



*Didactic guide*

**PATAGONIAN WATERS**

*from the mountain range to the sea*



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## Introduction

Water is a part of nature that is with us all the time, from something as simple as washing our faces to wake us up to every cell of our bodies. From an **ancestral vision**, water is connected to emotions, to purification and to cleaning rituals. In a certain way, there is a wise relationship with the physical-chemical characteristics of this element.

Water is known as a universal solvent, capable of dissolving gases, salts and other liquids. Thanks to this characteristic, it is a **powerful medium** to transport nutrients between cells and ecosystems. Sadly, this also means that water is easily contaminated.

During its path from the mountains to the sea, water builds a close relationship with the ecosystems it comes into contact with. This means that the freshwater systems are highly vulnerable, given that an intervention in any component of the fluvial unit can generate a great impact on it, and even in other ecosystems.

We invite you, through this guide, to discover the Patagonia's freshwater systems, become enchanted with its mysteries, and live side by side with this beautiful area, protecting it through valuable actions in the search for **sustainable development**.

This guide is a trip to discover, get to know and explore **WATER**.

## Prologue

Just as the 20th century saw great scientific and technological progress, we feel that in the 21st century it will be the environment's turn. The environmental issues of our time - climate change, the accumulation of waste and especially plastics, the overexploitation of natural resources, the poor quality and distribution of freshwater - are threats that are so serious that they limit the current and future wellbeing of humanity.

The urgent need to solve environmental problems in the coming decades forces us to highlight that this will only be possible if every country has environmentally educated populations. It is necessary that we relearn the principles and limits of the ecosystems we depend upon. However, it is even more important to love nature and be capable of acting together, thinking about the common good and about the mid and long-term.

Being successful in this great challenge, means creating environmental education programs, providing physical sites to implement them, professional and qualified human resources to educate and developing programs and didactic resources that facilitate education both outdoors and in classrooms.

The Guide we mention here, "Patagonian Water: from the Mountains to the Sea", is meant to help with this important task, providing basic concepts, examples and a background of the local reality. Fundación MERI protects the exuberant nature of Melimoyu park in Northern Patagonia, with an outstanding team of professionals that support communities, teachers and schoolchildren, so they can reach the knowledge and experiences which promote love and care for the environment, focusing specially on water, from the glaciers to the sea.

On creating this Patagonian Waters Guide, Fundación MERI greatly strengthens its mission to provide Environmental Education for the conservation and sustainable development of Northern Patagonia and its inhabitants.

I wish to congratulate the team for this text, which I hope can benefit all those who want to encourage Environmental Education.

Ana María Vliegenthart  
Education Director - Fundación Parque Katalapi



## Words from the President

Water, an essential element for our survival, is a crucial part of our nature and geography. Its presence in rituals and religions, both in the east and west, symbolizes the importance humans have given it over time.

Despite the Earth being comprised by 70% of water, this element, vital for our lives and sustainability, is under threat. It is scarce and in jeopardy. In fact, only 3% of the world's water is fresh and its reserves are, to a great extent, in the glaciers, including those in our country, as well as in underground water, lakes and rivers.

Today, we are facing a complex scenario, where the combination of diverse human and natural factors, including the excessive use of plastic, the contamination of the atmosphere and the oceans, and fires caused by man, among other aspects, have led to an increase in the planet's temperature and the resulting extinction of hundreds of animal species, along with phenomena like droughts and thawing, that are affecting not just the availability of this resource, but also causing changes in our lifestyles.

**We have to rethink about the way we want to live in the next 30 years.**

We know that we cannot keep doing things in the same way, that we have to change as a society, become responsible for our acts and, more importantly, be respectful with nature. From this view, it

is important to build a model that innovates, based on integral and sustainable development.

The young Swedish activist, Greta Thunberg, at just 16, has raised her voice and stirred nations around the world, making them share her fear and panic, upon seeing what is happening before our very eyes every day. Apart from being a reference for all young people, this is a tremendous lesson for adults, so we can turn our view towards the obvious, looking towards the great questions about our way of life.

There is no time to lose. Facing this scenario and making the necessary changes is a task for each and every one as a single collective. We need to be many to cause a change in consciousness, to take care of our planet, the space where we live. The challenge is also on an individual scale: in our homes, schools, universities and companies. We are all called to start this change today.

We trust and value the great effort the boys and girls are representing. For this reason, from Filantropia Cortés Solari and Fundación MERI, we have focused our energy on education. We know that we are part of nature and the importance of preserving the essential contact with it. Nature helps us understand life better. It improves our human attitudes, making us feel alive.

**WE ARE NATURE** and we are part of this great ecosystem. When

something as essential as water is in jeopardy, then so are we, all of humanity.

*What happens when a species loses contact with its own ecosystem?* We want to promote the construction of a healthy society where all human beings, all living beings, can live together, where one and all respect nature. Those who pray for it, those whose heart beats for the Earth are those that we need.

We invite boys and girls, youth, adults and grandparents to join the great challenge that facing climate change involves, taking concrete, real actions.

We believe that it is necessary that teachers, through education, open up to this new paradigm and approach the great natural laboratories we have in the country. This way, in the near future, we will get to see great scientists, researchers, teachers, farmers, artists, all taking part, together, in this great change.

To help this vision, we have prepared this second educational guide, along with the scientists of Fundación MERI, of the Melimoyu Nature Reserve and a committed transdisciplinary team. This is a good source of knowledge and that all those who read it can help us to continue transmitting the importance of understanding the value of life and everything it gives us.



**Francisca Cortés Solari**  
President of Fundación MERI  
Filantropía Cortés Solari



## The origin of water

How was water formed on Earth? Scientists propose two ideas about the origin of water:

**Volcanic origin:** There is evidence that supports water was born from the Earth's core because. This, because the minerals it comprises had water and as volcanoes erupted, the water was released into the primitive atmosphere as gas. This gas condensed, giving life to the water cycle.

**Alien origin:** scientists hypothesize that water came to Earth in the form of microscopic crystals in a meteor storm. These had hit the *Earth's crust* over millions of years, forming the sea bed some 3.5 billion years ago, originating life. So, water may have fallen from heaven!



## Water only exists on Earth?

Astronomers are very interested in investigating about water on other planets, because the theory is that, if there's water, *there's life!*

On Mars, the climate does not allow liquid water to be on its surface. However, in 2018, scientists detected an underground lake under the ice of the red planet's south pole.

Another place where we have found water is in some of the more than 60 moons of Saturn, which is mainly made of ice. In fact, one of them called Enceladus, and is completely covered in ice, and under its south pole lies a large ocean.

There is water in many parts of the cosmos, from comets to planets. We keep learning the characteristics of water and the wonderful places where it can be found.





## What is water?

Water is the essential component for life on Earth.

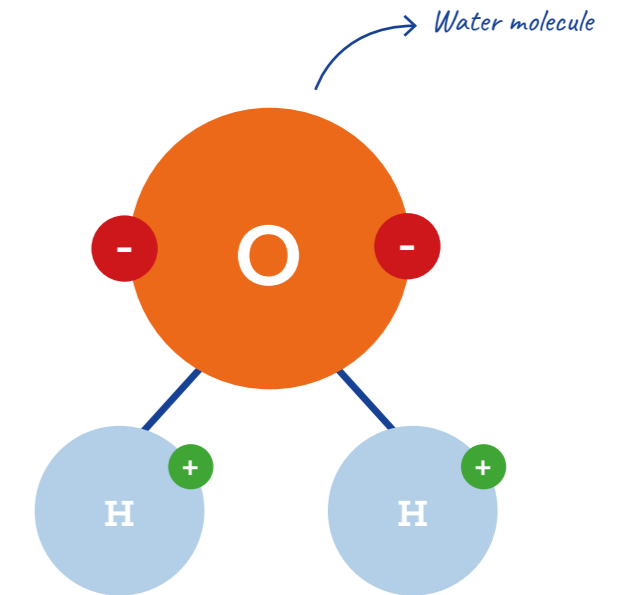
All living beings have water within. Its presence in practically everything, due to its magnificent molecular composition.

### What is a water molecule like?

It comprises three atoms: two hydrogen (H) and one oxygen (O), so its chemical formula is  $H_2O$ . These atoms are joined by a great force and, when balanced, organize forming a triangle.

The water molecule has electric asymmetry, that is to say, hydrogen atoms have a positive charge and the oxygen atom has a negative charge.

Water is almost the only compound with these molecular characteristics, which give it unique properties. We invite you to discover them!



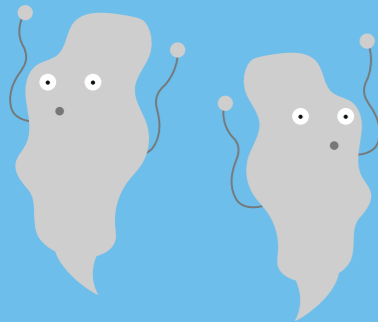
*Do you know that our body, just like the Earth, is 70% water?*

This image represents a drop of seawater augmented 10,000 times, based on the photograph of David Liittschwager.

## Properties of water

Water in nature can be found in three different states:

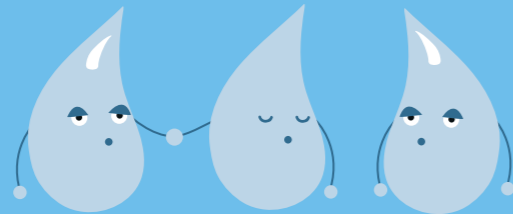
*Boy it's hot!*



**Gaseous as steam**

There is a weak attraction between the molecules which move freely through space. At a higher temperature, water molecules are agitated and occupy more space.

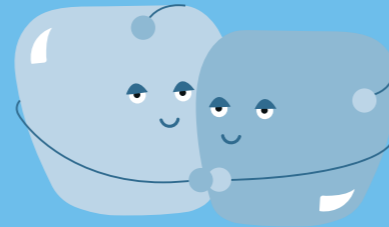
*Keep flowing sister!*



**Liquid**

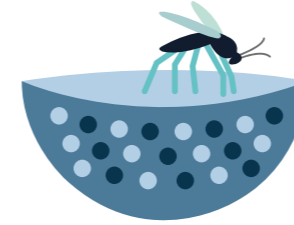
Molecules unite and break apart continuously. Water has a changing form and constant volume.

*Molecules, assemble!*



**Solid**

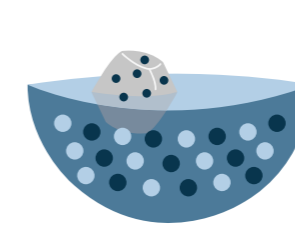
The molecules maintain an ordered structure. They are united and cannot endure changes in form.



**Surface tension**

Have you ever wondered why some insects can walk on water?

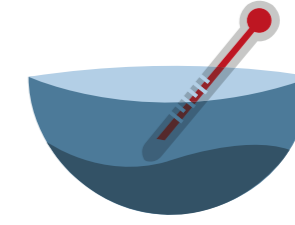
It is possible because of “surface tension”, as water molecules on the surface unite sideways and downwards, creating a layer of tension on which insects can walk.



**Density**

Why does ice float? Water molecules, depending on the temperature, are closer or farther from each other, that is to say, the water becomes more or less dense.

In ice, air is trapped between water molecules. This makes ice less dense than water in liquid state and, therefore, it floats.



**Specific heat**

Why on the beach the sand is hotter than the water? Water has a high heat capacity, so it needs more energy to increase its temperature. This explains why the sand on the beach is hotter than in the water, although both were under the sun for the same time.

This trait allows water to control temperature and the climate. Have you realized that days are fresher and nights warmer close to the sea? *Water helps us enjoy a pleasant climate!*



**Solvent capacity**

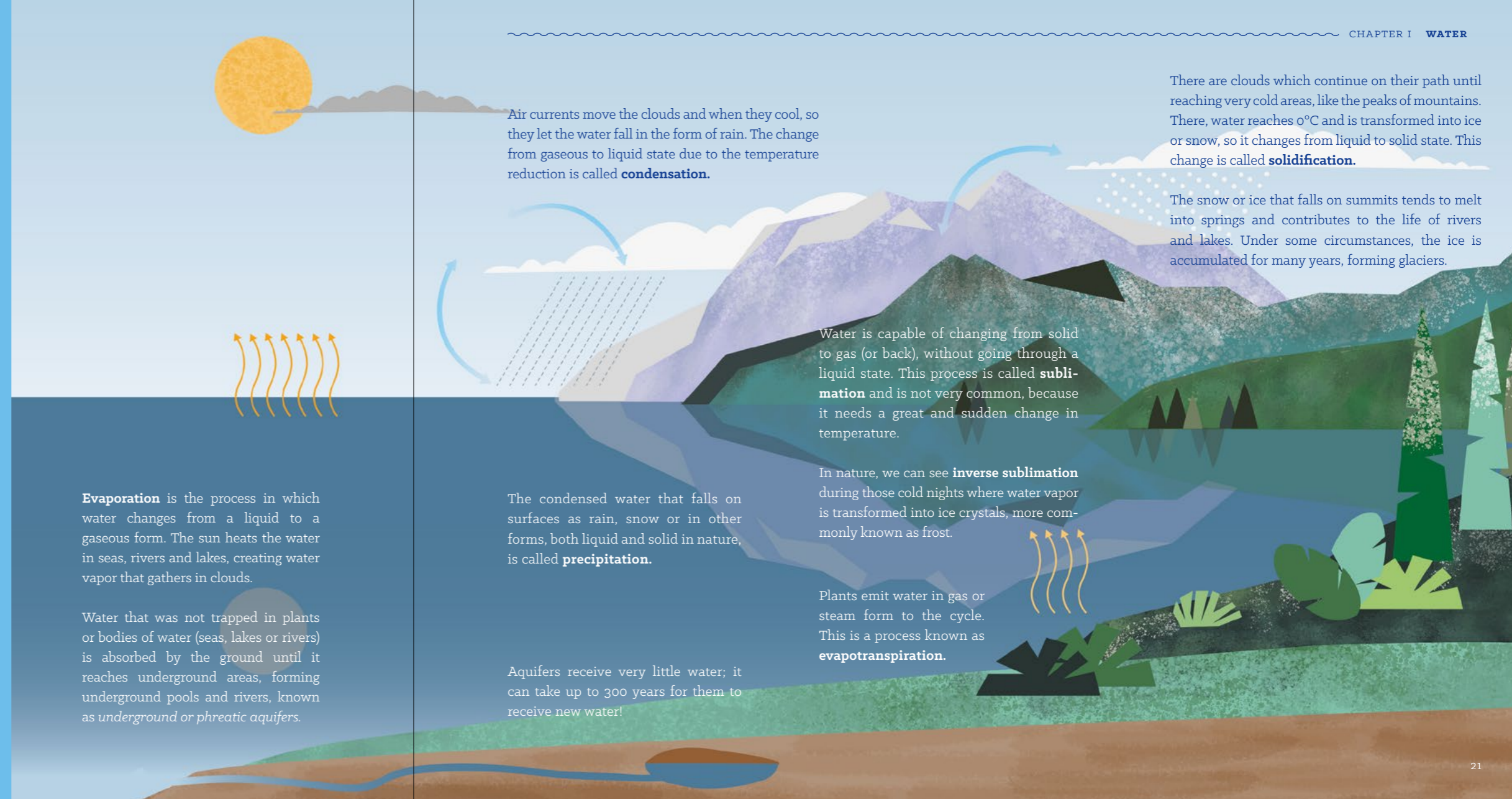
Why is water contaminated so easily? Water can dissolve a great variety of gases, salts and other liquids. This is because its molecules have a positive and a negative pole. The positive pole attracts compounds of a negative charge, and vice versa. This way, water molecules separate elements that were previously united.

