Annual report 2020

Focus on ecosystems

SVENSK DÄCKÅTERVINNING

Welcome to this annual report with a focus on ecosystems and tyre recycling

Why is Swedish Tyre Recycling (SDAB) writing an annual report with a focus on ecosystems?

The explanation is quite simple. Our mission is to find the best possible uses for recycled tyres from a societal as well as an environmental point of view. This means that we need to be at least as interested in what is best for society and the environment as we are in tyres. In 2019, Swedish Tyre Industry released the Swedish White Paper "The road to sustainability", where the industry´s approaches, principles and know-how was detailed in terms of how recycled tyres can contribute to reducing societies over-consumption of natural resources. One of the key ideas in the Swedish White Paper was to extend the life-span of existing materials by at least the same factor as Sweden's over-consumption of natural resources. (Sweden consume more than 4 times above the planets regenerative levels, Luxembourg 8 times, France 3 times according to World Wildlife Fund (WWF). The world average factor is 1.6).

If we examine sustainability closer, what precisely is the challenge really about? Our view is that it has to do with how our human societies impact the biosphere. That is to say, how we impact the natural living world. Today, this impact is often more negative than positive.

Sustainability is about life

At its core, sustainability is about protecting what is unique to our blue-green planet; life. And what, then, is life? Life originated on Earth about 3.8 billion years ago and has developed more and more complex life-forms whose existence is based on and intertwined chemically, physically and biologically with living, biodiverse ecosystems. The deeper we look, the harder it is to see where one life-form ends and another begins. Where do the tree's roots end and where does the fungal mycelium begin? Where does the human end and the gut flora begin? Unless we learn from, and adapt to, the way that ecosystems function, our activities risk to not only affect individual organisms, but also tearing down the very foundations for advanced forms of life as well as for our own society. Every day, we learn from the media and from observing our surroundings that ecosystems are under pressure from human activities.

System perspectives* and tyres

*(*see the glossary on p 35)*

This is why in this annual report, Svensk Däckåtervinning (Swedish Tyre Recycling) discusses how our materials affect ecosystems and how we can use recycled tyre-derived materials to support the natural development and recovery of ecosystems. By natural, we mean the way in which ecosystems would have continued on their own, with normal access to the conditions for life, uninfluenced by humans. The relationships are complicated, so there are a number of perspectives to take into account, but progress always starts with an ambition and continues by means of constructive dialogue. If worn-out tyres can support prosperity in the environment, what else is possible?

So, we invite you to a dialogue about ecosystems and system perspectives, as they relate to tyres as well as more generally.

Welcome to Tyre recycling 2.0

SVENSK DÄCKÅTERVINNING AB
Fredrik Ardefors, CEO

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Life has organised itself in ecosystems

According to The Swedish Museum of Natural History an ecosystem is "Everything that lives in a natural area, including the surroundings. Ecosystems can be small or large, such as the area around a tree stump, a garden or the whole planet Earth. Animals, plants, fungi and micro-organisms that live together in an ecosystem are dependent on each other and affect each other. All ecosystems need energy in order to function and the biggest source of energy is the sun. Green plants play an important role, as they transform solar energy into sugar (glucose) that animals can use as a source of energy. Every ecosystem also includes decomposers (scavengers, fungi, bacteria). The flow of energy from the sun to green plants and on to consumers (animals) and decomposers is connected in food chains. An ecosystem is made up of several short or long food chains which combine to form a food web." [our translation]

An unsurpassed capacity to survive and to thrive
Many things can disturb or destroy the balance of an ecosystem, such as forest fires, environmental destruction, changes in the climate or species going extinct. At the same time, ecosystems have an unsurpassed capacity to survive, heal and develop. It is thanks to the ecosystems that the planet has gone from a sulphurous hunk of rock to what we have today. Despite meteorites and natural disasters, the ecosystems have recovered. This does not mean that we can allow ourselves to misuse nature's gifts, but it does give us an opportunity to trust in the ecosystems and to support natural processes.

Ecosystems can handle a lot but not everything

Can't we just focus on optimising one thing at a time?
For at least the past 100 years, humans have tried to optimise nature's yields by identifying e.g. factors that influence growth and trying to enhance them. In agriculture extra nutrients have been supplied, such as nitrogen and phosphorous, but initial carelessness leads to significant leakage and today farms are a major source of eutrophication of our seas and lakes. Another example is the fight against insect pests which has also had an adverse effect on pollinating insects. Time and time again, it has become clear that humans have not fully understood the consequences of deliberately or inadvertently affecting natural ecosystems. Sometimes we have become wiser and adjusted or developed our activities, but even compensatory actions often have new consequences. Measures and effects quickly become very complex and incalculable in the short and long term.

Evidence-based for billions of years
Svensk Däckåtervinnings' position is that we do not know enough to intervene significantly in ecosystems. Nature itself has been evidence-based for billions of years and has proven itself to be resilient as well as inclined to develop over time in a way that human systems do not even come close to. Ideally, the planet should be composed of regenerative systems in which the needs of humans and other life forms are met within the boundaries of what the ecosystems can handle without being depleted or destroyed. There are also several positive examples of natural environments and ecosystems recovering after humans have let ancient natural mechanisms become re-established.

A more balanced ecosystem when wolves were reintroduced to Yellowstone

Researchers at Berkeley University in the US have studied what happened when wolves were reintroduced to Yellowstone National Park. They concluded that it has benefitted large groups of animals, from ravens to grizzly bears. They also showed that the comeback of the wolf coincided with the return of various plants. Plant diversity, in turn, affects insects and, as a consequence, birds. The relationships are complex and often difficult to determine unequivocally, but a change at the top of the food chain can impact many other parts of the ecosystem. Instead of a cyclical overpopulation of moose followed by rapid dying out, which was the pattern until the wolves were reintroduced, moose populations are now stable during the winter and spring. Researchers have later found that other factors have also supported this development, but the wolves' hunting has benefitted ravens, eagles, magpies, coyotes and bears, and interestingly particularly when bears emerge hungry from hibernation. There is also research that shows that reintroducing wolves has not fully compensated for the damage to the ecosystems caused by the previous extinction of wolves. Again, the relationships are complex, but one possible conclusion is that the balance that comes from having more species, each with their own unique role, in the ecosystem can make it more resilient, i.e. better at handling disturbances. It is important to reverse the question and ask what happens when one part of an ecosystem is affected adversely or disappears altogether. One should also take into account whether intervening in ecosystems has long-term effects, regardless of whether it is an intervention in a long-established system or in connection with trying to restore an ecosystem that humans once changed. Even restoration can necessitate important questions. Note that this example is from a national park and not a contribution to the debate about wolves in Sweden. Every ecosystem requires its own analysis.

Positive effects when beavers were reintroduced to the UK

A study from Exeter University shows how reintroducing beavers to the UK has changed the landscape and ecosystems in and around waterways. Beaver dams contribute to reducing pollution as well as increasing local populations of wildlife, including fish and amphibians. Beaver dams lower the speed of floods when there is too much rain and help to store water, which prevents rivers from drying out during warm periods without rain. The dams also filter out contaminants and prevent soil from being washed away.

