stolonifera	redosier dogwood	FACW
Eleocharis pauciflora	small-flowered spike-rush	OBL
Equisetum arvense	field horsetail	OBL
Equisetum fluviatile	water horsetail	OBL
Equisetum laevigatum	smooth horsetail	FACW
Eriophorum angustifolium	cottongrass	OBL
Menyanthes trifoliata	bog or buckbean	OBL
Parnassia fimbriata	fringed grass-of-Parnassus	OBL
Pinus contorta	lodgepole pine	FAC
Platatanthera dilatata	bog-candle	OBL
Potamogeton nodosus	long-leaved pondweed	OBL
Potentilla palustris	bog cinquefoil	OBL
Salix boothii	Booth's willow	OBL
Spiranthes romanzoffiana	ladies' tresses	OBL
Streptopus amplexifolius	clasping twistedstalk	FAC-
Thuja plicata	western redcedar	FAC
Utricularia minor	small bladderwort	OBL

*Key to plants in the National List of Plant Species that occur in Wetlands, Region 9 (Pacific Northwest) FAC = Facultative, FACW = facultative-wet, FACU = facultative-upland, OBL = obligate, NC = not classified; + indicates more wet, - indicates more upland.

A Model Ecosystem - emergent plants

Exercise: Inventory of emergent plants

Materials and preparation: For this exercise you will need flagging, yardsticks (or a 2 meter stick if available), rulers, a pocket knife, a hand lens, a tape measure and a plant list.

Wetlands have varying depths of water, and sometimes the depth fluctuates, often to the point where there is no water at all. The important thing that makes wetlands "wet", even when they are dry, is that the soil is saturated long enough *during the growing season* to exclude plants without adaptations for life in saturated soils. This is on the order of 14 to 21 days of soil saturation, during the time when plants are green.

Plants that live in deep water must have a way of connecting the roots to the photosynthetic and flowering portions. In really deep water, plants float freely or on long stems. In water less than approximately 6 feet, it is possible for a plant to support itself on its own stem, and the technical term for this is *emergent plants.*

Emergent plants can be recognized easily once they protrude above the water's surface, however when the stems are young they may at first be underwater. They generally have a straight, erect stem with flowering parts above the water surface. Examples include cattails, bulrushes, rushes, horsetails, sedges, reeds, and buttonweeds.

Examine some samples of emergent plants. Cut the stem lengthwise and observe what sort of inner structure is present. Is the stem rigid and strong? Does this help support the plant? Are other animals using the plants as supports for perching, landing, nesting, or egg-laying? Is the inner part of the stem solid, hollow, chambered or pithy. The last three structures contribute both buoyancy as well as oxygen transport to emergent plants.

Measure the height of the emergents. Now measure the depth of the water they are growing in. Count how many emergent species are growing within a 2 meter (6 feet) radius of a center point. Move to the edge of the area where there are less emergents and measure the water depth. Then determine how many emergents are growing within a 2 meter radius of that point and measure their heights. If desired, intermediate points can be sampled this way and graphed.

Do the heights of the emergent plants correlate with the depth of the water? Are the flowers of the emergents above or below the water? Why? Compare that with the flowers of floating and submerged aquatic plants.

Section 6 Wetland Ecology - A list of wetland adaptations

Plants

Emergent stems. This adaptation raises plants to the water surface and allows oxygen transport through the stems. *Example: rushes, Juncus spp., horsetails, Equisetum spp.*

Spongy, inflated leaves, stems or roots. Spongy tissues, often with an internal honeycomb structure, can provide buoyancy and oxygen transport. *Example: cattail, Typha latifolia, skunk cabbage, Lysichiton americanum.*

Floating leaves or stems. This adaptation allows air to reach the leaves of aquatic plants. *Example: water lilies, Nymphaea spp., pondweeds, Potamogeton spp.*

Polymorphic, and dissected leaves. Some wetland species produce variable leaf shapes as a response to varying water levels. *Example pondweeds, Potamogeton spp., water buttercup, Ranunculus aquatilis, water plantain, Alisma plantago-aquatica, cinquefoils, Potentilla spp.*

Symbiotic nitrogen fixation. Plant-bacterial partnerships have developed on the roots of some species. *Example alders, Alnus spp.*

Carnivorous or insectivorous plants. This is a response to low nutrient levels found in bogs. *Example: sticky leaves of butterwort, Pinguicula vulgaris and sundews, Drosera spp., trapdoors in bladderwort, Utricularia spp.*

