

Winter Wildlife

Environmental Education Lesson
EDWARDS CAMP AND CONFERENCE CENTER

SUMMARY

Students examine the amazing winter adaptations that wild animals exhibit. Students will apply these adaptations to our own winter survival.

USAGE

Use Sunset Hill area, hardwood forest. Allow 1 – 1 1/4 hours. Grade Levels 1-6

OBJECTIVE

Upon completion of this lesson students will . . .

- Understand wild animals react in 1 of 3 different ways to winter (adapt, 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 shelter cards
Animal cards
Examples of natural insulations (fur, down, cattail seeds)
Containers for “Jello” Frogs
Liquid Jello

INTRODUCTION

All living things need four things to survive food, water, shelter, and space. However, when seasons change, it is often difficult to find all of these items. Therefore animals must be able to change with the weather in order to survive. Their main force of surviving depends upon how well the animal can adapt to the weather changes. Some animals, may **migrate** (move to a different location), **hibernate**, or **adapt** (acclimate themselves to the weather.)

ACTIVITIES

What Do They Do?

Materials Needed: “What do they do pictures” and Answer Key, 3 Category Cards

To begin this activity talk about how animals adapt to the winter weather. First some animals such as bears or frogs will **hibernate**. During the time that these animals hibernate their systems will slow down to allow them to metabolize their food all winter long. Another type of adaptation is **migration**. This is most common to birds, they are often thought of flying south, or to a warmer place, in which they can find the four essential means to survive. The last main way that animals will survive the winter is by acclimating themselves to the cold or **adapting** to the cold. That means they will grow a winter coat, and **remain active** during the cold.

Hand out a picture to each of the students. Keep in mind that animals and people, need four things to survive (food, water, shelter, space). Place the three category cards in the middle of the circle of students. Have the students classify each of their animals into one of the following categories: Migrates, Hibernates, or Active. Have them place their pictures under the category in the middle of

the circle. Discuss the animals that remain active, how do they do this? Which category do people fit into during the winter?

Winter Preparations

Materials Needed: Insulation examples, Shelter Picture Photos

Do people have to do anything special to prepare for winter? What would happen if you went outside in just a t-shirt and shorts? What do clothes do for us? (Insulate – hold in heat, protect us from wind, elements) What physical adaptations do animals have that enable them to survive the cold? Warm fur coats, stored fats, sleep/hibernate. Pass around examples of natural insulations; fur, down, cattail seed. How do animals behave to help themselves survive the winter, (gather and store food, build shelter) show and discuss animal shelter picture.

What happens to the Frogs?

Materials Needed: Thermos of gelatin, empty film canisters

Have the students sit in a circle. Get out the toad (if have been trained on how to handle toad) Discuss what happens to the toad in the winter. Where do toads go? Do they hibernate? Migrate? Or Adapt? What do the students think? What are some types of reptiles and amphibians? Talk about the reptiles and amphibians all need the sun to warm up their body temperatures to survive. They do not keep a constant temperature like humans do. In the winter, this is hard to do. All reptiles and amphibians in Wisconsin need to hibernate. They can't adapt or migrate. Why can't they migrate? (too small, too slow, takes a lot of energy to migrate) Toads dig holes into the dirt or bury themselves under the leaf litter. They need to get down deep enough to avoid the winter freeze. Or find a good leaf pile that is producing enough heat to keep from freezing. How does a leaf pile produce heat? (decomposition) Talk about other reptiles and amphibians, like the painted turtles and box turtles. What do they do to survive? After the students have a good idea about how animals adapt to winter get them ready to head outside.

“Jello” Frogs

Before the students head out on a hike have them pair up with a partner. Give each pair a film canister filled ½ full of gelatin. Explain that this is their frog. They have to find an appropriate place to hibernate their frog. They can use whatever materials outside they find. Give them a big of flagging tape so that they can mark their spot where their frog is hibernating. Place one canister that you prepare right out in the open. This is the test model. After everyone has placed their frog, go on the survival search. Let them know that the gelatin represents their frogs blood. After the hike, come back to see if their frogs survived. If the gelatin hasn't solidified, then they survived hibernation. If it solidified, well then... Check the test model. How did it do? Discuss what worked to help with hibernation, what didn't work.

Survival Search

Now that students have the necessary background information tell them they are going on a “survival search.” They are going to seek out signs of animals getting ready for winter. Their mission is to discover where Edward's wildlife is weathering the seas of change. Your walk should lead you to a thickly wooded area. Look for tracks, burrow, nests, piles of leftover food, etc. Places where you are more likely to find signs of wildlife include: the edge of the marsh, around brush piles, around woodpiles, and places where there is cover out of the wind. Stop and talk about any signs of wildlife you find. From looking at the sign can you tell what the animal is doing to survive the winter? Can people learn something about survival from what the animal has done?

