Updated 12/2011

Winter Wildlife

Environmental Education Lesson Plan
Edwards Camp and Conference Center

Summary
Students examine the amazing winter adaptations that wild animals exhibit. They will learn survival strategies that animals use in order to survive the weather and other animals. Students will then apply these adaptation ideas to winter survival ideas in people.

Usage – Grade Levels 1-6. Use Sunset Hill area, hardwood forest. October through March

IL Standards
12.A.1a; 12.B.1a
12.B.2b
12.A.3c

Objective
Upon completion of this lesson students will . . .
- Understand wild animals react in 1 of 3 different ways to winter (tough it out, hibernate, or migrate)
- Be able to name at least 3 animals and how they adapt to winter
- Explain 3 survival/energy conservation lessons we have learned from wildlife

Materials
- Animal Winter Adaptation Cards
- Animal cards
- Examples of natural insulations (fur, down, cattail seeds)
- Film Canisters for "Jello" Frogs
- Liquid Jello
- Container of beans or corn
- 6 Animal Cut-outs

Set-Up
- One tablespoon of gelatin per cup of hot water to make frog mixture
- Fill one film canister for each student half way up.
- Place out winter adaptation cards.
- Place out the wooden animal cut-outs for the survival hike

Introduction (5 Minutes)
All living things need specific resources in order to survive. What are they? *Food, water, shelter, and air.* As the seasons change some of those resources become harder to find in their environment. What do animals in the area do in order to survive the winter time? *Hibernate, Migrate, or Tough It Out.*

Hibernation – A deep sleep where the animals go into a long period of inactivity. Their heart rate and body temperature drop drastically during this time. "True" Hibernators that we have in the area are woodchucks, ground squirrels and bats. Other animals such as bears are only light sleepers where they will wake and forage during the middle of the winter. A true hibernating animal will look as if it is dead.

Migration – Many animals will head to warmer climates for the winter. Many birds migrate not because they can't deal with the weather but because the food becomes much more scarce during the winter months.

Tough it Out – If animals do not leave the area or hibernate, then they must find another way to survive the winter. Animals will collect and store food in preparation of winter. Some animals get a thicker coat of fur/feathers or begin to store fat in their bodies. They also might start to insulate their nesting areas.

<u>What Do They Do?</u> (10 Minutes)
- Set up the three labels for Migration, Hibernation, and Toughing it Out.
- Hand out the animal pictures to the students.
- The students must decide on which animals belong to each group and place them accordingly.
- If you have more time and/or a more energetic group place the labels farther apart.

When all the pictures are placed in the correct places talk about each animal and why the students made the choices that they did.

<u>Winter Preparations</u> (20 Minutes)
In expectation of winter each animal has their own way of getting ready. For those animals planning to try to tough out the winter these preparations can be pretty involved.
What types of things do you think that they will do to prepare?
Collect food and store food, insulate their nests,
Animals such as squirrels will bury caches of food to be eaten later. Let the students know that they will have the opportunity to be squirrels today

- Divide the students into two groups; grey and red squirrels.
- Explain that these two species live in around Camp Edwards
- They look similar but prepare for winter in two different ways.
  - Red Squirrels hide all of their food in one place
  - Grey Squirrels hide their food in many different places.
- Give them 5 minutes to hide their food.
- Once they have hidden their food call them back together and let them know that we are going to play a game of winter survival. They will be going through three rounds of winter months. **December, January,** and **February**.
- In each round the students must collect 3 pieces of food from **ANY** cache, if they don't find enough food then they have not survived.
- There is no "defending" any cache of food as well as no stealing from any food held by a person.

Jello Frogs – (10 Minutes)

What happens to Reptiles and Amphibians in the winter? They are cold blooded so they cannot tough out the winter and most cannot migrate. All of the native reptiles and amphibians hibernate in some way shape or form. Many will bury themselves below the frost line or in a decaying pile of leaves so they won't freeze solid. Most amphibians and reptiles will die if they freeze solid so it is pretty important to find someplace that will shelter them.

In this activity the students will have the opportunity to help a "frog" survive the winter.

- Each student will be given a film canister filled with liquid jello.
- They have to find an appropriate place for their frog to hibernate.
- They can use any materials that they find outside.
- Give each student a piece of flagging tape to mark where their containers are.
- Have them place their "frog" then go on a hike and check the results when they return.
- If the Jello has solidified then their frog did not survive, if it is still liquid then it is "alive"

Survival Search (20 Minutes)

Now that the students have learned a good amount about winter animals and their adaptations for dealing with the cold it is time for a hike. Their goal of the "survival search" is to find examples of wildlife that is preparing for the winter. Your walk should lead you to many different areas that will allow you to find examples of our winter wildlife. You will want to look for tracks, burrows, or nests. You should visit many places in order to find many examples. These include **thickly wooded areas, the edge of the marsh,** around **brush piles,** and any place that **has cover from the wind.**

If you placed the animal cut-outs before class let the students know how many you placed out and see if they can find all 6.