Acid development. A special classes of mosses, the peat mosses, increase the acidity of the wetland environment while obtaining nutrients. *Example: Sphagnum spp.*

Shallow root systems. A response to anaerobic soils at depth, sometimes indicated by windthrown trees. *Example: Engelmann spruce, Picea engelmanii.* Upland species may be able to live on top of wetland by keeping their root systems above the level of saturation. *Example: rosy pussytoes, Antennaria microphylla.*

Buttressed tree trunks. *Example: redcedar, Thuja plicata, Engelmann spruce, Picea engelmanii.*

Multiple sprouting stems at the crown. *Example: willows, Salix spp.*

Modified reproduction. *Example: floating pollen of waterlilies, floating seeds of many plants, underwater flowers of pondweeds, Potamogeton spp.*

Adventitious roots or "water roots". Small roots on the stems of plants above the soil surface. *Example: black cottonwood, Populus trichocarpa, redosier dogwood, Cornus stolonifera.*

Nodal rooting. *Example: water buttercup, Ranunculus aquatilis, American brooklime, Veronica americana.*

Hypertrophied lenticels. Some plants produce enlarged lenticels (stem pores) in response to prolonged inundation. *Example: alders, Alnus spp.*

Pneumatophores. Modified roots that may serve as respiratory organs, such as cypress knees. *Example: bald cypress, Taxodium distichum.*

Animals

Specialized breathing organs. *Example gills in fish, or amphibians.*

Modified feeding behavior. Species inhabiting wetlands may have adaptations that allow specificity toward feeding on obligate wetland species plants. *Example: hinged jaw of dragonfly larva for feeding on wetland animals and macroinvertebrates.*

Modified legs. Aquatic and wetland-inhabiting birds and other species have many movement adaptations to wet life, such as webbed feet, or long legs, or wide hooves. *Example moose.*

Modified feeding organs. Aquatic and wetland-inhabiting species have many feeding adaptations to wet life, such as long bills, or filtering bills, or ciliated mouths. *Example: ducks.*

Anaerobic respiration. Cells may alter biochemical pathways normally associated with oxygen. Some bacteria use sulfate instead of oxygen as electron acceptors for respiration, giving marshes their characteristic rotten-egg odor. *Example: Desulfovibrio spp.*

Modified respiratory pigments. Some animals have high concentrations or modified circulatory pigments with high affinities for oxygen. *Example: nematode, Enoplus communis.*

Exercise: Discouraging herbivory - plant defense mechanisms

Preparation: Visit a wetland area with group of people and a botanist. From the list of plant adaptations above, find as many wetland adaptations as possible. Read the discussion below and locate as many plant defenses as possible. Note: for this exercise, do not to pick or touch any of the armed or poisonous plants. Have the botanist name the plants and explain the use of genus and species. Now have the botanist name some forage plants. Have individuals of the group review the exercise by pointing to the plants described by the botanist, and describing which ones are poisonous and which are not. How would an animal know not to eat the poisonous plants?

Wetland plants grow in a nutrient-poor environment, and consequently, many wetland plants are at the edge of survival. In order to discourage browsing, some plants have evolved defense mechanisms. Examples of defense mechanisms include the thorns of roses, the prickles of some currants and thistles, and the slightly poisonous spines of devil's club. A less obvious plant defense mechanism is the production of toxic substances. Wetlands have many well-known toxic plants, as in the following examples:

- Labrador tea (*Ledum* spp.) contains *ledol*, a narcotic.
- Monks-hood (*Aconitum* spp.) contains cardiac and nervous depressants that have been used as arrow poisons.
- Willow bark (*Salix* spp.) contains salicylic acids corrosive to smooth muscle.
- Bog-laurel (*Kalmia* spp.), and members of the rhododendron family contain andromeda-toxins, which are so poisonous that honey made from their flowers can be fatal to mammals.
- Valerian (*Valeriana* spp.) contains alkaloids with depressant actions.
- Nettles (*Urtica* spp.) have formic acid in hollow needles on their stem, which they automatically inject into the skin of animals that brush against them.
- The buttercup family (*Ranunculaceae,* except medow rue) has compounds in the leaves that can blister skin.
- Many plants, e.g., the umbel and mint families species contain numerous essential oils that can damage kidneys.
- Water-hemlock and Douglas hemlock (*Conium, Cicuta* spp.) have nicotine-like alkaloids and were notably used in the death sentence of Socrates. Even skin contact can absorb enough toxin to cause fatal reactions.
- Cow parsnip (*Heracleum lanatum*) contains furano-coumarins that cause allergic dermatitis.
- Horsetails (*Equisetum* spp.) contains silica to discourage grazers.
- Elegant death camas (*Zigadenus* spp.) contains toxins used as arrow poisons by native peoples.
- Hellebore (*Veratrum* spp.) contains alkaloids that lower blood pressure.