Thanks to its solvent power, water helps us by transporting nutrients between cells and in ecosystems. *However, this trait means water is easily contaminated!*

## Water cycle

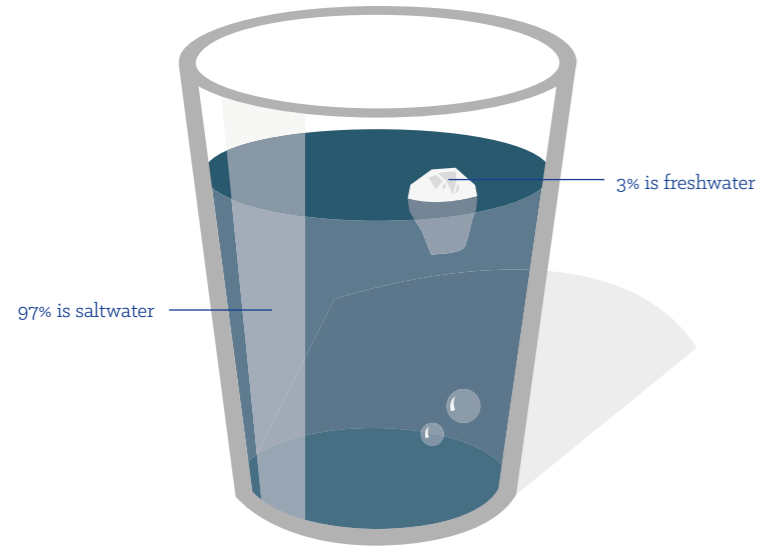
Water is constantly changing, going from one state to another thanks to changes in the temperature, ground, vegetation, geographical characteristics, among other factors.

The water that dinosaurs drank millions of years ago is the same that you drink today, and the same that your grandchildren will drink tomorrow.



## Water on Earth

Our planet has more water than land! Around 70% of the Earth's surface is covered by water.

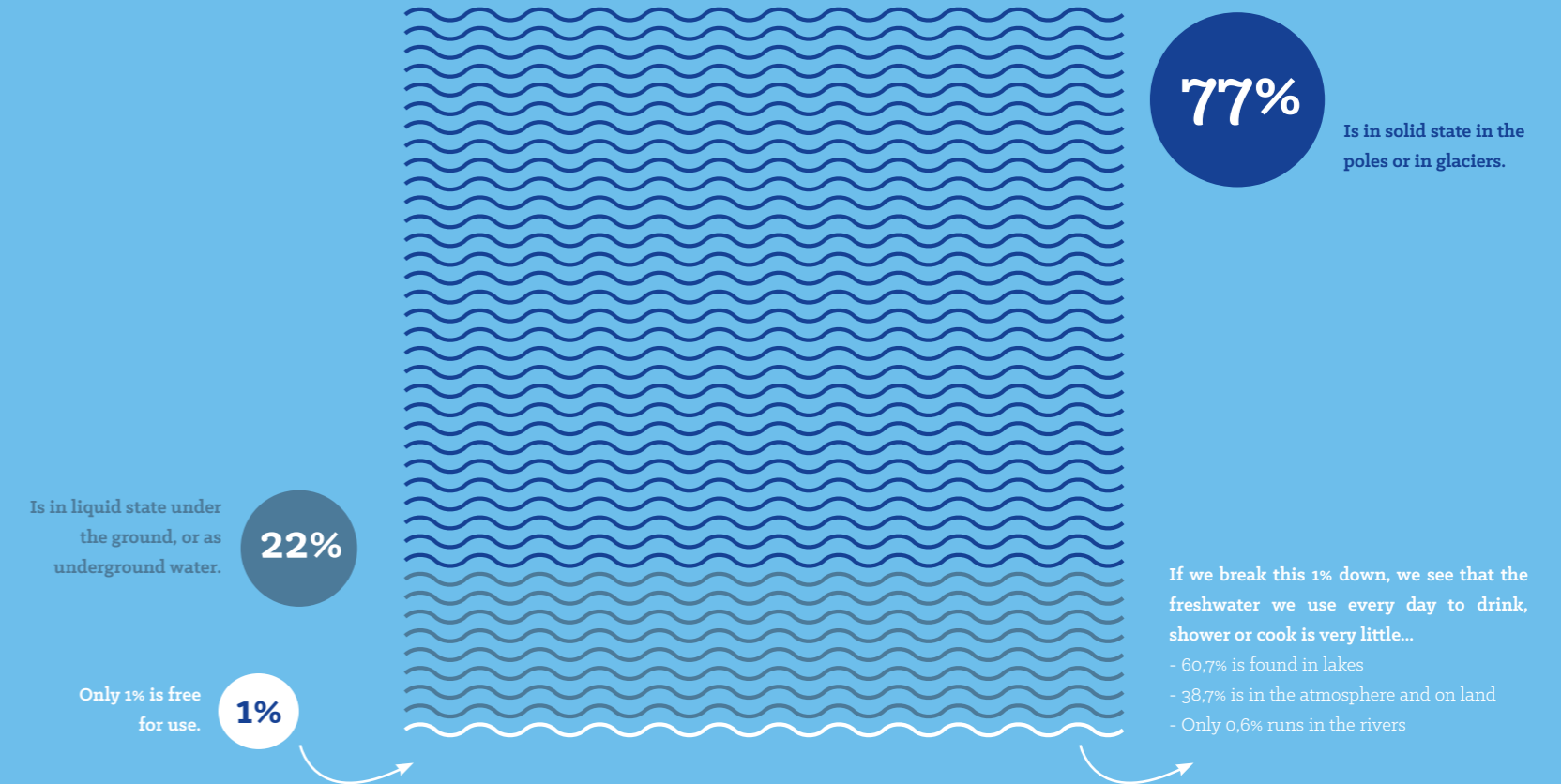


If we break down the Earth's water, **97%** of it is in the oceans as "saltwater", and the rest (**3%**) is "freshwater" in different states.

From this 3% of freshwater, most is in solid state; another percentage is underground, and only **1%** is available for consumption. Do you realize why we have to take care of it so much?

*What do you do to take care of water?*

Now, if we break this 3% down into its states, we find out that:



## The Watershed

### What is this?

This is a space formed by mountains, similar to a funnel in shape, where water accumulates and runs in different ways. Later, all this water joins a main river that reaches the sea or a lake, a swamp or an aquifer.

### How is it formed?

The watershed is formed by tectonic plates colliding or lava ejected by volcanoes that has cooled. This allows for the creation of new spaces to accumulate water. Sometimes, rocks and land come loose in the watershed's mountains, creating barriers which hold back the water. These are known as "natural reservoirs".

The watershed has a very important role in life:

#### Hydrological role

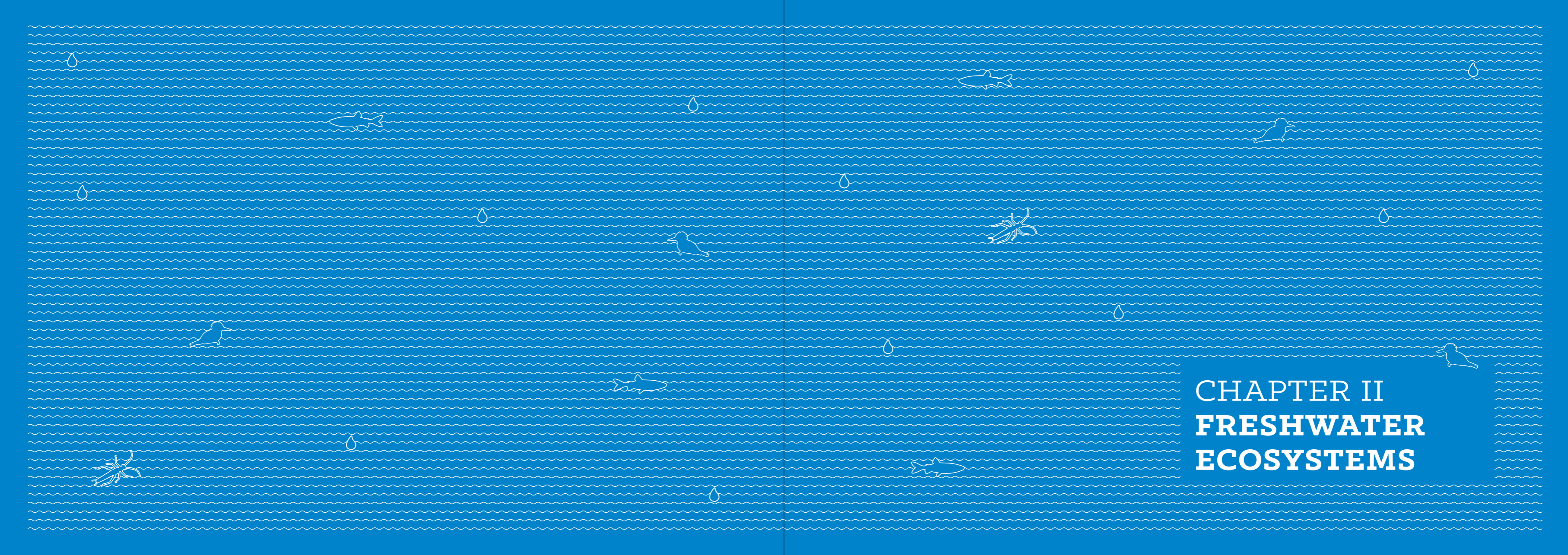
The watershed channels the water that is accumulated or runs in different ways, like rivers, estuaries, lakes, lagoons or glaciers, allowing the development of very different ecosystems.

Due to its large size, it is an important space for the water cycle to occur in, letting water to change its form while it moves over the earth's crust.

#### Ecological role

Because there are different forms of earth and water, this creates spaces in which different bacteria, fungi, plants and animals can live in different parts of the watershed, giving room for a high *biodiversity*.





CHAPTER II  
**FRESHWATER  
ECOSYSTEMS**

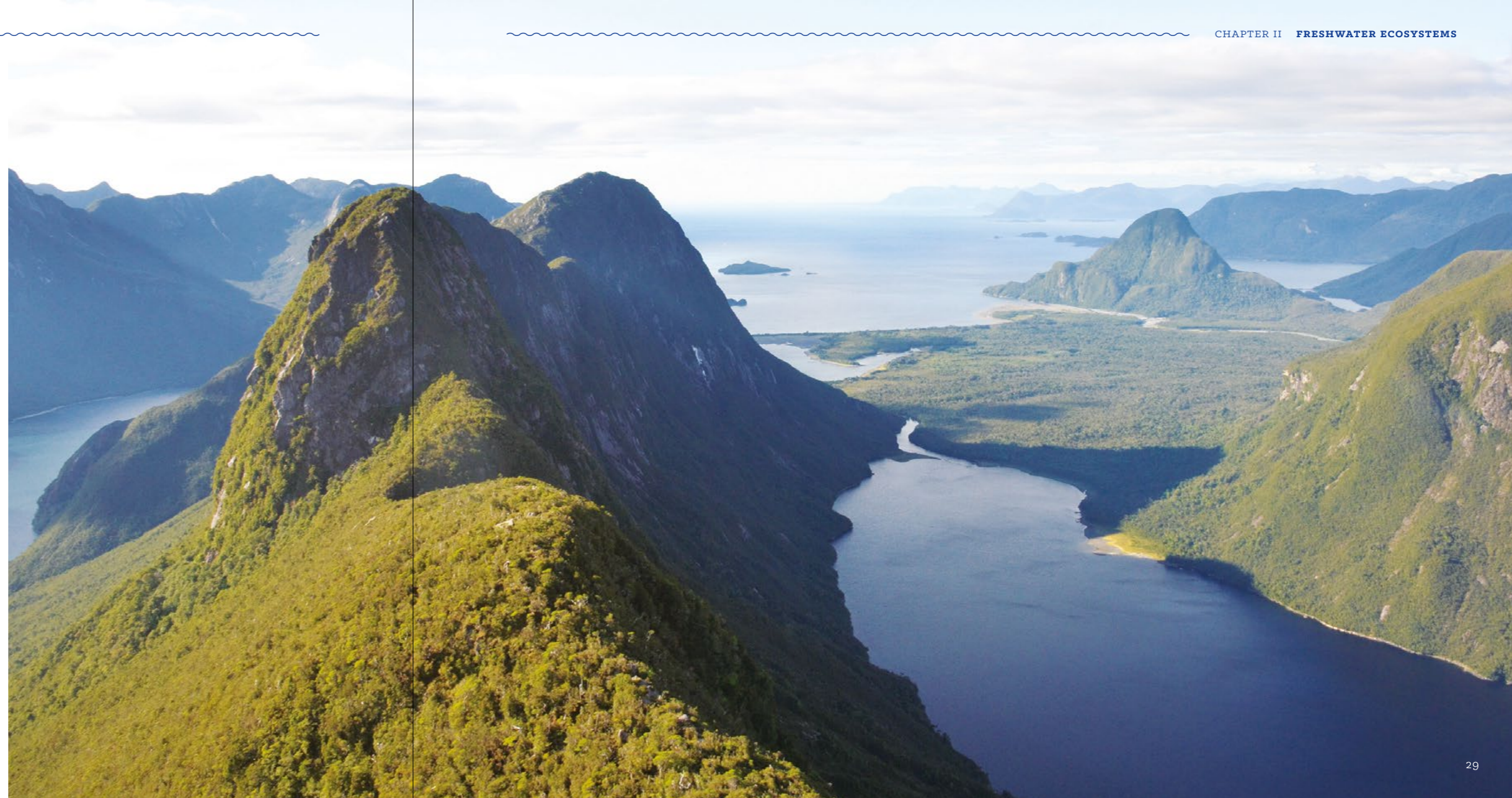
## The freshwater ecosystems: Glaciers, rivers, lakes, wetlands and fjords.

A freshwater ecosystem is a type of ecosystem where freshwater dominates, and it is the home for living beings that adapted there.

In Patagonia, there are freshwater systems that are born in the highest of the Andes' peaks, connecting glaciers with rivers, wetlands, fjords and the ocean. During their path, from the mountain range to the sea, they transport nutrients, making the possible the interaction between land and marine based ecosystems associated to freshwater systems. This allows the elements within the watershed to act as a living network.

### What is an ecosystem?

It is a space shared by living beings and non-living elements of the environment, and the vital relationship that exists between them.



A glacier is a large body of ice that is on land, and that remains in this form for many years. It is common to find them on mountain peaks or close to them, and although they are big and heavy, glaciers move slowly downwards, crushing rocks and shaping valleys.

Glaciers are currently fed by snow or hail that falls on the mountains and that is accumulated in layers, until it becomes a compact mass of solid ice.





## Glaciers

### Why are they important?

- They are a natural freshwater reserve.
- They are a key piece for the water cycle. When they melt in summer, they feed water into all the watershed's rivers, lakes, wetlands, and underground aquifers.
- Thanks to their water, every year they contribute in the fight against *desertification* and drought.

