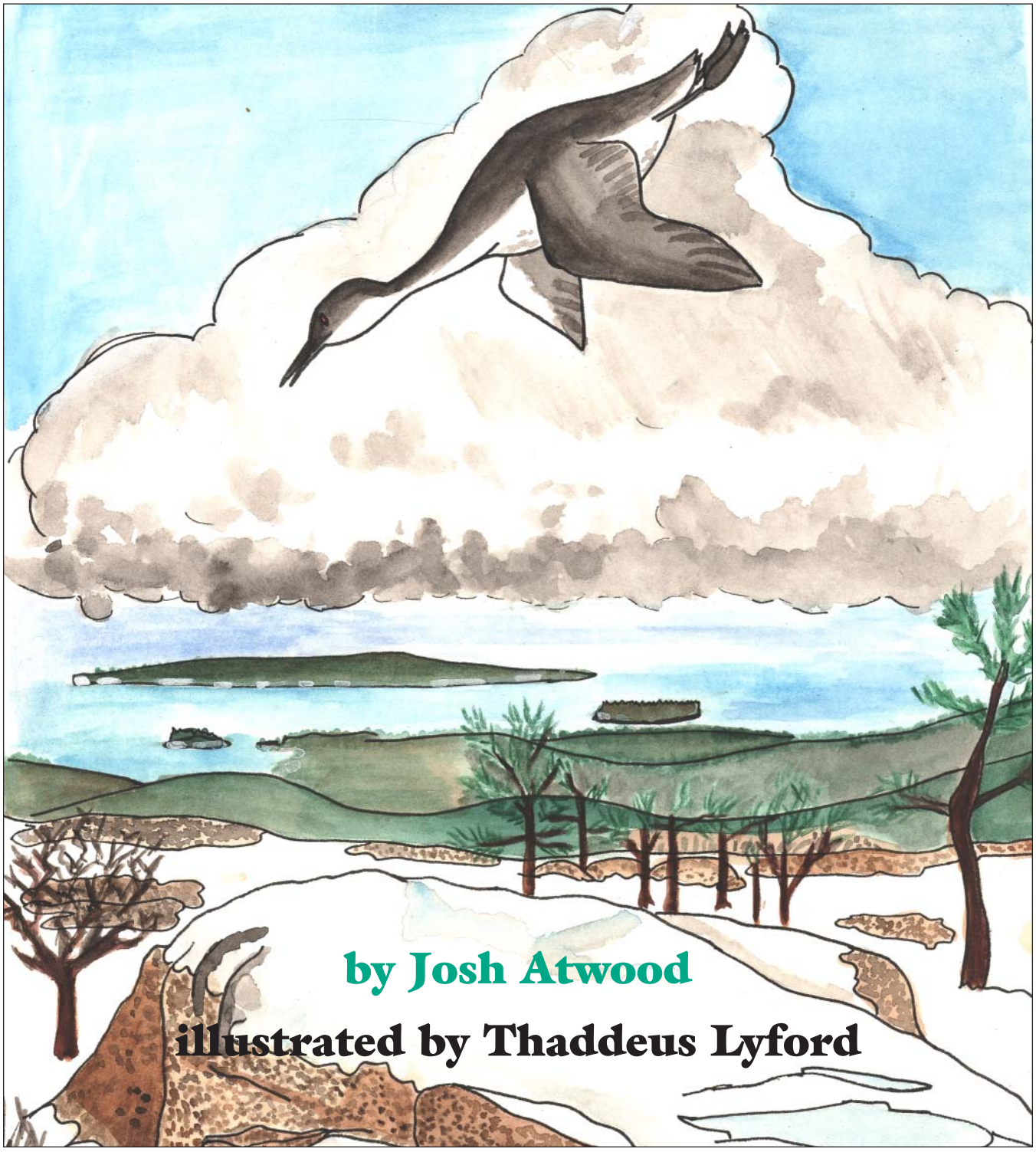
The Watershed Journey of Linus Loon



by Josh Atwood

illustrated by Thaddeus Lyford

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Additional copies of the text are available online, as are the following handbooks:

The Watershed Journey of Linus Loon: Educator Handbook. This handbook provides educators with background information on the ecological processes presented in the text, as well as a detailed correlation to the State of Maine Learning Results.

The Watershed Journey of Linus Loon: Student Handbook. This handbook contains the vocabulary words and Troll Questions for each chapter, as well as the Watershed Review. Each set of Troll Questions is accompanied by a worksheet that is formatted as a letter from the student to a Troll, providing answers to the Troll's inquiries. This handbook may be freely copied for each student in the class.

For any of these texts, please visit the Linus Loon website:
http://www.maine.gov/spo/mcp/resources/linus/index.php
Or contact Lorraine Lessard of the Maine Coastal Program, at
lorraine.lessard@maine.gov

Educators and students: Please share your thoughts on Linus and his story by leaving feedback on our website:
http://www.maine.gov/spo/mcp/resources/linus/index.php

The Watershed Journey of Linus Loon

BY

Josh Atwood

ILLUSTRATED BY

Thaddeus Lyford

Hold it right there! What is a watershed???

If you're going to read *The Watershed Journey of Linus Loon*, you should probably know what a watershed is. If you aren't sure or just plain don't know, this is your lucky day: you will find the definition right here.

Watershed *(n):* An area of land that drains into a particular lake, river, or ocean.

You may now continue to the story.

TL 2004

A Note on Gnomes and Trolls

All of the creatures you will meet in this story are real and can be found in Maine, except for gnomes and trolls. In this story, gnomes and trolls serve as guides for the journey of Linus as well as for your learning experience. Their existence in real life cannot be proved with any scientific certainty, and so they are said to be "imaginary." However, this is only because no one has ever caught a gnome or a troll.

Whether you believe in them or not, I happen to be a bit of an expert in the history of both gnomes and trolls. A few years ago I was riding my bike in the woods when I struck a tree root on the ground. Before I knew what had happened I had flown over my handlebars and crashed into an old tree stump about 10 feet away. The force of the impact knocked loose a tiny door at the base of the stump, and out of the door came a furious gnome. Apparently I had woken him up from a nap.

To make a long story short, I befriended the gnome, whose name was Booger. I know, it sounds like an awful name to us, but in gnome-language it means "historian." And that's just what Booger was, a historian of woodland creatures. We chatted for a while and he let me read books that he had written about gnomes and trolls, two species that I had not been able to learn about in my high school biology class. When I had finished we shook hands and I took a picture to remember him by. I would show it to you, I really would, but as luck would have it I didn't have any film in my camera that day.

At any rate, that is how I came to be one of the few human experts on gnomes and trolls, and I can tell you a bit about their species. Gnomes are very wise and are deeply interested in anything to do with nature. They are experts on the areas they live in and are often consulted for advice. In fact, they are considered by some to be the leaders of the ecosystems in which they live and are respected by all creatures.

Trolls are quite different from gnomes. While the two species share a deep interest in nature, trolls do not have great wisdom like gnomes. They are not stupid; they just don't have the knowledge of the gnomes. This is probably because trolls are allergic to paper (yes, it's sad but true) and therefore have not read many books. They are always interested in learning about nature though, and are very curious. They ask lots of questions and spend lots of time exploring in the outdoors.

So there you have it, a bit of information on two species that are rarely found in the wild and are even more rarely found in science books. Neither gnomes nor trolls are very fond of humans (gnomes say that we smell funny, and trolls are always afraid that we might have a bit of paper with us), so you probably won't find any if you go exploring. But even scientists will tell you that we know nothing with perfect certainty, so I suppose you never know what you may find if you go looking.

Chapter I

Leaving the Lake

On a lake in Maine there lived a loon. This particular loon was named Linus and was, at the moment our story begins, very upset. His left wing was broken and completely useless for the time being. It was getting to be early fall, and it was time for Linus Loon and his family to migrate to the ocean for the winter. Everyone in his family would be flying to the coast, except for Linus. With his broken wing, Linus was completely unable to fly. He would have to swim all the way from his home lake to the ocean. His mother and father had packed their bags that morning and gotten the rest of the little loons ready for the trip.

"I'm sorry you have to migrate alone this year," said Linus' father, Louis. "Your mother and I would swim with you for part of the way, but you know that loons need a quarter of a mile of open space just to take off. Even if we swam with you into the little pond just south of our lake, we would be unable fly away. Just follow the watershed, Linus, and you will make it to the ocean. Good luck, son!"

Linus said goodbye to his father and his mother, Lois. Then he said goodbye to his sister, Lani, and to his cousins: Laura, Lorraine, Lynnette, Liam, Leah, and Fred. Off they flew, and left Linus alone on the lake.

He wanted to leave at once. He packed a couple of pickerel (his favorite fish) into his knapsack and tucked the knapsack underneath his wings for safekeeping. He had only one stop to make before he left the lake. He wanted to visit the Lake Gnome for advice before he began his trip.

The Lake Gnome lived at the south end of the lake, just near the outlet that led to the nearest pond. He had a small house made of cattail stems that was decorated with yellow pond lilies. He spent most of his time inside, sitting on a rock and writing books about the **ecology** of his lake. Everyone that lived in and around the lake and the nearby ponds knew that the Lake Gnome was the smartest and wisest creature in the **ecosystem**. Animals often came to him for advice.

Linus swam into the Lake Gnome's house and said, "O wise Lake Gnome, I am about to leave on a long and difficult journey, and I have come to hear your advice!" The Lake Gnome looked up from the book he was writing. He was a thin, old gnome and wore a bright red hat.

"Hello young Linus Loon. I know the journey you speak of, for it is clearly time for your kind to travel to the sea, yet with your broken arm you shall have to swim rather than fly!" It

seemed that the Lake Gnome knew all about Linus' trip, without Linus having to say a word about it. "You were right to visit me," said the Lake Gnome. "There are many dangers on the path that lies before you, and some dangers that are around you already! Did you know, for example, that the fish in your knapsack might very well be poisoned?"

Linus was shocked. His jaw dropped to the floor. Well, actually, his beak dropped to the floor, because loons don't have jaws. He hadn't expected to run into danger before leaving his own lake! And as for the poisoned fish, how could that be? He had caught these fish himself while diving underwater in the lake. And who would want to poison little old Linus Loon?

"I can see you are worried about your possibly poisoned pickerel," said the Lake Gnome. "Let me explain. You and your fish are part of a food chain. A **food chain** is a series of living things that eat one another. Each **organism** in the food chain feeds on the organism that comes just before it in the chain. So the chain that you and your fish are part of might look something like this:

Phytoplankton—Small fish—Large Fish—Loon

So you see, the small fish eats the phytoplankton, the large fish eats the small fish, and the loon eats the large fish. The organism doing the eating is called the **consumer**. If there is hunting involved, the consumer is also called a **predator**, and the organism that gets eaten is called the **prey**."