Section 6 Wetland Ecology

Discussion: Moose and moose-moss - generalist or specialist?

Specialists are species with a specific food or habitat preference; *generalists* are those species that don't have special habitat or nutrient requirements. For instance, insect pollination is an example of specialization, whereas wind pollination is a generalist strategy. Extreme specialists with a very narrow range of habitat requirements are also termed *obligate* to that habitat. *Facultative species* are those that can meet their life requirements in either of two or more different habitats. As browsers, moose are generalists in that they *can* use a diversity of species, but they are also specialists in the sense that in certain seasons, they *must* browse and forage in wetlands.

Questions:

1. Fill in the blanks. The slide alder is adapted to living in avalanche chutes, but it is sometimes found growing in wetlands. It is ________ (facultative or obligate) to wetlands.

2. The mountain alder lives in both riparian wetlands as well as isolated wetlands. It is ________ (facultative or obligate) to wetlands.

When two different species live together the relationship is termed a symbiosis. When two different species each benefits from close and obligatory contact with the other, the relationship is termed *mutualism*. When one of the species benefits and the other is neither benefited or harmed, the relationship is termed *commensalism*. When one species benefits and the other is harmed, the relationship is termed *parasitism*.

3. Mosses in the genus *Splachnum* are both rare and beautiful examples of specialists. They form miniature purple or yellow parasols several inches tall, and grow strictly on moose dung. Their spores are dispersed by flies which appear to use the parasols as landing pads. The flies can land on other types of vegetation so they are ________ (facultative or obligate) to the moss for landing pads. The mosses are ________ (facultative or obligate) to the flies? *Answer:* Since both flies and moss benefit from the relationship, the relationship is mutualistic, however only the moss is obligately tied to the relationship.

4. The mosses are ________ (facultative or obligate) to the moose? Do the moose benefit from the moss? *Answer:* the moss is obligately tied to life on moose dung, but the moss does not contribute any habitat requirements to the moose.

5. The relationship between moss and moose is ________ (mutualism, commensalism, parasitism).

Section 6 Wetland Ecology

Anaerobic Environments

The saturated soils of wetlands have their interstitial pore spaces filled, and this hinders the exchange of gases and nutrients necessary for plant growth, and thus limits wetland floras to those plants that can tolerate saturated soils or which have adaptations that make nutrients and oxygen available to the plant.

The lack of oxygen in wetlands means that the rate of decomposition, or the breakdown of dead tissues into smaller and smaller components, is greatly reduced. Decomposition depends on both physical factors and chemical factors. Physically, plants break down through breakage, freezing, and consumption by animals. The primary means of chemical breakdown is through oxidation by air. There is little or no air in the pore spaces of wetland soils, and thus decomposition is slowed down. An environment without oxygen is termed *anaerobic*.

Because of low oxygen levels, decomposition of organic matter is slowed, and long-dead material may be very well preserved. It is believed many fossils localities formed in this way, and a number of important historic and cultural sites have preserved glimpses of the clothing, foods, and even buried remains of long-vanished cultures. Scientists take advantage of the preservation of plant spores and seeds to infer what plants were growing on a site hundreds or even thousands of years ago.

Exercise: decomposition in anaerobic environments

Preparation: Visit a bog (or other wetland with organic soils) environment. Bring shovel, ruler, pocket knife, magnifying glasses, and if available, microscope.

Signs of anaerobic environments are apparent by inspection of wetland soils. Find an area within a wetland with organic soils. Being careful with shovels, dig a pit until the organic horizon is plainly visible. Using the ruler, sample pieces of the soil every inch down, well into the organic layer. Have the group observe each sample with a magnifying glass or microscope.

Look for pieces of intact plant tissue, seeds, macroinvertebrates, nematodes, and animal signs. Does the decomposition change with depth? How many years do you think are represented by each inch of soil (hint: look for layers of volcanic ash, or pieces of vegetation that no longer occur on the site. If hardpan is hit, then the depth to the hardpan, might date to the wetland's formation atop glacial soils, approximately 10,000 years). What other indicators of anaerobic conditions are present in the soil? (Hint: look for dark coloration due to tannic acid reduction and sniff for sulfidic rotten egg odor). Save some of the samples for the previous exercise.

