Les communs de Gaia

Cherish your planet!

(to your level)

Table des matières

I. Dear reader!

The booklet you're about to read acts as a simple guide for you to know how to help "Mother Nature".

We can act and change our consumptive habits to reduce often invisible impacts. Some tools can be used as well in order to reduce our impact. However, we won't talk about this in here!

Indeed, even if these themes remain important as they should be taken into account, they usually explain how to reduce negative impacts, which still impacts negatively the planet even when reduced…

This booklet will teach us to have a positive environmental impact and to cherish our planet accordingly, to our level! (The title is self-explanatory…) To sum it up, we will see how to stimulate, welcome, protect, repair life…

As we did not discover anything, and we simply rely on our knowledge from different fields, the content in this booklet uses the equivalent of a public-domain license. If Earth is a common property to all species inhabiting it, let's all share our knowledge so that we can improve our cohabitation!

We also rely on works from the "free culture" social movement, based on sharing openly, which means that the photos, pictures, icons, fonts, software, etc., everything comes from this type of culture tied to the commons!

This work being collaborative means that you can add anything you wish, as well as making it more consistent. This document is definitely imperfect, incomplete, and may present some mistakes. You can contact us at bonjour@graineahumus.org to take part in improving this booklet. Together, let's do more! We wish you a pleasant read!

> Tu dis : « Cette pensée est à moi. » Non mon frère,
> Elle est en toi, rien n'est à nous.
> Tous l'ont eue ou l'auront. Ravisseur téméraire, Au domaine commun bien loin de la soustraire, Rends-la comme un dépôt : Partager est si doux ![1]
>
> Henri-Frédéric Amiel, Rien n'est à nous

1 You say: "This thought is mine." No brother,
It's in you, nothing is ours.
Everyone had it or will have it, Daring abductor, To the common domain far from taking it away, Return it back like a delivery: Sharing is so sweet!

II. Licenses

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Picture from Dominicus Johannes Bergsma (Creative Commons BY–SA license).

III. Introduction

Throughout this guide, you will discover three aspects to help out nature: soil, water cycle, and life accommodation.

We address those three themes separately to grasp them better, but they are in reality interconnected.

That is why we will guide you through these themes, to see what you can do on a local scale in favor of the environment.

We will talk about soil improvement, welcoming living things (insects, small mammals, birds, bats…), resilience, water savings, protection against "natural damages", construction of eco-friendly materials…

An awful lot of issues that could be isolated are in fact linked to one another and share common causes.

Needless to say, we must not forget that our consumption have real impacts—usually invisible—but we should focus on the positive ones we can have here and now.

In short, let's see how to cherish the planet to our level!

With "natural" methods, we will use raw products, not blended with anything nor easily separable, that can go back into the soil without any risk of pollution. We will keep matter extractions to the minimum and do our best with what is on hand.
Those methods are planned in order to be financially accessible for most people!

IV. Understand your soil!

Look around you. Most of the items surrounding you come from the soil. Same thing goes for what you eat.

Creating a single centimeter of soil takes between a hundred years and thousands of years. Something to think about, right?

Soil serves as a media for growth of all forms of life, and you can start helping by trying to understand the soil better.

When taking care of the earth to look after Earth, we take into consideration another level far more within our reach.

By knowing your soil, you know how to revitalize it and welcome plant life, as well as animal life. This allows you to create a wildlife pond, use building materials that can go back into the soil, grow food…

Through soil relief and structure, we can forecast a number of disasters (flood, drought, mudslide…).

To understand this concept better, we should not think of the soil as some simple inert support, but rather like an element full of life interacting with water, the atmosphere, plants, animals, bacteria, mushrooms…

IV.1. What is soil?

IV.1.1. Multiple definitions

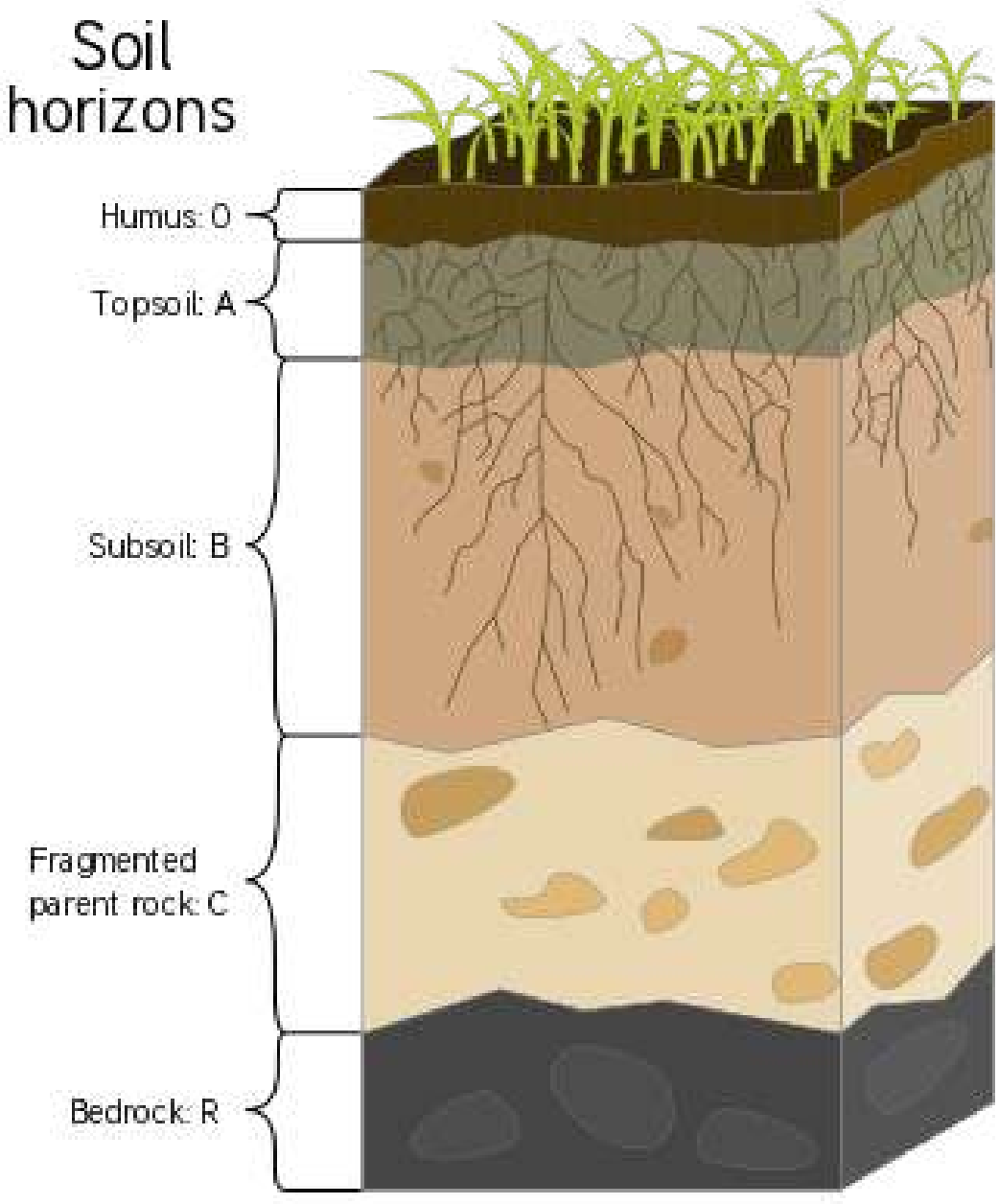
We know what soil is intuitively. Yet, many definitions can be given.

We can associate soil to soil horizons, soil textures, earth or even the superficial layer of Earth's crust.

Let's take a closer look, shall we?

IV.1.2. Soil horizons

Like a mille-feuille, soil is divided into multiple layers between the surface and the parent rock. Examining the concept of soil horizons through a simple illustration (see below) reveals similarities with a timeline, only it is read from bottom to top.



Soil horizons, adapted by Wilsonbiggs (Creative Commons BY-SA license).

The fragmented rock and decayed organic matter (from soil life: animals, plants...) piled up through hundred of thousands, if not millions of years. The only thing to add is the effect of climate to have our soil.

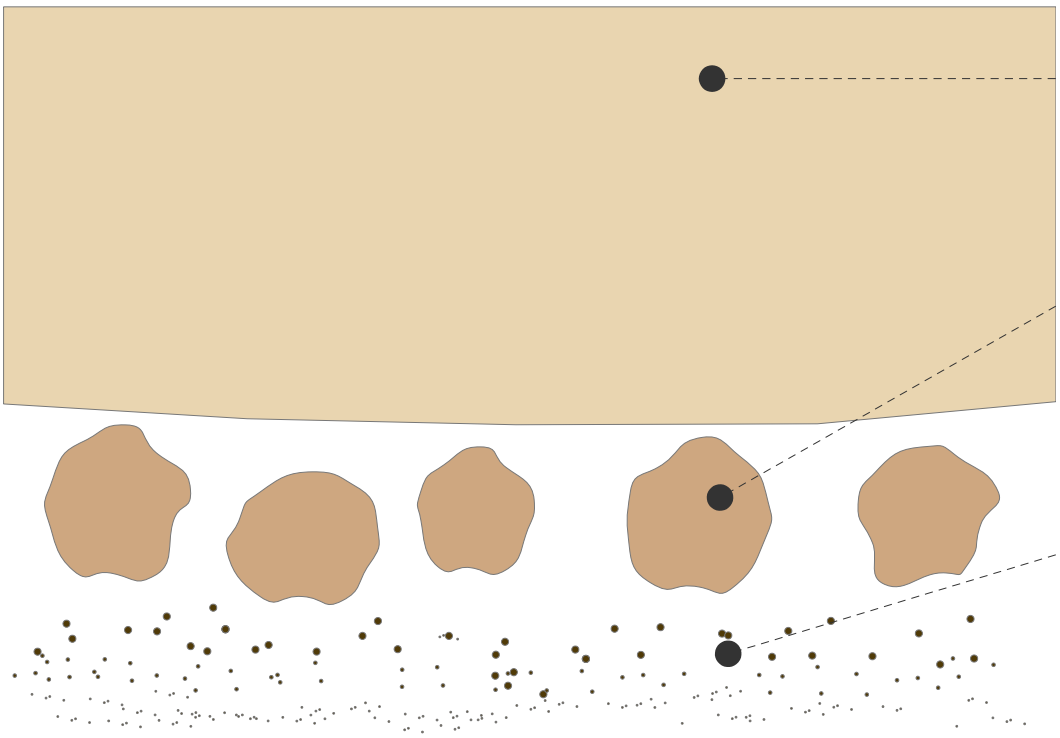
The 0 horizon, at the top, is filled with organic matter, bacteria, mushrooms, and small insects that help decaying matter necessary for plants.

Soil comes in various profiles, sizes, compositions, textures, properties, and even colors.

Soil profile (Badgworthy Hill, Devon, England) from Joris Egger (Creative Commons BY-SA license).

IV.1.3. Texture

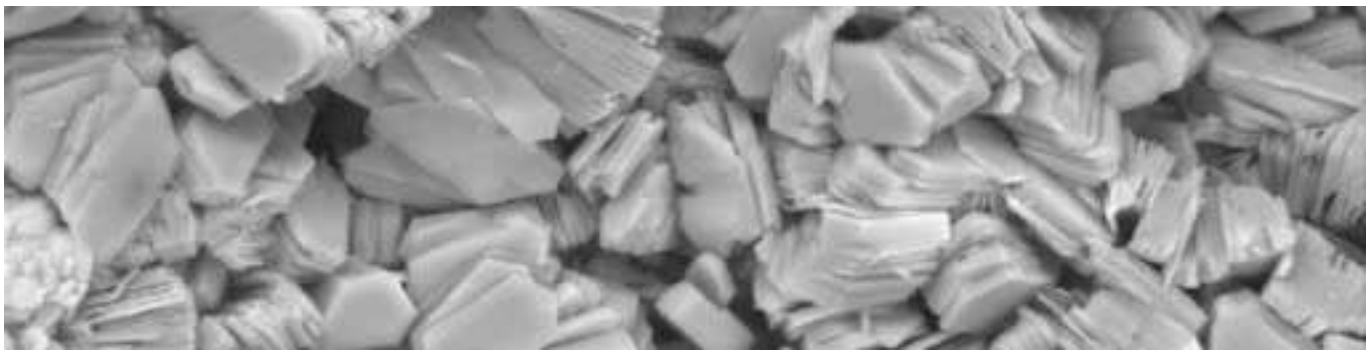
Soil texture is divided into three types, for each one is defined by a specific size.



Size of sand, silt, and clay grains (x1000 magnification).

The sole purpose of the illustration (see above) is to show the differences in size. In reality, sand and silt look like grain, whereas clay looks like stacked plates.

Soil is usually, exceptions aside, a mix of those three textures: sand, silt, and clay.



Clay under the microscope, by Paedona (Creative Commons BY-SA license).

The soil texture will determine its characteristics.

Soil containing sand will be well aerated, easy to work with, low in water retention, poor in nutrients, and low in cation exchange capacity.

Silt is fertile when coming from alluvial deposits (e.g., during floods), but it can induce “soil crusting” on the surface, preventing water and air to penetrate.

Clay ensures a chemically rich soil, however impermeable and poorly aerated which blocks roots to penetrate. When damp, clay presents a high plasticity, but becomes compact as it dries out.

Soil is a mix of these three structures, to which we add organic matter, minerals, ions (from the atmosphere, waterways, rocks…), and pore spaces for air or water.

To sum it up, let’s see what soil is composed of.

Soil = texture* + nutrients** + pore spaces***

* Texture = clay + silt + sand
** Nutrients = minerals + organic matter + ions
*** Pore spaces = air or water

We now get the fully developed composition:

Soil = (clay + silt + sand) + (minerals + organic matter + ions) + (air + water)

We can break down soil with its texture, its fertility, but also its water and air storage capacity.

We will see afterwards that those three factors are in correlation with each other.

IV.2. Soil analysis

You can do lots of tests in the garden or someplace you can access the soil easily.

We will focus on a few tests that should be rather informative.

IV.2.1. Soil extraction

In order to examine the soil, you must make sure that the test will be representative of the site! Indeed, you may encounter fill dirt in some places or former walls (now buried) that can change the nature of the soil…

Bioindicators can help determine if the soil is homogeneous or not. Is the soil covered everywhere? Are the plants here all the same and evenly distributed and with a similar density?

As such, you can run as many tests as you wish on parcels that are seemingly different.

To the naked eye, you can notice a difference between the plants at the top and the bottom of a slope, but also between vegetation at the base of a wall and vegetation far from the said wall. For the same soil type, you can note that the wind, sun, and rain exposure, and the height can interfere with the presence of vegetation.

IV.2.2. Texture

The jar test is a very common test to determine soil texture.

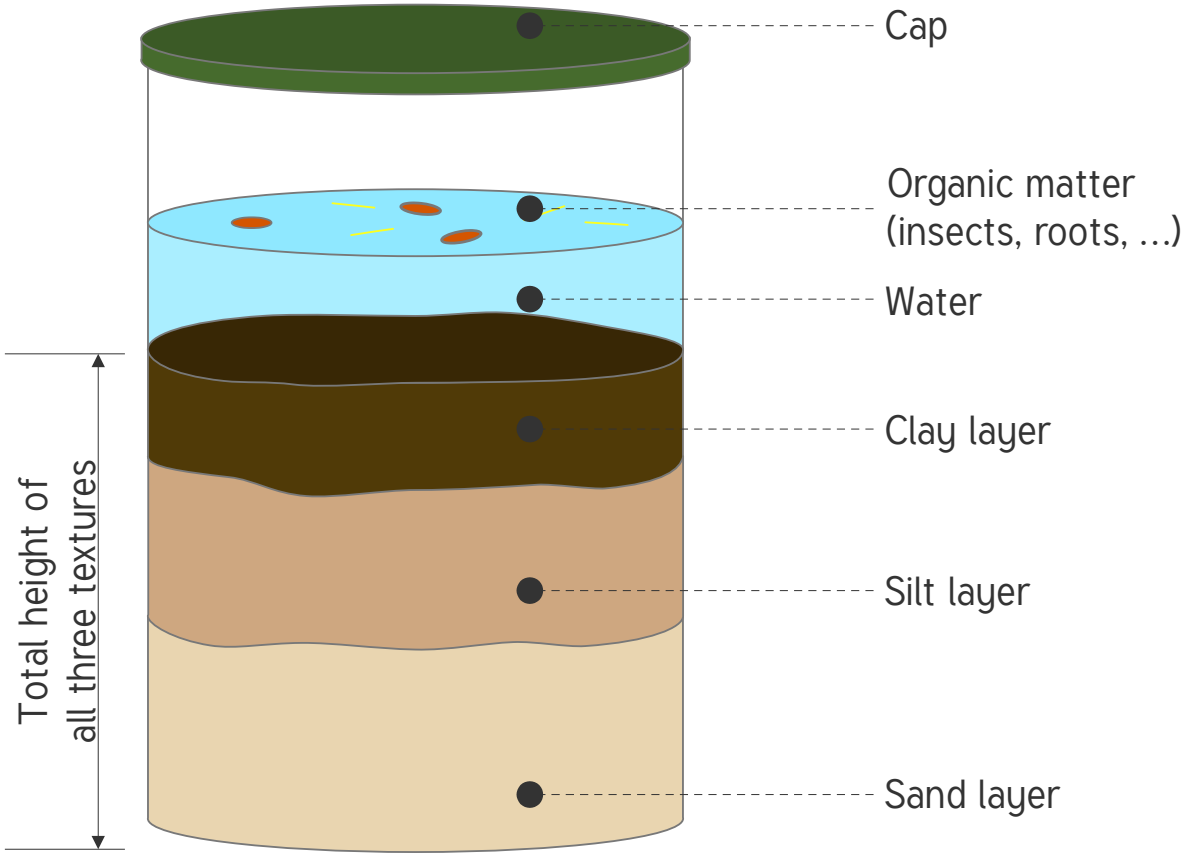
- The texture is defined by the proportion of sand, silt, and clay. As you start removing the superficial top layer of the soil, dig a small square (sides of 20cm are enough) with a spade. You can put this layer back once the test is done.
- Extract a large handful of soil between 10 and 15 centimeters deep.
- Sift the sampled soil (to avoid any big chunks) and place it into a straight-edged jar.
- Fill the jar approximately 3/4 full with water and shake vigorously with the cap back on.
- After 30 minutes, stir with a spoon. If there is any remaining chunk, shake the mixture again. Repeat the process until there isn't any chunk left.
- Let the mixture set and decant for 24 to 48 hours.

- Three layers should be formed by now: the sand at the bottom, the silt in the middle, and the clay on top of it.
- Measure the height of each layer.
- Use a cross-multiplication to get the percentages of each texture.

Layer height / Total height of all layers = Percentage of the layer

Let's say we have 3cm of clay, 4cm of silt, and 5cm of sand. The total height is 12cm (sand, silt, and clay).

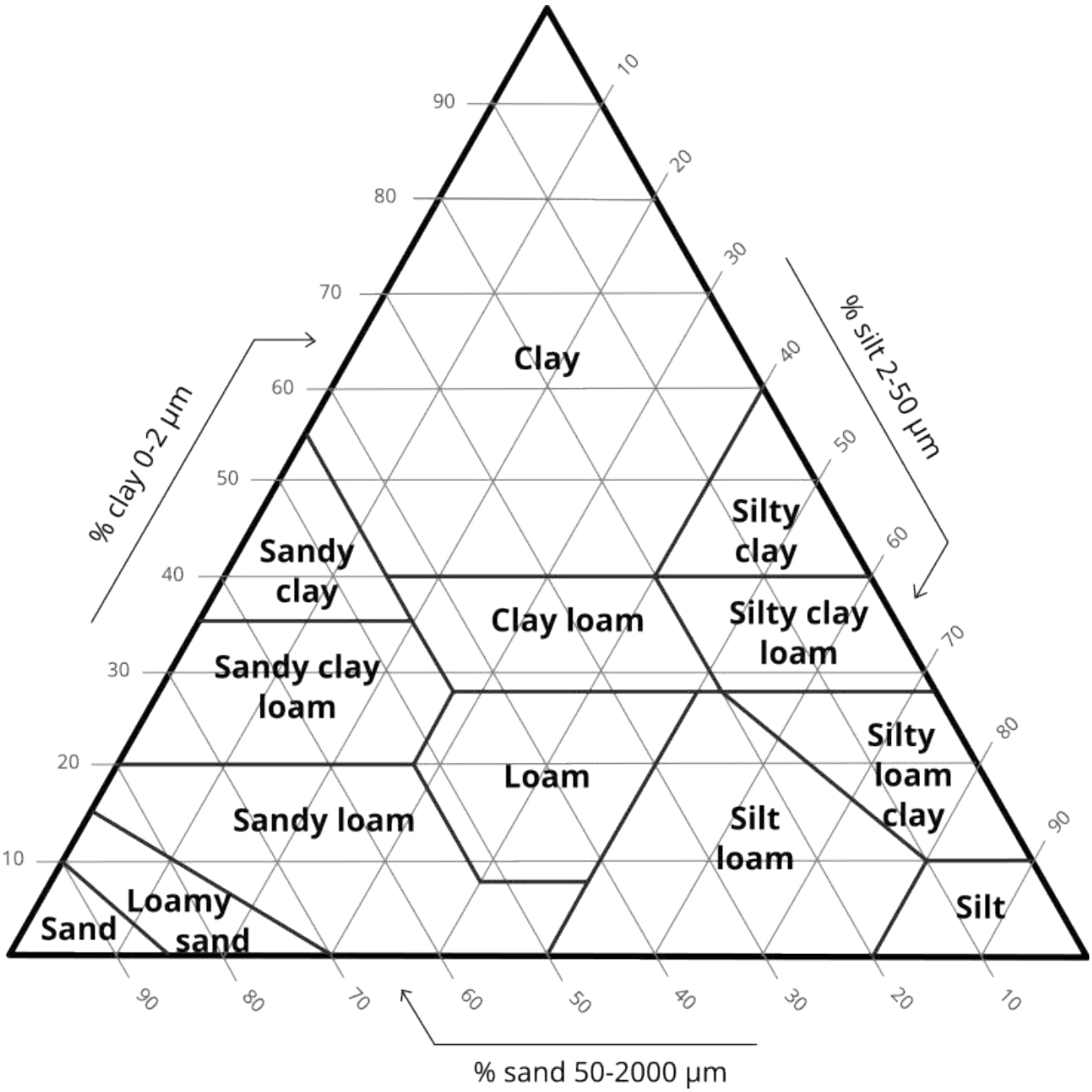
That means we have 3 / 12 = 0,25, so 25% of clay.
4 / 12 = 0,33, so 33% of silt.
5 / 12 = 0,42, so 42% of sand.



Layers disposition in the jar test.

At the top, organic matter may float around. If you can see some, just ignore it.

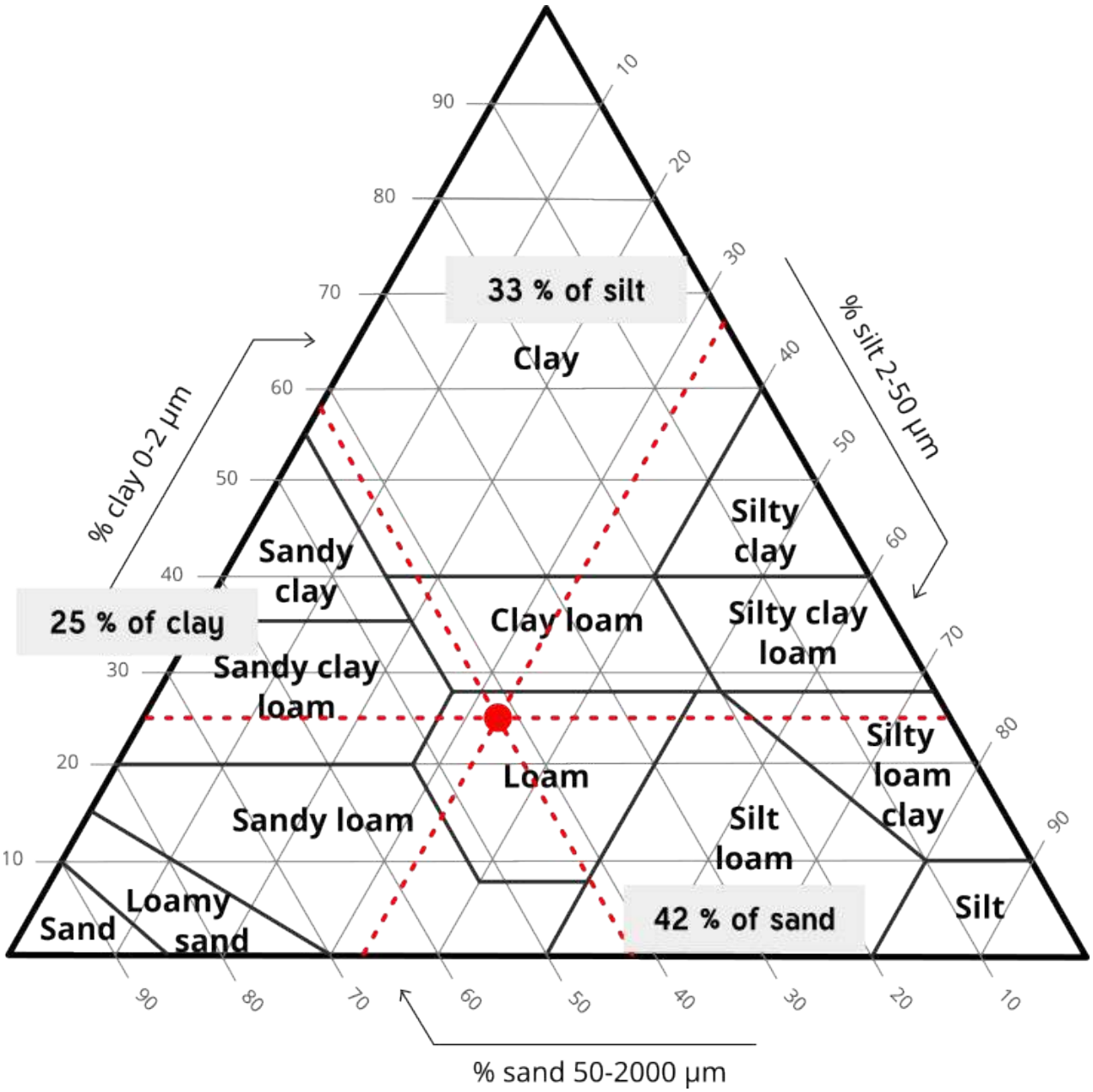
Using the following pyramid, find the percentages of clay, silt, and sand in order to trace lines. The spot where the three lines intersect gives you the general texture of your soil.



Soil texture classification by Benitronne (Creative Commons BY-SA license).