The underground ecosystem

One of the most intricate ecosystems is found in the ground under our feet, under fields and forests. For millions of years, fungi (mycelia) and plants have worked together in that fungi take up nutrients from the soil and transform them into a shape that plants want and can absorb through their roots. In exchange, plants give fungi carbohydrates, sugar. In everyday language, what we call "mushrooms" or "toadstools" are actually the fruits of the mycelium, and correspond to the apples on a tree. Here, we will use the word "fungi" to mean the whole organism. Fungi do not photosynthesise which means they cannot generate carbohydrates, that is, energy. On the other hand, they multiply the plant's capacity to absorb water and nutrients from the soil using their widespread underground networks.

1,500 different signal substances

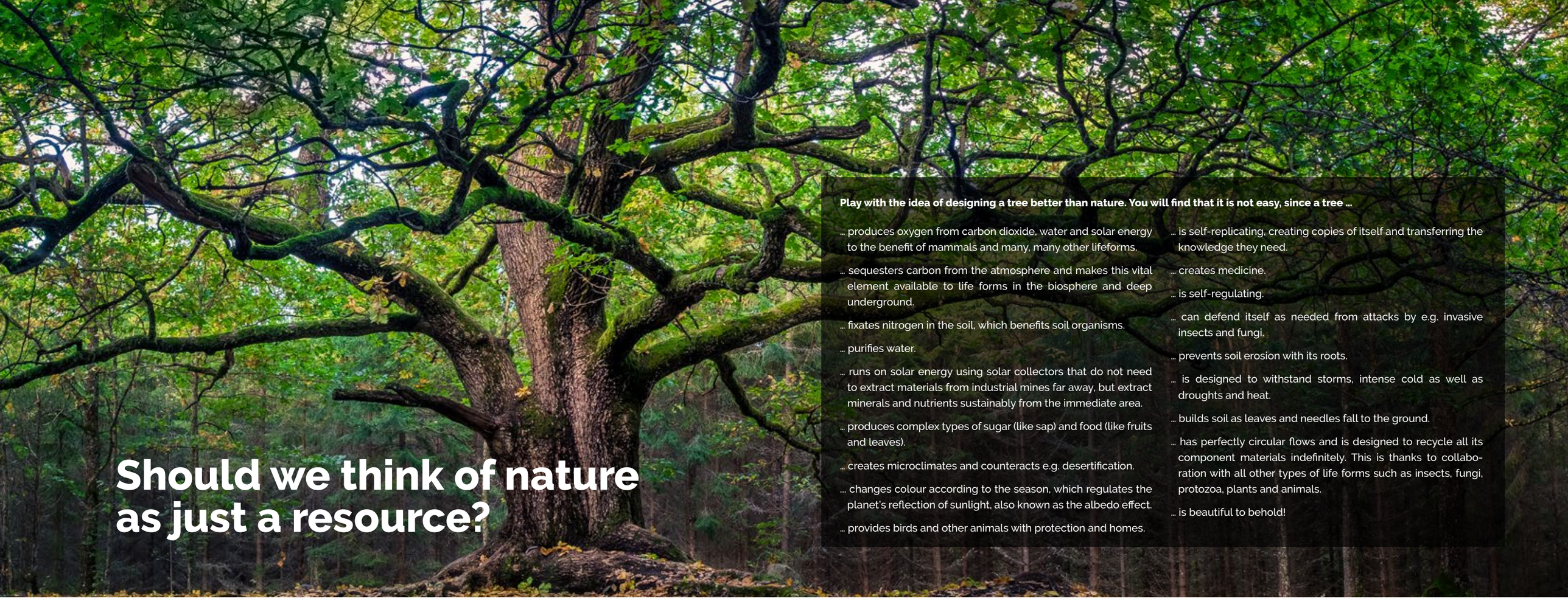
Studies have shown that plants can communicate with one another via underground networks of roots, mycelium, etc. Up to 1 500 different signal substances have been identified and a tree that has been attacked by pests can send for substances from others, which are then secreted to scare the pest off. The underground ecosystem also includes animals, such as worms, bacteria and nematodes.

Fungi, one of the kingdoms of life

Fungi are easy to overlook, although they are everywhere. Both inside us and outside us. They eat stone, produce soil, process contaminants, feed and kill plants, survive in space, induce psychedelic visions, produce food, create medicines, manipulate animal behaviour and affect the Earth's atmosphere. Fungi are a crucial part of understanding the planet on which we live, how we think, feel and act. Despite this, their lives are basically hidden from us. Only a small fraction of fungi has even been documented. The more we learn about fungi, the less becomes comprehensible without them. Fungi make up one of the taxonomic kingdoms on the tree of life, as broad and thriving as plants or animals. They keep us alive, as well as all the other forms of life we depend on. Fungi have been changing the conditions for life on Earth for billions of years, and they continue to do so.

An interconnected biosphere

The three examples of wolves, beavers and fungi have been chosen to show how unexpected and complex the relationships in natural ecosystems can be. In one case, how an animal's reintroduction to an ecosystem influences many other organisms, and in the second case, how a different animal's natural activity can increase biodiversity as well as reduce erosion and balance access to water, benefitting many animals, plants and people. The example of fungi is another proof of nature's ingenuity. The examples are intended to highlight how interconnected the biosphere is and how important it is to understand the relationships so as not to act inadvertently to the detriment of the environment and of humans.



Should we think of nature as just a resource?

Play with the idea of designing a tree better than nature. You will find that it is not easy, since a tree ...

... produces oxygen from carbon dioxide, water and solar energy to the benefit of mammals and many, many other lifeforms.

... sequesters carbon from the atmosphere and makes this vital element available to life forms in the biosphere and deep underground.

... fixates nitrogen in the soil, which benefits soil organisms.

... purifies water.

... runs on solar energy using solar collectors that do not need to extract materials from industrial mines far away, but extract minerals and nutrients sustainably from the immediate area.

... produces complex types of sugar (like sap) and food (like fruits and leaves).

... creates microclimates and counteracts e.g. desertification.

... changes colour according to the season, which regulates the planet's reflection of sunlight, also known as the albedo effect.

... provides birds and other animals with protection and homes.

... is self-replicating, creating copies of itself and transferring the knowledge they need.

... creates medicine.

... is self-regulating.

... can defend itself as needed from attacks by e.g. invasive insects and fungi.

... prevents soil erosion with its roots.

... is designed to withstand storms, intense cold as well as droughts and heat.

... builds soil as leaves and needles fall to the ground.

... has perfectly circular flows and is designed to recycle all its component materials indefinitely. This is thanks to collaboration with all other types of life forms such as insects, fungi, protozoa, plants and animals.

... is beautiful to behold!

These days we tend to think of nature as a resource, a depot for our needs of things like building materials, fuel, food and recreation. Nature can also be thought of as a source of learning. This has become more and more urgent the closer we move towards the boundaries of what the ecosystems can handle in terms of degradation, contamination and resource usage. For a long time, society has extracted much more than the ecosystems have time to reproduce. This is not only true of natural resources, but also of how we treat nature.

Tailored solutions to support life systems

Luckily, nature is a rich source of learning and inspiration that can help us to tailor our solutions to support life systems. For billions of years, nature has sedimented contaminants and made the air, seas and ecosystems cleaner and cleaner over time. Biodiversity and relationships have become richer, more intricate and advanced. Nature, with its ecosystems, is a model for the solutions of tomorrow. Learning from nature is very much about changing perspectives and looking at how nature solves problems. A tree is often seen as wood and fuel, but if we think of it as an example of design, a different picture emerges. What we see is limited by what we look for.