"Wait, I don't understand," said Linus. "What are phytoplankton, and what do they eat?"

"Very good, young Linus, you are beginning to think with a questioning mind. Phytoplankton are tiny plants that live in the water and can only be seen with a microscope. They eat nothing! They are plants, so they use sunlight to get energy instead of eating food. If you stop to think about it, every food chain must start with a plant. If you had a food chain made up of only animals, what would be at the bottom of the food chain? Whatever it was, it would need something to eat and therefore would not be the end of the chain. Therefore all chains must begin with a plant. Plants are called **producers**, because they produce the energy that is used in the food chain."

"That's all very interesting," said Linus, "but what has this got to do with my fish possibly being poisoned?"

"Ah, I was just getting to that," replied the gnome. "What would happen if a toxic chemical, or poison, entered the food chain? Let's imagine that a small fish eats a plant that has a toxic chemical on it. The small fish would be poisoned. But it gets worse. Let me explain to you a simple process with a difficult name: **biomagnification**."

"Biomagnification?" Linus asked.

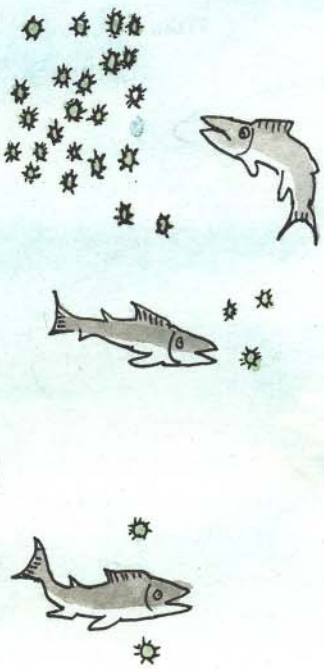
"Yes, biomagnification," answered the Lake Gnome. "Biomagnification is a process by which toxic chemicals can build up in a food chain. Let's imagine that a crop duster goes over a lake, and a toxic chemical gets into the water. Imagine that each phytoplankton in the lake gets a little piece of poison on it. We'll call each piece one 'unit.' Remember our food chain? Well, let's say that each small fish in the lake eats 10 phytoplankton. The toxic chemical passes from the phytoplankton into the small fish's body."

BIOMAGNIFICATION & THE FOOD CHAIN

-PHYTOPLANKTON-
EACH HAS 1 UNIT OF THE CHEMICAL

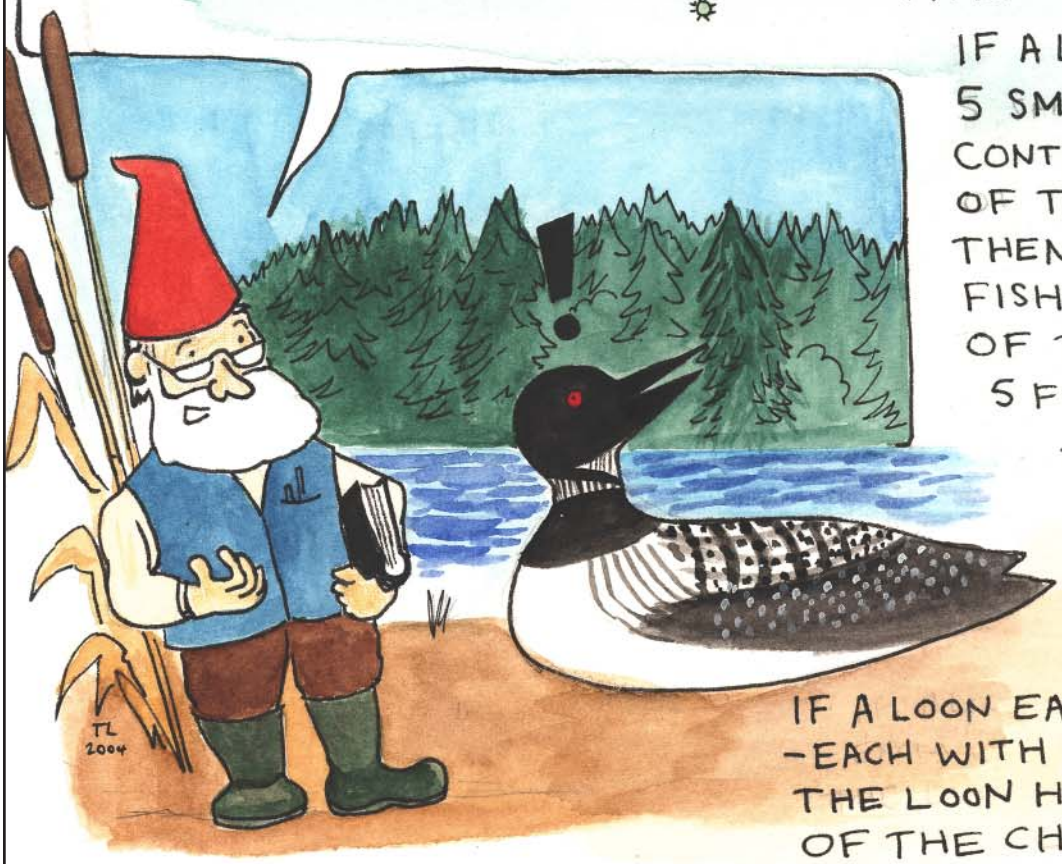
AND ARE EATEN BY...

-SMALL FISH-
EACH SMALL FISH EATS 10 PHYTOPLANKTON. NOW, EACH SMALL FISH HAS **10 UNITS** OF THE CHEMICAL.



-LARGE FISH...
...EAT THE SMALL FISH.

IF A LARGE FISH EATS 5 SMALL FISH, EACH CONTAINING 10 UNITS OF THE CHEMICAL, THEN EACH LARGE FISH HAS **50 UNITS** OF THE CHEMICAL:
5 FISH X 10 UNITS
= 50 UNITS



IF A LOON EATS 5 LARGE FISH -EACH WITH 50 UNITS- THEN THE LOON HAS **250 UNITS** OF THE CHEMICAL.
5 LARGE FISH x 50 UNITS = 250 UNITS

“But the fish ate ten phytoplankton,” said Linus. “Does that mean that it has ten units of poison?”

“Yes. And having ten units of poison in your body is much worse than having only one unit of poison! Now imagine if each large fish living in this lake eats five small fish. The toxic chemical will pass from each small fish to the big fish.

Linus thought for a moment. “If the big fish eats five small fish, each with ten units of the chemical, then the big fish will have...” Linus did some quick math in his head and exclaimed, “five times ten...the big fish will have 50 units of poison when it is done eating!”

“Very good,” said the Lake Gnome. “Now, let’s imagine that a loon eats five large fish. If each large fish has 50 units of poison in it, the loon will end up with 250 units of poison!”

“This is getting out of control,” said Linus.

“Yes it is, and that is my point! Biomagnification means that toxic chemicals build up in a food chain. Already we have imagined going from one unit of poison for a single phytoplankton to 250 units of poison for a single loon! When you have a lot of a toxic chemical in a single animal, the poison can be very harmful or even deadly to the animal.”

“That’s why you said my fish could be poisoned, isn’t it?” asked Linus.

“Yes, but do not worry, Linus. Not all fish are poisoned, but you will have to watch what you eat. Chemicals such as lead or mercury are common in lakes nowadays. They can enter the watershed from the atmosphere, and can be very harmful to organisms such as loons.”

“I’ll be sure to be careful. What else should I look out for on my journey?”

“I do not have time to discuss all of these matters in detail, if you want to learn more about problems in the watershed, you will have to visit the gnomes that live in the other places you will visit. Before your trip is over, you will have to visit a bog, a river, and an estuary, and then finally you will come to the ocean. Look for the other gnomes!”

Linus thanked the Lake Gnome for his advice and turned to go. From the corner of his eye he saw a face in the window of the Lake Gnome’s house. A troll had been listening to them the whole time! Linus swam from the house of the Lake Gnome into the lake’s outlet. He passed the Lake Troll, who had sat down on the shore and was scratching his head in thought.

With his knapsack safely tucked under his wings and his head a little wiser from his visit with the Lake Gnome, Linus swam through the outlet and into the nearby pond. His journey had begun!

Questions from the Lake Troll

1. Most people think that humans are at the top of the food chain. What if you were suddenly lost in the jungle with no way to defend yourself? Can you think of any predators for which humans might be prey?
2. Think about what you brought for lunch today. Can you think of all of the steps in your food chain? Remember that every food chain starts with a plant. How about your dog or cat's food chain?
3. Where do you think most of the food in your community comes from?
4. In biomagnification, why can the animals that are lower on the food chain survive, while animals that are higher up on the food chain feel the effects of the toxic chemical?
5. Some people live in different parts of the country during different seasons. If you travel to a summer home or a camp every year, you are making a trip very similar to a migrating bird. Birds travel by instinct as well as by sight and an internal compass. How do you find your way back to the same spot every year? How is this similar to or different from how a bird finds its way?

Chapter One Vocabulary

Ecology—The study of interactions between the living and physical parts of the environment.

Ecosystem—A community of organisms and the physical environment they interact with.

Food Chain—A series of organisms in which each organism is eaten by the organism following it in the chain.

Organism—A living thing: animal, plant, fungus, or microbe.

Predator—An organism that hunts and feeds on another living thing.

Prey—An organism that is eaten by another organism.

Consumer—An organism that acquires energy by eating another organism.

Producer—An organism that acquires energy from the sun, such as plants or algae.

Biomagnification—A process by which substances become more concentrated in the bodies of organisms as they move up a food chain.


DRAGONFLY
PITCHER PLANT
MOSQUITO
MARE'S TAILS
SPHAGNUM MOSS
YELLOW LADY'S SLIPPER
MONARCH BUTTERFLY
GREEN FROG

Chapter Two

From Pond to Bog

Linus swam through the little pond that lay just south of his lake. It was an encouraging place to be. Although he was in a place completely new to him, it was still very familiar. Many of the same organisms that lived in the pond were organisms that could be found in his lake. He saw cattails, yellow pond lilies, and water celery. Zooming around on the surface of the water were whirligig beetles and water striders. Underneath the water, Linus saw snapping turtles. Overhead a great blue heron flew, looking very majestic. The only real difference between his lake and this pond was that the pond was smaller than the lake, and not as deep.

Linus passed through the pond without running into any trouble, but he couldn't help thinking about what the Lake Gnome had said. As he swam he noticed small fish and large fish and thought about biomagnification. Was it at work in this pond? It was just about time for lunch, so Linus took out his pickerel and looked them over carefully. They looked healthy, so he ate them.

As the sun began to sink on his first day of traveling, Linus found the tiny outlet of the pond and swam into it. At the end of the outlet, he came into a pool of still, stagnant water. Linus was in a bog. There were no large trees in the bog, but there were many smaller plants growing out of a thick carpeting of sphagnum moss. Everything was very moist, and there were many open spots of water here and there throughout the bog.