Classifying the general texture helps to define the different characteristics for the soil. No soil is ideal, only a soil adapted to the present ecosystem, to our dedicated or wished use.

For our example, here are the values.



Example with 25% of clay, 33% of silt, and 42% of sand, resulting in a "silty" soil.

IV.2.2.a. Aeration

We consider that sand aerates the soil and compacts it, but not as much as clay.

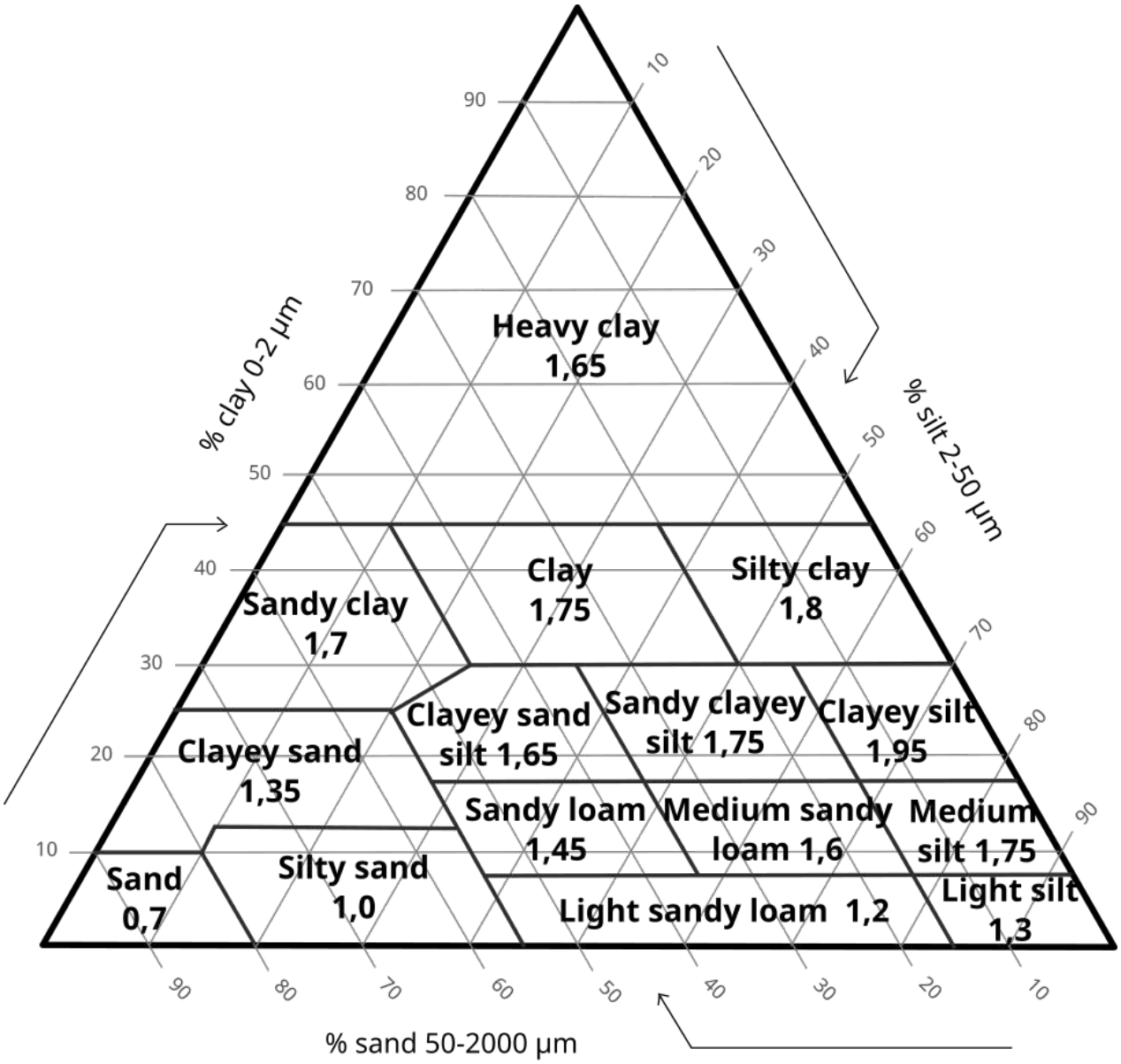
IV.2.2.b. Nutrients

Sand has a low cation exchange capacity. Clay has the capacity to hold cations, especially when it forms the clay–humus complex that we will go over later. Silt found after a flood is composed of alluviums, a fertile sediment deposit that is carried by a waters body.

IV.2.2.c. Water retention

Sandy soils have low water retention. When damp, clay presents a high plasticity but becomes compact as it dries out.

The Jamagne's triangle here after shows for each soil type its available water capacity, that is to say the amount of water available for plants. The bigger the number, the greater the amount.



Jamagne's triangle (1977) by Florent Beck (Creative Commons BY-SA license).

You certainly noticed that the classification was different from the previous triangle. If we take our example, our silt is now considered clayey sand silt.

We will focus more on the texture percentages or on the given data—here, the available water capacity.

IV.2.2.d. Other characteristics

As previously said, silt can cause soil crusting, preventing water and air to penetrate.

Clay is impermeable when its water capacity is saturated, which could block roots to penetrate.

Soil crusting from silt. Picture by Tiia Monto (Creative Commons BY-SA license). The silt layer is fine, unlike dry clay that contracts, and which aspect looks similar to silt at first glance.

IV.2.3. The sausage test

For this test, take a handful of soil from a depth around 10 to 15 centimeters.

Wet it to compress it. Then, follow the next steps in the right order.

IV.2.3.a. Step 1

Roll the sample into a 3cm diameter ball.

Put the ball down on a flat and hard surface. If the ball falls apart, you have a sandy soil.

IV.2.3.b. Step 2

On a flat and hard surface, roll the ball into a 10 cm long sausage shape, with a diameter of 1 cm. Roll the ball with your hands so that the soil sample dries out. During the process, you are allowed to wet the sample.

If the sausage falls apart, the soil is either sand or silty sand.

If the sausage sticks together, it contains at least 10% of clay.

IV.2.3.c. Step 3

Bend the sausage into a semicircle.

If the sausage falls apart, the soil is fine silt.

If the sausage sticks together, it contains at least 15% of clay.

IV.2.3.d. Step 4

Continue to bend the sausage to form a full circle.

If the sausage falls apart, the soil is fine silty clay (10% to 28% of clay).

If the sausage sticks together but cracks slightly, then it is silty clay (around 30% to 40% of clay).

If the sausage sticks together without any cracks, there is at least 50% of clay.

IV.2.3.e. Step 5

If the sausage (stuck together without any cracks) can still be bent to form an 8, it is heavy clay. (50% to 100% of clay).

IV.2.4. Visual tests

You can carry out other tests, rather informative, relying on sight only. For instance, when you take a soil sample for these tests, you can look for a biological activity (especially insects and earthworms) and its intensity.

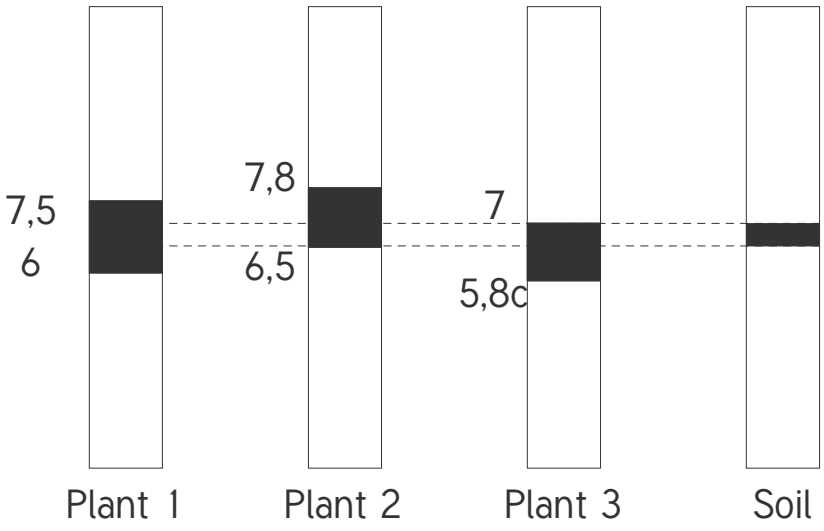
IV.2.4.a. Bioindicators

Identifying the prevailing perennials can help you understand your soil better. Indeed, they present affinities in terms of nutrients, watering, texture, pH…

It is usually easier to identify plants when they are blooming. You can find books, online forums, or quite simply free applications like “Seek” associated to the website www.inaturalist.org. Once those plants are identified, we can start looking for their affinities.

pH (potential of hydrogen) is one of many key elements that determine if a soil is rather acid, neutral or alkaline. Usually, the pH values range from 0 (acid) to 7 (neutral) to 14 (alkaline).

For instance, if you have three plants growing from the same soil, look into their pH preferences; you are looking for a pH tolerance, and not a precise value. You then find the common ground to know the approximate soil pH.



The common ground of these three plants gives us a soil pH between 6.5 and 7.

The presence of multiple zones with different bioindicators on one same ground surely indicates many soil types.

IV.2.4.b. Humus

According to the texture and size of organic matter on the surface, you can grasp how rich in humus the soil is.

If the matter is airy, lumpy, dark colored (brownish, even black), similar to what we can find in forests, combined with its typical smell, then you have a humus-rich soil. The thicker the layer gets, the more material there is. Humus holds water, but we will talk about this later (as promised) with the clay-humus complex.

When organic matter is as fine as sand, it results from mineralization that increases the risk of runoff, meaning that rain will likely displace matter towards waterways.

IV.2.4.c. VESS

Many methods still exist, notably one that is called VESS, in other words "Visual Evaluation of Soil Structure".

We don't have any license-free visuals, which means that we can't show you anything legally. Thus, we approach this method only by name. Nevertheless, you can easily find content about this method on the internet.

Thanks to VESS, you can quickly see if a soil is intact, friable, firm, or compact.

IV.2.5. pH

We previously talked about a method using bioindicators to determine the pH of a soil, but we will now explain two others, the first one being rather approximate, and the second one more precise.

IV.2.5.a. White vinegar and baking soda

Take a soil sample, 5cm deep, and separate it into two piles.

Pour some white vinegar on the first pile. If the reaction forms bubbles, the pH is alkaline and so is the soil.

Pour some demineralized water (with a neutral pH) on the second pile to create mud, then add baking soda. If you see a reaction, then the soil is acid.

If none of the tests gets a reaction, then the soil is neutral.

Unfortunately, this test does not give precise results...

IV.2.5.b. Red cabbage test

You can test your soil with red cabbage as well. Every chemistry teacher knows this test, as red cabbage changes color depending on the pH.

Put 4 to 5 red cabbage leaves in a liter of demineralized water, and bring it to a boil for 15 minutes.

Let it cool, and filter the new liquid, now called solution. You can store it for 15 days in the refrigerator.

In a glass container, dip a small handful of soil into the solution.

The more the color verges on light purple, if not pink, the more the soil is acid.

The more the color verges on dark blue, dark green, if not light green, the more the soil is alkaline.

Respective pH of 1, 3, 5, 7, 8, 9,10, 11, and 13. Picture by Supermartl (Creative Commons BY-SA license).

In each tube, we poured the same amount of each material with a known pH (vinegar, baking soda...).

With these standard values, we can make a comparison with our samples.

IV.3. Map of the soil

You now know the type of your soil, or soils—in case one same ground presents multiple soil types. You also grasp what are the different plants growing on your soil and their affinities.

Bioindicators are actually linked to biotic factors, being living components.

pH or texture is linked to abiotic factors: as they are non-living components, they represent environmental conditions influencing the living.

For now, we haven't talked much about abiotic factors, notably temperatures, wind, relief (aka topography), sunshine, the presence of a wall...

This is why we are going to draw a map with slopes, a compass, prevailing wind directions, and other elements on the ground. Temperatures and climate are non-negotiable factors to think about.

IV.3.1. Choice of the elements

You can add elements to the soil through many ways.

The simplest one is to use perennials as bioindicators. If they are naturally present, you can add others plants growing in similar conditions.

If you wish for something a bit more complete, you can definitely learn to understand the biotic constraints and characteristics.

IV.3.2. Map

We would not recommend to hand-draw the map. Alternatively, you can find cadastral maps online or even maps from satellite imagery on the internet. You can draw the map to scale if that is what you want (it is preferable), but simply marking the dimensions works just as well.

IV.3.3. Compass

Signal the north using a compass. You can use online satellite maps with the north placed at the top, although it is not specified.

IV.3.4. Prevailing winds

For prevailing winds, you can once again find what you need online, but be careful with microclimates!

In this case, pay attention to the trees and bushes surrounding the areas. If they are asymmetrical, with one side fuller than the other or if they are leaning, this is a sign of prevailing winds. However, as many explanations can be given for this phenomenon, it is best to check with several trees. That is what we call anemomorphosis—quite tough to fit in a sentence, so feel free to use this word to display your knowledge ;)

Distinct anemomorphosis, Jericoacoara National Park. Picture by Joao lara mesquita (Creative Commons BY-SA license).

IV.3.5. Slopes

In some cases, it is better to know the exact profile of your ground. It does however require some skills with a planting line, a garden hose, and a meter (a bit of mathematics, but cheap), or you can just bring out the big guns with a theodolite if your budget is bigger!

For most surfaces, you can easily see the slopes when it rains, or to the naked eye if it is obvious, like it is most of the times.

IV.3.6. Temperatures

You should take into account when it starts frosting again, so you don't lose your sowings at the prime of their lives.

The plants you choose should be compatible with the temperatures.

IV.3.7. Humidity

A plant with a high need in water should not be placed in a dry space, as it would not be a fitting choice in terms of environment and durability... So we adapt, and we choose perennial and local plants.

IV.3.8. Other elements

Stone walls have an effect on the soil as they add limestone, making the soil more alkaline at the base of the said walls.

If neighboring walls, buildings, and other types of constructions are too elevated, it can prevail the presence of light.

You can also think about practical ideas for access to water, tools, pathways...

If you're looking for inspirations in terms of practicality or aestheticism, the internet and specialized books and magazines can be great resources!

IV.4. Approaches

Now you have quite a few information about your soil. But what can you do with that? The approach depends on the philosophy and technical approaches.

IV.4.1. Philosophical

After analyzing the soil, we know its nature and plant essences in presence. Here is a list of the different approaches you can try. Respecting the nature of the soil is the least damageable approach for the preexisting ecosystem, as it is already adapted to its environment.

IV.4.1.a. Not doing anything

A possibility is to not do anything if the soil is fertile, with a well-developed fauna and flora. Generally speaking, acting carefully allows to preserve what is present and to gradually enrich it if needed.

IV.4.1.b. Acting in harmony with things as they stand

According to the nature of the soil, plant essences and living things, we follow the same path. We plant local and perennial essences, close to the existent conditions, that consume low to no water...

IV.4.1.c. Modifying things as they stand in harmony

A modification can be done upon time, with ground-covers that change the nature of the soil for example, a compost provision, favorable conditions to the welcoming of life.

IV.4.1.d. Radically modifying things as they stand

Modifying things as they stand can be meaningful, particularly in the treatment of polluted soils. If techniques such as the earth's excavation (to replace it), such as liming (addition of a base on an acidic soil) or a heavy earthwork exist, we will not approach them because they are not always beneficial for the present ecosystem or not accessible to everyone.

> We will see later how to correlate the soil approaches with the welcoming of life.

IV.4.2. Technical

As you saw earlier, the soil as a support of life is made of a texture, nutrients and gaps. pH is most often related to these components. Here, we voluntarily ignore every form of pollutant that may exist.

In a practical way, in terms of modes of action, we can act upon the components of the soil (texture, nutrients and gaps).

Here is a last conceptual approach to become aware of the possibilities, before getting into concrete examples.

Those examples are used to perceive the remarks better. They do not always constitute recommended approaches according to the situation!

IV.4.2.a. Not doing anything

If this is a deliberate and pertinent choice, it is always the first thing to consider.

IV.4.2.b. Adding elements

Adding elements can be done on the surface or by incorporation. The air can be added by decompacting the soil, either through heavy methods such as sub-soiling, or more discreet methods such as the broadfork.

IV.4.2.c. Removing elements

Elements can be removed through a visual sorting (for rocks), sieving or sedimentation for thinner elements.

IV.4.2.d. Adding soil

It is often done for vegetable gardens for example, or to fill the holes in again with levee dirt.

IV.4.2.e. Removing soil

It can be done to access resources or to create an artificial lake, for example.

IV.4.2.f. Modifying

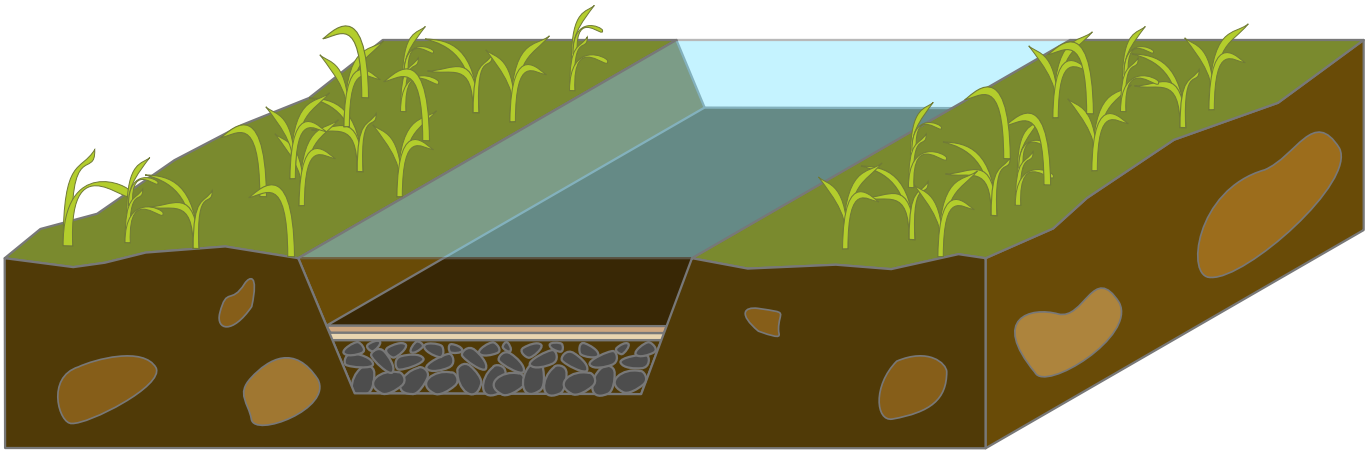
Adding matter can radically modify the soil, like what does liming for the pH, or by small touches, like the Fabaceae (aka legumes) that we will see later.

IV.4.2.g. Stacking

Adding a layer on top of the dirt is done in the case of a culture on a shallow soil, not adapted to begin with. This stacking can be a decompacted culture board, a culture on mound with imported matter...

IV.4.2.h. Reorganizing

After removing elements, we can sort them to put them back by layer. It can be used within the framework of tarpaulin-free artificial ponds. You can, in that case, create an impermeable superior layer with clay, inferior layers with rocks to stabilize, and intermediate layers with rocks decreasing in size.



Bottom of a pond with a decreasing granularity and a clay layer at the top.

IV.4.2.i. Cleaning

You can clean on-site in the case of pollution (with thermal, physical, chemical or biological means) or elsewhere (ex-situ cleaning).

Many techniques are an arrangement of the primary techniques mentioned hereinabove.

V. Act with your soil!

We will not treat vegetable gardens in detail, as it is a topic on itself, not always advantageous to the several forms of living things depending on the practices.
There are however means causing less damage and can even have a positive impact, such as the No-till farming techniques, direct seedling, agroforestry, and other approaches in favor of the preservation or the regeneration of soils.

V.1. Not scheduling

To be in harmony with our environment, try not to schedule beforehand and act according to the nature of the soil.

V.2. Plant essences

After analysis of the soil, you plant local and perennial adapted essences.

Try your neighbors, as they might have this type of plant and can collect for you cuttings or offshoots—that is "baby plants" growing near the "mother plant" or are attached to it. Gather seeds from the plants when you are roaming around the neighborhood. Prefer plants consuming low to no water. Diversify as much as possible the plants and their heights.

V.3. Compost

If you wish to know everything about compost, we wrote "The (almost) ultimate guide for composting", available on the website www.graineahumus.org. As of now, we will summarize it.

Making one's own compost allows to feed the soil based on one's bio-wastes: kitchen wastes, table wastes, green space wastes and other organic wastes with no pathogenic risk.

Matter called "brown matters" (wood, dried leaves...) are added to green wastes (also called "bio-wastes", quoted in the previous paragraph), in a more or less equivalent quantity. Without brown materials, there is no compost, only rotting matter.

Frequent airing (at least once a month) is necessary to activate bacteria and the insects responsible in breaking down the provisions. It is possible to air less if we are using structuring brown materials (grinds or others that leave gaps, hence air, to bacteria).

The structuring brown materials will need less airing than small brown materials.

Bio-wastes must be cut so that they break down faster (e.g.: an apple cut in four).

Tilling every three months allows to get a ripe compost at nine months.

It is advised to have 2 to 3 piles (from 0 to 3 months, 3 to 6 months, and 6 to 9 months for example). In fact, depending on the age, the temperatures, and the humidity, the "inhabitants" living inside those piles are not the same.

The compost bin should be sheltered from rain, direct sun, and wind that will make it dry.

To get a nice compost, only experience will make you able to identify certain aspects, like the presence of such-and-such insects. These aspects, called bioindicators, indicate us many insights about what's going on. Here are some bioindicators.

V.3.1. Midges, smells

The amounts of brown materials, relatively to green materials, depend on what we are using. If there are too many flies, strong smells or even a sticky mass aspect, the compost probably lacks brown materials and needs shuffling. If you see compact balls, you have to decompact, shuffle and ventilate.

V.3.2. Mycelia filaments on the surface

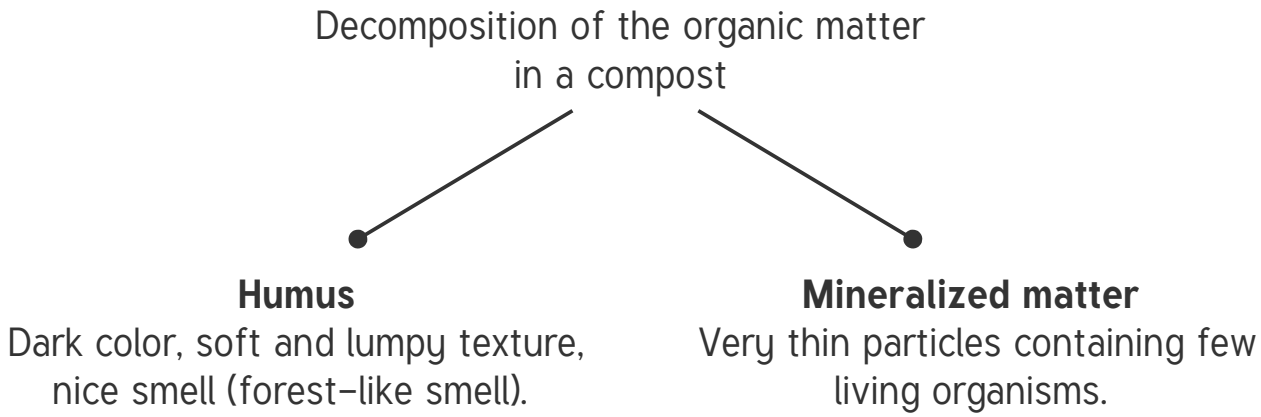
A compost is slightly wet, especially if it's young. On the surface, if it develops a huge amount of mycelian filaments, it is too dry. It is important to verify the state of the compost, in which case, with a headed watering pot, you will have to water the compost-ideally rain water at ambient temperature.

Mycelian filaments. Picture by "Lex vB" (Creative Commons BY-SA license).

V.3.3. Humus

In a compost, we are usually trying to get a humus.

Humus is a rich living material that is crucial for holding nutritional elements.



Two life paths for a same compost with the existing nuances between the two.

Obtaining a humus will allow the creation of a clay-humus complex that preserves the nutrients for the plants and the bacteria in the soil. As for a mineralized matter, it is washed away by runoff and leaching. Having a healthy soil is important due to the very strong dependence on imported nutrients in France[2].

2 95.1% for minerals used as fertilizers: in 2017.
Source: https://www.notre-environnement.gouv.fr/themes/economie/l-agriculture-ressources/article/les-livraisons-d-engrais-en-france (french)

V.3.4. Clay–humus complex

The clay–humus complex retains the nutrients in the soil. Let's see in detail the steps of the formation of this complex which allows the preservation or the restoration of soils.

V.3.4.a. Fungi and glomalin

First of all, some fungi[3] produce a protein—the glomalin—which is excreted by the roots. We will meet that protein again a little bit later... Within composts, these fungi are often present.

V.3.4.b. Humus and Clay

Humus can be bound with clay, to act as a "nutrients magnet".

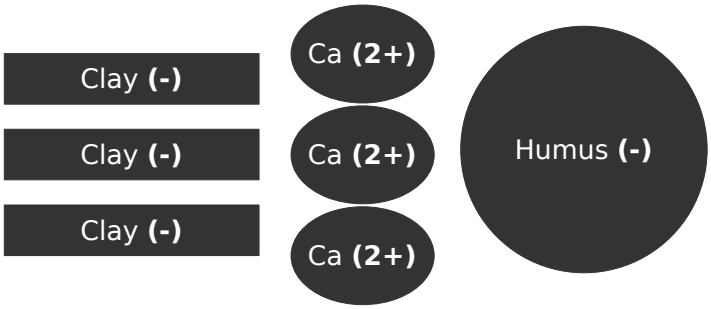
However, clay and humus are negatively charged and do not attract.

Ions (atom or group of atoms) are indeed negatively or positively charged and thus, the opposites do attract, just like magnets.

- When negatively charged, the ions gain one or several electrons (e^-). We speak of anions.
- When positively charged, the ions gain one or several electrons (e^-). They are known as cations.

If a positive element is put between clay and humus, it is possible to associate them.