The example of the tree shows that nature often solves challenges in ways that are marvellously well-designed, functional and resource-efficient. There are many examples of ways in which we are already learning from nature, such as aeroplane wings inspired by bats, wetsuits made of materials modelled on sharkskin and air conditioning inspired by penguins' skeletons or the ventilation solutions in termite mounds, so as to eliminate the need for chemicals and energy-craving ventilation systems.

Nature as a guide

It turns out that even city districts can become sources of fresh air rather than pollution, purify water rather than contaminate it. By learning from nature, we can already discover further advantages, such as better adaptability to changes in the water, and less reliance on external resources like electricity and drinking water. But this requires us to make the effort to take an interest in how nature solves different things, and to accept that we need to change many of our current solutions.

Are humans ecosystems too?

Can you say that a human is an ecosystem? Yes, there is evidence to support this notion, and that all mammals, for instance, can be said to constitute ecosystems in their own right. Our intestines contain billions of bacteria that collaborate with the body in order for it to function. Recent research has also shown how our gut flora is linked to our brain function. We humans are home to countless commensal (i.e. that do not normally affect us adversely) bacteria, fungi, protozoa and miniscule insect species. Most commensal species of bacteria depend on reproducing on or inside us to survive. Our own survival is also likely to depend on the presence of these microorganisms.

How do tyres fit into all this?

Our conclusion from studying the conditions for life on planet Earth is that we need to safeguard natural ecosystems and their capacity to survive, recover and develop. Therefore, everything we do should be looked at from the point of view of how it affects the ecosystems, which includes tyre recycling. All human activity affects our surroundings and not always adversely. The important thing is to satisfy our needs without sabotaging the conditions for other life forms or for future humans. As we have seen, nature has the capacity to heal itself and we can rely on that to a certain extent, but not bank on it. But isn't it almost impossible to know how tyres affect ecosystems? Yes, but we have to start somewhere. As a first step, we have chosen to start with the applications for recycled tyre-derived materials. First, we will take an in-depth look at the uses, needs and functions of tyre-derived materials, which will give perspectives and references to orders of magnitude. Then we will discuss how tyre-derived materials can be used to provide the required benefits, what the alternatives are and what the effects are. If the effects are adverse, we will see if there are ways to reduce or manage them.

The examples in this annual report have been chosen to give a very simplified idea of how ecosystems can function, and to provide a starting point for reflecting on what can happen if something goes wrong..

Tyre shreds can reduce the eutrophication of seas and lakes

Tyre rubber with steel cord has been proven to have a unique capacity to purify water and bind e.g. phosphorous to its surface. Along with researchers and entrepreneurs, Svensk Däckåtervinning has developed the idea of purifying water using tyre-derived materials, an application that originated in the USA. Three effects are combined to purify water, after tyre shreds have been pre-treated using a process for which we have now applied for a patent. Contaminants are removed from the surface texture of the rubber and the cleaned surface is exposed to purify running waste water, agricultural leakage or for the industrial purification of polluted water from e.g. mines. An ion exchange mechanism is utilised to bind e.g. phosphorous to the surface. Finally, aerobic as well as anaerobic biofilms are established on the surface by microorganisms finding a habitat there. The microorganisms then continue to purify the water in much the same way as in traditional suage water treatment using natural gravel. The pre-treatment of the rubber reduces the amount of zinc and stops the material from leaking undesirable substances into the surroundings. A final treatment makes the tyre shreds release the attached phosphorus as well as the biofilm, and the phosphorous can be extracted and reused.

What explicit effects does the use of tyres have on ecosystems?

The eutrophication of the Baltic Sea and many lakes is a well-known and extensively studied problem. Nutrients leak from oversaturated agricultural land and sewage systems into lakes and seas, fuels unnatural algal growth and affects other plants and animals. When the dead plants and animals sink to the bottom, the decomposition process uses up the available oxygen. The consequence is severely affected ecosystems with dead zones on lake and sea floors and corresponding decreases in species and populations. The combination with overfishing is devastating. According to the World Wildlife Fund (WWF), the dead zones on the floor of the Baltic Sea correspond to more than twice the area of Denmark.

As large quantities of tyre shreds are available, it can provide a solution for capturing phosphorous before it reaches the sea. Attempts are also being made to clean seas and lakes by collecting sludge that contains phosphorous and letting it pass through containers filled with tyre shreds to bind it.

Replacing natural gravel in suage water treatment

Tyre shreds can also be used in land treatment for e.g. individual waste water systems, which have traditionally used natural gravel from eskers. Sweden currently has between 350 000 and 450 000 obsolete individual waste water systems, and replacing them with solutions that use natural gravel would have a serious effect on the country's eskers, which have already been overexploited. Trials using crushed stone have demonstrated technical challenges and high costs.

Since the Ice Age, the eskers have acted as waterways and have proven to be irreplaceable for regulating water flow as well as for purifying water. Eskers also provide a unique habitat which disappears when they are excavated.

A lot of sport on a small surface protects nature

The reason for using artificial turf is that more and more people want to play sport all year round. Football has a very beneficial effect on public health. In Denmark, a new study shows that football is a better form of exercise than jogging, interval training or weight lifting when considering a combination of the effects on muscle mass, fitness, body fat and bone density. Another type of football – walking football – provides good exercise for seniors. Most people can start playing football as a form of exercise at any time. You do not have to have played football before or to be in good shape. The societal benefits of football in the small Kingdom of Sweden (10 million inhabitants) amount to a staggering € 2.3 billion worth of economic, social and health-related effects. Investing € one in grassroots football results in € ten in return. But more football fields are needed, according to the Swedish Football Association. The number of hours of play on artificial turf with tyre granulate is five to ten times higher than on natural grass, which makes it more accessible. This has meant that artificial turf pitches have had a very beneficial effect on football in general and public health in particular.

Effects on ecosystems

Recycled tyre-derived material in the shape of granulate is used as infill in artificial turf pitches to provide a softer surface, the correct trajectory for the ball and drainage, to avoid freezing, protect players' knees and ankles, protect the plastic blades from wear, etc. Initial studies in Italy and the Netherlands indicate that rain water in urban areas is cleaner after being filtered through an artificial turf pitch.

The main effect on ecosystems is that artificial turf frees up land for other uses. Sweden's approximately 1 200 artificial turf pitches, each with an area of 7 600 square metres, cover a surface of just under 1 000 hectares. They replace in the order of 8 000 hectares of natural turf pitches to provide the same amount of available playing time. Particularly in urban environments, parks and green spaces provide important interruptions in an otherwise technical environment. Natural turf requires watering, mowing, fertiliser and weed control, and yet is not accessible enough except in small parts of the country.

Few alternatives from a system point of view

Systems analyses of biological infill materials show that the equivalent of up to 130 football pitches of cork oak groves are required to provide each pitch with cork. Although cork oak groves are some of the most biodiverse and regenerative ecosystems, the current population is not enough to cover Europe's needs. Other suggestions are bio-infill from sugar cane waste, logging residues from Swedish forests and various seeds and casings. However, environmental impact assessments, including impact on ecosystems, have not been carried out for these materials.

What happens to the forest and the natural decomposition of logging residues, which play an important role in supporting the work of underground ecosystems to support new plantings, when they are vacuumed up? Would it be better to leave sugar cane waste, too? What types of chemical treatment are needed to stop these materials from rotting or going mouldy? The questions compile.