The sun dipped behind the forest of pine and fir trees and night came to the bog. It was an altogether creepy place and Linus had no interest in spending the night there. If you really want to know, he was terrified. There was an eerie mist in the air, and green frogs were croaking all around him. Mosquitoes buzzed about his head. He tried to sound his loon call, but it stuck in his throat and all that came out was a teeny "eek!"

When the sun came up the next morning, Linus thought the bog looked much different that it had the night before. It was no longer silent and eerie, it was full of activity and beauty! Dragonflies buzzed around his head. He admired their beautiful laced wings, their shining, colorful bodies, and their huge compound eyes. He followed a group of the dragonflies to a different

section of the bog, and noticed a great deal of living things. He saw beautiful monarch butterflies with their bright orange and black wings. On shore he saw a redbelly snake slithering past, and noticed a barred owl perched in a tree. It was staring unblinkingly at a swamp rabbit, who seemed to have no idea he was being watched. In the distance Linus saw a huge, gangly brown animal, and recognized it at once as a moose.

As he watched the insects, he saw some of them enter into a strange plant. Several insects flew in, but none seemed to be coming out! A strange thought crossed Linus' mind: what if the plant was eating those insects? Although he did not know it, he had guessed correctly. Linus was looking at a pitcher plant, one of the very few **carnivorous** plants found in Maine. The pitcher plant has a long, slender tube lined with downward pointing hairs. These hairs make it easy for insects to climb into the plant as they look for food. When the insects try to leave, the hairs hold them back, and they become trapped at the bottom of the tube! There they are digested by the plant's juices, allowing the plant to get energy and nutrients from the insect's body.

Linus was amazed by the pitcher plant and began swimming around to look at the other plants in the bog. There were so many! On the shore he saw cedar trees alongside pitch pines. In the shallow waters he saw horsetails, lady's slippers, and irises. It even looked to Linus as though the plants were somehow taking over the open water. The sphagnum moss had grown so thick in some places of the bog that it became difficult for Linus to find a path to swim along. He became frustrated and gave up trying to cross the bog for the time being.

It was about time for breakfast, but Linus was out of fish. He found an area in the bog with some open water and dove down into it. "Holy mackerel!" thought Linus. "Where have all the fish gone?" Linus saw that there was very little animal life underwater in the bog. He surfaced again and thought, "What is going on in this place? Perhaps it's time I visited the Bog Gnome."

Linus swam to the far side of the bog with great difficulty. In places the plants had grown so thick that he had to step out of the water to cross over them. The Bog Gnome's house was not hard to find: it was made of sticks and sat upon a boulder at the edge of the bog. Linus knocked on the door and entered.

"Good day to you!" said the Bog Gnome. He was wearing a muddy brown tunic and a greenish brown hat. Linus bowed his head in respect. "What is it that I can help you with, young loon?"

"O wise Bog Gnome," began Linus. "I am on a journey to the sea, and it has taken me through your bog. Before I left my home on the lake, I was advised by the Lake Gnome to seek out the wise leaders of other ecosystems if I had any questions."

"Well, you have come to the right place for wisdom, but what is it that bothers you about my bog?"

"Two things. The first is not a bother, just a curiosity. I noticed a plant that seems to be eating insects, and I would like to know a bit more about that. The second is a real bother, though: there are too few fish! What happened to them?" asked Linus.

"Ah, you have asked two questions that you think are quite unrelated, but I will tell you that both of your questions have to do with plants! But let's take them one at a time. First, you are quite right about the plant you saw. It does eat insects, which is very unusual for a plant. As you know, most plants get their energy from the sun and do not need to eat anything else. But this plant that you saw, the pitcher plant, gets its energy from another organism, just like

animals do! You see, there are only two kinds of creatures in the world when it comes to getting energy: those that make their own energy with the help of the sun, and those that get energy from other living things. As you know, we call these categories 'producers' and 'consumers.' Most plants are producers, but the pitcher plant you found is an odd case: it is a consumer!"

"Let me talk a bit more about energy," the gnome continued. "When an organism gets energy from the sun or from eating another organism, it uses that energy to make **tissue**."

"Why?" asked Linus. "Does it have a runny nose?"

The Bog Gnome looked at him sternly. "Don't be silly, not that kind of tissue. This tissue is what makes up an organism's body. A plant's body is made up of plant tissue, and your body is made up of animal tissue: muscle, bone, skin, it's all tissue! Anyway, when organisms use energy to make tissue, it is called 'production': they are producing the tissue. For producers, it is called primary production. For consumers, it is called secondary production. Do you see the difference?"

"I think so," said Linus. "**Primary production** makes tissue with energy from the sun, but **secondary production** makes tissue using energy gained by eating other organisms."

"You've got it. That is what makes the pitcher plant you saw so interesting. It is part of a small group of plants that uses secondary production. All other plants use primary production, and that is how all the food in our world begins: plants use energy from the sun to make tissue, creating food that will sustain whatever animal eats that plant."

"I see," said Linus. "But how on earth does this relate to the fact that I missed lunch?"

"The reason you could not find enough fish to eat is that my bog is experiencing too much primary production! In short, there are too many plants. Let me tell you about a simple process with a difficult name..."

"This sounds familiar..." thought Linus. "Do all gnomes talk this way?"

The gnome continued. "The process I want to tell you about is called **eutrophication**. It is pronounced yoo-tro-fi-kay-shun. Got it? It means that there are too many plants in a body of water, and that the water body is actually filling up with plants! It all begins with something called **nutrients**. You've heard of these before, there are nutrients in the food we eat everyday. They are good for you. Plants need nutrients to grow. What has happened in my bog is that there are too many nutrients being put into the water. They are coming from the farm that lies just on the other side of the row of trees behind my house. The farmer there has been putting fertilizer on his crops. Fertilizer is full of nutrients, and as rainwater runs down the hill and into this bog, it carries nutrients with it. Some of those nutrients end up in the bog.

"While having a certain amount of nutrients is good for plants, having too many of them can be a really bad thing! The plants use those extra nutrients and begin to grow really fast. Suddenly there are lots of plants in the bog. The bog begins to fill up as plants on the surface of the water die and sink to the bottom. Then something happens that will explain why you didn't find many fish today."

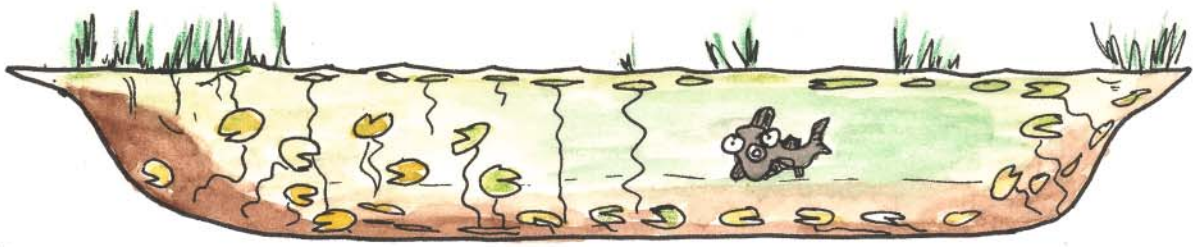
"What is it?" asked Linus, eager to finally hear the answer to his question.

"The dead plants on the bottom of the bog are decomposed by bacteria. When bacteria are decomposing plants, they are using oxygen. They take this oxygen out of the water around

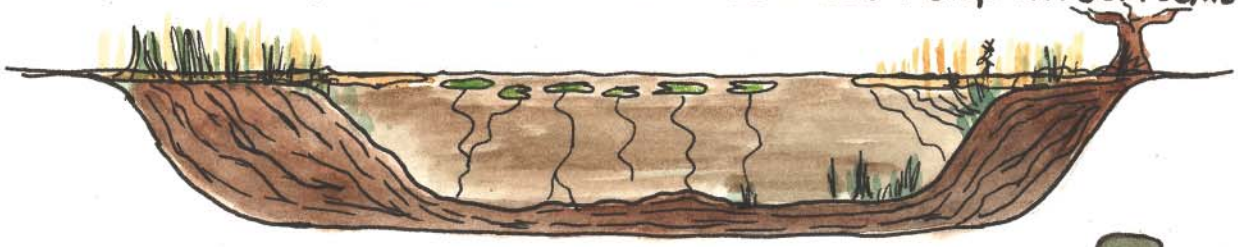
NUTRIENTS & EUTROPHICATION

NUTRIENTS - FERTILIZER FROM A NEARBY FARM - ENTER THE LAKE VIA A STREAM

PLANTS GROW AND MULTIPLY RAPIDLY; ALGAL BLOOM OCCURS



PLANTS DIE AND SINK, BACTERIA USES OXYGEN TO DECOMPOSE THEM, FISH SUFFOCATE



THE LAKE HAS NO OXYGEN AND NO ANIMALS - PLANTS TAKE OVER

TL 2004

them. Soon, the bog does not have as much oxygen in it as it used to. This is bad news for animals living in the bog; they need the oxygen to breathe! So you see, there aren't many fish in this bog because there isn't much oxygen in the water for them to breathe. And all of this happened because there are too many plants, because there are too many nutrients!"

"So the problem came from the farm," said Linus.

"In this case, yes," replied the Bog Gnome. "But eutrophication can also be caused by people putting fertilizer on their lawns, or any other instance in which nutrients are added to an ecosystem. Putting too many nutrients into a body of water is called **nutrient loading** and the result is a body of water with little oxygen that may fill in with plants. That is what I mean by eutrophication. That is just what is happening to my bog, because the farmer up the hill is putting too much fertilizer on his fields. I am sorry it has meant that you will have to go without breakfast today, but you'll have to keep looking out for it as you travel through the watershed! Eutrophication does not occur only in bogs, it can happen in ponds and even in lakes. Beware as you travel!"

With that, Linus thanked the Bog Gnome and turned to go. If he wanted a meal today, he would have to leave the bog by nightfall. He started out the door when he heard someone yell "Ow!" and tumble backwards. He heard a splash and looked down into the water to see the Bog Troll, who had been listening at the door. When Linus came through, the Troll was knocked backwards down the rock and into the bog. Linus said he was sorry and swam away. The Bog Troll looked after him and scratched his chin in thought.

Linus found a small path of water leading out of the bog. He swam away, not knowing where he would end up next.

Questions from the Bog Troll

1. The pitcher plant is one of the few carnivorous plants in Maine. Do some research and see if you can find the names of others! Make sure to find out how the other carnivorous plants trap their food!

2. Which of these terms apply to you (you can choose more than one): producer, consumer, predator, prey, primary producer, secondary producer.

3. The terms “primary production” and “secondary production” suggest that organisms are producing something. What are they making?