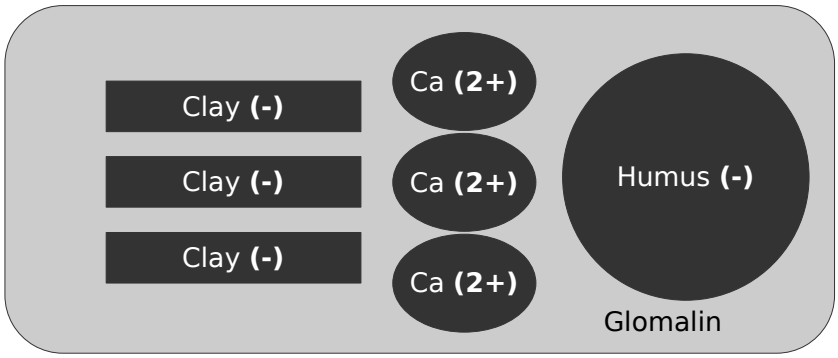
3 Glomerales order of symbiotic fungi (mycorrhizal fungi)



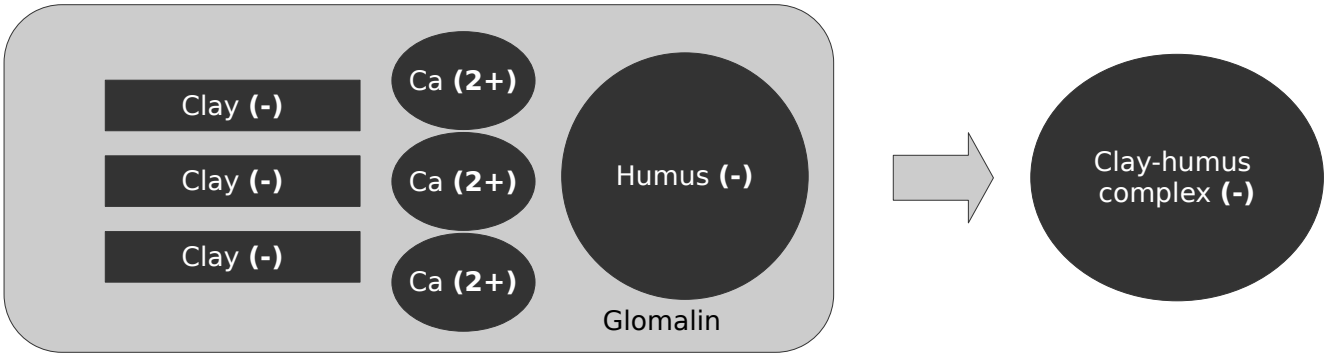
A classic method of binding humus to clay is through calcium (Ca2+). There are other means, like with iron hydroxide (III) Fe(OH)3. The humus can also cling on several positive charges located on they clay's breaking points.

The association of humus and clay is called clay–humus complex, and it generally has a negative charge.

The fungus' glomalin acts as a binder that reinforces this complex.

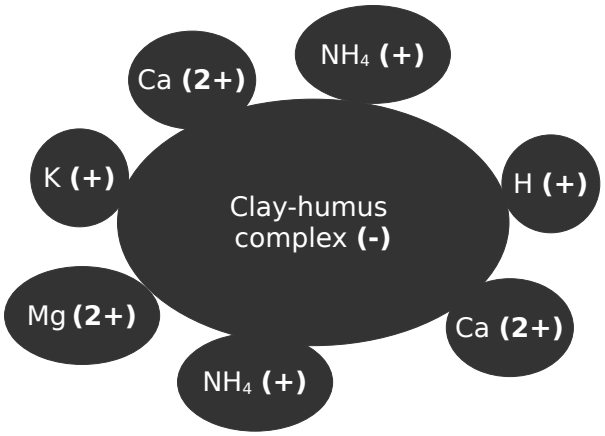


The glomalin acts like a "glue".

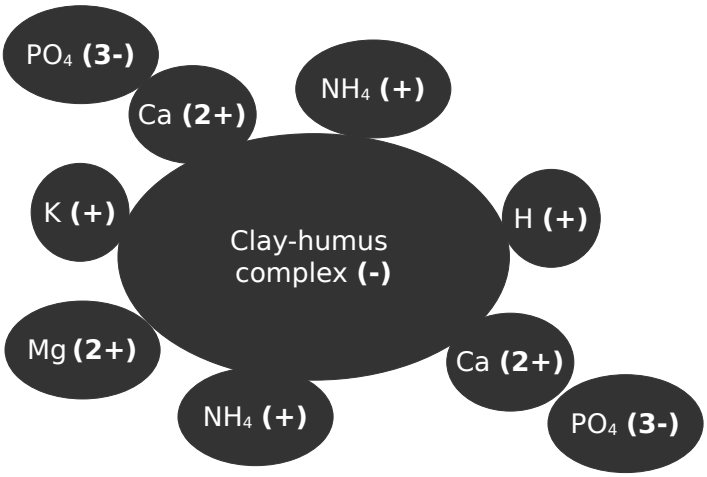


To simplify, we will now note the clay-humus complex as indicated hereinabove.

As the clay–humus complex is negatively charged, it will attract positive elements. Because they are attracted, they are not going into water tables or rivers, but are used locally as nutrients tanks.



The cations are attracted by the negatively charged clay-humus complex.



The peripheral cations can then attract negatively charged anions.

As such, the presence of fungi, earthworms and organic matters is a key element in the development of rich and healthy soils.

V.3.5. Types of compost uses

V.3.5.a. Potting soil

A potting soil is a mix of dirt and compost. It is placed in a hole just before you plant or around a fortnight before (usually in the spring, but also in the summer in the vegetable garden). The quantity, type, and quality of the potting soil differs for every plant.

V.3.5.b. Potting soil from propagation

It is a sieved potting soil used to make seedlings and cuttings. The quality of the potting soil (such as the ratio of compost to sandy dirt) depends on the plant. We place generally the cutting in pots, into greenhouses or not.

V.3.5.c. Compost

Compost is more often used on the surface. It may be added to the soil[4] by scratching it or using a hoe.

- Spread the compost at the stem of the flowerbeds and along the borders before incorporating it (around 3kg of compost per m^2).
- Place a 3 to 5cm layer of compost on hoed soil at the stem of shrubs, fruit trees, rosebushes, and perennials.

In the vegetable garden[5], incorporate the compost to the soil a few weeks before the seedlings. Bury 20 liters of the mixture (¼ of compost and ¾ of dirt) per m^2 of plantation hole. You can also use:

- 2 liters/m^2 of compost (garlic, onions, shallots, potatoes…),
- 4 liters/m^2 of compost (beans, carrots, endives…),
- 5 to 8 liters/m^2 of compost (tomatoes, bell peppers, lettuce, leeks, strawberry plants, marrows, melons…).

You can find more information on the internet or even in books, such as the excellent *Le guide terre vivante - Composts & paillages* by PÉPIN Denis. (ISBN 978-2-36098-718-4)

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4 Data given by Rustica.
Source https://www.rustica.fr/permaculture/toutes-astuces-pour-bien-utiliser-compost,18304.html (french)

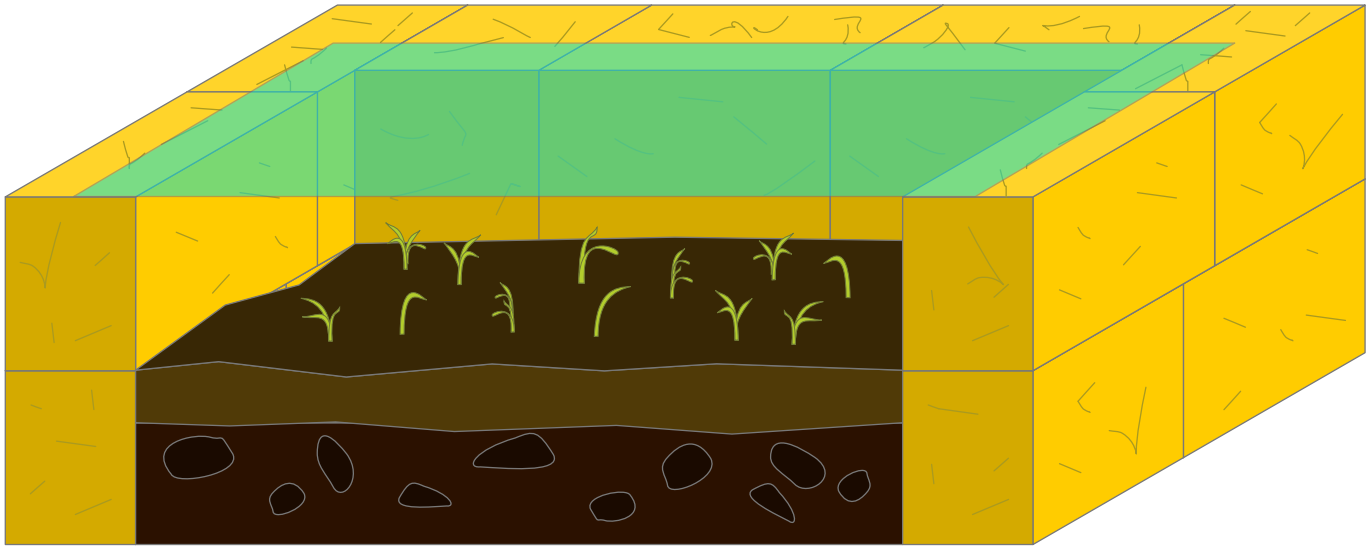
5 Data given by Rustica.
Source https://www.rustica.fr/permaculture/toutes-astuces-pour-bien-utiliser-compost,18304.html (french)

V.3.5.d. Hotbeds

The hotbed is a method to grow early vegetables, using the heat of a compost (around 3 to 4 months of maturation) or a (still fresh) manure that we cover with a potting soil. At that moment, the compost, or the manure, the temperature exceeds 60°C.

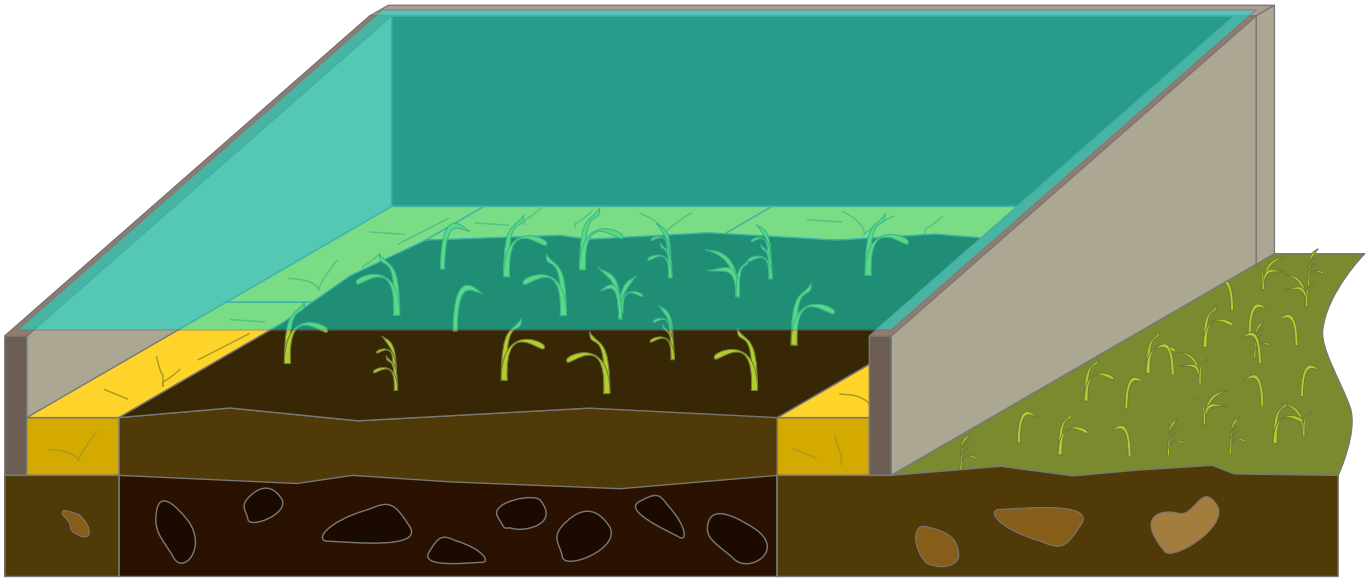
You can use this with the hay culture technique, or in mini-greenhouses.

Hay culture will create a frame on which we place around 40cm of manure or compost, then 20cm of potting soil above, and finally covering with a glass pane for a greenhouse effect. It is important to check that the temperature doesn't go above 25°C before planting.



Cross-section view of a hay frame, filled with a hotbed and potting soil. Greenhouse effect with a glass pane placed above.

For a mini-greenhouse, the idea is the same. With the same quantities as for hay culture, you put your compost or manure, then add potting soil above. To top it off, put hay on the edges to keep the heat.



Cross-section view of a mini-greenhouse filled with a buried hotbed and potting soil isolated by hay. Greenhouse effect with a glass placed above.

Do not hesitate to do some research before the implementation!

Hay culture (but not for early produces) in Stadtkyll, Germany. Photo by "Colling-architektur" (Creative Commons BY-SA license).

V.4. Amendment

If your soil is poor in nitrogen, it should be visible with bioindicators such as a reduced growth of plants, a low blossoming (not very abundant and in small quantity), pale green leaves that turn yellow when aging and necrotize, etc.

We can now plant Fabaceae if the soil is adapted. They will gather atmospheric nitrogen in nodules at their roots and release them in the soil when they die.

As we said before, we can use compost or manure, liquid manure, or even donkey or horse dung. To understand what filing or incorporation should be used depending on the usage, you will have to do some research. These information can be quickly found on the Internet or in specialized books. The use of multiple reliable information sources allows you to compare their relevance.

For potting soil, the base of 1/3 of compost for 2/3 of dirt is often used. However, it varies greatly, sometimes going up to only 10% of potting soil and the addition, or not, of sand.

Whenever we speak of amendments, compost or fertilizer, some terms are often used. We will not be insisting on that point in this document, because the goal is that everyone can participate in the life of one, not to have an exclusively mechanical or chemical approach.
Here are non exhaustive common terms.

NPK
These symbols that are on fertilizers represent the chemical elements of nitrogen (N), phosphorus (P) and potassium (K). Other elements such as calcium (Ca) are also mentioned. Each plant has specific needs. The chemical-only consideration is done by putting some doses on agricultural soils that are often lacking some life.
If the NPK is actually important, an aerated living soil has needs that will be, most of the time, satisfied through compost, manure or liquid manure in a quantity adapted to the type of plants.
France resorts to importations of up to 95% for minerals used as fertilizers[6], and there are issues of provisions supply, resources and geopolitical conflict around that question. At the same, time, we resort to the treatment of table wastes, kitchen wastes, garden wastes, urine, fecal matters and other organic matters such as organic wastes. These matters contain elements that we import as fertilizer. This raises important questions of resilience.

6 Source https://www.notre-environnement.gouv.fr/themes/economie/l-agriculture-ressources/article/les-livraisons-d-engrais-en-france (french)

C

Carbon (C), mentioned in the Compost section, comes from the atmosphere. Generally, plants absorb CO_2 (Carbon dioxide) and release O_2 (Dioxygen). So they keep the C (carbon) and use it mainly to create cellulose—green and flexible as for leaves or grass—or lignin, a hard matter like in the branches or in the trunk.

N

If the carbon cycle can be easily simplified, that is not the case for nitrogen, as it exists under many forms. Nitrogen, ammonium, ammonia, nitrite, nitrate, total nitrogen, etc. It can be quite confusing. Let's simplify that without altering reality.

• First of all, the atmosphere is composed of 78% of nitrogen (N2), which the soil can hardly assimilate. Fabaceae (also known as legumes) and some trees can fix nitrogen. The nitrogen is released in the soil when the plant, which had stored it, dies. Hence the use of Fabaceae in intermediate culture.

• The forms of nitrogen in the soil suffer plenty of chemical reactions that lead to forms that can be used by plants. The presence of bacteria participates to it. So a living soil is necessary to create these reactions.

• The excess of nitrogen can pollute waterways and water tables. Preserving nitrogen in the soil allows to reduce, even to avoid it. The clay–humus complex steps in, as well as the water retention ability of the soil.

• An amendment will bring forms of nitrogen that were contained in organic matter. For the compost, manure or liquid manure, there are correlation tables between the type of culture and the quantities to apply.

C/N

We also speak of C/N relation. It is the relation of carbon and nitrogen mass that is not always easy to understand, as every matter has a different rate and a different density.

To compost, we consider this ideal report to C/N = 25 or 30. In fact, it corresponds to a bucket of green matter for a bucket of brown matter.

V.5. Soil aeration

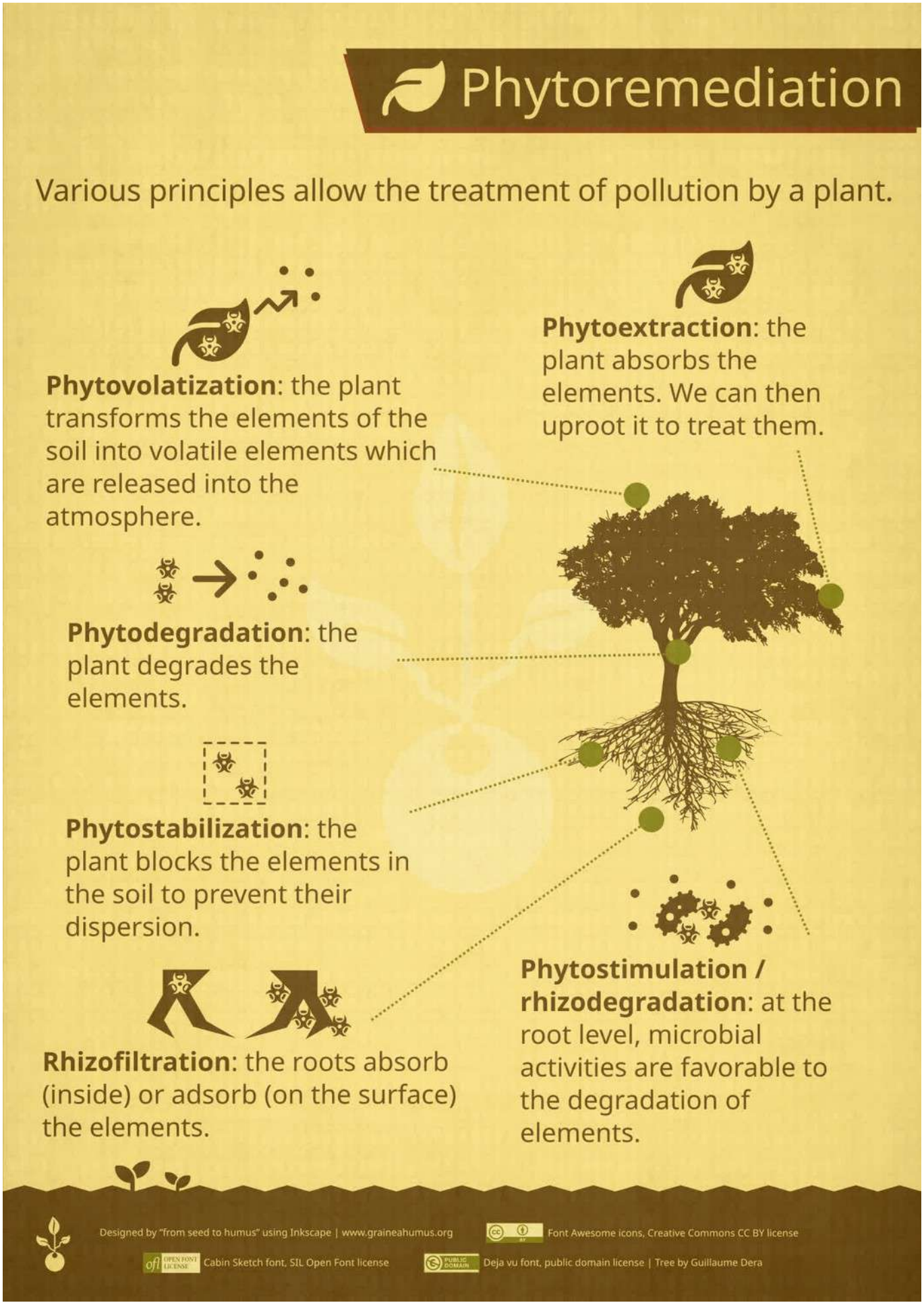
Poorly-aerated soils can be uncompacted with a broadfork or surface scraping tools (scratches, rattle...) or even through adding compost to reactivate the clay-humus complex and add worms that ventilate the soil.

For large agricultural surfaces, methods such as subsoiling are applied. There is a manner to do it in a relevant way—the information can be found on the Internet once again.

V.6. Cleaning

It is possible to clean soils through bioremediation, that defines the methods of biological depollution.

We can use bacteria, microorganisms, insects, plants (phytoremediation), fungi (mycoremediation), algae (phycoremediation), etc. According to the plants, the conditions and the pollutants, many principles can be used. Each pollutant can have proper plants to apply in specific conditions.



Phytoremediation principle. The principles can be more or less transposable to other bioremediations. Tree by Guillaume Dera (CC0 License).

V.7. Materials

We can think of the soil as a material, but the goal of this booklet is the positive impact, not the impact reduction, even though it has a certain interest.

Thus, even though clayey soil allows for many things, we will not get into pottery, nor construction such as rammed earth, the cob, mud-bricks, dirt primers, the wallow or the adobe…

However, it shows how the soil has long been present in the history of humanity.

“Amàco – l'atelier matières à construire” has also really good videos shared under “Creative Commons BY-NC-ND” licenses on YouTube and a website www.amaco.org that shares plenty of information about soil construction.

On the Internet, we also find information about extracting clay, no-wheel pottery or primitive pottery that require few to no material.

Some aspects of that part “Act with your soil!” are connected to other themes. Thus, other uses are seen further in the part regarding water restorative management and the welcoming of life.

VI. Ecological water management

Behind that quite barbarous name for the uninitiated, hides the water cycle whose study is called “hydrology” and that you may have seen at school, though it might be a distant memory.

Ecological management is said “restorative” if it “repairs”, “rehabilitates” or “improves”. It is said “conservatory” if it plans to keep an already present good condition.

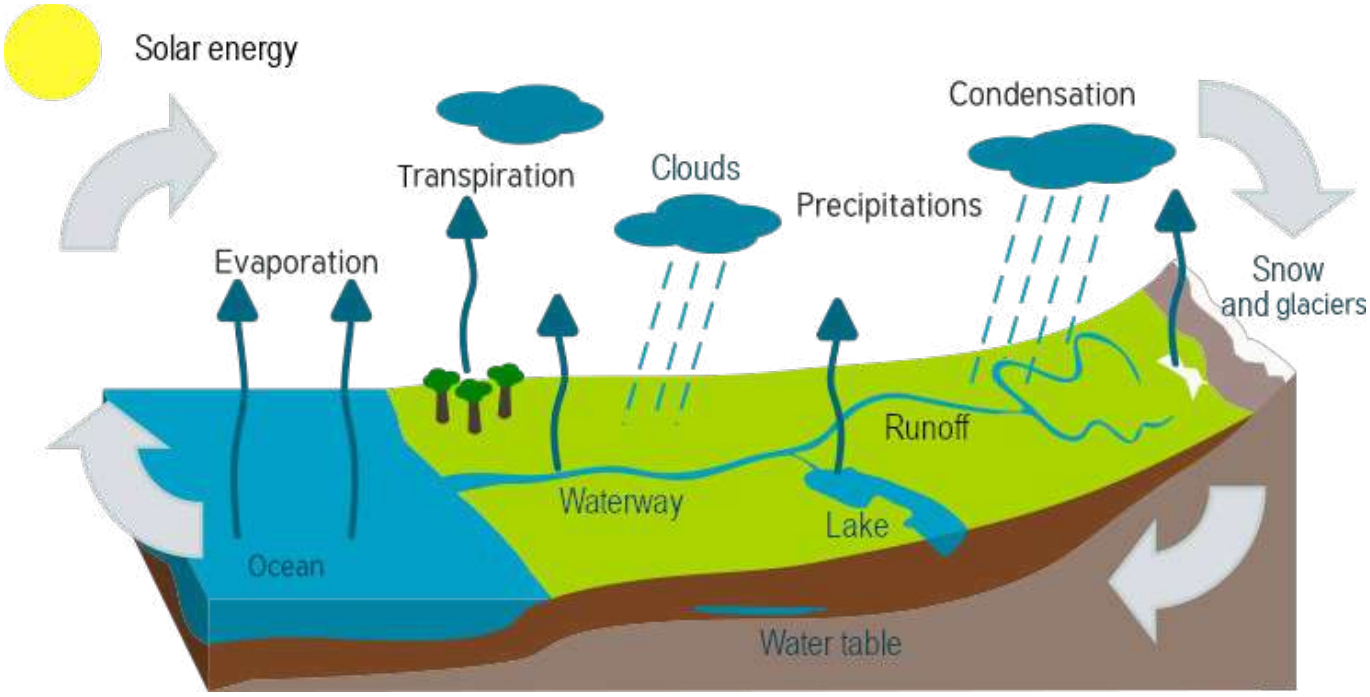
Ecological management takes methods from rainwater integrated management, soil mechanics, topography and other sciences and techniques mastered for a long time.

VI.1. Hydrology

Hydrology is the study of the cycle of water.

In simple terms: water circulates. It falls because of gravity and raises through evaporation, and the cycle goes for another round.

It’s a base, but a simplified vision that does not show much of the place of biotic (living things), that consumes, stores and sweats water: we speak of transpiration. The water coming from this phenomenon on the continent would represent, depending on the areas, around 2/3 of available water.



By Graineahumus, adapted from Benutzer:Joooo (Creative Commons BY-SA license).

In truth, the cycles are plural: we often speak of blue water and green water.

Blue water is the visible water. Green water is the water we don't see, stored in wet soils, in the biomass, in plants…
Moreover, it is important to not interrupt the cycle to prevent it from breaking, but slowing down water allows its use for living things at every level.

We deem the cycle of water to be very disrupted by many phenomenons that we will see later (waterproofed soils, rectified rivers, hedge reduction, exposed soils, disappearance of forests and local plants, poorly maintained ditches, tamped down soils, small retention ponds in decline, decreasing duck ponds, etc.)

The ecological management is the way one can help the cycle of water to restore balance, to decontaminate. This also allows to reduce floods, droughts, mudslides, erosion, etc., and contributes to a better water retention for fauna and flora.

VI.2. Water availability

Water is precious, but we rarely notice the rarity of drinking water on an Earth covered with more than 70% of water. Only 0.0001% of the Earth's water is freshwater and drinkable, thus available for living things.