Stop and talk about any wildlife signs that you find.

- What animal do you think made the signs?
- Can you tell what the animal is doing for the winter?
- What can we learn about survival from the animal?

Be sure to check on the "frogs" at the end of the hike.

Conclusion (10 minutes)

- What are three ways animals react to approaching winter?
- Name an animal that is active in the winter and how does it survive.
- Explain what we can learn from animals to make us more energy efficient.

Animal Winter Adaptations

1. Migration and Movement. Many species migrate between seasons. Some, such as the arctic tern, travel 10,000 miles between winter and summer habitats. It's difficult to ignore the migration of geese, cranes, and ducks . . . and difficult to believe that monarch butterflies actually migrate to Mexico. How in the world do tiny hummingbirds fly all the way across the Gulf of Mexico? The return of the colorful and vociferous warblers becomes obvious in the Spring, but their departure in the Fall is generally missed. The first Spring bluebird is noted by many . . . but few can mark their departure date.

Migration is not always a dramatic, long-distance affair. Other species, such as white-tailed deer, move to areas that are more survivable. Deer pretty much vacate the Lake Superior watershed during the deep snow season. Biologists have been able to track some of these migration patterns in the U.P. Reptiles and amphibians move to protected places underground or under water to avoid freezing temperatures. Fishes will move to different waters. More recently, most of us noted the indoor migration of the Asian ladybird beetle!

For those people who prefer to be indoors most of the winter, the outdoors may appear to be uniformly cold and uncomfortable. However, there are many microclimates where winter stress is significantly lower. Logs, caves, holes, dead trees, spruce and cedar stands, under snow, and human structures are examples of places that provide shelter from winter extremes. These are critical places for wildlife.

Not all animals that migrate leave Wisconsin, either. Some actually migrate *TO Wisconsin* for the winter or on a cyclical basis! Chickadees and great gray owls are two good examples. The playful, curious, and nearly fearless whisky-jack makes its presence well-known at camps and many winter feeders. We need to remember that our winters are not as severe as we sometimes boast about. There is a large land mass to our north where winters are considerably longer and colder!

2. Torpidity is a controlled reduction of body metabolism, evidenced by low oxygen consumption rates and lower body temperatures. A key part of the definition is accurate metabolic control. It is a phenomenon restricted to warm-blooded animals. Cold-blooded animals experience different physiology in response to adverse conditions. Some animals will undergo daily states of torpidity as a response to a lack of food and in combination with other environmental conditions. Other species undergo seasonal torpidity. In the north, **hibernation** is the most dramatic form.

Many northern species undergo metabolic changes that allow them to "sleep" through the winter. Sleep, of course, is not what they do, but torpor can superficially appear that way. The most advanced form of torpor is hibernation. Hibernation is quite complex and fascinating. Although definitions are evasive, hibernation is a *controlled* significant drop in metabolism to a selected level, although the term hibernation is sometimes used for cold-blooded animals and any form of winter dormancy. Chipmunks, certain mice, ground squirrels, and groundhogs are examples of true hibernators. Their body temperatures are maintained a few degrees above their ambient environment, which is usually in a place protected from weather extremes. Hibernators are usually small animals because small animals have high rates of metabolism to begin with. Increases in these already high rates of metabolism in order to maintain body temperature comes at a metabolic cost that is just too high for some species.

True hibernators cannot be easily "woken up". They are largely unresponsive to external stimuli. Generally they maintain only a sufficient amount of specialized fat reserves to carry them through the winter season and arouse them during the late winter or early spring. Arousal is a very expensive metabolic process that they can usually afford to do only a few times, sometimes only once. Bears do not hibernate, although this continues to be argued. Their body temperatures drop only a few degrees and metabolism is reduced to only moderate rates. Female bears give birth during the winter, something that would not be possible for a true hibernator. Lastly, bears can easily be aroused in the winter and then drop back into a state of torpidity. Don't be fooled by a "hibernating" bear in its den!