However, there are also concerns about the use of rubber granulate. One of them involves leakage of undesirable substances and the other is the risk that granulate will end up in the wrong place in a natural environment. Both will be addressed on the following pages

Plant substrates in urban environments

This application does not exist yet, but the need has been raised in various contexts. One problem in our cities is that it is hard for vegetation to thrive when it is embedded in hard surfaces. For example, the ground around a tree often becomes compacted and when it is surrounded by asphalt. Rain water runs away from it, or accumulates in the area around the trunk. Another problem is that the tree's roots do not establish the crucial mycorrhiza (which is a kind of partnership or collaboration) with mycelium in the ground, which leads to long term problems with e.g. nutrient uptake, even when the tree is given fertiliser. In fact, the viability of plants and mycelia decreases with increased fertilisation if the soil is low in zinc. It is not unusual to have to replace trees in urban environments when they are only 15 years old, often at a cost of over € 5 000 per tree. One solution might be to mix the soil around plants in urban environments with tyre granulate. This would make the soil looser and improve the tree's capacity to absorb water and nutrients.

Beneficial substances in rubber materials?

By choosing the right type of mycelium, beneficial substances in rubber materials can be extracted and prepared to act as nutrients for the tree's roots to absorb. Mycelia have been identified which process e.g. organic hydrocarbons such as PAH and the micronutrient zinc. Exactly the same substances that are found in tyre rubber and that can be detrimental in high concentrations in the wrong place. In this way, they can be put to good use instead.

Using nature's own intelligence and systems to transform technical substances into nutrients at the end of the product's life is an important field of knowledge for the future. The mycelium collaborates with bacteria and plants to transform the tyre-derived material back into living matter. The importance of e.g. zinc for plants' capacity to absorb nutrients and the relationships between plants, bacteria and mycelia have been well studied, but the applications are lagging behind. Svensk Däckåtervinning believes that these unexpected meetings could constitute the quantum leaps that the circular economy needs.

Particular areas of attention before using tyre-derived materials

Although the use of recycled tyre-derived materials has been proven to have many beneficial effects, one always should review the advantages and disadvantages of the material for a particular application. For tyre-derived materials, five primary areas of note have been identified where possible uncertainties or risks should be studied to determine whether the application should be avoided or whether the situation can be managed.

Zinc

Zinc is a naturally occurring element that is rarely found in its pure form but more often in the form of zinc oxide. About 1.5 percent by weight of zinc is added in the production of tyres to aid vulcanisation, i.e. the creation of lateral sulphuric bonds between the long carbon chains in the rubber. Vulcanisation is key in creating the unique properties of rubber, and also makes the material very chemically stable. The added zink is evenly distributed throughout the material and migrates initially from newly fractured surfaces to the surroundings. This means that new shreds can release zinc for 1–2 weeks into running water or if they come into contact with the ground. Washing the material minimises the leakage of zinc.

An essential mineral

According to the Swedish Food Agency, zinc is "an essential mineral. It is found in hundreds of enzymes in the body that affect the circulation of proteins, carbohydrates, fats, nucleic acids and some vitamins such as vitamin A. Zinc is also vital to the immune system." According to the Swedish Environmental Protection Agency zinc is "a nutrient that plants and animals require in small amounts, but excessive levels can be toxic". "Excessive levels of zinc have proven to be harmful to water-dwelling organisms and can cause behavioural and reproductive disorders". "The burning of biomass to generate electricity and heat is currently the largest source of airborn zinc in Sweden. The largest source of emissions of zinc into aquatic environments is the pulp industry, followed by smaller emissions from water treatment plants."

In ecosystems, zinc, iron and manganese are necessary to create chlorophyll and are particularly important during plants' growth phase. On land, the issue of zinc is about it being accessible in the right chemical form for plants to absorb it, and about the amount (per unit of time) not being too high. Svensk Däckåtervinning has initiated research projects in this area

Leaked zinc not a problem

A lack of zinc in plants has been identified as a problem for growers and zinc is often found in nutrient solutions for agriculture and plant growing. Fungal mycelium probably plays an important role in preparing different substances for plants' roots to absorb and therefore the interaction between tyre-derived materials and mycelium is of extra interest. None of all the studies done have identified problems with zinc leaking from tyres into soil, so applications there need not be limited. However, further studies are recommended before tyre-derived materials are used in aquatic environments, as water-dwelling organisms can be sensitive to some forms of the substance.

Iron

Iron occurs naturally and is common in human applications, often in the shape of alloys. Iron is also an essential element for living organisms but should not be overdosed. Iron is mentioned as an area of note as tyre shreds with protruding steel cord can give rise to rust when they come into contact with oxygen and water. If the iron oxide is released it can discolour and even block pores and openings. Balance in ecosystems is important and tyre shreds with significant protrusions of steel cord are avoided in sensitive applications. However, tyre shreds without significant protrusions of steel cord do not leak enough iron to be a problem in most applications on land and in water.

6PPD

An antiozonant, an organic compound that prevents or delays damage caused by ozone, which is added to tyres to increase their resistance to ageing. 6PPD has a short lifespan in free form and according to the EU authority ECHA it is not in itself toxic, but when large amounts of ozone and UV radiation are present it can turn into 6PPD-quinone which is suspected to be harmful to some water-dwelling animals. With this in mind, as a precaution, the use of tyre-derived materials is not recommended when there is a risk of exposure to ozone and UV radiation in combination with mechanical abrasion.

PAH

Polycyclic aromatic hydrocarbon occurs naturally and is created wherever biological material is charred, e.g. in a forest fire. The substance has been found to be carcinogenic over certain concentrations. This is particularly true for so-called PAH8, the most dangerous form. PAH forms e.g. when meat or vegetables become charred on a barbeque and therefore very blackened parts should be removed. PAH used to be found in tyres as a component of the softening oils, highly aromatic oils, that were added to increase wet grip, but since 2010 these oils have been banned in tyres. EU regulations only permit up to 10 parts of PAH8 per million in tyres based on assessments of health and safety risks in tyre production, i.e., before the material has been vulcanised. The finished product is stable and it is very difficult even using strong solvents to extract the remaining PAH, primarily found in the carbon black (the black component) in tyres, which is added as a binding agent. Measurements show that recycled tyre rubber has a PAH content of 1.6–8 ppm and the ECHA has set a limit of 20 ppm for exposure from the material in connection with play and sports on artificial surfaces made of the material. In ecosystems PAH can bio-accumulate, but based on natural occurrences, e.g. from forest fires that form coal and ash, no conclusions have been drawn that suggest problems.