*Is water a living or non-living element? What do you think?*

### How does global warming affect the glaciers?

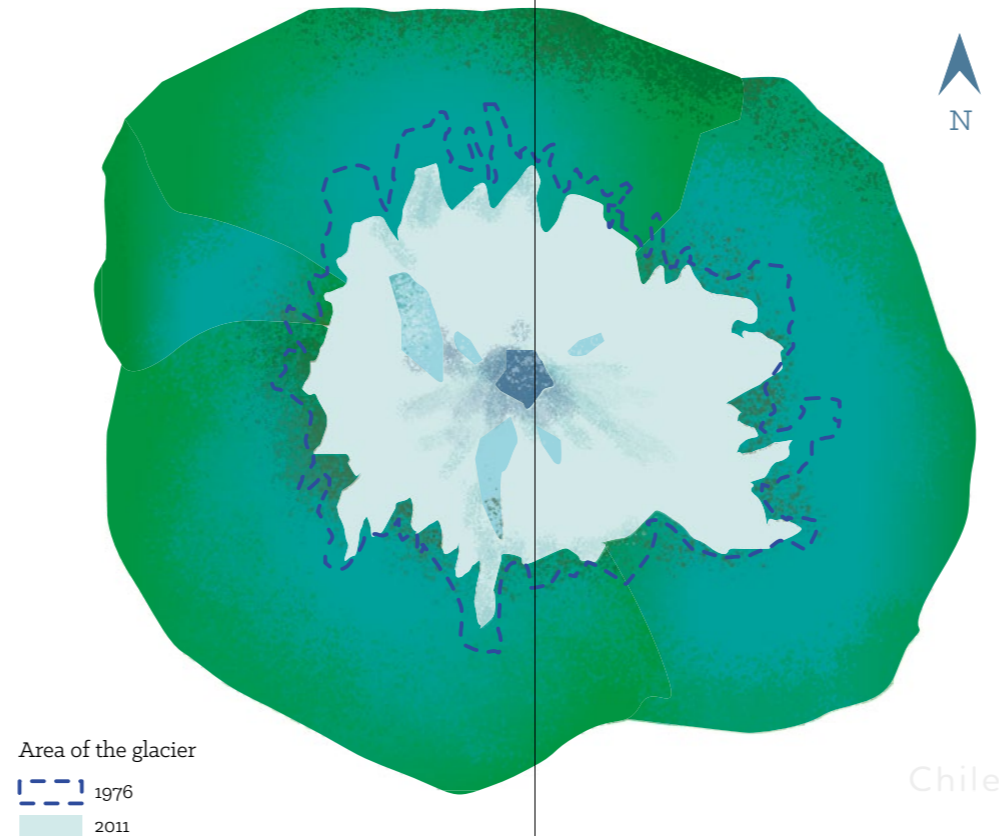
Global warming has an effect on two factors that allow a glacier's conservation: *precipitation and temperature*. Snow (solid precipitation) feeds the glacier, and this demands low temperatures so that the ice remains in that state for many years. If temperatures increase and precipitation falls, the glacier begins to recede.

If glaciers disappear, the watershed could not receive freshwater, affecting all ecosystems and people.

### How do scientists study changes in the glaciers and global warming?

One of the ways of studying a glacier is by measuring how much a glacier moves forwards or backwards over land. This way, it is possible to analyze the amount of water that enters and leaves the glacier.

Aerial view of Melimoyu Volcano



### Some of the glaciers on continental Chile are:



**Melimoyu Glacier**

It is located in the north of the Aysén Region, on top of a volcano with the same name. The Melimoyu glacier is formed by seven smaller glaciers which feed the Palena, Añihué, Bahía Mala and Marchant rivers. The latter flows into Melimoyu bay.



**Northern Patagonian Ice Field**

It is found in the Aysén region and has a surface area of 4,200 km<sup>2</sup>. It is bordered by the Nef, San Rafael, Jorge Montt and San Quintín Glaciers.



**Southern Patagonian Ice Field**

Found between the Aysén and Magallanes regions, it has a surface area of 16,800 km<sup>2</sup> and is bordered by 49 glaciers. The Southern Ice Fields are shared by Argentina and Chile, with 85% in the latter.

A river is a natural water current which flows continuously from higher to lower areas.

Generally, the mouth of rivers is close to an ocean. Although it is also possible that they flow into lakes or other rivers of the same watershed.



## Shapes of a river

Along their route, rivers along can take different shapes, and each one has a name:



### Straight

They move to the mouth in a straight line.



### Winding

This forms more or less noticeable curves from one side to another.

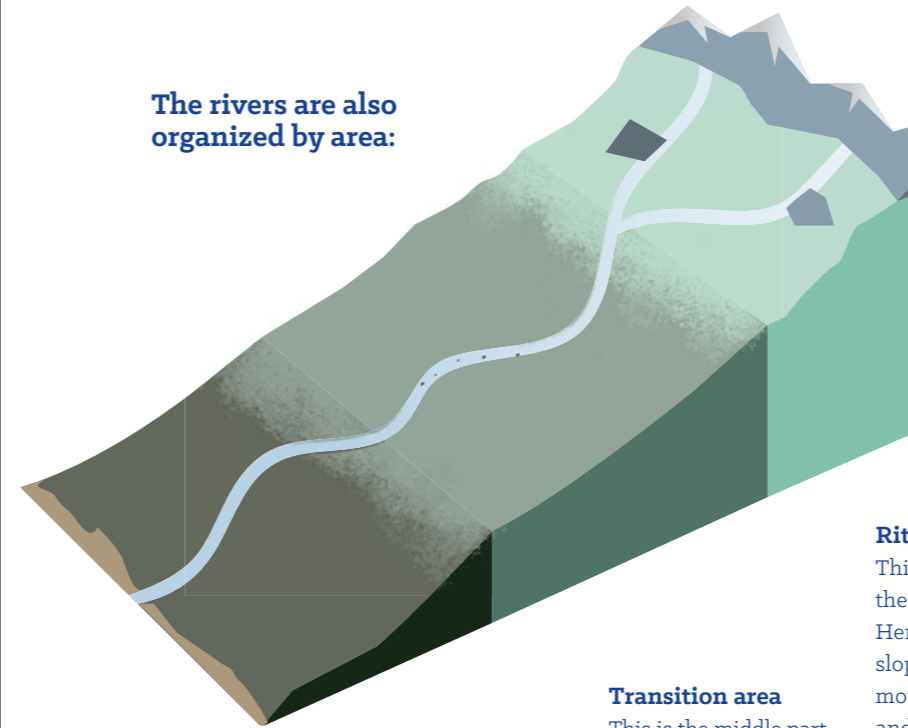


### Braided

They are formed by many channels, separated by small islands made of sediments.

*Which straight, winding or braided rivers do you know?*

The rivers are also organized by area:



### Rithron

This is the area at the top of the river. Here there are a lot of slopes, and the water moves with more force and faster, dragging all the material on its path. It leaves very large and sharp stones on the riverbed.

### Transition area

This is the middle part of the river. Here, the river does not run very quickly and its bed has a mix of small stones and sand.

### Potamon

This is the mouth of a river. The water flows slowly, and the bed has a lot of sand because all the stones and organic material have been broken down into smaller bits.

What is the role of rivers in the ecosystem?

Rivers are vital for water basins, because they gather all the water that runs in the watershed in a single location.

Therefore, every water basin has a **main river** into which the water drains. Also, rivers maintain the water cycle because they return frozen waters of the mountains to lakes, aquifers and oceans.

## River mouth

The amount of water that runs along a river is called "**flow**", and it is measured in m<sup>3</sup>/s. They can carry more or less water in their stream, depending on the contributions received.

When they flow into the sea, they can form a kind of triangle, which is called a **delta**, that is full of sediments dragged along their path.

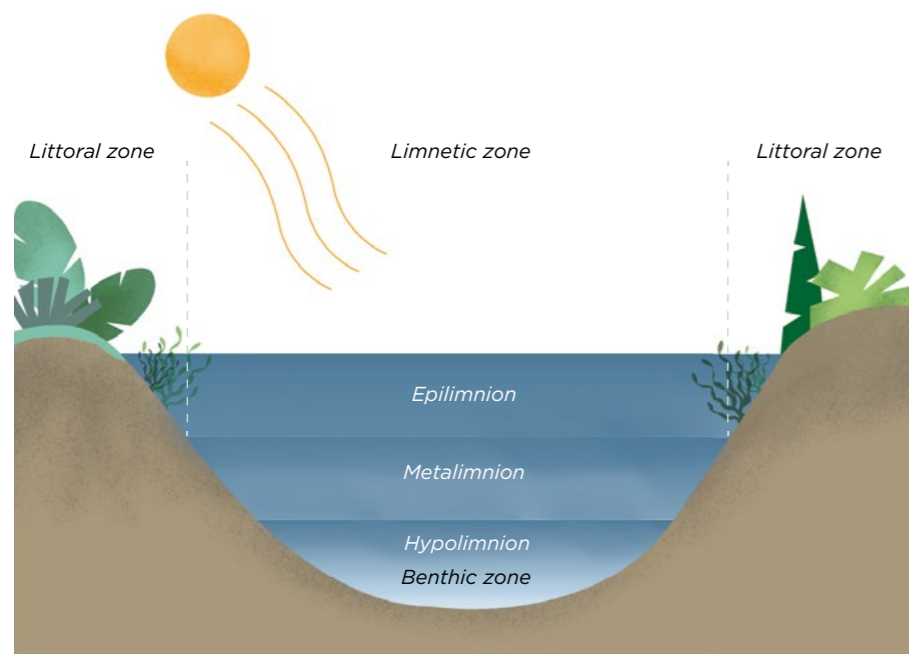
A lake or lagoon is an accumulation of freshwater, saltwater or a mix of both, in places where the land sinks down.

Most of the time, the water that lakes accumulate comes from rivers or aquifers and remains there because the amount of water that it loses is less than the water it receives.



Lakes and lagoons

## Zones of a lake



### Littoral zone

This is the water at the lake's edge. It is shallow and has sunlight, so plants with roots can grow. Here, there is a lot of dissolved and particulate organic matter.

### Limnetic zone

This is the deep-water zone, where there is enough light to allow photosynthesis.

### Benthic zone

This is lakebed, where there is mud, stones, sand, along with remains of plants and animals that sink and decompose. Sunlight does not reach here, so photosynthesis is not possible.

### Epilimnion

It is the upper layer of the lake, where the water is rich in nutrients and receives a great amount of sunlight, hence photosynthesis occurs. It is an ideal place for phytoplankton to grow. Its temperature is stable, thanks to the wind that moves the water.

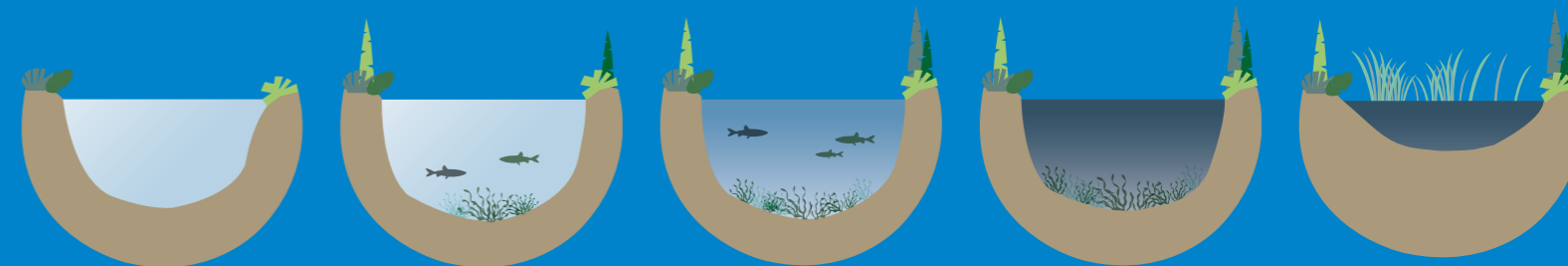
### Metalimnion

It is an intermediate layer of water, where not much sunlight gets through, and the temperature lowers little by little. This layer separates the (lukewarm and light) surface water from the deep (cold and dense) water.

### Hypolimnion

A deeper, colder and denser layer. This zone is almost pitch black and accumulates remains of plants and animals, which are consumed by the organisms living here.

## Evolution of the lakes



### Oligotrophic

This term refers to young lakes, with few species of flora and fauna. Their waters have a lot of oxygen, but few nutrients. These crystalline waters have the potential to be consumed by us. In Chile, they can be found in the south or up high in the mountains.

### Mesotrophic

Lakes with clear waters and with enough nutrients to allow aquatic plants and animal to coexist without any problems.

### Eutrophic

Evolved lakes, that have a lot of photosynthesis. These can be in two phases:

**Clear phase**, thanks to the presence of many aquatic plants that keep the water clear.

**Dark phase**, because of the turbid water that is caused by a limited number of aquatic plants. Different animals and plants live in eutrophic lakes, where they accumulate and rot on the lakebed after they die.

### Hypertrophic

A lake with a surplus of nutrients that causes an excessive growth of phytoplankton or aquatic plants. Upon dying, these plants increase the decomposition and exhaust the water's oxygen, causing the death of many aquatic animals. Humans are speeding up this process, by pouring water with detergents or organic waste that increases nutrient levels in the lake, altering its balance.

### Blockage

This is the last stage of a lake. After a long time, so much sediment builds up on its bed, that only a layer of water remains, creating something that is somewhat similar to a swamp.

A wetland is a low-lying flooded sector of land, which allows the development of **biodiversity-rich ecosystems**.

There are different types of wetlands, but they all share three traits:

1. They have water on the surface or down to the roots of the vegetation that lives there.
2. The ground beneath the wetlands has unique characteristics, which allows water to accumulate.
3. Plants that resist moisture and permanent flooding live there.



## Types of wetlands

Wetlands house both land and aquatic ecosystems. They are *ecotone*, or in other words, transition zones between two ecosystems.

### Peatbogs

This is a special type of wetland, covered by a layer of moss from the Sphagnum family, which can absorb up to 98% of its weight in water. For this reason, they are an important reserve of freshwater. In addition, they store *carbon dioxide* as peat for many years, which helps fight climate change.



When you visit a peatbog, touch it! You'll see they are like a great sponge!



Wetlands can be classified by the type of water they receive: if salty then they are called **saline wetlands** and if fresh, **freshwater wetlands**.

**Marine:** these have coastal influences and may be coastal lagoons and wetlands, rocky coasts and coral reefs.

**Estuarine:** these are formed in areas where freshwater and saltwater mixes (mouths of rivers).

**Lacustrine:** these are formed next or close to lakes or lagoons.

**Riverside:** they are close to rivers and estuaries.

**Marshy:** swampy wetlands.

**Artificial:** those created by man, like tanks, wastewater pools and canals.



Marine wetland



Lacustrine wetland



Marshy wetland



Artificial wetland

Source of images: shutterstock.



## Wetlands have ecological benefits and provide ecosystemic services for human beings.

**They are cradles of biodiversity**, because they provide homes to reptiles, amphibians and fish. They are also used for resting, feeding, reproduction and nesting by migrating birds. They have high levels of endemism and, because they are the stopover of migrating birds, they are internationally important ecosystems, like coral reefs and rainforests.

**They are the “kidneys of nature”**, as they filter and clean water contaminated with heavy metals, fertilizers and pesticides, given that they have plants that store these contaminants in their roots. Sediment and some animals also help to clean this water.

**They are carbon dioxide (CO<sub>2</sub>) collectors**, because they can absorb large amounts of this gas, helping mitigate climate change. Peat bogs can absorb 40% of the CO<sub>2</sub> that the world’s industries generate. If they are burned or drained, they would release this gas into the environment.

**They can refill underground pools.** When there is a lot of water available, may it be in the form of rain, rivers, lakes or other sources, they lead it underground and contribute to aquifers.



**They are water reserves**, since they act as sponges absorbing and storing the rainwater underground, which they slowly release in dry seasons.

**They provide food**, because most of the fish we eat, grow at some point of their life in wetlands.

**They protect against climatic events**, like tidal surges, floods and tsunamis, because they direct and hold the water inside them.

**Their attractive landscapes have a great biological and scenic value**, allowing communities who live nearby to profit from activities like tourism in the wetlands. This includes aquatic tourism, birdwatching and photography, among many others.

**It is essential that this tourism is made responsibly, so it doesn't affect the ecosystems!**



Fjords constitute a water ecosystem comprising freshwater that comes from glaciers, rivers, rainfall, and even from aquifers and saltwater from the ocean, which also makes it a large estuary.



## Fjords

### How were they formed?

Fjords emerged during the last ice age, when the enormous ice masses flooded the valleys of the Coastal Mountain Range.

These valleys were flooded with saltwater from the oceans and freshwater from the melting glaciers.

These spaces, where the waters mix, also called *fjords*, are considered a deep extensive estuary.

### Estuarine circulation

The freshwater, as it is less dense, flows close to the surface towards the ocean, while the saltwater, which is denser due to the dissolved salts, flows under the freshwater in the other direction, towards the mountains. This phenomenon is called *estuarine circulation*.

### Why are they important?

- They form a freshwater reserve and form part of Patagonia's freshwater ecosystems.

- As they are a water mixing zone with a great amount of nutrients, they are an area with high primary production. For example, a lot of microalgae (and/or phytoplankton) grows there.