When you reach the woods, ask the students where they would like to be if they were a bird, (the pines/woods, or another habitat they just walked through). Where is there less wind? Explain that when animals sense a winter storm coming they must find secure cover. What will happen if they do not have secure cover? (May die from exposure). Many animals, especially birds make use of the pine plantation at these times.

Winter coats with a layer of long and short hair, curl up in a ball to cover head when sleeping, oils on fur and feathers to prevent water soaking through, fluffing layers of fur or feathers to hold in body heat). Review how animals build shelters to keep warm in winter. What have we learned from animals and their homes that have helped us and our homes become more energy efficient?

WRAP-UP

- What are the 3 ways animals react to the approaching winter (migrate, hibernate, adapt)
- Name an animal that is active during the winter, how does it survive the winter? (Store food, grow a winter, build a burrow, cavities in trees, stick or leaf nest, burrow under the snow etc.)
- Explain a lesson we have learned from wildlife about energy conservation.
- How can we be more energy efficient in our own homes? (Shut drapes at night, storms and plastic over windows, efficient insulation, hay bales or raked leaves around foundation.)

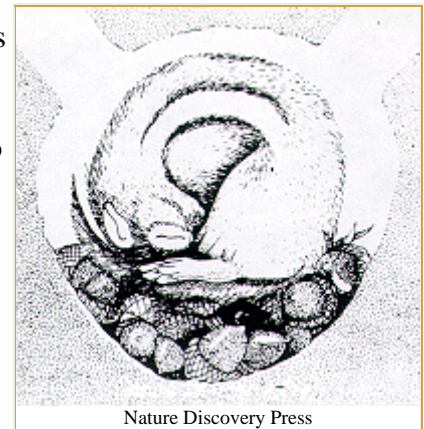
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Extra Information

Snug in the Snow

What happens to animals when the days get shorter and the snow starts to fly? Many head for warmer climates. Others get ready for winter by putting on a thick coat of fur. Some animals head underground for a long winter's nap. This is called hibernation. These hibernators go into a deep sleep. If you saw a hibernating animal you might think it was dead.

Sleeping all winter takes preparation and animals that hibernate begin preparing for it in the fall. They try to put on as much fat as possible because they won't be eating much during the winter. Animals that hibernate also put on a special kind of fat, called brown fat. This special fat is found across the back and shoulders of hibernating animals, close to an animal's organs (brain, liver). Brown fat works fast to deliver quick energy to an animal coming out of hibernation.



Hibernation is still a bit of a mystery for scientists. How does an animal know when it's time to get ready for hibernation? How does their body know to slow down during hibernation? Scientists have found a special substance in the blood of hibernating animals. It's called HIT (Hibernation Inducement

Trigger). If blood is taken from a hibernating ground squirrel in the winter and injected into an active squirrel in the spring, the active squirrel goes into hibernation. (Pretty weird, huh?)

There are different kinds of hibernation. The "true" hibernators sleep so deeply that they are almost impossible to wake up. Woodchucks, ground squirrels and [bats](#) are "true" hibernators. A woodchuck's heart rate goes from 80 beats a minute when active to 4 or 5 beats a minute when in hibernation. Its body temperature drops from 98 degrees Fahrenheit to 38 degrees Fahrenheit. And, the woodchuck's incisors, which grow continuously and are kept short by all the gnawing it does, quit growing during hibernation. True hibernators do get up every few weeks to nibble on food, and in the case of the woodchuck, use an underground toilet room. When bats are ready to hibernate, they must find a place that stays above freezing. They gather together in caves called hibernacula.

[Bears](#) are not "true" hibernators. They are one of the "light sleepers." They are easily awakened from their winter slumbers. These in-between hibernators are simply taking long winter naps. Skunks, raccoons, opossums are also in this group. These animals breathe a little more slowly and lower their body temperature a few degrees while sleeping, but they wake up to forage between winter snows.

Can you think of any other animals that hibernate? How about our cold-blooded friends--[snakes](#), [turtles](#), and [frogs](#). Since cold-blooded animals can't warm themselves up, they need to find a way to protect themselves from the cold. Frogs and turtles bury themselves in the mud below the frostline. They get oxygen from air trapped in the mud. In the spring when the sun warms the mud, out they'll come. Some snakes head underground to hibernate, others gather together in sheltered places, like rotted out logs. Imagine walking in the woods on a spring day and coming across a bunch of snakes emerging from their wintering spot. What a sight that would be!

Hibernation is still somewhat of a mystery and an amazing animal adaptation. The next time you are sitting around the fireplace all snug, warming up after playing outside, think about all the animals that are sleeping, snug in the snow.

Keeping Warm Under a White Blanket

Another adaptation for many plants and animals is to make the most of a blanket of snow. Air is trapped amongst the snow flakes as they fall and this provides good insulation. The temperature under a layer of snow does not usually fall below freezing. The heat from any animals or plants under the snow is trapped in a warm 'igloo'. Small mammals, such as mice, voles and lemmings, can remain active throughout the winter, searching for plant food in a network of tunnels under the snow. The polar bear digs out a den on snowy slopes to give birth or shelter during blizzards. It curls up and lets the snow drift around its body to form an insulating layer.