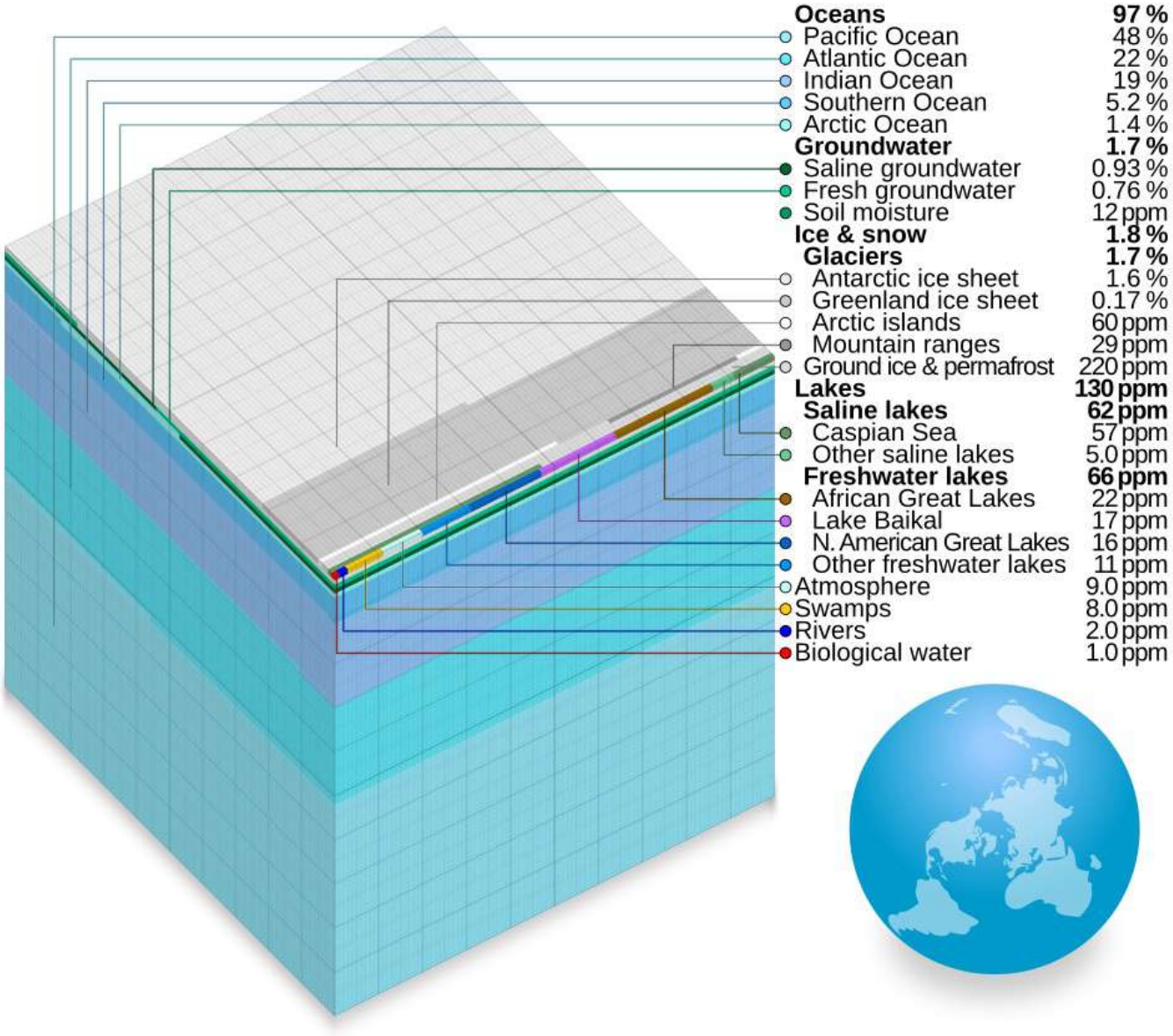


Diagram by cmglee (Creative Commons BY-SA license).

Water, essential to life, has a special place within the living things. But water is also a moving fluid. Spade, drought, flood phenomenons, etc., can be reduced, or even disappear locally. For that, you must be interested in the path that freshwater mainly follows and its interactions with soil and plants more specifically. Thus, we can advocate for an access to water for all the living things, including humans, obviously, and take part in the fight against natural catastrophes.

VII. Hydrological approaches

To apprehend the different approaches, we will first take an interest in surface water, then to water economy, and finally to its living aspect.

VII.1. Slowing down

Understanding the topography, the soil/water contact surface, the vegetal cover and the type of soil have major effects.

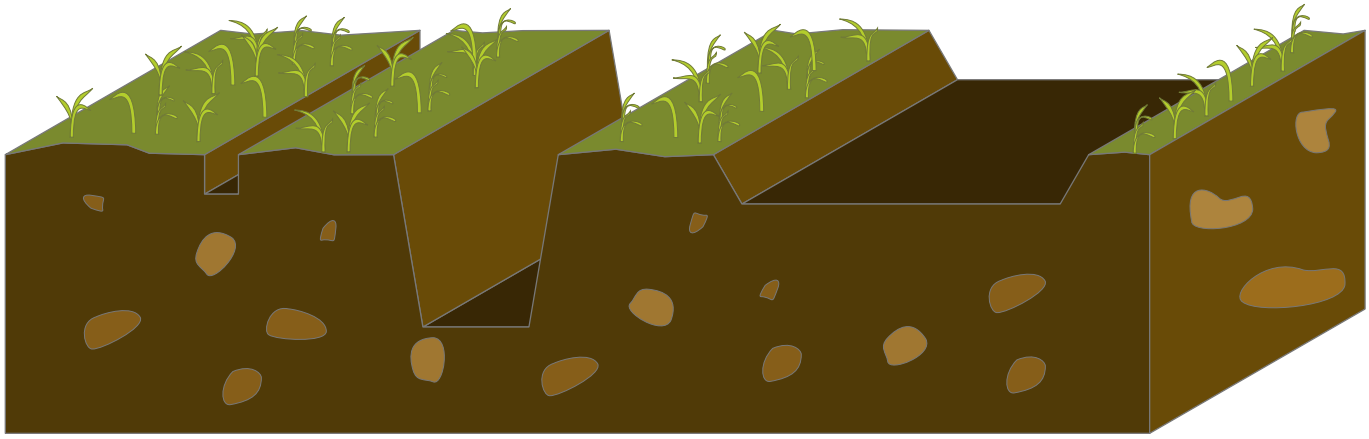
VII.1.1. Topography

The topography of the ground participates in the trajectory, the discharge and the speed of runoff water and surface waters.

VII.1.1.a. Trench

We can act by creating an excavation that will guide the water. The trench will have different names depending on the lengths (width and depth) and its uses: channel, ditch, drainage channel/swale...

For the flow of water in a trench, we generally provide for a slope of minimum 1%.

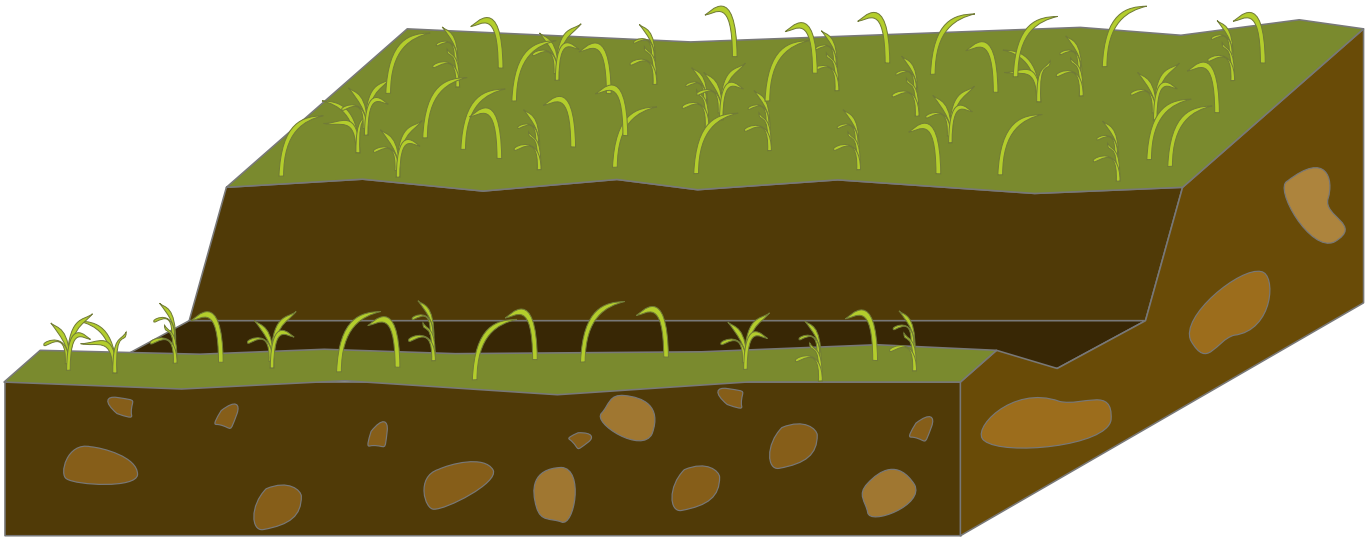


From left to right, a shallow channel for weak to moderate discharges. A ditch, most of the times on the border of grounds for strong discharges. Finally, a drainage channel (or swale) is generally dug perpendicularly to the slope of a soil.

A drainage channel or a swale is a shallow and large ditch located on a smooth slope to gather runoff water or an overflow. It follows the curves of the soil levels.

On a same slope, there can be several ones in parallel, interconnected or not.

The drainage channel allows to gather runoff waters or an overflow, in order to store them in the soil, aiming for a future evaporation (transpiration) or to reconstitute water tables.



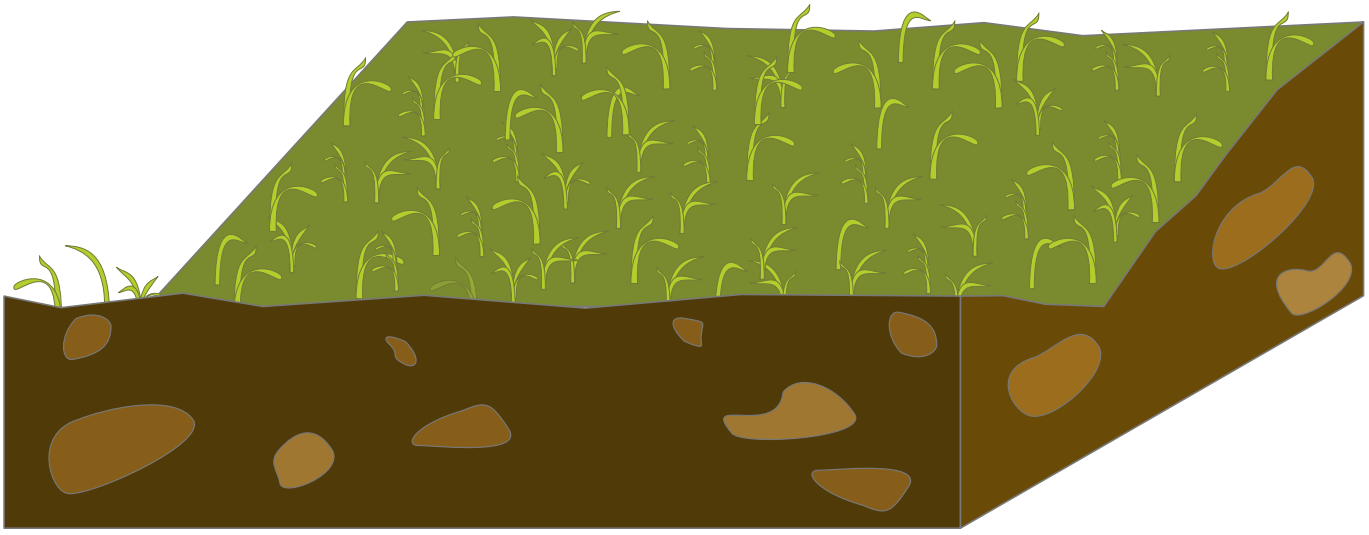
Swale-like trench dug in a sloped soil.

The drainage channel can be tilted, if we want to evacuate water overflows, or not, if we want to absorb water on-site.

VII.1.1.b. Counter-slope

A counter-slope can be natural or not. Water accumulates in the lowest point. Again, that point can be sloped to evacuate water, or not, to absorb water.

Plants are generally different on that low point that accumulates water and flushing matter (particles of soil gathered from the rain or runoff).



Counter-slope in a sloped soil.

VII.1.1.c. Slope rectification

In the past, slopes have been "rectified" in many civilizations.

We find terrace cultivation in many cultures, like in Provence where “restanques” (dry-stone walls) are used, but also in the Inca civilization.

Olive groves cultivated in terraces (“restanques”) in the “Porte Rouge” neighborhood of Levens village (Alpes-Maritime, France). Photo by Éric Coffinet (CC0 license).

VII.1.1.d. Course detour

The topography draws the beds of waterways, however small (such as rivulets) or big they are, however ephemeral or long-lasting they are. Some waterways are regular and slow, others are more boisterous and fast.

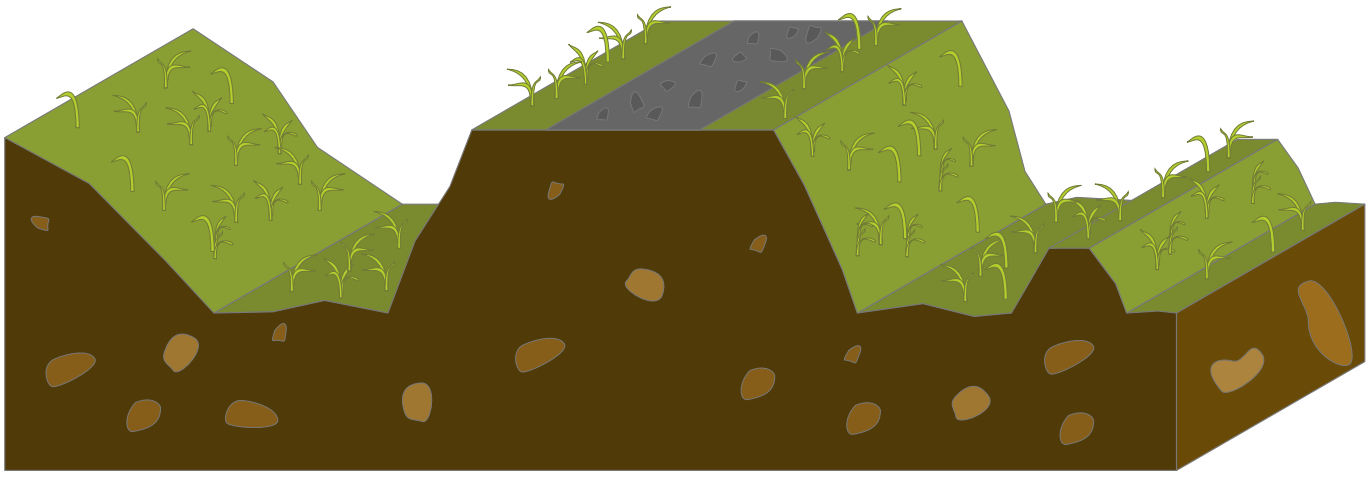
A mere obstacle, placed or here by chance, or a trench can divert a waterway. We see it more on slow waterways that have a weak discharge.

To protect a zone and bring water to a more ideal land, a trench or an obstacle are tools that can be really efficient.

VII.1.1.e. Obstacle

Soil topography obstacles are the exact opposite of trenches.

Depending on the size and its uses, you can find mounds, levees or even slopes.



From left to right, a slope, then a levee (here equipped with a pathway). The levee is a security that blocks important amounts of water. On the right, the mound which has the same goal as the levee, but for much smaller amounts of water.

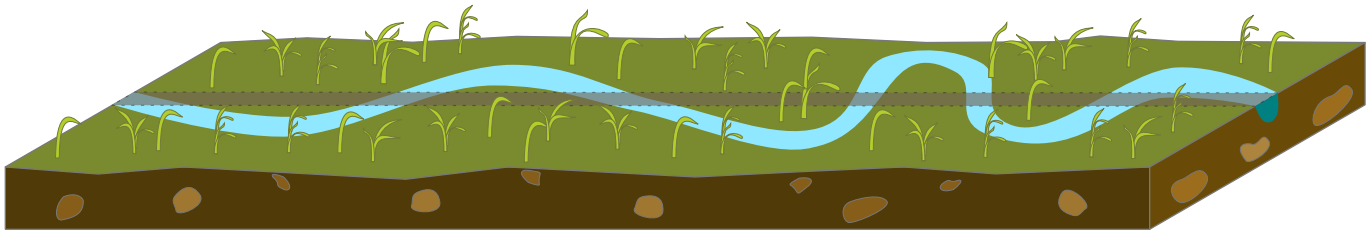
Obstacles can also come from the presence of rocks or even vegetal obstacles, such as hedges, trees, bushes, and shrubs.

VII.1.2. Meander

The curves of waterways are called meanders and help to slow down said waterways.

Saloum Delta National Park, a mangrove forest region in Senegal. Photo by USGS (CC0 license).

In many countries, urbanization and land consolidation policies led to the river restoration. Hydromorphological (the shape of water) alteration generated many ecological malfunctions.



The meander of a river in blue, and a river restoration in grey.

Meanders allow for a greater mobility of water in space, but also of its sediments, its fauna and flora.

The more meanders there are, the more diverse the surfaces of the bottom of the bed, zones (more or less deep or more or less calm) and bank surfaces are. Thus, it offers a habitat to more living things, in both number and diversity. That richness implies ecological functions (decontamination, water retention, water oxygenation, etc.) which offer advantages for ecosystems (benefit for humans such as nutrition, access to drinkable water, leisure, freshness...).

A remeandering is sometimes done by retracing the old outline of the waterway's bed or by creating a new one, close to its original style.

VII.1.3. Soil type

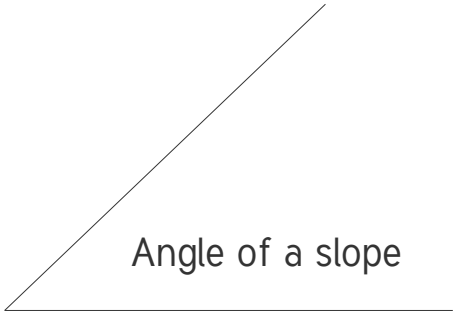
The soil texture can have an influence on the soil flushing, the landslides, the soil erosion, the bursting of slopes, etc.

Depending on the components of the soil, we can have something more or less impermeable with clay or a non porous parent rock. On the contrary, the soil can be very draining with sand or a good layer of humus.

A soil containing clay and stones (from 20 to 60 millimeters) will tend to offer a nice stability for a pathway suitable for motor vehicles. Clay stabilizes stones, the latter retain clay in case of rain.

As for a bare slope, it will retain water very poorly, unlike a green soil. The more dense the vegetation, the more it will retain water, reduce flushing, and hold the soil in itself. Besides flushing, plants can filter runoff waters, that will fill the water tables.

Finally, the types of soil and the humidity rate play a big role on the stability of a sloped soil. So we consider a certain degree that varies depending the type of soil and that you shouldn't exceed when building a mound or a levee.



Here is, hereinafter, an example of slope natural angles according to the type of soil:

- Sand: 10 to 20°;
- Gravel, small stones: 30 to 40°;
- Vegetal dirt or clay: 30 to 50°.

If we exceed these values, the slope may break.

Some elements offer more stability for slopes, such as revegetation, living or not, barriers like fascines, or a laying of stone.

Fascines near the Percho peak (Saint-Pierre-Quiberon Wild coast) that protects dunes from erosion. Photo by Moreau.henri (Creative Commons BY-SA license).

The notions of slopes and protection against erosion come into play in many types of areas such as banks, dunes, as well as in the leveling of many types of soil.

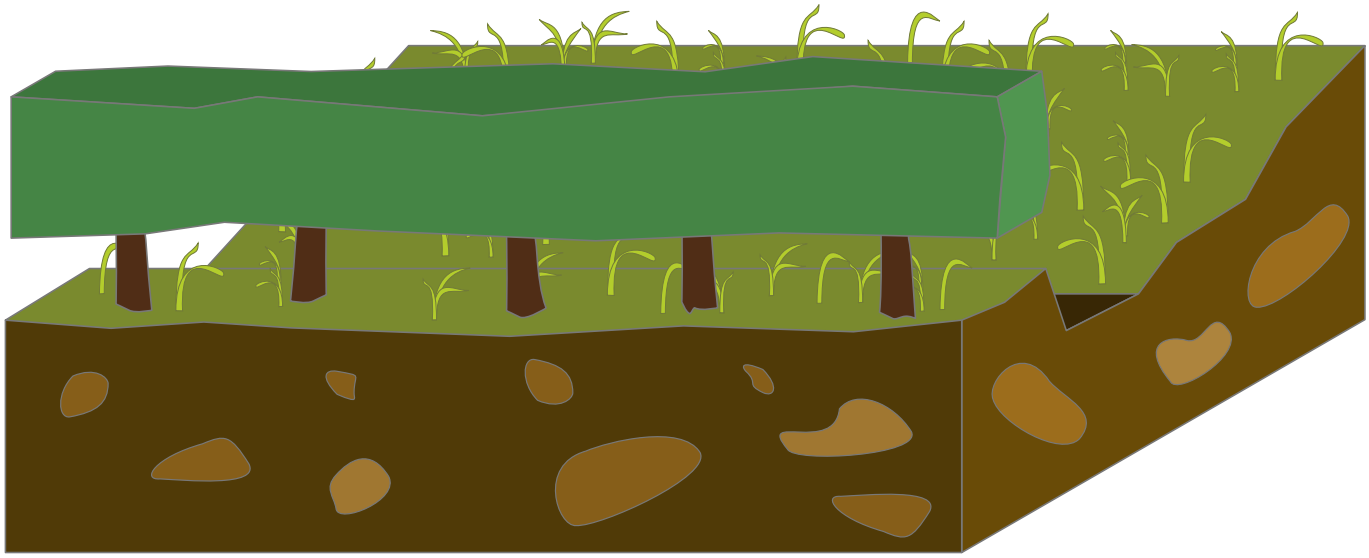
VII.1.4. Multiple approaches

You have to understand that the methods presented here to slow down water also have other interests and that they can be cumulative. Let's see some examples.

VII.1.4.a. Swale hedge

A swale hedge is made of (from upstream to downstream of the slope):

- a large and shallow ditch;
- a mound;
- a mound revegetation.



The swale hedge maximizes water reception by incorporating several aspects.

VII.1.4.b. Strip farming

On a slope, strip farming divides a field into long narrow strips at the same altitude and uses a rotation of cultures.

Alternating the strips aims at preventing erosion. We can also develop a permanent and protective vegetation on some strips.

Aerial photograph of a strip culture around Jefferson, Monroe County, Wisconsin (1957). Photo by E. W. Cole, employee of the United States' Ministry of Agriculture in public domain.

VII.1.4.c. Contour plowing

Contour plowing, or contour farming, uses a principle close to strip farming, by defining levels of altitude.

Then, a plowing creates trenches perpendicular to the slope.

It maximizes water retention and avoids erosion.

Modern approaches such as "Keyline Design" reclaim this method by spacing the trenches and looking for more permanent cultures, as used in permaculture.

Keyline applied to a 73-hectare ranch in Oaxaca, Mexico. Picture by VillaTierradelSol (Creative Commons BY-SA license).

VII.2. Absorbing

VII.2.1. Vegetation cover

The vegetation cover has a strong incidence on water absorption in the soil. The density of the vegetation cover increases transpiration, which transfers water from the soil to the atmosphere through the evaporation at the level of the soil and plant transpiration.

The plants help to purify water and to the capture for water tables. The vegetation cover restricts landslides, floods and sewers' charge.

VII.2.2. Soil type

As we saw in the part about soil, with the Jamagne triangle, each soil has a water absorption capacity linked to its texture.

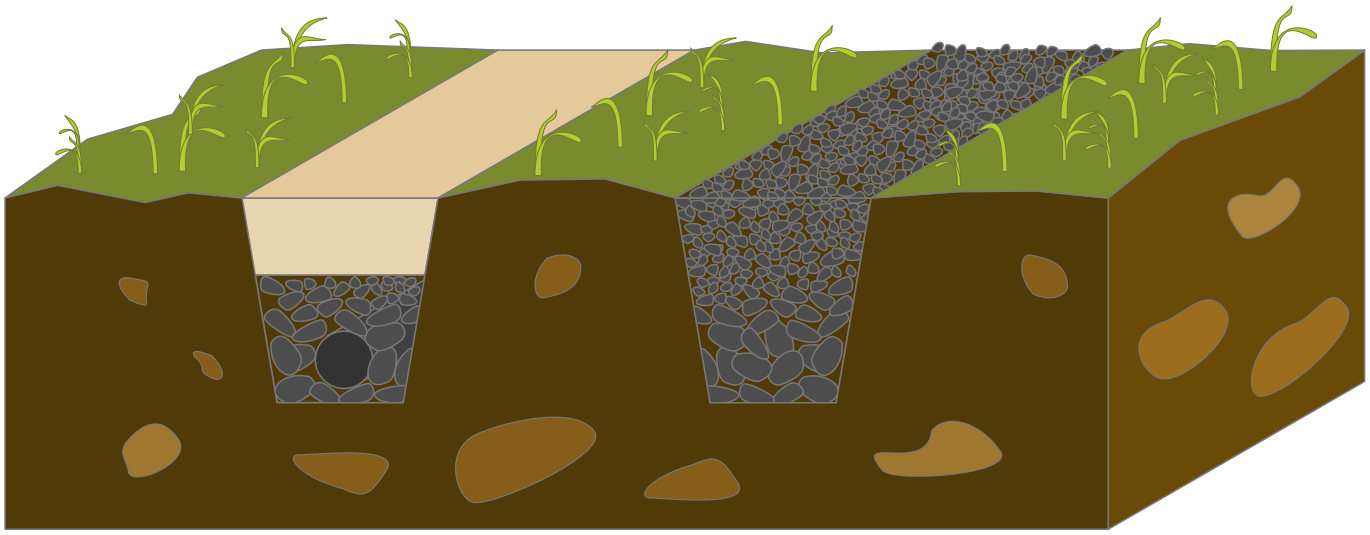
Ventilation is of great importance by adding "gaps" that could become saturated with water.

A humic "litter" (surface soil), or a very humic soil, absorbs much more water than a soil that isn't.

Let's not forget that the clay–humus complex, tackled in the part about soil, also increases the vegetation cover in terms of plant development, and consequently, water reception as well.

VII.2.3. Drainage

A drain can absorb water, or redirect it elsewhere. It is often made of a buried pierced hosepipe on a stone bed whose size decreases as it gets closer to the surface.



On the left, a drain on a stone bed covered with sand. On the right, a simple trench filled with stones of decreasing granularity.

A drain usually uses a hosepipe, which guides water to an exit point.

However, on a simple stone bed, the drain will be used to absorb water directly, except if the trench is surrounded by an impermeable layer (non porous parent rock, very clayey dirt, concrete culvert, etc.).

VII.3. Storing

Storing rain water allows, according to the employed methods, a further use and/or a regulation of volumes by creating a “buffer storage” and/or welcoming fauna and flora like a pond.

VII.3.1. Rain water tank

Water can be stored in a rain water tank.