Dormancy in cold-blooded animals is a reduced state of metabolic activity largely controlled by environmental conditions. Cold-blooded animals must become dormant during the winter because they lack the internal control over their metabolism. Many seek sheltered places and undergo chemical changes to prevent their tissues from freezing. Others can tolerate certain levels of ice between cells, commonly in tandem with chemical changes. Spring peepers, chorus frogs, gray tree frogs, and wood frogs tolerate and regulate a frozen state. Good snow cover is essential to survival, as they overwinter under leaf litter on the forest floor. These frogs thaw out in the spring, which is why we hear them sing so early in the season on those increasingly warm evenings.

Insects overwinter as eggs, pupae, or adults. Dormancy is often coupled with specialized chemical adaptations to help survive the winter season. Some have the ability to resist freezing, others can tolerate freezing to certain degrees. There are also insects that can employ either strategy. Chemicals associated with dormancy are sugars and certain alcohols such as glycerol, sorbitol, mannitol, and ethylene glycol.

3. Toughing It Out. Winter remains an active time of the year because many species have adapted to active lifestyles during the winter. Cold-blooded animals (amphibian, reptiles, and insects) must find sheltered places where they can ride out the winter without freezing and being eaten by predators. Fish continue to be active (as ice-fishers know!) but often at a reduced rate. For some species, the winter energy equation is always negative, meaning they cannot consume or conserve enough energy to survive the winter. While consumption and conservation are critical, these species must rely on fat reserves and their margin for survival is often slim. This is part of the reason why long and severe winters can take a heavy toll on wildlife populations whose northern range occurs in Michigan.

- Northern species of a particular genus or similar class of birds or mammals tend to be larger in size, although this is not always true. Larger body size means a higher body mass-to-surface area ratio. It's easier to retain heat. Polar bears are larger than tropical bears.

- Body appendages tend to get smaller in the north, as a heat conservation measure. Snowshoe hares have smaller ears that cottontail rabbits. Mammalian legs and snouts are frequently shorter and stouter.

- Specialized fat, called brown fat, is produced during the food-rich seasons and expended during cold seasons. This is also the kind of fat that most hibernators use for arousal and many migrators use for fuel.
- Various "heat exchange" mechanisms can be found in animal circulatory systems that reduce heat loss to body extremities.
- Certain fish and herptiles produce chemicals within and between cell walls that can lower their freezing temperature a few degrees. In sheltered environmental niches, these few degrees can mean the difference between life and death.
- Some mammals, such as flying squirrels and small rodents, will occupy collective dens to conserve body heat, even though some species are non-colonial during the warm season. This is part of the reason that some species of snakes will do the same thing.
- Food preferences change with the season. Some browsers, such as white-tailed deer, have changes in digestive enzymes to cope with the different food sources. This is one of the reasons why biologists argue against winter deer feeding. If not done correctly, a deer can starve to death with a belly full of corn.
- Ruffed grouse "snow roost" during periods of extreme cold. Snow provides a very effective barrier against severe cold. They will rest under the snow until the severe weather passes. Folks who snowshoe or cross-country ski too close to these snow roosts are often caught off-guard when a grouse explodes out of the snow. Large piles of grouse droppings are spring-time indicators of how severe the winter was.
- Aquatic mammals, such as otter and mink, grow thick layers of insulating fat and have specialized fur. Similarly, ducks, geese, and swans have feathers and oil glands that keep water away from the skin. Some have efficient circulatory heat exchangers between the body and the feet. It's usually not the cold that causes waterfowl to migrate. It's more a matter of food shortages.
- Birds and mammals undergo seasonal changes in feathers and pelage. Trappers know that winter pelts are the highest quality because they are thicker and have different kinds of hair.
- Muskrats and beaver construct shelters, partly for protection from severe weather. A number of animals dig burrows, such as groundhogs, foxes, chipmunks, and moles.
- Many species of birds can adjust their internal body temperature downward to reduce the temperature gradient with environmental temperatures, thus reducing heat loss. They also tend to shiver a lot to maintain body temperatures.

Winter Adaptations for Trees

Trees must have adaptations to survive the cold and drying conditions of winter. Trees cannot change their location or behavior like animals can, so they must rely on physiological and structural adaptations.

The height advantage of trees becomes a liability in the winter, as tissues are exposed to the weather. There are four basic strategies that trees employ.

1. Either leaf drop or adaptations for leaf retention.
2. A physiological acclimation process.
3. Resolution of water issues.
4. Methods of reducing mechanical damage.

Leaf Drop

Leaves are a major source of water loss and are difficult to protect from winter conditions. Most trees drop leaves in the autumn to avoid these problems. Conifers are the exception and will looked at in the next section.