4. Nutrients are good for plants, and in fact plants need them to survive. But too many nutrients in a water body can result in eutrophication. This situation is similar to you and your dinner: you need food to survive, but too many cheeseburgers can lead to a stomachache. Can you think of any other examples (not related to food) where there is too much of a good thing?

5. Imagine that the sun has suddenly stopped shining. What will happen to primary production, and then what will happen to consumers?

6. How could nutrient loading happen in your community? Do a lot of people you know fertilize their lawns?

Chapter Two Vocabulary

Carnivorous—Meat-eating. An adjective used to describe carnivores (organisms that eat animals).

Tissue—A group of cells that perform a function together. In animals, examples include skin, bone, and muscle. Examples of plant tissue include bark, xylem, and phloem.

Primary production—The production of plant tissue using energy from the sun. This is how energy enters all food chains.

Secondary production—The production of tissue using energy acquired from eating other organisms.

Nutrients—Material used by living organisms to grow, maintain, or repair the body of the organism. In the case of plants, "nutrients" often refers to elements such as nitrogen and phosphorous.

Eutrophication—The process by which a water body fills in as nutrient-rich water supports the growth of algae and plants. The decomposition of these plants by bacteria uses up the oxygen in the water.

Nutrient loading—The act of putting more nutrients into an ecosystem than would naturally be there. This can result in eutrophication.


BEAVER
RIVER OTTER
SALMON
RACCOON
FIDDLEHEADS
FERNS
COMMON MERGANSER
PAINTED TURTLE
BROOK TROUT
SMALLMOUTH BASS
CADDISFLY LARVA
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Chapter Three

Into the Current

The outlet from the bog took Linus through a thick patch of pine trees. It was dark underneath the shade of the pines, and Linus was soon blinded when he popped out of the dense forest and into a small open area. He saw that the outlet he was swimming along joined into a fast moving stream. Linus had only ever lived on the still waters of a lake, and was amazed to see water rushing around rocks and tumbling over waterfalls. White foam sprayed around in the current and a soft gurgle filled the air.

He looked around at the **flora** and **fauna** of the stream. He saw brook trout with their slender, streamlined bodies, and salmon playing in the waterfalls. Smallmouth bass were also to be found underwater, and Linus began to get hungry. He saw caddisfly larvae attached to rocks underwater. They had hooks on their bodies that allowed them to stay attached to the rocks while the fast moving current swirled around them. He also saw a painted turtle, which has a dark green shell with yellow and red seams. He brought his head out of the water just in time to see a merganser duck swim by.

Looking towards the shore, he noticed some of the beautiful plants found alongside a stream. He saw hemlock trees, and of course pine and fir trees as well. He saw many ferns along the ground, and noticed lilies and fiddleheads. What a spot!

Linus stared at the waterfalls for a while and thought about where all that water was coming from. Surely it couldn't be coming from ponds and lakes; if that were true, wouldn't the ponds and lakes dry up as the water flowed away? And where was all the water going? If it was headed to the ocean, why didn't the ocean keep getting bigger and bigger as streams and rivers flowed into it?

He thought about this as he headed down stream. It was so easy to travel by stream; he just let the current take him and kept on daydreaming. He was so lost in thought that he was surprised when he came to his senses and found that the stream had widened and had slowed down considerably. Looking back, he saw that his stream had flowed into a large, slow moving river.

The river moved along and Linus noticed that many of the plants and animals he had seen in the stream were also in the river. As he drifted, he watched the shore and saw raccoons darting among the plants. At the water's edge, a beaver was busy building a house, but had become distracted by a laughing river otter. The beaver slapped his flat tail on the water menacingly and gave the otter a very dirty look before lumbering off to find more wood.

Linus again wondered where all the water came from and where it was going. There was so much water here! This question was really bugging him. He decided it was time to find the River Gnome, who was sure to live around the river somewhere...but where? Linus looked for him high and low, and finally spotted a tree stump on the shore that had a little door carved into its base.

The sun began to set on the third day of his journey as Linus entered the house of the River Gnome. "O wise River Gnome," began Linus. "I am on a journey..."

"Save your words, Linus Loon! I know all about your journey," interrupted the River Gnome. He was a portly fellow and wore a bright blue hat and coat.

"How did you know my name? I've never met you before," said Linus.

"Gnome-post of course. We gnomes have a very sophisticated mail service that uses chickadees as mail carriers. My friend the Bog Gnome sent word that you would be coming through this way, so I've been preparing for your visit!" And he had: there was a small table laden with fish of all sorts that lived in the river and its neighboring streams. "Tonight we will feast together, and you shall be my guest for the night!"

Linus happily accepted the offer of dinner and a warm place to sleep for the night. As they ate, Linus and the River Gnome talked about the places Linus had seen and the places he had yet to visit before he made it to the ocean. Linus suddenly remembered the question that had bothered him all day, and was so excited to ask it that he interrupted the River Gnome in mid-sentence.

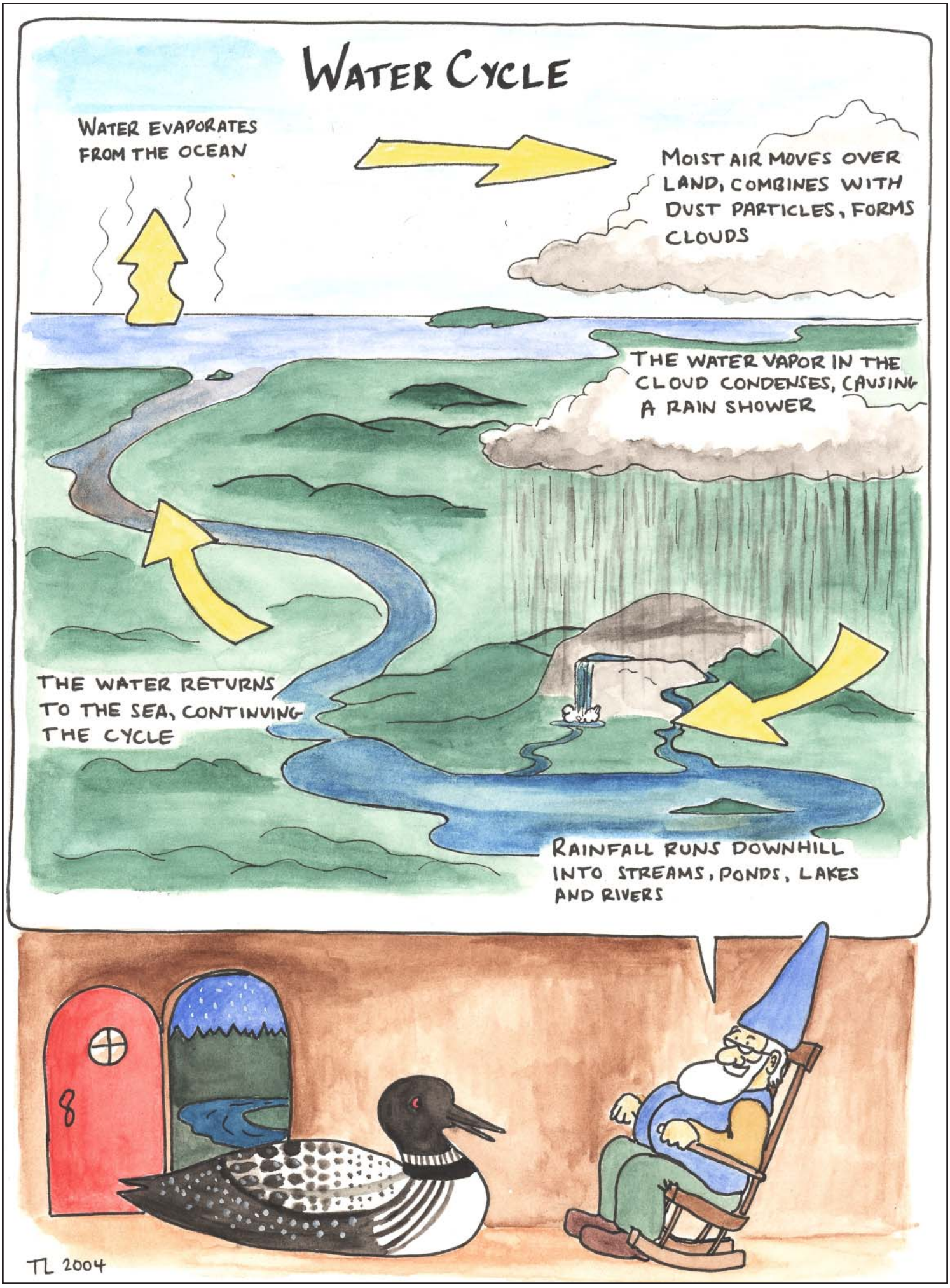
"Where does all the water in this river come from and where does it go? Why doesn't the river's source dry up as the water flows out of it, and why doesn't the ocean rise as streams and rivers flow into it?"

"Ah, young Linus Loon, you are not thinking about the watershed in the right way," began the River Gnome. "You are imagining that a watershed begins in a lake or pond, and ends with the ocean. But it is not so! The flow of water through the watershed is not like a line with a start and an end, it is like a circle that goes on forever without end!" With an old, crooked finger, the River Gnome drew a circle in the air. Linus looked at him, eager to understand.

"The river you swam on today is part of the **water cycle**. If I am going to tell you about the water cycle, you will have to learn two new terms. The first is **evaporation**, which is the act of water changing from liquid to vapor form. This can happen when water heats up. Think about making dinner over a fire or on a stovetop: when you heat up the liquid water, it turns into steam. That's evaporation! Evaporation happens slowly all the time. Water from lakes, rivers, or the ocean evaporates and becomes water vapor. Water vapor is kind of like steam. It just means that water is in the air rather than on the ground. Water vapor is what makes up our clouds.

"The other new word you will have to learn today is **condensation**. This is the opposite of evaporation. This is the act of water vapor turning into liquid water. This can happen when you cool water vapor. Remember I told you that clouds are made up of water vapor? Well, what do you think happens when the water vapor in clouds experiences condensation? We get rain!

"You can think of the water cycle as having only two parts: water from the earth evaporates into the clouds, and then the water vapor turns into rain and comes back to the earth! Once it is back on the earth, the water can evaporate again and become water vapor. You see, it's a cycle! Water does this over and over again, and has been doing it for billions of years.