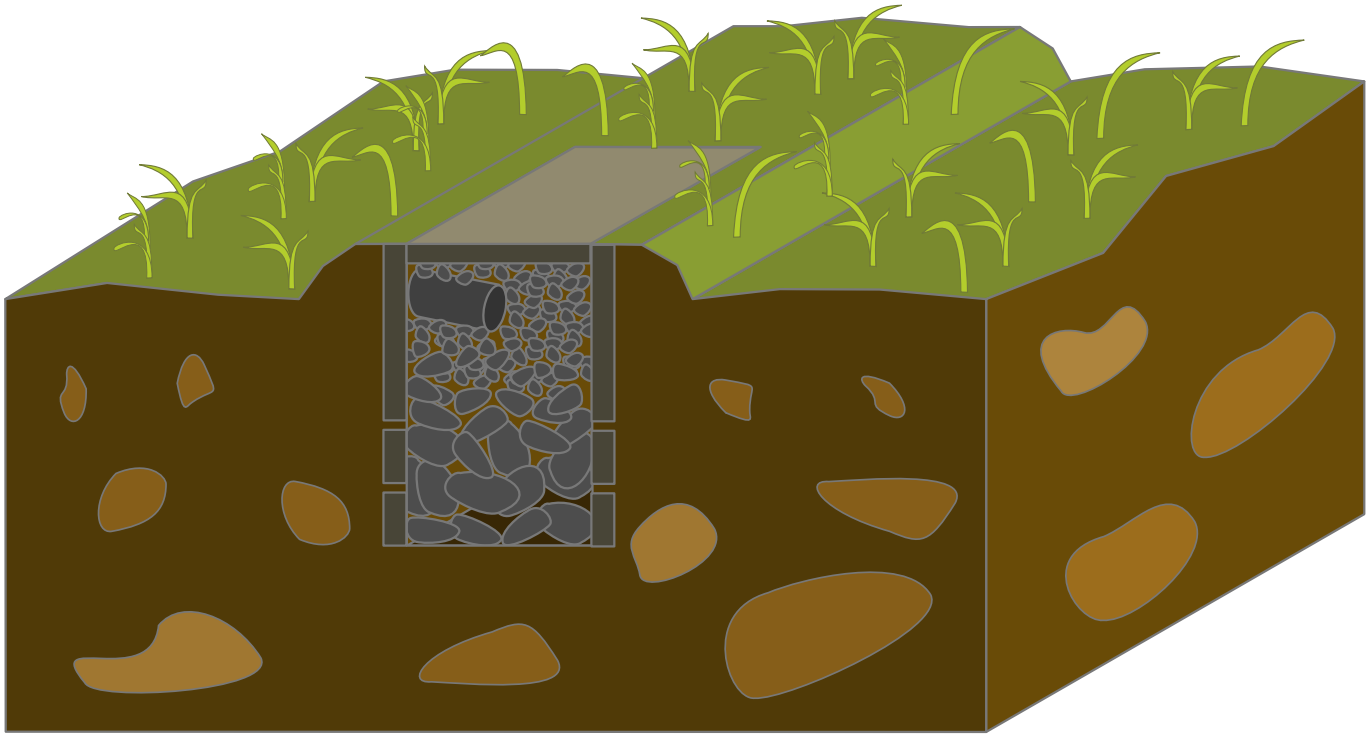
The rain water tank can either be on the surface or buried.

The uses are limited, depending on each country's legislation.

Rain water tank, Rwanda, near Kigali. Photo by C.Rieck, SuSanA Administration (Creative Commons BY license).

VII.3.2. Dry well

The dry well temporarily gathers rainwater and surface water for a slower infiltration into the soil.



A potential type of dry well. The water from above going into the well generally seeps through holes in the walls or by the bottom of the well. Basic models with natural materials can also be efficient (see the diagram with a trench filled with stones in the part "VII.2.3. Drainage").

VII.3.3. Watering point

Water that is stored on the surface, that doesn't stagnate, will allow the local fauna and flora to drink and could welcome a specific ecosystem (amphibians, fish, aquatic plants, etc.).

No matter the shape (pond, duck pond...), to prevent water to infiltrate, you will need an impermeable soil. We mainly use natural materials like a non porous parent rock or generally clay (if we avoid tarpaulins).

If a soil doesn't provide a layer impermeable enough, the "soil reorganization" method can be applied. This method required to excavate the soil 80cm deeper than the depth wanted.

Soil materials must be separated by size. It can be done with the eye for the biggest rocks. Else, you can use grids, handsieves, or vibrating screens for thinner rocks.

As for dirt, hand sieves or vibrating screens can be an option, but soil sedimentation in water can also do the trick.

We can also import clayey dirt from an excavation on a worksite for example (for heavy clay type, see the part dedicated to soil).

Start by placing back the bigger rocks at the bottom, and then cover them with smaller and smaller rocks until you put sand (the whole structure to a height of 50cm). Then, put clayey dirt that you will compact to a height of around 30cm.

Wet the clay and wait for it to absorb the water before adding more, to test the pond's impermeability.

Warning!
- Think up of a gentle slope, a floating bridge, stacked up rocks, or other systems to prevent small animals from drowning.
- A duck pond, just like a ditch, needs maintenance.
- A duck pond is a bush in the making. In fact, the plants that grow there will release organic matter at some point that will be used for plants as they grow more numerous and bigger. They will end up absorbing all the available water, except if we do a clearing of the pond every 20 to 25 years or so.
- A permeable pond is not necessarily useful. If your soil doesn't hold water, a wet zone that clears out will be as much important as a pond in terms of biodiversity.

VII.4. Connecting

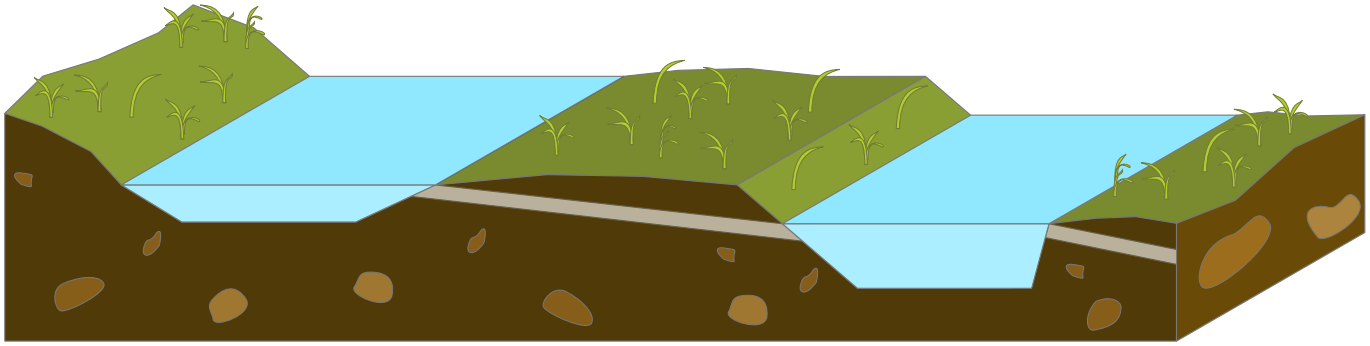
When joining different ecological habitats together, the network created is called "green infrastructure". When speaking about watering points, we speak of "blue infrastructure". A junction between those two areas is called "green corridor".

It is best for living things to not block a waterway that flows on your terrain, including for a run or a runnel.

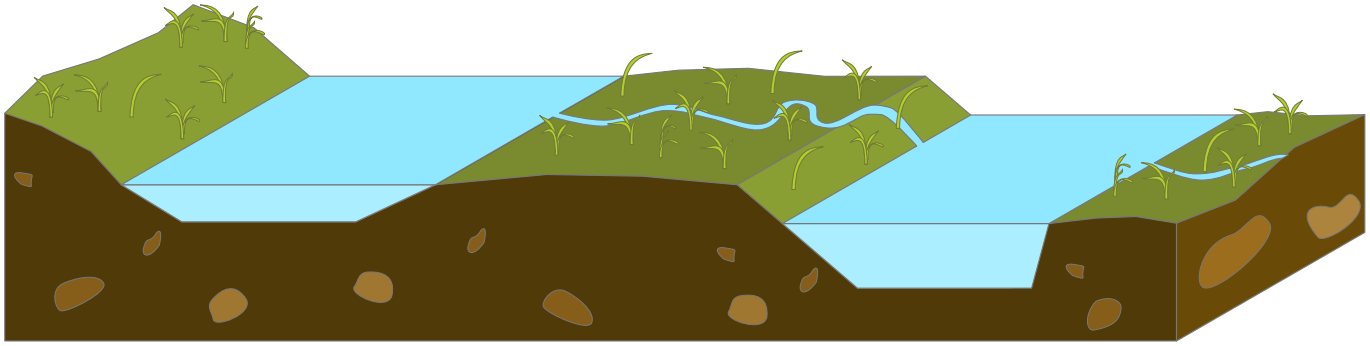
Moreover, the connections between the diverse watering points allow to discharge water overflows in areas that can still welcome them.

VII.4.1.a. Passage of water

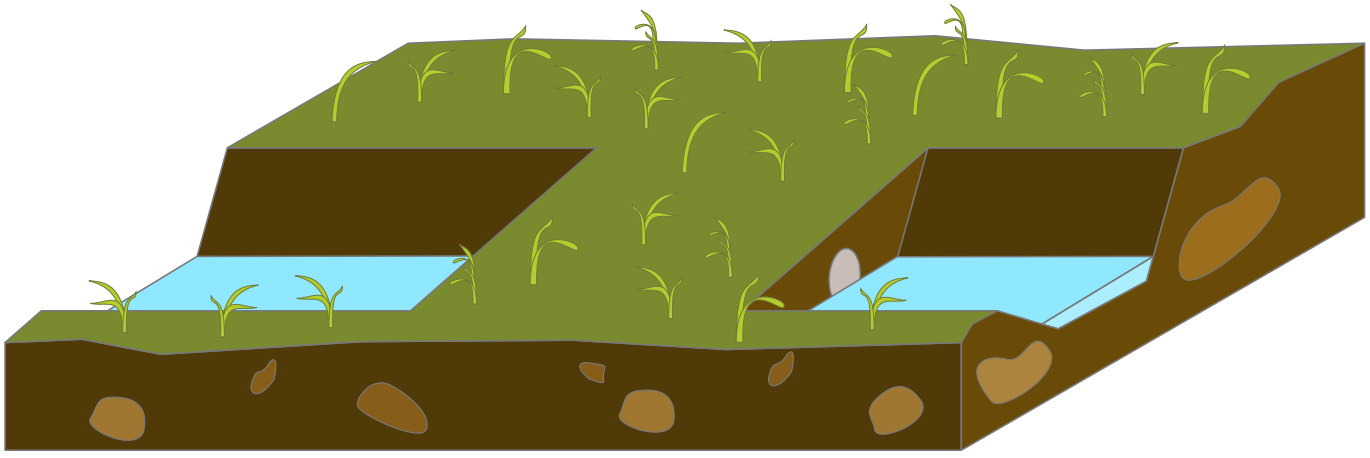
To allow passage of water, we generally connect two watering points with a trench when on the surface, or a hosepipe when buried. To prevent a hosepipe from clogging, you can use a grid or some rocks to filter what is coming upstream.



Example of two watering points connected with hosepipes. The overflow discharges from the upper part of the highest watering point to the lowest watering point.



Example of two watering points connected with trenches. Maintenance is easier than with hosepipes.



For passageways on a ditch, a circular culvert like here is used to allow passage of water. Bridges are sometimes used as well.

VII.5. Saving water

There are many ways to save water. Even though this would need more details, here is a first glance as a list. Methodologically speaking, it can be interesting to see:

- What is our situation?
- What elements are applicable to this situation?
- What elements do we need to apply depending on the existing obligations? (time, money, labor, technical means, proximity...)
- What planning can we have?

Some elements put aside according to the obligations of the moment can still be reconsidered later if those obligations change.

VII.5.1. In the garden

VII.5.1.a. Local plants

Using selected local plants, adapted to the territory and consuming less water, allows to reduce or stop watering. Moreover, they are adapted to the local ecosystem and are more perennials.

VII.5.1.b. Watering

- Using porous watering (porous ceramic cones, porous terracotta pot...)
- Using drop-by-drop watering.
- Making a pergola or an arch covered with plants. We use this method to cover more space with shadow during sun episodes and to avoid strong heatwaves. Depending on the essence, various insects and birds can then come as well.
- Favoring plants less or not dependent to water.

VII.5.1.c. Ventilating the soil without flipping it

To avoid flipping the soil, depending on the surface, the allocated time, the durability, the situation, we can:

- use a broadfork;
- carry out subsoiling;
- use ground covers to ventilate on the surface;
- favor the arrival of life in the soil (including earthworms);

- avoid the passage of heavy machines that compress the soil, or limit them to a pathway;
- decompact the soil without flipping it;
- carry out a soil ventilation…

A ventilated soil has more gaps and is then more able to absorb water.

VII.5.1.d. Ground covers

To save water, we can use ground cover perennials that will reduce soil evaporation.

Mulching or soil covering reduce watering, by reducing water loss and maintaining more stable temperatures. It also helps to preserve on-site organic matter (carbon among others). Mulching grass can be done on-site or be moved the closest to the plants' roots. Soil covering is done with hay.

VII.5.2. Cover crops

Cover crops help to absorb rain water and water overflows.

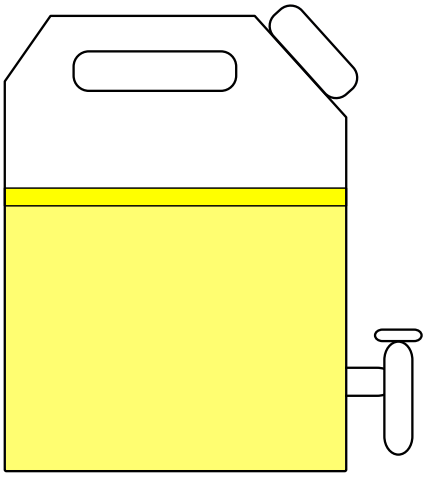
In the agricultural sphere, cover crops are also used to improve the soil (in rotation, in intercultural operations, in association, in flowery meadows, in bioremediation…) or to trap nitrates with Fabaceae for example.

VII.5.3. Habitat

VII.5.3.a. Equipment

- Installing a thermostatic mixing valve.
- Installing an economical handheld shower head.
- Installing a relief valve.
- Using composting toilets. Composting toilets are usually easy, but can be more complex.
    - Some can separate urine and fecal matter. Fecal matter can be composted. In France, it is advised to do it for two years, with a ventilation every month, via plowing, to activate aerobic bacteria that consume air.
    - As part of urine separation (which reduces smells), urine can be collected in a jerrycan containing oil, which prevents the contact between air and urine, and by extent some chemical reactions. Oil

prevents smells if it is placed above urine. A faucet at the bottom of the jerrycan allows to gather urine while conserving the oil.



A urine separator helps to an easier management. Urine is straight away reusable.

- Using a shower stopper that only triggers water when you hold the showerhead and when pressing a button.
- Owning a urinal, or even a plant urinal or a waterless urinal.
- Using phyto-purification; for example to treat, or reuse wastewaters.
- Installing a faucet aerator. Installing two faucet aerators improves water flow and increases its efficiency.
- Using high-tank toilets. A high tank increases water pression that arrives in the basin and is more efficient. Generally, a high-tank system doesn't have a double flow and the maintenance is harder to access. These two points of conception could benefit from a rework to get a more viable solution...
- Collecting rain water. You can't drink rain water or use it to wash your body. It is advised to refer to the legislation in effect in one's country. There are several levels of rain water recuperation. The simplest methods are done with rain water tanks, trenches for agriculture or even retention ponds. Thus, we mainly use gravity as energy. Buried tanks are also an option for a domestic use (again, not to drink, nor to wash one's body). Many methods exist.
- Changing the flush system. An economical flush system helps to reduce water and money spending quickly.

VII.5.4. Water reuse

VII.5.4.a. Greywater reuse

In some countries, greywater reuse is practiced and sometimes even encouraged. In other countries, the practice is quite limited.

In a more industrial–based process, treatments through reverse osmosis, filtration, decantation, absorption, adsorption, centrifuge or through biological treatment are ways to reuse water if it matches the legislative framework.

VII.5.4.b. Reusing water used to cook or wash food

As long as the water used to cook or wash the food isn't thrown away, it isn't considered greywater. Moreover, this type of water is destined to a dietary use, making it quite safe. They can be used for toilet flushing or watering plants (non salted water) for example.

Cooking water when boiling hot can be used as a weedkiller. Water from cooking vegetables can also be used for soups and broths. You can also cook other aliments (rice, pasta, quinoa,...) by adding some flavor.

VII.5.5. Fixing

Notice the leaks! An easy method to implement is to watch out for consumption at night when no one is using water. You can also compare your consumption to the national average to see if something is abnormal. Noticing leaks in order to eliminate them must be a priority. You can stop them, replace the seals or call a professional if it becomes necessary; for example if you can't determine the origin of a leak.

VII.5.6. Habit

Changing your habits can require some communication, an awareness...

- Washing the dishes by hand before it dries.
- For by–hand dish washing, cleaning in containers (trays, saucepans...).
- Preferring "eco" programs or short cycles.
- Filling the dishwasher and washing machine.
- Avoiding prewashing if it's useless.

- Using a prewashing tray with a less clear water, or even a cool cooking or rinsing water, is very economical especially when there is a lot of dishes to wash by hand.
- Washing one's vehicle with a wet sponge and soap.
- Using water according to the use. Letting the faucet opened with tons of water running is not useful, a trickle should be enough. For many uses (hand washing, by-hand dish washing…), this can be suitable.
- Shutting the water off if not used. To reduce consumption, try shutting the water off when you take a shower, shave or brush your teeth for example.
- Adjusting the toilet flush allows to correlate one's evacuation demand and one's consumption.
- Changing the cooking method. A steam cooking, pilaf or a pressure cooker uses less water than creole cooking.
- Taking showers rather than baths. The shower uses around five times less water than the bath.
- Washing with a washcloth. Washing with a wet washcloth and rinsing uses 2 to 5 liters of water instead of 35 to 60 liters for a shower.

VII.5.7. Cities

VII.5.7.a. Permeable coatings

Permeable coatings can absorb rain water to return it to the soil. Several solutions exist:

- Cobblestones (with filtering seals, turfed, perforated or with interstices);
- Porous coatings or a reservoir pavement;
- Natural areas or lawns.

The lack of soil permeability in cities increases problems:

- Excess of water in water treatment plants during heavy rain periods (therefore the overflow is not treated);
- Water table alimentation deficit;
- Upstream or on-site flood;
- Pollution of waters (self-purification that can't be implemented for quantities above their capacities).

VII.5.7.b. Dry well

Dry well store water temporarily, allowing a slower infiltration in the soil.

VII.5.8. Companies

VII.5.8.a. Creating semi-open circuits

In a semi-open circuit, the fluid (water, oil, gas…) mix most of the time with other elements like another fluid (liquid or gaseous) or impurities, for example.

The idea is to separate the elements (through reverse osmosis, filtering, decanting, absorption, adsorption, centrifuge or biological treatment) for them to be reused.

You can also do it by changing the state of the matter. For example, an evaporating water can encounter a metallic surface placed above, allowing its condensation and recuperation as a liquid.

VII.5.8.b. Consumption reduction

Acting upon one's consumption is a strong gesture towards environment and resilience.

You can act upon the consumption on several levels:

- conception, design;
- sources;
- usage practices;
- end-of-cycle practices (reuse, industrial symbiosis…).

Therefore we can:

- use passive energies rather than electrical energies;
- reuse losses (usually for heat and water);
- restrict the needs (with equipment or practices);
- support change, inform on good behaviors;
- adjust appliances, use them well and assure regular maintenance…

A global thinking therefore establishes.

The changes are more durable when they are documented and we incorporate appropriate data or ticklers. This allows to not lose the uses in case of a staff renewal.

VII.5.8.c. Reusing lost waters in a flow

Lost waters can be reused by being cleaned, separated, or by changing their state (e.g. from steam to liquid).

Sometimes, their calorific powers (for hot or cold water, steam or ice) can also be recycled.

Finally, for filthy waters, the "stain" can also be reused (as a raw material, compost, other recycling processes…).

VII.5.8.d. Industrial symbiosis

One's wastes can be other's resources.

If an internal use isn't possible for a treated water at the end of a production cycle, it can pick the interest of neighboring companies that might have an other use for it.

Furthermore, a neighboring company can have a treatment producing an excess that can interest us.

We can also share costs to make a treatment possible, allowing a reuse that we can't take upon on our own.

VII.6. Living water

To avoid a standing stagnating water, you can get it oxygenated in several ways. Let's see the ones that do not need electricity.

The "shishi-odoshi" (a bamboo pivoting by bringing water), small "rapids" with rocks sticking out, meandering curves, rocks in the angles where water comes a bit fast.

Souzu, a kind of shishi-odoshi, at Shisen-dō temple, a Buddhist temple in the Sakyō-ku neighborhood, Kyoto, Japan. Picture by 利用者:十一 *(Creative Commons BY-SA license).*

You can also use oxygenating and/or filtering aquatic plants in permanent watering points.

For dirty and/or polluted waters, you can consider filtering and bioremediation approaches.

For moving waters, the water/air contacts step in. Therefore, currents, rapids and waterfalls oxygenate water.

VIII. Welcoming ecosystems

Taking care of the soil and water circulation already gives you a bonus for diversity. We can even go further by thinking to the living beings' habitats, their daily life (alimentation, movement, reproduction...).

A "natural" shelter (a rock pile, a bush, a tree, tall grass...) is often more resilient, perennial and evolutive than a "fabricated" habitat like a birdhouse, for example.

However, you must be careful to that specialization "nature/construction". In fact, there are plenty of good reasons to build a habitat. This strategy can be temporary, while an ecosystem is being restored, mainly in very urbanized environments with heavy ecological pressure. It is possible to justify these practices for emergencies during forced transfer after constructions or environmental catastrophes. We can also evoke the case of hurt animal shelters...[7] Finally, the human presence and their constructions can also attract species by opportunism. We can find these species in areas likely to be habitats (under certain conditions), mostly along the edges of riverbanks, steeples, ditches, attics, roof overhangs... In short, nature and construction are not antagonistic.

The richer an ecosystem is in diversity and population, the more ecological functions mentioned beforehand (remediation, water retention, water oxygenation...) there are, and they induce ecosystemic services, beneficial for the human kind.

For animals, installing a shelter is a little help we can offer to nature, but doesn't automatically imply its occupation!

Besides fortune, there are criteria that influence more the animal presence. The existence of food and water sources, security, climate, sun exposition, location, the adaptation of the habitat to the present species, etc., are as much criteria that come under consideration.

Therefore, it is good to identify the species present on-site, or nearby, to build a compatible shelter and know their presence factors.

We will also evoke plants life, that is also keen on diversity.

7 Some associations can bring their expertise in that case. According to the situations, this can be prohibited, not advised, advised under conditions...

VIII.1. Identification

The identification of a species allows to know it better and get a better understanding of its mode of life and needs. Like human beings, a species needs to drink, to eat, to be in a favorable environment, to be safe...

There are resources that can give a little help to identify a species.

VIII.1.1. Associations

We can contact an association. Here are some national organizations.

- In Belgium: The Ligue royale belge pour la protection des oiseaux (LRPBO).
- In France: France Nature Environnement (FNE), the League for the Protection of Birds (LPO).
- In Switzerland: The Swiss Association for the Protection of Birds (ASPO), and the Centre de Coordination Ouest for the study and protection of bats (CCO).

Both in Belgium and France, if the LRBPO and the LPO are originally oriented towards birds, their areas of expertise also consider other species.

VIII.1.2. Books

- Le guide Ornitho (Guide Delachaux), also available as an app.
- Chauves-souris d'Europe (Guide Delachaux).
- Le Hérisson d'Europe (Delachaux et Niestlé).
- Insectes de France et d'Europe (Guide Delachaux).
- Petit traité du jardin punk (Éric Lenoir).
- Le grand traité du jardin punk (Éric Lenoir).
- Je sème des engrais verts (Terre vivante).

VIII.1.3. Apps

- Recognition by questions, sounds or photographs depending on the apps.
- iNaturalist (www.inaturalist.org), also available as a website.
- Seek by iNaturalist.
- Clés de forêt by the National Forests Office (France).
- Merlin Bird ID by Cornell Lab (merlin.allaboutbirds.org).

- Picture Bird – Bird Identifier (www.picturebirdai.com).
- BirdNET (birdnet.cornell.edu).

VIII.1.4. Forums

- Identifying animal or plant species

https://forums.futura-sciences.com/identification-especes-animales-vegetales/

- Identifying animal species

https://www.aujardin.org/viewforum.php?f=69

VIII.1.5. Atlas

- Presence, distribution, tendencies and sizes

Oiseaux de France (oiseauxdefrance.org)

VIII.2. Generalities about the animal presence

VIII.2.1. A suitable place

If an animal exists in the vicinity, there is a reason.

Animals have natural needs (alimentation, habitat, reproduction...). If an animal exists nearby, it is without a doubt because the area is suitable for its development.

Inquire about animal protection associations or by your own means allows to know the animal's mode of life, and thus, its needs. Therefore, we can avoid cutting grass in some places, let rotten fruits on the ground or some berries on a bush, use plants that insects are keen on, place the habitat near a source of nutrition... So many possibilities that depend on the species.