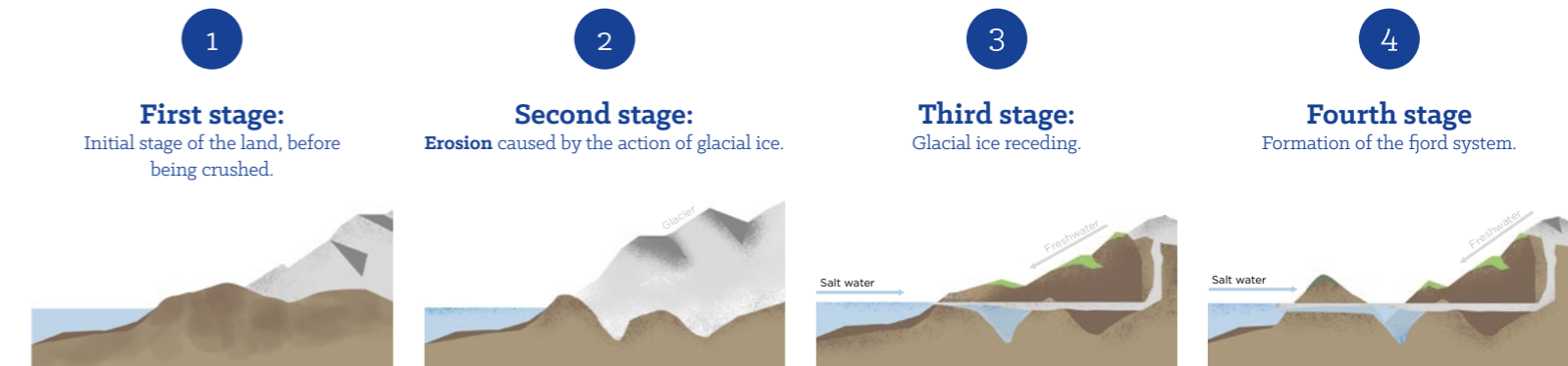
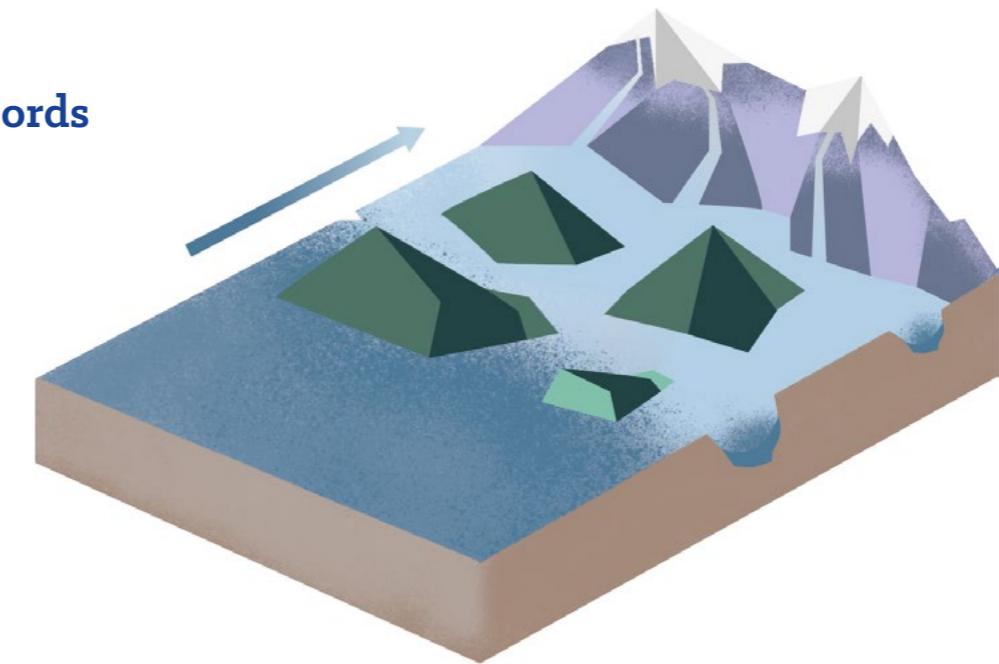
This allows small crustaceans like krill, which are food for animals like fish, whales and other species, to grow.

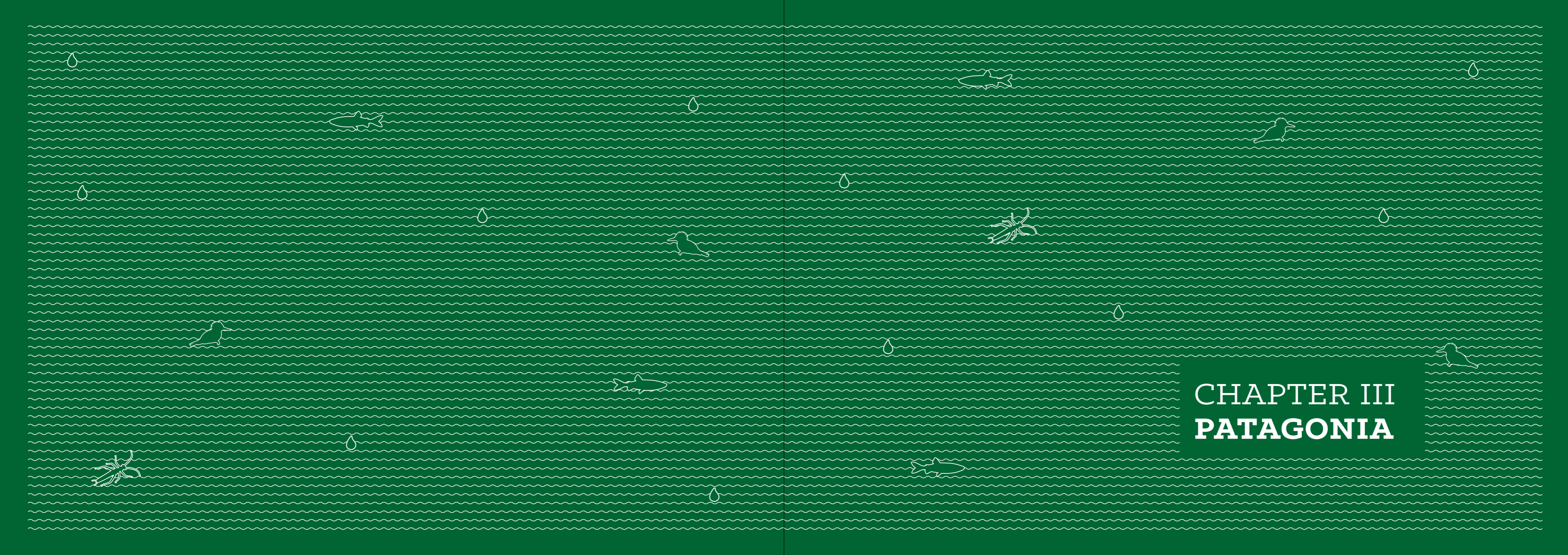
Fjords contribute greatly to marine life and the world. Any change in the freshwater provided can change the balance of both marine life and the air we breathe.



The largest fjord is in Norway. One of the three deepest is in Chile: the Messier Fjord, which is 1270m deep.

## Formation of fjords





CHAPTER III  
**PATAGONIA**

## Patagonia, the cradle of life

The Patagonia is an area that is considered a water reserve, due to the large number of glaciers, rivers, lakes, wetlands and fjords that it houses.

It is an network of life and, at the same time, it's the habitat of many different species.

In this place we can find the Northern Patagonian Ice Fields, which are solely in Chile, and the Southern Patagonian Ice Fields, that are shared between Chile and Argentina. These are the largest template ice masses in the southern hemisphere, with the exception of Antarctica. The Patagonian rivers also have an important role, moving thawed water from the glaciers to the fjords.

The word Patagonia comes from "Patagons", the name that Europeans gave to the indigenous people they found on these lands. This ethnic group is also known as the Tehuelche.

Although Patagonia's borders tend to be a topic of discussion, in general terms almost 76% is attributed to Argentina, and the remaining 24% is in Chile. Chilean and Argentinean Patagonia are separated by the Andes mountain range, that acts as a wall that separates the biological and weather conditions of each side.



## The Chono, the people of the southern seas

Some historians say that this demonym means “rebels”, others “sailors” or “men with a canoe”.

Their territory spanned from the north of the Reloncaví estuary and the Chacao channel, to the Gulf of Penas in the south. They were sailors.

Historians agree that they had light skin, reddish hair, attributed to the cold and proximity to the pole, or because they consumed a lot of sea lion oil.

They were basically fishermen and collectors from the beach and sea. Their diet included what was caught at sea, which could be eaten raw or roasted, with a mix of mushrooms and berries.

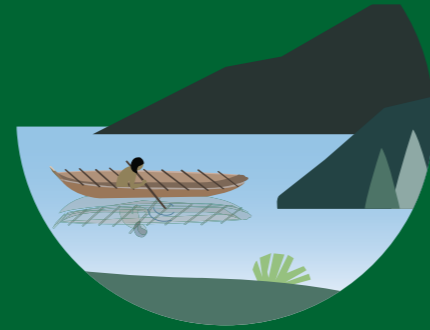
They lived most of the time on their dalcas (canoes), diving during the day, and spending brief moments close to the fires that they lit in their homes. Women were expert divers and would dive even when pregnant or shortly after giving birth. The men only kept the fire going or looked for firewood. Dogs were great assistants in the diving, and also good companions in the

cold, thanks to the heat their bodies irradiated and from their wool after being shorn.

They hunted sea lions beating them or using a net, as needed, or even with greater expertise, throwing harpoons from their boats or from land. In the case of whales, they had to wait until they beached themselves, an event which would lead to a feast with the surrounding villages.

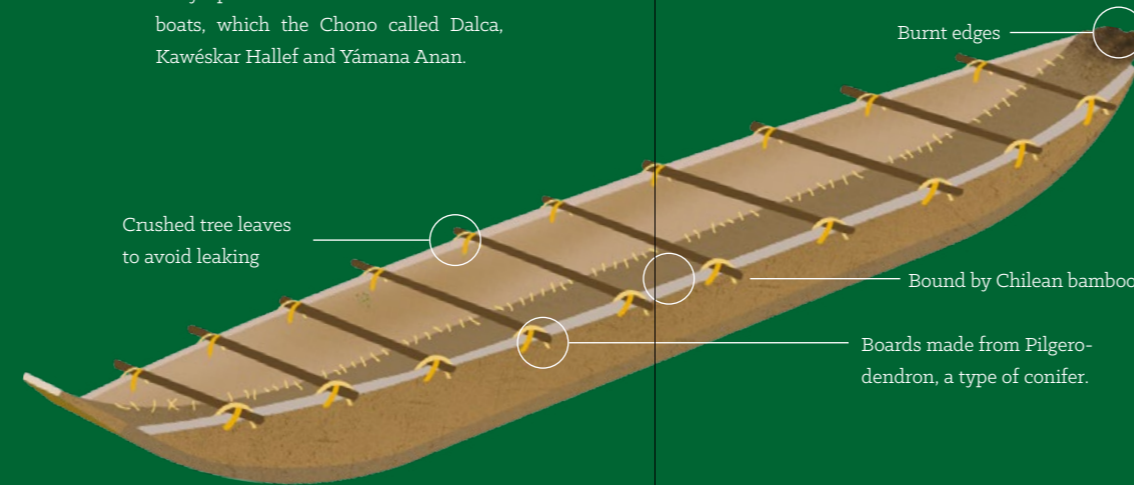
After the arrival of the Spanish, they were captured and used as compensation for the first colonists and trafficked as slaves, as more servants and labor was required in the central area.

The beliefs of the period meant they were not considered human, but rather as natives or savages, and they shared the destiny of so many others that today we acknowledge as our indigenous people, part of our history and who we are.



The Chono moved from one place to another thanks to the connectivity that the fjords, their aquatic highways, provided them.

They spent most of the time on their boats, which the Chono called Dalca, Kawéskar Hallef and Yámana Anan.



Little is known about the Chono,  
but some words remain in the  
Waiteka language, including:

*Acha:* Sky  
*Sépon:* Sun  
*Ponce:* Cloud  
*Kenkapon:* Rainbow  
*Kaáser:* Friend  
*Lam:* Kindness  
*Sérrisupon:* Good spirit  
*Sacima:* Bad spirit  
*Kixie:* Star  
*Seku:* Fire  
*Sercot:* Son  
*Teka Yema:* Native man  
*We:* Island  
*Kirake:* Moon  
*Soko:* Pacific Ocean  
*Qask:* Land  
*Sékewil:* Dream  
*Zuquena:* True  
*Vla:* Love

## Explorers and colonists

At the end of the 18th century, some explorers and sailors arrived to the inhospitable setting of southern Chile, seeking the mythical city of Caesarea.

Later, in the 19th century, the first colonists used the fjords and large rivers to explore Patagonia, to avoid crossing through the thick forests.

*Have you had the chance to meet a settler? We invite you to talk with them, and listen to their stories, full of stubbornness, courage and the lessons they have learned.*



CHAPTER IV  
**INHABITANTS  
AND THEIR ROLES**

## Matter - Energy - Ecology

The word ecology comes from the Greek *oikos*, inhabit, home and *logos*, knowledge, science.

Ecology is the science that studies the relationships between living beings and their habitat.

Nature is an interconnected network of energy. Energy that is constantly transforming. Human beings are not just part of nature, *we are nature!*

All organisms need nutrients and energy to live, and to obtain these, feed from one another, developing interconnections. In other words, life is a constant flow of energy transformation.

For example, algae feeds an aegla or pancora (crayfish), which is devoured by a common kingfisher and, when it dies, its matter and energy returns to the ecosystems.

This sequence of transferring matter and energy is known as the **trophic web**, also known as the **food chain**.

In freshwater systems, organic matter can come from processes inside or outside rivers, which are described as **autochthone** or **allochthone**.

In water, organic matter can sediment (accumulate on the bed or benthos), be transported (moved to other places) or used by aquatic life.

In addition, organic matter can come from inert things (rocks, sand, etc.) and is known as “**Detritus**”.

**Allochthone:** comes from outside the water. For example, leaves, branches, trunks and fruits from berry-growing plants, or feathers and droppings from land-based animals that fall into the water.

**Autochthone:** is created within the freshwater ecosystem thanks to aquatic living beings like animals, phytoplankton, plants and algae.

## Food chain

The food chain or trophic web is the process of transferring energy between living beings.

1

### Producers

The primary producers are organisms that can synthesize their own food through chemical processes, for example, photosynthesis. In freshwater systems, phytoplankton, aquatic plants and photosynthetic bacteria are primary producers.

2

Among animals, there are different types of consumers:

### Primary consumer (herbivores)

Animals that are fed by plants or algae. Thanks to them, the energy and material produced by photosynthesis enters the food chain.

### Secondary consumer (carnivores)

Animals that eat herbivores and receive just a small percentage of energy and matter.