WATER CYCLE
WATER EVAPORATES FROM THE OCEAN
MOIST AIR MOVES OVER LAND, COMBINES WITH DUST PARTICLES, FORMS CLOUDS
THE WATER VAPOR IN THE CLOUD CONDENSES, CAUSING A RAIN SHOWER
THE WATER RETURNS TO THE SEA, CONTINUING THE CYCLE
RAINFALL RUNS DOWNHILL INTO STREAMS, PONDS, LAKES AND RIVERS
TL 2004

"Let's look at the water cycle a bit more closely. There is no start or end to the water cycle, but let's begin with a lake, since that is your home. Water can leave the lake either by evaporating into the clouds, or by flowing out into a stream or river. Water can evaporate out of the river, or it can continue flowing along the course of the river until it reaches the ocean. The water will then remain in the ocean for a while, and will eventually evaporate into the air. The salt in the ocean stays behind, it does not evaporate. So one way or another, the water from your lake has become water vapor.

"The water vapor combines with dust in the atmosphere and makes clouds. The clouds might travel around for a while, but eventually the water vapor in them will condense, turning into raindrops. The raindrops fall down and either land in the ocean or on land. The water that falls on land then flows into a lake or stream, or down into the ground. Now we are right back where we started, and the cycle can happen all over again.

"You should notice, though, that the same water does not always return to the lake or pond it came from; water can travel all around the earth through the water cycle! Furthermore, water is rarely created or destroyed; the water we have today has been going through the water cycle for billions of years. Who knows where the water you drank today has been? It could have been in Australia last week, or maybe a dinosaur drank it long ago!"

Linus sat a while and pondered the implications of water moving around through a cycle. "So water that is in my lake could have come from another body of water. Does that mean that what happens to the water in my lake is affected by what happens in other bodies of water?"

"It certainly does," replied the River Gnome. "And what's more, what happens in your lake affects other bodies of water. The water cycle connects water bodies. For example, if there was an unusually small amount of water in your lake one summer, that would mean that less water would be flowing out into the ponds, bogs, streams, and rivers that your lake connects to. All of those water bodies would be affected by a change in your pond. The water cycle also connects watersheds with the atmosphere. Chemicals that we put into our air, like mercury, are likely to end up in our water."

"What about pollution on land?" asked Linus.

"Ah, now you've pinned the rose on the nose, so to speak. Pollution can travel through the watershed with water, meaning that problems that are caused locally (in one specific spot) can be spread over a great area. Pollution that can be traced back to a single spot or point is called **point source pollution**. Try to remember it this way: since the pollution comes from a single spot, you can take your finger and point at the source! Because the water cycle connects all bodies of water, point source pollution may travel. We must be especially careful of what we put into the water; our actions may have greater impacts than we think they will."

It had gotten late as they had talked. "Now it is time for sleep," said the River Gnome. "I will leave you with one last thought for today: we all live in a watershed, and the effects we have on the environment are spread throughout that watershed. The water cycle connects all. We should conserve our water bodies not only for ourselves, but for everyone else who lives in the watershed."

Linus thought about this for a minute and then went off to find a corner of the house to sleep in for the night. He approached a dark, shadowy corner and was about to settle down

for the night when out of the shadows popped a troll! Linus gave a surprised loon call, and the River Gnome came over to escort the troll out the door.

“Sorry about that,” said the River Gnome. “That was the River Troll, he’s always sneaking about my house looking for information. I hope he didn’t scare you too badly.”

“N-n-n-no, I’m f-f-f-fine,” lied Linus. His heart was pounding. He sat down and tried to drift off to sleep. Outside on the doorstep, the ousted River Troll sat and thought about all that he had heard that night.

Questions from the River Troll

1. Water is rarely created or destroyed; the same water flows through the water cycle over and over again. The water you drank this morning could have flowed down the Nile in ancient Egypt, or it could have been swallowed by a T-Rex, or maybe at one time it was rhinoceros sweat! Can you think of some other times and places your water could have been?

2. How are you connected to the watershed and the water cycle? Here's a hint: how does water get to your home? Where does water go that gets flushed down your drain?

3. Why do rivers and streams have more water flowing in the spring than in the summer or fall?

4. Imagine a year without rain. What would happen to the rest of the water cycle?

5. In the water cycle, water might evaporate from the ocean and come back to the ground as rainwater. Why does rainwater taste fresh if it came from the salty ocean?

6. What watershed do you live in? Look it up! (Hint: Any water that flows through your community is going somewhere, like a stream or a river. Where is your water going?)

Chapter Three Vocabulary

Flora—Plant life.

Fauna—Animal life.

Water Cycle—The path water takes as it changes state and moves through the environment.

Evaporation—The process by which liquid water becomes gaseous water, or water vapor.

Condensation—The process by which water vapor becomes liquid water.

Point source Pollution—Pollution that comes from a single source.


GREAT BLUE HERON
MARSH GRASS
BLACK DUCK
CORD GRASS
EEL GRASS
EEL
GREEN CRAB
SOFT SHELL CLAM
RAZOR CLAM
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Chapter Four

The River Meets the Sea

When the sun came up on the next day, Linus joined the River Gnome for breakfast. The River Gnome wished Linus well on the rest of his journey and said he would be sending word by Gnome-post to his friends in other parts of the watershed that Linus would be traveling through. Linus thanked him for his hospitality and swam away.

It was an easy day for Linus, who drifted along with the current of the river for quite a while. His journey did not seem so frightening now that he was well on his way and he had the help of all the gnomes in the watershed. In fact he was quite enjoying himself, the watershed was a nice place to be! It was full of interesting plants and animals, and he was enjoying learning about the watershed, how it worked and what problems it faced.

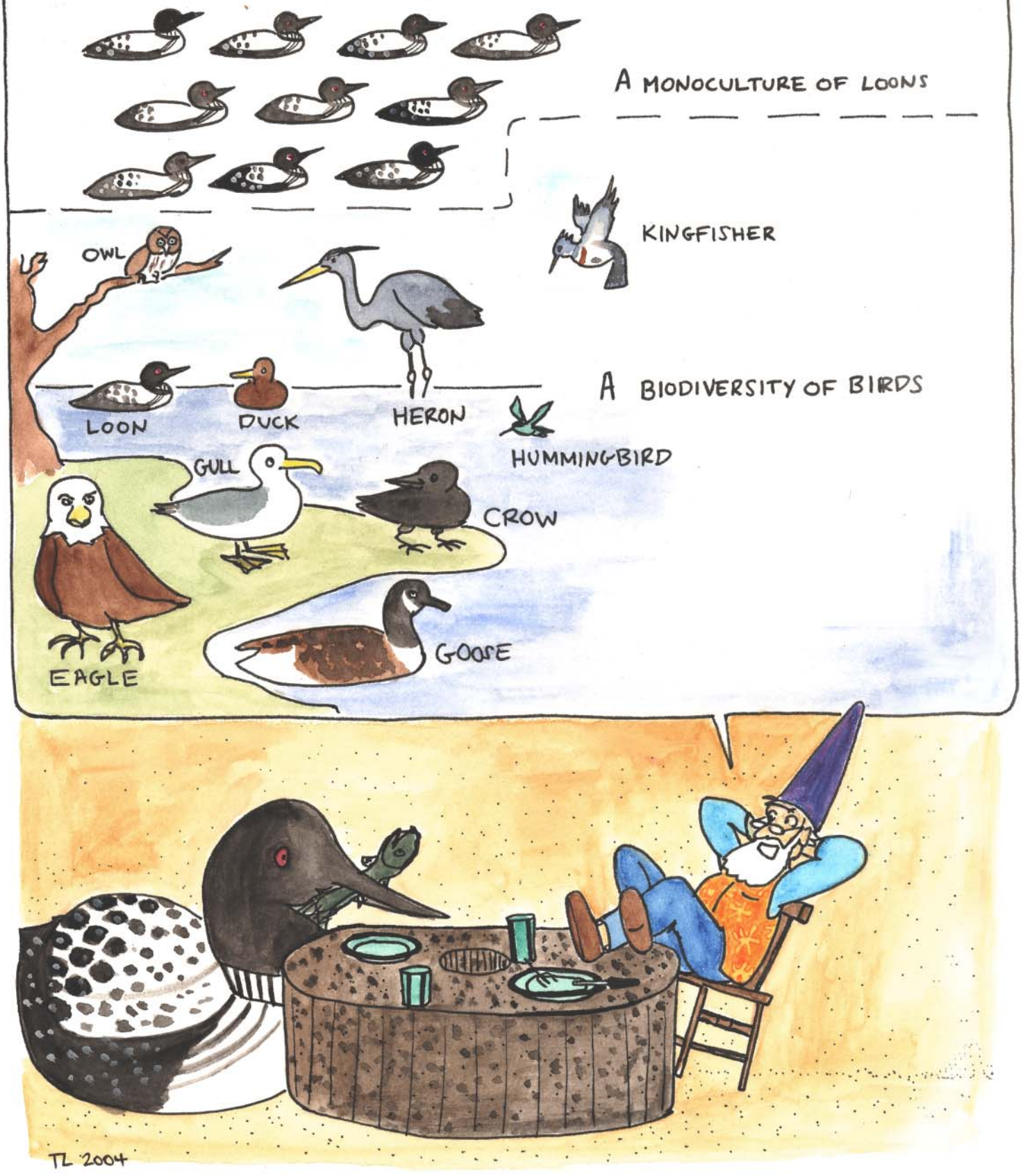
Suddenly Linus smelled a change in the air. He noticed a change in the water, too. He tasted salt! The water wasn't nearly as salty as the ocean, but the river was definitely getting saltier all of the sudden. Linus noticed a change in the vegetation around him. He came around a bend in the river. Ahead on the horizon he could see the river flowing into the ocean. He was almost there! Though it felt like ages ago, Linus remembered the Lake Gnome telling him that one of the places he would see before he got to the ocean was an **estuary**, where a freshwater river meets the saltwater ocean and the two mix together.

Linus looked around the estuary. He saw many animals and plants. Everywhere he looked he saw different kinds of grass growing up out of the water. There was eelgrass, cord grass, and salt grass. Cattails grew in the shallows, and further away near the beach Linus spotted a beach-head iris. He saw a group of black ducks swimming about the estuary, and noticed many eels swimming in the water. In the forest on the shore, Linus heard the birdsong of sandpipers. Everywhere he looked he saw fish swimming, and birds wading. Along the bottom of the estuary Linus saw shellfish with their shells opened slightly so they could eat.

Linus noticed that the water he was swimming in tasted **brackish**, or part fresh, part salty. The **salinity** of the estuary was somewhere between the level of salt in the ocean and the level of salt in the river.

Linus noticed how many organisms lived in the estuary. He also noticed that there were lots of different kinds of organisms. How could so many different species live in the same place? Was that healthy?

MONOCULTURE VS BIODIVERSITY



As Linus swam through the estuary he noticed that the bottom of the estuary changed from mud to sand. At the far end of the estuary he saw a beach. As he got closer he saw a sand castle on the part of the beach that lay facing the estuary. He knew at once that this was the house of the Estuary Gnome. He swam to the castle, and before he could enter, a gnome in a purple hat popped out of the door. "Welcome Linus! I am the Estuary Gnome, and today you are my guest! Come inside my castle, I have lunch ready for us."