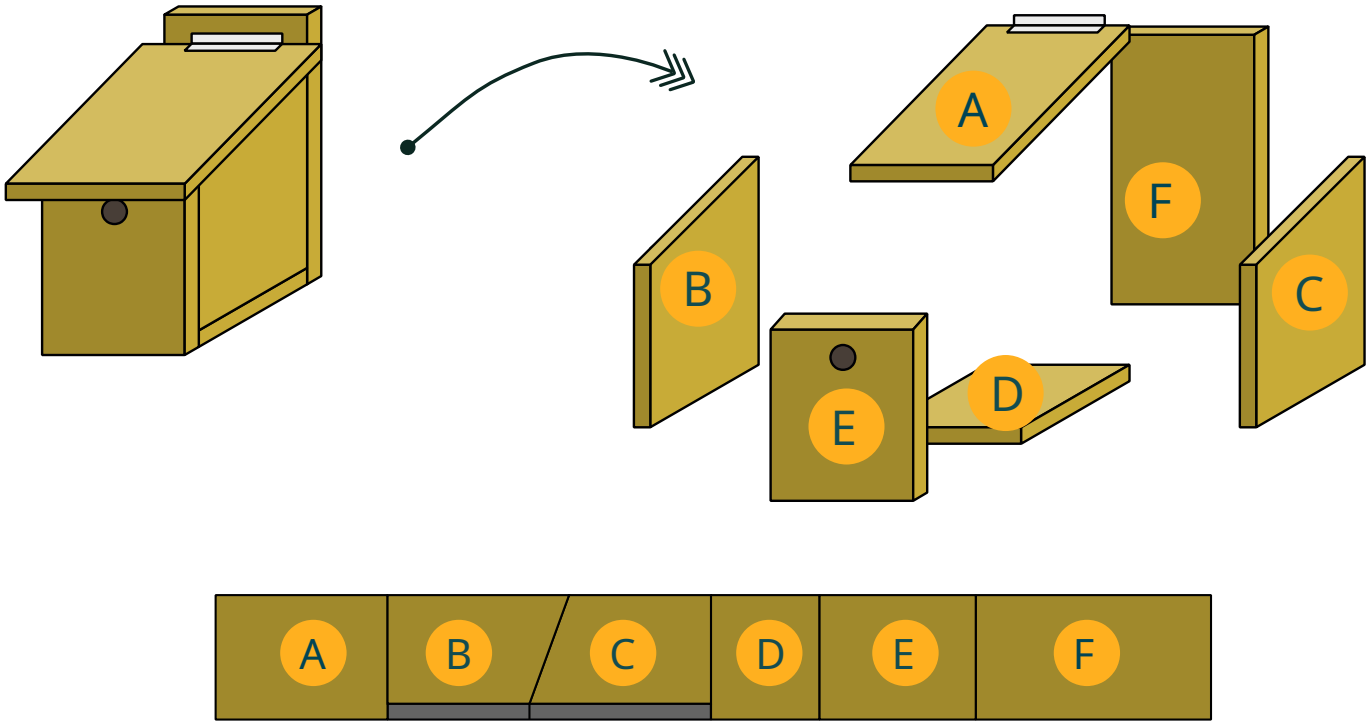
VIII.2.2. Environmental pressure

The presence of an animal can be due to an environmental pressure, its natural habitat having been destroyed, damaged... In that case, several solutions are possible:

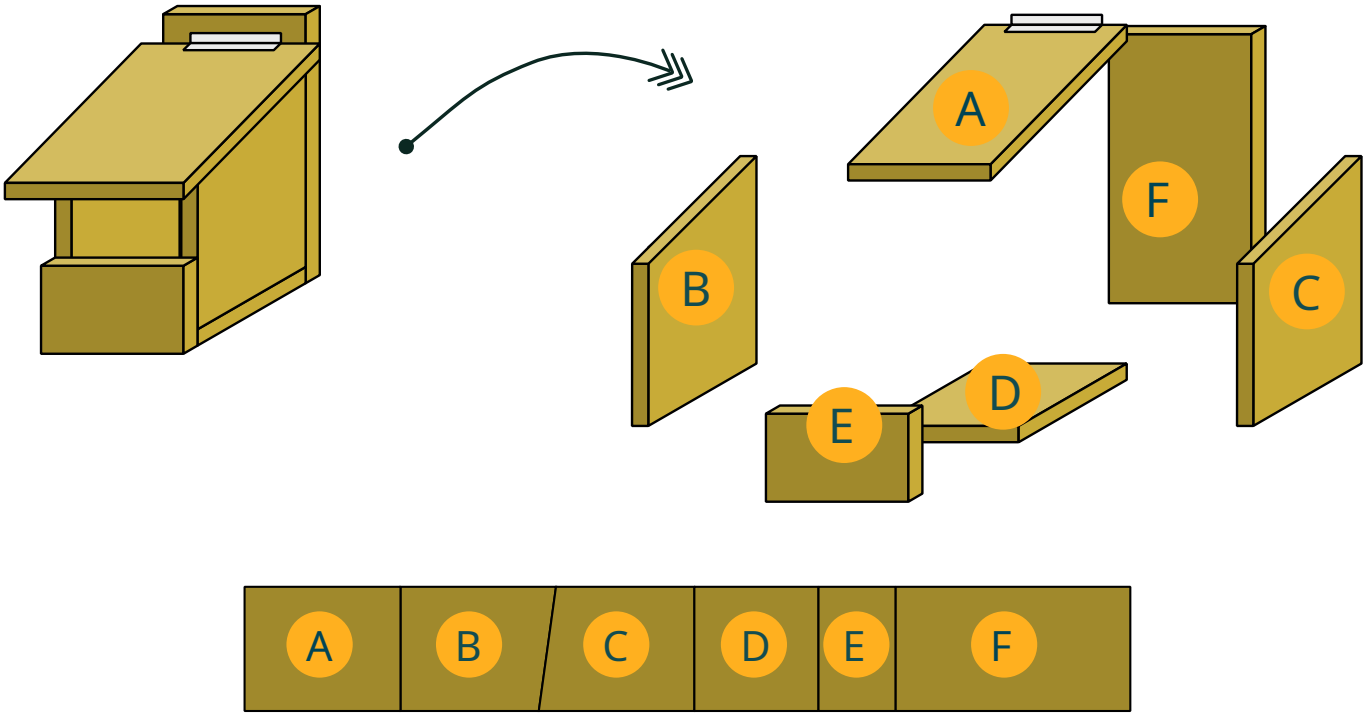
- the ecological restoration, that studies the surrounding ecosystem and the animal needs;
- the preservation, that protects threatened areas;
- the free evolution, that consists in letting space for nature and let it take its course...

VIII.3. Birds

In France, we often see two types of birdhouses: closed or semi-open birdhouses.



Exploded view of a closed birdhouse, with an example of a cutting on a board.



Exploded view of a semi-open birdhouse, with an example of a cutting on a board.

The choice of the type of birdhouse depends on the species.

Each birdhouse can have different dimensions that will be more suitable to some species of birds, hence the importance to adapt the birdhouse to what could be present around. The most magnificent Andean condor shelter will not be efficient in Brittany...

Moreover, the height and orientation in relation to the sun is also important.

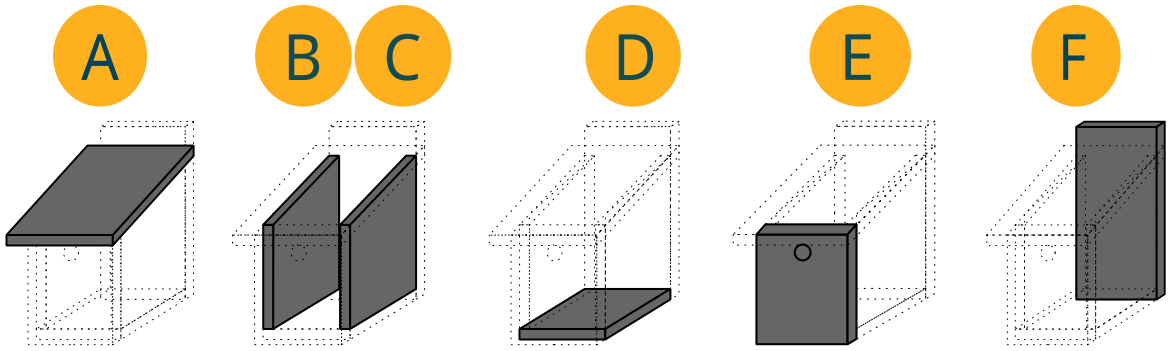
VIII.3.1. Species of birds for closed birdhouses

The types indicated thereafter correspond to the following species of bird.

- Type 1: For blue, marsh, crested or black tit.
- Type 2: For great tit, Eurasian tree sparrow, European pied flycatcher.
- Type 3: For wood nutnatch, common redstart.
- Type 4: For common starling.
- Type 5: For hoopoe.
- Type 6: For hoopoe, Eurasian scops owl, stock dove, common starling.
- Type 7: For tawny owl.

The dimensions used in the following table are in centimeters.

e indicates thickness. Therefore, if the cut board is 1.8cm thick, then $2e = 2 \times 1.8cm = 3.6cm$



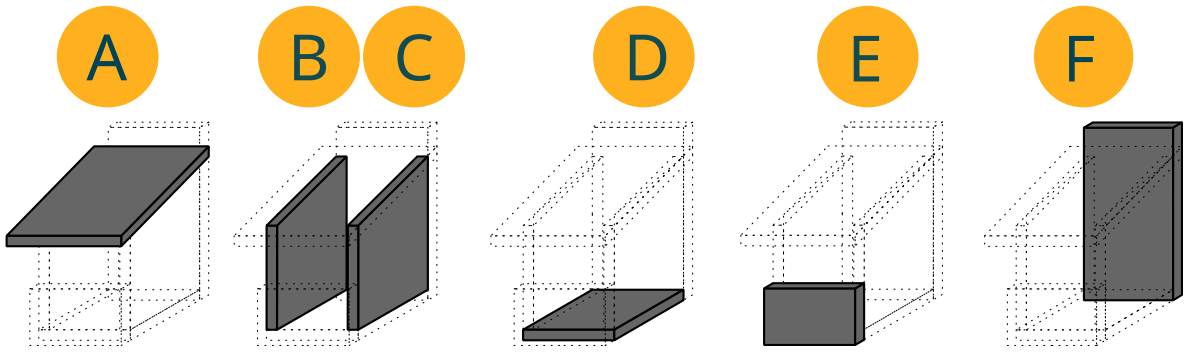
	A	B C	D	E	F
Type 1	17+e (depth) 18+2e (width)	14 (width) 25−e (front side) 28−e (back side)	14 (depth) 14+2e (width)	25 (height) 14+2e (width) 2.8 hole (diameter)	35 (height) 14+2e (width)
Type 2	17+e (depth) 18+2e (width)	14 (width) 25−e (front side) 28−e (back side)	14 (depth) 14+2e (width)	25 (height) 14+2e (width) 3.2 hole (diameter)	35 (height) 14+2e (width)
Type 3	17+e (depth) 18+2e (width)	14 (width) 25−e (front side) 28−e (back side)	14 (depth) 14+2e (width)	25 (height) 14+2e (width) 3.2 oval hole (width) on 4.8 (height)	35 (height) 14+2e (width)
Type 4	19,5+e (depth) 20+2e (width)	16 (width) 30−e (front side) 34−e (back side)	16 (depth) 16+2e (width)	30 (height) 16+2e (width) 4.5 oval hole (width) on 5.0 (height)	41 (height) 14+2e (width)
Type 5	23,5+e (depth) 24+2e (width)	20 (width) 33−e (front side) 36−e (back side)	20 (depth) 20+2e (width)	33 (height) 20+2e (width) 6.5 oval hole (width) on 7.0 (height)	43 (height) 20+2e (width)
Type 6	19,5+e (depth) 22+2e (width)	16 (width) 33−e (front side) 35−e (back side)	16 (depth) 16+2e (width)	33 (height) 16+2e (width) 9.0 hole (diameter)	42 (height) 16+2e (width)
Type 7	35+e (depth) 26+2e (width)	22 (width) 55−e (front side) 57−e (back side)	22 (depth) 22+2e (width)	55 (height) 22+2e (width) 12.0 hole (diameter)	64 (height) 22+2e (width)

Closed birdhouse usual dimensions depending on the species.

VIII.3.2. Species of birds for semi-open birdhouses

The types indicated thereafter correspond to the following species of bird.

- Type 8: For black redstart, European robin, white wagtail, spotted flycatcher.
- Type 9: For Eurasian kestrel.



	A	B C	D	E	F
Type 8	21+e (depth) 18+2e (width)	14 (width) 19+e (front side) 22+e (back side)	14 (depth) 14+2e (width)	10+e (height) 14+2e (width)	35 (height) 14+2e (width)
Type 9	60+e (depth) 30 (width)	50 (depth) 30 (width) No slope in that case.	50 (depth) 30 (width)	10+e (height) 30 (width)	30+2e (height) 30 (width)

Semi-open birdhouse usual dimensions depending on the species.

VIII.3.3. Recommendations

VIII.3.3.a. Paint and protection of the wood

Avoiding using paint to avoid potential toxicity. Even natural products are not likely to be good for health and were not made to be near living beings.

If you want to protect the wood (which is not necessarily useful), avoid saturators and wood stains. As for commercial wood oil, they are often not natural.

A two-layer linen oil protection is sufficient.

VIII.3.3.b. Wood

- Using fir tree, poplar, larch tree, eastern red cedar, alder tree, Douglas fir, black locust…
- Prohibiting pressed wood or plywood.

You can salvage wood. The latter must be at least Class 3 (made for outside use), but non chemically treated. Ecological construction/refurbishment companies are perfect for that, so you can salvage offcuts that have not been treated.

If we gather wood from pallets, we will look for the HT logo (heated wood to eliminate pathogens, the only non polluting phytosanitary treatment authorized in Europe).

It is important to avoid pallets with no indication or with an indication different from HT. Picture by "Oaktree b" (Free art license).

VIII.3.4. Installation

VIII.3.4.a. Birdhouse location

The birdhouse is neither in a shady place, nor in full sunlight. An East/South-East orientation is generally advised.

We will also avoid prevailing winds.

VIII.3.4.b. Birdhouse height

Species	Recommended height	Source
White wagtail	from 1.5 to 2m	Ornithomedia
Tawny owl	from 1.5 to 2m	LPO Drôme Ardèche
Eurasian kestrel	from 8 to 12m	Ornithomedia
Short-toed treecreeper	from 1.5 to 5m	Ornithomedia
Song thrush	at 6m, if possible on a tree with ivy	LPO Drôme Ardèche
Common hoopoe	from 1m to 1.20m	LPO Drôme Ardèche
Eurasian blackbird	from 1.5 to 6m	Ornithomedia
Coal tit	from 2 to 4m	LPO
Blue tit	from 2 to 5m	LPO
Great tit, Eurasian tree sparrow	from 2 to 6m	LPO
House sparrow	from 3 to 8m	LPO
Eurasian green woodpecker	from 2 to 6m	Ornithomedia
Great spotted woodpecker	from 3 to 5m	Ornithomedia
Common redstart	from 1.5 to 4m	LPO
Black redstart	from 2 to 6m	Ornithomedia
European robin	from 1.5 to 5m	Ornithomedia
Wood nutnatch, common starling	minimum 4m, optimum from 8 to 12m	LPO

Birdhouse usual height depending on the species.

VIII.3.4.c. Slanted birdhouse

Around the upper part of the back of the birdhouse, we fix a piece of batten or wood, so that this part of the birdhouse is slightly slanted forward to evacuate water and other liquids that could be in the birdhouse.

VIII.3.4.d. Protecting the tree

When we place the wire (or sheathed electric wire) around the tree to fix the birdhouse, we put a foam (or a “sausage” made of old fabric) between the tree and the wire, opposite to the birdhouse, to avoid damaging the tree.

VIII.3.5. Maintenance

Maintenance is done when the birdhouse isn't occupied. In metropolitan France, Switzerland or Belgium:

- around February, birds start to seek a place to live;
- from June to September, it is possible to have a second brood.

In January/February, we can therefore proceed to cleaning the birdhouse.

Be sure the birdhouse isn't occupied and if that's the case:

1– Wear gloves for safety, hygiene, and to reduce your smell.

2– Get the birdhouse down to be comfortably positioned (in case of an unpleasant surprise like insects, spiders, snakes, etc., you better be on the ground).

3– Empty the nest (whether it be in a good state, with a non viable egg, or insects).

4– Open the birdhouse and disassemble it if necessary.

- Clean it with boiling water by scrubbing it with a brush.
- You can also use house vinegar.
- You can dip it a few minutes in bleach, diluted up to 5 to 10% in case a rodent occupied it. In that case, rinse abundantly with boiling water and scrub with a brush.

5– Repair it if needed.

- Unclog the liquids' evacuation holes.
- Check waterproofness. If cracks let water in, fill them back in with wood pulp without solvent, or replace the damaged part.
- Check fastenings.

6– Let the birdhouse dry before putting it back empty in its original location.

Should you feed wild fauna?

You may mean well for feeding wild fauna. However, it should be done parsimoniously.
If we create dependence with the human being, several case-scenarios are possible.
• The animal won't be able to feed itself in the wild and will be endangered.
• The animal reproduces in a much higher number than normally and it creates an imbalance in the ecosystem.

The LPO recommends feeding birds only during the winter, especially during lasting cold period, when snow and frost restrict food access.

VIII.3.6. Alimentation

For the alimentation, give unprocessed food (salt and/or sugar free, not grilled...) such as:

- seed mixture;
- plain peanuts, walnuts;
- wilted fruits;
- vegetable fat balls (but palm oil free).

You can also mix vegetable fat ball and seeds in equal parts. After melting the vegetable fat ball in a saucepan, mix in the seeds. Put them in a recipient and wait for them to cool down before installing it. We can then put it in half a coconut, or other things, that could be hanged up.

By the end of winter, reduce the quantities so that birds complete their alimentation themselves and go seek what they need.

VIII.3.7. Trough

Birds also need water, that will have to be changed on a regular basis—especially for flat recipients, in which water will freeze.

Birds also like water for cleaning themselves. A shallow birdbath will also be appreciated.

VIII.3.8. Security

Bird feeder and trough will need to be put out of reach of predators. There are several models; hanged up or not.

VIII.3.9. Diseases

If there are many birds, providing for several locations allow to reduce too important concentrations that can enable diseases to propagate.

A scheduled cleaning of the trough and bird feeder also allow to avoid diseases to propagate.

Juvenile hoopoe. Photo by Charles J. Sharp (Creative Commons BY-SA license).

VIII.4. Bats

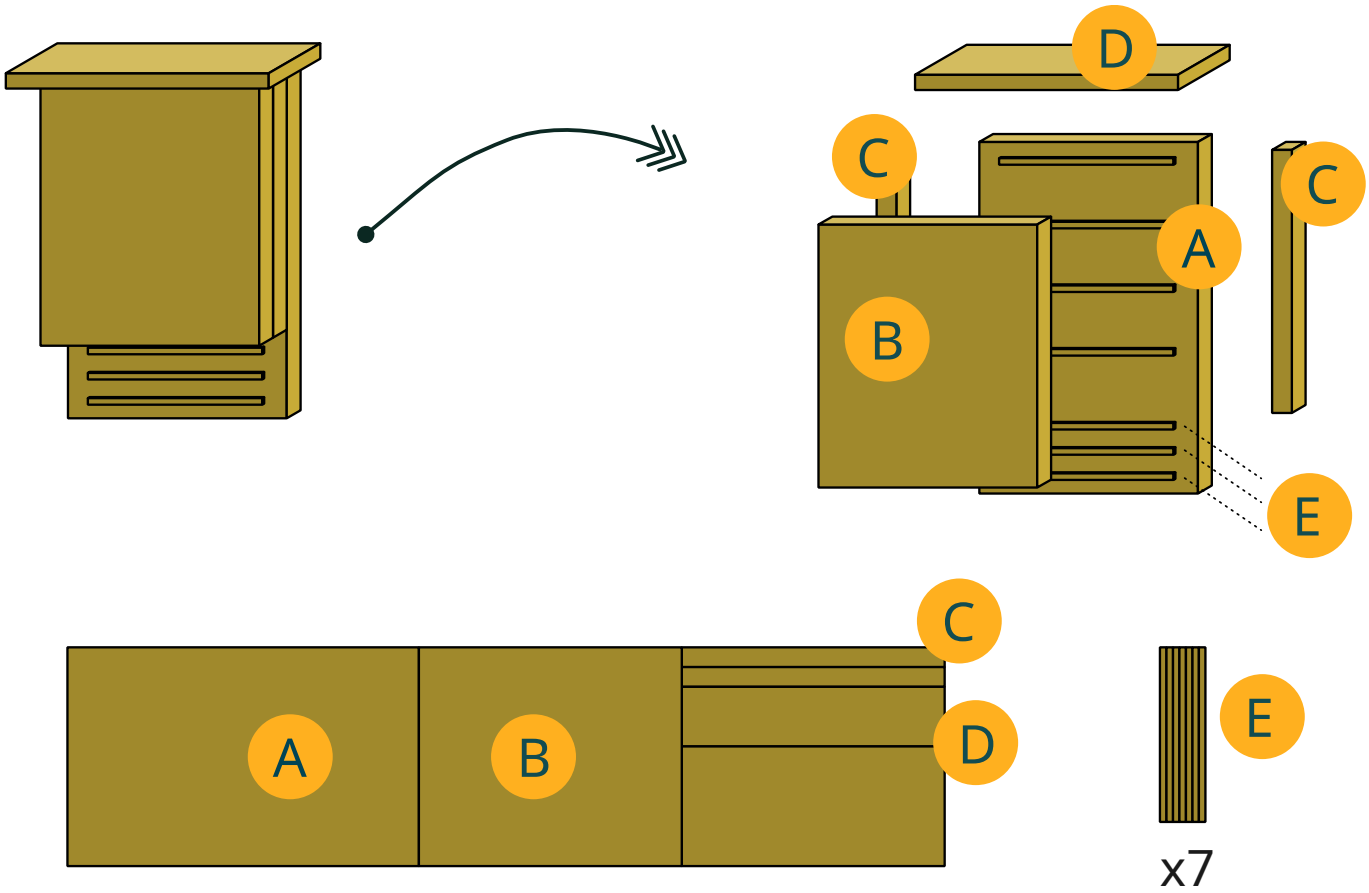
During the past ten decades, bats' natural habitats have decreased a lot.

In order to protect species such as the pipistrelle, the western barbastelle, the lesser horseshoe bat or the greater mouse-eared bat, it is possible to build a shelter to welcome them.

Installing a bat shelter is a little help we can offer to nature.

The presence of food sources, the security or even the height of the shelter are criteria that come under consideration in order for these flying mammals to take it up as their residence.

VIII.4.1. Drawing of a bat shelter



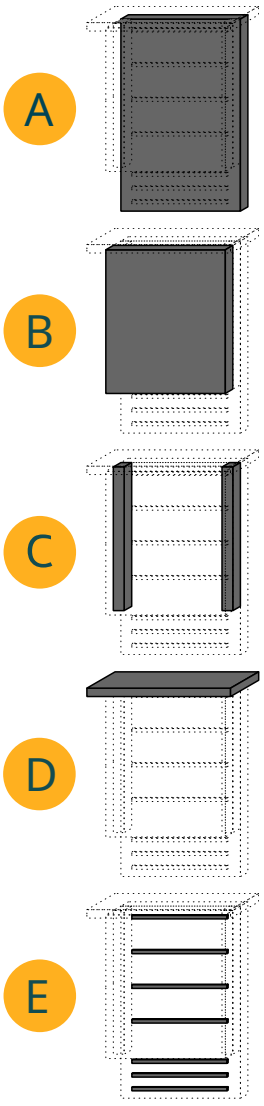
Exploded view of a bat shelter (thereafter, the values are inspired by the LPO Auvergne-Rhône-Alpes association).

The box is made of planks (A, B, C and D) 2.5cm thick.

The seven rods on which bats hang up are 7cm thick. They can be replaced by deep grooves of 3 to 5mm in plank A. In both cases, this is for the bats to hang onto.

The wood is a class 3 non treated one, made to be outside.

Do not sand the planks to keep a surface on which the bats can hang onto easily.



Dimensions (in cm)
40 (height) 25 (width) 2.5 (thickness)
30 (height) 25 (width) 2.5 (thickness)
2.5 (depth) 30 (height) 2.5 (thickness)
7 (depth) 30 (width) 2.5 (thickness)
20 (width) 1 (height) 0.3 à 0.5 (thickness) Amount: 7

Bat shelters type values.

VIII.4.2. Shelter's location

Fix the shelter on buildings, on trees at the edge of a forest, near a duck pond, in a glade or the garden.

Ideally, place the shelter on a followed flight or near a feeding area where bats are present.

It should be well exposed to the light (exposition between west, south and south–east).

Install the shelter as soon as winter ends (in March). Bats will be welcomed in that transition shelter when they stop hibernating.

VIII.4.3. Shelter's height

Put the shelter between 2.5 and 5m, on a building or adult tree, hidden from predators.

Ideally, use a metal fixation plate.

VIII.4.4. If fixed to a tree

When we place the wire (or sheathed electric wire) around the tree to fix the birdhouse, we put a foam (or a "sausage" made of old fabric) between the tree and the wire, on the opposite side to the birdhouse to avoid damaging the tree.

VIII.4.5. Maintenance

No maintenance is required. Disturbing bats during the day can be very harmful.

VIII.4.6. Food and water

Bats are autonomous on these aspects.

VIII.4.7. Diseases

If there are many bats, providing for several shelter locations allow to reduce too important concentrations that can enable diseases to propagate.

VIII.5. Hedgehog

Hedgehog is a protected species in many countries, it is prohibited to own one.

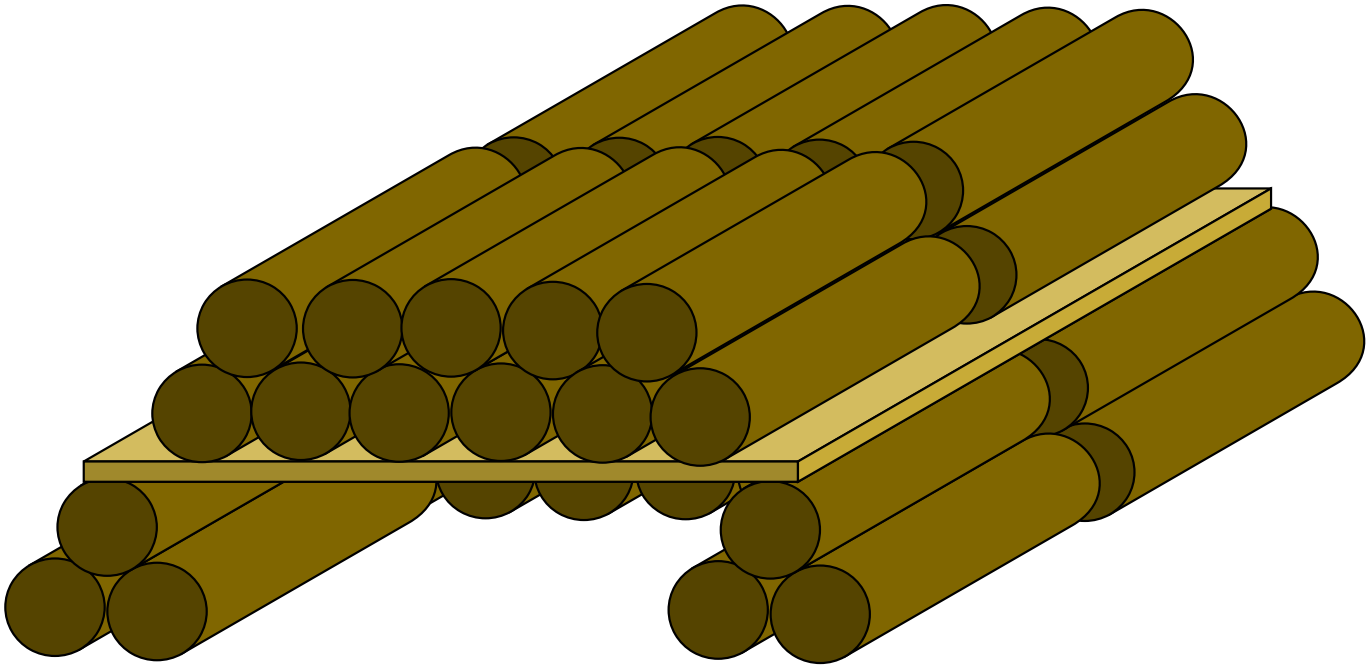
However, you can prepare a place for them to live, where you can give water or a natural source of food, and maybe one will settle in close to your home.

Don't force it! If you move a hedgehog, you could potentially separate it from its family!