Annual leaf and flower expansion requires tremendous inputs of water and nutrients. Trees must produce and store a sufficient amount of reserves during the four to five month period when leaves are photosynthesizing. Buds are usually set by the end of July. Above-ground growth also ceases in late summer.

Physiological processes, including leaf drop, are stimulated largely by changes in photoperiod. The lengthening dark period changes the production rates of a number of chemicals and hormones. The most important is probably the increase in abscisic acid (AA). AA slows protein and RNA (ribonucleic acid) production. Both are keys parts of growth. AA also increases cell membrane permeability, which is important in the acclimation process.

Chemical breakdown of the green chlorophyll molecules reveal the pigmentation of the yellow and orange carotenes and xanthophylls. The scarlet colors are enhanced by hard frosts affecting residual sugars and anthocyanins.

Abscission layers between the leaf stem and the twig are formed. Cells along this line expand at different rates, and enzymes degrade tissue. As a result, a physical line of weakness develops. *Scar tissue* is formed over the attachment point that prevents water loss. Gravity and wind cause leaves to drop.

Not all trees lose their leaves at the same. Black ash is usually the first to drop leaves. Some species will retain brown leaves well into the winter, especially oaks, ironwood, and beech. In May of each year, leaf growth can be tracked by species. Black ash and bigtooth aspen are among the last tree species to leaf-out.

Adaptations For Leaf Retention

In the north temperate forest, all broad-leafed trees lose their leaves. Each year conifers also drop leaves, similar to broad-leafed trees, they just don't shed them all. Most conifers retain needles for two to three years before shedding them. Although conifers require the resources to produce new needles each year, they gain a large measure of economy by using a set of needles for more than one year. The coniferous exception to this needle-retention strategy is the genus Larix, the tamarack and larches.

Conifer needles have a thick, waxy coating of cutin that significantly reduces water loss. Needles also have much tighter stomatal closure. Stomata are the pores that allow air and water to pass in and out of the needle. Lastly, tissues undergo an acclimation process, similar to other living tissues in trees.

Retaining needles allows trees to extend the length of the photosynthetic season. It also potentially allows trees to take advantage of winter thaws and, perhaps, even to permit slow rates of photosynthesis during cold weather. However, needle retention presents serious challenges in terms of water loss, water re-supply, and snow-loading.

Acclimation

Loosely analogous to animal hibernation, trees undergo changes that allow them to survive the cold, dry conditions of winter. This process occurs at the cellular level and exploits the physical properties of water.

All trees have a measurable "killing temperature", the temperature where ice crystals form within cell structures resulting in cell death. Killing temperatures vary among different species, between populations of the same species, and even among different tissues. In some cases, killing temperatures are limiting factors for species ranges.

Like leaf-drop, acclimation is prompted by changes in the photoperiod. Abscisic acid (AA), once again, plays a key role. Physiological changes include:

1. An increase in AA production.
2. Lipids (soluble fats) unsaturate.
3. Lipid concentration within cells increases.
4. Proteins de-polymerize.
5. Cell membrane permeability increases.

Solute concentrations within cells increase, slightly reducing the freezing point. Therefore, as temperatures drop, water outside cells freezes first. Freezing water releases small amounts of heat energy, which in turn, helps cell fluids remain unfrozen. Twig temperatures actually rise several degrees during this process. Water moves out of cells attracted to the ice crystals in the pore spaces. This process effectively reduces the freezing point of cell water to the killing temperature. Colder temperatures will begin to result in cell freezing and death.

Water Loss

Water is lost primarily from above-ground biomass. Bark and buds are fairly water-tight. Drastically lower levels of photosynthesis and respiration reduce water demand and subsequent loss. Conifers, however, have huge surface areas of living tissue in their needles. Any photosynthesis that might occur will increase water demand and risk of loss.

Water vapor moves from areas of high concentration to low concentration. Concentrations are usually higher inside needles, so the tendency is for water to be lost from foliage. Needles have advanced structures to present a barrier to water loss, but cannot eliminate it. In addition to tight stomatal closure and cutin, reduced air movement around needles will contribute to lower vapor gradients. Air "boundary layers" act like insulation. The dense foliage of conifers, especially stands of conifers, serves to mediate micro-environmental conditions somewhat. The fuzzy undersides of evergreen broad-leaf shrubs serve to increase this zone of "insulation".

Oddly enough, warm, sunny days present the greatest water retention challenges for conifer foliage. Dark needle coloration readily absorbs heat and raises needle temperatures significantly above ambient air temperatures. Metabolic rates rise and internal vapor pressure increases. Despite thicker air boundary layers, the net effect is greater water loss.