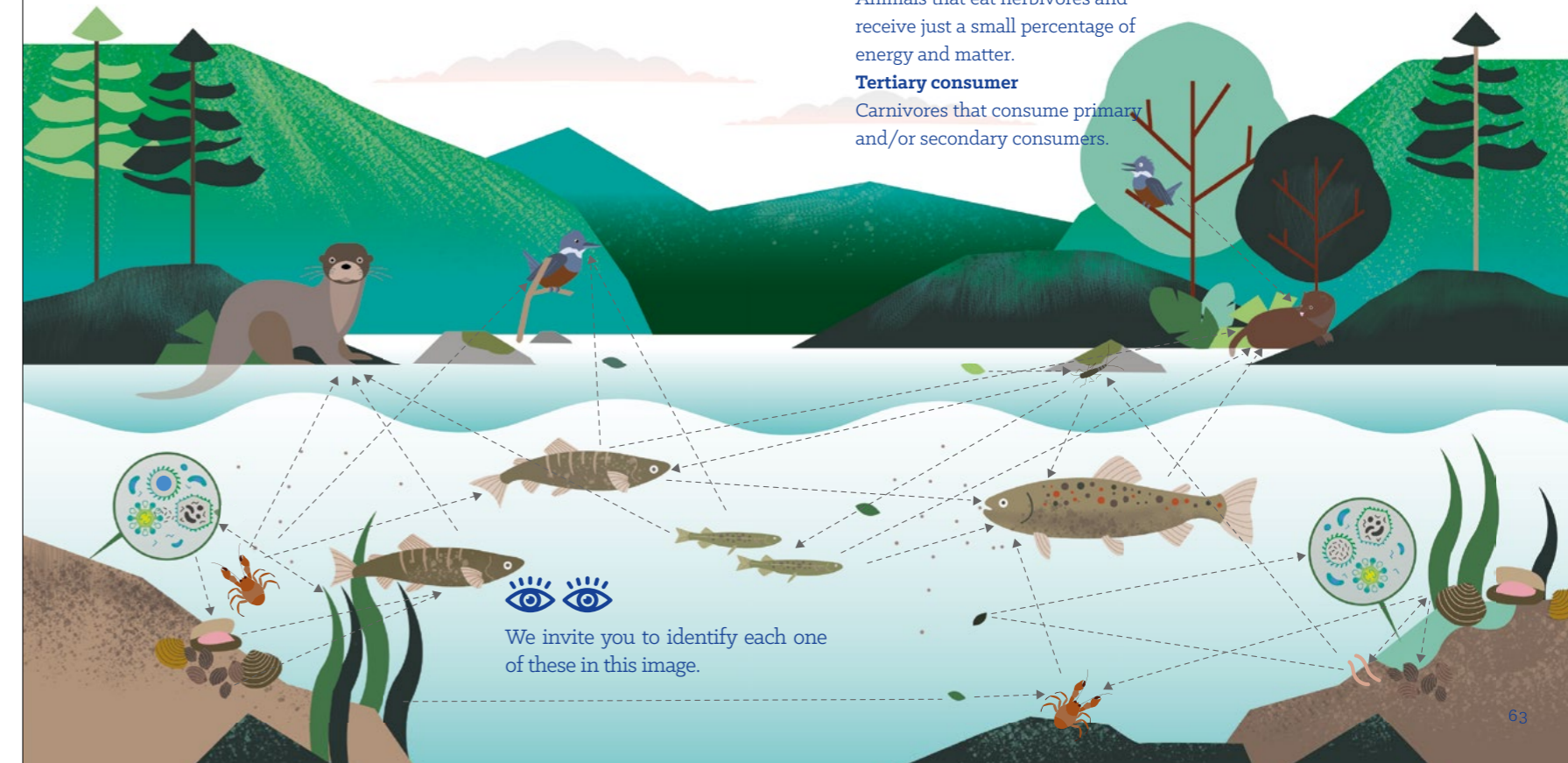
### Tertiary consumer

Carnivores that consume primary and/or secondary consumers.

3

### Saprophytes

These are the organisms that feed on feces, urine or animal and plant remains. Their role is transforming organic matter into inorganic so that it rejoins the ecosystem's matter cycle. *Imagine if they didn't exist, what do you think would happen?*



We invite you to identify each one of these in this image.



## Roles of aquatic macroinvertebrates

The top, middle and mouth zones in a river are connected, thus, plants and animals of each zone depend on the physical, chemical and biological processes of the rest. Because of to this connection, any disturbance in one zone of the river will affect the rest.

According to the **River Continuum** Concept, each river section receives different contributions of organic matter, and even changes the amount of sunlight, nutrients and dissolved oxygen. Aquatic animals are also fed in different ways. For this reason, aquatic plants and animals adapt to live in different parts of the river.

Aquatic insects (or macroinvertebrates) are very important for the River Continuum, because they help the degradation or transformation of organic matter along the river's entire route.

### The role of aquatic insects:

**Shredders:** They shred the leaves and branches that fall into the water into small pieces to eat microorganisms. *Examples: Plecopteran; collectors: trichopteran and ephemeroptera.*

**Collectors:** They eat large pieces of organic matter.

**Grazers, foragers, scrapers:** They eat microalgae stuck to rocks, trunks or riverbanks. *Example: chilina.*

**Filterers:** They obtain nutrients from filtering the water.

**Predators:** They eat other aquatic insects. *Example: dragonfly.*

**Detritivores:** They eat the remains of organic matter on the bed. *Example: aegla.*



## The role and biodiversity of Patagonia's inhabitants

### Who lives in freshwater systems?

**Biodiversity** refers to all the forms of life on the planet. All species play an ecological role in nature, and in freshwater systems we find a great variety of organisms or biodiversity that live and mix there, an expression of life on Earth.

#### Bacteria

Bacteria are the smallest living beings, so small that we can't see them with our eyes. They live in all known environments.

The most relevant role of bacteria is processing the environment's organic matter to return nutrients to the water, soil and air, a task known as decomposers or saprophytes.

Thanks to bacteria, other living beings can use these nutrients.



Bacteria were the first living beings on our planet, more than 3,5 billion years ago.

This image shows a drop of seawater augmented 10,000 times, based on the photograph of David Liittschwager.

## Flora

We can find different types of plants in freshwater systems, like aquatic plants and those which grow close to, or outside, the water.

Aquatic plants are not algae. They have roots, stems, leaves, flowers, fruit and seeds, but only live in freshwater like rivers, lakes and wetlands. They are the refuge and food for many species of insects, birds and mammals.

In addition, they have been classified into two large groups:

### Hydrophytes or aquatic plants

These have a large part of their body submerged. They can even grow in water. They all can photosynthesize in water.

### Helophytes or wetland plants

They grow in swamps, in other words, on the banks of rivers and lakes, where the soil has a lot of moisture and they have most of their bodies in open air.



### Chilean myrtle (*Luma apiculata*).

The Chilean myrtle is a perennial tree that is native to Chile and Argentina. Its reddish trunk is twisted and its bark breaks off, leaving white stains. Its dark green leaves are droplet-shaped and its flowers are white and attention-grabbing.

In Chile, we can see the Chilean myrtle from the Valparaíso Region to the Aysén Region. It always lives close to rivers, lakes or areas where there is a lot of moisture or rain. Thanks to its resistance to moist environments, it prevents soil erosion on the banks of rivers and lakes. *Help us investigate!*



The Chilean myrtle is a bank plant, it grows near to bodies of water, helping reduce erosion.

## Freshwater algae

We also find algae in freshwater systems. They provide nutrients to primary consumers who live underwater. They trap the sun's energy and transform it into organic matter and oxygen. This process is known as photosynthesis and constitutes the base of food chains and nutrient circulation.

Single-cell freshwater algae can be planktonic (from the Greek planktos, nomadic) as they float and drift in the water, or benthic (from the Greek, benthos, seabed) which live on the river and lakebed.

The *benthic* or phytobenthic algae are classified depending on the environment in which they grow:

**Epipellic algae:** grows on the sediment of the bed.

**Epilithic algae:** grows on rocks.

**Epiphytic algae:** grows on other plants.

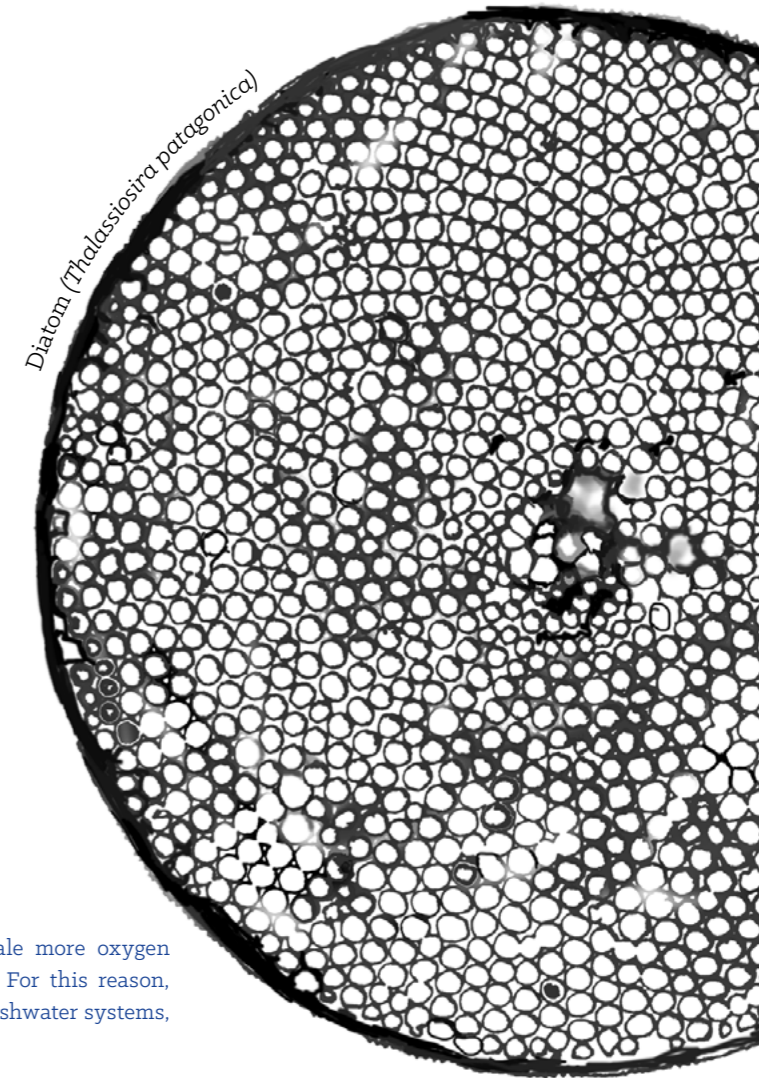
**Epizoic algae:** grows on animals' bodies.

**Episamic algae:** grows on grains of sand.



DIATOMS, GIVE  
ME AIR!

Diatoms, from the oceans, exhale more oxygen than all the world's rainforests. For this reason, they are essential, not just for freshwater systems, but for the entire planet.



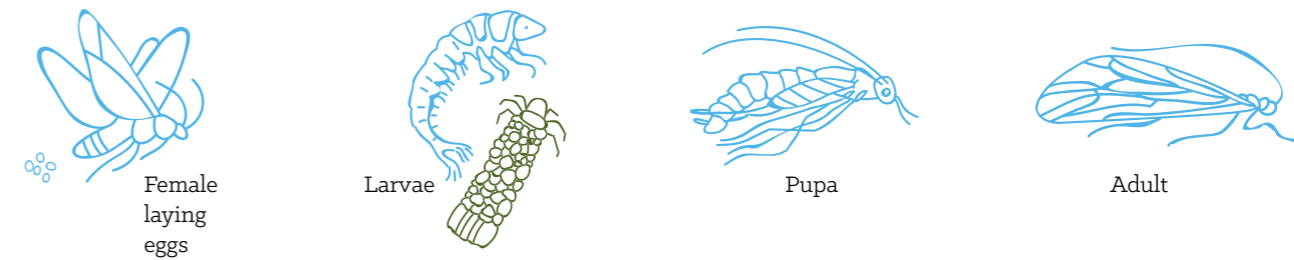


### Macroinvertebrates or aquatic insects

Macroinvertebrates are small organisms that live floating or swimming in water. These small animals help to transfer energy from the producers (aquatic and land-based plants) to fish, amphibians and aquatic birds (consumers).

All insects go through a **metamorphosis**. There are two types: complete metamorphosis (holometabolic), where their body transforms throughout their life; and incomplete metamorphosis (hemimetaboly), where only the size of their body varies.

### Complete metamorphosis



## Aquatic Insects

The number of aquatic insects (or macroinvertebrates) changes depending on the part of the river.

Each part is dominated by insects with different roles like shredders, collectors, grazers, predators, detritivores and filterers.

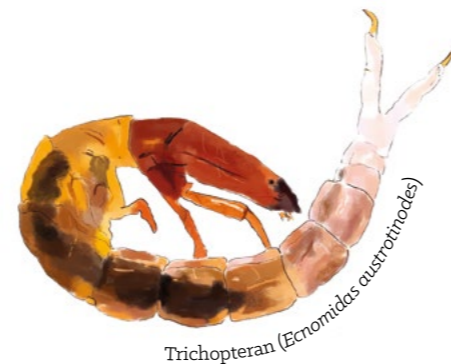


## Ephemeroptera

In Chile, there are about 57 species. They have jaws to crush leaves and branches, as well as tracheal gills on their abdomen, which appear like feathers or layers that let them breath.

## Dipterous

A group of insects with 11 common families. These are found in Chile's rivers and lakes and each one of them can live in different environmental conditions. Some live in detritus tubes, others dig tunnels, and some live freely. They can also be detritivores and predators, and can even tolerate water with almost no oxygen.



## Trichoptera

These are soft-bodied insects. When they are adults, they have two pairs of furry wings. For this reason they are also known as **caddysfly**. The aquatic larvae build "little houses" with different types of materials (pieces of leaves, branches, grains of sand, etc.) depending on the group they belong to.

The larval stage of the trichopteran can last from several months to years, depending on the species and the environmental factors.

*Did you know that these bugs collect leaves and branches to build shelters?*



## Plecoptera

Plecopteran prefer to live in fast-moving, turbulent, cold water with a lot of oxygen. As such, they tend to inhabit the rithron of the rivers. Therefore, they are indicators of good-quality water.

Shredder or collector macroinvertebrates, by crushing leaves that fall into the water and converting them into smaller pieces, allow other animals downstream to get energy and nutrients from them.

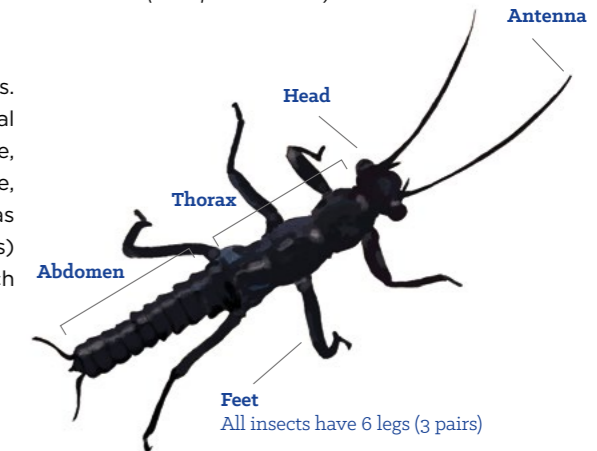
## Coleoptera

This group of insects have two pairs of wings. All of Chile's continental waters are ideal habitats for them, and while they are larvae, they live on the bed (or benthos). There, they fulfill different roles in the food chain, as predators, detritivores, herbivores (shredders) or omnivores. This role depends on which coleoptera family they belong to.

## Patagonian dragon (*Andiperla willinki*)

This is a **species** of plecopteran that lives on the Patagonian glaciers in Argentina and Chile. Spending its entire life on ice, it measures approximately 15 mm and feeds from bacteria that live there, brought by the wind. It also eats microalgae in the larvae phase and natural organic waste.

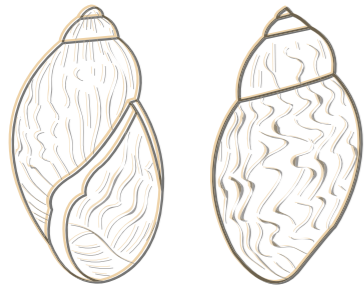
Patagonian dragon  
(*Andiperla willinki*)



## Mollusks

Freshwater mollusks are represented by the **chilinas**, a group of snails with a spiral shaped shell that protects the soft parts of their body. They feed from the film of microalgae formed on rocks and branches in the water.

### Geometry of the Chilina



Did you know that the name “Chilina” was inspired by the name of our country? Because they evolved and developed in Chile (The Chilina family is endemic of Chile).

## Crustaceans

Crustaceans are important in freshwater systems, as they are part of the diet of large fish, mammals and aquatic birds. They have an important role acting as **predators** and scavengers in the rivers.