Exercise: investigating decomposition and nutrient cycling in aerobic environments

Preparation: Visit a humic environment, preferably a forested wetland, with decomposing logs. Bring shovel, ruler, insect collection vials, pocket knife and magnifying glasses or microscope; bring samples from the previous exercise on anaerobic soils.

The top layer of soil contains the most organic matter. When this organic matter decays, it forms a rich, dark, well-aerated soil called topsoil. The organic part of topsoil is called humus. The topsoil is an important contributor to the life requirements in the food web. Without it, soil is merely ground-up rock, and nutrients are not readily available for growth. The difference between well-decayed humus and the humic histosols of wetlands is that humus is aerobic, with ample open space in the soil for gas exchange.

The process of oxidation is greatly sped up by nature's decomposers that help break up the soil into finer particles, exposing more wood surface area to the air. Decomposers include fungi, bacteria, worms, larval insects, wood and bark beetles, birds and animals.

The process of wood decay is extremely complex. Many species gnaw wood in concert with bacteria that inhabit their gut and help them breakdown resistant plant materials such as cellulose. But that is only a small part of the picture. Wood beetles also have specialized pockets on their back which carry fungi and bacteria into the galleries they carve. As they gnaw away, the wood is inoculated with the wood-stain fungi and bacteria from the pockets on the beetle's back. The wood-staining fungi then assist the process of breaking down the wood, and as they do they produce chemicals that signal other beetles that a decay is in process. Another wave of beetles may arrive either to mate with the first beetle, or to prey upon it. Meanwhile each successive wave of new beetles inoculates the log with new fungal species, and releases a different set of chemicals to attract mates. Secondary fungi move into the wood, following the wood-stain fungi. Eventually, over a process of many years, the log that has been home to so many animals is broken down to soil.

Using a flashlight, examine the holes in a rotten log. Don't stick bare hands into holes, since they may contain biting animals. Don't break the log apart, but gently pry up a section and observe the types of insects in the log. Scoop some of the log and its insects into the collection vials for observation. (When done with this exercise, put all the insects back and replace the top of the log.)

What is the difference between the animals and insects living in the log, versus those in the wetland? How is the soil structure, texture, and wetness different? Do you see any evidence of fungi? (Hint: look for white threads, mushroom bodies, and black stain fungi). Envision what the ground would look like without decomposers. In some wetlands, the undecayed plant material builds up so deep that the area becomes a dry upland, called a raised bog!

Succession - Forested wetlands

Preparation: Visit a forested wetland.

Habitats can change over time, even changing into different habitats. There is a dynamic interplay between forested uplands and wetlands called succession, meaning the successive change from one type to another. Although succession is usually envisioned as proceeding from lake to wetland to forested wetland, to upland forest, recent scientific studies demonstrate that the reverse is sometimes the case, or that forests and wetlands cycle back and forth in a sort of continuum.

Examples of wetland succession to forest are infilling of a former lakebed, or of peat buildup to form a raised peat upland above a former bog. An example of forest yielding to wetland, would forest mortality leading to decreased transpiration, and raised water tables. An example of a cyclic system has been documented in prairie potholes whereby wetland vegetation is wiped out by muskrats, and can't reestablish until a drought year exposes dry soil, whereupon typical succession follows until cattails once again dominate the site, ready for another muskrat invasion.

Visit a forested wetland and compare the plants seen with those seen in the bog. Which new species are present. Dig several soil test pits across the boundary from wetland to upland. Are the soils different? Observe characteristics of the water regime and sample for macroinvertebrates. What hydrologic differences can be observed? Do you think the area is moving toward or away from a wetland community, or is it stable?

Section 7 References - Glossary of wetland terms

adaptation. A genetic modification of a species that makes it more fit for existence under the conditions of its environment.

adventitious roots. Roots found on plant stems in positions where they normally do not occur.

aerobic. A situation in which molecular oxygen is part of the environment.

anaerobic. A situation in which molecular oxygen is effectively absent from the environment.

aquatic. Pertaining to deepwater environments.

aquifer. A subsurface formation containing permeable, saturated material that holds a usable supply of water.

benthic organisms. Species that live on the bottom of lakes, ponds, oceans, and tidal zones.

bog. A nutrient-poor peatland characterized by spongy mosses such as sphagnum, with no nutrient input except rainwater.

boreal. Pertaining to areas related to the north polar region.

bottomland. Land covering the base of a valley.

clay soil. Soils composed of clay minerals, which due to their microscopic plate structure and swellability, form waterproof seals when wetted.

commensalism. The relationship when two different species live together and one of the species benefits and the other is neither benefited or harmed.

community. All of the living species in a shared environment.