In nature, the hedgehog lives in hardwood woods, hedges, or even forest borders.

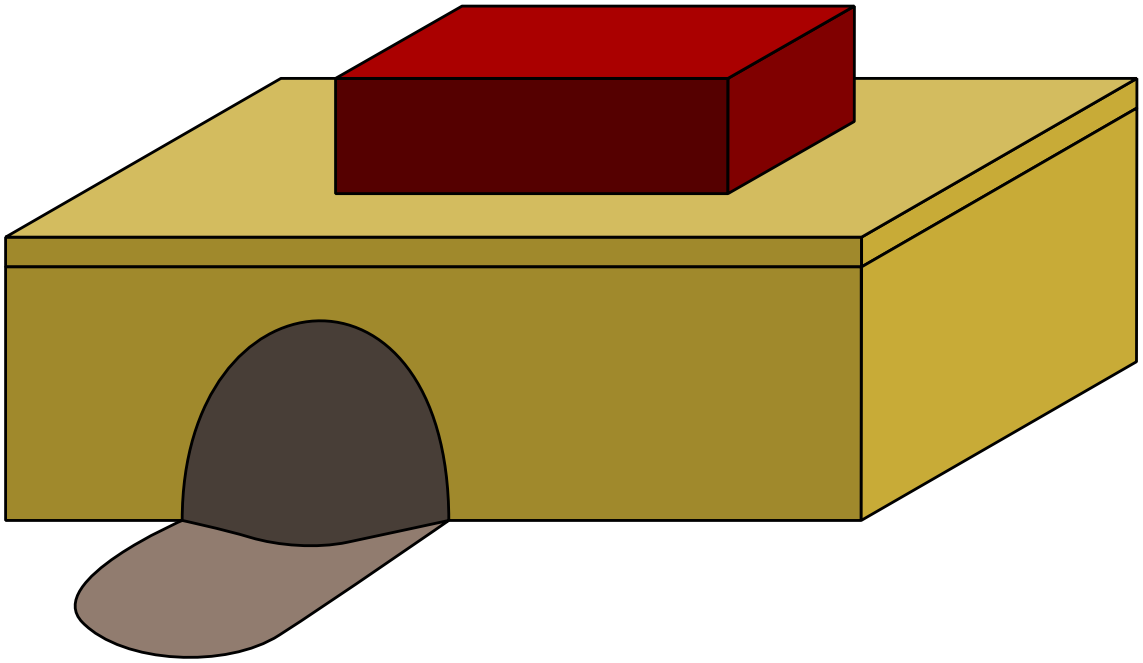
To imitate a natural shelter for the hedgehog, hedges, bushes or a pile of wood are ideal. A hedgehog can also lodge in a pile of compost or leaves that provide food.

It might be possible to set up a pile of wood or even a wine crate that you've flipped.



Pile of wood with a space set up to welcome a hedgehog.

The entrance is around 15 to 20cm high. Inside area of around 60cm by 40cm.



Flipped and ballasted wine crate allowing to welcome a hedgehog.

Here, we use a 12-wine-bottle crate of about 35cm wide, 50cm long and 17cm high; ideal dimensions.

We ballast the crate to prevent it from being flipped over and therefore exposing hedgehogs to predators, especially during hibernation, and then dig a small hole at the entrance to welcome the hedgehog.

The entrance hole in the crate is 12cm wide and 12cm high.

VIII.5.1. Artificial habitat

It must be placed in a calm and shady area, hidden from winds, rain, and direct sunlight (under a thicket, a hedge, or against a wall), oriented between south-west and south-east if possible.

VIII.5.2. Layout

In case of artificial habitat or natural area (like bushes or hedges):

- Provide for a pile of leaves and/or hay inside the shelter so the hedgehog can be protected from the cold during hibernation.
- Provide for a habitat sheltered from humidity by sealing the roof for instance.
- Avoid putting the shelter in a submersible area (mainly during hibernation) or in an area that accumulates water below a terrain, for example.

VIII.5.3. Maintenance

No maintenance is required. A reorganization might be done in an empty shelter outside the hibernation period.

VIII.5.4. Food and water

Avoid feeding hedgehogs, but you can place a “natural” source of food near them, like a pile of compost or leaves full of insects.

They will need plentiful energy to hibernate. Therefore, in Fall, we can put flour beetles, worms or dried insects in their way. They appreciate an alimentation rich in proteins and fats.

At the end of their hibernation, for 1 or 2 months, the starving and weakened hedgehogs also need to gather their forces back.

The hedgehogs can be opportunists, though originally insectivorous. They can eat plentiful things (animal kibble, fruits...). Nevertheless, if they are fed too often, they become human-being dependent and can’t manage their alimentation on their own. That is why the nearby source of food or insects on their path (in a reasonable amount, and only before and after hibernating) is ideal, but only if it is necessary (if weakened, starving...).

For water, a flat container (to prevent them from drowning) with ambient temperature water will do at the end of the hibernation, for 1 or 2 months. Water must be changed and the container must be cleaned every 2 to 3 days.

VIII.6. Insects and plants

The decline of insects is speeding up since the last decades, in total indifference. In thirty years, it is said that about 80% of insects disappeared in Europe. As they are a fundamental link to a sane ecosystem, this endangers many other species.

Insects do not elicit the same interest than mammals or huge trees. Often seen as nuisances, their roles are very diverse and unknown to the general public.

Unsuitable or poorly understood solutions to that disappearance are blooming in supermarkets, hardware and gardening stores.

Let's take stock of the subject, the functional solutions and the success conditions.

VIII.6.1. The insect hotel, an educational tool

The insect hotel is more and more known and used. However, it's an educational tool that doesn't guarantee insects to install.

The proximity of "accommodations" to attract different species, the interspecies competition for alimentation, locations too far from the needs of lodged species (alimentation, reproduction, lifestyle…) or even the installation in a total biological desert are all disadvantageous parameters.

Quite often, the educational aspect is unfortunately absent, making it difficult to understand which habitat corresponds to which species. Therefore, not only the item is useless but also might be expensive…

Generally, the habitats are supposed to be adapted for ladybugs, earwigs, lacewings, hover flies, mason bees or other solitary bees.

Finally, if the habitats are the ones of insects, they are also used by arachnids, mollusks, crustaceans, centipedes, small mammals, birds or even reptiles.

How to build (nearly) costly habitats with better efficiency?
This is what we're going to see…

Here is what we can learn from an insect hotel in terms of habitat.

Insect hotel. (1-Hay in a pot / 2-Rocks / 3-Hay / 4-Pinecones / 5-Pierced logs / 6-Hollow stems / 7-Partition tiles / 8-Pithy stems / 9-Piled-up slates / 10-Wood vertical cracks / 11-Partition tiles / 12-Piled-up slates / 13-Wood horizontal cracks / 14-Piled-up slates / 15-Log / 16-Hay / 17-Earth-hay mix / 18-Rocks / 19-Logs, branches, pile of leaves).

VIII.6.2. Insect details

With the following indications, can you find the correlation between the insect and its habitat? Several answers are possible.

VIII.6.2.a. Carpenter bee

Picture by Aethorn (CC BY-SA).

Carpenter bees are part of the genus called “Xylocopa” (“wood cutter” in ancient Greek).

They are harmless, though impressive in size.

The carpenter bee mainly digs in dead and soft wood to lay its eggs and build its nest.

It is part of the many solitary bees that do not have nor colony, nor queen.

Habitat 5, 15 or 19

VIII.6.2.b. Anthocoris

Picture by Mick Talbot (CC BY)

“Anthocoris” means “flower stink bug” in ancient Greek.

Its habitat and alimentation vary depending on its age. The adults often live in large leaves plants, in bark on the ground, and in flowers in which they hunt for other insects.

Their preys are mainly psyllids (hugely destructive) and aphids.

Habitat 15 or 19

VIII.6.2.c. Hairy-footed flower bee (Anthophora plumipes)

Picture byGilles San Martin (CC BY-SA)

“Anthophora” means “which bears the flower”, “plumipes” refers to its feathery legs.

This solitary bee likes earth-hay mixes, cob old buildings, clayey slopes, hollow pathways and gravel pits.

Habitat 17

VIII.6.2.d. Musk beetle (Aromia moschata)

Picture by Tocekas (CC BY-SA)

Also called “musk longhorn beetle”.

“Longhorn beetle” for its long horns, and “musk” that comes from the excretion of a musky smell released by this species.

It has a phytophagous alimentation (it eats plants) and a saproxylic cycle of life (it spends most of, if not all, its cycle of life in rotting wood).

Habitat 15 or 19

VIII.6.2.e. Golden ground beetle (Carabus auratus)

Picture by Francisco Welter-Schultes (CC0)

The golden ground beetle lives in hedges, under branches and rocks.

It loves clayey and silty soils.

That dreadful slug hunter has a 3-year lifespan.

Habitat 18 or 19

VIII.6.2.f. Chrysoperla carnea (commonly known as the green lacewing)

Picture by Donald Hobern (CC BY)

This pollinating insect eats pollen, nectar, and honeydew—from aphid among other.

The honeydew is more or less a sweet and liquid substance, coming from insects’ excretions.

It hides under piles of wood, grass or dried leaves, or even in hedges.

Habitat 1, 3, 4, 15, 16 ou 19

VIII.6.2.g. Woodlouse

Picture by Alexis (CC BY)

The woodlouse is one of the two fully terrestrial crustaceans along with the dwelling shrimp.

It inhabits in rather wet areas and lives between 2 and 4 years with monthly sloughing.

It is a detritivorous insect and therefore eats rotting vegetal matter.

It seems to have appeared around 115 million years ago, during the Cretaceous Era.

Habitat 15, 18 or 19

VIII.6.2.h. Ladybug

Picture by Nick (CC0)

The ladybug isn't always red. Among the 6,000 indexed species, some are orange, yellow, blue, pink…

Its vivid color scares its enemies. It can excrete a yellowish liquid with a pestilential smell and a very bitter taste.

During winter, the ladybug seeks a shelter in piles of food, on a dry stone wall, in the cracks of a wall, under a pile of dead leaves or even under barks.

Habitat 9, 13, 14, 15, 18 or 19

VIII.6.2.i. Vernal collete

Picture by Fritz Geller-Grimm (CC BY-SA)

Once again a solitary bee. There are up to 1,000 species in France and 16,000 in the world!

More than 85% of wild bees would be solitary bees.

It digs its nest in the sand of river valleys and in littoral zones.

Other habitat: sand

VIII.6.2.j. Forficula

Picture by Syrio (CC BY-SA)

It is also called “earwig”. The name could come from the ear shape of cut fruits (apples, apricots…) in which you find galleries made by insects or worms eaten by Forficula.

It seeks refuge in cool, dark and wet places, but sheltered from rain (hedges, holes in the wood, piles of rocks, or soil).

Habitat 1, 2, 3, 11, 12,14, 16, 18 or 19

VIII.6.2.k. Mud dauber

Picture by Alvesgaspar (CC BY-SA)

The mud dauber (or mud-dauber wasp) has a preference for certain construction materials. Coarse and porous surfaces such as brick, rock or rough timber will make it happy. These materials make an excellent base for the construction of clay pottery nests.

Habitat 2, 5, 7, 10, 11, 12, 13, 14, 17 or 18

VIII.6.2.l. Hérisson

Picture by Calle Eklund/V-wolf (CC BY-SA)

They appeared around 15 million years ago under their current shape.

Their 6,000 spikes are replaced every 18 months.

They curl up into a ball in order to defend themselves.

The female stretches its posterior legs and lays down its spikes for reproduction.

They are pink and hairless at birth.

They have a varied diet and like insects.

You can find them in a pile of compost, in a pile of dead leaves, in tall grass and bushes.

Habitat 19, 16 and more to eat

VIII.6.2.m. Lizard

Picture by A7 (CC BY-SA)

If cut, the lizard's tail grows back, but it takes more than 60 days for it to be functional.

It demands a lot of energy and the lizard loses maneuverability during the regrowth time.

This animal, said to be cold-blooded, loves heat and the sun.

Habitat 2, 9 or 18

VIII.6.2.n. Osmia (mason bee)

Picture by Frank Vassen) (CC BY)

The osmia is one of the seven families of solitary bees. There are around 35 species of osmia in France.

This mason bee keeps its habitat closed with mud.

It is said to be caulicolous.

Habitat 5 or 6

"Caulicolous" bees live in hollow stems.
"Bramble-dwellers" bees prefer pithy stems.
There are many other habitats for terricolous bees that live in the ground.

Through opportunism, certain insects can live in less adapted habitats but which exist in a habitable place for them in terms of alimentation, reproduction…

Generally speaking, for insects living in a hole (of wood, hollow stem, pithy stem, in the ground or in the sand…), the size of the entrance hole is slightly bigger than the animal to avoid other cohabitants and its depth allows it to feel safe.

VIII.6.2.o. Butterfly

Picture byTylwyth Eldar (CC BY-SA)

This insect has thousands of scales on its wings.

Depending on the species, they can hibernate as an "imago" adult, as an egg, a caterpillar or a chrysalis.

Some butterflies can travel thousands of kilometers.

Butterflies can be in need of shelters to protect themselves from wind, from rain or from winter's cold.

Habitat 10

VIII.6.2.p. Pemphredon

Picture by Pjt56 (CC BY-SA)

Those little ant-like black wasps are great aphid hunters.

As bramble-dwellers, they do their nest in plants with soft-pith stems.

Habitat 8

VIII.6.2.q. Rosalia longicorn

Picture by Sickdevice (CC BY-SA)

Capturing this longhorn beetle is forbidden in many European countries.

It has a saproxylophagous alimentation (it eats dead wood) and has a saproxylic cycle of life.

Habitat 15 or 19

VIII.6.2.r. European rhinoceros beetle

Picture by Adrian Tync

It's one of the biggest beetles in France.

Its dimorphism (the difference regarding its appearance between the male and the female) is strong. The female has just a single "tuber" on its head.

In regard to their favorite places, rhinoceros beetles

(CC BY-SA)

have a predilection for rotting wood.

Habitat 15 or 19

VIII.6.2.s. Paederus littoralis

Picture by Lmbuga (CC BY-SA)

Paederus regulate pests. The biggest ones eat flies, maggots, caterpillars or even aphids. The youngest ones like acarids, springtails…

They live in rocks, tiles and plant debris on the soil.

Habitat 14, 15, 16, 18 or 19

VIII.6.2.t. Hoverfly (syrphid)

Picture by Hans Hillewaert (CC BY-SA)

Despite its appearance, it's a fly. Its Greek etymology súrphos means "midge".

It pollinates flowers, and some species at their larval stage are aphid hunters.

They hibernate in old buildings, rock shelters, leaf litter, bottom face of evergreens leaves, hollows in barks, or under ivy foliage.

Habitat 5, 6, 15 18 or 19

VIII.6.3. Living things principles

Here are some general principles in order to develop the presence of living things on a soil.

A biological desert will not bring life, even if you install shelters!

In practice, we found living beings:

- because there is a source of food;
- because they can assure the stages of their cycles of life (including reproduction);
- because there is a certain safety (including the one provided by a shelter);
- because they can move (notions of ecological corridors)…

VIII.6.3.a. Plant presence

As we saw it in the part dedicated to soil, learning how to identify the type of soil allows to put the best suitable plant essences.

This can be done by identifying some species of plants that have an homogeneous and endemic presence and by comparing their common criteria. It provides information about the soil texture, (sandy, clayey or silty), the richness in organic matters, the pH or even about the water retention ability.

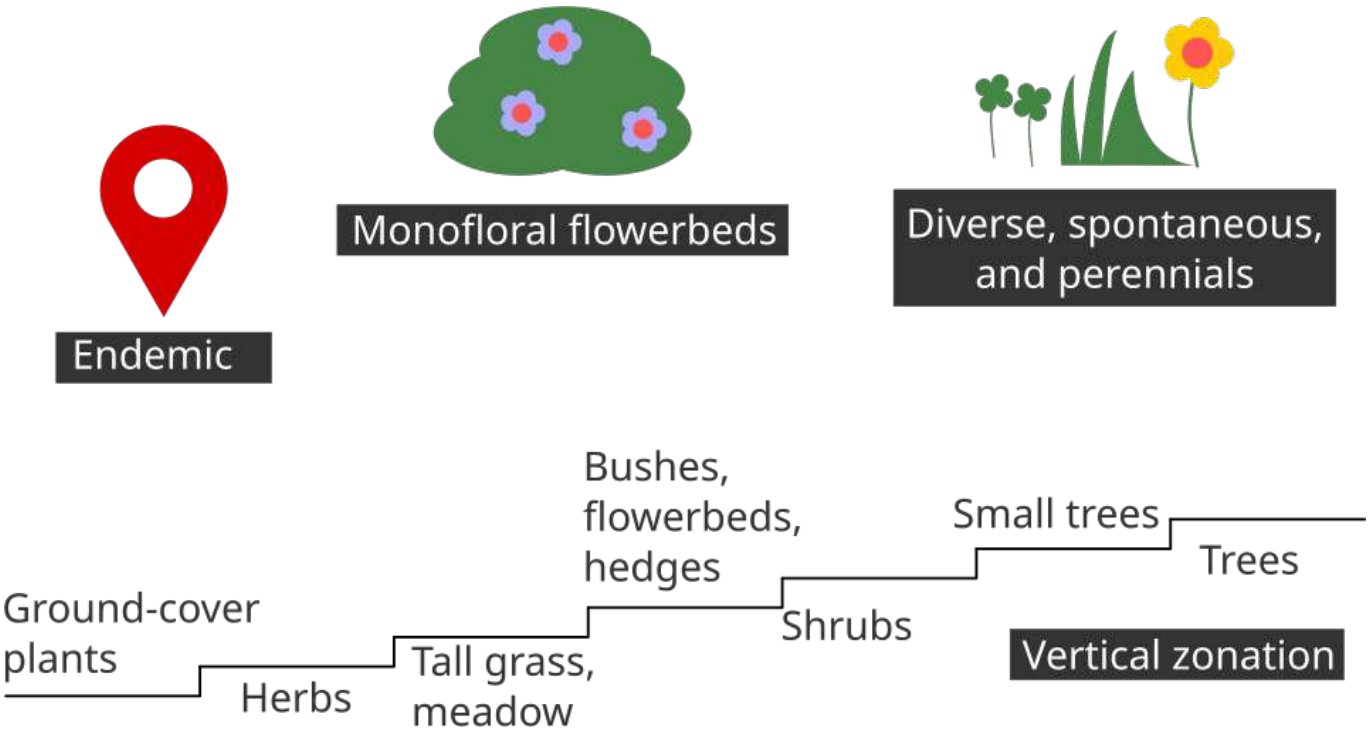
The type of soil can be identified with simple tests such as the one of the jar, which we have seen before (IV.2.2. Texture). It defines the soil texture, but also the useful reserve of water.

The soil pH is also a determining element.

Besides knowing one's soil, there are other principles which help to get plant diversity.

- Allowing indigenous plants to grow, planting or protecting local essences.
- You can trade with your neighbors or during grain stock markets. Preserve your grains in order to give them.
- Using nectar or berry plants will delight the local wildlife.
- For meadows in bloom, you can choose local, perennial flower species. This will help the pollinating and phytophagous insects to eat and drink, as well as being a reproduction support for many insects.

- Having well-chosen mono-floral flowerbeds for certain species of wild bees (the smallest ones gather pollen in an area that sometimes does not exceed 200 meters).
- Having "transitional" areas between herbaceous and wooded areas. You can achieve it by providing a terracing to create borders (with bushes and shrubs between them). Transitional areas, called "ecotones", are rich in diversity.



Practices that help with biodiversity and resilience.

VIII.6.4. Provision

A living soil will be far more welcoming in terms of biodiversity. Here are some elements that can help on poor soils.

VIII.6.4.a. Compost

Composting will bring life during the process and then, it will enrich the soil in the form of potting soil or by laying compost on a soil.

VIII.6.4.b. Green fertilizers

Green fertilizers are temporary ground cover plants, which are able to do many things:

- Fixing nitrogen (legume family);
- Fixing phosphorus (mustard and buckwheat);

- Fighting against invasive plants (brassica family, that also fix potassium and phosphorus from rocks);
- Ventilating the soil (grass family, among others);
- Neutralizing the pH;
- Fighting against erosion and leaching;
- Limiting water evaporation
- etc.

So we will use an appropriate fertilizer to one's soil and to its needs!

There are books and websites that list the green fertilizers.

Once at the end of their life, we can let green fertilizers on-site to mulch, put them in the compost, or even incorporate them for a nitrogen provision.

> Be careful: the books, including the ones about the associations of plants said "companions", bloom for some decades.
> Some associations are demonstrated and understood, but many are gardener's myths or local realities that depend on other criteria (climate, plant essences, types of soils...).
> Unfortunately, the myths are widespread and the scientific literature is not always accessible to everyone. Therefore, that topic is not that easy to deal with.

VIII.6.4.c. Evergreen ground covers

We can use an evergreen ground cover, in the form of perennial plant, to reduce the loss of water, ventilate the soils, reduce leaching...

VIII.6.5. Mulch

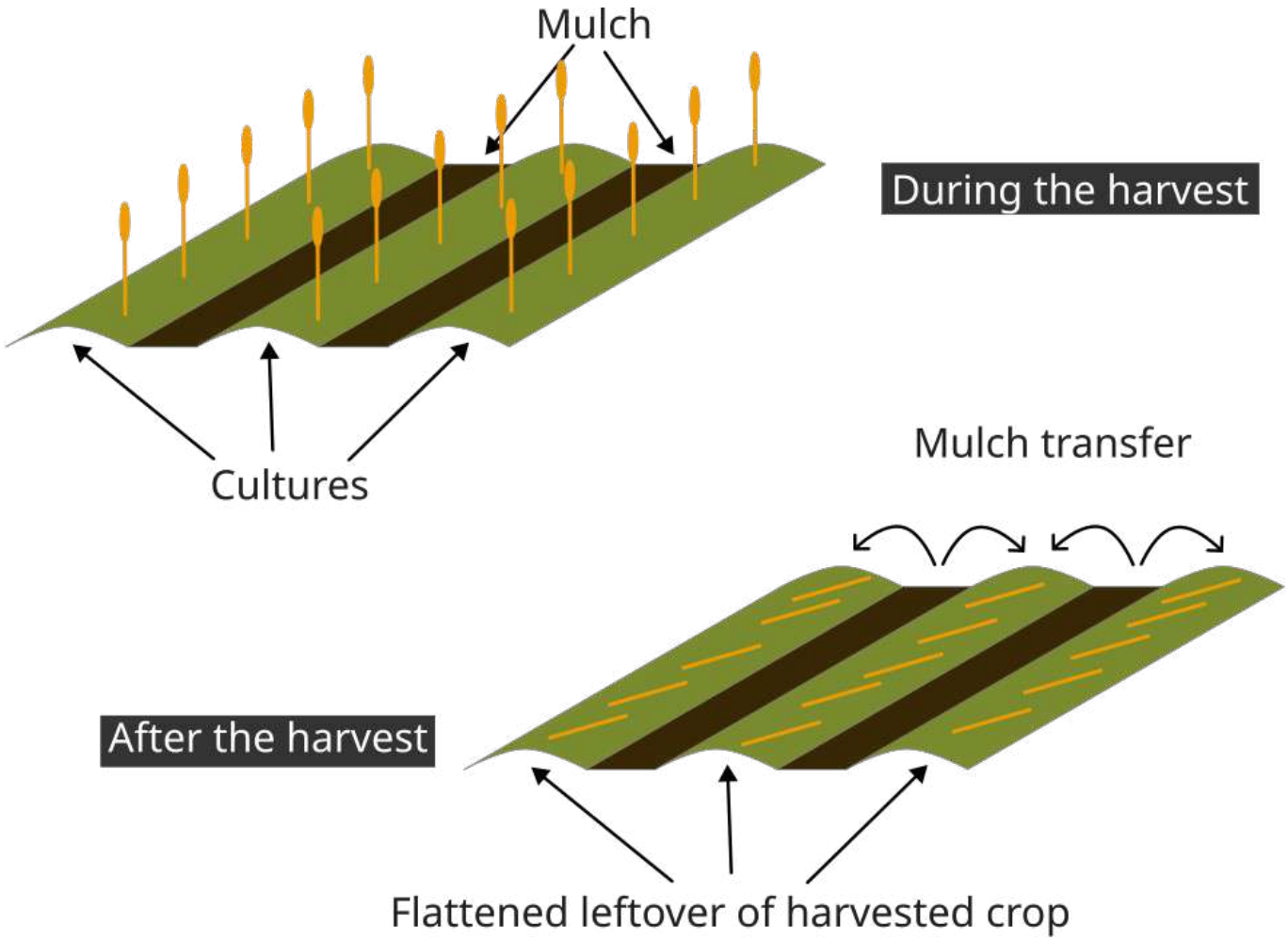
In nature, a living soil is hardly ever empty. To reduce evaporation, bring carbon or restore a soil, we can use mulch or straw-mulching.

Mulch consists in covering the soil with plants cut in tiny pieces (wood shavings, grass...). Straw mulching is a type of mulch with straw.

There is also the RCW (ramial chipped wood) that is not suitable for every soil. It's better for well-drained soils that are dry during summer, rocky...

For practical matters, we can use mulch between rows of culture to avoid sinking in the mud.

That way, we will be able to move them on the rows at the end of the harvest, to enrich them in carbon by putting them on flattened harvested crops, rich in nitrogen.



Catwalk reusing practice between two rows of mulch vegetable garden on crops.

VIII.6.6. Not flipping the soil over

- Avoid earthwork that disrupts the ecosystem.
- Do not flip the soil over, but ventilate it with a broadfork for example, compost on the surface that favors the presence of worms...
- We can remember that each habitat attracts certain species. The diversity of the set up will assure the diversity of the present species.

VIII.6.7. Water management

- Use evergreen ground covers.
- Mulch or straw-mulch to prevent the soil from drying.
- Water only if necessary, at the root of the plants and in the evening if the weather is hot.

- Favor non water-dependent plants.
- Use rain water or reuse cooking and vegetable washing water...
- Provide for ditches, swales or canals to allow surplus water to flow.
- Put the canals in the natural way of flowing of the terrain if there is a slope, even slight.
- A pond can gather water at the end of canals.

VIII.6.8. Ecological corridors

- Hedges are better than fences in terms of biodiversity.
- If you have a good relationship with your neighbors, you can participate in "ecological corridors" by leaving holes to allow species such as the hedgehog to travel from a garden to another.

VIII.6.9. Green waste management

- Leave dead leaves on the soil rather than picking everything up. Leave plant remains on the soil in a general way.
- Do not mow every surface, and keep flowered meadow areas (recommendation from 1/3 of the zones open to flowery meadows, more on sites not frequented by a building's occupiers).
- We can do a late scything (at the end of summer). Scythe at the most once a year or by a rota one year in two.

Pieces of advice in green wastes simplified management (parks and gardens)

The less matter transportation, the better!