Decapods correspond to the well-known crayfish, which have 5 pairs of feet and can measure between 1 and 20 cm. Crayfish are from the *Aegla* family and there are 18 **species** in Chile, 16 of which are endemic.



Macroinvertebrates give us information about the health of freshwater ecosystems. Experts collect them, classify them by groups and depending on the amount found, you can know how clean or contaminated a lake is.



You mean to say that there are 16 species of crayfish in Chile alone! Tikitikiti!

## Freshwater fish

Fish are the most diverse group of vertebrates that exists now and in the History of the planet. There are many exceptions, but generally a fish is an aquatic vertebrate covered by scales, with fins instead of limbs to move, and breathes through gills. In continental Chile, there are 47 species of freshwater fish, of which 80% are endemic and have conservation challenges. This is a group of vertebrates with a high conservation value and that are key in the functionality of these ecosystems.

The main role of freshwater fish is that they act as secondary (eating herbivores) and even tertiary (other predators) consumers. They have an important role in the food chain, by being consumed by larger predators like mammals and birds.

Some migrate to other water bodies to reproduce, feed or hibernate and depending on where they migrate, they can be grouped as:

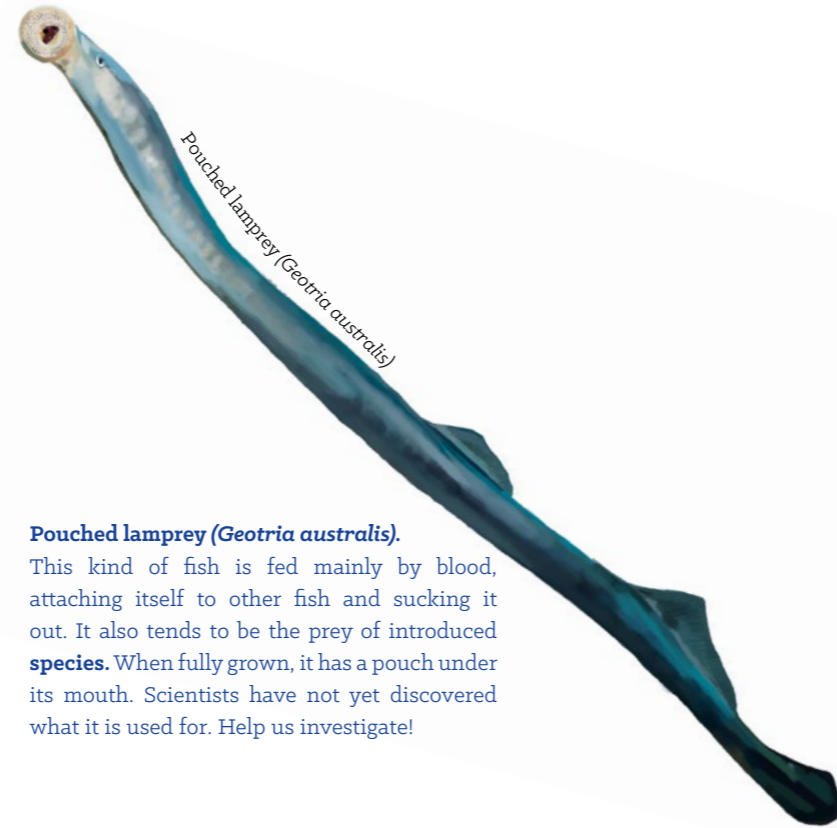
**Anadromous:** they live in saltwater and give birth in freshwater.

**Catadromous:** they live in freshwater and give birth in saltwater.

**Potadromous:** they migrate only in freshwater.

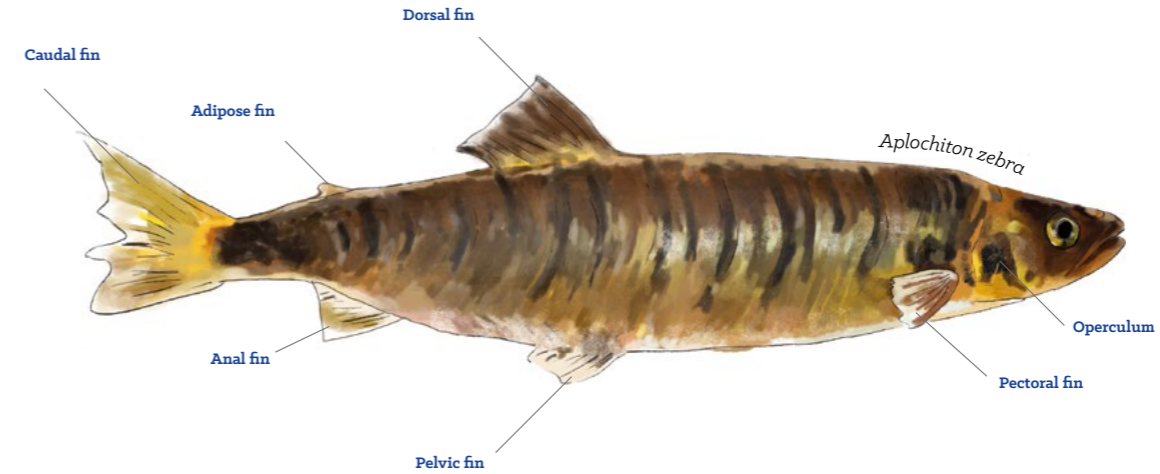
**Oceanodromous:** they migrate only in saltwater.

**Amphidromous:** they move between saltwater and freshwater several times during their life cycle.



### Pouched lamprey (*Geotria australis*).

This kind of fish is fed mainly by blood, attaching itself to other fish and sucking it out. It also tends to be the prey of introduced species. When fully grown, it has a pouch under its mouth. Scientists have not yet discovered what it is used for. Help us investigate!



### Aplochiton zebra or Peladilla.

It is a species that lives along the entire course of the rivers. As an adult, it migrates towards the deeper or littoral areas of the lakes. It feeds on immature insects, mainly dipterous. The aplochiton competes for food and space with salmonids, but it can also be preyed by them when young.



### Puye or common galaxias (*Galaxias maculatus*).

The puye is an active predator and adapts its diet depending on the type of environment. If it lives in lakes, it feeds on crustaceans, while if it lives in rivers, it mainly eats macroinvertebrates. Sadly, the puye is one of the favorite foods for brown trout (an exotic invasive species) in Patagonia's rivers.

Do you like my new profile picture?



## Amphibians

Amphibians are four-legged vertebrate animals with a skin that lacks scales, hair or feathers.

They go through **metamorphosis**, in other words, they transform their body and change their way of life completely changes. The larvae are born in an aquatic environment. They breathe through external gills and are detritivores or herbivores.

When adult, they become land animals, but continue to depend on the water. Their body changes. Now they breathe through their lungs and through their skin, taking advantage of the oxygen available in the water. They feed on insects like flies, mosquitoes and horseflies, helping us control their population. To reproduce, the female expels her eggs into an aqueous environment and while the eggs leave, the male impregnates them, beginning a new life cycle in the water.



*Please don't touch us! Remember that we breathe through our skin. You can watch us in detail by taking a photo and drawing us like a true naturalist.*



*We all like to have fun when the rain stops and the sun comes out, frogs do too! Take advantage of this moment to go out and search for them to get to know them better.*

The presence of amphibians in a freshwater ecosystem is a sign of its health. As amphibians have a thin skin and breathe through it, they are very sensitive to contaminants and disease in the water or environment that surrounds them.



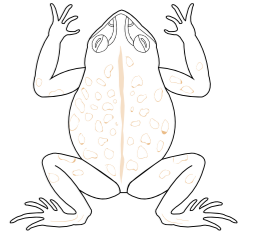
*Emilio's ground frog (Eupsophus emiliopugini)*



*If you are close to a home of frogs, you will hear many frogs croaking in the evening, when it is time to eat.*

### **Emilio's ground frog (Eupsophus emiliopugini):**

Out of danger and endemic. It lives in myrtle forests, forests inundated with myrtaceae, arayan, luma, pitra and meli trees. This frog is out in the day and at night it shelters under tepual foliage, in openings and between fallen trunks and their roots.



### **Mable wood frog (Batrachyla antartandica):**

Endemic and out of danger, it lives in the native forest, especially in gorges and bodies of water, as well as in swamps and lagoons. It is tree-dwelling and climbs through bushes. It is nocturnal, and by day it hides under trunks and rocks. It leaves its eggs in flooded areas surrounded by vegetation.



Great egret (*Ardea alba*)

## Birds

Birds are the most diverse group of vertebrates in Chile. Many of them live on continental waters or estuary areas. These habitats provide food, shelter and an important space for reproduction.

There are five species of heron in Chile, and only the snowy heron looks like the great heron. You can recognize them by the color of their beak and feet: the snowy heron has a black beak and yellow feet.



*I can also be an egret.*

### Great heron (*Ardea alba*).

With white plumage, black feet, yellow eyes and beak, it can grow a meter tall. It lives in the shallow parts of wetlands, lakes and estuaries as, although it is an aquatic bird, it does not know how to swim. It feeds on small fish, frogs and shrimp. This species of heron is found in all continents except for Antarctica.

Neotropic cormorant (*Phalacrocorax brasilianus*)

The cormorant can swim, submerging almost its entire body, leaving just its neck and head visible.

### Neotropic cormorant (*Phalacrocorax brasilianus*).

It lives mainly at sea, but inhabits exposed coasts, channels and bays. It can be seen in small groups or large flocks. It interacts with freshwater systems through fish and small crustaceans, because it feeds on a large variety of these.



*And when it rains, how do you do it Neo?*



Birds are the most diverse group of vertebrates in Chile.

**Ringed kingfisher (*Megaceryle torquata*):**

Its head is bluish-gray, with a reddish-brown chest that has a small gray line on males and a larger one on females. It lives along rivers and lakes in the south of Chile, from the top to the mouth in protected bays of the fjords and channels. As its name says, it is a great fisher, balancing over itself to dive into and trap fish of up to 20 cm, which are swimming close to the surface.

**Magellanic Penguin****(*Spheniscus magellanicus*):**

Measuring up to 73 cm in length, they mainly live in the open sea and the fjords in the Aysén Region. You can recognize them by a double black stripe on the chest.



Ringed kingfisher (*Megaceryle torquata*)

You can see the Ringed Kingfisher waiting patiently on a branch, before diving in.

**Mammals**

Mammals have four main features:

- 1) they are warm-blooded animals.
- 2) they have hair at least at some stage of their life.
- 3) they breathe through a pair of lungs.
- 4) they are fed milk during the first months of life.

Freshwater mammals live all or part of the time in freshwater or estuarine bodies. In Chile, the otter and coypu stand out.



Southern river otter (*Lontra provocax*)

Mammals in freshwater ecosystems can have different roles depending on their diet and habitat.

In addition, mammals like the marine otter, common sea lion and the South American fur seal, can be found in coastal settings and fjords.



South American sea lion (*Otaria flavescens*)

#### **Southern river otter (*Lontra provocax*).**

This is a solitary animal and only gathers during reproduction periods. It eats mainly fish and crustaceans (crayfish), sometimes mollusks, amphibians, and aquatic birds. In freshwater ecosystems, it prefers rivers and lakes with plenty of bankside vegetation comprising trees and roots. This mammal acts as a **predator** in rivers and lakes.

#### **Coypu (*Myocastor coipus*).**

This is the largest rodent in Chile. It can measure up to 52 cm and weigh 7 kg. It is an herbivore and its diet is based on reeds and bulrushes. It forms colonies of up to 13 individuals, but when they reach full maturity, they tend to be alone. They build underground shelters to protect themselves and to bring up their offspring. They also build platforms with different plants which they use for food and rest. They are often seen in lagoons, lakes, rivers and wetlands.



Guess who I am, a river or sea otter?

#### **Marine otter (*Lontra felina*).**

The second otter **species** that lives in Chile and the smallest kind in the world, weighs between 3 to 5 kg, growing to a maximum of one meter in length. It has a dense dark brown coat which keeps it warm while it dives into the cold sea waters. It feeds on crustaceans, mollusks, fish and sometimes birds and mammals.

#### **South American sea lion (*Otaria flavescens*).**

Sea lions live in colonies on rocky sediment. They are seen hunting in the channels and they mainly eat fish, octopus and crustaceans, although they can head up rivers following the migration of fish. It is an able **predator**, which places it at the top of the food chain.

#### **South American fur seal (*Arctophoca australis*).**

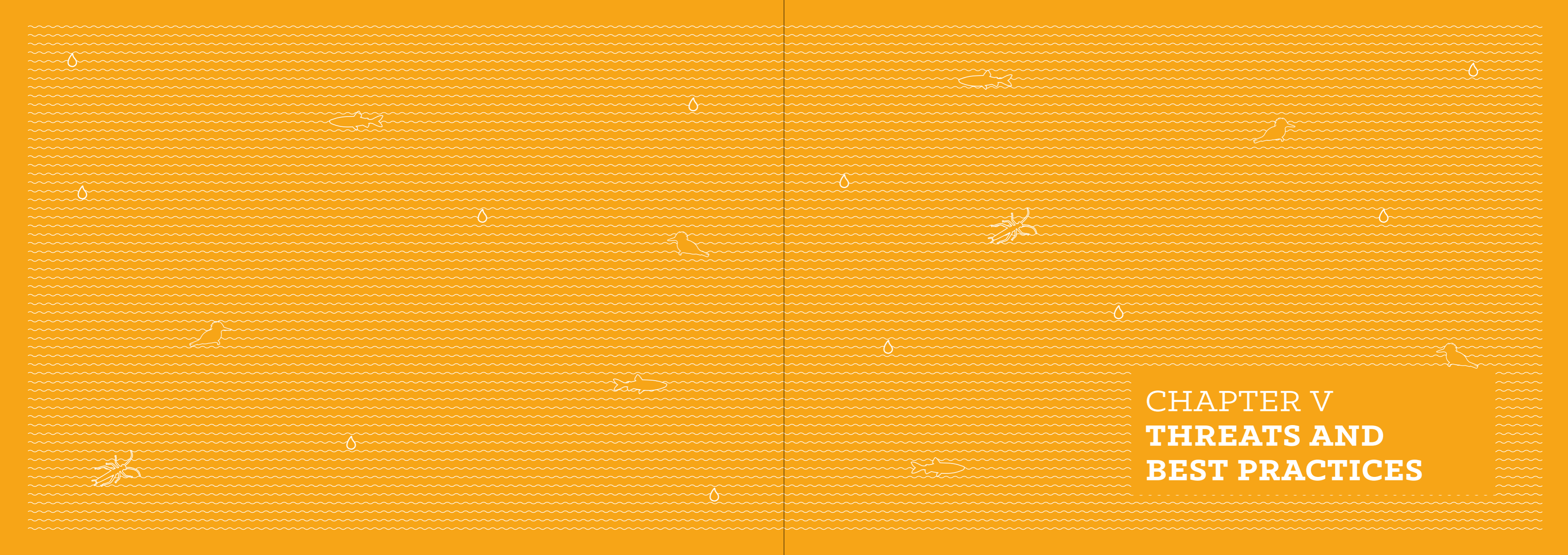
It has a finer skin than the sea lion and two layers of fur. Just like the South American sea lion, it lives in fjords and feeds on fish, octopus and crustaceans, acting as a **predator** in the food chain.



Marine otter



Southern river otter



CHAPTER V  
**THREATS AND  
BEST PRACTICES**

## Introduced species: salmonids, minks, didymo, beavers and gorse.



### What is an exotic or introduced species?

These are animals or plants that have been introduced by humans from another habitat, region or country.

An exotic species becomes invasive if it:

- lives in a different habitat that lets it reproduce quickly.
- dominates and competes with the native species for food, water and shelter.

Exotic invasive species are one of the main causes of the disappearance of native plants and animals around the world.