1–3 ppm in sensitive areas

The Swedish Environmental Protection Agency has set the limit for PAH in soil at 1–3 ppm in particularly sensitive areas and up to 20 ppm in less sensitive areas. The guide values for water are lower, but there are not many norms for drinking water except for some values. The leakage

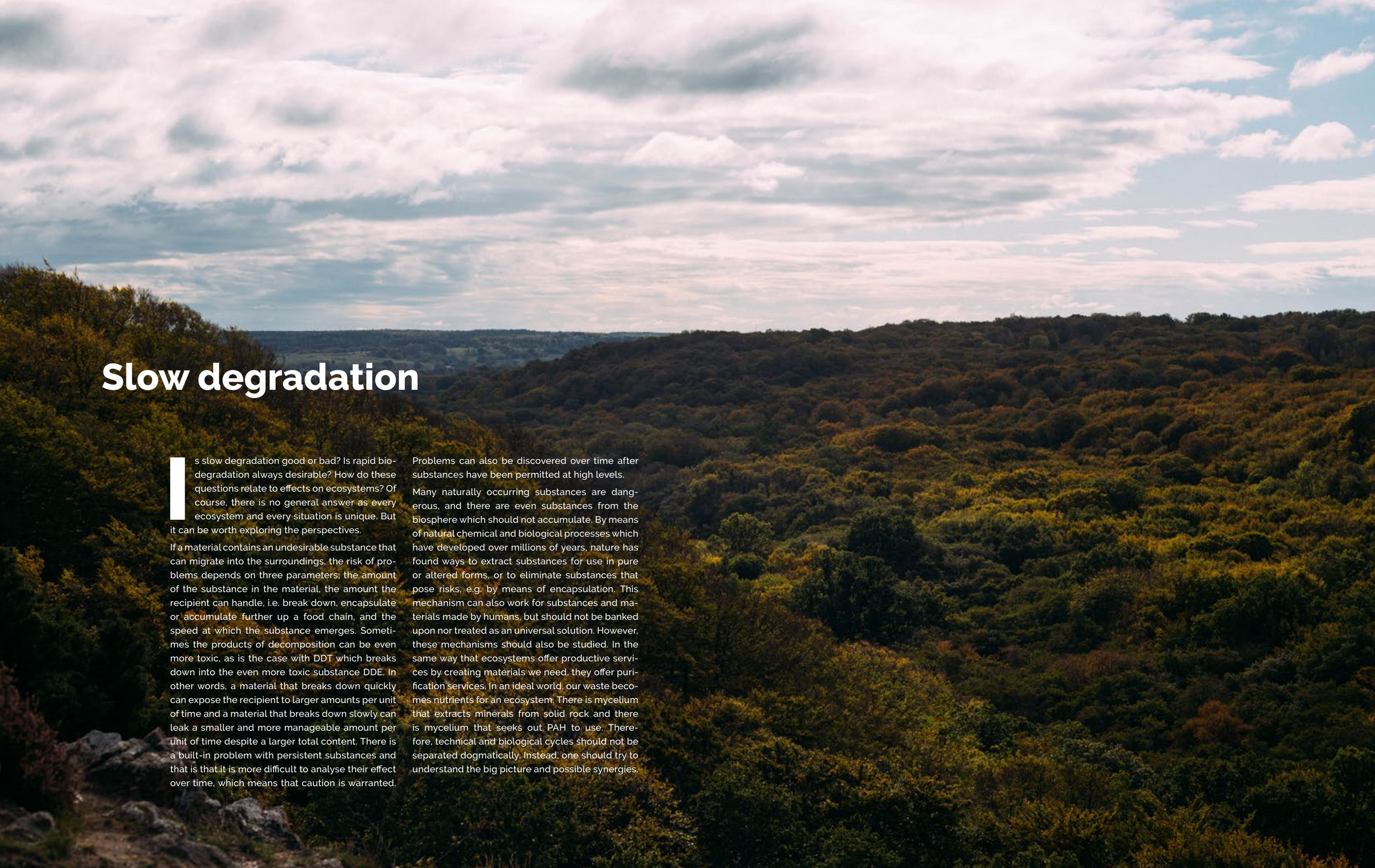
per unit of time from these low content levels is negligible and there are currently no recommendations to limit the use of tyre-derived materials based on the risk of PAH leakage.

Particles in nature

Chemically and biologically, rubber particles are viewed as posing a low risk and even tests that correspond to ingesting the material have shown it not to be dangerous. Tests on worms that were give an 50/50 granulate/soil mixture to live in demonstrated no hormonal, or other, traces in the worms compared to a control population, but slightly lower growth was detected, probably because of the lower nutrient content when the mixture was only 50% soil. It remains to be seen whether the particles in themselves can be harmful to ecosystems. Particles can cause problems in the digestive tract of fish, according to studies at Gothenburg University. However, the material does not float around, being mistaken for food in the sea. On land there is nothing to suggest that animals eat the granulate. All the same, when loose material is used, it should be accompanied by measures to minimise waste and leakage.

Microparticles

Tyre-derived materials have been suspected to be a major source of microplastics, both from tyre wear and from applications using loose rubber granulate. We will not comment further on tyre wear here, other than to say that the amount of wear is relatively undisputed, whereas much remains unknown about how the particles spread and are broken down and how they affect ecosystems. Studies have demonstrated a devulcanisation effect at the moment of abrasion and that natural decomposition with a half-life of of 16 months can take place near roads. However, there is a lot of uncertainty about these mechanisms and how the material decomposes. In loose recycled granulate there is no devulcanisation. Instead, the particles are very chemically stable. They are heavier than water and settle. Leakage from the material is minimal. This has been shown e.g. in studies of players and leakage from applications in artificial turf pitches.



Slow degradation

Is slow degradation good or bad? Is rapid biodegradation always desirable? How do these questions relate to effects on ecosystems? Of course, there is no general answer as every ecosystem and every situation is unique. But it can be worth exploring the perspectives.

If a material contains an undesirable substance that can migrate into the surroundings, the risk of problems depends on three parameters; the amount of the substance in the material, the amount the recipient can handle, i.e. break down, encapsulate or accumulate further up a food chain, and the speed at which the substance emerges. Sometimes the products of decomposition can be even more toxic, as is the case with DDT which breaks down into the even more toxic substance DDE. In other words, a material that breaks down quickly can expose the recipient to larger amounts per unit of time and a material that breaks down slowly can leak a smaller and more manageable amount per unit of time despite a larger total content. There is a built-in problem with persistent substances and that is that it is more difficult to analyse their effect over time, which means that caution is warranted. Problems can also be discovered over time after substances have been permitted at high levels.

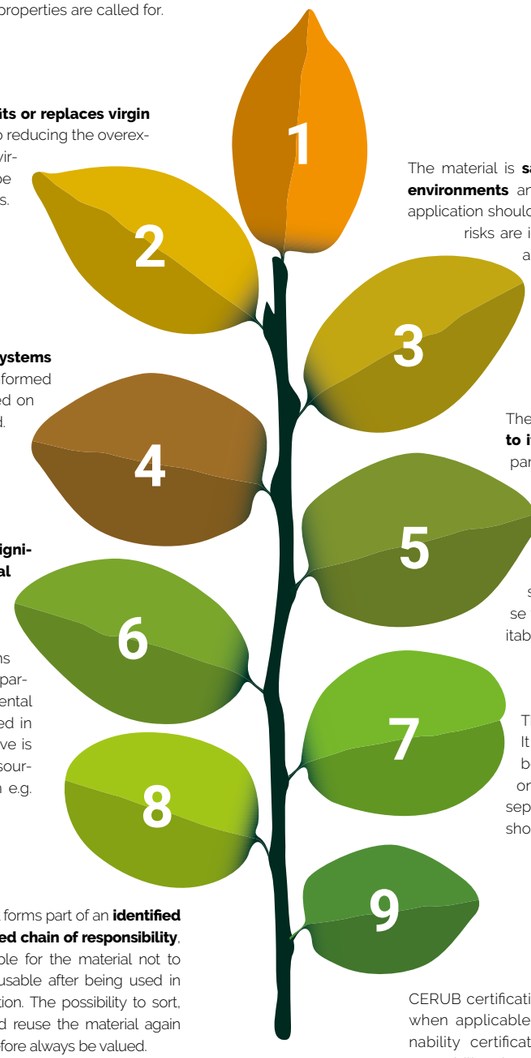
Many naturally occurring substances are dangerous, and there are even substances from the biosphere which should not accumulate. By means of natural chemical and biological processes which have developed over millions of years, nature has found ways to extract substances for use in pure or altered forms, or to eliminate substances that pose risks, e.g. by means of encapsulation. This mechanism can also work for substances and materials made by humans, but should not be banked upon nor treated as an universal solution. However, these mechanisms should also be studied. In the same way that ecosystems offer productive services by creating materials we need, they offer purification services. In an ideal world, our waste becomes nutrients for an ecosystem. There is mycelium that extracts minerals from solid rock and there is mycelium that seeks out PAH to use. Therefore, technical and biological cycles should not be separated dogmatically. Instead, one should try to understand the big picture and possible synergies.