Cordilleran ice sheet. The ice sheet formed on the west half of North America during the Pleistocene Epoch.

cover (plant). The area of a species of plant as projected on an imaginary horizontal plane.

delineation. The process of marking the boundary of a wetland.

dominant species. A plant exerting a controlling influence on the plant community, or in which its coverage is relatively high.

ecology. The study of the interactions of a system of organisms living in a defined environment, from the Greek, *oikos*, habitat or home.

eutrophic. Oxygen depletion of a body of water caused by excessive growth and decay of organisms.

emergent plant. A rooted herbaceous plant species that has parts extending above the water surface.

facultative. A species that can meet its life requirements in either of two or more habitats.

fen. A mineral-rich peatland which receives most of its nutrients by spring water. Fens are classified as rich (in minerals) or poor (grading into a bog).

flora. A list of all plant species occurring in a given area.

generalist. A species having a broad food requirement or habitat preference.

geomorphology. The science of landforms.

habitat. The environment occupied by individuals of a particular species.

herbaceous plant. A nonwoody plant.

histosols. Organic soils that have organic soil materials in more than half of the upper 80 cm.

hydric soils. A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that restrict the growth of vegetation to species adapted to those conditions.

hydrology. The science dealing with the properties, distribution, and circulation of water.

marsh. A wetland without peat, with fluctuating water levels and dominated by herbaceous vegetation, and having decomposed organics in the soil layer.

mire. A peat-forming wetland, including bogs and fens; a peatland.

moraine. A mass of rock debris deposited by a glacier.

muck. Highly decomposed, dark organic material in which the original plant parts are not recognizable.

muskeg. A boreal swamp or bog formed by the accumulation of organic matter in a cold, wet environment, without drainage, and low in phosphorus and nitrates.

mutualism. The relationship when two different species live together and both species benefit from the obligatory contact.

nutrients. Elements or compounds required for the growth or survival of organisms.

obligate. A species which requires a certain habitat or conditions to live.

organic soil. A soil is classified as organic when it is (1) saturated for prolonged periods and has more than 30% organic matter in clay soils, or 20% organic matter (non-clay soils), or 34% organic matter (non-saturated soils).

pH. A measure of the relative acidity or basicity of a solution based on a scale of 1 to 14, where 1 is acidic, 7 is neutral, and 14 is basic.

parasitism. The relationship when two different species live together and one species benefit while the other is harmed.

population. A group of individuals of the same species that occurs in a given area.

respiration. The sum total of metabolic processes associated with conversion of stored (chemical) energy into kinetic (physical) energy for use by an organism.

rhizosphere. The zone of soil in which interactions between living plant roots and microorganisms occur.

riparian. Areas affected by the proximity of an adjacent river or stream.

symbiosis. The relationship when two different species live together, and at least one is obligately tied to the relationship.

peatland. A wetland with partially carbonized vegetable soils derived from the buildup of organic matter. Peatlands occupy three percent of the world's land area, but store 20 percent of the world's soil carbon pool.

Pleistocene epoch. A geological epoch of the Quaternary Period, during which the ice sheets of the northern hemisphere were advancing, and including the time during the previous interglacial, from 1.6 million years ago to 10,000 years ago.

plot. A defined area of land used for measuring or observing existing conditions.

remote sensing. Methods of generating maps, views and information about a land area through aerial photography and satellite imagery.

specialist. A species with a specific food or habitat requirement. *See generalist.*

sphagnum moss. A group of pale-colored mosses with clumped leaves that are characteristic of peatlands, which are derived from their accumulation over centuries. Phenolic compounds such as sphagnol tend to accumulate in muskegs and bogs, making such areas acidic.

topography. The configuration of a land surface, including its relief and the position of natural and man-made features.

transect. A line on the ground along which observations are made at a predetermined distance interval.

transpiration. The process in plants by which water vapor is released into the gaseous environment, primarily through pores called stomata.

tree. A woody plant capable of reaching a height greater than 10 meters with a single stem.

unconsolidated parent material. Material from which soil develops, usually formed by weathering of rock or placement by natural forces of water, wind or gravity.

upland. An area that is not a wetland, nor aquatic.

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