Origin of the introduced species



Introduced species are the result of our intentional or accidental action. These species alter the balance of a habitat and threaten ecosystems. **But if we are part of the problem, we can also be part of the solution.**

Among the main **exotic invasive species** found in Chilean Patagonia, we can find:

### Salmonids

This group of introduced fish that are known for being greatly damaging. Trout and salmon are found among them. They are carnivores, they feed on the **native species** of aquatic insects, mollusks, crustaceans and small fish. This is the widest spread freshwater **invasive species** in the world. It can live in rivers, lakes and even migrate to sea. The only place it has not colonized is Antarctica.

In the Aysén Region we can find the brown trout (*Salmo trutta*) and the rainbow trout (*Oncorhynchus mykiss*), which lives in part of the river that has a lot of current and low temperatures.

### Impact of salmon

The salmon industry grew as an economic activity in the 1970s, and from the 1980s it began to have the highest growth rates of the fishing sector, positioning the country second in the world for salmon and trout production.

When salmon escape captivity, they can:

- Compete for food and space with native species.
- Prey on benthic communities, invertebrates and fish.
- Infect other species with diseases.



Brown trout (*Salmo trutta*)



*You snooze, you lose.*



Salmonids were introduced at the beginning of the 1900s with the purpose of sport fishing.

**Salmonids are voracious predators. They feed on native fish and compete with them for food and space, they can also infect the native freshwater fauna with diseases.**



**How do you prevent the impact of salmonids?**



By not "planting" or repopulating bodies of water with any salmonid species.

If salmon escape, the best thing to do is report this to the National Fishing and Fisheries Service (SERNAPESCA) at any of their offices or at the telephone number 800 320 032.

**Mink (*Neovison vison*)**

The mink is among the 24 invasive mammal **species** of Chile and is a “damaging or harmful **species**” according to the Ministry of Agriculture’s 1996 hunting law. It is an able **predator** that easily adapts to any environment, and can feed on birds and their eggs, amphibians, rodents, fish and other animals. It also competes with native animals, like the river otter, for food and shelter.

**How was it introduced?**

It was introduced in Punta Arenas in the 20th century for its use in the fur industry (sale of fur). It became invasive when the industry went bankrupt and decided to release them. Since then, they have moved to the north of Chile, and are found from Cape Horn to the La Araucania Region.

**How can the impact of the mink be controlled?**

With joint work of public institutions (ministries, municipalities, regional governments, universities, etc.) to define actions that control their populations. For example, by capturing them with traps and bait. This is of great importance between the Regions of Los Rios, Los Lagos, Aysén and Magallanes.

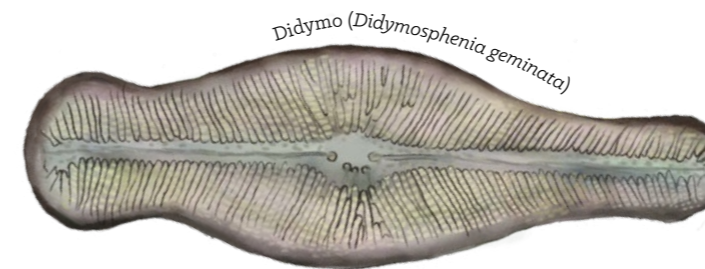
Another novel strategy includes the river otter, as they share habitats and ecological niches, which makes control easier.

**Didymo (*Didymosphenia geminata*)**

This is a microalgae originally from the mountains in the northern hemisphere. It can grow in large colonies and it sticks itself to rocks and riverbeds, forming a layer called “rock snot”. It has become an invasive species in Patagonia, as it invades new areas, moved by animals like the mink. Sometimes the invasion is so vast that the fish have to move to other bodies of water to survive.

**How was it introduced?**

The didymo was introduced, like in most of the world, by sports fishermen who did not wash or disinfected their fishing equipment as they came to Chile. It has spread over the watersheds of continental Chile.



Chile. Ministry of Economy, Development and Tourism. SERNAPESCA. Stop the Didymo Campaign- Retrieved from: <http://didymo.sernapesca.cl/medidas.php>

**How can the impact of the didymo be controlled?**

The Ministry of Economy, Development and Tourism, to prevent its spread, started the “Stop the Didymo” campaign, with a list of actions:



Removing all visible remains of algae from fishing gear.



Avoid wearing boots or other pieces of clothing made from absorbent materials.



After activities in rivers or lakes, wash and disinfect all the things that were used. Do not return the cleaning water to the environment, and hopefully use biodegradable cleaning elements.



When you fish, transport the fish in sealed containers to avoid water spillage and do not release the fish into another body of water.



After the activity, do not use your gear and boots for two days, until they are completely dry.

**American Beaver (*Castor canadensis*)**

Native rodent of North America. It likes to live in aquatic environments surrounded by forests. There, they build their dams with water entries, using mainly trees. These lairs create natural dams and flood areas that previously did not have water.

Trees, in their natural environment, grow quickly and the forests recover their original state in less than five years. However, in Patagonia, our trees do not grow or recover so fast. When there are no more trees, the beavers move on to another place looking for more construction material and food.

It is estimated that it takes 20 years for the ecosystem to recover.

**How was it introduced?**

It was introduced in Argentina in 1946 to use its fur and make coats, but the industry failed. They were released in Tierra del Fuego, spreading through the forests of the Magallanes Region and Argentina.



## ! How can the impact of the beaver be controlled?

As a result of its impact on Magellanic forests, it can be hunted all year round, following these actions:

Avoid unnecessary suffering for captured animals. All living beings deserve respect and when they are killed, this must be done as quickly as possible.

Use hunting equipment or traps recommended for each animal, don't improvise.

Keep hunting equipment or traps in a good condition. Never move or release a harmful species in other areas.

Prevent the capture of protected animals.

Do not install more traps that you can handle.

Constantly check the traps and send reports to the authorities.



Invasive species are not "bad" per se. But the imbalance that their introduction and spread provokes in the habitat seriously affects the ecosystem.

**Gorse (*Ulex europaeus*)**

This is a bush from the bean family, and it was introduced from Europe to Chile to create living fences and contain sandy soils. It can grow up to 2 meters tall, has yellow flowers and its stalks are covered with hair and large thorns.

It spreads quickly, invading meadows, road verges, areas around telephone and electricity lines. It also invades areas of **native species**, like the beach strawberry (*Fragaria chilensis*), which grows on the Chiloe dunes and in the south of Chile.

The branches that are found on the lower part of the bush, because they are shaded by higher branches, die and remain dry. This makes the thorns burn easily, and it is considered as fire hazard.

- It produces a lot of seeds.
- Its seeds can survive in the ground for many years, thanks to their strong cover
- It grows quickly
- Its roots are deep and can use nutrients and water that other plants cannot reach.
- It has thorns as a protection mechanism
- It has no natural enemies

## ! How do you prevent it from spreading?

If you are going to remove the plant, try to do so in January and August. This way, you limit its development before fall, along with its spring growth.

Fertilize the soils with phosphorus and nitrogen. Gorse prefers soil with low fertility.

If you have cattle, let it feed on the meadows with offshoots of gorse.

Make sure that the grazing area is proportional to the amount of cattle, so that the gorse cannot invade it.

In sloped areas, grow crops using terracing or help spread the native vegetation. This will avoid soil erosion.

Do not burn the vegetation.







## Water contamination

Contamination is any element, substance, energy or radiation that by being present in the environment in a certain amount and for a given time, becomes hazardous for the health of people and ecosystems.

### What is water contamination?

It is the act of adding substances or elements that exceed the limits that nature can handle, or that do not belong to the water or the environment. It can come from natural and/or human sources. Some types of water contaminants are:

- Pathogenic microorganisms (biological contamination)
- Liquid Industrial Waste (LIW)
- Chemical substances
- Radioactive substances
- Hydrocarbons (petroleum) and oils



Gray water is water that comes from the kitchen or washing. It contains detergents, grease, soap, organic matter and nutrients.

Wastewater contains feces and urine. It must not be released without treatment.

### Industrial Water

This is known as Liquid Industrial Waste (LIW). This is water disposed after industrial processes. All economic activity generates LIW, from agriculture, fish farming, cattle rearing, mining, paper production, to nuclear energy.

LIW that is released into natural water without being treated is the main cause of industrial water contamination.

It is harmful for the environment because it adds contaminating agents into nature, damaging its health and disbalancing natural cycles.

### Household water

This is the water that is disposed of from the house where cleaning chemicals, oils, feces and urine are mixed.

In major cities, the sewers take the dirty water to treatment plants to later return it to nature without causing major damage.

In many rural areas there are no treatment plants. It is recommended to build a waste and gray water separation system, to reuse the latter. For example: water from the basin can go to the toilet's tank.



## Chemical contamination

Chemical substances in freshwater can come from different sources. We will address the issue of mining as in Chile, this is an important source of contamination.

Mining uses toxic substances to extract ore, and it accumulates the wastewater it generates in pools known as “tailings reservoirs”.

The tailings reservoirs have very strict safety and construction conditions to avoid their spillage, runoff due to rain, evaporation or leakage into aquifers.

LIW contained in the reservoirs can have chemical elements like Mercury (Hg), Arsenic (As), Lead (Pb), Cadmium (Cd), Cyanide (CN-), among others. If it were to be spilled into the environment, it would affect the biodiversity and ecosystems in its surroundings.

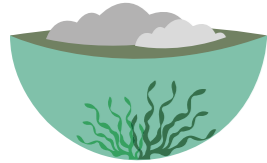


### How can you prevent the impact of chemical contamination?

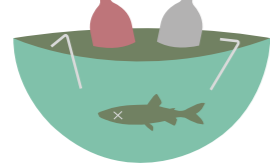
- **Report bad environmental practices:** In Chile, the public institution called the Environment Superintendence (SMA) receives reports from citizens when there is damage to the environment.
- **Citizen Environmental Participation (PAC in Spanish):** take part in citizen consultation processes for mining projects that may be built close to where you live. The PAC gathers all the opinions, doubts and criticisms of the people affected by the project.
- **Informed citizenry:** the Chilean Environmental Assessment Service (SEA) decides whether the industry can be built. SEA uploads information of all the industrial projects that persons and companies want to build in Chile, including mining projects.

## Physical contamination

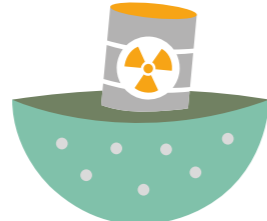
We understand physical contamination as all the elements that enter the water, change the natural processes and affect aquatic life. These elements may be:



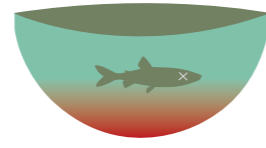
**Foam:** comes from detergents that are poured into the water and that add nutrients like phosphates ( $PO_4-3$ ). The excessive addition of phosphate leads to microalgae growing uncontrolled and speeds up **eutrophication** processes in water courses and bodies of water.



**Bulky elements (trash):** large volume waste, like tires, plastics, debris, among others, is dragged by the water and can be ingested by animals or they can get caught and be mutilated by them.



**Radioactive substances:** these are substances that emit radioactivity and come from human sources, like medical tools or waste from nuclear energy production, which gets mixed with the water and accumulates in the bodies of the living beings in a higher level than in the environment.



**Heat:** sometimes industries return water at high temperatures, which alters the growth and reproduction of aquatic **species**.



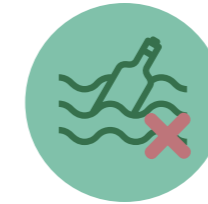
**Materials in suspension:** there are many small particles of matter that come together in the water and block sunlight from entering. This reduces photosynthesis and consequently primary production, lowering its contribution of energy to the rest of the food chain.

## ! How can physical and biological contamination be prevented?

The best way is to channel wastewater to water treatment plants. We can all help from our homes.



To generate less foam, use detergents with low phosphate content or that are biodegradable.



Do not throw trash into bodies of water or water streams and, if you can, collect the trash that you can.



If you see wastewater is being illegally dumped, report it to the Environment Superintendence.



80% of the plastic waste that is found in the ocean is produced on land. Remember water has diverse and connected ecosystems. Your day-to-day actions have repercussions in different places. Avoid single use plastics!

## Biological contamination

On the other hand, biological contamination is the presence of microorganisms in the water that can cause illnesses for people and animals (called pathogens). For example, viruses, bacteria and protozoa which transmit different illnesses like hepatitis or typhus.

Pathogen organisms reach the water through the excrement that is mixed with it. In fact, if there is a large amount of it in the water, it can consume a lot of oxygen impeding other aquatic life forms from expanding.



## How can we take care about the amount, quality and use of water in our houses?

Here you will find a series of tips to put into practice in the kitchen, bathroom and in the cleaning or your house. If you apply them, you will be helping to fight chemical, physical and biological contamination, and you will also be addressing climate change.



### In the kitchen

1. Prepare a "soapy mix" (mix of detergent and water in a bowl) to clean utensils and then rinse. This way, you will avoid washing dishes with the water running.
2. Shut off the water valve if you are going away for many days. This will prevent possible leaks.
3. Use flow reducers, diffusers and aerators to reduce the flow of water from faucets.
4. To get rid of used oil and other chemicals (solvents, paint, etc.) pour them into a plastic bottle and take them to the appropriate places.



### In the bathroom

We use 75% of all the water a home consumes in the bathroom, so take note of these suggestions:

1. Keep the water heater at a reasonable temperature, to avoid adding cold water while you bathe.
2. Take short showers. A five-minute shower consumes around 100 liters of water, and a bath uses 250% more. How much water do you consume in your shower?
3. Don't leave the water running when brushing your teeth.
4. Make sure that the WC and the faucets do not have leaks.
5. Put a big bottle full of water, sand or stones in your WC. It will save water and maintain the pressure.



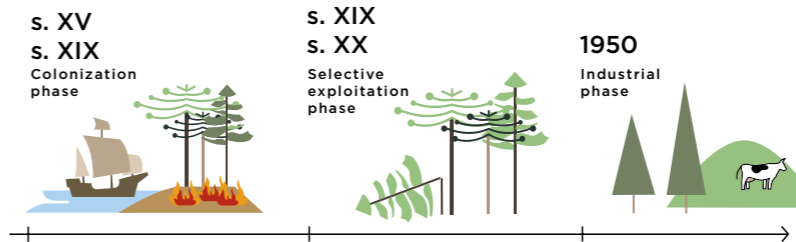
### Cleaning the house

1. Common chemical products in supermarkets are often toxic, but there are ecological and economic ways to clean. For example, sodium bicarbonate removes grease and mold.
2. We also find environmentally friendly cleaning products, so see if they comply with these characteristics:
  - Chlorofluorocarbon (CFC) free, damaging substances that break down the ozone layer.
  - Least amount of wrapping possible.
  - Not toxic or corrosive, to prevent damaging people and nature.
  - Phosphate free.
  - Multiuse, economic and reusable.
  - Rechargeable.

## Deforestation

Deforestation is the loss of native forest, either by natural causes like volcanic eruptions, droughts, glaciation or by human causes, like single-crop farming, intentional fires, tree cutting or urban sprawl.

Agriculture, the forestry industry, cattle rearing, and urban sprawl are the main causes of deforestation. The first two because they cultivate large areas of land with a single type of plant to obtain profits. This is known as **monoculture** or single-crop farming, and cattle rearing because large areas of land are cleared for prairies that feed cattle.



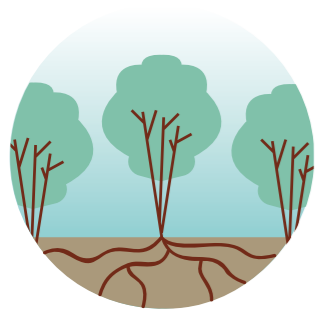
Deforestation to extract firewood or burning it intentionally, and clearing the land for agriculture and cattle farming. This happened in the south of the VIII Region and includes the fires caused during the Arauco War.

The best larch trees, monkey puzzles and conifers were cut down. This practice of cutting down the best trees is known as "brandishing".