A model for optimising the benefits of recycling of materials

The current "linear" economy, which is not sustainable, results in, among other things, accelerating extinction of species, unnatural climate change, ocean acidification, depletion of natural resources and destabilisation of ecosystems; the planet's life-supporting systems. These are symptoms of a larger issue which is how we treat the planet's resources, how we think about nature. It is also about the present and the future, about not avoiding difficult questions and about making it possible to take a circular approach. One obvious conclusion from this line of reasoning is that we need to make the best possible use of the products and materials that are already in circulation.

Recycling is not enough

Unfortunately, recycling is not enough. If we are to address today's challenges of adapting to a shift within planetary boundaries, we need to direct our efforts where they will benefit the living natural world the most. Resource use and land use perspectives are the main drivers of the destabilisation and depletion of ecosystems, which Svensk Däckåtervinning can affect by means of our recycling solutions. For a different company, perhaps it might be phasing out harmful chemicals. A systems perspective is needed. More on how we have done this can be found in the Swedish White Paper for sustainability in the tyre sector (2019). In the Swedish White Paper we have defined a number of criteria for recycling tyre-derived materials. They are based on a systems perspective on sustainability and where the company can make the most difference. The criteria primarily concern new applications for recycled tyre-derived materials, but ultimately all types of recycling and use of materials, including biological materials. Here are the criteria, which have now been updated to include an ecosystem perspective:



1 **Demand for the material is based on real need** based on its properties and on commercial terms. These terms stem from the material providing real benefits where its properties are called for.

2 The material adds **unique benefits or replaces virgin materials** In order to contribute to reducing the overextraction of the Earth's resources, virgin materials should be able to be replaced by tyre-derived materials.

3 The material is **safe for human health and natural environments** and any risks can be managed. The application should comply with laws and regulations. If risks are identified, the application can still be acceptable, if the risks can be managed. This can be done by limiting use in time or space, using special equipment or reducing exposure.

4 The material's **effect on ecosystems should be identified** and an informed decision about its suitability based on this effect should be documented.

5 The material **performs well in relation to its total environmental effect** compared with the alternatives. Life cycle analyses (LCA) measure the performance of the material based on its total environmental effect compared with alternatives with the same application. The recycled material should not perform significantly worse than other alternatives for it to be suitable for use.

6 The material does **not have significantly larger environmental benefits in a different application**. To avoid sub-optimisation, alternative usages should be explored. Even if a material performs better than other alternatives in a particular application, the environmental benefits may be larger if it is used in other applications. This perspective is particularly relevant for limited resources, which can be the case with e.g. some types of tyres.

7 The material **can be recycled again**. It is preferable for the material not to become unusable after being used in one application. The possibility to sort, separate and reuse the material again should therefore always be valued.

8 The material forms part of an **identified and allocated chain of responsibility**. It is preferable for the material not to become unusable after being used in one application. The possibility to sort, separate and reuse the material again should therefore always be valued.

9 CERUB certification or the equivalent, when applicable. CERUB is a sustainability certification that guarantees traceability, documentation and transparency for recycled tyre-derived materials.

Closing reflections

With this annual report, Svensk Däckåtervinning has attempted to put our business into a deeper systems perspective than before. We believe that ecosystems are the core of life.

With this document, we aim to create interest and constructive debate. To increase curiosity about something we seem to be growing more and more alienated from. To question ourselves and to see what happens when we leave safe and familiar paths and ways of thinking. Along the way, we have come across some interesting observations from the public environmental debate which may serve as further points for discussion.

A circular economy versus sustainability

It is important to differentiate between goals and means. A sustainable society is the goal, i.e. a society that treats life on Earth with care as well as providing rich opportunities for humans and other life forms to develop. A circular economy is one of several means to reach increased sustainability, a tool for reducing the need for new resources to be extracted from the biosphere and technosphere. But sometimes it costs more to recycle than to extract new materials, so each situation needs to be analysed.

Technical versus biological materials

The current trend is for everything to be "bio", but the biosphere has a limited capacity to fulfil all our desires. By failing to adapt our needs to the regenerative capacity of the biosphere, we create an overburden that is simply unsustainable. It may be better to permit the "surgical" extraction of technical materials with a limited effect on the ecosystems, than to rely on major extraction from the biosphere. Compare, for example, boring one hole for natural gas with chopping down rainforests to produce biofuels. Again, one size does not fit all. A complete analysis is necessary in each specific case.

Biodiversity versus ecosystems

Biodiversity is a technical measurement of the number of species in a given area, but it says nothing about the functioning of the ecosystem. Of course, it is possible to demonstrate high biodiversity by establishing small reserves of species, which prop up ecosystems in the short term, but which destabilise them at the same time. Biodiversity is high in Stockholm thanks to all the large Nordic animals at Skansen's zoo, but Sweden's capital does not have a functioning natural ecosystem that includes these animals. Similarly, the term 'forest' has been watered down to include monocultural forest plantations, that displace ecosystems, instead of the biodiversity offered by natural, mixed forests.

Anthropocentrism versus the romanticising of nature

Taking nature as one's point of departure may seem romantic and backward. In this day and age, it is a common conception that humans should put things right, "save", control and develop the planet based on our needs. Humans' needs should not be marginalised, but neither should our understanding and capacity reach the level of hubris. Technical solutions and calculations have their place, but there is also value in a closer connection to nature. The closer humans get to the ecosystems, the more natural it will be for us to take responsibility for our effects on them.

We hope to hear from the readers of this annual report so that we can chart a course together towards a sustainable future, based on today's realities, but with the ecosystems and care for living systems as points of departure.

This is Svensk Däckåtervinning

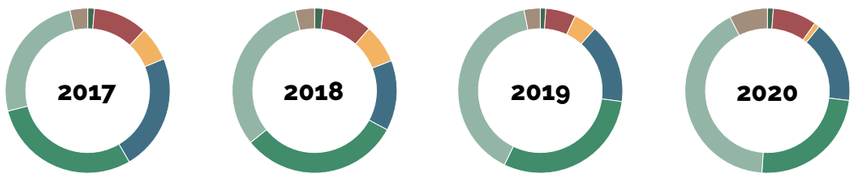
Extended Producer Responsibility (EPR) means that whoever puts tyres on the market also needs to take responsibility for what happens to them once they come to the end of their life. Sweden has the oldest producer responsibility scheme for tyres in the world, established in 1994. Gradually, similar regulations have grown to encompass cars, electric and electronic products, newspapers, cardboard, metal, plastic and glass, in Sweden and other countries. These producer responsibility schemes are all aimed to increase the degree of collection and recycling, and thereby support a circular economy. Producer responsibility schemes are currently in place in about 15 countries in the EU as well as a handful of countries in other parts of the world.