Therefore, we prefer a process in the following order.

- Is it really necessary to cut, prune or remove:
  - Everywhere?
  - Here and there only?

- Can we leave on-site:
  - The grass on the soil;
  - The leaves where they fall…

- Can we bring to the closest point:
  - The grass, leaves and branches at the roots of trees or bushes…

- Can we put it on-site:
  - By making a pile of leaves, grass, etc., that rot on-site.
  - The grass, leaves / branches crushed as a munch?
  - Using the ground material for compost.

- If we're unable to manage that on-site:
  - Can we manage it collectively with neighbors?
  - Is there any place around where those resources would be useful?
  - Does a recycling center or a green waste recycling facility allow matter to be revalued?

A "green waste recycling facility" is an alternative to a recycling center to allow collecting and reusing green wastes for local uses.

VIII.6.10. Protection

- Avoid phytosanitary products.
- Feed birds by cold weather.
- If you have too much "pest" insects, favor the habitats of insectivorous species (bats, birds, frogs, hedgehogs, ladybugs, smooth-bellied spikelegs, earwigs, lacewings if your terrain allows it and depending on the type of pest insect...), support the presence of plants that will make them flee or even prepare homemade recipes to get rid of them (nettle [or other plants] manure).
- If you have a watering point (pond or others), putting a plank (or equivalent) bridging the pond and the ground will allow to avoid small animals to drown.

VIII.6.11. Habitats

We can convert spaces adapted to the ecosystem on a terrain. With the clues given in the "pedagogy" part (insect hotel), will you be able to find what species use what habitat? The sunshine, the exposure to wind or humidity are factors playing on the species that come to shelter.

VIII.6.11.a. Wood

- Diverse woods

Depending on wood essences, whether they be on the ground or higher, dry or wet, and depending on the size, the diversity of living beings will show.

Having dead wood (in a corner of a garden, in a sunny place or in half-shade) can promote the arrival of insects that eat it and reproduce in it. A dead trunk up or laying on the side are two different environments that attract different species.

- Stump

A stump cut living or a dead stump will have different ecosystems.

- Low pile of wood

Xylophagous insects (woodlouse, larvae...), their predators (such as ground beetles) or even mosses or fungi can settle in or go by alimenting.

- Bark and dead leaves for anthocoris

VIII.6.11.b. Other plants

- Pile of straw sheltered from humidity

A pile of dry straw will attract more inhabitants and could be used for birds to build their nests. Birds are also keen on animal hair to build a nest.

- Pinecones

Pinecones must also be in a dry place to be useful to hibernating ladybugs. Must be protected, with a wire fence for example, in order not to be used as small rodents' food.

- Pile of grass…

VIII.6.11.c. Rocks

- Pile of stones

Having a pile of rocks welcomes certain kinds of insects, but also other small animals.

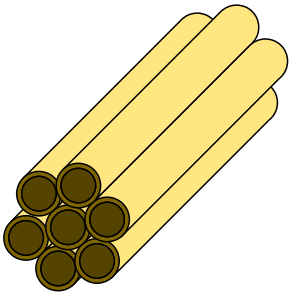
- Dry stones wall

In the sun, rocks attract lizards. The presence of cavities and their sizes can represent a habitat for many living species.

VIII.6.11.d. Constructions

In a general way, the habitats must be placed sheltered from wind and rain, neither in full sunlight nor in complete shadow.

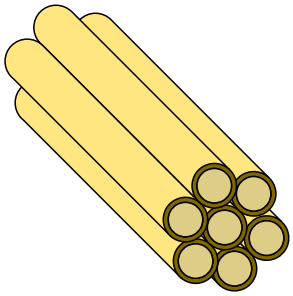
Pithy stems bundle of sticks



Cut pithy stems (raspberry bush, elder, rose bush, wahoo…), 10 to 20cm long, and make bundles of sticks. They must be placed in a mural cavity or a shrub. We can tie them with raffia or iron wire, which will be also used to hang it to a branch.

Ideal for smooth-bellied spikelegs, aphid wasps and other hymenoptera.

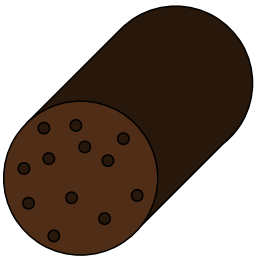
Hollow stems bundle of sticks



Cut hollow stems (bamboo, Japanese knotweed…), 10 to 20cm long, and make bundles of sticks. They must be placed in a mural cavity or a shrub. We can tie them with raffia or iron wire, which will be also used to hang it to a branch.

Ideal for solitary bees and solitary wasps.

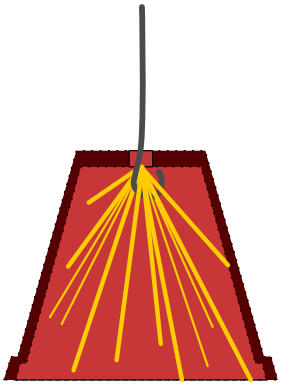
Pierced hard wood log



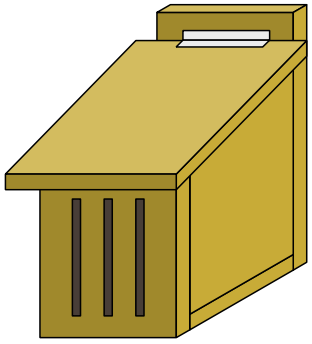
With holes from 3 to 10mm of diameter and 3 to 10cm deep, we can attract solitary bees, solitary wasps or ladybugs. They should not be placed directly on the ground, in order to avoid them being consumed by xylophagous.

Raw earth jars with hay/straw

A flipped-over jar filled with straw or hay must be installed in a tree. Adapted to orchards where aphids and psyllids strike, these habitats will welcome Forficula auricularia (earwigs), that are fond of that.



Vertical cracks

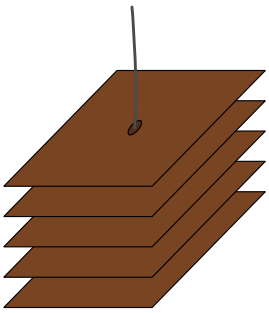


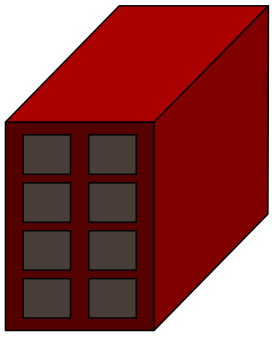
Resembling a closed birdhouse, but with cracks by way of entrances (5 to 10cm high and 1 to 1.5cm wide), this shelter of 15 to 20cm high (and 10cm by 10cm or so of inside surface) garners butterflies.

Horizontal wood strips

Cut square boards quite thin (0.5 to 1cm thick) with a side of about 15cm. Make a hole in the center, thread an iron wire in it while separating each board with 1-cm-thick holds.

This will also be useful for ladybugs as a place of hibernation. They must be placed at a certain height.





Bricks

Hollow bricks filled with a mixture of clay and 2/3 chopped straw or hay can shelter solitary bees.

VIII.6.12. Multiplying the living things

There are many practices to multiply the living things. Here are some of them.

VIII.6.13. Cutting

Propagation consists in taking a part of a plant in order to get a new one by multiplication. Depending on the plants, it is possible to cut the stems, leaves or roots. Some plants can be cut all year long, others during specific moments.

VIII.6.13.a. Cutting period

Herbaceous plants are (almost) all the plants that are not trees, with some tiny exceptions. Like grass, they have a flexible green and soft stem (by opposition to trees' solid hard brown branches). Propagation is done on a young plant in spring.

Semi-woody plants are the plants which base becomes wood around summer.

Their cutting is done during the July-September period.

For dry-timber plants, propagation is done between November and February.

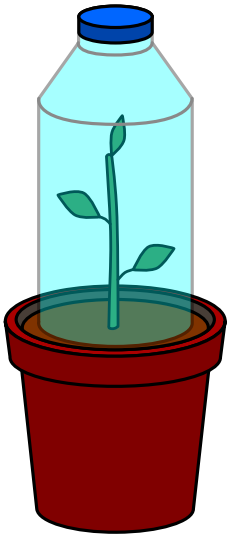
Leaves and house plants are done all year long, but the ideal cuttings are done between spring and the start of summer.

For roots, it's done during the dormancy period, around the end of fall and during winter.

VIII.6.13.b. General pieces of advice

- Having very sharp and clean cutting tools (preferably knives, utility knives eventually).
- Selecting sound and healthy plants' parts, but only with leaves (in the case of cutting a stem). If there are any buds, flowers or fruits, the beginning of the cutting will be too demanding in energy. You will have to remove them.
- The rooting hormone increases the success rates, but it's not essential. You can find willow or bramble-based homemade recipes.
- The propagation potting soil must be light. We will add 1 part of sand for 3 parts of potting soil. The potting soil is itself made of 2 parts of vegetal dirt, for 1 part of compost. The propagation potting soil can be leveled to remove crude elements.
- The cuttings need heat, humidity and light. We can put them in propagation greenhouse or "steamed" cutting for the heat and greenhouse effect, by

always leaving the potting soil slightly wet. We can also put them near a window inside.



Examples of a “steamed” cutting with a plastic bottle.

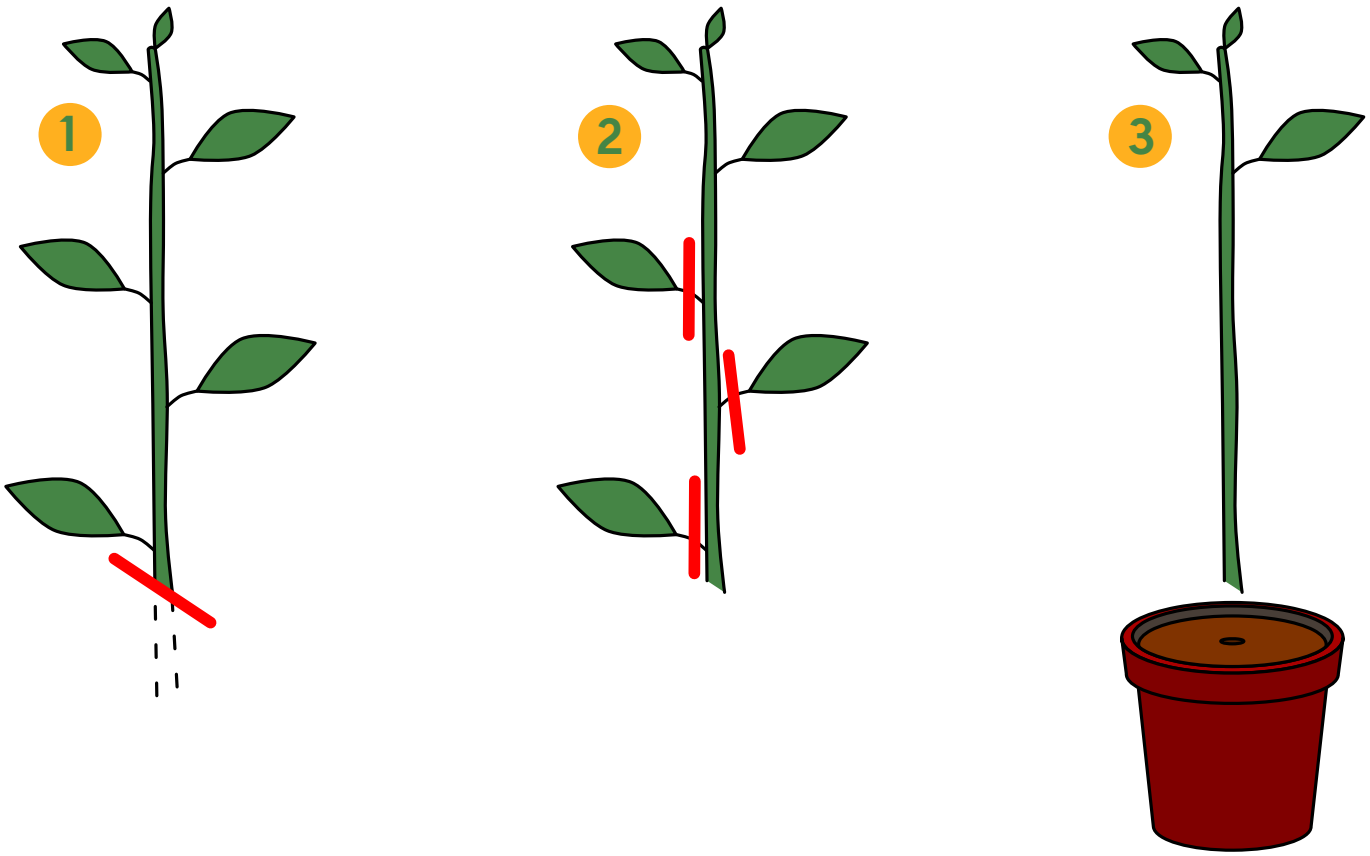
VIII.6.13.c. Herbaceous stem cutting

We take a sound stem (10 to 15cm) by cutting in bevel, right below a node.

We remove the leaves from the base and we keep 2 to 3 of them at the top. If those leaves are big, then we can cut them to reduce their size. The goal is to get enough energy to develop roots, but not to use too much of it for the leaves and to limit evaporation by the plant.

We use some rooting hormone and we plant in a light potting soil. With a finger or a small tubular item, e.g. a pencil, we dig a hole to transfer the leaf into it; then, we fill the hole back in and tamp down the soil at the root of the plant. Therefore, we keep the rooting hormone where it was placed The next step is to wet the potting soil.

We put the cutting jar sheltered in a bright, wet and warm place (but without direct sunlight to avoid drying the potting soil).



Example of a cutting of a jarred herbaceous stem with no rooting hormone.

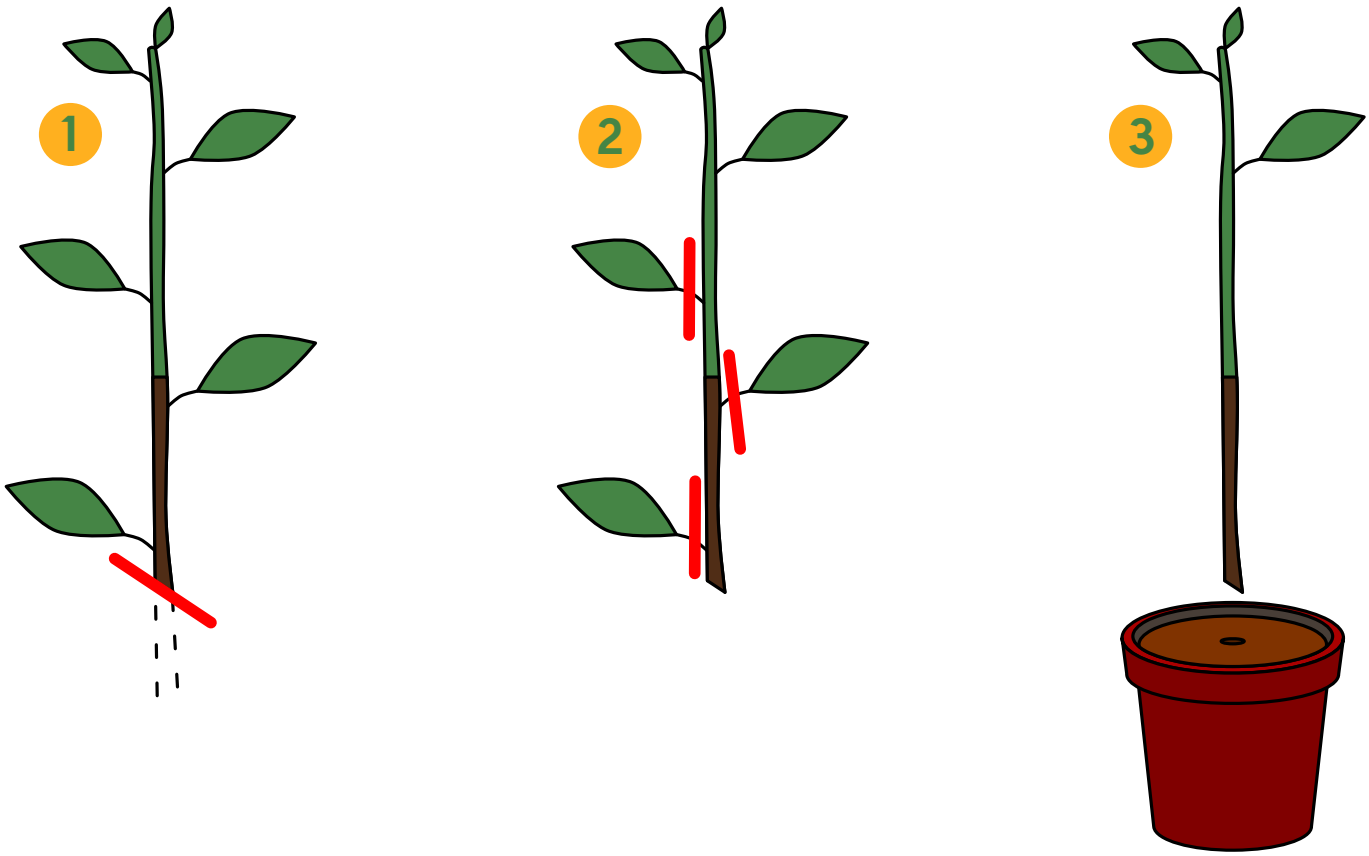
VIII.6.13.d. Semi-woody stem cutting

We take a sound stem that is still soft on the extremity (10 to 15cm) and which base has become a bit woody (it looks like wood, either already brown or green but hard). We cut in bevel, right under a node.

We remove the leaves from the base and we keep 2 to 3 of them at the top. If those leaves are big, then we can cut them to reduce their size.

We use some rooting hormone and we plant in a light potting soil. With a finger or a small tubular item, e.g. a pencil, we dig a hole to transfer the leaf into it; then, we fill the hole back in and tamp down the soil at the root of the plant. Therefore, we keep the rooting hormone where it was placed The next step is to wet the potting soil.

We put the cutting jar sheltered in a bright, wet and warm place (but without direct sunlight to avoid drying the potting soil).



Example of a cutting of a jarred semi-woody stem with no rooting hormone.

VIII.6.13.e. Dry timber stem cutting

Make a trench in which we add sand to drain the water, in a place sheltered from the wind and direct sunlight.

We take a healthy branch (15 to 20cm) by cutting the bottom part in a 45 degree angle right below a node, and the upper part above a node.

After applying rooting hormones, we plant the branch in a light potting soil put in the trench. With a finger or a small tubular item, e.g. a pencil, we dig a hole to transfer the leaf into it; then, we fill the hole back in and tamp down the soil at the root of the plant. The next step is to wet the potting soil.

At the beginning of spring, we can transfer the cuttings to a greenhouse or a pot.

VIII.6.13.f. Leaf propagation

This method is particularly efficient for succulent plants.

We take a healthy leaf, and keep its base (the petiole for stemmed plants, nonexistent for succulents).

If we cut a leaf from a succulent, we let it dry for 2 to 3 days so that the base creates a thin crust.

We plant 2cm of the base of the leaf in addition to the petiole (if existent) in a light potting soil. With a finger or a small tubular item, e.g. a pencil, we dig a hole to transfer the leaf into it; then, we fill the hole back in and tamp down the soil at the root of the plant. The next step is to wet the potting soil.

We put the cutting jar sheltered in a bright, wet and warm place (but without direct sunlight to avoid drying the potting soil).

Example of a potted succulent leaf with no rooting hormone.

VIII.6.13.g. Root cuttings

Especially efficient for plants that multiply thanks to basal shoots (suckers).

We select a healthy and well vigorous sample. As the process can weaken the plant, we choose a robust part.

We dig to see the root system, and we cut pieces of the young and thick roots (5cm long for thick roots, 10cm for the thinnest).

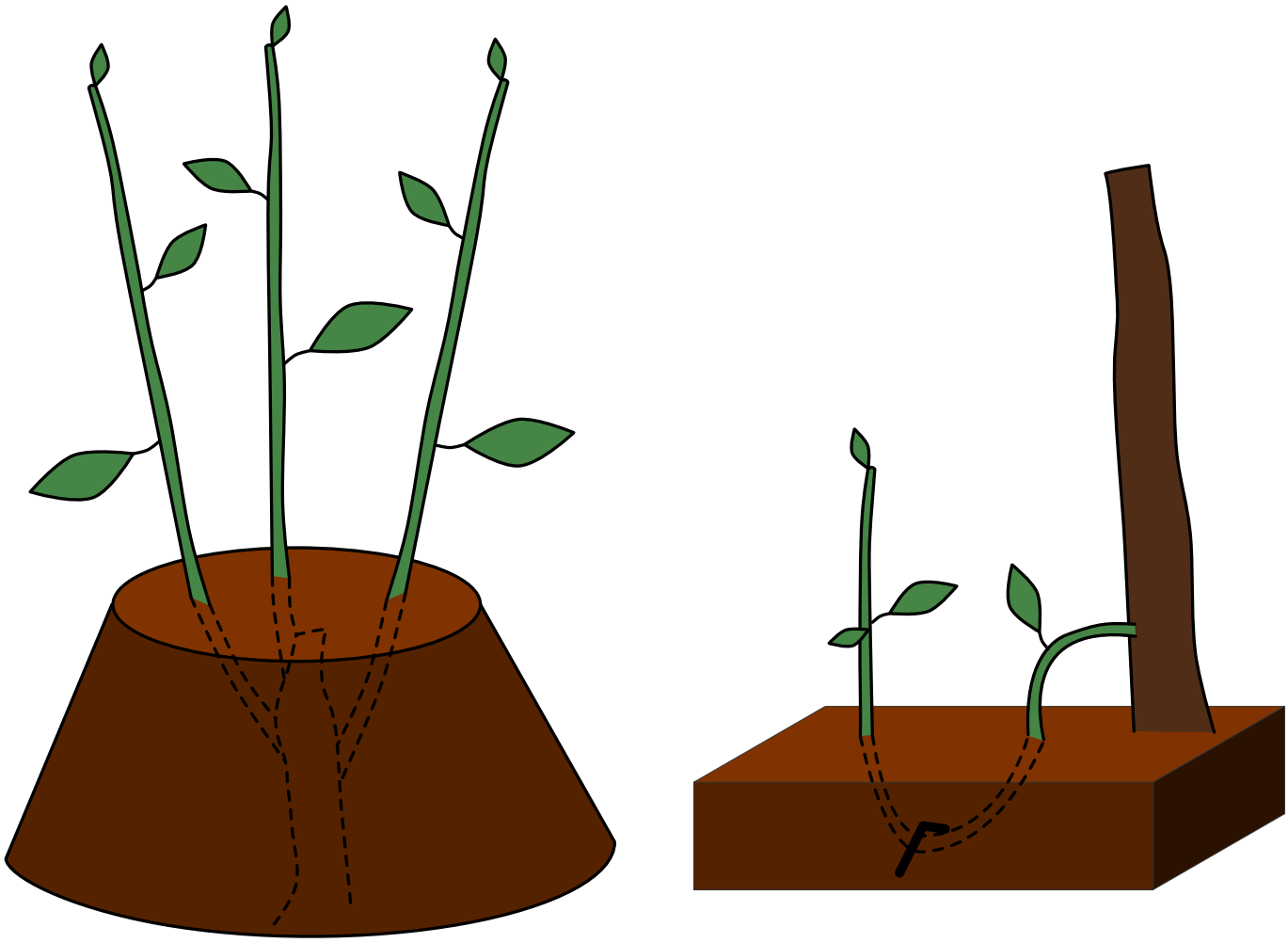
We replant the mother plant.

We plant the roots in a light potting soil, but on the surface: horizontally with 1cm of potting soil that covers them for the thinnest roots, vertically and at potting soil level for the thickest ones. The next step is to wet the potting soil.

We put the cutting jar sheltered in a bright, wet and warm place (but without direct sunlight to avoid drying the potting soil).

VIII.6.14. Layering

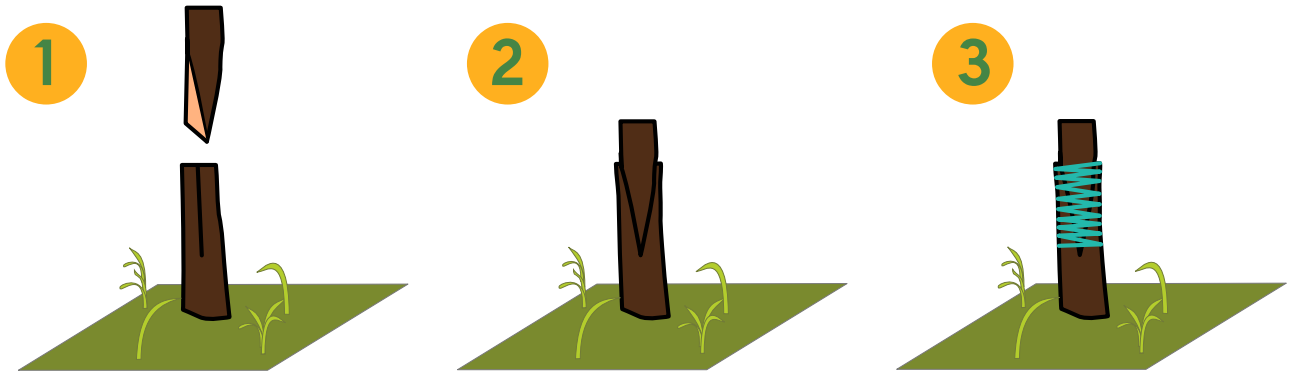
Layering propagates the plant by creating roots on buried branches.



Examples of types of layering: mound layering on the left, and simple layering on the right, which is the most common one.

VIII.6.15. Grafting

The principle of grafting is to put a selected graft, generally a dry timber stem, on a compatible rootstock. Not every support is compatible with any plants.



1-The graft has a contact surface maximum ready to be inserted in the pruned rootstock. 2-The insertion is efficient. 3-The junction between the two parts must be consolidated the time the graft operates.

VIII.6.16. Seed bombs

Seed bombs are used to grow plants on hardly accessible areas.

Here is a recipe.

- Mix 2 volumes of clayey dirt for 1 volume of potting soil.
- Add seeds to the mixture.
- Gradually add water in small quantity to the mixture and form a compact yet slightly wet ball.
- Throw the seed bomb in inaccessible spaces or place them where you want.

VIII.6.17. Seed library

A seed library consists in gathering seeds that we trade on a local level.

Putting them in a dry and shady place, as well as tagging the seeds are good practices to guarantee the success of that process.

IX. Conclusion

We hope you liked to read this booklet and that you learned things. From our part, we hope to go a little further...

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> When the last tree will be chopped down, the last river polluted, the last fish captured, you will see that money don't feed people.
>
> Native American quote, unknown author
> (Word gathered by "Alanis Obomsawin" in "Who is the Chairman of this Meeting?" in the chapter "Conversations with North American Indians".)

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