The loss of forest continues today because the industry seeks to free up space and plant introduced trees (pine, eucalyptus, etc.) or to grow ever larger amounts of fruit trees, vegetables and fodder for cattle.

The forests of the center, south and deep south of Chile are being threatened by the expansion of the agriculture and forestry industries. These industries use single crops to cover the demand for fruit, vegetables, paper, wood, meat and milk.

## The effects of deforestation are diverse:



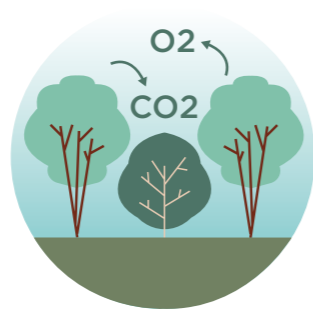
### Alterations in water:

The water available in the ground is altered, as the forests retain the water and spread it to other ecosystems.



### Increased erosion:

The forests protect the land against erosion, especially on slopes, because they prevent that water running over the surface drags soil with nutrients with it, soil that is vital for plants to grow.



### Reduction of the natural cleansing of the air:

Forests capture CO<sub>2</sub> and produce oxygen, vital for life on the planet.



### Degradation of the habitat:

Native forests are the home to different species of animals and plants.

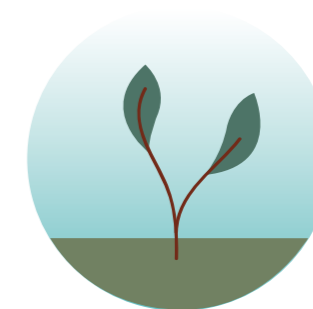
## ! How do we prevent deforestation?



Buy certified firewood; in other words, that have less than 25% moisture, which makes them more efficient to light a fire. If you cannot find it, make sure to dry the logs as much as you can before using them.



If your parents, uncles and aunts or grandparents want to get logs, suggest using a forest "management plan", which allows getting the logs and other resources without exhausting them.



If you can, plant one or more trees, and choose the native species from where you live.



Use paper responsibly, print on both sides of the page, reuse sheets or create your own paper.

## Climate change

The Earth's climate has varied throughout the planet's existence. In this so-called Anthropocene era, human beings are the first species that has completely changed the climate. It is what we have called Climate Change. This change is specifically defined by Global Warming, which has caused the following:

- The temperature of the atmosphere and ocean has risen.
- The amount of snow and ice has been reduced.
- Sea levels have increased.
- The magnitude of weather events is greater (storms, typhoons, droughts, etc.)

Chile is a country that is vulnerable to global warming according to the United Nation's Framework Convention on Climate Change (UNFCCC), because its coast is low-lying, it has extensive arid and semi-arid areas and its glaciers are sensitive to the temperature.



### Rainfall:

It will lessen between 5% and 15% between the watersheds of the Copiapo and Aysén Rivers.



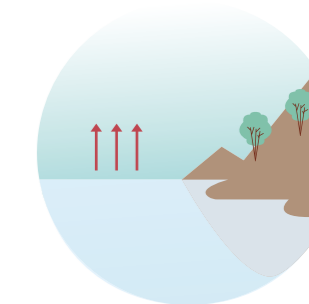
### Temperatures:

A temperature increase is expected in the entire country, with a projection ranging from higher to lower from the north to the south from the east to the west (mountains to the sea).



### Biodiversity:

The Patagonian ecosystems are also at risk, especially the high-lying ecosystems. It is expected that the 0°C isotherm (point where solid rainfall begins) will be higher. This could lead to the mountains storing less water in solid state (ice or snow), which would affect the water available in the watersheds, whose main supply comes from the thawing in the mountains and the rainfall.



### Changes in the salinity in the estuary ecosystems:

The increase of the sea level and the glaciers receding would affect freshwater bodies.

Climate change can cause effects on all species, as well as in the ecosystemic balance. Species that resist new climate conditions and can adapt will survive, and those who cannot, will disappear.

**Do you believe that we are capable of adapting?**

**What must we change to survive?**

**Ask your parents and grandparents what changes they see in the weather! What changes have you seen?**

**Which best practices do you use in your home to fight climate change?**

**Which new habits can you add to your life to reduce the impact on the planet?**

## ! How can climate change be fought?

Climate change affects the entire world. The actions of every one of us are important and can transform society's habits.



Reducing emissions of greenhouse gases, preferring ecological transportation like bicycles, classifying your trash and making compost. You'll get the best soil for your garden. Use the 3R (reduce, reuse and recycle) and remember the fourth R, **Repair!**



Reuse gray water and rainwater.



Be efficient in how you use water. Reduce your consumption.



Consume products consciously.

- Avoid disposable products
- Choose products with less packaging
- Consume locally
- Work on a family vegetable garden



Educate and share your knowledge to look after your country!

## Construction of dams or reservoirs

Reservoirs are artificial constructions that change the natural flow of a river, because a barrier is built to flood a piece of land that did not have water before.

Dams can supply drinking water to human settlements, provide water for agriculture, be used for energy production and even for recreation.

However, building them uses a lot of land, which brings different consequences like changing the natural shape of the land and the natural processes of the watershed.

Dams alter the nature and its inhabitants, because they generate:

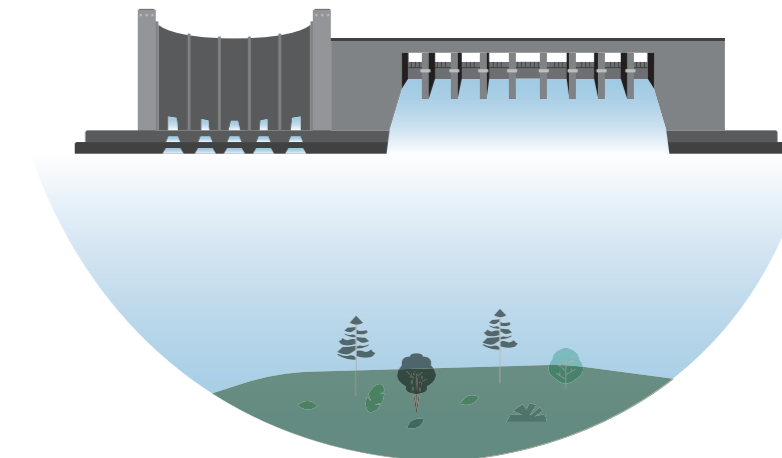
**Discontinuity:** remember the river is connected, in other words, there is transportation of nutrients and energy from the top to the mouth.

If a dam is at any section of the river, it will break this natural flow and affect all the ecosystems that are above and below this.

**It affects freshwater fish:** it affects their migration routes and their growth, food, reproduction, mortality and habitat. For example, the pouched lamprey is a native fish that migrates in summer from the mouth to the top of the river to reproduce and, if a dam were to be built in the middle of the river, they could not complete their cycle and would disappear over time.

**Changes in the watershed's functioning:** a dam changes the contribution of water to the rivers, its control over extreme floods or droughts, and responses to climate change.

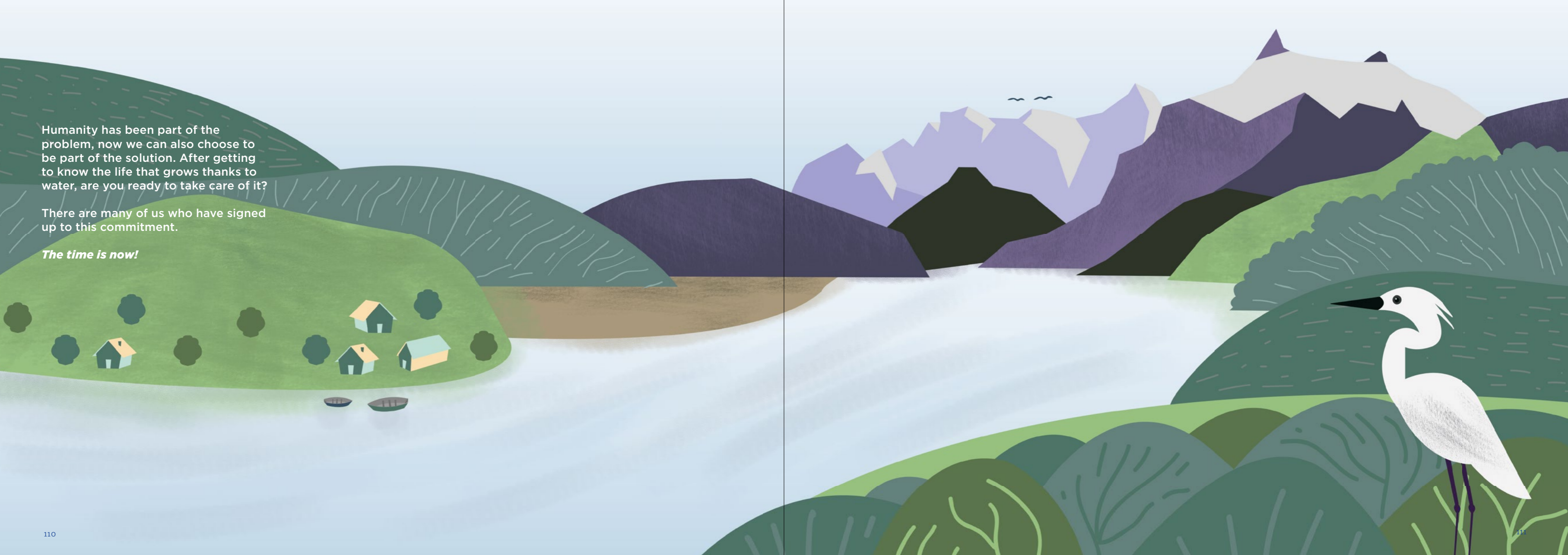
Sometimes dams cause more floods, because they increase the flow of rivers, which drags more soil and sediment, affecting the natural flows of nutrients and energy.



Humanity has been part of the problem, now we can also choose to be part of the solution. After getting to know the life that grows thanks to water, are you ready to take care of it?

There are many of us who have signed up to this commitment.

***The time is now!***





## Glossary

**Abiotic:** (from the Greek a: without; bios: life) Non-living components of an ecosystem, like the water, air, earth, light, nutrients, among others.

**Aquaculture:** Set of techniques which are used to grow aquatic species, both animals and plants.

**Continental waters:** Bodies of permanent freshwater that are above or below ground.

**Allochthone:** Matter which is found in a site other than its place of origin.

**Altitude:** Height above sea level.

**Autochthone:** This refers to something that has originated from the same place where it is found.

**Autotrophic:** Living being which manufactures its own food, starting from inorganic matter, like plants.

**Benthic:** Flora or fauna that lives in contact or depends on the bed of a body of water.

**Biodiversity:** Variety of living species that inhabit an environment.

**Biotic:** (from the Greek bios: living) Every living thing that makes up an ecosystem, in other words, bacteria, insects, fungi, plants and animals.

**Bioindicator:** A living being that shows the conditions the state of the natural environment in which it lives.

**Bioaccumulation:** Accumulation of living beings of chemical substances (mainly the toxic) which reach

amounts that are higher than those in their environment or in the food.

**Estuarine circulation:** Meeting point between fresh and saltwater. Freshwater, on being less dense, flows close to the surface towards the ocean, while saltwater on being denser, flows under the freshwater and in the opposite direction (towards the mountains).

**Chlorophyll:** Pigment which gives the green color to plants, bacteria and microalgae, which allows the process of photosynthesis.

**Earth's crust or lithosphere\*:** The layer of external rock which encircles Planet Earth. It is thinnest on the ocean floor, with a thickness of 7 km, and thickest on the continents with a thickness of up to 70 km in mountainous areas.

**Ramsar Convention:** International agreement signed by different countries, including Chile, in 1971 in Ramsar (Iran), where they committed to caring for and suitably using wetlands.

**Chlorofluorocarbons (CFC):** Family of gases, formed by carbon, chlorine and fluorine, which are mainly used as coolants in industries and as propellants of aerosols. They can remain in the atmosphere for between 50 and 200 years, contributing to the destruction of the ozone layer.

**Body of water:** Accumulation of freshwater (rivers, lakes, estuaries) or saltwater (oceans and seas) in depressions or deep holes in the earth's crust.

**Density:** Amount of matter (mass) that a body has in a unit of volume.

**Desertification:** Degradation of land in arid zones due to human activities (overexploitation of the land, mining, overgrazing and indiscriminate felling) and climate change.

**Predator:** Animal that hunts other animals for food and subsistence.

**Mouth:** Place where a river ends or enters another body of water, be this a lake or the sea.

**Detritus:** Particles which appear from the decomposition of a rock or another body.

**Carbon dioxide (CO<sub>2</sub>):** Gas which is released as waste from the breathing of living beings, the burning of fossil fuels, volcanic eruptions, deforestation and other sources.

**Ecotone:** Transition area of two or more ecosystems, where many species that are characteristic of the two adjoining ecosystems, cohabit.

**Erosion:** Wear of the earth's crust, soils and rocks caused by different agents like the wind, rain, rivers, waves, glaciers, sand, sun, among others.

**Species:** In biology, this is a set of organisms that can cross breed between them and have fertile offspring.

**Endemism:** This is a species that is spread across a reduced geographical area and that is not found naturally in other parts of the world. Endemism, therefore, refers to a species that can only be found naturally in one place.

**Introduced (or exotic) species:** Species that is not native to a place or area. The introduction may be accidental or intentionally transported by humans to a new location.

**Invasive species:** The introduced animal or vegetable species, which has a high reproductive capacity and spread, which potentially has negative impacts on the ecosystem.

**Native species:** This refers to the species that is naturally spreads in a given place or ecosystem.

**Eutrophication:** Process when nutrients in a river or lake increase, especially compounds with nitrogen (N) and phosphorus (P).

**Photosynthesis:** Process where plants, algae and micro-organisms produce their food (sugars) from carbon dioxide and oxygen in the presence of chlorophyll, which captures solar energy, finally releasing oxygen.

**Glaciation:** Long-lasting period where the planet's temperature decreases, generating the expansion of the continental ice of the polar ice caps and the glaciers. As a result, large areas which did not have ice or snow, are covered by these.

**Gregarian:** That live in groups or in communities.

**Habitat:** Place were the life of a species or of an animal or vegetable community develops.

**Heterotrophic:** Organisms which need to be fed from other organisms, like birds and us, human beings.

**0°C Isotherm:** Altitude where the temperature reaches 0°C and allows water to fall as a solid (snow).

**Heavy metal or trace metal:** Chemical element that is commonly known as being toxic in large amounts for animals and plants.

**Metamorphosis:** Transformation the certain animals

experience during their life.

**Monoculture:** Farming system which grows only one vegetable species on all the available land.

**Ecological niche:** This is the place which a species or population occupies in the ecosystem, depending on the relationship with other living beings or role in the ecosystem.

**Tectonic plate:** Fragments of the lithosphere which are moving the Earth's upper mantle. There are 28 plates on the planet and these can move apart from each other, collide (which generates earthquakes) or rise one on top of the other.

**pH:** Unit of measurement which measures the acidity of a body.

**Riverside:** This refers to the bank, which is the shore of a body of water.

**Salty:** Contains salt or tastes of it.

**Saprophagous:** Living being which feeds from decomposing organic matter.

**Drought:** Lack of rain for a prolonged period of time that produces dryness on the soil and lack of water.

**Ecosystemic services:** Benefits that humans obtain from ecosystems. Can be direct (water, food, among others) or indirect (functioning of the ecosystem's processes which generate direct services).

**Solvent substance:** Substances which have the capacity of dissolving.

**Peat:** Dark brown organic material that is rich in carbon and nutrients, which is created from vegetable remains which slowly decompose in peat bogs. The formation of peat is the first stage of the process where vegetation is transformed into carbon ore, being able to see the decomposing vegetable remains. Peat can be used as fuel or organic manure.

**Vivipary:** Animals before being born are developed within a special structure within the female's womb.

**Mediterranean zone:** This zone extends from a little to the north of Santiago through to Chillan and from the coast to the foothills. It is characterized by humid and cold winters and dry and hot summers.

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