Linus gladly accepted and entered the castle. Linus and the Estuary Gnome talked all through lunch. The Estuary Gnome was eager for news about his friends in other parts of the watershed. When Linus had told him all about his journey so far, the discussion turned to the topic of estuaries.

"Estuaries are highly productive," said the Estuary Gnome. "There are many nutrients brought down the river, and they stay in the estuary rather than travel out into the sea. The waves and the tides keep them here! I know you have learned that too many nutrients can cause eutrophication, but you needn't worry. In my estuary, we have just the right amount of nutrients to support a highly productive community of plants, which in turn support many animals.

"You have also noticed, no doubt, that the water in my estuary gets saltier as you travel from the river to the ocean. This is also a unique aspect of estuaries. Organisms with different abilities to handle salt are able to live in different parts of the estuary. Those that are able to live with a lot of salt may live nearer the ocean; those that do not handle salt well may live nearer the river. And there is a whole spectrum of species in between! Everyone has their own spot in an estuary!"

Linus asked about the number of different species in the watershed. "Ah, that is a sign of a healthy ecosystem!" said the Estuary Gnome. "The variety of species in a certain area is called **biodiversity**. Maybe you've heard of diversity before; a diverse group is a group that has a lot of differences between the members of the group. Biodiversity refers to the number of different species in an area. If there are a lot of different species in an area, the area is said to biologically diverse. It has a lot of biodiversity!"

"What's so great about biodiversity?" asked Linus. "How does having lots of different organisms in an area make the area healthy?"

"Well," began the gnome, "Let's imagine an ecosystem with very little biodiversity. If we had an area that contained organisms of only one species, we would call it a monoculture. A large field of tomatoes is a **monoculture**: there's nothing there but tomatoes. What if we had a sudden frost? All the tomatoes would die and there would be no organisms in the ecosystem.

"Now lets imagine an area with a lot of biodiversity. There are tomatoes, potatoes, beets, and squash. Different species have different strengths and weaknesses, right? We already saw that tomatoes are very weak when it comes to frost. But maybe the other vegetables in the field are not as affected by frost. So when the temperature drops this time, the tomatoes die, but we still have potatoes, beets, and squash. The ecosystem will have lost one of its species, but it still has three left.

Linus thought about this for a moment. "So having species with different strengths and weaknesses ensures that an entire ecosystem won't collapse just from a single bad event?"

“Right,” answered the gnome. “Monocultures are very easily destroyed by a single catastrophe, but areas with a lot of biodiversity are much harder to destroy. That is why I can be confident that my estuary will stay healthy. There are so many species that whatever happens to the estuary, some will still be able to survive here.”

Linus thanked the Estuary Gnome for lunch, but told him that he would like to push on and reach the ocean today. With any luck, he would be able to find his family by nightfall. The Estuary Gnome showed Linus the way out of the sand castle. Linus headed down the beach. He turned around to wave goodbye and noticed that two eyes were watching him from one of the turrets of the castle. Another troll! Those guys were everywhere.

The Estuary Troll sat high up in the turret, watching Linus move down the beach. He sat there for the rest of the day, picking sand out of his hair and trying to organize his thoughts.

Questions from the Estuary Troll

1. Look back at the pictures of the Bog Troll and the River Troll. Which ecosystem is more biodiverse? Remember to count plant species as well as animal species.
2. How many different species can you think of in your house or in your backyard? Count the different types of pets you have, as well any critters like gophers, and spiders. Remember to count plant species, like maples and pine trees. Don't forget to include humans as a species!
3. Have you ever heard the term "diversity" before? How was it used, and what did it mean? How is that different from or similar to biodiversity?
4. The Estuary Gnome said that there is a lot of salt in the estuary near the ocean, and not much salt in the estuary near the river. How salty is the water in the middle of the estuary?
5. Different species live in different areas of the estuary depending on how well they deal with saltwater. How much do you like salt? If you were an estuary organism, where in the estuary would you want to live?

Chapter Four Vocabulary

Estuary—An ecosystem in which a freshwater river mixes with water from the ocean.

Brackish—An adjective describing a mixture that is part salty, part fresh.

Salinity—A measure of saltiness (the amount of salt in a certain amount of water).

Biodiversity—The range or variety of species in an area.

Monoculture—An ecosystem containing only one species.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Chapter Five:

The Edge of the Ocean

Linus did not cross the beach and hop in the ocean at first. It felt good to use his legs to walk on shore after being in the water for so long. Besides, the Maine ocean is cold in the early fall, and Linus was in no hurry to leave the warm sand. He walked down the beach, but saw no humans. It was fall after all, and most of the tourists had made their own migrations out of Maine.

Suddenly Linus stumbled head over feet into the sand. He hopped up immediately and dusted the sand out of his feathers to save his dignity. The beach looked empty, but he wouldn't have anyone thinking he was a clumsy dodo bird- what had made him trip? He looked down and saw a set of six plastic rings tangled around his feet. They were the kind of plastic rings that humans take off of six-packs of soda. With some difficulty, Linus managed to wriggle out of the plastic and continued to walk moodily down the beach. He became angrier and angrier as he walked along. The beach was full of trash! Here and there he found bottles, plastic bags, broken glass, and everywhere he looked he saw cigarette butts. Uggh!

Who had done this? Linus tried to imagine someone who might have left all this trash behind. He imagined a monster: a huge, green monster with hair coming out his nose. Instead of sweat, oil poured out of its armpits as it slimed its way down the beach like a giant slug. The monster belched as it drank 10 six-packs of soda at a time, letting the plastic rings and empty bottles fall to the ground. It had 3 sets of hands, each carrying a plastic bag filled with broken glass. It spread the glass around the beach just for fun, and then dropped the plastic bag onto the sand when it was empty. Worst of all, the monster had a thousand mouths, each one smoking a cigarette and spitting the butt onto the ground when it was finished. Linus shuddered at the thought of it.

Linus decided it was time to leave the beach. He was worried that he might cut his feet on the broken glass. He turned away from the beach and headed down to the water.

The waves were not very big that day, so Linus did not have much trouble swimming out into the water. The salinity of the water was much higher than it had been in the estuary. He saw great clumps of seaweed floating in the water, some of it reaching down to the rocks below. Looking down into the water he saw salmon swimming about, as well as seals. He even spotted a whale.

Linus began to get excited: he had finally made it to the ocean! He was almost finished with his journey. All he had to do was find his family. But Linus saw something then that took away all the excitement of finally reaching the ocean. More trash! He saw more bits of plastic and other trash floating in the water. Linus became upset again and decided it was high time he visited the Ocean Gnome. Surely the Ocean Gnome would know what to do about this problem.

Linus swam on for a while before he spotted a tiny raft floating in the water. Upon the raft there was a gnome sitting cross-legged, reading a book. He was wearing a dark blue tunic and had a matching blue hat upon his little head. He had set a small sail up on the raft and was drifting here and there with the wind over the surface of the water. As Linus approached, the gnome smiled and waved.

"Hello Linus," said the ocean gnome. "I've been expecting you! I received word from the River Gnome that you would be by this way. Let me be the first to congratulate you on a quest well-fulfilled: welcome to the ocean!"

"Thank you, wise Ocean Gnome. The journey was not as difficult as I thought it would be. To tell the truth, I'm kind of sad that it's over now. I really enjoyed all the parts of the watershed. But my joy at reaching the ocean has been replaced by concern: your beach and ocean are full of trash!"

"I know," said the Ocean Gnome slowly. "It is truly a tragedy."

"Well why don't you find whatever monster put all the trash here and make him clean it up!?"

The Ocean Gnome looked sad but chuckled at the mention of a monster. "Linus, the **debris**, or trash, found in my ecosystem did not come all at once from a single, terrible monster. The trash has come one piece at a time from ordinary humans. They do not realize the damage that they are doing."

"How can they not realize it?" asked Linus.

"Well, the polluting of my ecosystem came about by **nonpoint source pollution**. Do you remember what the River Gnome told you about point source pollution? He mentioned in his letter that he had spoken with you about pollution that comes from a single source, like a paper mill or an oil refinery. If there truly were a monster on my beach leaving all this debris behind, we would call that point source pollution. As you can probably tell, the opposite of that process is nonpoint source pollution. Nonpoint source pollution does not come from one specific source; it comes from lots of different sources, a little bit at a time. You can remember it this way: since the pollution does not come from one spot, you cannot point your finger at the source."

"I still don't understand why people don't realize how much trash they are putting onto the beach and into the ocean," said Linus.

"Sometimes it can be difficult for people to see that they are contributing to nonpoint source pollution," replied the Ocean Gnome. "Each person does not leave a great amount of debris on the beach. They might leave one soda bottle. They think to themselves, 'I know it's wrong to pollute, but it's only one soda bottle, it doesn't make a difference.' That's where they are wrong. They do not realize that even if they leave only one soda bottle, they are contributing to nonpoint source pollution as a whole. If each person on the beach leaves only one soda bottle, how many bottles will be left at the end of the day? A lot! Nonpoint source pollution adds up, one piece of debris at a time."

Linus thought for a minute about what the Ocean Gnome had said. "Can nonpoint source pollution occur with **pollutants** other than trash?"

"Of course it can! Linus, you have reached the end of your journey. With all that you have learned from the gnomes, can you think of other forms of nonpoint source pollution?"

Linus thought back to his talks with the Lake Gnome, the Bog Gnome, the River Gnome, and the Estuary Gnome. Was there a pollutant other than trash that people threw away in small amounts that added up to a big problem in the environment? "I've got it!" shouted Linus. "The Lake Gnome told me about biomagnification, which occurs when toxic chemicals enter into an ecosystem. The Bog Gnome told me about eutrophication, which occurs when too many nutrients enter an ecosystem. Could those be examples of nonpoint source pollution?"

"Very good, young Linus. You have learned much on your trip. Toxic chemicals and excess nutrients can indeed enter ecosystems by nonpoint source pollution. Consider waterways that are near towns or cities with a lot of people. Toxic chemicals from household cleaners could be washed down the drain. Oil from cars can get washed into storm drains in the street. All of these chemicals end up in the watershed sooner or later. Each person may have only put a tiny amount of chemicals down the drain, but the chemicals from each person add up to a huge problem."

The Ocean Gnome continued. "Also consider rural areas that specialize in agriculture. Imagine a stream that passes by a number of farms before emptying into a lake. The amount of nutrients from fertilizer entering the stream from each farm might be small, but if there are a lot of farms along the stream, there will still be a large amount of nutrients entering into the lake."

Linus thought some more about his talks with the other gnomes. "But when I was talking with the Bog Gnome," he said, "he told me that the eutrophication occurring in his bog was due to a single farm, not a whole bunch of them."