Svensk Däckåtervinning AB is the tyre industry's response to the Swedish regulation on producer responsibility for tyres (1994:1236) and is tasked with organising the collection and recycling of all worn-out tyres. The monitoring bodies are the Swedish Environmental Protection Agency and municipal environmental departments. Since operations began in January 1995, every year between 90 and 100 percent of all worn-out tyres have been collected. In recent years, the extent of collection has exceeded 100 percent. The producer responsibility scheme is financed by a recycling fee paid by importers, but they in turn usually charge distributors a fee, and they in turn pass it on to consumers. Thus, consumers take their environmental responsibility by paying a recycling fee when they buy new tyres.

84 574 tonnes of tyres were recycled in 2020

In 2020 Ragn-Sells Tyre Recycling recycled 84 574 tonnes of tyres on behalf of Svensk Däckåtervinning, which is a decrease from 2019 when 93 010 tonnes were recycled. 90 548 tonnes were collected in 2020 compared with 92 574 tonnes in 2019. Thus, the decrease in recycling in 2020 compared with 2019 was caused partly by a decrease in collection and partly by some accumulation of stock during the year. Covid-19 has had some effect in that sales of tyres have decreased somewhat, which means that fewer worn-out tyres have come in to tyre workshops to be collected. Ragn-Sells Tyre Recycling reports decreased volumes for energy recovery as well as for granulate (the latter because the granulate factory has halted production) and increased volumes for recycling, bomb blankets and material substitution.

Quantities of recycled tyres by category of recycling 2017–2020 (tonnes)



Category of recycling	2017	2018	2019	2020
Retreading	21	0	0	0
Export of whole tyres	1,134	1,529	1,002	982
Recycling of materials : blasting mats	9,335	8,874	5,495	7,290
Recycling of materials: granulate	5,962	6,905	4,174	883
Other recycling of materials	20,102	12,505	14,552	13,608
Energy recovery	25,864	28,357	27,952	20,427
Energy recovery: cement industry	22,445	29,065	36,870	35,053
Material substitution	3,039	3,422	2,964	6,331
Total recycling	**87,903**	**90,657**	**93,010**	**84,574**

Tyre rubber has many qualities that have been refined over the years

The unique properties of tyre-derived materials enable a wide range of applications. Today, these advanced rubber materials are produced according to strict rules and high demands of customers in terms of health, the environment and sustainability. This makes the materials suitable for new applications for many years after the tyre has been removed from the car.

For over 100 years, these materials have been developed to be:

- **ELASTIC**
- **TEMPERATURE-INSENSITIVE**
- **UV-RESISTANT**
- **ISOLATING**
- **PRESSURE-DISTRIBUTING**
- **SHOCK-ABSORBENT**
- **FRICTION-CREATING**
- **SOUND-ABSORBENT**
- **AND TO PROVIDE WATER EVACUATION**

Tyre shreds distribute loads and provide an excellent surface for biofilm.

Isolates, provides support and can be re-cast
Free form rubber granulate isolates, provides support, reduces wear, etc and can be re-cast into new products. When added to cement and asphalt, it improves their properties.

Fibreboard, concrete and textiles
The textile provides extra strength to the tyre and the strong fibres reinforce fibreboard, concrete, as well as textile mats, etc

Used again and again
The steel from the reinforcement layers and wires is well-known in recycling circles and can be used as it is or be re-cast.

Binding agent and pigment
Carbon black from pyrolysis becomes a new raw material to act as a binding agent, pigment, etc.

Rubber products
Devulcanised rubber is ready to be turned into new rubber products.

Oils, lubricant and fuel
Pyrolysis oil made from tyres has a low sulphur content and is refined into high technology oils, additives or lubricants or becomes liquid fuel.

High energy
Rubber has a high and unfluctuating energy content for the final energy recovery.

Important events during 2020

FIRST QUARTER

In January, Svensk Däckåtervinning participated at the Auto Fair and spoke about the changes facing the tyre industry when it comes to tyre recycling. The headline was "Can tyres save the world"?

In connection with Tyre Industry Day in Stockholm at the end of 2019, the Swedish Tyre Industry launched the Swedish White Paper "The road to sustainability", which was distributed at the beginning of 2020 and continues to be distributed to operators in the industry as well as to the general public.

CERUB.org was launched in 2020 by the four producer responsibility organisations in Sweden, Finland, Norway and the Netherlands. The aim of the world's first sustainability certification for recycled tyre-derived materials is to facilitate the recycling of tyre-derived materials and to ensure that the entire recycling chain meets the highest environmental and health standards. A CERUB certification guarantees a responsible production chain, a transparent flow of materials and that the material fulfils all regulatory environmental and health requirements for its intended final use.

SECOND QUARTER

In April, the extensive European study ERASSTRI confirms that playing football on artificial turf pitches with rubber granulate from recycled tyres does not pose any health risks. The study, which ran for three years and was divided into three sub-studies under the supervision of the German research institute FoBiG, was published in the journal Science of the Total Environment. The background of the study was concerns that playing on artificial turf pitches with rubber granulate infill from recycled tyres could expose football players to health risks.

THIRD QUARTER

As more natural gravel quarries have reached their maximum capacity, finding enough uncontaminated material for water purification has become a growing concern. Here, rubber has a part to play as a replacement for natural gravel. Many countries, including the US, use tyre shreds as an environmentally friendly way to purify contaminated water, and have done so for several years. We have been pleased to note that the interest in this method increase also in Sweden. Along with others, Svensk Däckåtervinning is developing a concept for water purification and is conducting experiments, for instance, in ways where tyre-derived materials can improve existing solutions for individual waste water. .

Rubber concrete is an exciting combination of materials, each with completely different properties. During the autumn, Svensk Däckåtervinning was contacted by an entrepreneur who has created "soft" concrete containing rubber granulate. As a first application, this soft concrete will be used as a surface with springy properties for equestrian surfaces. The rubber concrete, which is soft and compresses under pressure, means that the cushioning in equestrian surfaces can be better suited for horses' needs and prevent injuries. Using rubber concrete saves resources. Over time, rubber concrete will be used in more products and applications.

FOURTH QUARTER

Tyre shreds have a high capacity for drainage, up to 10 times higher than natural gravel, and therefore they are attractive for various applications such as the isolation and keeping house foundations dry. Now, the function of tyre shreds is going to be evaluated in an application for French Drains in agriculture. French drains drain arable land in order to increase yield. Tyre shreds can replace plastic pipes, providing a cheaper and more resilient structure with a longer lifespan, decreasing the use of resources.

In mid-December, Svensk Däckåtervinning updated www.sdab.se with a clearer content structure and an uncluttered, stylish and user-friendly layout. Emphasis has also been placed on highlighting the company's work towards a circular economy and involvement in research.