Adaptations for the Coming Winter

One of the more obvious survival strategies is to simply move to a warmer climate. Migratory bird flights are in evidence this time of year. Fewer songbirds can be found, and the noisy migratory flocks of geese increase in number. Even so, many species of birds will remain in northern areas, some migrating from areas further north. And in the south, increased species diversity can be seen in bird populations as migratory species appear, some to "hang around" for the winter, others just passing through on their way to the tropics.

Birds that remain in northern areas have great insulation in their winter plumage. But food may be scarce, so bird feeders on your school grounds will attract many resident species.

Squirrels and chipmunks are two small mammals that are usually abundant. Students can watch their food-gathering activities as they store nuts and seeds. They also gather grasses and other materials to line and insulate their nests, as do mice. Mice also make their presence known in the home or school as cooler weather causes them to seek shelter in warm buildings.

Larger mammals like raccoons, skunks, and opossums also prepare for winter by storing fat and lining their nests. These animals do not truly hibernate and may venture out during warm spells. Deer also store up fat through the summer, but face food shortages if winter is severe. They can be very destructive in orchards and even in your yards in their quest for winter forage.

Invertebrates also take “time out.” Most insect species spend the winter in egg, larval, or pupal stages – though many also overwinter as adults. The “wooly bear” caterpillars can be seen crossing roads in their wanderings to find a suitable spot to pupate. Some species overwinter below ground, insulated from severe cold. Others weave tough, insulated cocoons for protection, and in many species body fluids have “anti-freeze” for survival in freezing temperatures.

Winter is the most stressful time of year in the north for most forms of life. The key hardships are a lack of food and cold temperatures. However, don't let a reduction in activity appear as if there is nothing going on in the woods!

A lack of food occurs for at least two reasons, both related to low temperatures. The first reason has to do with a reduction in active plant life. Plants, of course, are the sources of nearly all food chains. The second reason has to do with availability. For many animals, food sources are buried under snow or ice. Deep snow is not a problem for all creatures. To field mice, it is a protective layer against most predators. To predators, deep snow means a time of going hungry.

Specialized adaptation to winter involves exploring chemistry, physics, and animal behavior. Managing an energy budget is the key to survival. There are many ways to manage this budget, primarily through combinations of physical attributes (morphology, habitat, and behavior) and physiological capabilities (body chemistry and metabolic controls).

How Do Animals Respond to Cold Winters?

There are three main strategies to surviving inclement conditions, migration, dormancy, and toughing it out. Each species is suited to a particular variant of one strategy or the other, or a combination of strategic elements.



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 migrators leave Michigan, either. Some actually migrate *TO Michigan* 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. During lows in the snowshoe hare population cycles, Canada lynx may roam into the U.P. in search of food. 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. Dormancy. There are several forms of dormancy as the taxonomic groups are surveyed. Definitions are difficult due to the many variations of dormancy. There has been a lot of research into how animals cope with inclement weather, winter in this case.

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. Torpidity is not restricted to northern species and can be found in the tropics, too. **Estivation** is a kind of torpidity in very hot and dry conditions.

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.

Plants also experience dormancy but cannot relocate to sheltered places, other than reverting to seeds on the ground and roots under the ground. [Tree adaptations](#) are covered on another page.



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.

There is a wide array of morphological, physiological, and behavioral adaptations for winter survival. A few examples are provided below, but investigations into the lives of active winter animals will reveal many combinations of survival strategies.

- Bergmann's Rule states that 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. White-tailed deer in Michigan dress out at higher weights than their counterparts in Texas or Florida.
- Body appendages tend to get smaller in the north, as a heat conservation measure. Snowshoe hares have smaller ears than 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.

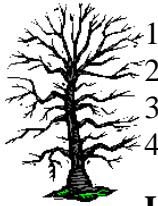
- Certain fish and herptiles produce chemicals within and between cell walls that can lower their freezing temperature a few degrees. In sheltered environmental niches, these few degrees can mean the difference between life and death.
- Some mammals, such as flying squirrels and small rodents, will occupy 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 OF 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 be 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 key 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 time. 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 Michigan’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.

Many birds feed on the rich flower buds of trees. Ruffed grouse are particularly well-known for their affinity for the male flower buds of quaking aspen. However, flower bud browsing has seldom, if

ever, resulted in significant damage. Plantations grown for fruit or seed production may be an exception.

The final winter challenge for trees is human-caused. Trees along major roads may eventually show signs of poisoning from road salts and vehicle exhaust. Some species are more resistant to these pollutants. The more vulnerable species include; white pine, red pine, hemlock, basswood, ironwood, sugar maple, and red maple.