The Ocean Gnome was ready with an answer. "Certainly toxic chemicals or nutrients could come from a single source, such as a single farm with no others around, or a large factory or mill. But those problems are examples of point source pollution, and are much easier to fix than are situations with nonpoint source pollution."

"Why is that?" asked Linus.

"With point source pollution, you can stop or slow the entry of pollutants into the waterway by fixing the problem right at the source. You can imagine making a factory pump out less oil, or putting filters on its pipes that flow out into waterways. You could tell the farmer who lives near the bog to put less fertilizer on his crops, or plant a buffer of trees to reduce the amount of rainwater running from his farm into the bog. But what would you do in the example I gave you where there were lots of farms along a stream?"

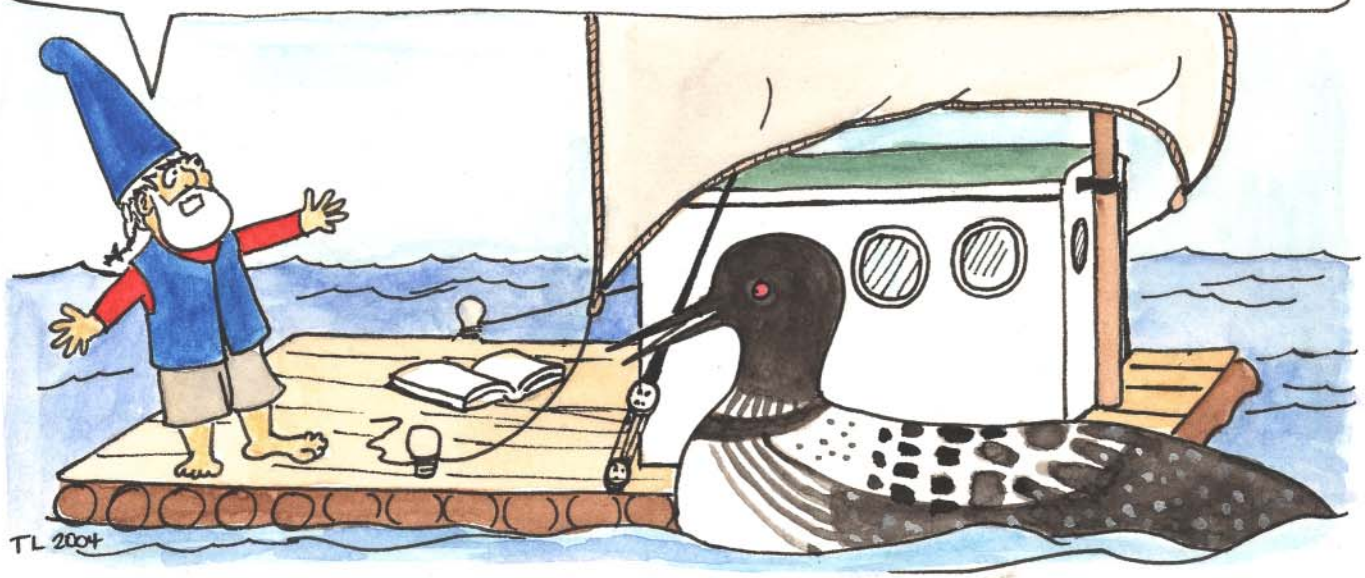
"I guess you would have to tell all of the farmers to reduce the amount of fertilizer they use," answered Linus.

"Right, and that is a lot harder than getting just one farmer to reduce his fertilizing. And it becomes even harder when you think about examples like the people living in a city, who fertilize their lawns or wash chemicals down their drains. How can you make sure that each of those people stops putting nutrients on their lawns, or toxic chemicals into the sink? How can you make sure that no one on my beach leaves any trash?"

NON-POINT SOURCE POLLUTION

OTHER SOURCES OF NON-POINT SOURCE POLLUTION INCLUDE:

- OIL RUNOFF FROM STREETS, PARKING LOTS & DRIVEWAYS INTO STORM DRAINS
- EXCESS FERTILIZERS, HERBICIDES & INSECTICIDES (WEED & BUG KILLER)
- BAD OR FAULTY SEWAGE SYSTEMS
- DIRT RUNOFF FROM WASHED-OUT OR BADLY MAINTAINED DIRT ROADS



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“I guess that would be pretty hard,” said Linus. “Maybe if there was a law saying people couldn’t leave trash on the beach, or maybe if there were more trash cans on the beach, there would be less pollution?”

“There are a number of things you can do,” said the Ocean Gnome. “There are lots of ways to reduce pollution, but ultimately you have to count on the people doing the polluting to clean up their act. At my beach, it is up to the beachgoers to make sure that they don’t leave anything behind, no matter how small they might think it is.”

Linus thought a bit more. “So the only real weapon against nonpoint source pollution...”

“...Is knowledge! People have to understand nonpoint source pollution before they can realize how much damage they are doing to the environment. People have to realize that every bit of pollution counts, no matter how small: it all adds up!”

“Is there anything I can do to help?” asked Linus.

“I wish there were, Linus. You have a good heart. What we really need is for people to spread the word about nonpoint source pollution and to make sure that they and their friends and family stop polluting, even in the tiniest amounts. I appreciate your offer to help, Linus, but I think people would have a hard time taking advice from a talking loon.”

“Or a gnome,” said Linus.

“You are quite right,” said the Ocean Gnome. “It looks like we will have to rely on humans to take care of this problem, and to spread the word about nonpoint source pollution! I only hope it is a task that they are willing to undertake!”

“Me too!” said Linus. “Well, it looks like the day is really getting on, and I’m hoping to find my family before nightfall. Thanks for talking with me. I hope the people on your beach will be cleaner next year!”

“So do I Linus, so do I. Now, farewell, Linus! Stop by and visit any time. And if you really want to learn more about the watershed and the problems facing it, I suggest you visit the King Gnome, who lives high up on Cadillac Mountain!”

Linus swam off to visit his family. As he left the Ocean Gnome’s raft, he noticed a tube coming up from the surface of the ocean. It was a snorkel! Suddenly a troll stuck his head up out of the water. After Linus had swum away, the Ocean Troll got a confused look on his face as he thought about all he had overheard that day.

It wasn’t long until Linus saw nine familiar shapes floating in the water. As he got closer he recognized Louis and Lois (his parents) and Lani, Laura, Lorraine, Lynnette, Liam, Leah, and even Fred. Everyone had migrated safely! Linus was very happy to see them all, and he spent hours that night telling them all about the things he had seen and everything he had learned from the gnomes. Everyone was fascinated by Linus’ descriptions of the sights and sounds of the watershed, and they were very concerned about all the environmental problems that Linus had seen. When he had finished his story, everyone in his family came to the same conclusion: it is a beautiful and fascinating world that we live in, and it needs to be protected!

Questions from the Ocean Troll

1. Why is it that people who contribute to nonpoint source pollution can have trouble seeing their impacts on the environment?
2. Have you noticed nonpoint source pollution in your community? Oil spots on the street or trash on the playground are examples. Can you think of others?
3. Can you think of ways that you might contribute to nonpoint source pollution?
4. What is the difference between point source and nonpoint source pollution? Can you think of some examples of each?
5. Why is nonpoint source pollution harder to take care of than point source pollution?

Chapter Five Vocabulary

Debris—Something that has been thrown away (trash).

Nonpoint source pollution—Pollution that comes from many different sources.

Pollutants—Substances that contaminate air, water, or soil.


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Epilogue:

On the Mountain of the King Gnome

It was midwinter. Wind howled across the ocean water and huge waves rose and fell. It was cold, and it was wet. You can imagine why Linus Loon was ready to go on a little vacation. It had been five months since Linus finished his migratory journey and had arrived in the ocean. As always, his feathers had turned to a brownish color and his nice white spots had disappeared for the winter. As he had sat on the cold water these past months, bobbing up and down, he had been thinking about what the gnomes had told him on his journey. The watershed was such an amazing place. He was concerned with all the problems he had learned about, and wondered if enough was being done to protect the watershed. Finally, he decided it was time to visit the King Gnome.

Linus' wing had healed since his journey and was working perfectly. He started flapping and began to run along the surface of the water. He ran for a quarter of a mile, picking up speed, when suddenly the ground dropped into the distance and Linus took to the air. He zoomed upwards for a while before leveling off at cruising altitude. Before long he spotted a mountain by the sea. He knew it had to be Cadillac Mountain. He closed in and prepared to land.

Linus found the King Gnome sitting in the snow at the top of the mountain. He wore a bright gold hat and had a royal blue tunic. He was currently deep in conversation with a seagull, but when he saw Linus approaching he wished the seagull farewell and turned to greet his new visitor.

"Linus Loon, I presume!" said the King Gnome. "I have been waiting for your arrival for some time now. It has been five months since your meeting with the Ocean Gnome; he told me that you would be visiting straight away!"

"I'm sorry that I'm late," answered Linus, "I've been visiting with my family. But I've come at last to hear what you have to say about the watershed."

"Linus, I have very little to say to you regarding the watershed. You have heard so much already from the other gnomes. You have seen the plants and animals of a lake, a pond, a bog, a stream, a river, an estuary, and the ocean. And most importantly, let's not forget everything you've learned about environmental issues in the watershed!

"First you learned about the **food chain**. You learned that a food chain is a way of describing who eats whom. Each **organism** in the food chain is eaten by the organism that comes directly after it in the chain. You know that every food chain starts with a **producer**, a plant or fungus that uses the sun's energy to make plant **tissue** through **primary production**. You learned that the organisms in the food chain that eat other plants or animals to get energy are called **consumers**. These organisms use **secondary production** to make tissue in order to grow or repair their bodies. You even learned that certain **carnivorous** consumers, called **predators**, hunt and kill their food source, called **prey**.

"Then Linus, you learned about something very important. **Biomagnification**, the process by which toxic chemicals or poisons enter an ecosystem and become more concentrated as they move up the food chain. At first, there might be only one unit of the chemical in the body of each organism. However, because each organism in the food chain needs to eat multiple other organisms to survive, the amount of the chemical in the body of each organism quickly increases as you move up the food chain. In the example given to you by the Lake Gnome, it took only three steps in the food chain to reach 250 units of the chemical inside a single loon!

"Then you had a lesson in **nutrients**. You learned that plants use nutrients to grow. However, too many nutrients can result in too much primary production. Putting too many nutrients into an ecosystem is called **nutrient loading**, and it can result in **eutrophication**. Eutrophication is when a body of water begins to fill up because there is too much plant growth. And you remember, of course, what effect this has on other organisms in the pond?"

"Oh yes," said Linus. "As plants die, they sink to the bottom of the water body. There, bacteria decompose them. This process requires oxygen. The bacteria take the oxygen out of the surrounding water, leaving little or no oxygen for other organisms in the water. Soon the other organisms die, leaving no fish for my lunch!"