Cloudy, windy days are actually better for conifers. Clouds block warming solar energy and wind readily removes heat from the needles, reducing the vapor pressure gradient.

Water Supply

Conifers have larger winter water demands than most broad-leaf trees (some hardwoods have photosynthetic bark and branches, which increases water demand). Without re-supply sources, trees would die from water loss. However, freezing temperatures and frozen water would make re-supply seem impossible.

There are three potential sources of water; 1) the soil, 2) internal tree reservoirs, and 3) subnivean (below snow) vapor absorption.

Soils are not always frozen. In fact, much of Wisconsin's soil remains unfrozen for all or part of the winter. The insulating effects of snow can result in ground thaws or prevent freezing in the first place. This means that liquid water is available. Transportation above-ground becomes an issue, discussed later.

The sapwood of trees and branches contains water. Oftentimes this water is frozen and unavailable. However, differential warming (solar insolation) and winter thaws can melt the sapwood water, making it available for transport.

Lastly, conifer branches below snow-level might benefit from higher water vapor concentrations *outside* the foliage. Potentially, this absorbed water could be transported to other locations in the tree.

Water Transport

Given that liquid water sources exist during the winter, the problem of transport remains. Water cannot be moved while frozen, so temperatures along a transport line from source to sink must be near or above freezing.

Water is moved within a tree through the xylem, which consists of cells that make up long tubes, called tracheids. The strong cohesive properties of water permit continuous columns of water to be "pulled" through the tracheids. If a water column is broken, it is virtually impossible to restore the column.

When tracheid water freezes, two things potentially break the water column. Ice crystals stop the flow. More importantly, as ice forms, dissolved gases are expelled and form gaps in the column. Upon thawing, these air gaps remain, rendering the column unusable for water transport. Hardwood (broad-leaf) trees grow new xylem cells in the spring to re-establish the water transport system.

Conifers have some fascinating adaptations that overcome the problem of broken water columns.

Within the transport tubes, conifers have tiny "check valves" between each tracheid. Ice formation and volume expansion increase pressure within a water column causing the "float" within the check valve to seal the ends of each tracheid making up a tube. The float is called a "torus". The expelled gas is held under pressure within the tube by the incredibly strong tracheid walls. Measurements have demonstrated that the tracheids can hold pressure up to 900 psi. When the ice crystals melt, the gas is forced back into solution, pressure returns to normal, the tori migrate back to the middle of the check valve, and the water column is restored.

Water column restoration in conifers can occur multiple times during the winter during warm periods or when solar insolation is high. Foliar water stress caused by those warm, sunny winter days can be alleviated by restored water columns supplying water from any of the available water sources.

In addition to the clever adaptations of conifer xylem cells, there is evidence suggesting that water can also be diffused from cell to cell via the phloem, in both hardwoods and softwoods (conifers). Diffusion is slow but may be sufficient to meet the water demands of dormant hardwood species that appear to have no other winter water transport system. This may help explain why some hardwood species, such as paper birch, can survive winter conditions right up to the treeline.

Other Winter Season Challenges to Survival

Conifers have higher leaf densities than hardwoods. This means snow can quickly accumulate to the point of stem and branch breakage. Ice storms can be even more detrimental. To offset this snow-loading problem, conifers display alternative growth and branching patterns.

Conifers have a single leader or main stem (determinant growth), as opposed to the many leaders of hardwoods (indeterminant growth). The subsequent cone shape more effectively sheds snow. Conifer branches grow at more obtuse angles to the main stem. This allows branches to reach snow-shedding angles with less bending. Longer wood fibers also generally provide more flexibility.

Denser conifer foliage offers greater wind resistance, potentially leading to breakage, especially when foliage is loaded with snow and ice. Trees on the perimeter of conifer stands take the brunt of wind damage, but the dense foliage also protects those individuals internal to the stand. This factor creates typical stand shapes in mountainous terrain, but is not as pronounced in Michigan. However, Michigan conifers sometimes do display "flagging" in the direction away from prevailing winds. Tall white pine are particularly noteworthy in this regard.

Many conifer species become targets for animal browsing during the winter. Foliage contains some of the better sources of nutrients, although they are poor compared to summer food availability. In many parts of Michigan, high deer densities have eliminated the regeneration of most tree species (hardwoods and softwoods), along with other plant forms. High moose densities have had tremendous impacts on the vegetation of Isle Royale.

Porcupines, rabbits, and mice find sustenance in the living bark and phloem tissue of trees. If the bark is chewed all the way around the stem, the girdling will kill the tree beyond that point. Girdling is an especially severe problem in certain conifer plantations and young trees in old fields.