In mid-December, the Circular Economy certification system CERUB was nominated for The Recircle Awards, a new global event designed to bring attention to businesses' and individuals' contributions to the tyre, retreading and recycling industry for a circular economy. CERUB was nominated in the category The Business Innovation, a prize for the most innovative new business concept within the recycling industry.

At the end of December, the Swedish government determined the directive for the Swedish Environmental Protection Agency for the 2021 year of operation. As part of the government's decision, the agency was given a task called 'waste as a resource', of which one part was: "The Swedish Environmental Protection Agency should analyse the prerequisites including advantages and disadvantages of national criteria for when waste ceases to be waste (End-of-Waste criteria) and assess whether it might be relevant to develop national end of waste criteria." [our translation]

Ordlista

Abiotic *is a word for non-living features of our world, such as mountains, air and water, and processes that are not caused by living beings.*

Acidification *is a build-up of hydrogen ions in soil or water, which increases acidity and decreases pH. A drop in the pH-value by one unit corresponds to a tenfold increase in the level of hydrogen ions.*

Aerobe *is an organism that can survive and grow in an oxygenated environment. In contrast, an anaerobe is an organism that does not require oxygen for growth. Some anaerobes react adversely or even die in the presence of oxygen.*

Amphibians *are a class of vertebrates believed to have evolved from sarcopterygian fish (an order of fish with bony-limbed fins) and are divided into three orders; frogs and toads; salamanders and caecilians.*

Anaerobic biofilm *is composed of microorganisms, including bacteria, who collaborate to break down biological substances such as sewage sludge and thereby have a purifying effect on the water.*

Bioaccumulation *is the accumulation of environmental toxins in a biological organism, usually an animal. These environmental toxins are absorbed via polluted air, water or food.*

Biodiversity *is an abundance of species, environments and genes that is important for nature to function properly, for our survival and for the right of all species to exist. Biodiversity is the genetic variety within species as well as the diversity of ecosystems.*

Biotic *describes a process or environmental factor achieved by living beings.*

Biosphere *is a collective term for the parts of Earth where life can exist. It can be thought of as a large ecosystem, containing all the smaller ecosystems on Earth. In the biosphere, life is preserved by the cycling of materials and the flow of energy from the sun.*

Biotope *is a habitat, the external environment in which a particular plant or animal community belongs. It may be a habitat type such as a spruce forest with bilberry bushes, a bog or a salt meadow.*

CERUB® *is a sustainability certification that guarantees traceability, documentation and transparency for recycled tyre-derived materials. The tyre industry is the first in the world to create a sustainability certification for our shared endeavour towards a circular economy.*

Circular economy *is an economy, in which financial resources are managed in cycles inspired by nature. Circular economic models are often the opposite of a linear economy, in which raw materials and resources move in a straight line from extraction to destruction via a -usually brief – period of consumption.*

DDE *– dichlorodiphenyldichloroethylene, is a toxic chemical compound formed by the loss of hydrogen chloride (dehydrohalogenation) from DDT, of which it is one of the more common breakdown products.*

DDT *– dichlorodiphenyltrichloroethane, is a toxic, colourless, tasteless, and almost odorless crystalline chemical compound. Originally developed as an insecticide.*

Decomposition *is a process in nature in which organic material, mostly dead plants, fungi, algae and animals, are mainly transformed into inorganic molecules.*

End-of-life tyres *is a tire that can no longer serve its original purpose or for other reasons are not, reused for their original purpose. If they are recycled correctly, worn-out tyres are a major resource, extending the lifespan of the material by creating new applications.*

Eutrophication *is caused by excessive levels of nutrients, such as nitrogen and phosphorous, being added to soil or water to such an extent that the ecosystem's capacity to benefit from the nutrients is exceeded.*

Habitat *means living environment. The particular ecological conditions that provide a living environment for a particular organism or group of organisms.*

Logging residues *– simply put, the remaining pieces of the tree after its logs have been removed. In Swedish, this is called GROT which means Branches, Roots and the Tip of the tree.*

Meteorites *are solid bodies from space that have fallen onto the Earth's surface.*

Microorganisms *are organisms that cannot be seen with the naked eye, i.e. they are smaller than a few tenths of a millimetre, such as bacteria and algae.*

Monoculture *is an agricultural system one-sidedly focused on a single crop, such a wheat, cotton, coffee or cocoa. In Swedish forestry it can be planting a single species of tree, such as spruce, after the forest is removed by clearcutting.*

Mycelium *can be described as the root system of fungi. The well-known fruiting body of fungi is the part of the fungus that the mycelium produces when it finds that it is time to reproduce and propagate via the air. There are species that distribute 30 000 million spores per day. Mycelium is much more extensive than can usually be observed, for example there may be several tonnes of mycelium in one hectare of natural forest.*

Mycorrhiza *iis the name of the complex relationship between mycelia and the roots of a plant when they live in symbiosis (mutual collaboration) with each other.*

Natural development of ecosystems *– In this annual report, Svensk Däckåtervinning discusses how our materials affect ecosystems and how we can use recycled tyre-derived materials to support the natural development and recovery of ecosystems. By natural, we mean the way in which ecosystems would have continued on their own, with normal access to the conditions for life, uninfluenced by humans.*

Natural gravel *is a technical term for naturally sorted types of stone, gravel and sand.*

Nematodes *are microorganisms, a type of roundworm and one of the Earth's most common multicellular animals. They are simple, invertebrate, non-segmented animals.*

Photosynthesis *is the process whereby plants store energy from the sun in sugar molecules, releasing oxygen. It can be thought of as the other half of cellular respiration, whereby complex organisms – such as humans – utilise the stored energy of sugar for various processes and reactions. Cellular respiration and photosynthesis are both, in their own ways, absolutely necessary for life on Earth. Overall equation for photosynthesis: Water + carbon dioxide + solar energy → carbohydrates + oxygen. Overall equation for cellular respiration: Carbohydrates + oxygen → carbon dioxide + water + energy.*

Protozoa *is a dated, but common, collective term for single-celled organisms that used to be regarded as part of the animal kingdom, but that are now grouped in a separate category between plants and animals. Protozoa are a many-faceted group found in all environments and include free-living, symbiotic and parasitic species.*

Regenerative *is defined in different ways in different contexts. By regenerative agriculture, we mean practices that increase the vitality of an ecosystem.*

System perspective *is used to provide an overview of a complex problem, challenge or situation. The aim is to identify the total impact of different courses of action.*

Termite mounds *are termite dwellings that extend above the ground. They can be up to four metres high. Termite nests can also reach far underground.*

Zinc oxide *is a chemical compound of zinc and oxygen that occurs naturally as the mineral zincite and in the soil.*

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ABOUT SVENSK DÄCKÅTERVINNING

Our task is to organise the collection and recycling of worn-out tyres in Sweden. The Swedish Tyre Recycling Association is managed independently. The association is constructed as a an "SVB Company", which by law may not pay dividends or otherwise benefit the founders. A majority of the directors of the board are external experts. The company is a non-profit-organisation, and one of the few EPR companies that have created a fund from recycling fees in order to ensure the optimisation of tyre recycling. The recycling fee that producers pay when they put new tyres on the Swedish market finances the collection, processing and recycling of worn-out tyres. Svensk Däckåtervinning has contracted Ragn-Sells to collect, treat and sell the recycled materials. Svensk Däckåtervinning have no vested interest in any one application over another. However, we have high ambitions for tyre recycling to be a role-model in the transition to a circular economy.