"Yes, very good, Linus," continued the gnome. "Then I believe you learned how all bodies of water are interconnected. And of course, because everyone relies on water in some way or another, this means that all areas and all organisms are connected by the **water cycle**. You know that in the water cycle, water flows through the ecosystems of the earth, and eventually **evaporates** into the air and becomes water vapor. In the air, the water vapor combines with dust to form clouds. Inside the clouds, water vapor eventually **condenses**, turning into rain and returning to the earth to start the cycle all over again.

"You have also studied estuaries. You have experienced first hand that the **salinity** of **brackish** water is higher than that of a freshwater river, but lower than that of the saltwater ocean. You know that estuaries are highly productive areas because a good amount of nutrients brought by the river are trapped there by the tides, supporting many plants and animals.

"I believe the Estuary Gnome also told you about **biodiversity**, the variety of species in an ecosystem. You know that different species have different strengths and weaknesses. This means that when an environmental catastrophe strikes, some of the organisms in the ecosystem will be harmed, but some will survive. So biodiversity protects an ecosystem and makes it healthy. If there is no biodiversity, we call that ecosystem a **monoculture**. It is not very healthy, because a single catastrophe could wipe out all the organisms in the ecosystem!

"Finally your journey brought you to the beach and the ocean. There you saw a lot of **debris** on the beach and in the water. You learned that this debris was the result of **nonpoint source pollution**. You learned that nonpoint source pollution has many different sources and comes in little pieces at a time. This is the opposite of **point source pollution**, where a single source releases a large amount of **pollutants** into the environment.

"You even looked back and realized that biomagnification and eutrophication could happen by point source pollution when a single large factory or farm releases pollutants, or by nonpoint source pollution, when many people in one area release pollutants into a water body.

"Indeed you have learned much, Linus Loon, about the interactions between **flora**, **fauna**, and their physical environments. The study of those interactions is **ecology**!"

Linus was impressed, thinking back at everything he had learned. But a worried look came over his face. "I know I have learned a lot, but isn't there anything else you have to teach me?"

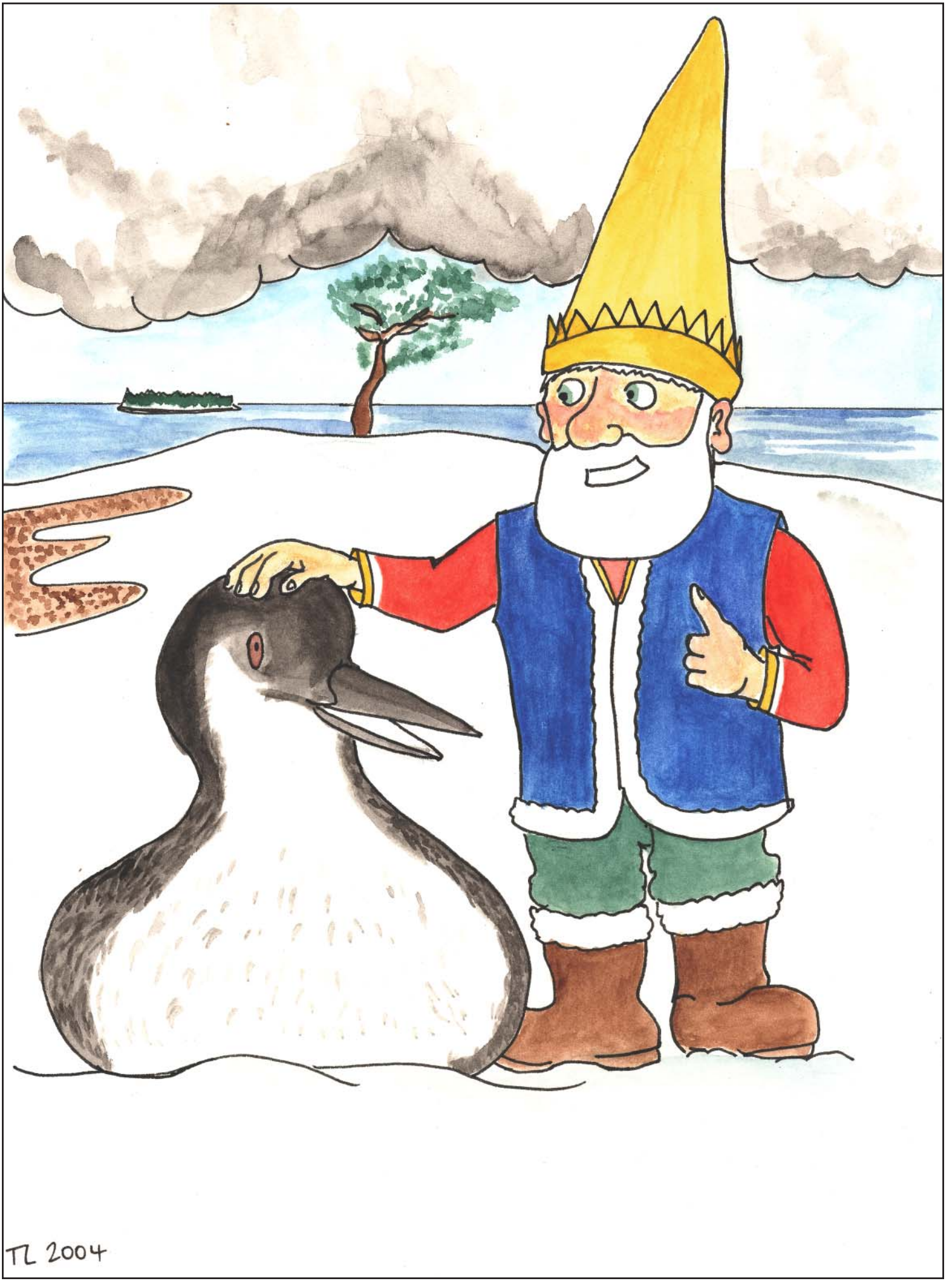
"Hmmm…" said the King Gnome. He looked at Linus with a twinkle in his eye. "Perhaps there is. I know that you have become frustrated by the problems of nonpoint source pollution. You know that point source pollution is much easier to clean up than is nonpoint source pollution, because you can simply go to the source and fix the problem. But it is much harder with nonpoint source pollution. When there are so many sources of pollution, it is difficult to fix them all. It is especially tough, because people often don't realize that they are contributing to the problem, because they think that leaving behind one piece of trash or putting just a little bit of toxic chemicals down the sink won't matter much to the environment. People don't realize that pollution adds up!

"But here is my new lesson for you, Linus. Little bits of pollution may add up into a big problem, but the same can be said of trying to clean up the environment: every little bit of effort made to clean up the environment adds up into a big help! Remember the dirty beach that you saw? Well, what if each person who went to the beach picked up just one piece of debris while they were there? Imagine how much cleaner the beach would be at the end of the day! If everyone pitched in and cleaned up just a little bit, think about how much better the world would be! And if everyone made sure that they didn't leave any trash at the beach or put any chemicals down the sink, think about how much cleaner our environment would be in the future!

"I am going to teach you one last word, Linus. The word is **conservation**, and it means almost the same as 'protection.' It is the management and care for our environment and all the wonderful resources in it. What we need, Linus, is for people to start thinking about conservation in their everyday lives.

"The way conservation works right now is that most of the effort is being made by environmental organizations or groups. In a way, you could call this system '**point source conservation**.' The conservation effort is coming from specific groups that spend a lot of time, energy, and money to protect the environment.

"What I want to suggest to you is a movement towards what I like to call '**nonpoint source conservation**.' Can you imagine what that might be? Instead of relying on a few groups to protect our environment, each person would make sure that he or she does not harm the environment. Further more, each person would put forth just a little bit of effort to clean up pollution. It would all add up, and the effect would be amazing!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"Of course, nonpoint source conservation depends on two things. One is that people are willing to do their part to protect our natural environment. The other is even more basic. Can you guess what it is?"

Linus thought back to the Ocean Gnome. "Knowledge!" he shouted.

"That's right!" said the King Gnome. "People must know about the problems the environment is facing. They must know what is wrong and how they can help!"

"But how will they know?" asked Linus. "The Ocean Gnome told me that the people would not listen to a talking loon or a gnome. Who will tell the humans what must be done? I guess we will have to hope that people who have learned about problems in the environment will spread the word and educate others about nonpoint source pollution."

The sun began to set. Linus thanked the King Gnome, who shook his wing. The gnome said, "It is the duty of the gnomes to educate others about the environment. I thank you, Linus, for being such a good student!" Linus flew back to meet his family, thinking about everything he knew about the environment and the watershed. It was such a wonderful place. "If conservation is in the hands of humans," he thought, "I certainly hope that they will do their part to protect the world we live in and the water we rely on!"

The Watershed Review:

Questions from the King Troll

The King Gnome watched Linus fly away that day, but he was not the only one with his eyes on the sky. Further down on the mountain, the King Troll was watching Linus go. He had been listening to what the King Gnome had been saying, and his head was just about to burst with questions. Being the king of all trolls, he is especially inquisitive. Can you help him?

1. Write a poem or short story that uses the following words:

Ecosystem, organism, flora, fauna, conservation.

2. Place the following words underneath the organism that they describe (coyote, rabbit, or clover). You may use the same word for more than one organism.

   Consumer, producer, carnivorous, primary production, secondary production, predator.

   Coyote Rabbit Clover

3. Use the following words to fill in the blanks in the sentences below. Use each word only once.

   Tissue, nutrient loading, water cycle, evaporation, condensation, brackish, salinity, biodiversity, monoculture, debris.

a. While a _____ only has one type of organism in it, an ecosystem with lots of different species of organisms has a lot of _____ .

b. _____ water isn't very salty, but it's not fresh water either. Its _____ is somewhere in between ocean and fresh water.

c. In the_____ , water leaves the surface of the earth by _____ and becomes vapor. Later, the water vapor becomes rain and falls back to earth through the process of _____ .

d. Primary production means that plants are using energy from the sun to create _____ .

e. _____ can happen when people put too much fertilizer on their lawns.

f. Another word for trash is _____ .

4. Draw three simple pictures using the following words. Label your drawings.

Picture #1: Pollutants, biomagnification, food chain

Picture #2: Nutrients, eutrophication

Picture #3: Point source pollution, Nonpoint source pollution

5. What does nonpoint source conservation mean to you?

Nonpoint source conservation

Here are some questions about how you could help out the King Gnome and Linus:

What could you do around the house to make sure you pollute as little as possible?

What could you do in your everyday life or at school to make sure you pollute as little as possible?

What could you do to help clean up the environment, other than your house or school?

The King Gnome said, "It is the duty of the gnomes to educate others about the environment." You could be an honorary gnome by telling others about environmental problems and solutions. Who could you tell about nonpoint source pollution and nonpoint source conservation?

Be a Gnome, Spread the Word!